UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

February 13, 2002

MEMORANDUM TO: ACRS Members

FROM: Michael T. Markley, Senior Staff Engineer
ACRS

SUBJECT: CERTIFICATION OF THE MINUTES OF THE JOINT MEETING OF THE ACRS SUBCOMMITTEES ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT - NOVEMBER 15, 2001 - ROCKVILLE, MARYLAND

The minutes of the subject meeting, issued February 11, 2002, have been certified as the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc: via E-mail
J. Larkins
S. Bahadur
H. Larson
S. Duraiswamy
ACRS Staff Engineers
ACRS Fellows

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

MEMORANDUM TO: Michael T. Markley, Senior Staff Engineer

FROM: William J. Shack, Chairman
Materials and Metallurgy Subcommittee

SUBJECT: CERTIFICATION OF THE SUMMARY/MINUTES OF THE MEETING OF THE JOINT MEETING OF THE ACRS SUBCOMMITTEES ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT - NOVEMBER 15, 2001 - ROCKVILLE, MARYLAND

I do hereby certify that, to the best of my knowledge and belief, the minutes of the subject meeting on November 15, 2001, are an accurate record of the proceedings for that meeting.

2/13/02

William J. Shack, Chairman Date
Materials and Metallurgy Subcommittee

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

PRE-DECISIONAL

February 11, 2002

MEMORANDUM TO: Dr. William J. Shack, Chairman
Materials and Metallurgy Subcommittee

Dr. Graham B. Wallis, Chairman
Thermal-Hydraulic Phenomena Subcommittee

Dr. George E. Apostolakis, Chairman
Reliability and Probabilistic Risk Assessment Subcommittee

FROM: Michael T. Markley, Senior Staff Engineer

SUBJECT: WORKING COPY OF THE MINUTES OF THE JOINT MEETING OF THE ACRS SUBCOMMITTEES ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT - NOVEMBER 15, 2001, ROCKVILLE, MARYLAND

A working copy of the minutes for the subject meeting is attached for your review. Please review and comment on them at your soonest convenience. Copies are being sent to each ACRS Member who attended the meeting for information and/or review.

Attachment:
As Stated

cc: ACRS Members
J. Larkins
S. Bahadur
H. Larson
S. Duraiswamy
ACRS Staff and Fellows

CERTIFIED BY: Date:2/11/02

W. Shack - 2/13/02

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
JOINT MEETING OF THE ACRS SUBCOMMITTEES ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT
MEETING MINUTES - NOVEMBER 15, 2001
ROCKVILLE, MARYLAND

INTRODUCTION

The ACRS Subcommittees on Materials and Metallurgy, Thermal-Hydraulic Phenomena, and Reliability and Probabilistic Risk Assessment met on November 15, 2001, at 11545 Rockville Pike, Rockville, MD, in Room T-2B3. The purpose of this meeting was to discuss the status of NRC staff and industry initiatives to risk-inform the technical requirements of 10 CFR 50.46 for emergency core cooling systems (ECCS) for light-water nuclear power reactors.

The Subcommittees received no written comments from members of the public regarding the meeting. The entire meeting was open to public attendance. Mr. Michael T. Markley was the cognizant ACRS staff engineer for this meeting. The meeting was convened at 8:30 a.m. and adjourned at 12:10 p.m.

ATTENDEES

ACRS Members

W. Shack, Chairman
M. Bonaca, Member
T. Kress, Member
D. Powers, Member
M. Markley, ACRS Staff

Principal NRC Speakers

S. Bajorek, RES*
M. Drouin, RES
C. Fairbanks, RES
T. King, RES
A. Kuritsky, RES
N. Lauben, RES
R. Meyer, RES

Principal Industry Speakers

None.

RES Office of Nuclear Regulatory Research

There were approximately four members of the public in attendance at this meeting. A complete list of attendees is in the ACRS Office File, and will be made available upon request. The presentation slides and handouts used during the meeting are attached to the office copy of these minutes.

OPENING REMARKS BY THE SUBCOMMITTEE CHAIRMAN

Dr. William Shack, Chairman of the ACRS Subcommittee Materials and Metallurgy convened the meeting at 8:30 a.m. He announced that the joint meeting of the Advisory Committee on Reactor Safeguards (ACRS) Subcommittees on Human Factors and NRC Safety Research Program, previously scheduled for November 15, had been postponed. Dr. Shack stated that this was a joint meeting of the ACRS Subcommittees on Materials and Metallurgy, Thermal-Hydraulic Phenomena, and Reliability and Probabilistic Risk Assessment. He noted that Dr. Graham Wallis, Chairman of the Subcommittee on Thermal-Hydraulic Phenomena and Dr. George Apostolakis, Chairman of the Subcommittee on Reliability and PRA were unable to attend this meeting and that the Subcommittees were proceeding with this meeting on their behalf. He introduced the other ACRS Members in attendance and stated that the purpose of this meeting was to discuss the status of NRC staff and industry initiatives to risk-inform the technical requirements of 10 CFR 50.46 for emergency core cooling systems (ECCS) for light-water nuclear power reactors.

Dr. Shack noted that the Subcommittee had received no written comments from members of the public regarding the meeting.

DISCUSSION OF AGENDA ITEMS

NRC Staff Presentation

Ms. Mary Drouin, RES, led the discussion for the NRC staff. Mr. Alan Kuritsky, RES, provided supporting discussion. Messrs. Thomas King, Norm Lauben, Ralph Meyer, and Steven Bajorek and Ms. Carollyn Fairbanks, RES, provided brief presentations and/or supporting discussion. The staff discussed the background for risk-informing 10 CFR 50.46, recommended changes to Appendix K and General Design Criteria 35 (GDC-35) of 10 CFR Part 50, and technical work needed to support proposed rulemaking. Significant points raised during the presentation include:

- The Commission has not yet voted on the staff's feasibility study (SECY-01-0133) for risk-informing 10 CFR 50.46. The staff is continuing to meet with stakeholders to discuss progress on selected technical issues in parallel with Commission deliberation on these matters.

- The Nuclear Energy Institute (NEI) submitted a petition for rulemaking (PRM-50-74) dated October 4, 2001. In that petition, NEI requested the staff to amend the regulations to allow licensees to voluntarily adopt the most current industry Standard for decay heat power (ANS/ANSI-5.1-1994). The staff is currently evaluating the petition.

- Possible short-term revisions to 10 CFR 50.46 include proposed changes to ECCS acceptance criteria and evaluation model (Appendix K). The staff also proposes short-term activities to develop a voluntary risk-informed alternative to the reliability requirements (GDC-35).

- The current version of Appendix K makes no break size distinction concerning decay heat requirements. The staff stated that some models required by Appendix K may not be conservative and noted that there are potential errors in the uncertainty methods described in the decay heat curve of the 1994 ANS Standard. The staff is evaluating these issues and plans to revise Regulatory Guide 1.157 to endorse the 1994 version of the Standard with exceptions and clarifications, as appropriate.

- The staff proposes to delete the current simultaneous loss-of-offsite power requirement and single failure criterion. Two performance-based options were offered to accomplish ECCS reliability.

  Option 1: Generic approach that defines, by plant group, a minimal set of equipment to meet ECCS reliability.

  Option 2: Plant-specific approach where licensees establish functional reliability that is commensurate with LOCA frequency.

- Long-term considerations include evaluating the definition of a spectrum of break sizes for large-break loss-of-coolant accident analysis (LBLOCA). However, the technical justification may be increasingly complex and more difficult as smaller break sizes are considered.

SUBCOMMITTEE COMMENTS, CONCERNS, AND RECOMMENDATIONS

Subcommittee members raised the following significant points during its discussion with NRC staff and industry representatives:

- Dr. Shack questioned why the review for adopting the decay heat curve in the 1994 ANS Standard would require a lengthy review. The staff stated that it depends on how much margin the licensee/applicant wants to shave off margin afforded by the Standard. The staff stated that the NRC Office of Research is comparing the uncertainties and conservatism in the various Standards. The staff noted that several organizations have done "realistic" analyses yielding substantially different results. The staff stated that more work is needed to evaluate these differences.

- Dr. Kress questioned what the staff meant by non-conservatism with respect to the evaluation model. The staff stated that potential sources of non-conservatism exist in specific models required by Appendix K and that uncertainties have not been accounted for. The staff also stated that thermal-hydraulic processes have been observed in experimental programs since 1973 that are not specifically addressed in Appendix K.

- Dr. Shack questioned what analytical methods the staff might pursue in calculating peak clad temperature given the temperature and strain history. In particular, he questioned what temperature and strain history you put it through before deciding what test is appropriate. Dr. Powers expressed concern regarding how ductility is evaluated. The staff acknowledged that selection of the appropriate tests will be important. The staff stated that they are exploring the effects of various heating and cooling rates and highlighted plans to have laboratory tests performed.

- Dr. Powers questioned the apparent assumption that ECCS was installed to respond to an event during full-power operations. He noted that ECCS is needed for a range of operational modes and suggested that other events be considered (e.g., low-power and shutdown, external events, sabotage, etc.). The staff agreed and noted that risk insights suggest that other modes of operation can be significant. The staff stated that issue of sabotage is being reevaluated as a result of the tragedies at the World Trade Center and Pentagon on September 11, 2001.

STAFF AND INDUSTRY COMMITMENTS

NRC staff and industry representatives agreed to perform the following follow-up actions in response to Subcommittee questions and comments:

- Dr. Shack suggested that criteria for peak clad temperature and fuel oxidation be included in a regulatory guide instead of being retained in the rule. Dr. Kress stated that peak clad temperature will be key in preventing runaway oxidation. The staff acknowledged that a huge oxidation addition occurs at peak clad temperatures above 2200 degrees Fahrenheit. The staff agreed to consider Dr. Shack's recommendation in their continuing evaluation.

SUBCOMMITTEE DECISIONS

At the conclusion of the meeting, Subcommittee members expressed concern over the extensive analysis and resultant time needed for making changes to the technical requirements of 10 CFR 50.46. Dr. Bonaca suggested that an extensive trade-off analysis will be needed for evaluating the various options under consideration. Dr. Shack questioned where the "low-hanging fruit" or easily adoptable changes might be if endorsing the 1994 ANS Standard is proves to be too difficult. Drs. Kress expressed concern about using frequencies to deal with LOOP-LOCA. Drs. Kress, Bonaca, and Powers expressed concern regarding how defense in depth might be applied. The staff suggested that these items as well as the issues related to non-conservatism be discussed during future meetings. The Subcommittee agreed.

FOLLOW-UP ACTIONS

Dr. Powers suggested that the staff prepare a paper on the technical challenges associated with adopting the decay heat curve in the 1994 ANS Standard. The staff agreed to pursue preparation of such a paper and to report to the Subcommittee during a future meeting on this matter.

BACKGROUND MATERIALS PROVIDED TO THE SUBCOMMITTEE PRIOR TO THIS MEETING

1. Subcommittee agenda.
2. Subcommittee status report.
3. 10 CFR Part 50, Appendix A, Criterion 35, "Emergency core cooling."

4. Report dated July 25, 2001, from George E. Apostolakis, Chairman, ACRS, to Richard A. Meserve, Chairman, NRC, Subject: Feasibility Study on Risk-Informing the Technical requirements of 10 CFR 50.46 for Emergency Core Cooling Systems.
5. Letter dated October 1, 2001, from William D. Travers, Executive Director for Operations, NRC, to George E. Apostolakis, ACRS, Subject: Feasibility Study on Risk-Informing the Technical requirements of 10 CFR 50.46 for Emergency Core Cooling Systems.
6. NRC and industry meeting handouts on Loss-of-Coolant Accident/Loss-of-Offsite Power Accident Requirements, October 17, 2001.
7. Nuclear Energy Institute, Petition for Rulemaking [Docket No. PRM-50-74], Subject: dated October 4, 2001.

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Note: Additional details of this meeting can be obtained from a transcript of this meeting available for downloading or viewing on the Internet at "http://www.nrc.gov/ACRSACNW" or can be purchased from Neal R. Gross and Co., Inc., (Court Reporters and Transcribers) 1323 Rhode Island Avenue, N.W., Washington, DC 20005 (202) 234-4433.

REVISED 11/7/01

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
JOINT MEETING OF THE ACRS SUBCOMMITTEES ON
MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA,
AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT
ROOM T-2B3, 11545 ROCKVILLE PIKE, ROCKVILLE, MD
NOVEMBER 15, 2001

ACRS Contact: Michael T. Markley (301) 415-6885
E-mail: mtm@nrc.gov

- PROPOSED SCHEDULE -

	TOPIC	PRESENTER	TIME
1)	**Introduction**		8:30-8:35 am
•	Review goals and objectives for this meeting; introductory remarks	Bill Shack, ACRS	
•	Status of risk-informing 10 CFR 50.46 for emergency core cooling systems (ECCS): - ACRS report dated July 25, 2001, - Commission action on SECY-01-133 feasibility study, and - NEI petition for rulemaking dated October 4, 2001		
2)	**NRC Staff Presentation**		8:35-~~10:15 am~~ 10:50 am
•	Status of technical work on 10 CFR 50.46 - Loss-of-coolant accident/ loss-of-offsite power (LOCA/LOOP) - ECCS reliability - ECCS evaluation model and acceptance criteria - NEI petition for rulemaking - Large-break loss-of-coolant accident (LBLOCA) redefinition	~~Mark Cunningham~~ Tom King, RES Mary Drouin, RES Alan Kuritzky, RES Carolyn Fairbanks, RES Norm Lauben, RES Ralph Meyer, RES Steve Bajorek, RES	
	****BREAK****		~~10:15-10:30 am~~ 10:50-11:05 am

3) NRC Staff Presentation - continued ~~10:30~~ 11:05-11:30 am

- Status of technical work on 10 CFR 50.46 — ~~Mark Cunningham, RES~~ Mary Drouin, RES; Alan Kuritzky, RES; Carolyn Fairbanks, RES; ~~Norm Lauben, RES~~
  - Loss-of-coolant accident/ loss-of-offsite power (LOCA/LOOP)
  - ECCS reliability
  - ECCS evaluation model and acceptance criteria
  - NEI petition for rulemaking
  - Large-break loss-of-coolant accident (LBLOCA) redefinition

~~**4) Industry Comments** 11:30-11:45 am~~

- ~~Comments on NRC technical approach and NEI petition for rulemaking — Tony Pietrangelo, NEI (Tentative)~~
- ~~Owners Group perspectives — TBD~~

5) ACRS General Discussion and Adjournment ~~11:45-12:00 noon~~ 11:30 12:10 pm

- General discussion and comments by Members of the Subcommittee; items for full ACRS meetings — Bill Shack, ACRS

<u>Note</u>: **Presentation time should not exceed 50% of the total time allocated for a specific item. Number of copies of presentation materials to be provided to the ACRS/ ACNW - 35.**

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETINGS ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

NOVEMBER 15, 2001
Date

PLEASE PRINT

NAME	AFFILIATION
Mary Drouin	RES/DRAA/PRAB
Mark Kowal	NRR/DSSA/SRXB
Rob Taylor	NRR/DSSA/SRXB
Alan Kuritzky	RES/DRAA/PRAB
Ralph Meyer	RES
Steve West	NRR
Jack Rosenthal	RES
Francis Akstulewicz	NRR
Charles Ader	RES
S.M. Bajorek	RES
F. Orr	NRR/SRXB
J. Lazevnick	NRR/EEIB
Glenn Kelly	NRR
Sudhamay Basu	RES
Matthew A. Mitchell	NRR/DE/EMCB
Isabelle Schoenfeld	OEDO

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETINGS ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

NOVEMBER 15, 2001
Date

PLEASE PRINT

ATTENDEES PLEASE SIGN-IN FOR THE MEETING

NAME	AFFILIATION
C Fairbanks	RES/DET/MEB
Ellen Anderson	NEI
Ian Rickard	Westinghouse Co.
Jennifer Uhle	RES/DSARE

Markley

(1)

RISK-INFORMING 10 CFR 50.46

Presented to
ACRS Subcommittees on Materials and Metallurgy,
Thermal-Hydraulic Phenomena, and Reliability and
Probabilistic Risk Assessement

Presented by
Mary Drouin, Alan Kuritzky, Steve Bajorek,
Norm Lauben, and Carolyn Fairbanks
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission

November 15, 2001

(A)

OUTLINE

- Purpose/goal of meeting
- Background - Risk-informing 10 CFR 50.46
- Recommended changes to 10 CFR 50.46 (including Appendix K and GDC 35)
- Technical work to support rulemaking for changes to 10 CFR 50.46
- Status and schedule

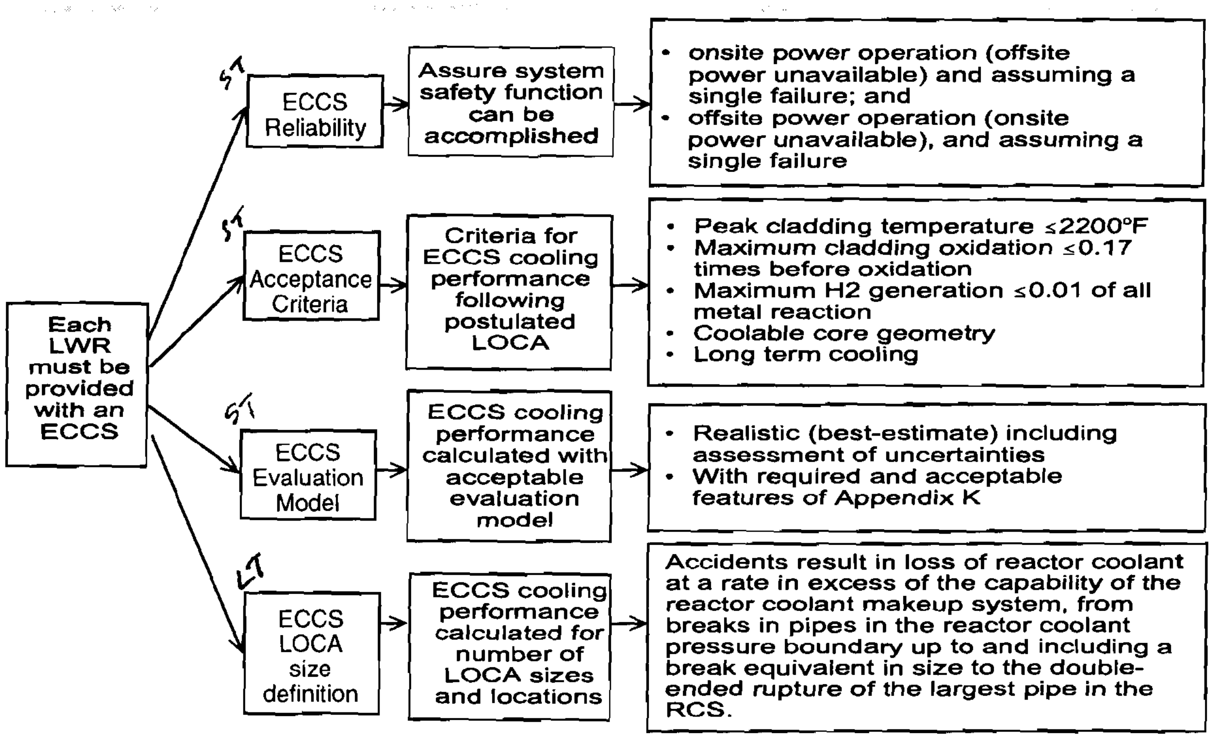
PURPOSE/GOAL OF MEETING

- Provide status report on staff's efforts to risk-inform 10 CFR 50.46
- Solicit feedback and comments from ACRS on:
  - Overall approach
  - Technical and implementation issues
  - Feasibility
- No letter requested

BACKGROUND

- **SECY 98-300:** staff options for risk-informed revisions to 10 CFR Part 50
- **SECY-99-264:** staff proposed plan for risk-informing technical requirements in 10 CFR Part 50 (Option 3)
- **SECY-00-0086:** staff proposed framework (Revision 0) for risk-informing technical requirements in 10 CFR Part 50 (Option 3)
- **SECY-00-0198:** staff proposed framework (Revision 2) for risk-informing technical requirements in 10 CFR Part 50 (Option 3), and proposed recommendations for a risk-informed 10 CFR 50.44 (Combustible Gas Control)
- **SECY-01-0133:** staff proposed recommendations for a risk-informed 10 CFR 50.46, Appendix A General Design Criterion 35, and Appendix K (Emergency Core Cooling)

OVERVIEW OF 50.46 (including Appendix K and GDC 35)



RECOMMENDED CHANGES TO 10 CFR 50.46 (including Appendix K and GDC 35)

- Short-term considerations:
  - Changes to the technical requirements of the ***current*** 50.46 (voluntary) related to acceptance criteria and evaluation model
  - Development of a voluntary risk-informed ***alternative*** to the reliability requirements in 50.46
- Long-term considerations:
  - Evaluation of the definition of the spectrum of break sizes
- All proposed changes follow the Option 3 framework guidelines with respect to quantitative goals and consideration of defense-in-depth

TECHNICAL WORK TO SUPPORT RULEMAKING

Changes to Technical Requirements of Current 50.46 (and Appendix K) Related to Acceptance Criteria and Evaluation Model

D

NEI PETITION FOR AMENDING APPENDIX K TO 10 CFR PART 50 ECCS EVALUATION MODELS (PRM-50-74, SEPTEMBER 6, 2001)

- Allow licensees optional adoption of the latest consensus standard on decay heat rates (ANS/ANSI-5.1-1994)
- Allow optional adoption by licensees of subsequent revisions to this standard that are endorsed by NRC
- Purpose of the petition: NEI letter dated, September 10, 2001 -- separate this piece of proposed change from others in SECY-01-0133 to expedite this rule change
- Staff is currently evaluating the petition

TECHNICAL WORK TO SUPPORT RULEMAKING

Risk-Informed Alternative to Reliability Requirements in 50.46 (GDC 35)

PROPOSED RISK-INFORMED ALTERNATIVE TO 50.46

- Replace with more risk-informed and realistic approaches
- Delete current simultaneous loss of offsite power requirement and single failure criterion
- Two performance-based options offered to accomplish ECCS reliability:
  - Option 1. A generic approach that defines, by plant group, a set of minimal equipment required to meet an established ECCS reliability, such that licensees will not have to perform any technical analysis.
  - Option 2. A plant-specific approach where licensees establish an ECCS functional reliability requirement that is commensurate with the LOCA frequency

PROPOSED PRODUCTS FROM TECHNICAL WORK

- For Option 1, the staff would generate two matrices which would be incorporated into a Regulatory Guide:
  - Systemic success criteria for preventing core damage defined for each category of accidents, as a function of plant type (or group)
  - Failure assumptions (e.g., failures of electric power or ECCS trains) specified for use by various plant types/groups in the ECCS performance evaluations (i.e., thermal-hydraulic calculations)
- For Option 2, a Regulatory Guide containing the requirements for performing a plant-specific ECCS reliability calculation would be generated.

TASKS TO SUPPORT RULEMAKING

1. Approach
2. Plant Information
3. Calculations
   a. Thermal-hydraulic calculations
   b. LOOP probability
   c. LOCA frequency estimation
4. Check Approach
5. Classification
   a. Group plant information (single failure criterion)
   b. Feature identification (LOCA/LOOP)
6. Model Development
7. Results
8. Final Report

Meetings

SIGNIFICANT TECHNICAL AND IMPLEMENTION ISSUES

- LOCA Scope and Frequency
  - Need to address aging effects, unknown failure mechanisms, non-pipe-break LOCAs, non-seismic indirect initiators, seismic LOCAs, and low power and shutdown LOCAs
- Conditional LOOP Probability
  - Due to scarcity of consequential LOOP data for updating probabilities, reactor trip events and ECCS actuation events are used as surrogates. ECCS actuation events most closely resemble LOCA events, but data is very limited. Reactor trip events are less severe than LOCAs since the ECCS equipment is not loaded onto the safety buses. Operation under degraded grid voltage conditions can further exacerbate this difference in severity.
- Credit for Non-ECCS Systems
  - ECCS functional reliability threshold is derived from PRA CDF calculations, which include credit for non-ECCS systems. May need sub-threshold to assure a minimum reliability of actual ECCS systems.

TECHNICAL WORK TO SUPPORT FEASIBILITY STUDY OF ADDITIONAL CHANGES TO 50.46

Evaluation of the Definition of the Spectrum of Break Sizes Relevant to 50.46

LBLOCA PLANS

- Program Objective - Establish technical bases for redefinition of the LBLOCA
- Program Approach
  - Task 1: Review strengths and weaknesses of other codes
  - Task 2: Refine deterministic models
  - Task 3: Updating/developing codes
  - Task 4: Sample plant evaluations
  - Task 5: Make comparisons to other codes
  - Task 6: Draft technical bases for LBLOCA regulatory guide

STATUS AND SCHEDULE

- Changes to the technical requirements of the current 50.46 related to acceptance criteria and evaluation model:
  - Develop proposed rule — 12 months from SRM
  - Complete technical work— On or before July 2002
- Development of a voluntary risk-informed alternative to the reliability requirements in 50.46:
  - Develop proposed rule — 12 months from SRM
  - Complete technical work— On or before April 2002
- Evaluation of the definition of the spectrum of break sizes:
  - Complete feasibility study— Up to 3 years
- Staff is working closely with stakeholders:
  - Public meeting on LOCA frequencies (August 1, 2001)
  - Public teleconference on LOCA-LOOP (August 30, 2001)
  - Public meeting on LOCA-LOOP (October 17, 2001)
  - Upcoming public meetings on LOCA-LOOP (November 29, 2001), LOCA frequencies (TBD), changes to Appendix K (TBD)

Risk Informed Regulation Consideration Of Appendix K Analysis Requirements

Presentation to the ACRS Subcommittees on Materials and Metallurgy, Thermal-Hydraulic Phenomena, and Reliability and Probabilistic Risk Assessment

November 15, 2001

Stephen M. Bajorek, G. Norman Lauben, Ralph O. Meyer
Safety Margins and Systems Analysis Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

Replacing the Decay Heat Models in 50.46

Presentation to the ACRS Subcommittees on
Materials and Metallurgy, Thermal-Hydraulic Phenomena,
and Reliability and Probabilistic Risk Assessment

November 15, 2001

G. Norman Lauben
Safety Margins and Systems Analysis Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

REPLACING THE DECAY HEAT MODELS IN 50.46

- 10CFR50.46 and Appendix K, promulgated in 1974, required the use of the draft 1971 ANS decay heat standard with a multiplier of 1.2 and the assumption of infinite operating time for use in ECCS evaluation models.

1. Research and analysis since 1974 has shown that the most significant conservatism in Appendix K is the decay heat requirement.

2. The 1988 ECCS rule change allowed use of a realistic evaluation model analysis option with an uncertainty evaluation as an alternative to the conservative Appendix K. The only specific technical requirements for the realistic option relate to break spectrum and GDC 35.

3. Regulatory Guide 1.157, which accompanied the 1988 rule change, declared the acceptability of using the 1979 ANS decay heat standard for the realistic option.

4. There is nothing to prevent a licensee/applicant from using all or part of the newer 1994 ANS decay heat standard today as part of the realistic option. However, the staff intends to modify R.G. 1.157 to endorse ANS1994 either in full or in part.

- The 1994 ANS-5 standard is potentially more accurate and less conservative than the 1971 draft standard, but requires more choices to be specified by the user.
    1. If NRC makes the choices ahead of time, either in the Appendix K revision or an Appendix K related regulatory guide, the regulatory process is likely to be more predictable and stable.
    2. If each applicant or licensee selects the options, a lengthy review process may result.

REPLACEMENT OF APPENDIX K DECAY HEAT REQUIREMENT

- The key choices that must be made are:

1. Operating Time - Infinite operating time is the simple choice in Appendix K. A bounding histogram of operating cycles would be possible and less conservative.

2. Fission Fractions Per Isotope - The 1971 standard assumed ^{235}U as the only fissionable isotope. Three additional isotopes are used in the 1994 standard. Fission fractions vary with time and space.

3. Neutron Capture - This effect was added in the 1979 and 1994 standards. The effect is burnup dependent and adds to the decay heat.

4. Fission Energy - Each fissionable isotope has different recoverable fission energies which are required for use in the standard. The values and uncertainties for fission energies are not specified in the standard.

5. Actinide (Heavy Element) Decay - The same basic equations are described in the 1971, 1979 and 1994 standards. However, the required ^{239}U fission yield is not specified and is burnup dependent.

6. Tabular Data - Three tables are provided for each of the four fissionable isotopes. The selection must be made depending on the method chosen for calculating decay heat.

DECAY HEAT UNCERTAINTY AND CONSERVATISM

1. Since 1973 it has been recognized that the Appendix K application of the 1971 standard has a degree of conservatism that exceeds the decay heat uncertainty.

2. The uncertainty methods described in the 1994 standard do not appear to be nearly as large as the 1971 standard.

3. Use of the 1994 standard with nominal inputs and uncertainties could result in a substantial reduction of overall conservatism in Appendix K analysis.

4. Thus if the magnitude of one or more non-conservatisms is too large, the "appropriate" overall conservatism may be in jeopardy.

5. The current version of Appendix K makes no break size distinction concerning the application of the decay heat requirement.

    A. Longer transients, such as small breaks, would derive a substantially larger benefit from a reduction in decay heat compared to faster large breaks.
    B. Among the required features of Appendix K, decay heat is the only one that has clear application to small breaks.

6. RES is evaluating potential errors in the uncertainty methods described in the 1979 and 1994 standards. Therefore, previous sensitivities may not be appropriate. We will formally contact ANS when the evaluation is complete.

7. Thus, additional work is needed to either modify the standard and/or its application.

8. The context for the decay heat work is described in the next presentation.

Revision of ECCS Evaluation Model Requirements

Presentation to the ACRS Subcommittees on
Materials and Metallurgy, Thermal-Hydraulic Phenomena,
and Reliability and Probabilistic Risk Assessment

November 15, 2001

Stephen M. Bajorek
Safety Margins and Systems Analysis Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

BACKGROUND

1. SECY-01-133 states:

   "The staff recommends that rulemaking should be undertaken to change the current 50.46. ....
   ....
   ..... In the near term, this revision would involve an update of Appendix K requirements based on more current and realistic information. ....

   As part of this update, the staff will also consider the recognized non-conservatisms and model limitations to insure that proper safety focus is incorporated in any new rule.

   ....; in summary, the staff will undertake work to:

   - support removal of unnecessary conservatisms from Appendix K."

2. The principal focus of this effort has been on:

   A. Replacement of the Appendix K requirement to use 1.2 X 1971 ANS decay heat standard with a requirement based on the 1994 ANS decay heat standard.

   B. Options to address non-conservatisms in existing Appendix K evaluation models.

Appendix K "Non-Conservatisms"

<u>Sources of potential non-conservatism</u>:

1. Specific models required by Appendix K that may not be conservative, (Example: Dougal- Rohsenow for post-CHF heat transfer.)

2. Large calculational uncertainties that are on the order of the overall conservatism of the EM. This was a main concern of SECY-86-318, ("Revision of the ECCS Rule Contained in Appendix K and Section 50.46 of 10 CFR Part 50) which recommended that the Appendix K decay heat guidelines <u>not</u> be revised unless model uncertainties were accounded for.

3. Thermal-hydraulic processes that have been observed in experimental programs since 1973, but are not specifically addressed by Appendix K.

NON-CONSERVATISMS IN APPENDIX K LBLOCA EVALUATION MODELS

Downcomer Boiling -

1. Analyses and 2D/3D tests show that wall heat can cause downcomer boiling after accumulator injection is terminated.

2. Voiding in the downcomer can result in a significant reduction in downcomer head. This reduces the flooding rate and increases the PCT. In today's code assessment domain, this would be considered a highly ranked phenomenon.

3. Typically, PWR Appendix K reflood models do not model downcomer boiling. Yet, for at least some plants in all three PWR vendor designs, the existence of downcomer boiling has at least been acknowledged.

4. The most vulnerable plants are those with low containment back-pressure and plants with relatively low pumped SI flow. It appears that downcomer injection geometry can also be a significant factor.

Fuel Relocation -

1. Experiments in PBF-LOC, FR2 (Germany) and FLASH5 (France) showed significant fuel movement in regions where clad has ballooned.

2. Relocation of additional fuel into ballooned region increases local power and increases conductance between pellets and clad.

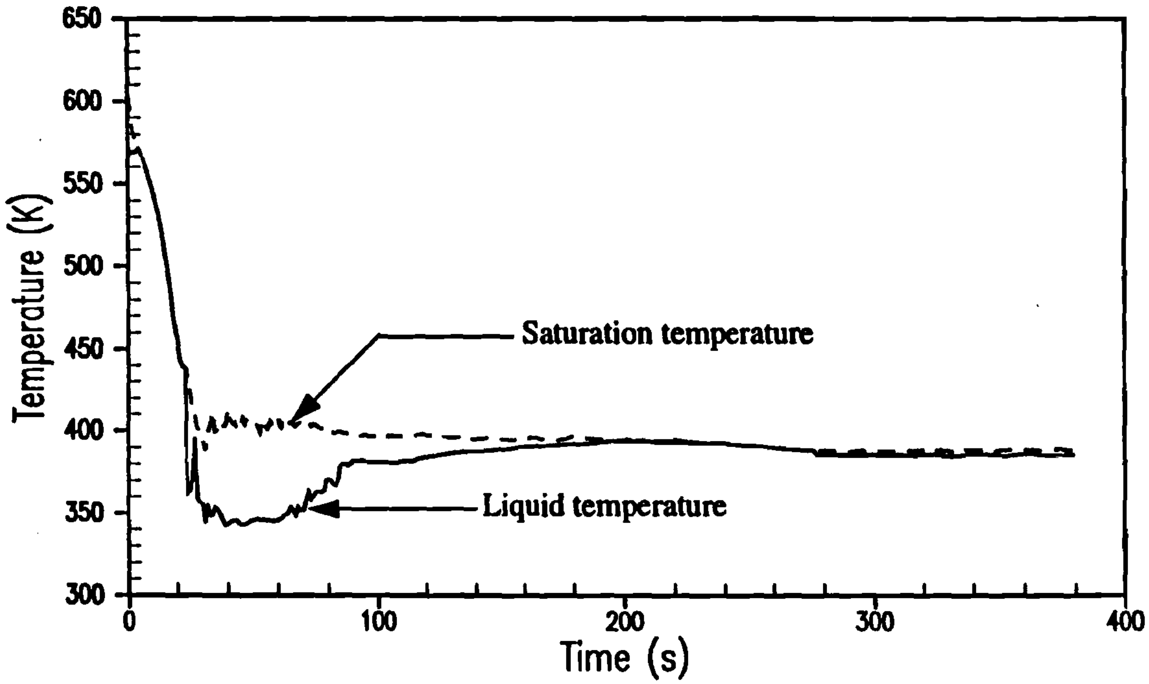
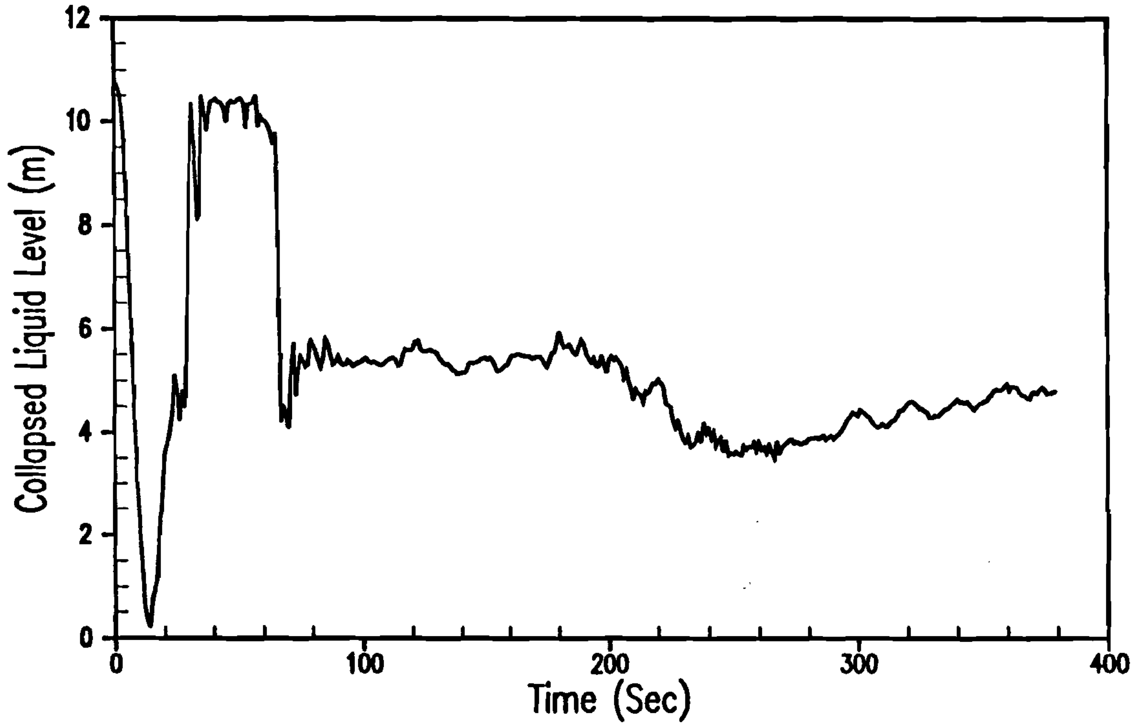


Figure 6-12. System 80 downcomer liquid and saturation temperatures.



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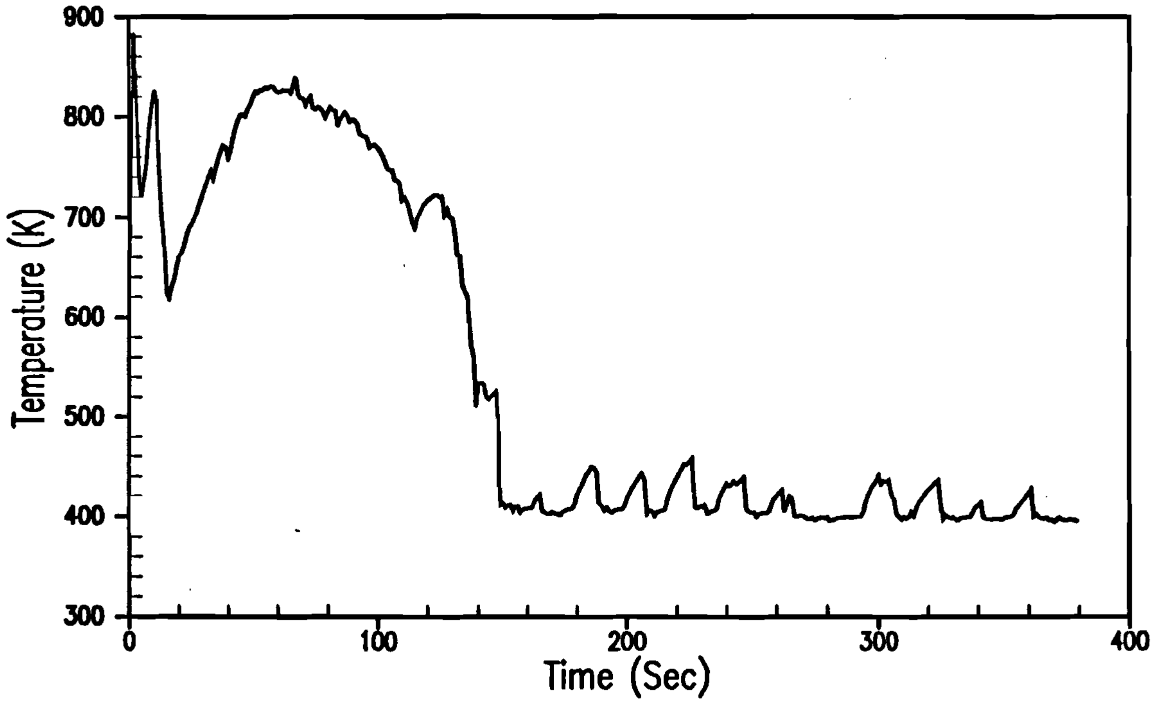

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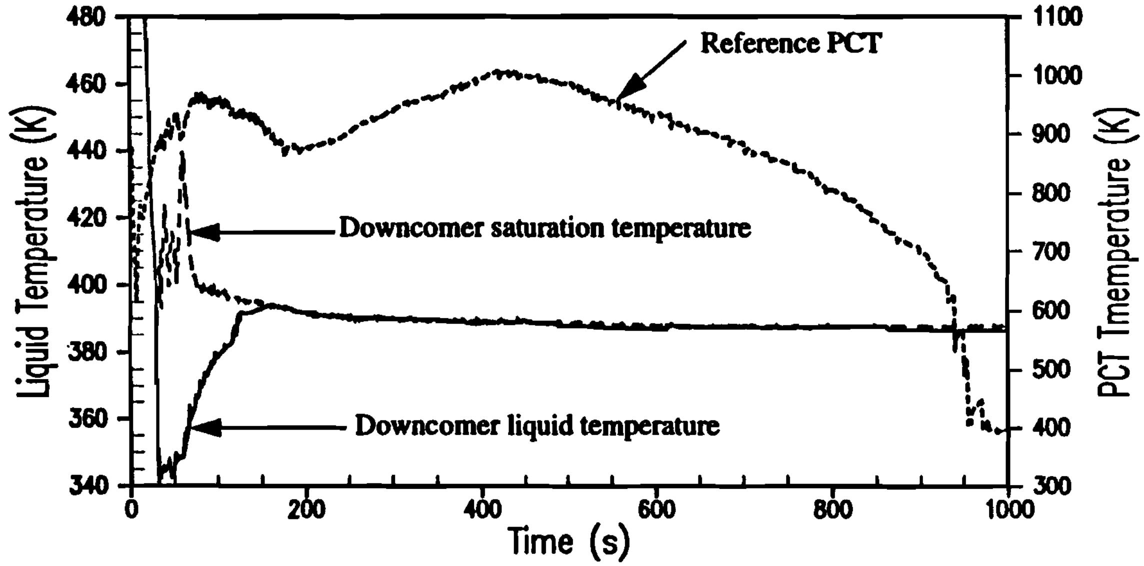

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Table 1: LBLOCA ΔPCT Estimates

Process	ΔPCT	Basis
Decay Heat	-250 to -400 °F	Westinghouse estimate based on App. K EM calculations. ANS 1971 + 1.20 replaced with ANS 1979 + 2σ.
Decay Heat	-372 °F	NRC contractor RELAP calculations for CE 2700 MWt (Millstone 2) plant. ANS 1971 + 1.20 replaced with ANS 1979 + 2σ.
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Fuel Relocation	+313 °F	Results reported in technical paper by IPSN presenting CATHARE2 analysis. Framatome PWR (W 3-loop PWR). A burst zone 70% filling fraction.
Secondary to Primary SG Tubesheet Leakage	Not known	Would contribute to steam binding. Non-conservative plant boundary condition currently ignored.

Table 2: SBLOCA ΔPCT Estimates

Process	ΔPCT	Basis
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Fuel Relocation	Not known	Clad swell may occur in SBLOCA.
Operator Action	+ several 100 °F	Pump trip with off site power available depends on operator recognition and adherence to EOPs. Known post-TMI pump trip issue. Trip at inopportune time can cause deep uncovery.
Level Swell Uncertainty	+ several 100 °F	NRC contractor estimate. Mixture level swell (code interfacial drag) is highly ranked PIRT process.
Loop Seal Clearance	+/- several 100 °F	

OPTIONS FOR REVISING ECCS EVALUATION MODEL REQUIREMENTS (CONT.)

Option A:

Appendix K - Replace 1.2 X ANS 1971 decay heat with ANS 94 plus uncertainty appropriate to decay heat uncertainties only. Licensees would be required to consider non-conservatisms.

Realistic Option - Revise Reg. Guide 1.157 clarifying appropriate use of decay heat standard, metal-water reaction and uncertainty assessment.

Pros:

1. Satisfies SECY-01-133 expectations by including Appendix K decay heat benefits and explicitly addresses non-conservatisms

Cons:

1. New methodology may require NRR review and may require significant licensee resources.
2. Additional experimental information may be needed to fully address some non-conservatisms.
3. May be difficult to identify all substantive non-conservatisms.
4. May not be attractive to vendors/utilities and therefore not used.
5. No assurance of conservatism unless model uncertainties considered.
6. Would delay transition to modern thermal-hydraulic codes.

OPTIONS FOR REVISING ECCS EVALUATION MODEL REQUIREMENTS (CONT.)

Option B:

Appendix K - Replace 1.2 X ANS 71 decay heat with ANS 94 X conservative multiplier that approximates realistic results.

Realistic Option - Revise Reg. Guide 1.157, clarifying appropriate use of 1994 decay heat standard, metal-water reaction and uncertainty assessment.

Pros:

1. Reduces vendor/licensee costs
2. Minimizes NRR review costs
3. Satisfies SECY-01-133 expectations

Cons:

1. May not be technically achievable. Multiplier is plant and EM dependent. Conservative selection may be more restrictive than 1.2 X ANS 71 decay heat for some plant types.
2. Alternative Appendix K would not necessarily be conservative for LBLOCA unless model uncertainties considered.
3. Removes the only important SBLOCA analysis conservatism. Would be no assurance that SBLOCA analysis remains conservative.
4. Sensitivity of NRC audit tools and vendor Evaluation Models differ.
5. Contrary to recommendations in SECY-86-318 by addressing uncertainties.
6. Would delay transition to modern thermal-hydraulic codes.
7. Requires extensive staff resources to determine plant type and accident specific multipliers.
8. Not applicable to advanced plants. May not support plant power uprates.

OPTIONS FOR REVISING ECCS EVALUATION MODEL REQUIREMENTS

Option C:

Appendix K - Retain existing Appendix K for conservative analysis option.

Realistic Option - Revise Reg. Guide 1.157 clarifying appropriate use of 1994 decay heat standard, metal-water reaction and uncertainty assessment.

Pros:

1. Maintains safety margins and is consistent with SECY-86-318. Margins are either conservative with Appendix K EM, or quantified in a Best Estimate EM.
2. Clear guidelines for review exist. No re-review necessary
3. Encourages vendors/licensees to use a more accurate codes & technology
4. No additional resources applied to Appendix K.
5. Maintains public confidence by allowing a reduction in LOCA margin only if the remaining margin is quantified.

Cons:

1. Minimal added reduction in regulatory burden.
2. May not satisfy expectations described in SECY-01-133.

Action Plan

1. Develop a complete list of non-conservatisms.

2. Identify experimental data that demonstrates the non-conservatisms and compare the experimental and full scale plant range of conditions.

3. Hold a public meeting to discuss alternative approaches to Appendix K.

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REPLACE PRESCRIPTIVE ECCS CRITERIA IN 50.46 WITH PERFORMANCE-BASED REQUIREMENTS

(1) Peak Cladding Temperature (2200°F) . . . . Keep
Prescriptive but may serve well for all alloy types and burnups

(2) Maximum Cladding Oxidation (17%) . . . . Remove
Prescriptive and may depend on alloy type and burnup

(3) Maximum Hydrogen Generation (1%) . . . . Keep
Prescriptive but does not depend on alloy type or burnup

(4) Coolable Geometry . . . . Keep
Not prescriptive

(5) Long-Term Cooling . . . . Keep
Not prescriptive

////////////////////////////////

Replace #2 with requirement to retain post-quench ductility and put details in Reg. Guide

Remove restriction to Zircaloy and ZIRLO and apply to all zirconium-based alloys

PERFORMANCE-BASED EMBRITTLEMENT CRITERIA REGULATORY GUIDE

- Follow logic from the 1973 opinion of the Commission on the ECCS hearings
- Keep 2200°F as the peak cladding temperature for all cases
- Determine an oxidation limit based on ring-compression tests
- Specify conditions for the ring-compression tests
- Specify testing of fresh and high-burnup cladding of alloy in question

Pros:
1. Eliminates need for exemptions for new cladding alloys
2. Technically better than present regulation

Cons:
1. Could result in a backfit for some approved cases
2. Will be 1-2 yrs before anyone is able to try out this Reg. Guide

RISK-INFORMING 10 CFR 50.46

Presented to
ACRS Subcommittees on Materials and Metallurgy, Thermal-Hydraulic Phenomena, and Reliability and Probabilistic Risk Assessement

Presented by
Mary Drouin, Alan Kuritzky, Steve Bajorek, Norm Lauben, and Carolyn Fairbanks
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission

November 15, 2001

OUTLINE

- Purpose/goal of meeting
- Background - Risk-informing 10 CFR 50.46
- Recommended changes to 10 CFR 50.46 (including Appendix K and GDC 35)
- Technical work to support rulemaking for changes to 10 CFR 50.46
- Status and schedule

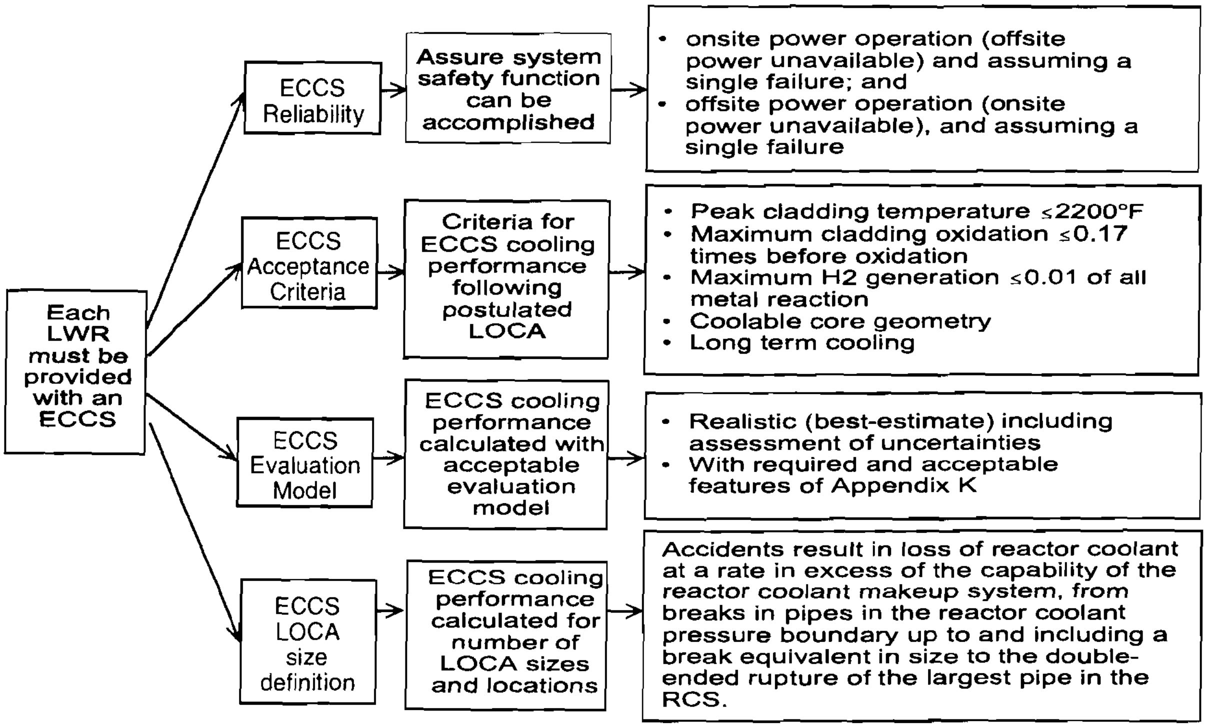
PURPOSE/GOAL OF MEETING

- Provide status report on staff's efforts to risk-inform 10 CFR 50.46
- Solicit feedback and comments from ACRS on:
  - Overall approach
  - Technical and implementation issues
  - Feasibility
- No letter requested

BACKGROUND

- **SECY 98-300:** staff options for risk-informed revisions to 10 CFR Part 50
- **SECY-99-264:** staff proposed plan for risk-informing technical requirements in 10 CFR Part 50 (Option 3)
- **SECY-00-0086:** staff proposed framework (Revision 0) for risk-informing technical requirements in 10 CFR Part 50 (Option 3)
- **SECY-00-0198:** staff proposed framework (Revision 2) for risk-informing technical requirements in 10 CFR Part 50 (Option 3), and proposed recommendations for a risk-informed 10 CFR 50.44 (Combustible Gas Control)
- **SECY-01-0133:** staff proposed recommendations for a risk-informed 10 CFR 50.46, Appendix A General Design Criterion 35, and Appendix K (Emergency Core Cooling)

OVERVIEW OF 50.46 (including Appendix K and GDC 35)



RECOMMENDED CHANGES TO 10 CFR 50.46 (including Appendix K and GDC 35)

- Short-term considerations:
  - Changes to the technical requirements of the ***current*** 50.46 (voluntary) related to acceptance criteria and evaluation model
  - Development of a voluntary risk-informed ***alternative*** to the reliability requirements in 50.46
- Long-term considerations:
  - Evaluation of the definition of the spectrum of break sizes
- All proposed changes follow the Option 3 framework guidelines with respect to quantitative goals and consideration of defense-in-depth

TECHNICAL WORK TO SUPPORT RULEMAKING

Changes to Technical Requirements of Current 50.46 (and Appendix K) Related to Acceptance Criteria and Evaluation Model

NEI PETITION FOR AMENDING APPENDIX K TO 10 CFR PART 50 ECCS EVALUATION MODELS (PRM-50-74, SEPTEMBER 6, 2001)

- Allow licensees optional adoption of the latest consensus standard on decay heat rates (ANS/ANSI-5.1-1994)
- Allow optional adoption by licensees of subsequent revisions to this standard that are endorsed by NRC
- Purpose of the petition: NEI letter dated, September 10, 2001 -- separate this piece of proposed change from others in SECY-01-0133 to expedite this rule change
- Staff is currently evaluating the petition

TECHNICAL WORK TO SUPPORT RULEMAKING

Risk-Informed Alternative to Reliability Requirements in 50.46 (GDC 35)

PROPOSED RISK-INFORMED ALTERNATIVE TO 50.46

- Replace with more risk-informed and realistic approaches
- Delete current simultaneous loss of offsite power requirement and single failure criterion
- Two performance-based options offered to accomplish ECCS reliability:
  - Option 1. A generic approach that defines, by plant group, a set of minimal equipment required to meet an established ECCS reliability, such that licensees will not have to perform any technical analysis.
  - Option 2. A plant-specific approach where licensees establish an ECCS functional reliability requirement that is commensurate with the LOCA frequency

PROPOSED PRODUCTS FROM TECHNICAL WORK

- For Option 1, the staff would generate two matrices which would be incorporated into a Regulatory Guide:
  - Systemic success criteria for preventing core damage defined for each category of accidents, as a function of plant type (or group)
  - Failure assumptions (e.g., failures of electric power or ECCS trains) specified for use by various plant types/groups in the ECCS performance evaluations (i.e., thermal-hydraulic calculations)
- For Option 2, a Regulatory Guide containing the requirements for performing a plant-specific ECCS reliability calculation would be generated.

TASKS TO SUPPORT RULEMAKING

1. Approach
2. Plant Information
3. Calculations
   a. Thermal-hydraulic calculations
   b. LOOP probability
   c. LOCA frequency estimation
4. Check Approach
5. Classification
   a. Group plant information (single failure criterion)
   b. Feature identification (LOCA/LOOP)
6. Model Development
7. Results
8. Final Report

Meetings

SIGNIFICANT TECHNICAL AND IMPLEMENTION ISSUES

- LOCA Scope and Frequency
  - Need to address aging effects, unknown failure mechanisms, non-pipe-break LOCAs, non-seismic indirect initiators, seismic LOCAs, and low power and shutdown LOCAs
- Conditional LOOP Probability
  - Due to scarcity of consequential LOOP data for updating probabilities, reactor trip events and ECCS actuation events are used as surrogates. ECCS actuation events most closely resemble LOCA events, but data is very limited. Reactor trip events are less severe than LOCAs since the ECCS equipment is not loaded onto the safety buses. Operation under degraded grid voltage conditions can further exacerbate this difference in severity.
- Credit for Non-ECCS Systems
  - ECCS functional reliability threshold is derived from PRA CDF calculations, which include credit for non-ECCS systems. May need sub-threshold to assure a minimum reliability of actual ECCS systems.

TECHNICAL WORK TO SUPPORT FEASIBILITY STUDY OF ADDITIONAL CHANGES TO 50.46

Evaluation of the Definition of the Spectrum of Break Sizes Relevant to 50.46

LBLOCA PLANS

- Program Objective - Establish technical bases for redefinition of the LBLOCA
- Program Approach
  - Task 1: Review strengths and weaknesses of other codes
  - Task 2: Refine deterministic models
  - Task 3: Updating/developing codes
  - Task 4: Sample plant evaluations
  - Task 5: Make comparisons to other codes
  - Task 6: Draft technical bases for LBLOCA regulatory guide

STATUS AND SCHEDULE

- Changes to the technical requirements of the current 50.46 related to acceptance criteria and evaluation model:
  - Develop proposed rule — 12 months from SRM
  - Complete technical work— On or before July 2002
- Development of a voluntary risk-informed alternative to the reliability requirements in 50.46:
  - Develop proposed rule — 12 months from SRM
  - Complete technical work— On or before April 2002
- Evaluation of the definition of the spectrum of break sizes:
  - Complete feasibility study— Up to 3 years
- Staff is working closely with stakeholders:
  - Public meeting on LOCA frequencies (August 1, 2001)
  - Public teleconference on LOCA-LOOP (August 30, 2001)
  - Public meeting on LOCA-LOOP (October 17, 2001)
  - Upcoming public meetings on LOCA-LOOP (November 29, 2001), LOCA frequencies (TBD), changes to Appendix K (TBD)

Risk Informed Regulation Consideration Of Appendix K Analysis Requirements

Presentation to the ACRS Subcommittees on Materials and Metallurgy, Thermal-Hydraulic Phenomena, and Reliability and Probabilistic Risk Assessment

November 15, 2001

Stephen M. Bajorek, G. Norman Lauben, Ralph O. Meyer
Safety Margins and Systems Analysis Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

Replacing the Decay Heat Models in 50.46

Presentation to the ACRS Subcommittees on
Materials and Metallurgy, Thermal-Hydraulic Phenomena,
and Reliability and Probabilistic Risk Assessment

November 15, 2001

G. Norman Lauben
Safety Margins and Systems Analysis Branch
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REPLACING THE DECAY HEAT MODELS IN 50.46

- 10CFR50.46 and Appendix K, promulgated in 1974, required the use of the draft 1971 ANS decay heat standard with a multiplier of 1.2 and the assumption of infinite operating time for use in ECCS evaluation models.

- Research and analysis since 1974 has shown that the most significant conservatism in Appendix K is the decay heat requirement.

- The 1988 ECCS rule change allowed use of a realistic evaluation model analysis option with an uncertainty evaluation as an alternative to the conservative Appendix K. The only specific technical requirements for the realistic option relate to break spectrum and GDC 35.

- Regulatory Guide 1.157, which accompanied the 1988 rule change, declared the acceptability of using the 1979 ANS decay heat standard for the realistic option.

- There is nothing to prevent a licensee/applicant from using all or part of the newer 1994 ANS decay heat standard today as part of the realistic option. However, the staff intends to modify R.G. 1.157 to endorse ANS1994 either in full or in part.

The 1994 ANS-5 standard is potentially more accurate and less conservative than the 1971 draft standard, but requires more choices to be specified by the user.

1. If NRC makes the choices ahead of time, either in the Appendix K revision or an Appendix K related regulatory guide, the regulatory process is likely to be more predictable and stable.
2. If each applicant or licensee selects the options, a lengthy review process may result.

REPLACEMENT OF APPENDIX K DECAY HEAT REQUIREMENT

The key choices that must be made are:

1. Operating Time - Infinite operating time is the simple choice in Appendix K. A bounding histogram of operating cycles would be possible and less conservative.

2. Fission Fractions Per Isotope - The 1971 standard assumed ^{235}U as the only fissionable isotope. Three additional isotopes are used in the 1994 standard. Fission fractions vary with time and space.

3. Neutron Capture - This effect was added in the 1979 and 1994 standards. The effect is burnup dependent and adds to the decay heat.

4. Fission Energy - Each fissionable isotope has different recoverable fission energies which are required for use in the standard. The values and uncertainties for fission energies are not specified in the standard.

5. Actinide (Heavy Element) Decay - The same basic equations are described in the 1971, 1979 and 1994 standards. However, the required ^{239}U fission yield is not specified and is burnup dependent.

6. Tabular Data - Three tables are provided for each of the four fissionable isotopes. The selection must be made depending on the method chosen for calculating decay heat.

DECAY HEAT UNCERTAINTY AND CONSERVATISM

1. Since 1973 it has been recognized that the Appendix K application of the 1971 standard has a degree of conservatism that exceeds the decay heat uncertainty.

2. The uncertainty methods described in the 1994 standard do not appear to be nearly as large as the 1971 standard.

3. Use of the 1994 standard with nominal inputs and uncertainties could result in a substantial reduction of overall conservatism in Appendix K analysis.

4. Thus if the magnitude of one or more non-conservatisms is too large, the "appropriate" overall conservatism may be in jeopardy.

5. The current version of Appendix K makes no break size distinction concerning the application of the decay heat requirement.

   A. Longer transients, such as small breaks, would derive a substantially larger benefit from a reduction in decay heat compared to faster large breaks.
   B. Among the required features of Appendix K, decay heat is the only one that has clear application to small breaks.

6. RES is evaluating potential errors in the uncertainty methods described in the 1979 and 1994 standards. Therefore, previous sensitivities may not be appropriate. We will formally contact ANS when the evaluation is complete.

7. Thus, additional work is needed to either modify the standard and/or its application.

8. The context for the decay heat work is described in the next presentation.

Revision of ECCS Evaluation Model Requirements

Presentation to the ACRS Subcommittees on
Materials and Metallurgy, Thermal-Hydraulic Phenomena,
and Reliability and Probabilistic Risk Assessment

November 15, 2001

Stephen M. Bajorek
Safety Margins and Systems Analysis Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

BACKGROUND

- SECY-01-133 states:

  "The staff recommends that rulemaking should be undertaken to change the current 50.46. ....

  ....

  ..... In the near term, this revision would involve an update of Appendix K requirements based on more current and realistic information. ....

  As part of this update, the staff will also consider the recognized non-conservatisms and model limitations to insure that proper safety focus is incorporated in any new rule.

  ....; in summary, the staff will undertake work to:

  - support removal of unnecessary conservatisms from Appendix K."

- The principal focus of this effort has been on:

A. Replacement of the Appendix K requirement to use 1.2 X 1971 ANS decay heat standard with a requirement based on the 1994 ANS decay heat standard.

B. Options to address non-conservatisms in existing Appendix K evaluation models.

Appendix K "Non-Conservatisms"

Sources of potential non-conservatism:

1. Specific models required by Appendix K that may not be conservative, (Example: Dougal- Rohsenow for post-CHF heat transfer.)

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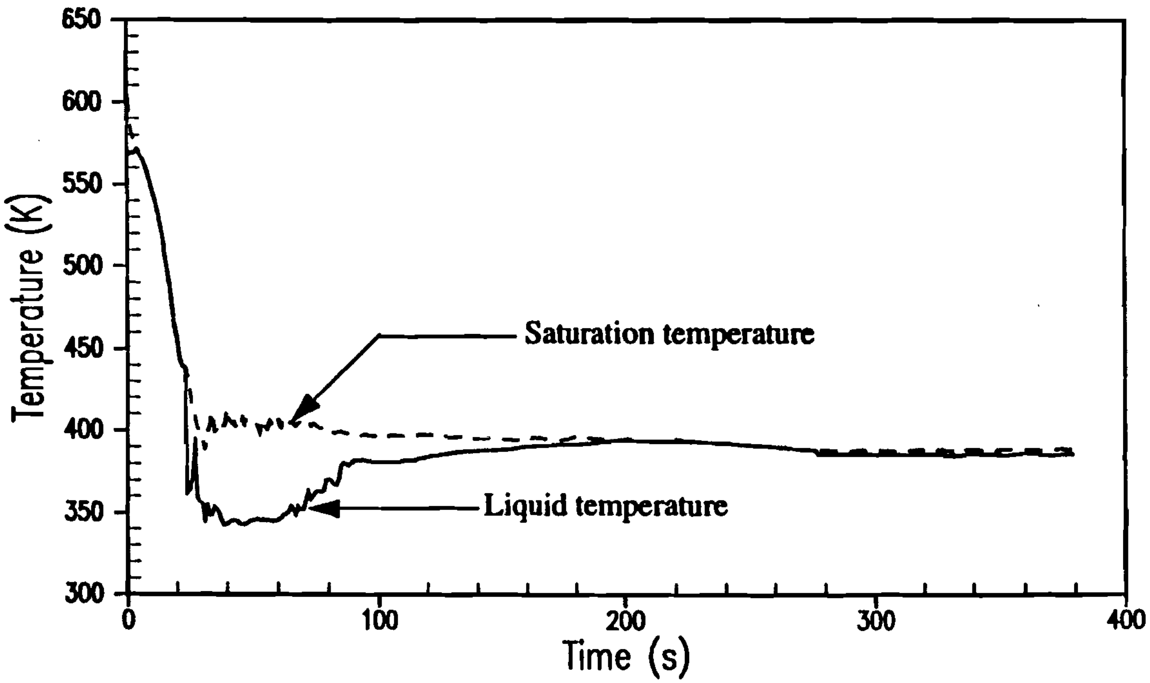

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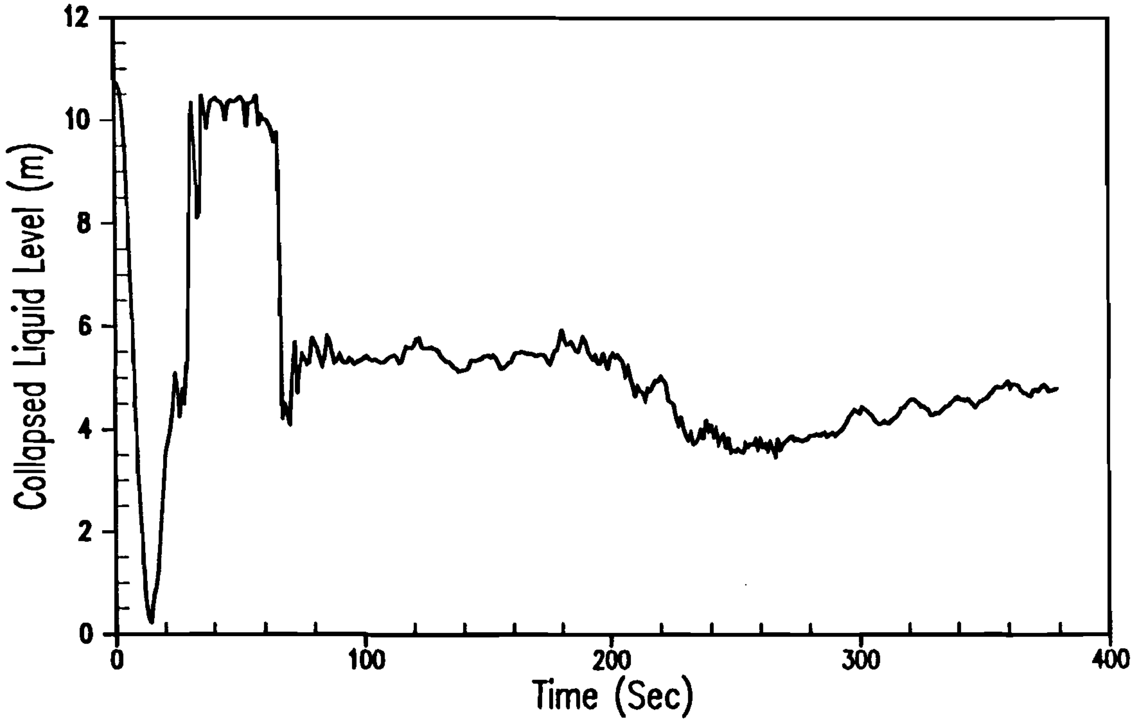

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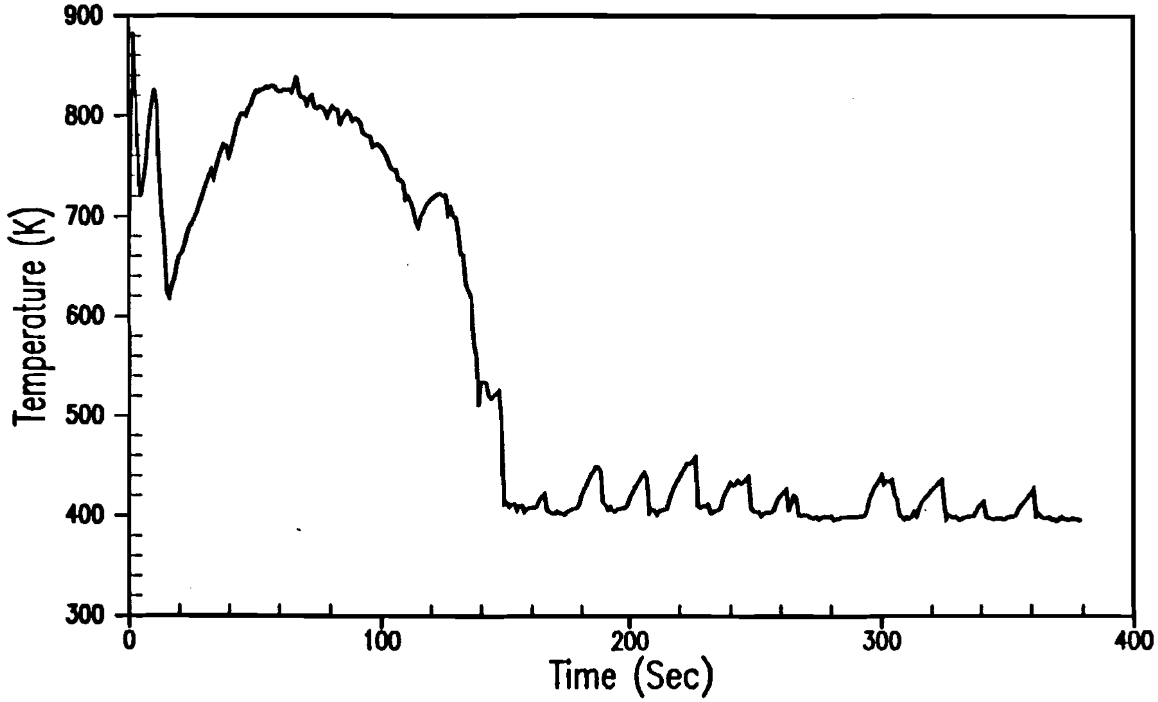

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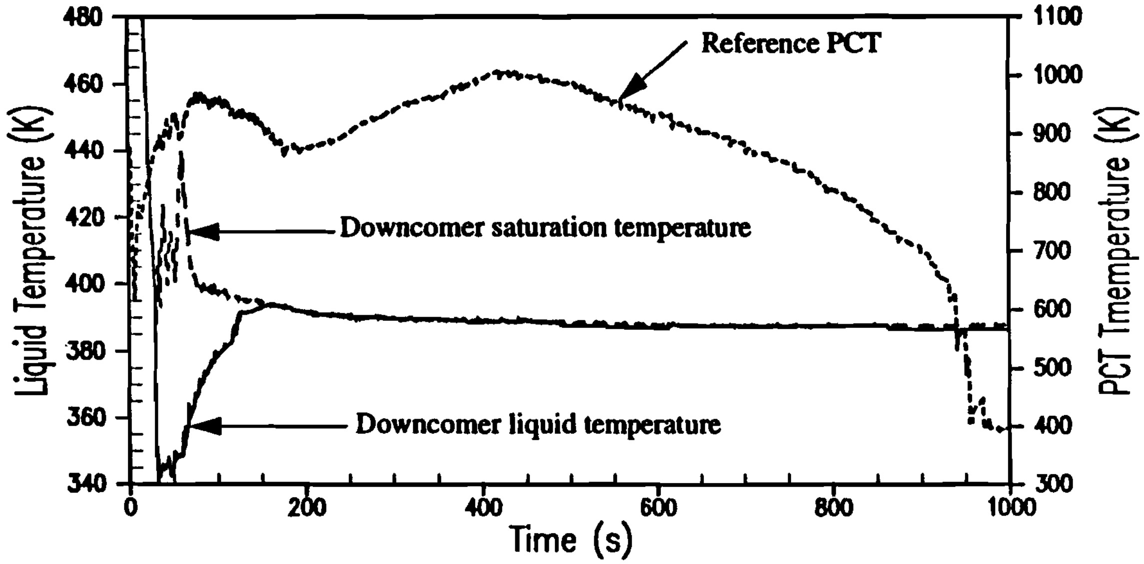

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1. Reduces vendor/licensee costs
2. Minimizes NRR review costs
3. Satisfies SECY-01-133 expectations

Cons:

1. May not be technically achievable. Multiplier is plant and EM dependent. Conservative selection may be more restrictive than 1.2 X ANS 71 decay heat for some plant types.
2. Alternative Appendix K would not necessarily be conservative for LBLOCA unless model uncertainties considered.
3. Removes the only important SBLOCA analysis conservatism. Would be no assurance that SBLOCA analysis remains conservative.
4. Sensitivity of NRC audit tools and vendor Evaluation Models differ.
5. Contrary to recommendations in SECY-86-318 by addressing uncertainties.
6. Would delay transition to modern thermal-hydraulic codes.
7. Requires extensive staff resources to determine plant type and accident specific multipliers.
8. Not applicable to advanced plants. May not support plant power uprates.

OPTIONS FOR REVISING ECCS EVALUATION MODEL REQUIREMENTS

Option C:

Appendix K - Retain existing Appendix K for conservative analysis option.

Realistic Option - Revise Reg. Guide 1.157 clarifying appropriate use of 1994 decay heat standard, metal-water reaction and uncertainty assessment.

Pros:

1. Maintains safety margins and is consistent with SECY-86-318. Margins are either conservative with Appendix K EM, or quantified in a Best Estimate EM.
2. Clear guidelines for review exist. No re-review necessary
3. Encourages vendors/licensees to use a more accurate codes & technology
4. No additional resources applied to Appendix K.
5. Maintains public confidence by allowing a reduction in LOCA margin only if the remaining margin is quantified.

Cons:

1. Minimal added reduction in regulatory burden.
2. May not satisfy expectations described in SECY-01-133.

Action Plan

1. Develop a complete list of non-conservatisms.

2. Identify experimental data that demonstrates the non-conservatisms and compare the experimental and full scale plant range of conditions.

3. Hold a public meeting to discuss alternative approaches to Appendix K.

Action Plan

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REPLACE PRESCRIPTIVE ECCS CRITERIA IN 50.46 WITH PERFORMANCE-BASED REQUIREMENTS

1) Peak Cladding Temperature (2200°F) . . . . Keep
Prescriptive but may serve well for all alloy types and burnups

2) Maximum Cladding Oxidation (17%) . . . . Remove
Prescriptive and may depend on alloy type and burnup

3) Maximum Hydrogen Generation (1%) . . . . Keep
Prescriptive but does not depend on alloy type or burnup

4) Coolable Geometry . . . . Keep
Not prescriptive

5) Long-Term Cooling . . . . Keep
Not prescriptive

////////////////////////////////

Replace #2 with requirement to retain post-quench ductility and put details in Reg. Guide

Remove restriction to Zircaloy and ZIRLO and apply to all zirconium-based alloys

PERFORMANCE-BASED EMBRITTLEMENT CRITERIA REGULATORY GUIDE

- Follow logic from the 1973 opinion of the Commission on the ECCS hearings
- Keep 2200°F as the peak cladding temperature for all cases
- Determine an oxidation limit based on ring-compression tests
- Specify conditions for the ring-compression tests
- Specify testing of fresh and high-burnup cladding of alloy in question

Pros:
1. Eliminates need for exemptions for new cladding alloys
2. Technically better than present regulation

Cons:
1. Could result in a backfit for some approved cases
2. Will be 1-2 yrs before anyone is able to try out this Reg. Guide

REVISED 11/7/01

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
JOINT MEETING OF THE ACRS SUBCOMMITTEES ON
MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA,
AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT
ROOM T-2B3, 11545 ROCKVILLE PIKE, ROCKVILLE, MD
NOVEMBER 15, 2001

ACRS Contact: Michael T. Markley (301) 415-6885
E-mail: mtm@nrc.gov

- PROPOSED SCHEDULE -

	TOPIC	PRESENTER	TIME
1)	**Introduction**		8:30-8:35 am
•	Review goals and objectives for this meeting; introductory remarks	Bill Shack, ACRS	
•	Status of risk-informing 10 CFR 50.46 for emergency core cooling systems (ECCS): - ACRS report dated July 25, 2001, - Commission action on SECY-01-133 feasibility study, and - NEI petition for rulemaking dated October 4, 2001		
2)	**NRC Staff Presentation**		8:35-10:50 am ~~10:15 am~~
•	Status of technical work on 10 CFR 50.46 - Loss-of-coolant accident/ loss-of-offsite power (LOCA/LOOP) - ECCS reliability - ECCS evaluation model and acceptance criteria - NEI petition for rulemaking - Large-break loss-of-coolant accident (LBLOCA) redefinition	Tom King ~~Mark Cunningham~~, RES Mary Drouin, RES Alan Kuritzky, RES Carolyn Fairbanks, RES Norm Lauben, RES Ralph Meyer, RES Steve Bajorek, RES	
	****BREAK****		10:50-11:05 am ~~10:15-10:30 am~~

3) NRC Staff Presentation - continued 11:05 ~~10:30~~-11:30 am

- Status of technical work on 10 CFR 50.46 — ~~Mark Cunningham, RES~~ Mary Drouin, RES; Alan Kuritzky, RES; Carolyn Fairbanks, RES; ~~Norm Lauben, RES~~
  - Loss-of-coolant accident/ loss-of-offsite power (LOCA/LOOP)
  - ECCS reliability
  - ECCS evaluation model and acceptance criteria
  - NEI petition for rulemaking
  - Large-break loss-of-coolant accident (LBLOCA) redefinition

~~**4) Industry Comments**~~ ~~11:30-11:45 am~~

- ~~Comments on NRC technical approach and NEI petition for rulemaking~~ — ~~Tony Pietrangelo, NEI (Tentative)~~
- ~~Owners Group perspectives~~ — ~~TBD~~

5) ACRS General Discussion and Adjournment 11:30 12:10 pm ~~11:45-12:00 noon~~

- General discussion and comments by Members of the Subcommittee; items for full ACRS meetings — Bill Shack, ACRS

__Note__: **Presentation time should not exceed 50% of the total time allocated for a specific item. Number of copies of presentation materials to be provided to the ACRS/ ACNW - 35.**

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETINGS ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

NOVEMBER 15, 2001
Date

PLEASE PRINT

NAME	AFFILIATION
Mary Drouin	RES/DRAA/PRAB
Mark Kowal	NRR/DSSA/SRXB
Rob Taylor	NRR/DSSA/SRXB
Alan Kuritzky	RES/DRAA/PRAB
Ralph Meyer	RES
Steve West	NRR
Jack Rosenthal	RES
Francis Akstulewicz	NRR
Charles Ader	RES
S.M. Bajorek	RES
F. Orr	NRR/SRXB
J. Lazevnick	NRR/EEIB
Glenn Kelly	NRR
Sudhamay Basu	RES
Matthew A. Mitchell	NRR/DE/EMCB
Isabelle Schoenfeld	OEDO

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETINGS ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

NOVEMBER 15, 2001
Date

PLEASE PRINT

ATTENDEES PLEASE SIGN-IN FOR THE MEETING

NAME	AFFILIATION
C Fairbanks	RES/DET/MEB
Ellen Anderson	NEI
Ian Rickard	Westinghouse Co.
Jennifer Uhle	RES/DSARE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

February 13, 2002

MEMORANDUM TO: ACRS Members

FROM: Michael T. Markley, Senior Staff Engineer
ACRS

SUBJECT: CERTIFICATION OF THE MINUTES OF THE JOINT MEETING OF THE ACRS SUBCOMMITTEES ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT - NOVEMBER 15, 2001 - ROCKVILLE, MARYLAND

The minutes of the subject meeting, issued February 11, 2002, have been certified as the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc: via E-mail
J. Larkins
S. Bahadur
H. Larson
S. Duraiswamy
ACRS Staff Engineers
ACRS Fellows

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

MEMORANDUM TO: Michael T. Markley, Senior Staff Engineer

FROM: William J. Shack, Chairman
Materials and Metallurgy Subcommittee

SUBJECT: CERTIFICATION OF THE SUMMARY/MINUTES OF THE MEETING OF THE JOINT MEETING OF THE ACRS SUBCOMMITTEES ON MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA, AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT - NOVEMBER 15, 2001 - ROCKVILLE, MARYLAND

I do hereby certify that, to the best of my knowledge and belief, the minutes of the subject meeting on November 15, 2001, are an accurate record of the proceedings for that meeting.

2/13/02

William J. Shack, Chairman Date
Materials and Metallurgy Subcommittee

CERTIFIED BY:
W. Shack - 2/13/02

Date:2/11/02

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
JOINT MEETING OF THE ACRS SUBCOMMITTEES ON
MATERIALS AND METALLURGY, THERMAL-HYDRAULIC PHENOMENA,
AND RELIABILITY AND PROBABILISTIC RISK ASSESSMENT
MEETING MINUTES - NOVEMBER 15, 2001
ROCKVILLE, MARYLAND

INTRODUCTION

The ACRS Subcommittees on Materials and Metallurgy, Thermal-Hydraulic Phenomena, and Reliability and Probabilistic Risk Assessment met on November 15, 2001, at 11545 Rockville Pike, Rockville, MD, in Room T-2B3. The purpose of this meeting was to discuss the status of NRC staff and industry initiatives to risk-inform the technical requirements of 10 CFR 50.46 for emergency core cooling systems (ECCS) for light-water nuclear power reactors.

The Subcommittees received no written comments from members of the public regarding the meeting. The entire meeting was open to public attendance. Mr. Michael T. Markley was the cognizant ACRS staff engineer for this meeting. The meeting was convened at 8:30 a.m. and adjourned at 12:10 p.m.

ATTENDEES

ACRS Members

W. Shack, Chairman
M. Bonaca, Member
T. Kress, Member
D. Powers, Member
M. Markley, ACRS Staff

Principal NRC Speakers

S. Bajorek, RES*
M. Drouin, RES
C. Fairbanks, RES
T. King, RES
A. Kuritsky, RES
N. Lauben, RES
R. Meyer, RES

Principal Industry Speakers

None.

RES Office of Nuclear Regulatory Research

There were approximately four members of the public in attendance at this meeting. A complete list of attendees is in the ACRS Office File, and will be made available upon request. The presentation slides and handouts used during the meeting are attached to the office copy of these minutes.

OPENING REMARKS BY THE SUBCOMMITTEE CHAIRMAN

Dr. William Shack, Chairman of the ACRS Subcommittee Materials and Metallurgy convened the meeting at 8:30 a.m. He announced that the joint meeting of the Advisory Committee on Reactor Safeguards (ACRS) Subcommittees on Human Factors and NRC Safety Research Program, previously scheduled for November 15, had been postponed. Dr. Shack stated that this was a joint meeting of the ACRS Subcommittees on Materials and Metallurgy, Thermal-Hydraulic Phenomena, and Reliability and Probabilistic Risk Assessment. He noted that Dr. Graham Wallis, Chairman of the Subcommittee on Thermal-Hydraulic Phenomena and Dr. George Apostolakis, Chairman of the Subcommittee on Reliability and PRA were unable to attend this meeting and that the Subcommittees were proceeding with this meeting on their behalf. He introduced the other ACRS Members in attendance and stated that the purpose of this meeting was to discuss the status of NRC staff and industry initiatives to risk-inform the technical requirements of 10 CFR 50.46 for emergency core cooling systems (ECCS) for light-water nuclear power reactors.

Dr. Shack noted that the Subcommittee had received no written comments from members of the public regarding the meeting.

DISCUSSION OF AGENDA ITEMS

NRC Staff Presentation

Ms. Mary Drouin, RES, led the discussion for the NRC staff. Mr. Alan Kuritsky, RES, provided supporting discussion. Messrs. Thomas King, Norm Lauben, Ralph Meyer, and Steven Bajorek and Ms. Carollyn Fairbanks, RES, provided brief presentations and/or supporting discussion. The staff discussed the background for risk-informing 10 CFR 50.46, recommended changes to Appendix K and General Design Criteria 35 (GDC-35) of 10 CFR Part 50, and technical work needed to support proposed rulemaking. Significant points raised during the presentation include:

- The Commission has not yet voted on the staff's feasibility study (SECY-01-0133) for risk-informing 10 CFR 50.46. The staff is continuing to meet with stakeholders to discuss progress on selected technical issues in parallel with Commission deliberation on these matters.

- The Nuclear Energy Institute (NEI) submitted a petition for rulemaking (PRM-50-74) dated October 4, 2001. In that petition, NEI requested the staff to amend the regulations to allow licensees to voluntarily adopt the most current industry Standard for decay heat power (ANS/ANSI-5.1-1994). The staff is currently evaluating the petition.

- Possible short-term revisions to 10 CFR 50.46 include proposed changes to ECCS acceptance criteria and evaluation model (Appendix K). The staff also proposes short-term activities to develop a voluntary risk-informed alternative to the reliability requirements (GDC-35).

- The current version of Appendix K makes no break size distinction concerning decay heat requirements. The staff stated that some models required by Appendix K may not be conservative and noted that there are potential errors in the uncertainty methods described in the decay heat curve of the 1994 ANS Standard. The staff is evaluating these issues and plans to revise Regulatory Guide 1.157 to endorse the 1994 version of the Standard with exceptions and clarifications, as appropriate.

- The staff proposes to delete the current simultaneous loss-of-offsite power requirement and single failure criterion. Two performance-based options were offered to accomplish ECCS reliability.

  Option 1: Generic approach that defines, by plant group, a minimal set of equipment to meet ECCS reliability.

  Option 2: Plant-specific approach where licensees establish functional reliability that is commensurate with LOCA frequency.

- Long-term considerations include evaluating the definition of a spectrum of break sizes for large-break loss-of-coolant accident analysis (LBLOCA). However, the technical justification may be increasingly complex and more difficult as smaller break sizes are considered.

SUBCOMMITTEE COMMENTS, CONCERNS, AND RECOMMENDATIONS

Subcommittee members raised the following significant points during its discussion with NRC staff and industry representatives:

- Dr. Shack questioned why the review for adopting the decay heat curve in the 1994 ANS Standard would require a lengthy review. The staff stated that it depends on how much margin the licensee/applicant wants to shave off margin afforded by the Standard. The staff stated that the NRC Office of Research is comparing the uncertainties and conservatism in the various Standards. The staff noted that several organizations have done "realistic" analyses yielding substantially different results. The staff stated that more work is needed to evaluate these differences.

- Dr. Kress questioned what the staff meant by non-conservatism with respect to the evaluation model. The staff stated that potential sources of non-conservatism exist in specific models required by Appendix K and that uncertainties have not been accounted for. The staff also stated that thermal-hydraulic processes have been observed in experimental programs since 1973 that are not specifically addressed in Appendix K.

- Dr. Shack questioned what analytical methods the staff might pursue in calculating peak clad temperature given the temperature and strain history. In particular, he questioned what temperature and strain history you put it through before deciding what test is appropriate. Dr. Powers expressed concern regarding how ductility is evaluated. The staff acknowledged that selection of the appropriate tests will be important. The staff stated that they are exploring the effects of various heating and cooling rates and highlighted plans to have laboratory tests performed.

- Dr. Powers questioned the apparent assumption that ECCS was installed to respond to an event during full-power operations. He noted that ECCS is needed for a range of operational modes and suggested that other events be considered (e.g., low-power and shutdown, external events, sabotage, etc.). The staff agreed and noted that risk insights suggest that other modes of operation can be significant. The staff stated that issue of sabotage is being reevaluated as a result of the tragedies at the World Trade Center and Pentagon on September 11, 2001.

STAFF AND INDUSTRY COMMITMENTS

NRC staff and industry representatives agreed to perform the following follow-up actions in response to Subcommittee questions and comments:

- Dr. Shack suggested that criteria for peak clad temperature and fuel oxidation be included in a regulatory guide instead of being retained in the rule. Dr. Kress stated that peak clad temperature will be key in preventing runaway oxidation. The staff acknowledged that a huge oxidation addition occurs at peak clad temperatures above 2200 degrees Fahrenheit. The staff agreed to consider Dr. Shack's recommendation in their continuing evaluation.

SUBCOMMITTEE DECISIONS

At the conclusion of the meeting, Subcommittee members expressed concern over the extensive analysis and resultant time needed for making changes to the technical requirements of 10 CFR 50.46. Dr. Bonaca suggested that an extensive trade-off analysis will be needed for evaluating the various options under consideration. Dr. Shack questioned where the "low-hanging fruit" or easily adoptable changes might be if endorsing the 1994 ANS Standard is proves to be too difficult. Drs. Kress expressed concern about using frequencies to deal with LOOP-LOCA. Drs. Kress, Bonaca, and Powers expressed concern regarding how defense in depth might be applied. The staff suggested that these items as well as the issues related to non-conservatism be discussed during future meetings. The Subcommittee agreed.

FOLLOW-UP ACTIONS

Dr. Powers suggested that the staff prepare a paper on the technical challenges associated with adopting the decay heat curve in the 1994 ANS Standard. The staff agreed to pursue preparation of such a paper and to report to the Subcommittee during a future meeting on this matter.

BACKGROUND MATERIALS PROVIDED TO THE SUBCOMMITTEE PRIOR TO THIS MEETING

1. Subcommittee agenda.
2. Subcommittee status report.
3. 10 CFR Part 50, Appendix A, Criterion 35, "Emergency core cooling."

4. Report dated July 25, 2001, from George E. Apostolakis, Chairman, ACRS, to Richard A. Meserve, Chairman, NRC, Subject: Feasibility Study on Risk-Informing the Technical requirements of 10 CFR 50.46 for Emergency Core Cooling Systems.
5. Letter dated October 1, 2001, from William D. Travers, Executive Director for Operations, NRC, to George E. Apostolakis, ACRS, Subject: Feasibility Study on Risk-Informing the Technical requirements of 10 CFR 50.46 for Emergency Core Cooling Systems.
6. NRC and industry meeting handouts on Loss-of-Coolant Accident/Loss-of-Offsite Power Accident Requirements, October 17, 2001.
7. Nuclear Energy Institute, Petition for Rulemaking [Docket No. PRM-50-74], Subject: dated October 4, 2001.

****

Note: Additional details of this meeting can be obtained from a transcript of this meeting available for downloading or viewing on the Internet at "http://www.nrc.gov/ACRSACNW" or can be purchased from Neal R. Gross and Co., Inc., (Court Reporters and Transcribers) 1323 Rhode Island Avenue, N.W., Washington, DC 20005 (202) 234-4433.

2. DCS Proposed PSSCs, Design Bases (DB), And Controls

- Public receptor: low consequences
  - - no PSSCs
- SRS site worker: low consequences
  - - no PSSCs
- Facility worker:
  - Emergency control room A/C system
  - Rad PSSCs provide adequate protection
  - No additional chem PSSCs needed

(From CAR page 5.5-44)

2. DCS Proposed PSSCs, Design Bases (DB), And Controls

... but PSSCs from Chapter 8, Chem. Safety:

- Admin. Controls on makeup, concentrations
- Vents and offgases
- Non-explosive mixtures - gases, evaporators, HAN/hydrazine
- Few specifics given

3. Status of Review

Activities

- Review ongoing
  - CAR, RAI responses, literature
  - With DCS: meetings and calls
- "Ruff" draft of SER

3. Status of Review (cont.)

Main Findings

- General lack of specificity for chemical PSSCs and DBs
- Texts imply more PSSCs and DBs
- Heavy reliance on operators and administrative controls

4. Current Issues

- Administrative controls
- High alpha stream and wastes
- Electrolyzers
- Evaporators
- Uranium isotopic dilution

Nuclear Criticality Safety Review for the MOX Fuel Fabrication Facility

Christopher Tripp

NCS Risk at MOX Facility

- Criticality and fire dominant risks.

- Criticality risk similar to HEU facilities.
  - Of 22 process accidents, 19 involved Pu/HEU (8 Pu, 11 HEU).
  - All 22 process accidents involved solutions in process tanks.

- Areas of greatest risk:
  - Aqueous Polishing--solutions of ^{239}Pu.
  - MOX Process--
    - uncontained Pu powder.
    - uncontained MOX powder.

NCS Controls for MOX Facility

- NCS Bases:
  - Aqueous Polishing: favorable geometry for $Pu(NO_3)_x$ solutions, spacing.
  - MOX Process: Isotopics, moderation, geometry, mass, *etc*....
- Design relies heavily on geometry and other passive controls.

Regulatory Requirements for NCS*

- §70.24 Criticality accident alarms and emergency procedures
- §70.61(b) High consequence events "highly unlikely"
- §70.61(d) Subcritical under normal and credible abnormal conditions. Primary means of protection by prevention.
- §70.64(a)(9) Adherence to double contingency principle (DCP)

*MOX SRP discusses acceptable ways of meeting above requirements.

Design Bases for Criticality Safety

- §70.23(b) states Commission will approve construction upon a determination that the design bases of the principal SSCs provide reasonable assurance of protection against the consequences of potential accidents.
- Principal SSCs and IROFS for criticality hazards to be identified.
- Reasonable assurance of safety largely based on NCS Program.

Open NCS Issues

- Staff Qualifications:
  - Construction phase: focus on NCS staff qualifications for design.
  - Unique issues:
    - no facility-specific experience
    - other industry experience not as applicable (non-Pu).

- Subcritical Margin*:
  - $k_{calc} + 2\sigma \leq USL = 1 - \beta - \Delta\beta - \Delta k_m$ ($\beta \equiv$ bias)
  - 5 different validations/USLs :
    - Part I: Pu-solutions, MOX pellets, rods, assemblies
    - Part II: PuO_2 powders, MOX powders, Pu-oxalate solutions
  - $\Delta k_m = 0.05$ historically accepted for uranium systems.
  - Part II will require new analytical tools.

*Validation Report reviewed in addition to CAR.

Open NCS Issues

- DCP and "Highly Unlikely"*:
  - Index likelihood method proposed in SRP Appendix A.
  - DCS agreed to index method for other hazards than criticality.
  - DCS initially proposed DCP sufficient to meet §70.61(b).
  - DCS proposed *robust* DCP (DC + management measures and standards).
  - Staff determined that robust DCP not sufficient.

*Criticality considered high-consequence event due to facility worker dose. Only likelihood determination involved.

Fire Safety

Sharon Steele

Overview

- Standard Review Plan
- Major Aspects of Fire Safety
- Status of Review/ Open Issues
- Summary

Standard Review Plan

NRC Guidance for

- Fuel Cycle Facilities, and
- Reactors, where appropriate

DOE Standard, "Fire Protection Design Criteria"

National Fire Protection Association Standards

Major Aspects of Fire Safety

- Administrative Controls/ Fire Protection Program
- Detection/ Suppression
- Manual Fire Fighting
- Compartmentation
- Fire Hazard Analysis

Fire Hazards Analysis (FHA)

- Systematic analysis of fire hazards
- Determine the adequacy of plant fire safety
- Divides the facility into Fire areas
- Analyzes risks
- Develop design basis fire scenarios - Principal SSCs

Appplicant's Proposal for Administrative Controls/ Fire Protection Program

Administrative Controls

- Procedures - Ignition Sources, Combustibles
- Periodic Surveillances -Transient Combustibles, Fire Protection Systems
- Principal SSC

Fire Protection Program

- Policy - protection of IROFS
- Organizational Responsibilities - Procedures, Maintenance, Inspection and Testing, Control of Design Changes, Record Keeping, Fire Emergency Plans

Applicant's Proposal for Fire Detection/Suppression

- Detection and Alarm:
  - Smoke and heat detectors, manual pull station
  - Provide visual or audible alarms
  - Indicate and transmit alarms to attended locations
- Suppression:
  - Sprinklers - Hallways, stairwells, offices
  - Clean Agent - Fissile materials
  - Portable

Applicant's Proposal for Manual Fire Fighting

- Baseline Needs Assessment:
  - Minimum Staffing Requirements
  - Organization and Coordination of Resources
  - Personal Protective and Fire Fighting Equipment
  - Training
  - Fire Emergency Planning
- FHA will determine the need for a separate emergency response team

Applicant's Proposal for Compartmentation

- Fire Areas - separate operations, hazards, redundant PSSCs
- Two-hour fire barriers (minimum)
- Openings in Barriers - fire doors, dampers, penetration seals
- Fire Barriers are consisdered Principal SSCs

Open Items

Polycarbonate Window Materials

- NFPA 801, Standard for Facilities Handling Radioactive Materials --glove box construction materials must be non-combustible
- Demonstrate an equivalent level of fire protection:
  - Difficult to ignite or sustain combustion
  - Administrative and protective features
- Effect of polycarbonate combustion on margin of safety
- NRC requested additional justification that flashover will not occur

Open Items Cont'd

Combustible Loading Controls

- Combustible Loading Controls ONLY to protect various forms of Pu that are not in fire-qualified containers
  - canister
  - fuel rods
  - final HEPA filter
- NRC requested details on:
  - additional surveillances to augment controls
  - fire analysis
  - non-credited detection

Summary

- Addressed Major Aspects of Fire Safety
- Commitments to develop administrative controls, a fire protection program, and a baseline needs assessment for the manual fire fighting
- Presented physical fire protection features and Fire Hazards Analysis
- Identified Open Fire Safety Issues
- NRC will continue to review additional information in order to complete Safety Evaluation Report

Confinement Systems

Tim Johnson

Regulatory Requirements

- Under 10CFR70.23(a)(3), equipment and facilities must be adequate to protect health and minimize danger to life and property

- Confinement and ventilation systems are important in minimizing release and dispersal of radioactive material

Design Basis Objectives

- Principal structures, systems, and components (SSCs) of confinement system must perform safety functions under conditions requiring confinement

- Systems must exhibit defense-in-depth

Applicable Regulatory Guidance

- MOX Standard Review Plan (NUREG-1718, Section 11.4.5)

- Fuel Cycle Facility Accident Analysis Handbook (NUREG/CR-6410)

- Regulatory Guide 3.12, "General Design Guide for Ventilation Systems of Plutonium Process Design and Fuel Fabrication Plants"

Proposed Confinement System

- Release of radioactive materials minimized by:
  - Static barriers (e.g., gloveboxes, process cells, etc.)
  - Dynamic barriers (ventilation systems)

Key Design Features of Ventilation Systems

- Four ventilation zones with leakage moving from least hazardous zones to most hazardous zones
  - C4 zone: -1.2 to -2.0 inches WG
  - C3 zone: -0.5 to -0.7 inches WG
  - C2 zone: -0.2 to -0.4 inches WG
  - C1 zone: ambient pressure

Key Design Features of Ventilation Systems

- Supply air system
  - HEPA filtration
  - Redundant fans
- C4 confinement system
  - Redundant final filter assemblies
  - Two banks of HEPAs per final assembly
  - Four redundant fans
  - HEPAs at gloveboxes and C3 boundary

Key Design Features of Ventilation Systems

- C3 confinement system
  - Redundant filter assemblies
  - Two banks of HEPAs per assembly
  - Two redundant fans

HEPA Filter Removal Efficiency

- DCS proposing to use a 10^{-4} release fraction in its accident analysis

- Because of past experiences where fire damage has occurred in filtration systems and due to uncertainties in fire analysis, NRC staff requested further justification of proposed removal efficiencies

HEPA Filter Removal Efficiency

- DCS provided justification by calculation
- NRC staff remains concerned that uncertainties in fire analysis and HEPA filter performance dictate a more conservative margin
- DCS's approach is to further refine its basis for airflow environmental conditions to support credit for higher particulate removal efficiencies

Use of Sand Filters

- Environmental impact statement (EIS) scoping comments suggested that impacts of using sand filters should be considered

- DOE Savannah River Site has historically used sand filters in ventilation systems

- NRC to discuss advantages and disadvantages in EIS

Use of Sand Filters

- Preliminary analysis shows:
  - Similar particulate removal efficiencies
  - Similar life-cycle costs
  - Sand filters have higher installation and decommissioning costs but lower maintenance costs
  - Sand filters can withstand severe fires

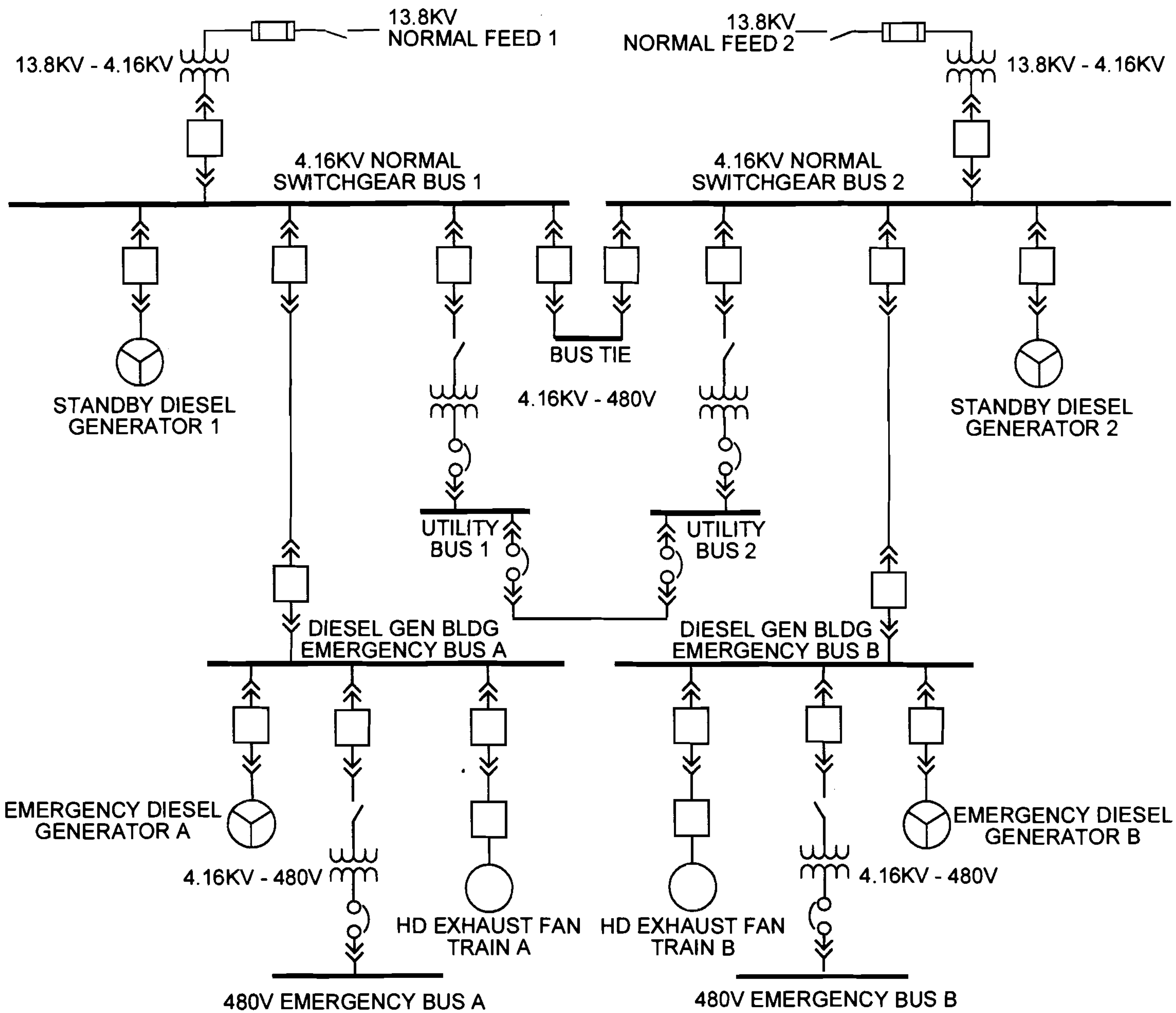
Summary

- NRC staff reviewing design basis for confinement systems
- Principal issue is how much credit should be given for HEPA filter particulate removal efficiency
- EIS will consider impacts of sand filter use

Electrical

Fred Burrows

MOX FUEL FABRICATION FACILITY
Main One-Line Diagram



MOX NORMAL AC POWER SYSTEM

- Two separate 13.8 KV feeds
- Two 100 % capacity transformers each with 4.16 KV bus
- Automatic 4.16 KV bus cross-connect on loss of feed
- Additional 480 V bus crossties for maintenance
- Designed to IEEE Std 765 as non-principal SSC

MOX STANDBY AC POWER SYSTEM

- Two separate 4.16 KV Standby Diesel Generators
- Two 120/208 V uninterruptible power supplies
- On loss of offsite feed and failure of transfer, provides for safe shutdown of process
- Designed to IEEE Std 446 as non-principal SSC

MOX EMERGENCY AC POWER SYSTEM

- Two separate, redundant 4.16 KV Emergency Diesel Generators
- Two 480 V uninterruptible power supplies
- Two 120 V uninterruptible power supplies
- On loss of other sources, provides power to principal SSCs
- Designed to IEEE standards for Class 1E power systems such as IEEE Std 308 and 387 as principal SSC

MOX NORMAL DC POWER SYSTEM

- Two separate 125 V batteries each with a charger
- Provides power for breaker control and DC loads
- Designed to IEEE Std 485 for battery sizing and IEEE Std 484 for installation as non-principal SSC

MOX EMERGENCY DC POWER SYSTEM

- Two separate, redundant 125 V batteries each with charger
- Provides power for emergency breaker control, emergency lighting, and principal SSCs
- Designed to IEEE standards for Class 1E DC systems such as IEEE Std 946, 450, and 485 as principal SSC

SUMMARY

- Robust electrical system design
- Emergency AC and DC power systems designed for:
  - Redundancy and independence
  - No single failure vulnerability
  - Sufficient capacity and capability
  - Quality assurance, maintenance, and qualification programs
- Minor issues related to specific IEEE standards and associated regulatory guides

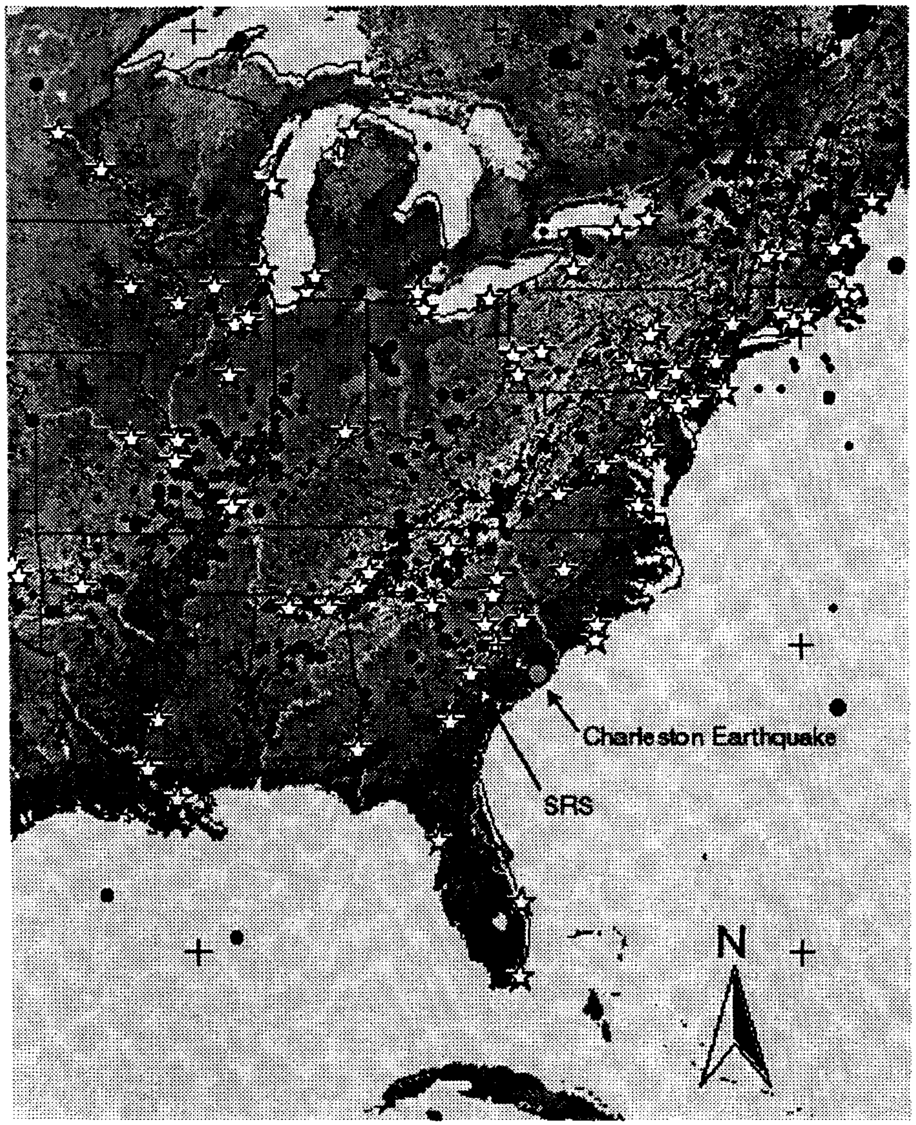
MIXED OXIDE FUEL FABRICATION FACILITY

John Stamatakos

Seismic Hazard Assessment

- DCS Developed Probabilistic Seismic Hazard Assessment (PSHA) Generic for the Entire Savannah River Site (SRS)
  - Establish Design Basis Earthquake (DBE) implementing DOE Standard 1023-95 (parallels methodology in Regulatory Guide 1.165)
  - DBE Based on DOE Performance Categories defined in DOE Standard 1020- 95 with PC3 and PC4 (Mean Hazards at $5*10^{-4}$ per and $1*10^{-4}$ per Year probability of exceedence)
  - Develop SRS PSHA using mean LLBL and EPRI bedrock-level uniform hazard spectra (UHS)

Charleston Earthquake



- Perform historical check: DBE Spectra envelopes UHS based on Charleston 1886 Earthquake (M=7.2 at Distance of 120 km from the site)

Site Response

- ♦ DCS developed site-specific PSHA, soil surface design spectra
  - Use SRS-specific ground motion attenuation models to generate site specific PSHA
  - Use SRS soil profile data to develop SRS site-wide soil response model
  - Use SRS mean soil amplifications to scale bedrock UHS to soil surface
  - Develop alternative site-specific amplification functions (bedrock to soil surface) to validate site-wide response model
  - For soil stability analyses, use bedrock PC-3 ground motions scaled so that when amplified they will produce surface ground motions with 0.20 PGA.

Design Basis

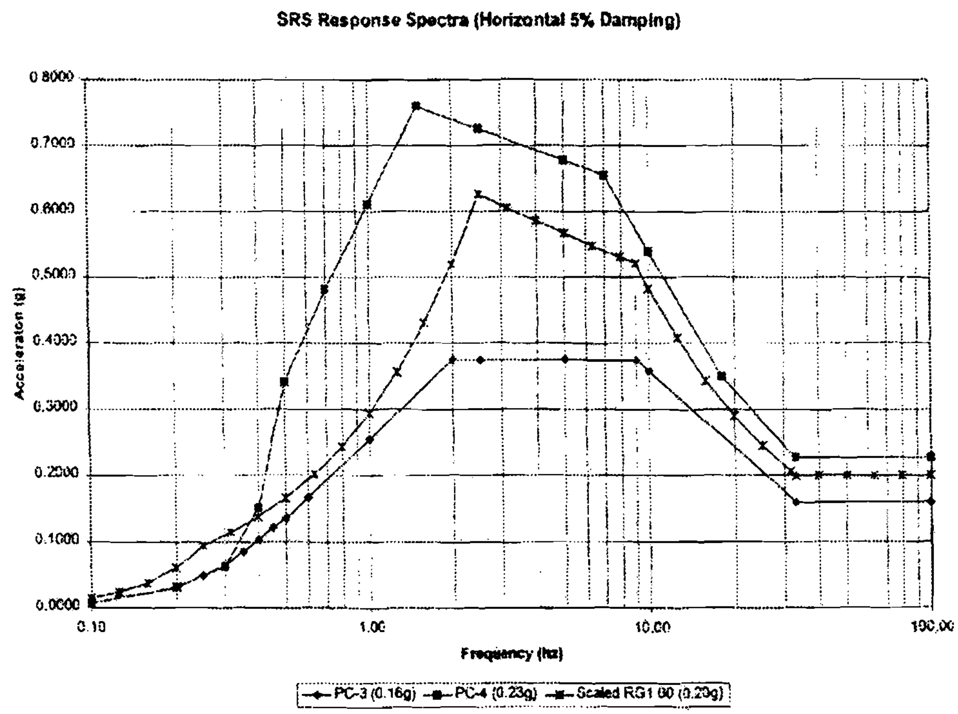
♦ DCS Seismic Design Basis

– DCS selected goal of $1*10^{-4}$ per year for ground motions at frequencies of interest.

– Use Regulatory Guide 1.60 horizontal soil surface spectrum scaled to 0.20 PGA to meet this goal.

– Resulting spectrum comparable to design basis for Vogtle NPP (10CFR§50).

– Vertical spectrum is also based on regulatory Guide 1.60 scaled to 0.20 g PGA



Staff Evaluation of PSHA

- Likelihood of Seismic Events
  - Evaluating whether DCS needs to modify LLBL and EPRI hazard results to Include a more active and closer Charleston source
- Groundmotion Attenuation
  - Evaluating differences in predicted ground motions between CAR and USGS NEHRP results. Difference appear to be in choice and the weighting of alternative ground motion attenuation functions
- Site Response
  - Evaluating DCS site response model and alternative site-specific amplification functions

Material Control and Accounting (MC&A)

Tom Pham

MOX MC&A PROGRAM REQUIREMENTS

- Program will be in accordance with 10 CFR Part 74 - Subpart E (§74.51-59)
- Submittal of a Fundamental Nuclear Material Control Plan (FNMCP) per guidelines of NUREG-1280

APPLICANT'S PROPOSED MC&A PROGRAM

- Main elements of DCS MC&A program:
  - Process monitoring
  - Item monitoring
  - Receipt measurement
  - Measurement control
  - Physical inventory

SUMMARY

- Overall approach of MC&A is adequate
- No outstanding issues at this stage
- Further review at operation license application

Physical Security

Nancy Fragoyannis

MOX Physical Protection

- Measures for the protection of nuclear material or facilities designed to prevent unauthorized removal or sabotage

Safeguards Approach

Design Basis Threat Statementshypothetical threat model which serves as a basis for which safeguards systems are designed

represents adversary characteristics baseline(ACD)
assures and adequate standardized level of security
comparability with DOE/DOD threat models
security measures are a function of consequences

Safeguards Approach

- Graded approach to safeguards based on material significance
- Defense in depth
  - multiple barriers, alarms, communications, response
- Graceful degradation

Safeguards Approach

- Response to security events
  - licensee provides immediate reaction
  - LLEA, FBI provide reinforcements
- Implementation of NRC-approved physical protection systems subject to inspection and adequacy evaluation

	Category I	Category II	Category III
Plutonium	>2kg	<2kg	<500g
Uranium 235 >20%	>5kg	<5kg/>1kg	<1kg/>15g
Uranium 235 >10% <20%		>10kg	<10kg/>1kg
Uranium 235 >natural < 10%			>10kg

*The protection of nuclear material with a radiation level that exceeds 100 rad/hr at one meter unshielded, which is classified as Cat. I or II, may be reduced one category level (i.e., Research Reactors)

NRC Design Basis Threat Statements

- External Threat
  - violence, deception, stealth
  - small group
  - well trained, dedicated
  - active or passive assistance by an insider
  - hand carried weapons
  - hand carried equipment
  - ability to operate as two or more teams
  - use of land vehicle for transportation of personnel, equipment, or standoff vehicle bomb attack

NRC Design Basis Threat Statements

- Insider Threat
  - insider in any position/conspiracy between individuals in any position

Protective Measures for MOX

- Physical Protection, T&Q and Contingency plans approved by NRC
- Dual perimeter fences with isolation zone
- Vehicle barriers at the perimeter
- Perimeter intrusion detection and assessment system (PIDAS) with sufficient illumination
- Occupied access control point, search for contraband materials (firearms, explosives, etc.)

Protective Measures for MOX

- Hardened central alarm station, independent secondary alarm station
- Multiple means of off-site communications
- Arrangements with local police response forces
- Armed security force on site
- Qualifications and training for security force members

Protective Measures for MOX

- Designated tactical response team (TRT) with special qualifications and training
- Performance evaluations through frequent tactical exercises
- MAAs locked and alarmed, access limited and controlled

Storage of HEU & PU in vaults

- Volumetric alarms for unoccupied areas

Protective Measures for MOX

- MAA/PA Exit searches for unauthorized HEU
- Controls to protect against internal conspiracies
- Personnel screening program (fitness for duty - access authorization program)
- Government-run clearance program

MOX Physical Protection Summary

- NRC provided DCS with detailed SRP and other info for PP design
- DCS presented detailed pp plan/protective strategy to NRC
- MOX Facility located on SRS/DOE Facility
- MOX Facility protected by SRS Guard Force
- NRC observed SRS F-O-F exercises

MOX Physical Protection Summary

- MOX Facility, in addition to meeting NRC regs.- must meet certain DOE "Landlord" requirements
- DCS plan meets and in some areas exceeds NRC regs
- Security at MOX facility adequately protects public health and safety(based on current threat estimates-pre 9/11/2001 events)

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Instrumentation and Controls

John Calvert

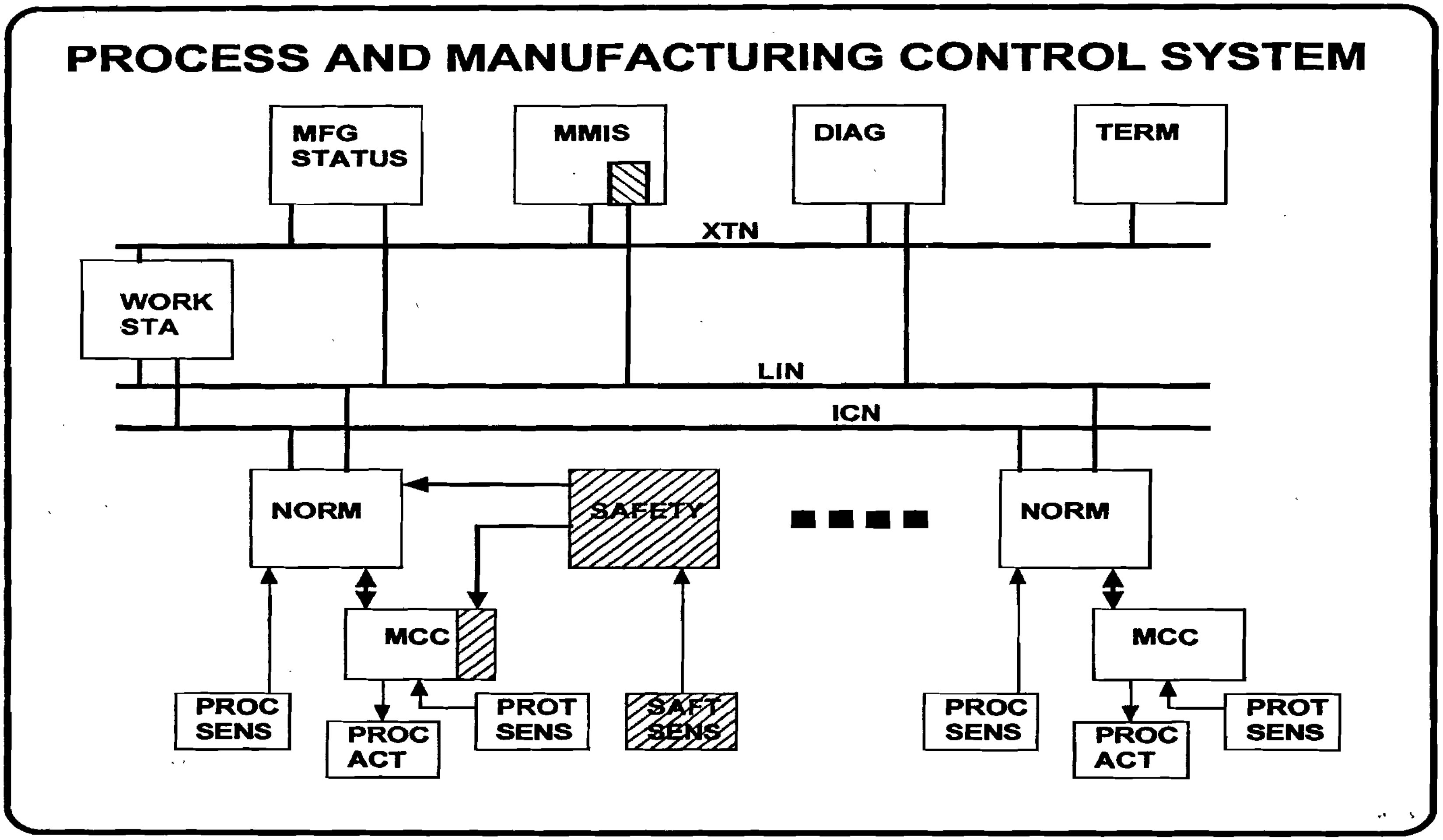
Instrumentation and Controls

- Overview and principal structure, system, components (PSSC)
- System Architecture
- Design bases
- Summary

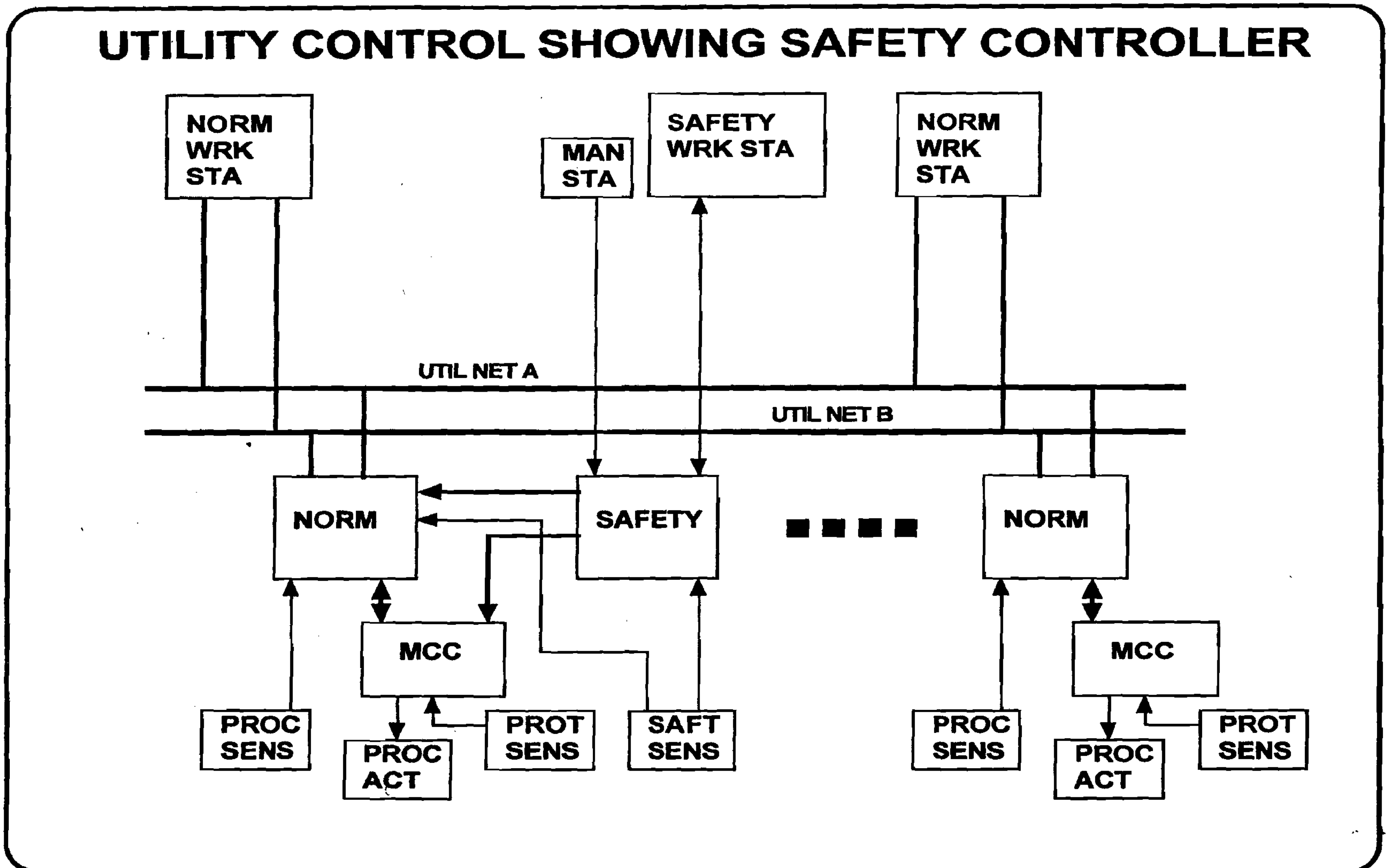
Overview and PSSCs

SYSTEM		SUB-	SYSTEM		CONTROL ROOM(S)
	Normal	Protective	PSSC Safety	Safety	
MOX Process Control	X	X	X	X	6
Aqueous Process Control	X	X	X	X	1
Utility Control	X	X		X	1 alternate
Emergency Control			PSSC		2

System Architecture



System Architecture



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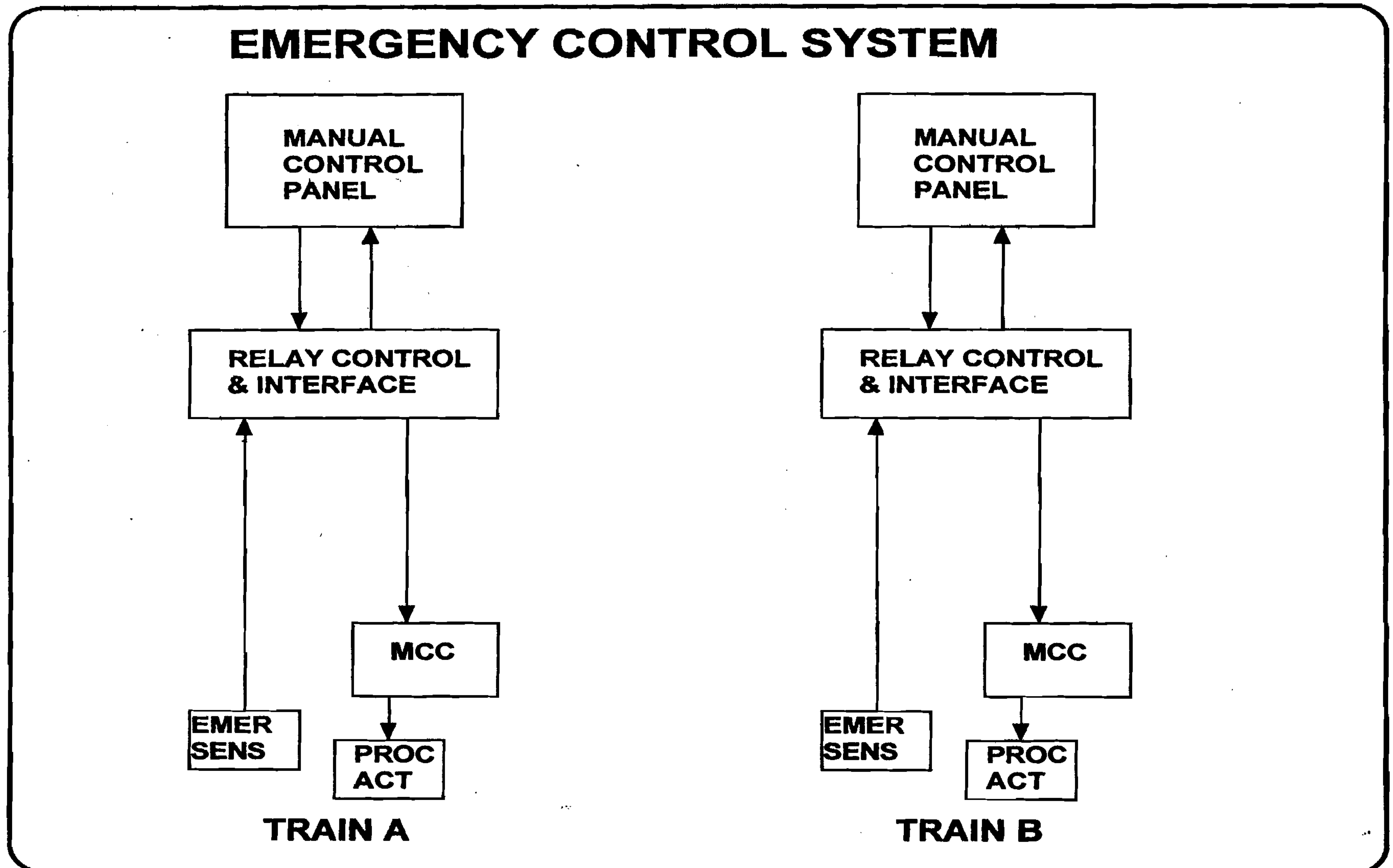
System Architecture



PSSC Design Bases

Safety Control Subsystem

- Function
  - Ensure safety limits not exceeded
  - Prevent/mitigate undesirable conditions/events
- Design
  - Appropriate standards used for
    - System design, programmable electronic system design
    - Software: life cycle, requirements, reviews, verification/validation, configuration management
    - Set points, independence, separation, isolation, EMI
  - Each controller is single channel, separate, independent, interface with NPSSCs isolated.

PSSC Design Bases

Emergency Control System

- Function
  - Ensure that certain safety systems operate as needed to mitigate consequences of accidents
- Design
  - Two redundant, separate, independent trains
  - Primarily manual control of selected systems
  - Appropriate standards used for system design, single failure, status/periodic test, qualification, seismic, separation, independence, EMI, grounding

Summary

- Appropriate standards used for design bases
  - Proper application of the standards pending response to RAI
- Design bases commitments appropriate for construction application
- Allocation of safety controllers to process modules that are PSSCs pending response to RAI