GE Nuclear Energy

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October 12, 2001
MFN 01-060

US Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Proj 710

Attention: Chief, Information Management Branch
Program Management
Policy Development and Analysis Staff

Subject: **SAFER/GESTR-LOCA Analysis Process Seminar – October 18, 2001 GE Presentation Slides**

Reference: MFN 01-052, same subject, dated October 4, 2001

Enclosed are the final presentation slides for the October 18 seminar on the SAFER/GESTR-LOCA analysis process. This transmittal supersedes the draft presentation submitted previously in the above referenced letter.

The attached affidavit identifies that the presentation contains proprietary information of the type that GE maintains in confidence and withholds from public disclosure. The proprietary information has been indicated by "bars" drawn in the margin of the slides of this presentation and by the words "GE Company Proprietary" in the slide titles. The information has been handled and classified as proprietary to GE as indicated in the attached affidavit. GE hereby requests that this information be withheld from public disclosure in accordance with the provisions of 10CFR 2.790.

A non-proprietary version of the presentation also is included with this transmittal.

Sincerely,

J.F. Klapproth, Manager
Engineering and Technology

Attachments:
1) Presentation – SAFER/GESTR LOCA Analysis Process, Dan Pappone, October 2001 (proprietary version)
2) Presentation – SAFER/GESTR LOCA Analysis Process, Dan Pappone, October 2001 (non-proprietary version)
3) Affidavit George B. Stramback, dated October 12, 2001

cc: R.M. Pulsifer (NRC)
D.C. Pappone (GE

D065

General Electric Company

AFFIDAVIT

I, George B. Stramback, being duly sworn, depose and state as follows:

(1) I am Project Manager, Regulatory Services, General Electric Company ("GE") and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Attachment 1 to GE letter MFN 01-060, J. F. Klapproth to NRC, *SAFER/GESTR-LOCA Analysis Process Seminar – October 18, 2001 GE Presentation Slides*, dated October 12, 2001. The proprietary information in attachment 1 (*SAFER/GESTR LOCA Analysis Process, Proprietary Presentation, Dan Pappone, October 2001*) is identified by GE Proprietary Information of the slide and side-bars by the specific presentation material.

(3) In making this application for withholding of proprietary information of which it is the owner, GE relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), 2.790(a)(4), and 2.790(d)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals cost or price information, production capacities, budget levels, or commercial strategies of General Electric, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future General Electric customer-funded development plans and programs, of potential commercial value to General Electric;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in both paragraphs (4)a. and (4)b., above.

(5) The information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GE, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within GE is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GE are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed information about the results of analytical models, methods and processes, including computer codes, which GE has developed, obtained NRC approval of, and applied to perform evaluations of the loss-of-coolant accident for the BWR.

The development and approval of the BWR loss-of-coolant accident analysis computer codes was achieved at a significant cost, on the order of several million dollars, to GE.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GE.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GE's competitive advantage will be lost if its competitors are able to use the results of the GE experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GE would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GE of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

STATE OF CALIFORNIA)
) ss:
COUNTY OF SANTA CLARA)

George B. Stramback, being duly sworn, deposes and says:

That he has read the foregoing affidavit and the matters stated therein are true and correct to the best of his knowledge, information, and belief.

Executed at San Jose, California, this 12th day of October 2001.

George B. Stramback
General Electric Company

Subscribed and sworn before me this 12th day of October 2001.

TERRY J. MORGAN
Commission # 1304914
Notary Public - California
Santa Clara County
My Comm. Expires May 18, 2005

Notary Public, State of California

GE Nuclear Energy

SAFER/GESTR
LOCA Analysis Process

D.C. Pappone
October 2001

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Objectives

- Overview of BWR LOCA Event
- Overview of BWR ECCS Configurations
- Overview of SAFER/GESTR LOCA Methodology
- SAFER Applications
  - Full SAFER Analysis
  - New Fuel Introduction
  - Reload Analysis
  - Constant Pressure Power Uprate
  - Thermal Power Optimization

Event Overview

- Emergency Core Cooling Systems
- BWR Break Spectrum Response

- Design Basis Accident Recirculation Line Break
- Small Break
- Intermediate Size Break

Emergency Core Cooling Systems

- All plants have
  - 2 core spray systems
  - Automatic Depressurization System
- Jet pump plants have
  - 3-4 low pressure ECC systems
  - 1 high pressure ECC system

Basic ECCS network defines break spectrum response for all BWRs

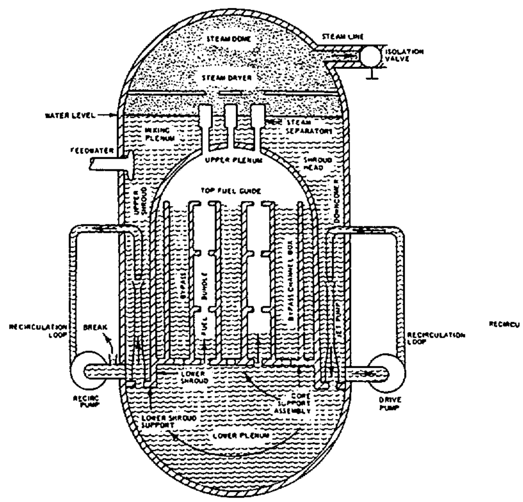
BWR Break Spectrum Response

DBA Recirculation Line Break

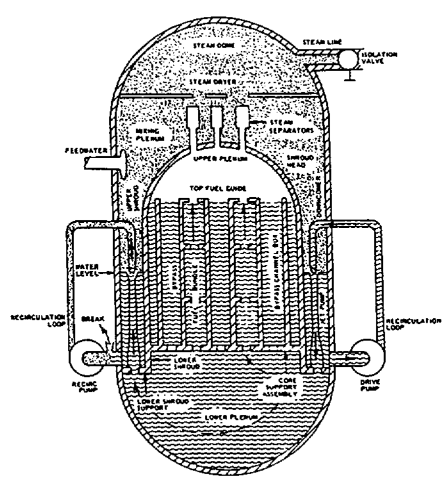
Vessel Response

- Rapid core flow decrease
- Downcomer empties - vessel depressurizes
- Lower plenum flashing
- Core uncovers, vessel empties
- ECCS injection
- Region inside core shroud refloods
  - Core reflooded to 2/3 core height

DBA Recirculation Line Break



DBA Recirculation Line Break



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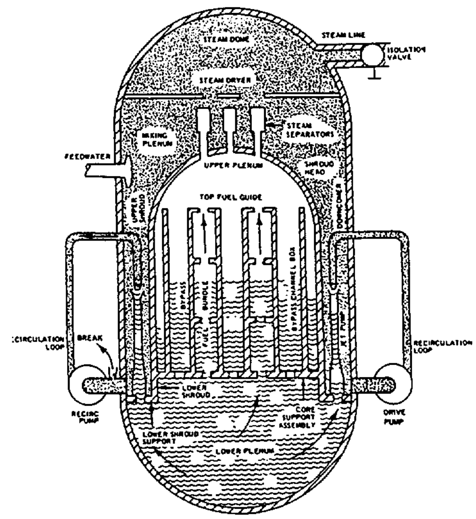
DBA Recirculation Line Break



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DBA Recirculation Line Break

DBA Recirculation Line Break

DBA Recirculation Line Break

Fuel Temperature Response

- Rapid core flow decrease
  - Boiling transition (dryout) of fuel
    (Nucleate boiling → film boiling)
  - First peak heatup (driven by fuel stored energy)
- Lower plenum flashing
  - Film boiling → transition boiling
  - End of first peak heatup

DBA Recirculation Line Break

Fuel Heatup (continued)

- Core uncovers
  - Second peak heatup (driven by decay heat)
  - Steam cooling
- ECCS injection
  - Spray cooling
- Core reflood
  - Film boiling → transition boiling → nucleate boiling
  - End of second peak heatup

DBA Recirculation Line Break

Small Break

Vessel and Fuel Heatup Response

- Vessel does not depressurize through break
- Longer core flow coastdown
  - No dryout
  - No first peak PCT
- HPCS primary makeup system
  - Little or no core uncovery and heatup
- ADS plus low pressure ECCS backs up HPCS
  - Fuel heatup can be as high as DBA

Small Break

Small Break

Small Break

Intermediate Size Break

Vessel and Fuel Heatup Response

- Vessel slowly depressurizes through break
- Less water loss from vessel
- Longer core flow coastdown
  - No dryout
  - No first peak PCT
- Low pressure ECCS primary makeup systems
  - ADS helps vessel depressurization
  - Fuel heatup less than DBA or small break

Intermediate Size Break

Intermediate Size Break

Intermediate Size Break

ECCS Configurations

- Emergency Core Cooling Systems
- BWR/2 (non-jet pump)
- BWR/3-4 (jet pump)
- BWR/5-6 (jet pump)

ECCS Overview

- High Pressure Core Spray (HPCS) Pump
  - Injects over full vessel pressure range
  - Makeup for small breaks, isolation events
  - Core Spray Cooling/Flooding
  - BWR/5-6
- High Pressure Coolant Injection (HPCI) Pump
  - Injects over high, intermediate vessel pressure range
  - Makeup for small breaks, isolation events
  - Injects through feedwater (outside core shroud)
  - Steam driven
  - BWR/3-4

ECCS Overview

- Low Pressure Core Spray (LPCS) Pump
  - Core Spray Cooling/Flooding
  - All BWRs
- Low Pressure Coolant Injection (LPCI) Pumps
  - Inject through recirc loop into Lower Plenum (BWR/3-4) or directly in Core Bypass Region (BWR/5-6)
  - Core Flooding

ECCS Overview

- Automatic Depressurization System (ADS)
  - Depressurize vessel through selected safety/relief valves
  - Turns small break into large break
  - Allows low pressure ECCS to inject
  - All BWRs
- Isolation or Emergency Condenser
  - Heat removal
  - No inventory addition or loss
  - BWR/2, some BWR/3s

Emergency Core Cooling Systems

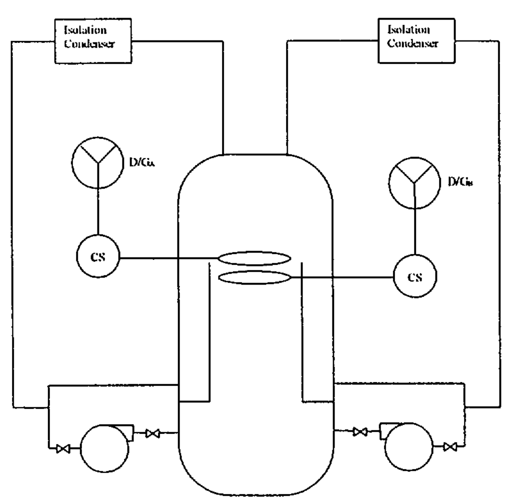
- Makeup systems (CS, LPCI, HPCI) initiate on
  - Low reactor water level

  or
  - High drywell pressure
- ADS initiates on
  - Low reactor water level and high drywell pressure

  or
  - Low reactor water level for extended time
- Isolation condenser initiates on
  - Low reactor water level

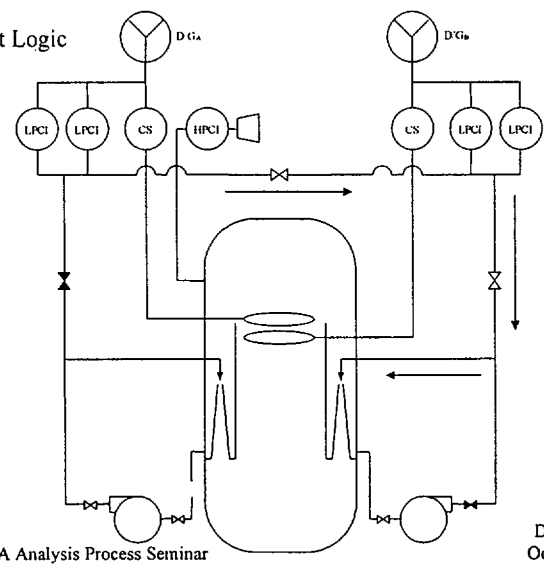
  or
  - High vessel pressure

BWR/2



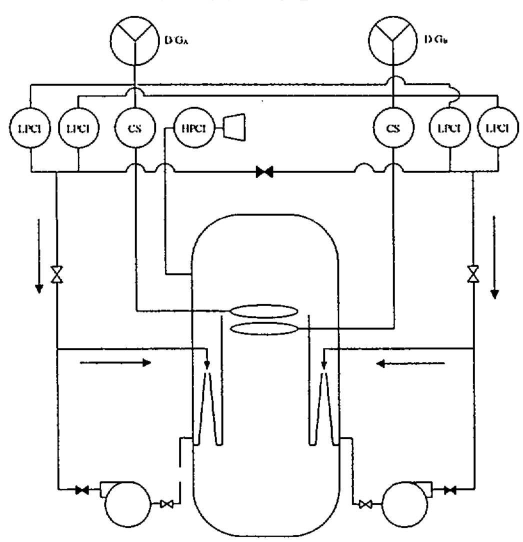
BWR/3-4

LPCI Loop Select Logic

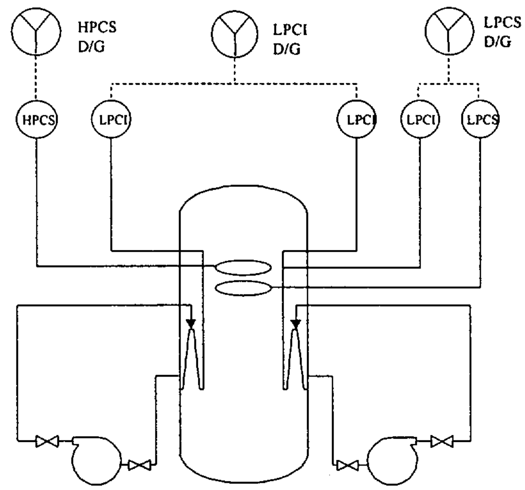


BWR/3-4

LPCI-Mod



BWR/5-6



TECHNOLOGY DEVELOPMENT

- Level of LOCA knowledge dictated ECC system design, regulations, and evaluation models

Development History

- Individual phenomena studied first
- Separate effects tests (1960s)
  - Break flow
  - Fuel heatup
  - Spray cooling
  - Boiling transition
- Conservative evaluation models required
- Simple, conservative system design process

Development History

- Integrated System Tests (1970s)
  - Reactor and ECCS modeled
  - 30° Sector core spray test
- Demonstrated margin in ECCS designs
- Basis for realistic evaluation models
- Regulations changed to allow realistic models

REGULATORY REQUIREMENTS

- NRC allowed more realistic models like SAFER based on testing experience

Regulatory History

- Original acceptance limit - no core melt (~3300°F)
  - GE used 2700°F PCT design limit
- Early 1970s - ECCS Rulemaking
  - 2300°F interim PCT limit
- 1974 - 10CFR50.46, Appendix K
  - Defined acceptance criteria, required models
- 1988 - 10CFR50.46 revised
  - Realistic models allowed

Current Requirements

- 10CFR50.46
  - Requires ECCS performance analysis
  - Allows realistic models or conservative Appendix K based models
  - Defines acceptance criteria
- 10CFR50 Appendix K
  - Defines required models
- General Design Criteria (10CFR50 Appendix A)
  - Design for any pipe break
  - Assume single failure
  - Assume limiting power source

Evaluation Model Requirements

- 10CFR50.46 allows two types of models:
- Appendix K models
  - Use required and acceptable models specified in Appendix K
  - Conservatism in individual models, therefore PCT is conservative
- Realistic models
  - Qualified against experimental basis
  - 95th percentile upper bound PCT $\leq$ 2200°F
  - Conservatism assured by upper bound PCT calculation

Evaluation Model Requirements

- SAFER uses realistic model approach but still must meet Appendix K requirements
  - Approved before 1988 change to 10CFR50.46
  - Follows SECY-83-472
  - SAFER uses nominal models, correlations
  - Break spectrum, single failure analyses use nominal assumptions
  - Licensing PCT uses required Appendix K models
  - Upper bound PCT calculation to assure Licensing basis PCT is conservative

GE LOCA MODEL HISTORY

- Original Design Models
  - 1960s, simple, conservative
  - Used for ECC system design through BWR/6
- SAFE/REFLOOD/CHASTE
  - 1970s, met Appendix K requirements
  - Conservative model
- SAFER/GESTR-LOCA
  - 1984, based on integrated system tests
  - "Realistic" model

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SAFER/GESTR-LOCA EVALUATION MODEL

- Evaluation model is the calculational framework required to evaluate the reactor system behavior during a LOCA
- Evaluation model consists of:
  - Mathematical models
  - Computer codes
  - Input values
  - Assumptions
  - Process for treating input and output
  - Hand calculations

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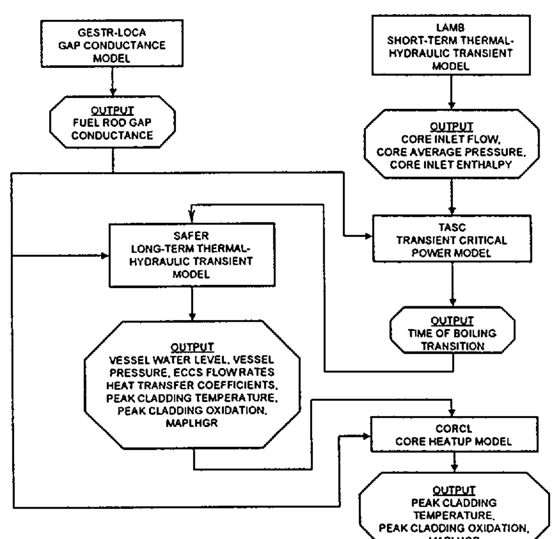
SAFER/GESTR Model



SAFER Development History

- SAFER01 (1981-3) development version submitted to NRC
  - based on SAFE/REFLOOD
- SAFER02 (1984) approved version for jet pump plants
- SAFER03 (1987) extended methodology to non-jet pump plants, CORCOOL heatup model (non-jet pump plants only)
- SAFER04 (1987) enhancements for low ECCS flow rates (used only for KKM)
- SAFER04V (1988) moved to VAX platform, current version for both jet pump and non-jet pump plants, CORCOOL heatup model (non-jet pump plants only)

Acceptance Criteria

- Demonstrate compliance with 10CFR50.46 acceptance criteria
  - PCT ≤ 2200°F
  - Local Oxidation ≤ 17%
  - Core Wide Metal Water Reaction ≤ 1%
  - Coolable Geometry
  - Long-term Cooling

Acceptance Criteria

- PCT, Local Oxidation, Core-Wide Metal Water Reaction calculated in plant-specific SAFER analysis
- Coolable Geometry demonstrated generically
  - PCT < 2200°F, Local Oxidation < 17%
- Long-Term Cooling demonstrated generically

Long-Term Cooling

- Long-term cooling provided by
  - Core reflooded above top of active fuel
  - Core reflooded to top of jet pumps with one core spray system operating at rated flow
- Adequate spray distribution required to ensure uncovered portion of bundle remains wetted
- Adequate spray distribution assured by
  - Confirming spray sparger is intact and meets design condition (inspection)
  - Providing design flow rate to sparger

SAFER Application NRC SER Requirements

- Licensing Basis PCT ≤ 2200°F
- Upper Bound PCT < Licensing Basis PCT
- Upper Bound PCT < 1600°F (jet pump plants)
- Break spectrum consistent with generic LTR
- ECCS configuration, operating parameters consistent with generic

SAFER Analysis Inputs

- ECCS Parameters
- Instrument setpoints
- Single Failures
- Plant operating conditions
- Fuel inputs
- Plant modeling inputs
- Plant mods, crack leakage, etc.
- Model switches, correlation coefficients defined in technical control files, code defaults - not changed by users

Boiling Transition Calculations

- Boiling transition for each fuel node calculated using LAMB/TASC codes
  - Vessel blowdown conditions from LAMB
  - Time of boiling transition for each node from TASC (fuel dependent)
-
-

SAFER Calculations

- Determine limiting single failure, fuel type
- Analyze break spectrum using limiting fuel type
  - Full spectrum using nominal inputs
  - Appendix K spectrum extent based on nominal results
- Determine Upper Bound PCT
- Determine Licensing Basis PCT
- Analyze alternate operating modes (MELLLA, ICF, SLO)
- Determine MAPLHGR multipliers
- Calculate core wide metal water reaction

Nominal Model Assumptions

1. Decay Heat
2. Transition Boiling Temperature
3. Break Flow

4. Metal-Water Reaction
5. Core Power
6. Peak Linear Heat Generation Rate

7. Bypass Leakage Coefficients
8. Initial Operating Minimum Critical Power Ratio (MCPR)
9. ECCS Water Temperature
10. ECCS Initiation Signals
11. Automatic Depressurization System
12. ECCS Available — Systems remaining after worst single failure
13. Stored Energy
14. Fuel Rod Internal Pressure
15. Fuel Exposure

Appendix K Model Assumptions

1.	Decay Heat	1971 ANS + 20%
2.	Transition Boiling Temperature	Transition boiling allowed during blowdown only until cladding superheat exceeds 300°F
3.	Break Flow	Moody Slip Flow Model with discharge coefficients of 1.0, 0.8, and 0.6
4.	Metal–Water Reaction	Baker–Just
5.	Core Power	Licensed Power x 1.02
6.	Peak Linear Heat Generation Rate	x 1.02 kW/ft for GE8 and GE10, x 1.02 kW/ft for GE14
7.	Bypass Leakage Coefficients	
8.	Initial Operating Minimum Critical Power Ratio (MCPR)	/1.02 for GE8, GE10 /1.02 for GE14
9.	ECCS Water Enthalpy (Temperature)	120°F (original App. K value)
10.	ECCS Initiation Signals	Limiting Setpoint Values
11.	Automatic Depressurization System	
12.	ECCS Available	Systems remaining after worst single failure
13.	Stored Energy	
14.	Fuel Rod Internal Pressure	
15.	Fuel Exposure	Limiting fuel exposure which maximizes PCT

Analysis Assumptions

Analysis Assumptions

PLANT INPUTS AND INITIAL CONDITIONS

- Analysis defines limits for
  - ECCS inputs
  - Fuel inputs
  - Reactor operating conditions
- Nominal values used for
  - Vessel geometry
  - non-ECC systems (feedwater, SRVs)

Vessel and Non-ECCS System Inputs

- Vessel and internals geometry
  - Volumes
  - Heat slab definition (surface area, thickness, mass)
  - Flow paths
- Feedwater, recirc, SRV performance parameters

-

Fuel Inputs

Fuel Parameter	Analysis Value GE8	GE10	GE14
PLHGR (kW/ft) – Appendix K – Nominal			
MAPLHGR (kW/ft) – Appendix K – Nominal			
Worst Case Pellet Exposure for ECCS Evaluation (MWd/MTU)			
LHGR-Exposure Limit Curve used in the LOCA Analysis (kW/ft vs MWd/MTU)			
Initial Operating MCPR – LOCA Analysis Limit – Appendix K – Nominal			
Axial Peaking Factor			
Number of Fuel Rods per Bundle	62	60	92

ECC System Inputs

- SAFER analysis defines performance requirements for ECCS
  - Initiation signals
  - Startup time delays
  - Flow rates
-

Sensitivity to Inputs

- Analysis is sensitive to
- Analysis is somewhat sensitive to
- Analysis is not sensitive to

Break Spectrum Calculations
Recirculation Line Breaks

Non-Recirculation Line Breaks

-
- Break locations analyzed
  - Core Spray Line Break
  - Feedwater Line Break
  - Steamline Break Inside Containment
  - Steamline Break Outside Containment
  - LPCI Line Break
- Automatic LPCI Diversion
-

SENSITIVITY STUDIES

- Extended Operating Domain
  - Maximum Extended Load Line Limit Analysis (MELLLA)
  - Increased Core Flow (ICF)
- Alternate Operating Modes
  - Single Loop Operation (SLO)
  - Feedwater Temperature Reduction (FWTR)
  - Feedwater Heater Out Of Service (FHOOS)

SENSITIVITY STUDIES

Upper Bound PCT

Upper Bound PCT

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Upper Bound PCT
Significant Parameters

Licensing Basis PCT

$PCT_{Licensing} = PCT_{Nominal} + ADDER$.

The adder is calculated as follows:

$ADDER^2 = [PCT_{App.\,K} - PCT_{Nominal}]^2 + \Sigma\,(\delta\,PCT_i)^2$,

where:

$PCT_{App.\,K}$ = Peak cladding temperature from calculation using Appendix K specified models and inputs.

$PCT_{Nominal}$ = Peak cladding temperature from nominal case.

$\Sigma(\delta\,PCT_i)$ = Plant variable uncertainty term.

The plant variable uncertainty term accounts statistically for the uncertainty in parameters which are not specifically addressed by 10CFR50 Appendix K.

Licensing Basis PCT
Plant Variable Uncertainties

New Fuel Introduction

New Fuel Introduction

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Reload Analyses

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Constant Pressure Power Uprate

Constant Pressure Power Uprate

Thermal Power Optimization