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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
FIRE PROTECTION SUBCOMMITTEE
SUBCOMMITTEE MEETING MINUTES
FEBRUARY 29, 1996
ROCKVILLE, MARYLAND

INTRODUCTION

The Advisory Committee on Reactor Safeguards (ACRS) Subcommittee on Fire Protection held a meeting on February 29, 1996, in Room T-2 B3, 11545 Rockville Pike, Rockville, Maryland, with representatives of the U.S. Nuclear Regulatory Commission (NRC) and their consultants. The purpose of this meeting was to gather information concerning (1) a probabilistic risk assessment (PRA) model for evaluating fire risk during a self-induced station blackout (SISBO) and scoping analyses of degraded fire barriers developed by Brookhaven National Laboratory (BNL), (2) the status of the NRC Fire Protection Plan, and (3) the assessment of fire models developed for performance-based fire protection regulations. The entire meeting was open to the public. Mr. Noel Dudley was the Designated Federal Official (DFO) for this meeting. The meeting was convened at 8:30 a.m. and adjourned at 5:35 p.m.

ATTENDEES

ACRS Members/ACRS Consultants

I. Catton, Chairman
M. Fontana, Member
T. Kress, Member
G. Apostolakis, Member
W. Lindblad, Member
R. Seale, Member
D. Karydas, Invited Expert
J. Quintiere, Consultant
R. Zalosh, Invited Expert
N. Dudley, DFO

Principal NRC Speakers and Consultants

S. West, Office of Nuclear Reactor Regulation, Division of Systems Safety and Analysis, Plant Systems Branch (NRR/DSSA/SPLB)
P. Madden, NRR/DSSA/SPLB
E. Connell, NRR/DSSA/SPLB
K. Sullivan, BNL
J. Higgins, BNL
S. Wong, BNL
G. Martinez, BNL
L. Cooper, National Institute of Standards Technology (NIST)
K. Steckler, NIST
P. Kadambi, Office of Nuclear Regulatory Research (RES)
M. Dey, RES

DESIGNATED ORIGINAL

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No written comments or requests for time for oral statements were received from members of the public. Approximately 12 members of the public attended the meeting. A list of those who registered is available in the ACRS Office.

OPENING REMARKS BY THE SUBCOMMITTEE CHAIRMAN

Dr. Ivan Catton, Chairman of the Fire Protection Subcommittee, convened the meeting at 8:30 a.m. He stated that the primary reason for the meeting was to discuss (1) a PRA model for evaluating fire risk during a SISBO and (2) scoping analyses of degraded fire barriers developed by BNL, (3) the status of the NRC Fire Protection Plan, and (4) the assessment of the fire models developed for performance-based fire protection regulations. He also stated that the subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full committee.

DISCUSSION OF ITEMS

Probabilistic Risk Assessment Model for Fire During Safe Shutdown Following a Self-Induced Station Blackout – Mr. Pat Madden, NRR

Mr. Pat Madden, NRR, provided brief introductory remarks and said that BNL is the primary contractor and has the lead for developing the PRA model and the scoping analyses noted above.

Mr. Sullivan, BNL, presented the background of the issues that led to the initiation of the study, as well as a summary of the conclusions that were achieved from the BNL review of alternative shutdown procedures. Mr. Sullivan also stated that this study had been essentially divided in two distinct phases. Phase one involves the scoping evaluation for alternative shutdown methodologies, including a review of alternative shutdown procedures developed by all operating plants. Phase II involves the validation of the Phase I findings and adapting the generic model to site-specific parameters. Mr. Higgins of BNL discussed the results of the SISBO study. Mr. Martinez-Guridi of BNL discussed the approach used for developing the PRA model to estimate the contribution from the SISBO event to core-damage frequency (CDF), Mr. Wong of BNL presented the evaluation of scoping analyses of degraded fire barriers. Significant points made during the discussion include the following:

Background

The SBO approach was initially identified at the Trojan Nuclear Power Plant during an NRC fire protection inspection in 1988. This approach was used to shut down the reactor in the event of a fire either in the control room (CR) or cable spreading room (CSR). This methodology was also used to reduce the number of modifications necessary to ensure electrical isolation. This approach satisfies the regulatory criteria; however, the licensee may place the plant in a more degraded condition because the operators may not be able to restore power in a limited amount of time. The consequences associated with the inability to regain a functional source of ac power may be severe, with recovery not obtainable.

Results of the Self-Induced Station Blackout Study and Risk Analysis Model for Self-Induced Station Blackout - Mr. Higgins/Mr. Martinez-Guridi, BNL

Mr. Higgins presented the conclusions of the SISBO risk study during Phase I and Mr. Martinez-Guridi discussed the overall approach used to perform this study. The objective of this study was to evaluate the relative risk significance and the absolute risk significance of SISBO in order to prevent spurious actuations of associated circuits during a fire either in the CR or CSR. This study was performed in plants that had full electrical isolation schemes (FEISs) and in older plants that have minimal electrical isolation schemes (MEISs). A standard PRA model, using event tree methods was developed to evaluate the risk associated with the various options in the event of a fire either in the CR or the CSR. The model incorporated the frequency of a fire occurrence, the FEIS, the SISBO factor, potential spurious actuations, failures of equipment, and the operator's recovery actions. The model was evaluated with and without the electrical isolation scheme, and also with and without the SISBO factor.

The probability of a spurious actuation of equipment as a result of a fire is difficult to determine and is plant specific. The probability was varied parametrically to determine the effect of such a probability on the overall risk associated with such fires. The probability values selected for this study ranged from 1×10^{-3} to 0.5. The spurious actuation chosen was the spurious opening of the pressurizer power-operated relief valve. An integral part of the risk model was the analysis of the reactor coolant pump (RCP) seal loss-of-coolant accident (LOCA) phenomenon. The RCP seal LOCA model developed in NUREG-1150 was used after it was modified to include new and more detailed information. The time in which an alternate shutdown procedure may impose a SISBO in the event of a fire can vary; hence, this model evaluated four cases with the SBO time varying from 1 to 4 hours. The results of the risk analyses

are obtained by plotting the contribution to CDF per year resulting from the two fire scenarios, a fire in the CR and in the CSR. For each case, the CDF changes as the probability of spurious actuation varies from 1x 10^{-3} to 0.5. For the plant that has an FEIS, there is still some probability of spurious actuation because there is a time delay, after the fire starts, before all isolation switches are actuated. For this case, the probability is in the high 10^{-6} range. A plant that has no FEIS and that does not impose an SBO has a CDF in the high 10^{-5} range as a result of these fire sequences. The study has certain uncertainties and limitations that are inherent in any PRA. Essentially, the probability is not conditional, but it is an absolute value.

Scoping Analysis of Degraded Fire Barriers – Mr. S. Wong, BNL

Mr. Wong discussed the background and the objectives of the scoping analyses of degraded fire barriers. The BNL studies also evaluated the impact of degraded fire barriers and assessed the magnitude of the relative effects of failure of various fire protection features. Mr. Wong stated that the approach taken to perform the risk evaluation utilized an event tree/fault tree methodology to characterize the expected plant risks resulting from failed or degraded fire mitigation features. For a particular fault tree, some of the variables included suppression effectiveness, fire brigade response, and proper notification of the operators so they could, in turn, notify the fire brigade to come on site to suppress the fire. The risk impact of degraded fire barrier performance for fire barriers with 1-hour or 3-hour fire resistance ratings and their aging effects were also considered in developing the models. The study included the risk variations resulting from changes in fire barrier failure probabilities of mitigation features by using a generic risk model. The generic risk model characterized potential core-damage scenarios resulting from failure of the fire barrier performance subsequent to fire initiating events. CDF was assumed to be 1.0 for fire initiation probability. The sensitivity evaluations indicated that the degraded performance of 3-hour rated fire barriers has a somewhat higher impact on conditional core damage probability (CCDP) than that of the 1-hour rated fire barriers. At the base case, the failure probability and the CCDP resulting from degraded performance of 3-hour rated fire barriers were about a factor of 2 higher than those for 1-hour rated fire barriers. The sensitivity evaluations also showed that automatic fire suppression systems played an important role in reducing fire risks for scenarios involving degraded performance of 1-hour rated fire enclosures.

Phase II Evaluation of Station Blackout-Related Issues – Mr. K. Sullivan, BNL

Mr. Sullivan presented the scope of the Phase II evaluation of the SBO related issues. Phase II will include the validation of the Phase I findings and adapting the generic model to site-specific parameters.

Development of the Alternative Fire Endurance Time-Temperature Curve for Nuclear Power Plants – Mr. E. Connell, NRR

Mr. Connell of NRR introduced Ken Steckler and L. Cooper of NIST. NIST has the contract to develop the alternative fire endurance time-temperature curve for nuclear power plants (NPPs). The work being developed by NIST was in response to a Staff Requirement Memorandum dated June 27, 1994, relating to the feasibility of developing alternative time-temperature fire endurance curves to replace the current industry standard American Society for Testing Materials (ASTM) E-119.

Mr. Steckler provided a brief overview of the development of the ASTM E-119 curve. He concluded that the hydrocarbon temperature-time curves appear to be the only alternative curves widely used for fire barrier endurance testing. The historical information revealed that the development of any new temperature-time curves for compartment applications would likely depend upon mathematical modeling. A major weakness of room-fire models lies in their inability to accurately simulate burning rates under real fire conditions. For example, much of the modeling work aimed at creating alternative temperature-time exposures was based on the burning characteristics of cellulosic fuels.

Mr. Cooper stated that the objective of this project was to assess the feasibility of and propose a methodology for evaluating NPP fire barrier performance that takes into account NPP-specific environments. Mr. Cooper proposed the following: (1) use the results to establish an ASTM E-119-type method of evaluating the performance of structural fire barriers relative to the indirect exposure and establish the corresponding methods for assembly of fire barriers, (2) perform experiments on available ASTM E-119-type furnaces to establish that the new test fire curves are attainable and reproducible, (3) use model simulations to determine the direct exposure threats to barriers.

Status of the Fire Protection Action Plan and an Update on Penetration Seals – Mr. S. West, NRR

Mr. West of NRR briefly discussed the status of the four fire protection issues, namely, Thermo-Lag fire barriers, fire barrier penetration seals, the fire protection functional inspection program, and the fire protection task action plan. Mr. West stated that Thermo-Lag has been used in 86 units and the licensee for these units have submitted a corrective action program and a schedule for implementing their corrective actions. He also stated that 28 licensees of the 86 original units have either replaced Thermo-Lag or implemented the corrective actions to comply with Appendix R to 10 CFR Part 50. The staff's ongoing generic assessment program in the area of penetration seals is very comprehensive. The staff has completed the inspections of six reactors, two installation vendors, and the Dow Corning Corporation. The assessment report will recommend eliminating noncombustible material criteria and enhancing the inspection guidance for penetration seals. This report will be completed in June 1996. Mr. West provided a brief overview of the new fire protection functional inspection (FPFI) program. This program will include new inspection procedures and guidance, pilot inspections, fire barriers and penetration seals, emergency lighting, and safe shutdown analyses. The staff developed the Fire Protection Task Action Plan to manage the recommendations resulting from assessments of the staff review process for Thermo-Lag fire barriers. Current staff activities include developing performance-based fire protection regulations, evaluating fire barriers other than Thermo-Lag, and evaluating SISBOs.

Status of Fire Protection Rulemaking – Mr. P. Kadambi, RES

Mr. Kadambi of RES presented a brief history of fire protection rulemaking. He also stated that RES intends to develop a Commission paper to define the option for the preparation of rulemaking and that the comments received from the public will be considered during the process.

SUBCOMMITTEE COMMENTS AND CONCERNS

The following comments were made by members or consultants of the subcommittee:

- The BNL study focused on the effectiveness of the procedures used to mitigate fires and did not address the probabilistic treatment of fires. The scope of the study did not include a number of issues that could affect the conclusions. For example, the BNL study addressed neither the effects of fire and smoke on human actions, nor the possible damage to

sensitive electronic control and safety instrumentation. The study is weak in the areas of modeling human actions for the manual shut down and restart of electrical equipment after an SBO condition. Because of the limitations of the analysis and the failure to quantify uncertainties, no substantive conclusion can be drawn from this scoping study.

- The analysis of degraded fire barriers developed by BNL was based on event tree/fault tree models. Although this is a step in right direction, the analysis does not use the best available methods for modeling fire propagation, detection, and suppression.

- The subcommittee questioned the need for a NIST study to develop the alternate time-temperature curves for the NPP fire barrier qualification.

Subcommittee Recommendations

The subcommittee recommended that representatives of the staff and BNL brief the full committee on the above-discussed issues.

The meeting was adjourned at 5:35 p.m. on February 29, 1996.

FOLLOWUP ACTIONS

The staff agreed to provide the following documents to the subcommittee:

- Request for procurement action for NIST to develop the alternative time-temperature curves for the NPP fire barrier qualification

- Fire Protection White Paper by NRR

- NRC Augmented Inspection Reports for Waterford, IR Nos. 50-382/95-15 and 50-382/95-17

- New Zealand performance-based fire regulations

- Meeting Notice for Kentucky Scale Model

- A copy of the International Rule-Net Study

- Draft commission paper on performance-based rulemaking

NOTE: Additional details of this meeting can be obtained from a transcript of this meeting available in the NRC Public Document Room, 2120 L Street, N.W., Washington, D.C. 20006, (202) 634-3274, or can be purchased from Neal R. Gross & Co., Inc., Court reporters and Transcribers, 1323 Rhode Island Avenue, N.W., Washington, D.C. 20005, (202) 234-4433.