FY 1978 PROGRESS REPORT: LLL FIELD TEST SYSTEMS DIVISION SUPPORT TO THE U.S. NUCLEAR REGULATORY COMMISSION

Robert P. Rumble

April 1979

MASTER

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FOREWORD

This report covers the work done during FY 1978 for the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, Division of Operating Reactors, by Lawrence Livermore Laboratory (LLL) under the direction of the Electronics Engineering Department, Field Test Systems Division. Paul Shemanski of the Plant Systems Branch, NRC, was the technical contact for the work on Selected Electrical, Instrumentation, and Control System Issues. Daniel McDonald of the Systematic Evaluation Program (SEP) Branch, NRC, was the technical contact for the work on the SEP. Personnel from EG&G/San Ramon Operations, LLL/Livermore, and LLL/Nevada performed the work. Tom Holdsworth of LLL was the principal investigator. Robert Rumble and Robert Latorre of LLL were responsible for the work on Select Issues and the SEP, respectively.

The NRC funded the work under the authorization titled "Electrical, Instrumentation, and Control System Support," B&R 20 19 04 031, FIN A-0231.

The following people contributed to this report: E. K. Collins, L. D. Crippen, V. R. Latorre, D. H. Laudenschach, B. G. Mayn, M. W. Nishimura, W. Reeves, N. L. Salmon.

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ABSTRACT

The Lawrence Livermore Laboratory (LLL) performed technical evaluations for the U.S. Nuclear Regulatory Commission, Division of Operating Reactors, as part of a continuing program. This report summarizes the work done in FY 78 and provides references to detailed reports. Evaluations were performed on Selected Electrical, Instrumentation, and Control System Issues in existing reactors. The Select Issues investigated include reactor coolant system overpressurization protection, flooding of plant safety-related equipment, anticipated transients without scram, and local power range monitor drift. Short-term technical assistance was also provided on the problem of cable leakage during LOCAs. In support of the Systematic Evaluation Program, LLL also began evaluating the plant protection systems in the 11 oldest operating power reactors in light of selected current criteria.

SUMMARY

INTRODUCTION

This year Lawrence Livermore Laboratory (LLL) started a program to provide technical assistance to the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, Division of Operating Reactors. LLL performed work for two NRC branches: the Plant Systems Branch and the Systematic Evaluation Program (SEP) Branch.

The program started in April, 1978. Staffing proceeded carefully, and several months were spent locating, orienting, and developing a staff to perform work defined by the NRC. Personnel from LLL/Livermore, LLL/Nevada, and EG&G/San Ramon Operations now work on the project.

SELECT ISSUES

We supplied assistance to the Plant Systems Branch on four Selected Electrical, Instrumentation, and Control System Issues.

Reactor Coolant System Overpressurization Protection

We reviewed five licensee submittals regarding overpressurization of the reactor vessel and piping at temperatures bracketing the nil-ductility temperature.

We wrote technical evaluations of the material submitted by

- Haddam Neck
- Millstone 2

- Point Beach 1 and 2
- H. B. Robinson 2
- Salem 1.

We found Salem 1, Point Beach 1 and 2, and Millstone 2 plants to be in compliance with all criteria and staff positions.

We found both the Haddam Neck and H. B. Robinson plants to be in compliance with current criteria in all but one area.

Flooding of Plant Safety-Related Equipment

We reviewed three licensee submittals regarding the consequences of water or chemical flooding of a facility to determine whether safety-related equipment would cease to function.

We performed technical evaluations of the following plants:

- Turkey Point 3 and 4
- Indian Point 2
- Palisades.

The material supplied regarding Indian Point 2 and Palisades was found inadequate to complete the review. Additional material and responses to specific questions were requested.

We wrote draft technical evaluation reports for Turkey Point 3 and 4. We also wrote a preliminary draft technical evaluation for Indian Point 2.

Other Issues

LLL also provided assistance on two other Select Issues: anticipated transients without scram and local power range monitor drift. Short-term technical assistance was provided on the problem of cable leakage during LOCAs.

SYSTEMATIC EVALUATION PROGRAM

LLL made progress this year on the SEP. We selected, assigned, and trained qualified personnel. We refined topic statements into specific tasking statements. We obtained and indexed large numbers of drawings and technical specifications needed to perform the tasks.

FINANCIAL DATA

We expended effort and dollars on the programs as follows:

	Effort, <u>man-mo</u>	Charges <u></u>
Selected Electrical, Instrumentation, and Control System Issues	18.5	\$ 81,000
Systematic Evaluation Program	<u>8.5</u>	<u>\$ 69,000</u>
Total	27	\$150,000

REPORTS

We issued drafts of seven reports during FY 78. The titles and authors are listed in the last section of this report.

INTRODUCTION

ORGANIZATION

This year Lawrence Livermore Laboratory (LLL) initiated a program of technical assistance to the U.S. Nuclear Regulatory Commission (NRC), Division of Operating Reactors (DOR). Figures 1 and 2 show the relevant parts of the NRC and LLL organizations involved in this effort.

ORIENTATION AND TRAINING

Orientation for all personnel included:

- A one-day visit to the Diablo Canyon Nuclear Power Plant. This trip was extremely useful because it let us see parts of a reactor that would be impossible to see in an operating reactor and difficult to see in one previously operated.
- A trip to Washington, D.C., to become familiar with the personnel and facilities at NRC headquarters.

R. P. Rumble, M. W. Nishimura, D. H. Laudenbach, and G. St. Leger-Barter were introduced to NRC field procedures during plant visits concerned with the safe-shutdown topics.

R. P. Rumble and V. R. Latorre attended a three-day American Nuclear Society topical meeting on Probabilistic Analysis of Nuclear Reactor Safety.

All personnel working on the program became familiar with the documents and judgment which constitute the regulatory basis and framework.

*replaced by G. Lainas
(August 1978)

FIG. 1. Selected part of the NRC organization chart showing branches interacting with LLL Field Test Systems Division.

FIG. 2. LLL project management structure for Field Test Systems Division support to the NRC/DOR.

We obtained and/or reproduced copies of regulatory and training documents, and organized and distributed them. These included:

- Title 10 of the Code of Federal Regulations (CFR)
- Regulatory Guides (complete)
- Selected IEEE Standards
- Standard Technical Specifications
- General Description of a Boiling Water Reactor (BWR)
- Typical plant piping diagrams for the four manufacturers' steam plants
- Standard Review Plan.

We generated an alphabetical list of acronyms used by the NRC and the nuclear reactor industry.

TASKING

For reporting purposes, the work was divided into two areas, depending on which NRC/DOR branch was responsible. The Plant Systems Branch is responsible for the work formally titled "Electrical, Instrumentation, and Control System Support." This work will be referred to by the working title "Select Issues" throughout the rest of this report. The Systematic Evaluation Program Branch is responsible for the work on the SEP.

SELECT ISSUES

INTRODUCTION

Over the years, as a result of reviewing the experience at operating reactors, the NRC has identified a number of issues involving reactor safety. The DOR of the NRC has defined these issues and the reactors to which they pertain. It has asked the operators of affected nuclear power plants to respond to questions pertaining to these issues. LLL assisted the NRC by:

- Examining the technical content of the nuclear power plant licensees' responses, using current regulations, criteria, and staff positions as a basis.
- Performing further investigation as needed to resolve the problem, including conferring directly with the licensees, making trips to operating reactors, and identifying additional needs.
- Writing technical evaluations on the basis of the information received. The NRC will use this analysis of the technical aspects of the issue to write a Safety Evaluation Report.

The tasking statement defined five Select Issues, which are discussed in the following five sections. A sixth section discusses short-term technical assistance provided by LLL.

REACTOR COOLANT SYSTEM OVERPRESSURIZATION PROTECTION

The first Select Issue is the adequacy of the low-temperature overpressure protection system. Nuclear power plant containment vessels and piping are made of steel which is brittle below some nil-ductility temperature (NDT). As the metal is irradiated with neutrons, the NDT rises to as much as 200 or 250°F (95 to 120°C). At normal operating temperatures, the metal is ductile and can thus withstand severe pressure transients. Below the NDT, however, the metal is brittle, and the same pressure transient might cause the metal to fracture. All nuclear power plants were asked to:

- Analyze the susceptibility of their plant to the occurrence of these overpressure transients.
- Analyze the plant's response to such events.
- Describe the measures (physical, electrical, and administrative) which they propose to take to prevent the occurrence of these pressure transients at low temperatures and/or to mitigate their consequences.

The governing criteria is contained in 10 CFR 50, Appendix G.

The design basis criteria applied in determining the acceptability of the electrical, instrumentation, and control aspects of the low-temperature overpressure protection system are:

- Operator Action--No credit can be taken for operator action until ten minutes after the operator is aware, through an action alarm, that a pressure transient is in progress.
- Single Failure Criterion--The low-temperature overpressure protection system should be designed to protect the reactor vessel, given a single failure in addition to the failure that initiated the pressure transient.
- Testability--The system should be testable on a periodic basis prior to the time the system is depended upon to perform its function.
- Seismic and IEEE-279 Criteria--The system should satisfy both seismic Category I and IEEE-279 criteria. The basic objective is that the system should not be vulnerable to a failure mode that would both initiate a pressure transient and disable the low-temperature overpressure mitigating system. Events such as loss of instrument air or loss of offsite power must be considered.

The pertinent staff positions concerned alarms (high pressure, isolation valve, enable, disable, pressure-operated relief valve (PORV) open), pressure transient reporting and recording requirements, and the disabling of nonessential components during cold shutdown.

The technical evaluation used the appropriate circuit and logic diagrams and system descriptions furnished by the licensees in response to a substantial number of questions and requests from the NRC. The plants satisfied the

design basis criteria with a few technical exceptions; these are noted in our reports. For example, it was recommended that both temperature and pressure signals have vital power sources and two PORV open alarms.

The following systems were evaluated under the guidance of the four design basis criteria, with specific attention given to various staff positions resulting from these criteria.

- Salem 1 pressurizer overpressure protection system
- Point Beach 1 and 2 overpressure mitigating system
- Haddam Neck overpressure protection system (OPS)
- Millstone 2 OPS
- H. B. Robinson 2 OPS.

The Haddam Neck OPS high pressure alarm instrumentation and the H. B. Robinson 2 OPS disable alarm instrumentation do not fully comply with the staff position. Section 4.5 of the full report on Haddam Neck and Sec. 4.8 of the full report on H. B. Robinson 2 discuss these issues. The remaining three systems were acceptable in all areas.

FLOODING OF PLANT SAFETY-RELATED EQUIPMENT

The second Select Issue is the susceptibility of safety-related systems to flooding or chemical release. We evaluated several operating plants to determine whether a pipe break would result in loss of functional capability of safety-related equipment. We performed the technical evaluations of plant flooding potential in much the same manner as the overpressure evaluation was conducted. The safety-related equipment which could be damaged by flooding or chemical release was identified. The measures that were taken by the licensee to minimize the danger of flooding and to protect safety-related equipment were evaluated. The results of these evaluations were submitted to the NRC, along with numerous recommendations and further questions.

The potential sources of flooding that were identified are (1) the circulating water system, (2) the fire protection system, (3) the component cooling system, (4) the drainage systems, (5) the chemical and volume control system, (6) the primary and service water tanks, (7) the feedwater system, and (8) the potable water system. The safety-related systems, equipment, or locations

that we thought required protection from flooding are (1) motor control centers, (2) residual heat removing pumps, (3) switchgear rooms, (4) safety injection pumps, (5) charging pumps, containment spray pumps, and boric acid transfer pumps, (6) component cooling water pumps, (7) auxiliary feedwater pumps, (8) control room, reactor protection equipment rooms, and battery rooms, (9) service water pumps, (10) emergency 480-V busses, and (11) diesel generators and intake structures.

Indian Point 2

We completed the preliminary Indian Point technical evaluation and the rough draft of the technical evaluation report in September, 1978. Since the review was based on a limited amount of documentation, and since no drawings were available at that time, many questions are posed in the report. Furthermore, there were indications that the licensee provided only a cursory review of the facility from the standpoint of the flooding of safety-related systems. Therefore, the report recommended that the facility essentially be reevaluated, and that the various questions brought up throughout the report be addressed prior to any determination of the acceptability of the licensee's review. Before the final draft of the report is issued, the drawings of the facility must also be reviewed.

Palisades

A preliminary technical evaluation of Palisades was completed in September, 1978. As a result of that evaluation, a set of questions was developed in September, 1978, for the licensee to respond to. Some of these questions were then forwarded by the NRC to the licensee.

Upon receipt of the drawings in November, a second technical evaluation was conducted which revealed some additional questions. Palisades was then contacted on November 29, 1978, and asked to respond to the questions. Palisades personnel were able to respond to some questions but requested a postponement in other cases. Palisades is planning to advise J. Burdoin of the NRC when they have obtained the necessary information. This information will then be provided to us so that the technical evaluation report may be completed. The report is partially written.

Turkey Point 3 and 4

We completed the Turkey Point technical evaluation and the technical evaluation report in August, 1978. Since the plant is an outdoor plant, the evaluation was quite straightforward. The major potential sources of flooding and the various safety-related systems and equipment were investigated on the basis of the available documentation.

Initially, it was recommended that three actions be taken by the licensee:

- Floor drains and drain pipes leading to the discharge canal should be checked annually to ensure that they are not clogged.
- Watertight doors should be installed in the 4160-V switchgear rooms.
- Doors which are to remain closed for safety reasons should be equipped with alarms to ensure that they remain closed.

These three issues were subsequently discussed (in FY 79) with Turkey Point personnel in a telephone conversation on November 29, 1978. As a result of this discussion and clarification, the recommendations were dropped.

ANTICIPATED TRANSIENTS WITHOUT SCRAM (ATWS)

Nuclear plants have safety and control systems to limit the consequences of temporary abnormal operating conditions or "anticipated transients." If there were a severe anticipated transient and the reactor shutdown system did not scram as desired, then an ATWS would occur.

The NRC has requested the BWR licensees to install a recirculation pump trip in partial fulfillment of the NRC staff position. We are in the process of evaluating the licensees' responses and will make recommendations to the NRC concerning the acceptability of the individual plant designs with regard to the ATWS requirements.

LOCAL POWER RANGE MONITORS (LPRMs)

An LPRM detector is a miniature fission chamber whose output signal is proportional to the ionization of the chamber gas by high-energy fission particles, and is thus a measure of the fission rate in the chamber. The chamber and its associated cable are separated by a ceramic-to-metal seal which isolates the gas (pure argon) in the chamber from the argon-air mixture in the cable. These seals gradually undergo fast-neutron damage which can result in a leak that permits a change in the gas concentrations. This redistribution of gases causes a change in the detector output due to a variance in the number of ionizations produced in the gas.

We are investigating the LPRM nonlinearity and drift problem that has occurred at operating BWRs because of internal seal leakage between the LPRM chamber and its associated cable. The result of our investigation will be criteria for the LPRMs that will enable the operating BWRs to determine if an LPRM has failed.

DIESEL GENERATOR STATUS ANNUNCIATORS

LLL was asked to evaluate licensees' responses to the NRC's inquiries regarding (1) conditions that could render a diesel generator unable to start, and (2) how those conditions would be announced in the control room. Responses were not received until FY 79; progress on this task will be reported in FY 79.

SHORT-TERM TECHNICAL ASSISTANCE

LLL provided short-term technical assistance on the problem of cables which are subjected to loss of coolant accident (LOCA) conditions. Under such conditions, the cables may have water forced into them. This may temporarily or permanently damage the electrical characteristics (insulation) of the cables. We wrote a Technical Note briefly describing the causes, cures, and probable consequences of such cable leakage. Since then, we have provided extensive consultation on this subject.

SYSTEMATIC EVALUATION PROGRAM

INTRODUCTION

The SEP is examining the 11 oldest operating power reactors:

- Big Rock
- Connecticut Yankee (Haddam Neck)
- Dresden 1 and 2
- Ginna
- Lacrosse
- Millstone 1
- Oyster Creek
- San Onofre
- Palisades
- Yankee Rowe.

The current nuclear power plant licensing criteria are used as a guideline to evaluate these plants. These criteria evolved after the 11 early reactors were built. The SEP will provide a uniform reevaluation of the safety of these reactors in light of the experience gained from these and other reactors. LLL support of the SEP requires the examination of some of the electrical, instrumentation, and control system aspects of the plant protection system (PPS). The PPS consists of all subsystems which perform a protective function for either the reactor (for example, the reactor trip system) or the public (for example, the containment spray system).

TASKING

Originally there were five topics assigned to LLL. Each is outlined below, as are two additional tasks.

Topic VI-7.A.3: Emergency Core Cooling System (ECCS) Actuation System

LLL was assigned to review the ECCS testing program to ensure that the entire system is tested under conditions as close to design conditions as possible, at the intervals specified by current criteria.

Topic VI-10.A: Testing of Reactor Trip System and Engineered Safety Features, Including Response Time Testing

LLL was asked to review the PPS test program to verify that the system is completely tested on a periodic basis, and to verify that the response time testing validates the response times assumed in the Final Safety Analysis Report.

Topic VII-1.A: Isolation of Reactor Protection System for Non-Safety Systems Including Qualification of Isolation Devices

Non-safety-grade systems sometimes receive control signals from the reactor protection systems. These non-safety-grade systems are required to have isolation devices on their inputs which ensure that the safety-grade reactor protection system cannot be affected if the non-safety-grade equipment fails. In addition, the safety-grade system wiring must have adequate physical isolation (i.e., separation per IEEE-384). LLL was assigned to review the physical and electrical isolation of the PPS.

Topic VII-2: Engineered Safety Features (ESF) System Control Logic and Design

LLL was assigned to review the PPS control system for conformance to the single-failure criteria (IEEE 279-1971), and to review the possible interactions with the power source (i.e., offsite vs onsite).

Topic VI-7.B: ESF Switchover from Injection to Recirculation Mode (Automatic ECCS Realignment)

This topic was resolved within the NRC and is no longer a part of LLL tasking.

Additional Tasking

Safe Shutdown. Another task was added as the program developed. LLL was asked to prepare for and participate in three safe-shutdown site visits. These visits examined the adequacy of the systems needed to safely shut down the reactor under various conditions, including uninhabitable control rooms. LLL was originally assigned to write a part of the safe-shutdown review report, but this task was later changed to reviewing the report.

Cable Testing--Steam Generator. LLL was asked to locate equipment and manpower to perform tests of cables and connectors in a simulated LOCA environment (live steam under pressure).

ACCOMPLISHMENTS

Tasking

We began our work on the SEP by working with the project monitor to take the topic definitions, which describe the NRC's concerns, and translate them into tasking statements and procedures. As time goes by, these tasking statements may have to be rewritten to reflect the NRC's changing concerns.

Material Control

As a necessary prelude to performing work at LLL, we received, organized, updated, and distributed a large volume of material at both LLL/Livermore and EG&G/San Ramon Operations for use on the SEP. This included Chronological Docket indexes and copies of the microfiched docket material. We began receiving aperture cards with piping and instrumentation diagrams.

Specification Comparison

When we began working on the SEP, the diagrams of the plants were still incomplete. To proceed, we decided to compare the plant technical specifications to the corresponding technical specification, as called for in Topics VI-10.A and VI-7.A.3. We started the comparisons on the specifications for the Ginna, Dresden 1, and Dresden 2 plants. In these reports we identify the testing interval requirements contained in the Standard Technical Specifications applicable to each plant. We identify the corresponding test interval requirement in the plant technical specification and provide a tabular summary of whether it meets the requirement of the Standard Technical Specification. We are writing a brief discussion for each plant technical specification that does not meet the corresponding Standard Technical Specification.

Steam Generator

We located a steam generator and autoclave capable of performing the desired cable and connector testing. The NRC decided to have the work done elsewhere.

Safe-Shutdown Review

LLL and EG&G participated in the safe-shutdown site visits to San Onofre, Dresden 1 and 2, and Big Rock Point. We will review the reports as requested during the next fiscal year.

FINANCIAL DATA

We expended effort and dollars on the program as follows:

	Effort, <u>man-mo</u>	Charges
Selected Electrical, Instrumentation, and Control System Issues	18.5	\$ 81,000
Systematic Evaluation Program	<u>8.5</u>	<u>\$ 69,000</u>
Total	27	\$150,000

REPORTS

During FY 78, we issued the following draft reports:

B. G. Mayn and V. R. Latorre, Electrical, Instrumentation, and Control Design Aspects of the Low Temperature Overpressure Protection System for Millstone, Unit 2, Lawrence Livermore Laboratory (June 2, 1978).

B. G. Mayn and V. R. Latorre, Electrical, Instrumentation, and Control Design Aspects of the Low Temperature Overpressure Protection System for H. B. Robinson, Unit 2, Lawrence Livermore Laboratory (June, 1978).

D. H. Laudенbach, Electrical, Instrumentation, and Control Design Aspects of the Low Temperature Overpressure Protection System for Haddam Neck, EG&G (July, 1978).

E. K. Collins, Technical Evaluation of the Susceptibility of Safety-Related Systems to Flooding or Release of Chemicals Caused by the Failure of Non-Category I Systems for Indian Point, Unit 2, EG&G (September, 1978).

E. K. Collins, Technical Evaluation of the Susceptibility of Safety-Related Systems to Flooding or Release of Chemicals Caused by the Failure of Non-Category I Systems for Turkey Point, Units 3 and 4, EG&G (August, 1978).

D. H. Laudенbach, Electrical, Instrumentation, and Control Design Aspects of the Low Temperature Overpressure Protection System for Point Beach, Units 1 and 2, EG&G (July, 1978).

D. H. Laudенbach, Electrical, Instrumentation, and Control Design Aspects of the Low Temperature Overpressure Protection System for Salem, Unit 1, EG&G (August, 1978).

W. E. Reeves, Conductor/Insulator Hydraulic Phenomenon, LLL/Nevada (August, 1978).

RPR/mh