UNITED STATES
NUCLEAR REGULATORY COMMISSION
Nuclear Safety Research Review Committee
Washington, D.C. 20555

23 November 1993

Mr. Eric S. Beckjord, Director
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Beckjord:

Enclosed is the report from the August 2 and 3, 1993 meeting of the Severe Accident Subcommittee of the Nuclear Safety Research Review Committee.

This report was discussed during a telephone conference meeting on October 27, 1993, in which nine of the ten members of the Committee participated. Three members (Dr. Isbin, Mr. Kinter, and Dr. Morrison) were present in person; the other members participated by conference telephone hookup. The Committee had the benefit of the presence in person and inputs to the discussion by the Director and other cognizant staff members of the Office of Nuclear Regulatory Research. The meeting was noticed in the *Federal Register* and was open to the public.

The Committee, after deliberating on the subcommittee report, endorsed it and has accepted it as a report of the Committee.

Sincerely,

David L. Morrison

David L. Morrison, Chairman
Nuclear Safety Research Review
Committee

DLM/eff

Enclosures (2)

INTRODUCTION

The Severe Accident (SA) Subcommittee [D. Morrison, F. Molz, R. Vogel, and H. Isbin] met with the staff from the Office of Nuclear Regulatory Research (RES) on August 2 & 3, 1993. The previous SA Subcommittee meeting had been held on June 2, 1992, to review the Severe Accident Research Review Plan (SARP). The SA Subcommittee's report was endorsed by the Nuclear Safety Research Committee (NSRRC) in an open meeting on October 22, 1992. Documents used by the Subcommittee for this meeting are noted in Appendix A. The agenda for the meeting is given in Appendix B, along with the listing of documents furnished during the meeting. Appendix C lists documents sent to the Subcommittee following the meeting. The purpose of the meeting was to review the progress being made on the issues noted in the updated SARP report taking into account the commitments made by the NSRRC to the Commissioners on July 8, 1993, and restated in the Chilk memo (see Appendix A).

PRIORITIZATION OF SEVERE ACCIDENT RESEARCH ISSUES

Risk Analysis remains as a tool for RES to influence the prioritization of severe accident research issues; however, since the development of SARP and issuance of NUREG-1365, Rev. 1 along with updates, Risk Analysis has not been used to either uncover any new SA issues nor to reorder previously determined priorities. Further, RES emphasized that all current issues are considered as major issues, and that there are no low priority items. The Subcommittee accepts these findings, and additional comments are provided in this report on several specific issues. RES discussed with the Subcommittee the delays in completing milestones set forth in NUREG-1365, Rev. 1, and provided the Subcommittee with the estimated additional costs. Budgeting and staffing are matters that the full Committee will be addressing during the 1993-4 time frame.

The current listing of SA issues, as given in NUREG-1365, Rev. 1, are as follows:

HIGH PRIORITY	Direct Containment Heating
	Advanced Light Water Reactors
	Severe Accident Codes: MELCOR, CONTAIN, SCDAP/RELAP 5
MEDIUM PRIORITY	Core Melt Progression
	Fuel Coolant Interactions & Debris Coolability
	Hydrogen Combustion and Transport Issues
	Fission Product Release (Air Ingression)
CONFIRMATORY	Phebus-FP and Code Assessment
COMPLETED	Mark 1 Liner Failure
	Scaling
	Core Concrete Interactions
	TMI-2 Vessel Investigation Program

CLOSURE

A continuing interest of the Subcommittee is to reexamine criteria for closure, the determination of when a SA issue has reached the closure stage, and the progress being made on closure. The Subcommittee appreciates the efforts by RES to keep it informed on the goals being sought, the processes involved, the milestones being attained, and on the updates being provided. RES confirmed that the goals of SARP remain as follows:

"...complete all the major SA experimental programs within the next 2 to 3 years" and "...closure of all SA issues ... in 4 years"

The Subcommittee concurs with RES on the goals, criteria and processes for closure as given in NUREG-1365, Rev. 1.

Along with closure of a SA issue is the need expressed by the Commissioners that maintenance of expertise will still be required. For example, the Commission seeks to assure that the United States maintains its world leadership in SA code development, assessment, and maintenance. To accomplish this would require RES to retain both in-house and contractor expertise. The Subcommittee concurs with these goals, but RES and the Commission have not yet developed a plan and a budget to define the necessary resources to achieve these goals.

DIRECT CONTAINMENT HEATING

The Subcommittee concurs with RES that there is a need for completing the resolution of the Direct Containment Heating (DCH) issue in an efficient and expeditious manner. The Risk Oriented Accident Assessment Methodology (ROAAM) used to resolve the DCH issue for the Zion containment was discussed. The accompanying report, NUREG/CR-6075, extends the DCH loading evaluations to other similar containments. The report represents the first step in a process of peer reviews to confirm the resolution for Zion. Discussions also included how a DCH program at SANDIA was initiated to encompass an integrated approach for resolving DCH for pressurized water reactors. The report applicable for Surry [NUREG/CR-6109 (August 31, 1993)], received after the Subcommittee meeting, is also undergoing peer review. The Subcommittee wishes to be kept informed on the progress of the peer reviews for the Zion and Surry reports.

A detailed mechanistic model for DCH in the CONTAIN code is undergoing additional improvements. RES reported that the intent of the CONTAIN DCH modelling is to remove conservatisms in the models used for the Zion and Surry reports, so that more realistic evaluations can be used for

containments, i.e. Ice Condensers and CE System 80 containments, where the loadings from DCH may become issues. Further input to this DCH model needs to await the completion of the testing program at Purdue.

Additionally, RES noted the use of a simplified DCH model for the MELCOR code. The Subcommittee does not have enough information to comment on the DCH modelling and applications planned for CONTAIN and MELCOR.

SEVERE ACCIDENT CODES

Significant progress has been made by RES in improving the SA codes in response to peer reviews, feedback from users of the codes (including the partners in the international cooperative programs), code developers' identification of problems, and code assessments. MELCOR is the designated overall integral code to be used in Probabilistic Risk Analysis (PRA) and audit evaluations. The detailed mechanistic code SCDAP/RELAP 5 is used for in-vessel severe accident analyses (including possible use for accident management strategies) and CONTAIN covers ex-vessel evaluations. RES indicated that all the needed improvements in modelling the AP-600 and SBWR will be completed in time for The Office of Nuclear Reactor Regulation's (NRR's) use in the certification process of the Advanced Light Water Reactors (ALWR's). Further, all the needed experiments for code assessments **are** in place or have already been carried out. The more detailed COMMIX code used for evaluating natural circulation and possible stratification in the containment of the AP-600 will be used to assess the ability of CONTAIN to handle these issues. CONTAIN will be benchmarked with the older containment code, CONTEMPT, to take advantage of prior studies.

The SA Subcommittee will coordinate its activities with the Advanced Reactor Subcommittee in providing oversight of the progress being made in code development and assessment for ALWR's. Additional SA considerations for the Advanced Reactor Subcommittee include a new RES program at Penn State designed to quantify the heat transfer from a debris-filled reactor vessel lower head to a surrounding water pool. This program would contribute to a resolution of the broader problem of demonstrating that with cavity flooding, the heat generation by the debris in the lower head will be coolable. The Subcommittee expressed its serious concern with the RES Staff's view that communications with DOE on ALWR's remain restricted. The NSRRC Chairman reminded the RES Staff of previous NSRRC reports involving the high level waste program where a similar lack of communications existed, and with NSRRC encouragment RES was able to establish a vastly improved coordination with DOE.

CORE MELT PROGRESSION

The Subcommittee recognizes that significant progress has been made in understanding the phenomena associated with core melt progression. Factors which contribute to this understanding are derived from the accomplishments of the TMI-2 Vessel Investigation Project, the accumulating tests involving core melt progression, and the accompanying use of the information base to set initial conditions for core melts in the resolution process for the Mark I Liner issue and for the DCH issue. With the additional tests already planned and with peer reviews for such tests in place, the Subcommittee believes that the core melt progression issue is close to resolution, and concurs with the milestones set by RES. Although RES emphasized that the late phase aspects of core melt progression need more

attention, the Subcommittee believes that no additional programs should be initiated until the results of the peer reviews have been assessed.

DEBRIS COOLABILITY

RES reported on the progress being made in defining a new MACE test (Melt Attack and Coolability Experiments). MACE is an element of the international ACE program (Advanced Containment Experiments) which involves 15 countries headed by EPRI (Electric Power Research Institute) and includes the participation of the NRC and DOE. One test is scheduled for March 1994. Tests up-to-date have not been conclusive. The NSRRC requests that it be kept informed on the progress being made in debris coolability.

HYDROGEN COMBUSTION AND TRANSPORT

The cooperative five-year program with the Japanese on obtaining a better understanding of combustion phenomena, particularly at high temperatures, is presented in NUREG-1365, along with the program at BNL and the cooperative program with the Russian Academy of Sciences and the Kurchatov Institute. An update on these activities was presented by RES. Oversight on the applications to ALWR's will be coordinated with the Advanced Reactor Subcommittee.

RASPLAV

RES described a new international program with the Organization for Economic Cooperation and Development (OECD) involving the Russian experimental program called RASPLAV. The goal of this program is to answer the question "Can external cooling of the reactor vessel stop the accident progression with part of the core relocated to the lower plenum?" The NSRRC requests that it be kept informed on the application of these studies

to the AP-600.

PHEBUS-FP

PRA studies indicate the relative importance of accident scenarios at low power and at shutdown in contributing to the overall risk. As a consequence, RES has placed fission product release in an air environment as a medium priority severe accident research project. PHEBUS is an in-pile test facility in France for studying fission product releases and is operated under an international arrangement, with RES contributing more than one million dollars per year. (About half the contributions are in cash and the rest in instrumentation and analyses.) The test matrix now includes two concluding tests sought by RES. One test involves a late phase core configuration, and the second test will use an air environment. Since only one test per year appears possible, the last two tests sought by RES may not be completed until the "end of the century". All the tests are termed confirmatory and will be used in code assessments. The overall costs for PHEBUS are about $150 million. The Subcommittee endorses RES's participation in PHEBUS-FP and believes that RES's presence and expertise will be beneficial to the project.

TMI-2 VESSEL INVESTIGATION PROJECT (VIP)

The TMI-2 VIP issue is an example of a successful international cooperative program whose objective has been to determine "...the margin of structural integrity that remained in the reactor pressure vessel". Factors investigated include the conditions and material properties of the lower head and the determination of the extent of the chemical and thermal attack and damage to the lower head. The completion of the work is in the final stages and the issue is considered to be essentially resolved. The

investigation established the importance of cooling the debris by water already present in the lower head. Current debris cooling models for the TMI-2 conditions apparently underestimate the extent of the cooling. The extensive investigations and the accompanying analyses provide improved understanding of the TMI-2 severe accident. The NSRRC commends the RES Staff for its participation and leadership in bringing this issue to a successful completion.

ACCIDENT MANAGEMENT

The NSRRC had been unaware that the Accident Management (AM) project had been closed out in FY 92. In the Subcommittee meeting, RES explained that the objectives of the Accident Management Research Program had been fulfilled, and the industry implementation of AM is being followed by NRR. RES, however, continues to consider strategies associated with severe accidents, such as

Depressurization to mitigate DCH; Debris cooling;

Cavity flooding; and Quenching of a degraded core.

The Subcommittee plans to keep abreast as to whether the results of the current research programs in the United States and abroad (Cooperative Severe Accident Research Program) are sufficient to provide input to accident management strategies.

MARK 1 LINER FAILURE ISSUE

Closure of the Mark 1 Liner Failure issue is the first high priority SA issue to be resolved. The conclusions are that with water present, "...liner failure is physically unreasonable", and without water present, "...liner failure is nearly certain." The Subcommittee concludes that RES sponsorship of ROAAM with the utilization of the process for peer reviews is the basis for this important accomplishment.

RISK ANALYSIS OF ACCIDENTS INITIATED DURING LOW POWER AND SHUTDOWN CONDITIONS

The presentation of the Probabilistic Risk Analysis (PRA) Branch (Division of Safety Issue Resolution, Office of Nuclear Regulatory Research) provided both BWR (Grand Gulf) and PWR (Surry) results and insights on core damage sequences at low power and shutdown conditions. No needed SA research has been determined; however, the PRA studies will have an impact on human factors (training and procedural matters), scheduling of plant maintenance, technical specifications during shutdown, and in allowances for component outages.

INDIVIDUAL PLANT EXAMINATION (IPE)

The Subcommittee was briefed on the background and objectives for the IPE's (and with external events, IPEEE's). RES presented a constructive environment for carrying out these reviews. Of the 59 IPE's received at the time of the Subcommittee meeting, eight reviews had been completed in the form of Safety Evaluation Reports (SER) which were sent to NRR. An additional twenty-one were under review. Several areas requiring further enhancement of the IPE's were identified, and possible applications of the IPE's were noted. The Subcommittee's probing was primarily directed at how RES SA results are to be used, and the Subcommittee was satisfied with the responses obtained. At a later date, the Subcommittee would like to review the implementation of SA results for the IPE's.

INTERNATIONAL COOPERATIVE PROGRAMS

The NSRRC has strongly erdorsed the role played by RES in international cooperative programs, involving research as well as the use of NRC SA codes. Examples have already been included in this report and others include participation in meetings of Specialists on Fuel Coolant

Interactions (FCI) and Core Concrete Interaction; participation in International Standard Problems; and participation in the Principal Working Group activities for the Committee on the Safety of Nuclear Installations (CSNI). The Subcommittee had the opportunity of reviewing a number of these programs in RES's presentations and commends RES in these continuing efforts.

PEER REVIEWS

NSRRC has also strongly endorsed the use of peer reviews. At the Subcommittee meeting, the increasing use of peer reviews was discussed. An extensive listing of peers had been prepared by RES covering the reviews for the resolution of the Mark 1 Liner issue, the resolution of the DCH issue, the resolution of Severe Accident Scaling Methodology; the review of SCDAP/RELAP 5, MELCOR, CONTAIN; and the review of the TMI-2 VIP, Structural Mechanics, and Metallurgical investigation. The use of peer reviews for the SA codes is costly (exceeding a million dollars per review including the costs for the National Laboratory preparations needed in the reviews), but considered necessary. Throughout other SA research projects, there are many uses for peer reviews. The Subcommittee expressed concerns that peer reviews may be reaching excessive proportions, depleting staff efforts and resources. The Subcommittee recommends that guidance be prepared on when there is a need for a peer review, objectives for the review, qualifications for the peers including use of international experts, number of peers needed for a review, and conduct of the peer reviews. For the SA programs, the Subcommittee would like to be kept informed on the initiation and accomplishments of the peer reviews.

RES STAFF EFFICIENCY & EFFECTIVENESS

In the meeting of the NSRRC with the Commissioners on July 8, 1993, the Committee committed to examining RES Staff efficiency and effectiveness. Further, the Commissioners requested the Committee to review how the Staff maintains its expertise through updated courses and training, and through professional activities and publications. The Subcommittee requested and obtained such information along with brief resumes for the project managers in RES. The RES Staff noted that project managers are under considerable scrutiny for the financial aspects of each project, and that consequently an undue amount of their efforts is siphoned away from the technical matters to the financial matters. Further, RES reported that this situation does not seem to be resolvable by bringing in others familiar with the financial requirements to provide the necessary relief. This factor and other factors that affect RES staff efficiency and effectiveness are to be considered by NSRRC in the 1993-4 time frame.

ADDITIONAL ITEMS

An update on Commissioner Rogers' discussion (See Appendix A) on the Severe Accident Rule Making was presented to the Subcommittee. The severe accident phenomena considered to be important to risk and therefore should be identified in the proposed rule are as follows:

Hydrogen generation and combustion/detonation; Fuel-coolant interaction; Core-concrete/structure interaction; High pressure melt ejection; Overpressure/overtemperature caused by decay heat/chemical energy; and Containment bypass

Since it was pointed out that ..."continuing NRC SA research program(s are) not needed to prepare or implement (the) rule", the Subcommittee has not taken a position on this matter.

In response to the Subcommittee's request, RES made a presentation on the planning of a Severe Accident Database (SADB). The program costs are $172,000 for two years. The Subcommittee requests that it be kept informed on the progress being made, and how SADB is being used.

The Subcommittee was impressed with the achievements of one RES staff member in providing in-house capabilities for using severe accident codes. RES is installing dedicated work stations for carrying out code calculations.

RES provided an update on the evaluations made by the Brookhaven National Laboratory of the MAAP code (version 3.0B) which is being used by utilities in the preparation of IPE's. BNL has concluded that more user guidance is needed. Also, RES reported that at the CSARP May 1993 meeting (see Appendix A) comparison code evaluations indicated significant differences in results for RES-sponsored SA codes and MAAP. The SA Subcommittee's interest is in following how RES is undertaking the assessments for the SA codes.

CONCLUDING STATEMENT

The SA Subcommittee believes that this report supported by the referenced material provides a general oversight of SARP and a starting basis for indepth reviews of selected projects and for compiling information which will be responsive to the commitments made to the Commissioners by the NSRRC. The Subcommittee has had the cooperation of RES and has benefitted from the review made by the full Committee.

Submitted by,

H. S. Isbin

H. S. Isbin, Chairman
NSRRC Severe Accident Subcommittee

APPENDIX A

Documents Furnished to the SA Subcommittee Prior to the August 2 & 3, 1993, Meeting

Biographical Information of Members of the Accident Evaluation Branch, Division of Systems Research, Office of Nuclear Regulatory Research, USNRC (7/93) and Recent Publications on NRC-Sponsored Severe Accident Research (7/93)

Commissioner K. C. Rogers, "Severe Accidents and Regulation", opening remarks at the Cooperative Severe Accident Research Program (CSARP), semi-annual meeting, Bethesda (5/3/93). (All the CSARP handouts were made available to the Subcommittee Chairman.)

S. J. Chilk to J. M. Taylor, July 21, 1993, Memo re Commission meeting with NSRRC on July 8, 1993. (The NSRRC will undertake preparing responses to the four items listed in the Memo.)

NUREG-1266, NRC SAFETY RESEARCH IN SUPPORT OF REGULATION -- FY 1992. (May 1993)

NUREG-1365, Rev. 1, SEVERE ACCIDENT RESEARCH PROGRAM PLAN UPDATE. (Manuscript completed March 1993, Published May 1993.)

Draft NUREG/CR-6025, THE PROBABILITY OF MARK 1 CONTAINMENT FAILURE BY MELT ATTACK OF THE LINER. (The draft report consists of five parts.) (Transmitted on July 15, 1993.)

NUREG/CR-6075 SAND93-1535, THE PROBABILITY OF CONTAINMENT FAILURE BY DIRECT CONTAINMENT HEATING IN ZION (June 1993)

APPENDIX B

AGENDA

NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE

SEVERE ACCIDENT SUBCOMMITTEE

Holiday Inn, Bethesda

August 2-3, 1993

August 2:

8:30 - 8:40	Opening remarks	H. Isbin, Chairman
8:40 - 9:25	Introduction - Criteria for closure - Use of risk analysis - Accident management - Budget/future activities	B. Sheron
9:25 - 10:10	Severe Accident Research Overview - Staffing - Issues prioritization and schedules - International programs - Peer review panels - Overview of programs	F. Eltawila
10:10 - 10:25	BREAK	
10:25 - 2:00	In-Vessel Phenomena	
10:25	Melt progression (ACRR & ex-reactor)	R. Wright
10:55	BREAK	
11:10	TMI-2 Vessel Investigation Project	A. Rubin
11:40	Fuel-coolant interactions	F. Eltawila
12:00	RASPLAV	F. Eltawila
12:15	LUNCH BREAK	
1:30	Lower head coolability	A. Behbahani
1:45	Overall summary of in-vessel research	A. Rubin
2:00 - 5:00	Ex-Vessel Phenomena	
2:00	Direct containment heating	R. Lee
3:00	BREAK	
3:15	Hydrogen transport and combustion	A. Malliakos
4:00	Mark I liner	S. Basu
4:20	Core-concrete interaction and debris coolability	C. Tinkler

	4:45	Overall summary of ex-vessel research	C. Tinkler
5:00 - 5:30	Subcommittee discussion		Subcommittee Members

August 3:

8:30 - 9:30	Risk Analysis		
	8:30	Introduction	J. Murphy
	8:35	Low-power and shutdown PRA	M. Cunningham
	9:10	Individual Plant Examinations (IPE & IEEE)	J. Flack
9:30 - 11:15	Severe Accident Codes		
	9:30	SCDAP/RELAP code	Y. Chen
	10:00	BREAK	
	10:15	CONTAIN code	A. Notafrancesco
	10:45	MELCOR code	R. Foulds
11:15 - 2:15	ALWR Specific Work		
	11:15	AP600 (CONTAIN, COMMIX)	A. Notafrancesco
	11:45	SBWR (CONTAIN)	A. Notafrancesco
	12:00	LUNCH BREAK	
	1:15	SBWR (MELCOR, SCDAP)	Y. Chen
	1:45	AP600 (MELCOR, SCDAP)	S. Basu/Y. Chen
2:15 - 3:30	Miscellaneous items		
	2:15	Phebus-FP (fission-product release)	R. Lee
	2:30	MAAP review results	A. Notafrancesco
	2:45	BREAK	
	3:00	In-house analytical capabilities	C. Gingrich
3:30 - 3:45	Concluding remarks		T. Speis
3:45 - 5:00	Subcommittee discussion		Subcommittee Members

STAFF PRESENTATIONS
NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE
SEVERE ACCIDENT SUBCOMMITTEE

AUGUST 2-3, 1993

Introduction	B. Sheron	A
Severe Accident Rule Making	T. King	B
Severe Accident Research Overview	F. Eltawila	C
In-Vessel Phenomena		
Melt Progression	R. Wright	D
TMI-2 Vessel Investigation Project	A. Rubin	E
Fuel-Coolant Interactions	F. Eltawila	F
RASPLAV	F. Eltawila	G
Lower Head Coolability	A. Behbahani	H
Overall Summary of In-Vessel Research	A. Rubin	I
Ex-Vessel Phenomena		
Direct Containment Heating	R. Lee	J
Hydrogen Transport and Combustion	A. Malliakos	K
Mark I Liner	S. Basu	L
Core-Concrete Interaction & Debris Coolability	C. Tinkler	M
Overall Summary of Ex-Vessel Research	C. Tinkler	N
Severe Accident Codes		
SCDAP/RELAP Code	Y. Chen	O
CONTAIN Code	A. Notafrancesco	P
MELCOR Code	R. Foulds	Q
ALWR Specific Work		
AP600 & SBWR CONTAIN, COMMIX)	A. Notafrancesco	R
SBWR (MELCOR, SCDAP)	Y. Chen	S
AP600 (MELCOR, SCDAP)	S. Basu/Y. Chen	T
Miscellaneous items		
Phebus-FP	R. Lee	U
MAAP Review Results	A. Notafrancesco	V
In-House Analytical Capabilities	C. Gingrich	W
Low-Power and Shutdown PRA	M. Cunningham	X
IPE	J. Flack	Y

APPENDIX C

Documents Sent to the Subcommittee Following the August 2 & 3, 1993, Subcommittee Meeting

Brian W. Sheron (Director of Division of Systems Research, Office of Nuclear Regulatory Research) August 12, 1993, Letter to Dr. David L. Morrison, Chairman, Nuclear Safety Research Review Committee) providing additional information on costs, and comments on coordination between code developers and the experimenters in the melt progression area. Enclosure of

> Brian W. Sheron Memo of November 6, 1992, to Ashok C. Thadani, Director of Systems Safety and Analysis, Office of Nuclear Reactor Regulation, STATUS OF BWR MARK 1 LINER MELTTHROUGH ISSUE, transmitting an Oct. 13, 1992, Memo from Sheron to Warren Minners, Director of Division of Safety Issue Resolution, Office of Nuclear Regulatory Research, MARK 1 LINER FAILURE CLOSURE AND RECOMMENDATIONS FOR IPE GUIDELINES.

Brian W. Sheron September 9, 1993, letter to David L. Morrison, transmitting

NUREG/CR-6109, "INTEGRATED REPORT ON DCH ISSUE RESOLUTION FOR PWRS", (Draft for Peer Review, August 31, 1993) Technical review is to be undertaken by 14 experts recommended by Enery Research, Inc. (ERI). The experts are to send their comments to ERI by October 27, 1993, and ERI will provide them to RES. It is expected that the comments and the authors' responses will be provided in an appendix to the report. The SA Subcommittee has not had the opportunity of reviewing NUREG/CR-6109 for inclusion in the Subcommittee's report. The SA Subcommittee plans to follow the progress of the preparation of the appendix.

NUREG/CR-5949, "ASSESSMENT OF THE POTENTIAL FOR HIGH PRESSURE MELT EJECTION RESULTING FROM THE SURRY STATION BLACKOUT TRANSIENT" (May 1993)

SAND93-1346, "A MECHANISM-SPECIFIC ANALYSIS METHODOLOGY FOR CONCRETE CONTAINMENT OVERPRESSURE FRAGILITY" (August 1993) (Preliminary copy for NRC review)

Eric S. Beckjord, Director, Office of Nuclear Regulatory Research, September 14, 1993, transmission of PEER REVIEWED PRODUCTS FOR FY 1992 (August 1933)