



November 5, 1981

SECY-81-641

POLICY ISSUE

(Information)

For: The Commissioners

From: William J. Dircks, Executive Director for Operations

Subject: ELECTROMAGNETIC PULSE (EMP) - EFFECTS ON NUCLEAR POWER PLANTS

Purpose: To provide the Commission with information on the status of the NRR investigation of the effects of EMP on nuclear power plants.

Background: The Commission, in the letter from the Secretary dated October 23, 1981, requested a status report on the ongoing NRR investigation of the EMP effects on nuclear power plants. The report was to include discussion of:

- 0 Accomplishments to date;
- 0 Projected accomplishments;
- 0 All staff activities on this subject; and,
- 0 The relationship of EMP concerns to the peacetime operation of nuclear power plants.

The discussions below and in Enclosure 1 are provided in response to that request.

At the direction of the Commission, a plan for the EMP investigation was submitted to the Commission in August 1980. The investigation is being implemented essentially in accordance with the plan, with the following changes: (1) The Defense Nuclear Agency is participating in the investigation as an unpaid consultant instead of an NRC contractor, and (2) An onsite confirmatory test program has been added. A copy of the original plan (Enclosure 2) is attached to provide additional background and detailed programmatic information.

Discussion: The electromagnetic pulse (EMP) from a high altitude nuclear weapon detonation will induce electrical transients in the instrumentation, control and power lines of nuclear power plants. The extent to which these EMP transients may cause critical plant electrical and electronic systems to fail or malfunction and ultimately result in damage to the reactor is not known. A single EMP could affect most of the nuclear power plants in the continental United States. EMP-like

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Discussion:
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effects can also be simulated locally using truck-transportable land based generators. The NRC Regulations (10 CFR 50.13) state that license applicants are not required to provide design features or other measures for the specific purpose of protection against the effects of (a) attacks and destructive acts; including sabotage, directed against the facility by an enemy to the United States, whether a foreign government or other person, or (b) use or deployment of weapons incident to U. S. defense activities.

The safety issue in regard to EMP effects on nuclear plants was first raised by a member of the staff (Demetrios Basdekas) in 1976 (documented in NUREG-0153). The issue was raised again by Mr. Basdekas in 1979 through letters to the Commission and other government officials including the President of the United States.

The present NRR investigation was initiated as a result of informal staff discussions with the five Commissioners in 1979. Subsequently, Commissioner Ahearne (then Chairman) instructed NRR to plan and carry out this investigation. The objectives of the investigation are: (1) to determine the vulnerability of selected safe shutdown systems of a specific nuclear plant to EMP effects due to nuclear weapon detonations and non-nuclear generators, (2) to determine how those safe shutdown systems vulnerable to EMP may best be hardened against EMP, and (3) to characterize to the extent possible the effects of EMP on nuclear plants in general based on the study of specific systems of the subject plant. The overall objective is to provide the Commission with a basis for considering the need for amending the regulations to include design requirements for the protection of nuclear power plants against the effects of EMP.

A technical assistance program with Sandia National Laboratory (SNL) was initiated in August 1980 to implement the investigation. The TVA Watts Bar plant was selected for the study. The program includes EMP coupling analysis, evaluation of failure threshold of selected safety equipment, and an onsite test program to obtain data for confirmation of the results of analyses. SNL and its subcontractors have all performed similar work for the Department of Defense (DOD)

Discussion:
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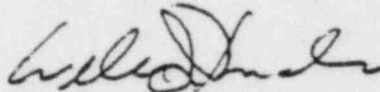
concerning the EMP vulnerability of military facilities. The Defense Nuclear Agency (DNA) of the DOD is participating in this program to provide assurance of the technical validity of the conclusions and recommendations. Additional assurance will be provided by a panel of independent experts which has been established to review the progress and results of the program. (The National Academy of Science has requested advance notification of review panel meetings and its representatives have attended several of them.) The completion of the program is scheduled for June 1982. Total funding, obligated and budgeted through completion, is \$635,000. The program is now approximately 40% complete and is considered to be within budget and schedule projections. Enclosure 1 includes a chart of the program milestones and their actual or projected completion dates.

Staff resources have been expended on this program since its inception in mid-1979 at a rate of approximately 0.25 staff-years per year. It is estimated that this rate will increase somewhat, and that an additional 0.30 staff-years will be required to complete the program. We do not believe that this level of effort has or will adversely affect NRR licensing activities or schedules.

EMP concerns during the peacetime operation of nuclear power plants derive from EMP which could be produced by terrorist actions involving nuclear weapon detonations or non-nuclear generators, or which could result from accidents involving U. S. or foreign nuclear weapons systems. The determination of the probability of occurrence of these types of EMP events is not within the scope of the current EMP investigation. However, consideration of effects due to non-nuclear generators is included in the investigation.

Discussion:
(continued)

Our preliminary conclusion is that a significant threat does not exist from non-nuclear generators because of the difficulty of deploying and operating such equipment in the vicinity of a plant without being detected, and because the effects of this type of equipment are low level and highly localized.



William J. Dircks
Executive Director for Operations

Enclosures:
As stated

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ENCLOSURE 1

STATUS REPORT ON THE NRR INVESTIGATION OF THE
EFFECTS OF EMP ON NUCLEAR POWER PLANTS

Accomplishments To Date (October 15, 1981)

A technical assistance program with Sandia National Laboratory (SNL) was initiated in August 1980 to implement the investigation. The full cooperation of TVA was obtained and its Watts Bar plant was selected as the study plant. SNL has subcontracted the performance of the EMP coupling analyses of the Watts Bar electrical circuits to Boeing Aerospace Company, the evaluation of the failure thresholds of selected safety equipment to Booz-Allen, and the planning and performance of the onsite testing required to confirm the validity of the results of the Boeing analyses to the IRT Corporation. SNL and these subcontractors have all performed similar work for the Department of Defense in the assessment of the EMP vulnerability of military facilities. Approximately 80% of the vulnerability and hardening analyses of the safety systems selected for evaluation have been completed. The overall program is considered to be approximately 40% complete and within schedule and budget projections. Major program milestones and their actual/projected completion are provided in the following chart:

MAJOR MILESTONES

<u>Description</u>	<u>Scheduled/Actual Start</u>	<u>Scheduled Completion</u>	<u>Actual/Projected Completion</u>
Detailed Plan for Study	9/80	12/80	12/80
Determine EMP Vulnerability for Group I Systems	9/80	10/81	12/81
Develop Hardening Recommendations for Group I Systems	2/81	10/81	12/81

<u>Description</u>	<u>Scheduled/Actual Start</u>	<u>Scheduled Completion</u>	<u>Actual/Projected Completion</u>
Determine EMP Vulnerability for Group II Systems	5/81	2/82	2/82
Develop Hardening Recommendations for Group II Systems	7/81	2/82	2/82
Measurement Test Plan	8/81	10/81	10/81
Measurement Tests	10/81	11/81	11/81
Determine Impact of EMP Hardening	10/81	2/82	4/82
Characterize EMP Effects on Nuclear Plants (All LWRs)	11/81	4/82	4/82
Perform Additional Studies to Judge EMP Capabilities	12/81	4/82	4/82
Prepare Summary Report	3/82	6/82	6/82

The Defense Nuclear Agency (DNA) of the DOD has provided the basic EMP characteristics data required for the analyses, and is participating in the investigation as an unpaid consultant instead of an NRC contractor as originally planned. This will provide assurance of the technical validity of the conclusions and recommendations of the investigation.

A review panel of EMP/nuclear-plant experts, including DNA representation, has been established to assist the staff in review of progress and results. The addition of onsite confirmatory testing to the program was a recommendation of the review panel. The work of this panel will provide additional assurance of the technical validity of the results of the investigation. The review panel is comprised of the following members:

G. Baker	Defense Nuclear Agency
P. R. Barnes	Oak Ridge National Laboratory
R. Burton	University of California
H. S. Cabayan	Lawrence Livermore National Laboratory
A. Latter	R&D Associates
C. Longmire	Mission Research
J. C. Mark	Advisory Committee on Reactor Safeguards

Projected Accomplishments

The major milestones of the EMP program and the actual or projected completion dates are listed in the above chart. The program is on schedule through completion of the Measurement Test Plan (10/81), and the necessary arrangements for performance of the Measurement Tests have been completed. No technical or administrative problems have been identified which would preclude meeting the projected completion schedule for all milestones.

The final report will include an assessment of the vulnerability to EMP of selected Watts Bar plant systems and LWRs in general, with defined uncertainties. The report will also include recommendations for additional studies if deemed necessary to resolve the issue of vulnerability to EMP. We expect that the staff and Review Panel will complete their review of the report in July 1982 and that it will be transmitted to the Commission in August. The Commission will be informed of any significant results or problems that may be identified prior to transmittal of the report.

EMP Concerns During Peacetime Operation of NPPs

EMP concerns during the peacetime operation of nuclear power plants derive from EMP which could be produced by terrorist actions involving nuclear weapon detonations or non-nuclear generators, or which could result from accidents involving U. S. or foreign nuclear weapon systems. The determination of the probability of occurrence of these types of EMP events is not within the scope of the current EMP investigation. However, consideration of effects due to non-nuclear generators is included in the investigation. These effects have been discussed extensively by the review panel and contractor personnel. The preliminary conclusion reached in these discussions is that a threat does not exist because of the near impossibility of deploying and operating the necessary equipment in the vicinity of a plant without being detected, and because the effects of this type of equipment are low level and highly localized. The final report will include an assessment of vulnerability to this type EMP.

Staff Resource Expenditure and Program Funding

Staff resources were required for planning the EMP investigation, to provide administrative support of the technical assistance program with SNL, and to coordinate the interfacing activities of the organizations participating in the program. Since inception of the current program in mid-1979, staff resources have been expended at a rate of approximately 0.25 staff-years per year. It is estimated that this rate will increase somewhat as the investigation nears completion, and that an additional 0.30 staff-years will be required to complete the program through staff review and issuance of the final report in August 1982. We do not believe that this level of effort will adversely affect NRR licensing activities or schedules.

NRC funding (obligated and budgeted) for the EMP program through completion totals \$635,000. Of this amount, \$55,000 is for the confirmatory testing. The program is presently within this budget projection.

ENCLOSURE 2

U. S. NUCLEAR REGULATORY COMMISSION
PLAN FOR INVESTIGATION OF THE
INTERACTION BETWEEN ELECTROMAGNETIC PULSE AND
COMMERCIAL NUCLEAR PLANT SYSTEMS

I. BACKGROUND

Electromagnetic Pulse (EMP) is the term used to describe the intense electromagnetic field generated by a high altitude nuclear weapon explosion. The EMP from a single explosion at sufficient altitude could generate large currents and voltages in electrical equipment over the continental United States.

U. S. Defense Department strategists have been concerned that EMP could be used to temporarily immobilize our land based retaliatory missiles, allowing these missiles to be destroyed, while on the ground, by highly localized nuclear strikes. Vital communications networks could also be disabled by EMP as a precursor to an attack. As a result, weapons systems and defense communications systems have been "hardened" against EMP by shielding or by installation of protective devices.

The possibility of nuclear attack against missile sites, preceded by EMP but not including directed attacks on population centers, leads to the concern that commercial nuclear plants may be adversely affected by EMP causing significant health effects, even when compared with those of the nuclear attack.

In addition to EMP generated as a part of a general nuclear attack by a major power there are the possibilities of terrorist explosions of nuclear devices and generation of EMP-like signals using land based generators.

Commercial nuclear plants have not been hardened against EMP. The effects of EMP on a nuclear plant (Sequoyah) have been studied by Oak Ridge National Laboratory, but too many issues were left unresolved by that study to conclusively show that nuclear plants can be safely shut down subsequent to an EMP. Some of the newer operating plants and plants still under construction use electrical equipment such as transistors, integrated circuits and other semi-conductors considered to be particularly vulnerable to high currents and voltages expected to be generated by EMP.

Because of the uncertainty about the effects of EMP on commercial nuclear plant shutdown capability, the NRC will conduct a study of these effects and how they can be avoided or mitigated.

II. GENERAL DESCRIPTION OF NRC STUDY PLAN

Objective

The study will have the following objectives: (1) to determine the vulnerability of selected safe shutdown systems of a specific nuclear plant to EMP effects due to nuclear weapons and non-nuclear generators, (2) to determine how those safe shutdown systems vulnerable to EMP may best be hardened against EMP, (3) to characterize to the extent possible the effects of EMP on nuclear plants in general based on the study of specific systems of the subject plant.

Organizational Responsibilities

The overall effort will be under direction of the Division of Systems Intergration of the Office of Nuclear Reactor Regulation. NRC will be aided in directing the study by the Defense Nuclear Agency (DNA).

The NRC will employ a contractor to undertake those aspects of the study requiring knowledge of the design, construction, and operation of nuclear plants. The DNA will employ contractors to undertake those aspects of the study requiring knowledge of the effects of EMP and the methods of hardening against EMP. The specific tasks assigned to these contractors are described in Section III.

Review Panel

A panel of experts, each of whom is familiar with EMP or nuclear plants, will regularly review the progress of the study. The review panel will provide independent judgment of the validity of the conclusions of the study and can recommend additional tasks or studies to be pursued by the contractors at the discretion of the NRC. Meetings will be held at approximately two month intervals.

Plant Chosen For Study

TVA has agreed to assist in the study and will choose a TVA PWR as the subject plant. The plant systems to be evaluated are discussed in Section IV.

Duration of Study and Schedule

The overall goal is to complete all program objectives by May 1, 1982. In addition, the NRC and DNA contractors will be requested to determine the vulnerability of the systems necessary for decay heat removal to hot shutdown and to develop necessary hardening recommendations for these systems by October 1, 1981.

An outline of the currently projected schedule is given in Table 2. A more detailed schedule will be prepared by the contractors.

III. NECESSARY TASKS AND RESPONSIBILITIES IN THE STUDY OF THE INTERACTION OF EMP WITH NUCLEAR POWER PLANT SYSTEMS

1. Identify the reactor plant systems or functions for which EMP vulnerability is to be addressed; indicate the priority or sequence in which these systems are to be investigated. (NRC Staff)
2. Identify the electrical components needed to operate those systems or to perform those functions specified in Step 1. (NRC Contractor)*
3. Determine the physical configurations of the structure housing the subject system, the arrangement of power cables and conductors entering these structures or connected to the system, or any other characteristic by which EMP can be coupled to the electrical components identified in Step 2. (NRC Contractors working with DNA Contractors)*
4. Based on justifiable assumptions regarding EMP sources and the information from Step 3, determine the EMP induced currents and voltages to which the electrical components of Step 2 will be subjected. (DNA Contractor)
5. Investigate and make a judgment of the validity of determining bounding values of currents and voltages for evaluating vulnerability of components during the remainder of the study. (DNA Contractor)
6. Based on the information from Step 4, determine whether the electrical components of the subject system will malfunction and/or be permanently damaged due to EMP. (NRC Contractor)
7. For each system with malfunctioning or failed components, determine whether the component malfunctions or failures will prohibit the system from fulfilling its intended functions. (NRC Contractor)
8. For those systems which will fail to function due to an EMP identify hardening alternatives and determine a recommended choice taking into account effectiveness and cost. (DNA Contractor)
9. Determine the impact of recommended hardening against EMP on the system performance and reliability in the absence of EMP. (NRC Contractor)
10. Based on the analysis of the effects of EMP on a specific set of plant systems -- and functions as outlined above, and on the similarities and differences between those systems and comparable systems at other plants, characterize the effects of EMP on nuclear plants in general including a judgment as to whether nuclear plants will retain safe shutdown capability subsequent to an EMP. (NRC Contractor and NRC Staff)

*TVA's contribution is essential to the successful completion of this task.

11. Upon request of the NRC, perform additional studies based on (a) information generated during the investigation (b) recommendations of the Review Panel. (NRC Contractors and DNA Contractors)
12. Prepare a report summarizing the above studies, including findings and recommendations. (NRC Staff and NRC Contractors)

IV. PLANT SYSTEMS TO BE EVALUATED

The plant systems to be evaluated will be chosen from those systems which must function properly to bring the plant to a stable condition such as hot shutdown or cold shutdown. A representative sample of plant electrical equipment should be included but the number of systems evaluated and the depth of the evaluation of some systems will be limited, if necessary, to meet the overall program schedule.

A preliminary selection of systems or functions to be evaluated is given in Table 1. The Priority I systems are primarily associated with achieving decay heat removal to hot shutdown; the Priority II systems are associated with achieving cold shutdown, reactivity control, and prevention or control of loss of coolant. Table 1 is subject to changes based on selection of a specific plant.

The success of the program is not predicated on the evaluation of all the systems listed in Table 1. Modifications to the extent and sequence of systems to be evaluated may become desirable during the study as a better understanding of the nature and difficulty of the problem is gained. Such modifications will be consistent with the objectives and schedule of the program.

V. Additional Studies

If, after the initial study is complete, the information available is insufficient to arrive at conclusive judgments regarding the general vulnerability of nuclear plants to EMP a plan for further studies will be developed. The studies may involve evaluation of BWR, human factors in responding to an EMP induced event, additional systems for a PWR, and computer protection systems.

TABLE 1 PWR SYSTEMS AND FUNCTIONS TO BE CONSIDERED IN EMP STUDY

Priority I

- (1) AC and DC Emergency Power
- (2) Auxiliary Feedwater System
- (3) Atmospheric Steam Relief Valves
- (4) Monitoring Systems (steam generator level and pressure, pressurizer level and pressure)
- (5) Steam Generator Isolation
- (6) Boration System
- (7) Service and Cooling Water System
- (8) Instrument Air
- (9) Ventilation Systems for the Above

Priority II

- (1) Power Operated Relief Valves
- (2) Residual Heat Removal System
- (3) Pressurizer Heaters and Sprays
- (4) Charging and Letdown Systems
- (5) Reactor Protection System
- (6) Communications Network For Coordinating Shutdown by Operators
- (7) Offsite Power
- (8) High Pressure Injection System
- (9) Engineered Safeguards Actuation System
- (10) Post Accident Monitoring Instruments

TABLE 7 SCHEDULE FOR INVESTIGATION OF INTERACTION BETWEEN EMP AND NUCLEAR PLANT SYSTEMS

<u>Milestone</u>	<u>Completion Date</u>
Select Plant and Indentify Systems for Study	1 Sept 1980
Initial Plant Visit	1 Oct. 1980
Characterization of Coupling Modes for Priority I Systems	1 Jan. 1981
Evaluation of EMP Induced Currents and Voltages for Priority I Systems	1 April 1981
Determination of Failure Potential For Priority I Systems	1 July 1981
Hardening Recommendations for Vulnerable Priority I Systems	1 Oct. 1981
Determine Impact of Hardening on Priority I System Reliability	1 Dec. 1981
Completion of Study Through Task 9 for Priority II Systems (As Allowed By Time and Resources)	1 Feb. 1982
Report on Potential Impact of EMP on Nuclear Plants in General	1 March 1982
Final Report Including Recommendations	1 May 1982