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Attachment 2

Millstone Nuclear Power Station, Unit No. 2
Root Cause Evaluation Team Summary Report

May 1994

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NORTHEAST UTILITIES SERVICE COMPANY

“Root Cause Evaluation of Millstone Unit 2’s Ability to
Assess, Classify, and Analyze Events”

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May 24, 1994

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EXECUTIVE SUMMARY

On May 12, 1994, a formal Root Cause Evaluation (RCE) was commenced to evaluate the reasons for failing to promptly assess, remedy and classify three operational events at the MP2 nuclear unit between April 20 - 23, 1994. These events involved a Reactor Coolant System unidentified leak on April 20, 1994, a Stuck Control Rod on April 22-23, 1994, and the inability to determine Shutdown Margin within one hour of recognizing the Stuck Rod and taking prompt action to place the plant in a safe and known condition in accordance with Technical Specification 3.0.3. The scope of this root cause evaluation was limited to the MP2 organization and management team.

The Root Cause Evaluation Team concludes that the events of April 20-23, 1994 resulted due to the failure of the facility to implement lasting and effective corrective action to previously identified problems. Specifically:

Global Root Causes

1. **Failure to recognize the significance of safety related events**

Note: This problem area was identified by the CH-442 Independent Review Team (IRT) in September, 1993. Due to the cultural and attitudinal nature of this issue, the corrective actions specified by the IRT may not have yet been successful.

2. **Failure to perform a comprehensive review of Emergency Plan EAL Tables and perform associated followup training.**

(Reference USNRC Report dated February 6, 1992)

The Specific Root Causes of the events of April 20-23, 1994 were identified using the TapRoot™ Evaluation System and are discussed in the body of the report.

Several short term recommendations are provided in Section 6.0 of this report to prevent the recurrence of similar events. They should be implemented prior to reactor startup. These recommendations focus on improving the MP2 EAL Tables, strengthening the role of the Shift Supervisor as a management representative with authority to classify events, providing training to operators on classifying Unusual Events, and improving procedures associated with classifying and responding to stuck control rods and dealing with Shutdown Margin. In addition, several long-term recommendations are provided to unit management to assist in improving unit operations.

The Team would like to thank the Millstone Unit 2 Staff for their support and candor during this root cause evaluation. The Team feels it is important to recognize the diligence and questioning attitudes exhibited by the SCO and Reactor Operators in identifying the stuck control rod on April 23, 1994, even after I&C trouble-shooting had incorrectly concluded it to be an indication problem. Throughout the event, the board operators continually questioned their indications until the stuck rod was identified.

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1.0 INTRODUCTION

On May 10, 1994, a formal Root Cause Evaluation (RCE) Team was assembled by the Director - Millstone Unit 2 (MP2) to evaluate the reasons for failing to promptly classify three events at the MP2 nuclear unit between April 20 - 23, 1994. The team also reviewed management's response to these events and the root cause capabilities of Millstone 2. The use of internal human factors engineering resources were used to evaluate the human factored aspects of these events. In addition, independent peer evaluators at the unit management and Operations Department management levels were used to evaluate the management response and cultural aspects of these events.

1.1 Scope

1. Review the operational aspects of the April 1994 events. Specifically:
 - a. RCS Leak Event (PIR 2-94-143)
 - b. Stuck Control Rod Event (PIRs 2-94-144, -145, -146)
 - c. Insufficient Shutdown Margin Event (PIR 2-94-147)
2. Review the Emergency Preparedness aspects of the April 1994 events (i.e. failure to meet MP2 Technical Specifications and the failure to properly use MP2's Emergency Action Level (EAL) Tables).
3. Assess the adequacy of MP2's root cause capability.
4. Assess the ability of MP2 to identify and ameliorate Control Rod Drive System malfunctions.
5. Assess recurring Emergency Planning problems at Millstone dealing with classifying events.

1.2 Event Descriptions

1.2.1 Event #1, "Unidentified Reactor Coolant System Leak"

At 1623 hours on April 20, 1994, the Degasifier System was placed in service to remove non-condensable gases from the MP2 Reactor Coolant System (RCS) in preparation for a planned reactor shutdown to support the repair of a degraded reactor coolant pump seal. Placing the Degasifier in service is an infrequent evolution for Millstone 2, as it is generally used only in preparation for reactor shutdown. During the lineup of the degasification system from the Clean Radioactive Waste System to the Volume Control Tank (VCT), decreasing VCT level was observed. The operators logged into Technical Specification Action Statement (TSAS) 3.4.6.2.b (unidentified RCS leakage greater than 1 gallon per minute) because the source of the leak was unknown. Aggressive investigation of the leak's source was performed over the next three hours by the operating crew, and the leak was finally isolated at 1930 hours.

After isolating the leak, the Shift Supervisor discussed the classification and reportability of the leak with the MP2 Duty Officer, On-Site Director of Station Emergency Operations (ODSEO), and the MP2 Operations Manager. Following a review of the Technical Specifications and EAL Tables, the decision was made not to report the event. Subsequent management review at the next day's Morning Meeting determined that the EAL Table had not been followed for RCS Leak reportability and an emergency notification (Unusual Event - Delta 1) was issued at 0934 on April 21, 1994 (approximately 16 hours late).

- 1.2.2 Event #2, "Immovable Control Element Assembly (CEA) in Mode 1", and
- 1.2.3 Event #3, "Failure to Calculate Shutdown Margin"

On April 22, 1994, at 2105 hours, a reactor shutdown was commenced in preparation for a planned maintenance outage to repair a degraded reactor coolant pump seal. At 2113 hours, while inserting Group 7 Control Rods for Axial Shape Index (ASI) control, a Group 7 Control Rod (CEA #65) did not move. The reactor power decrease was stopped and the Instrumentation & Controls (I&C) Department was contacted to assist in determining the problem with CEA #65. Subsequent trouble-shooting by an I&C Technician provided indications that CEA #65 was moveable and that the CEA reed switch position indicator for CEA #65 was inoperable. Accordingly, TSAS 3.1.3.3.b for the inoperable reed switch indicator was entered at 2143 hours, and the reactor shutdown recommenced using boration only to 70% power in accordance with the Technical Specification requirement.

Following shift turnover, the CEA Motion Inhibit (CMI) Interlock was first bypassed at 2312 hours to allow insertion of Group 7 control rods for ASI control. Group 7 rods were used over the next two hours as reactor power was reduced. At approximately 0056 hours, the MP2 Reactor Engineer was contacted by the Shift Supervisor to provide assistance concerning anomalous readings among the Reactor Protection System Channels. Subsequent review of Nuclear Instrumentation (NI) power levels and comparison between RPS Channels led the control room operators to declare CEA #65 inoperable at 0115 hours on April 23, 1994 when TSAS 3.1.3.1.a, "Inoperable CEA" was logged.

The MP2 Duty Officer was contacted by the Control Room at about 0130. The Reactor Engineer entered the Control Room at approximately 0135 and immediately began reviewing applicable computer printouts and instrumentation. At 0150, the Reactor Engineer confirmed that CEA #65 was still fully withdrawn and immediately informed the Shift Supervisor of this condition. The Duty Officer called the Operations Manager and Unit Director after being informed of the situation by the Control Room. At approximately 0230-0235, the MP2 Duty Officer and the MP2 Operations Manager arrived in the Control Room from their homes. A discussion regarding Shutdown Margin took place in the Shift Supervisor's Office between the Shift Supervisor, the MP2 Operations Manager, the MP2 Duty Officer, and the MP2 Reactor Engineer, and it was determined that Shutdown Margin could not be calculated because of the rod

configuration present and lack of any procedural guidance. Shortly thereafter at 0248-0250 hours, the plant was put in a known condition by removing power to CEA #65, followed by a Manual Reactor Trip. A General Interest Event - Posture Code Echo was sent over the Emergency Notification Reporting System at 0250 hours to inform applicable State and Federal authorities of the reactor trip. The operating crew then carried out applicable procedures to stabilize the unit in Mode 3.

An Unusual Event - Posture Code Delta 1 was declared for the Technical Specification required Shutdown at 0604 on April 23, 1994 (approximately 4 hours late) following a review of the PIR. Further discussions regarding Shutdown Margin resulted with another Unusual Event - Posture Code Delta 1 at 1435 on April 23, 1994 (approximately 12 hours late) for the missed Technical Specification Action Statement 3.1.3.1.a, regarding the determination of Shutdown Margin within one hour and resultant entry into TSAS 3.0.3.

1.2.4 Event #4, "Management's Response for Investigating Events 1, 2 and 3"

In the morning of April 23, 1994, the Plant Operations Review Committee (PORC) amended SP 2671, "Duty Officer Requirements After a Reactor Trip or ESF Actuation" to make it an option to perform formal root cause evaluations on reactor trips. As a result, no root cause evaluation was initiated because the reactor trip of April 23, 1994 was known to be a manual trip.

Following the events of April 20 - 23, 1994, the MP2 Licensing Engineer called the MP2 Unit Director and MP2 Operations Manager and recommended that a root cause investigation be performed to prepare the unit for an upcoming special NRC inspection scheduled to begin on May 2, 1994. The MP2 Unit Director concurred with the recommendation. The MP2 Licensing Engineer then called the Supervisor - Millstone ISEG to discuss having a root cause investigation performed. The ISEG Supervisor told him that he would take care of it. The MP2 Licensing Engineer did not follow up after this because he felt he had made the request to the right level of management and informed the appropriate unit management. The ISEG Supervisor assigned his Human Performance Enhancement System (HPES) Coordinator to work with representatives from the Emergency Planning Department. Several interviews were conducted, with the ultimate products being an Emergency Planning Department report and a separate HPES investigation. The ISEG Supervisor did not take an active role in planning the RCE because he was monitoring four other special requests for independent reviews that week, and because he was distracted by his preparations for an upcoming, extended (four week) business trip. The MP2 Unit Director called the MP2 Licensing Engineer back on Friday, April 28, 1994 and learned at that time that although a HPES investigation had been performed, the requested RCE had not been done.

Subsequent to the HPES investigation, an NRC Special Investigation of the events of April 20-23, 1994 was performed the week of May 2, 1994. At the NRC Exit on May 6, 1994, the NRC cited Northeast Utilities for not performing a critical self-assessment

(i.e. root cause) of the events. NU committed to performing a detailed root cause analysis and began forming a RCE Team the evening of May 6, 1994. The Team was assembled and began its investigation on May 12, 1994, following two days of team building and planning.

2.0 TEAM MEMBERS

<u>Name</u>	<u>Role</u>	<u>Title</u>
Kevin E. Gosselin	Lead Evaluator	Project Manager, Nuclear Planning
Robert J. Hanley	Member	Operations Training Manager - Seabrook
Robert J. Kastner	Member	Engineer, Nuclear Safety Engineering
Jeffrey G. Coon	Member	Engineer, Nuclear Safety Engineering
Joseph J. Parillo	Consultant	Supervisor, Nuclear Fuels Engineering
Robert Blackmore	Consultant	Station Manager - Maine Yankee (MY)
John Niles	Consultant	Assistant Operations Manager - MY
Allan M. Stave	Consultant	Senior Scientist, Human Factors Group

3.0 INDIVIDUALS CONTACTED

R. Amour	Millstone 2 Operations
J. Becker	Operations Manager - Millstone 2
G. Bouchard	Director - Millstone Unit 2
R. Borch	Millstone 2 Engineering
M. Brown	Director - Nuclear Training
R. Cimino	Millstone 2 Operator Training
J. Claire	Millstone 2 Operations
J. Deveau	NUSCO - Emergency Preparedness Technical Programs
B. Duffy	Millstone - Maintenance Engineering Services
D. Emborsky	Millstone 2 Operations
J. Fillion	Millstone 2 Operations
R. Heidecker	Manager - Operator Training Millstone 1 and 2
W. Heinig	Millstone Quality Services
C. Hines	Millstone 2 Operator Training Branch
J. Kunze	Millstone 2 Operations
T. McCance	Millstone Emergency Planning
D. Meekhoff	Millstone 2 Operator Training
G. Mendenhall	Millstone Assessment Services
R. Monast	General Nuclear Training - Root Cause Training
D. Mooney	Millstone 2 Operations
M. Mullin	Millstone 2 Operations
T. Myers	Millstone 2 Operations
C. Nelson	Millstone 2 Operations
L. Palone	HPES Coordinator - Millstone Station
J. Resetar	Millstone 2 Engineering
R. Rodgers	Director - Emergency Planning

3.0 INDIVIDUALS CONTACTED (Continued)

J. Smith	Millstone Training
W. Souder	Millstone Training
R. Spurr	Millstone 2 Operator Training Branch
R. Stotts	Millstone Training
S. Thickman	Supervisor - NUSCO Nuclear Safety Engineering
K. Truesdale	Millstone 2 Operations
M. Venable	Supervisor - Millstone ISEG
J. Watson	Millstone Station Emergency Preparedness Coordinator
R. H. Young	MP2 Licensing Engineer

4.0 ANALYSIS

Data was obtained through interviews, observation and the review of documentation. Event and Causal Factor Charts were developed and used by the RCE Team to analyze for root cause. Change Analysis and Barrier Analysis for each event were also conducted. The Specific Root Causes of the events were identified using the TapRoot™ Evaluation System.

TapRoot™ RESULTS

RCS Leak Missed Classification of April 20, 1993

1. "Management System - Standards, Policies, or Administrative Controls Less Than Adequate - Enforcement Less Than Adequate"

The Shift Supervisor responsibility for event classification and notification is clearly proceduralized. However, this responsibility was usurped by management in that classification decisions were made using group consensus.

Lessons learned about conservative decision making (CH-442) were forgotten.

2. "Management System - Corrective Action - Corrective Action not yet implemented"

NU committed to a comprehensive review of Millstone 1, 2, 3, and CY EAL Tables in 1992 after determining that an unclear EAL Table was the root cause of problems that led to a 1992 Notice of Violation. No comprehensive EAL Table review was conducted. Implementation of NUMARC EAL Tables was expected in the 1992/1993 time-frame, and has not been completed.

3. "Procedures - Followed Incorrectly - Ambiguous instructions"

The Tech Spec action statement for RCS leakage includes a time duration to

identify and/or stop the leak. The EAL table RCS leak criteria of "unidentified RCS leakage > 1 GPM" does not include the same time criteria. The shift found this difference confusing.

4. "Human Engineering - Complex System - Knowledge-based decision required"

The SS must recognize that the existing situation requires notification. The recognition process is not cued by written guidance in procedures. The recognition process consists of a mental cue alerting the SS to evaluate plant conditions against definitions of reportable events.

5. "Training - Understanding Less Than Adequate - Practice/repetition Less Than Adequate"

Simulator training including Unusual Event classification/notification is infrequent. Higher event classifications are more commonly practiced.

Stuck Rod/Shutdown Margin Event of April 22-23, 1994

1. "Procedures - Not Used or Followed Incorrectly"

The SS read the Tech Specs concerning shutdown margin determination, but did not carry through on the action. The SCO did not read the Tech Spec.

2. "Human Engineering - Complex System - Monitoring > 3 items at once."

The SS was supervising a planned plant shutdown complicated by the stuck rod and Channel C RPS problems. The SS and STA functions are performed by one individual.

3. "Other - Fatigue"

These events occurred on the second night of mid-shift. Circadian research shows that this is a point of low mental alertness in the rotating shift schedule. Additionally, the off-site personnel providing assistance were making complex decisions after little or no sleep.

4. "Human Engineering - Complex System - Knowledge-based decision required"

The SS must recognize that a situation exists which requires notification. The recognition process is not cued by written guidance in procedures. The recognition process consists of a mental cue alerting the SS to evaluate plant conditions against definitions of reportable events.

5. "Communications - Misunderstood Verbal Communications - Repeat back not used"

SS told control room to make a shutdown margin determination. No licensed operator heard the request, no repeat back was given.

DISCUSSION

The following areas were identified as significantly relevant to the events of April 20-23, 1994.

4.1 Operational Aspects

The root cause analysis of the events of April 20-23, 1994 identified three failed barriers which contributed to the events occurring. These are:

- a. Procedural guidance was not used or inadequate
- b. Communications and teamwork were less than adequate
- c. Management oversight failed to prevent the events from occurring

4.1.1 Procedural Guidance

Both the "RCS Leak" and the "Stuck Rod/Shutdown Margin" events exhibited late and non-conservatively called classifications. EPIP 4400, "Event Assessment, Classification, and Reportability" requires an emergency notification within 15 minutes of classification and within 1 hour of event initiation (occurrence).

Familiarity with the EAL Tables by SRO personnel is not sufficient to ensure entry/use of the EAL Tables during plant events, particularly for Unusual Event (UE) classifications. For example, both the Duty Officer (the Shift Supervisor read it to him over the phone) and Shift Supervisor read TSAS 3.1.3.1.a during the Stuck Rod event, but did not recognize it as an UE/Deita 1 classification per the EAL Tables.

The lack of procedural guidance in four areas contributed to the Stuck Rod/Shutdown Margin event. These are:

- (1) There were no guidelines or trouble-shooting guide to assist the I&C Technician in diagnosing the indication problem. Failure to identify the rod position early in the event started the shift on a path to eventually violate the control rod group alignment technical specifications.
- (2) There was minimal procedural guidance to assist the crew in responding to an inoperable CEA. Although OP2302A, "Control Element Drive System" has a section on inoperable CEA's, this procedural guidance was not known to the crew, and even if they had used the procedure, the table of contents does not list Section 6.0 where this guidance is contained.
- (3) There was no procedural guidance available to the crew (or available from the

Reactor Engineer) for calculating Shutdown Margin (SDM) or for responding to unknown SDM conditions.

- (4) In the Stuck Rod event, the Technical Specification Action Statements were not read by the SCO. The Shift Supervisor did not execute the Technical Specification requirement to verify SDM within one hour or enter Technical Specification 3.0.3 as a result.

4.1.2 Communications

Communication between the Reactor Engineer and Shift Supervisor during the Stuck Rod/SDM event were not sufficient or complete enough to guide the Shift Supervisor towards a correct strategy to deal with the event. The Reactor Engineer did not provide concise recommendations to the Shift Supervisor regarding SDM requirements or entrance into TSAS 3.0.3 if SDM could not be met.

The Shift Supervisor and SCO did not function as a team to decide where they were relative to Technical Specification requirements during the Stuck Rod/SDM event. The operating shift was so focused on performing a plant shutdown in a smooth, competent fashion, that when they concluded CEA #65 was full out at 0115 on April 23, 1994, they did not consider the seriousness of the situation. Instead, they continued with a normal shutdown. The Shift Supervisor did not manage the situation, and instead was distracted with shutdown related activities.

NOTE: It is important to recognize the diligence and questioning attitudes exhibited by the SCO and Reactor Operators in identifying that CEA #65 was stuck, even after I&C trouble-shooting had incorrectly concluded it to be an indication problem. Throughout the event, the board operators continually questioned their indications until the stuck rod was identified.

4.1.3 Management Oversight

Plant management representatives (Shift Supervisor, Duty Officer, Reactor Engineer, and the Operations Manager) did not fully recognize the seriousness of the Stuck Rod/SDM event with regard to classification, both during the event and after the plant had been placed in a safe condition. Specifically, a Group 7 CEA was misaligned by 90 steps, much greater than the Technical Specification allowed 10 step maximum misalignment requirement; a control rod was unmovable at the top of the core; Technical Specifications were not followed or entered (TSAS 3.1.3.1.a, TSAS 3.1.1.1, TSAS 3.0.3), and only a minimum classification (Posture Code Echo) was made at the time of the manual reactor trip instead of the required Unusual Event/Posture Code Delta 1.

Plant management did not provide sufficient oversight support to the Shift Supervisors during the events of April 20-23, 1994. Specifically, the Reactor Engineer did not give the Shift Supervisor guidance on verifying SDM or recommending alternative

courses of action if SDM could not be verified. The Duty Officer and Operations Manager did not recognize the need for timely classification of these two events. Similarly, in the RCS Leak event of April 20, 1994, the Duty Officer and Operations Manager both missed the opportunity to timely classify an Unusual Event in accordance with the EAL Tables.

NOTE: It is important to note that the Duty Officer and Operations Manager did ensure that the reactor was promptly placed in Mode 3 shortly after their arrival in the Control Room at approximately 0230 on April 23, 1994.

4.2 Emergency Planning

4.2.1 Previously identified EAL Table Weaknesses and Corrective Actions

In 1992, the NRC cited Millstone Station for a Notice of Violation due to several examples of on-shift operators' and ODSEOs' inability to properly classify certain events during walk-through examinations conducted as part of a January 1992 inspection. The NRC Inspection report stated "Inspector analysis of the classification errors concluded that the Unit 1 EAL charts were unclear. That resulted in the operators, who clearly recognized the postulated conditions, being unable to fit the conditions to the chart. These EALs were associated with the Barrier Failure Table and with the basis for concluding that a clad or RCS barrier failure had occurred based on containment monitor readings. Review of Unit 2 and 3 EALs revealed that they were similar enough to the Unit 1 EAL charts to be susceptible to similar classification errors."

In its response to the Commission, NU determined that the root cause of the Shift Supervisor failures was "potentially unclear wording on the EAL Barrier Failure Table." NU determined that the root cause of the ODSEO failures was "Inadequate frequency of EAL classification practice." NU's commitments from the subsequent Enforcement Conference (Reference USNRC letter dated February 6, 1992) were:

1. A comprehensive review of the event Based Tables and Barrier Failure Tables will be conducted for all three Millstone Units and CY.
2. NNECO will revise the Barrier Failure Table to clarify confusing wording.
3. EAL table revisions to NUMARC guidelines are currently on-going at all units, with expected completion in the 1992/1993 time frame.

The RCE Team determined that the Emergency Planning Department did not perform a comprehensive review of EAL Tables to address the 1992 NRC commitments. Instead, the Emergency Planning Department has relied on the continuous process of operator feedback to trainers and trainer feedback to Emergency Planning Department personnel for identification and correction of any weaknesses in EAL Tables.

Replacement of existing EAL tables with NUMARC tables was expected to resolve

many of the EAL ambiguity concerns. The EAL table revisions to NUMARC guidelines was not completed in the 1992/1993 time frame as committed. The EAL Table revisions are still in progress, and December, 1994 is the earliest expected completion of the Licensing review, NRC review, and operator training required prior to new EAL table use. The proposed new tables were developed by a task force which included personnel from Reactor Engineering, Radiological Assessment, Emergency Planning, and Operator Training. The MP2 Operations Department reviewed the new tables.

4.2.2 The Process of EAL Table Modification

The Emergency Preparedness Department is responsible for creation and modification of EAL Tables. EAL Table users include senior licensees, DSEOs, ODSEOs, and unit duty officers. The EAL tables were modified extensively in 1986, to include human factor concerns such as color and physical location of information. In an NRC Enforcement Conference letter of March 6, 1992, NNECO stated: "The (EAL) tables employ appropriate human factors and are considered among the finest in the industry by both NUMARC and INPO".

Ambiguity and "gray areas" exist in the current MP2 EAL Table. The presence of ambiguity is recognized by Duty Officers, operators, and Emergency Planning Department staff. Unusual event symptoms and conditions have produced the most debate about interpretation. Operators are frustrated with EAL tables because some past operator feedback about the tables has not resulted in EAL table changes or clarifications.

In an NRC Enforcement Conference letter of March 6, 1992, NNECO stated: "NNECO has demonstrated that EAL tables have been successfully used in most cases... EAL table adequacy is an ongoing process involving, in part, feedback from training exercises" and "Often, enhancements [to the EAL tables] are made based on user experience." In interviews, the RCE Team learned from the Director - Emergency Planning that he was not aware of any instance when a recommended change to the EAL's was not made. Discussions with the Millstone Emergency Planning Coordinator identified that very few requests for EAL Table clarification have been received.

The Emergency Planning Department does not receive much feedback on EAL Table adequacy from the EAL Table users. If users have questions or concerns about the words in the EAL Table, then users normally relay those questions to trainers, who relay the question to Emergency Planning personnel, who return the answer verbally to trainers, who then provide the answer verbally to the individual who originally asked the question. No formal process exists to document or share clarification of EAL ambiguities. Many interviewees stated that "it is too hard to change the EAL tables".

A MP2 EAL Table basis document does exist today. The basis document answers a few specific questions (for example, what is a "significant transient"?). The basis document provides little/no guidance for interpreting the gray areas of unusual event classification.

Commonality between CY and Millstone EAL Tables (where applicable) is not systematically pursued by the Nuclear Group. When a Millstone unit EAL table is changed, Millstone SORC compares all three Millstone Unit EAL tables to determine if other unit EAL changes are also needed.

The CY EAL table symptom for RCS leak was changed several years ago to read "Unidentified leak rate exceeds 1 GPM for > 4 hrs. **OR** >10 GPM identified RCS leak rate for > 4 hrs." A similar change was not made in the MP2 EAL Table. The MP2 EAL Table RCS leak symptom is worded: "Unidentified leakage > 1 GPM **OR** >10 GPM identified RCS leakage".

4.3. Training

The events of April 20-23, 1994 involved inappropriate actions by operators and management in the areas of shutdown margin determination, rod operability determination, emergency plan implementation, and the use of Technical Specifications and EAL Tables. The following weaknesses were exhibited: knowledge/skill mismatches, poor communications, and the inability to make sound and timely decisions.

4.3.1 Operator Training

Reactor Theory and Technical Specifications training were reviewed by the team. It was determined that there is initial and continuing training on both subjects. The requalification records show some individual performance problems in training, but that there is no systemic weakness in these areas. The analysis for reactor theory completed by the MP2 training staff was thorough and exceptionally analyzed. A test was administered the week of May 9, 1994 and the results showed weaknesses in some knowledge areas which are now scheduled for immediate training.

Simulator training was reviewed by the team through review of some lesson plans and observation of training in progress. Several lesson plans were reviewed by the RCE Team and it was observed that they did not contain cues for the instructor to ensure proper identification of emergency plan classifications is made during simulator training. During the observation by the RCE Team of a team building session on the simulator, emphasis for Unusual Event/Delta One classification was neither clearly exhibited nor corrected by the training instructors. Instructors did not require the Shift Supervisor to fill out the classification paperwork and equipment for making appropriate notifications was not available.

MP2 operators have had a decreasing trend in performance based upon the review of

INPO and NRC reports. The Training Department is conducting an Advanced Requalification Training Session for three weeks for each crew to address many previously identified issues. The current three week training session includes many of the operational aspects of the operator performance problems including roles and responsibilities. This training is very creative in addressing some of the current issues. This training will be effective only if MP2 management demonstrates its high expectations for Control Room performance.

4.3.2 Shift Supervisor Training

No MP2 Shift Supervisors have yet attended the INPO Accredited NU Shift Supervisor Program. A recent proposed change to the program provides flexibility for meeting shift staffing needs by allowing Shift Supervisors to stand watch in an acting status prior to completing the program. A review of the new program indicates that elements of the Shift Supervisors roles and responsibilities are contained in the program. Only one MP2 Shift Supervisor has attended the INPO Professional Development Seminar, but another is scheduled to attend in June 1994. Since the fall of 1993, continuing Shift Supervisor training has been incorporated into the Requalification Training Program.

4.3.3 EAL Table Training

EAL Training Process

MP2 senior license holders, DSEO/ODSEO's, and instructors take EAL classification tests quarterly. The test typically has four scenario descriptions, for which an event classification must be determined. An operator instructor administers the classification tests. The scenario descriptions are distributed to MP2 senior license holders, DSEO/ODSEO's, and instructors. The test administrator asks that event classifications be returned within four to six weeks. The test is not proctored. The test administrator usually has to track down late responders four to six weeks after the response period ends. After all tests are collected and graded, the test administrator returns an answer key to all test takers. An individual who misclassifies an event may not know about the misclassification for 8 weeks after taking the test when he receives the answer key. An individual who misclassifies events during the quarterly classification tests is "remediated" by being notified of the correct event classification.

Testing Criteria

NU's "Statement of Current Practice" from 1992 Enforcement Conference (memo NL-92-170) states "The pass/fail criterion for emergency preparedness written exams is 80%; for simulator exams, correct classification is required to pass the exam. Remediation is always required for failure."

Several interviewees stated that even though mistakes occurred for actual on-shift, in-the-plant event classifications, misclassifications on the quarterly classification tests

are rare. A summary of 1993 event classification testing based on 21 scenarios (four scenarios on four quarterly tests plus five scenarios in annual operator training) evaluated by 40 Shift Supervisor's, SRO's, DSEO's, ODSEO's, and instructors shows that mis-classifications are not uncommon.

<u>Event Classification</u>	<u># of Scenarios</u>	<u>% Correct Answers</u>
GE/A	1	87%
GE/B	4	79%
ALERT	4	79%
SAE	7	91%
UE	4	84%
ECHO	1	93%

Feedback to the group is by quarterly memo. Individual results are not provided, rather the results are grouped by job category. No evidence of remedial training for weak performers was identified by the RCE Team.

4.3.4 Duty Officer Training

The RCE Team learned through interviews that Duty Officer Training is considered by Duty Officers to be ineffective, and is generally comprised of an informal session once a year. Lack of meaningful training contributed to the Duty Officer's knowledge deficiencies for recognizing the significance of events and serving as a management oversight body to direct the appropriate emergency planning notifications.

4.4 Management/Culture

4.4.1 Management Response

Management involvement contributed to the events of April 20-23, 1994. Management failed to recognize the significance of the events with regard to classification requirements, both during and after their occurrence. During the events, management oversight failed to correctly identify the need to issue the required emergency notifications. After the events, management did not initiate a formal root cause investigation in accordance with NEO 2.38, "Nuclear Assessment Program" and NEO 3.15, "Root Cause Evaluation Program" until after being prompted by the NRC.

The response by management after the events of April 20-23, 1994 was fragmented and narrow in focus. On the morning of April 23, 1994, the Plant Operations Review Committee (PORC) amended SP 2671, "Duty Officer Requirements After a Reactor Trip or ESF Actuation" to make it an option to perform formal root cause evaluations on reactor trips. As a result of this procedure change, the PORC decided not to do an investigation of the April 23, 1994 reactor trip because the "cause" of the trip was known (i.e., they knew it was a manual trip). In actuality, they narrowly focused on

the effect of the Stuck Rod/SDM event (the manual trip), rather than investigating the cause. Despite prompting on April 25, 1994 by the MP2 Licensing Engineer to perform a root cause investigation, several layers of management and line personnel failed to follow-through and establish a formal root cause evaluation team.

Follow-up investigations by the Millstone HPES Coordinator and the Emergency Planning Departments were reactive in nature and narrowly focused. These evaluations did not seek out global root causes (i.e. management oversight, relationship to past events, etc.).

The issues presented in the 1993 2-CH-442 IRT Report are insightful and accurate, but the prescribed corrective actions have not yet solved some of the issues stated in the report several months after its issue. The issues surrounding the events of April 20-23, 1994 are similar to the IRT Report issues. These issues are: management's expectations on safe, conservative operation; plant ownership by senior reactor operators; the leadership role of the Shift Supervisor in the front line of nuclear safety; management's continuing reinforcement of a conservative operating philosophy; and fundamental cultural changes (e.g., ownership and Shift Supervisor roles) must occur.

Operations management stated in interviews that behaviors such as willful misconduct would justify grounds for removal from licensed duties until an investigation and remedial actions are completed. Lack of judgement or knowledge was not mentioned as a criteria. Actions following the events support this since no formal action was made by management to relieve responsible individuals as a precautionary measure pending an investigation. (NOTE: Some units (e.g. Seabrook) would elect to remove personnel from licensed duties following a similar investigation pending an investigation.)

4.4.2 Culture

MP2 underwent a major change in management in late 1993. However, the MP2 Operations Department's organizational behavior is still affected by a previous management style which stressed management concurrence on operational decisions. This attitudinal behavior led to the "decision by committee" approach used by Shift Supervisors in the events of April 20-23, 1994. The Shift Supervisors still do not feel that they own the plant and that they are in charge. The new Unit Director's style has not yet permeated the deep-seated cultural and attitudinal behaviors which remain instilled within the organization. These identical issues were identified in the 2-CH-442 IRT Report (Recommendations 7.1.1, 7.1.2, 7.2.1 and 7.2.2), but the corrective actions taken in response to the IRT Report have not yet taken hold within the organization.

Some operators interviewed feel that management does not listen to their concerns. This failure to listen and respond through actions rather than words has contributed to a culture which fosters the belief that ideas and recommendations for improvement

have low value. Operators are given the impression that they do not own their own procedures (i.e. EIPs). These procedures are often revised without any crew operator reviews.

Current organizational Shift Supervisor staffing levels do not provide sufficient flexibility to support a rotational position so that one Shift Supervisor at a time can go through the NU Shift Supervisor Program. The Shift Supervisor position is viewed as a dead-end position by the operators, rather than senior management's representative on-site. The opportunity for Shift Supervisors to move into middle management positions is rare. This contributes to the impression that corporate management holds little value for the Shift Supervisor position. There has been no recent action to prepare SCOs for assuming the Shift Supervisor position.

The level of trust between individuals and groups in the MP2 organization was stated by many interviewees as being low. This contributes to an unwillingness to effectively take action on complex, difficult problems and sometimes prevents the facility from even recognizing the seriousness of events.

Management at the facility has a sense of pride and dedication to safely operate the unit as evidenced by their work schedule of greater than 60 hours per week on a continuous basis. However, this heavy work load is a symptom of an organization which is constantly reacting to problems, instead of proactively analyzing global and programmatic issues for long-term solutions. MP2 management is constantly trying to stay ahead of problems which arise. This contributes to difficulty in keeping focus on broad perspective operational concerns.

The Emergency Planning Coordinator is typically not directly involved in developing or observing simulator training scenarios involving the emergency plan; instead, a triangular (Training, Operations, and Emergency Planning) communication network exists with one department talking to another to get information from the third. The problems associated with the inability to promptly classify events was recognized in 1992 by NU, however the Emergency Planning Department's and Training Department's response to correcting these deficiencies has been ineffective.

4.4.3 Organizational Design

Organizationally the Operations Department lacks two key components. The first is an SRO on-shift who can take care of the routine shift activities which are now hindering the Shift Supervisors from their oversight role as a shift manager. The second is a full-time Assistant Operations Manager who can take primary responsibility for the Shift Supervisors. This responsibility would include all career planning, functional reporting, providing direction, listening, and keeping Shift Supervisors informed about key events on a real time basis. Additionally, this position would act for the Operations Manager in his absence. These assessments were brought out by the Maine Yankee and Seabrook peer evaluators. Maine Yankee is the lowest cost nuclear power producer in the Northeast and is known for running

an austere unit, yet they have a full-time STA on each shift and a full-time Assistant Operations Manager to relieve the Operations Manager from day-to-day shift administration duties. Seabrook has a similar Operations organization.

The duty officer concept for MP2 is inconsistent with industry guidance and practice for maintaining the Shift Supervisor as the Senior Manager On-site for Operation of the unit. The Shift Supervisors have functionally delegated their management role for reporting and classification to the Duty Officer, although the Duty Officer typically has neither the extensive training nor the current operational experience to be a key decision maker.

4.4.4 Root Cause Capabilities of Millstone Unit 2

Millstone Unit 2 has no dedicated staff for performing formal root cause evaluations of events which occur at the unit. A review of training records determined that approximately twenty MP2 personnel have attended root cause analysis training. This training has not, in general, yet been utilized on a continuous basis by unit managers and supervisors. For many years, management at both Millstone, Connecticut Yankee and Berlin has relied on the root cause expertise of the NUSCO - Quality and Assessment Services, Nuclear Safety Engineering Branch. MP2 management has a mind-set that a root cause investigation always requires a team of people and is only used after large events have occurred.

Following the events of April 20-23, 1994, the Director - Millstone Unit 2 did not have trained and experience root cause resources available to him for performing a detailed assessment of the events. As a result, a special root cause team had to be assembled in an expeditious manner by gathering the needed resources from other groups within the Nuclear Group.

From a business process perspective, pulling needed resources from other groups disrupts the several business units for several weeks in order to address a singular problem in the corporation. Although this is deemed prudent when addressing issues of great importance to the corporation, the reactive nature of this response is not advantageous except for extreme emergencies. Ideally, the business unit should be structured so that the needed, trained and experienced resources are available to assist when the call is made. In times of little need, the resources can fulfill a secondary function which can be transferred quickly when their primary purpose for performing root cause investigations are required. Similarly, these resources could be used in a coaching or team leadership role to provide on-the-job training to junior root cause evaluators during an actual investigation.

5.0 CONCLUSIONS

5.1 Operations

1. Misinterpretation of the EAL Table as it relates to the Technical Specification

- requirements contributed to the late call for the RCS Leak event.
2. Lack of procedural guidance contributed to the inaccurate trouble-shooting of CEA #65 by I&C personnel.
3. Lack of procedural guidance for a Stuck Rod and the calculation of Shutdown Margin contributed to the inability of the shift to analyze and correct the Stuck Rod/Shutdown Margin event.
4. Operations management has not taken full ownership of the NU Shift Supervisor Program.

5.2 Emergency Planning

1. The MP2 EAL Table includes several unclear entries. Consequently, the table does not consistently support rapid, decisive event classification in a stressful operational environment.
2. Operator trainers have become middlemen relaying information between those that make, and those that use, the EAL Tables. This communications process is ineffective.
3. Emergency Planning's failure to perform a comprehensive review of all Millstone EAL tables after the 1992 NRC Commitment was made contributed to the improper RCS leak classification on April 20, 1994.
4. Operator knowledge of the EAL Table content and use needs strengthening.

5.3 Training

1. The licensed operators have knowledge weaknesses in Shutdown Margin and in the rod operability Technical Specifications.
2. Simulator training is ineffective in reinforcing skills associated with Unusual Event classifications.

5.4 Management/Culture

1. Management did not appreciate the significance of the Stuck Rod/Shutdown Margin event of April 23, 1994.
2. Ownership of the plant is not fully felt by the Shift Supervisors.
3. Cultural and attitudinal behaviors that emphasize concurrence from management for event classification contributed to the indecisive action of the Shift Supervisor during the Stuck Rod/Shutdown Margin event.
4. The issues surrounding the events of April 20-23, 1994 are similar to the 1993 IRT Report issues. Specifically:
 - a. Management's expectations on safe, conservative operation must be made clear and unambiguous, and continually reinforced.
 - b. Plant ownership must be understood by senior reactor operators.
 - c. Shift Supervisors must exhibit a leadership role for nuclear safety.
 - d. Management must make it their top priority to instill a conservative operating philosophy in the unit staff.
 - e. A fundamental culture change (e.g., ownership and Shift Supervisor roles) must occur.

6.0 RECOMMENDATIONS

6.1 SHORT TERM RECOMMENDATIONS

The Root Cause Evaluation Team recommends that the following Short Term (ST) recommendations be implemented or verified complete prior to reactor startup.

Operations

- ST-1 The Operations Manager should require all SRO licensed personnel to individually study the EAL Tables to ensure that they know and understand the types of events which constitute an Unusual Event classification.
- ST-2 The I&C department should develop a troubleshooting procedure for control rods that addresses how to determine whether a CEA is moving or not. If it is not possible to make an absolute determination if the rod is moving, the procedure should clearly state that I&C personnel assume it to be unmovable and immediately inform Operations of this determination.
- ST-3 The Technical Specifications should be completely reviewed by an Operations Department SRO to find any other TSAS or surveillance activities that have insufficient procedures (i.e. such as the SDM determination with stuck rod TSAS.)
- ST-4 Procedural guidance should be developed which describes expected operator response when an inoperable CEA is found. The procedure should specifically address SDM determination with a stuck CEA, TSAS requirements and Reportability. The procedure should specifically address what Technical Specification actions the shift should take and the time limits available while I&C is performing troubleshooting.

Emergency Planning

- ST-5 The MP2 Unit Director should direct a complete review of the MP2 EAL tables by an Operations Department SRO, Training Department representative and Emergency Planning representative to find all the classification problems similar to the RCS leakage EAL problem. All problems and ambiguities should be changed or, while waiting for formal changes, placed in an "interpretation book" (e.g. Technical Requirements Manual) that will allow for documentation of acceptability and uniformity of EAL interpretations. An example would be the acceptability of not calling CVCS leaks into tanks as RCS leaks. This process should focus specifically on "putting oneself" in the position of the operating shift, considering the exact indications they will use, and what potential ambiguity could take place in the classification process. (Management is encouraged to use those involved in the RCS Leak event of April 20, 1994 in this project.).

Training

- ST-6 Training should be conducted and a written exercise conducted to verify the following principles:
1. That the Shift Supervisor/SCO Team can **correctly recognize and classify** that an Unusual Event has occurred.
 2. That all Shift Supervisors will **conservatively call events that fall in a gray area** between two classifications or are borderline reportable/not reportable.
 3. That all Shift Supervisors can **correctly apply entry into TSAS 3.0.3** and make the resulting classification requirements.
- ST-7 SDM knowledge should be tested on all SRO's and depending on results, remediated if necessary. Particular emphasis should be placed on the importance of knowing SDM at all times and taking immediate actions per Technical Specifications to restore SDM if it is not met.

Management/Culture

- ST-8 Management should request external support (e.g. industry peers, INPO, etc.) to provide an industry perspective to assist facility management in establishing a safe, prudent course of action for MP2 prior to startup.
- ST-9 The MP2 Unit Director should make his expectations clear that the Shift Supervisors shall make all event classification decisions.

Engineering

- ST-10 The failure mechanism for CEA #65 should be determined to ensure that a similar failure mechanism is not possible for the other CEA's.

6.2 LONG TERM RECOMMENDATIONS

The Root Cause Evaluation Team recommends the following Long Term (LT) opportunities for improvement.

Emergency Planning

- LT-1 The Director - Emergency Planning should establish a process to formally address future EAL clarification. The process should have the following characteristics:
- (1) any question about EAL table interpretation or clarification should be transmitted from the Operations Department directly to designated Emergency Planning Department personnel (i.e. the training department should not play middle man),
 - (2) the Emergency Planning Department should provide a verbal answer to the question originator on the same day,
 - (3) the Emergency Planning Department should document the question and answer in writing, add the written information to the EAL table basis document with the concurrence of the Operations Department, distribute

the written information to EAL users (Shift Supervisor/SRO, DSEO, ODSEO) and operator training personnel, and (4) the Emergency Planning Department should evaluate every table clarification for applicability to all other NU plants.

- LT-2 The Director - Emergency Planning should encourage commonality (where applicable) between CY and Millstone unit EAL Tables.

Training

- LT-3 In the next normal requalification cycle, but no later than the beginning of the next operating cycle, simulator training and testing (preferably unannounced) should be conducted to verify the following principles:
1. That the Shift Supervisors can **correctly recognize, classify and notify within 1 hour** of the initiating event that an Unusual Event has occurred.
 2. That the Shift Supervisors will **conservatively call events that fall in a gray area** between two classifications or conservatively call events that are borderline reportable/not reportable.
 3. That the Shift Supervisors can **correctly apply entry into TSAS 3.0.3** and resulting classification requirements.
- Training Management, Plant Management, and Emergency Planning personnel should witness and provide feedback on these tests.
- LT-4 The Director - Nuclear Training should ensure that all simulator lesson plans include cues so that instructors can reinforce emergency plan classifications during simulator training.
- LT-5 The development of an ENRS mockup for the simulator should be considered to reinforce emergency classification and notification skills.
- LT-6 The Operations Manager should ensure that all Shift Supervisors attend the NU Shift Supervisor Program. This should be completed by all Shift Supervisors within three years. This training should include the lessons-learned from the three late classification events of April 20-23, 1994.
- LT-7 For any corrective actions which result from the events of April 20-23, 1994, the Training and Operations Departments should evaluate the training impact using established processes (i.e. the Training System Development process). Examples include, but are not limited to, new procedures, procedure changes, and any required changes in Shift Supervisor roles and responsibilities.
- LT-8 Duty Officer training should be conducted on any EAL Table interpretation document which results from the implementation of Short Term Recommendation ST-5.
- LT-9 The Operator Training Department should modify the quarterly scenario classification testing from four scenarios per quarter to at least eight scenarios per quarter in a proctored environment. Timely (within 24 hours) feedback should be provided on an **individual** basis and appropriate remedial training given. Continue until the overall

group of test takers scores an annual composite of better than 95%.

Management/Culture

- LT-10 Positive recognition by management of critical self-assessment and questioning attitudes should be publicly acknowledged. Reinforcing these behaviors through direct action is essential to establishing a quality culture where the individual is the first line of quality.
- LT-11 The Unit Director should meet frequently with Shift Supervisors, both formally and informally, to reinforce the importance of the Shift Supervisor's position as a management representative of the utility, responsible for safe operation of the unit.
- LT-12 Executive Management should establish an operating organization which is consistent with industry standards. As a minimum this should include an Assistant Operations Manager and an STA or Work Control SRO for each shift. The use of INPO as a resource should be considered to determine other operational needs.
- LT-13 The Senior Vice President - Millstone Station should evaluate Millstone Station's root cause assessment capabilities and demand that each department use their trained resources in root cause evaluation until there are qualified individuals in each discipline. (NOTE: A mentoring program using experienced in-house personnel (or qualified out-sources) could assist in providing on-the-job training of newly trained, inexperienced personnel on root cause techniques.)
- LT-14 Clear guidance should be developed by executive management on issues of removal from licensed duties. These should be clearly understood by the shift and management.
- LT-15 Management should perform periodic benchmarking of MP2's culture, and continue such benchmarking until the culture reaches an acceptable standard.
- LT-16 The Director - Millstone Unit 2 should send a copy of this report to the Manager, Nuclear Safety Engineering for generic lessons-learned evaluation as part of the NU in-house operating experience program.

7.0 COMMENTS

- 7.1 An area which was not explored due to scope and time limitation is the maintenance history of valves 2-LRR-7.1 and 2-LRR-8. These valves were found to be leaking by during the RCS Leak event of April 20, 1994. These valves, and any other problems with the Degasifier system, should be repaired as soon as practicable.
- 7.2 A minority opinion recommends that an Independent Review Team (IRT) be formed to look at issues outside the scope of this report (e.g. applicability of the events to the other four Northeast Utilities System units, management's role above the unit management level, and the effectiveness of the 1993 IRT report).

8.0 REFERENCES

EPIP 4400	"Event Assessment, Classification, and Reportability"
EPIP 4400	Form 4400-2 "Emergency Action Levels - Event Based Table"
EPIP 4404	"Notifications and Communications"
EPIP 4411	"Director of Station Emergency Operations"
OP 2302A	"Control Element Drive System"
OA-1	"Organization, Responsibilities, and Assumption of Responsibilities for Key Site Personnel"
OA-2	"Unit Duty Officer Responsibilities"
OP 276/2276/3276	"Conduct of Operations"
SP 2671	"Duty Officer Requirements After a Reactor Trip or ESF Actuation"
TQ-1	"Training and Qualification"
ACP-QA-10.01	"Plant Information Report"
2-OPS-1.02	"Operations Department Organization and Work Control Functions"
2-OPS-1.03	"Major Department Responsibilities"
2-OPS-1.16	"Unit 2 Operations Department Communications"
Memo MP-94-175	"NRC Non-Emergency Event Reports" of March 15, 1994
Memo MP-2-94-069	"Reportability" of April 25, 1994
Memo MP-2-94-079	"Recent MP2 Reportability Issues" of May 2, 1994
Memo EPC-92-009	"NRC Routine Emergency Preparedness Inspection" of 1/27/92.
Memo EPC-92-010	"NRC Routine Emergency Preparedness Inspection" of 1/28/92.
Memo EPC-92-011	"NRC Routine Emergency Preparedness Inspection" of 1/29/92.
Memo EPC-92-012	"NRC Routine Emergency Preparedness Inspection" of 1/30/92.

8.0 REFERENCES (Continued)

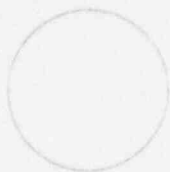
- Memo EPC-92-013 "NRC Routine Emergency Preparedness Inspection" of 1/31/92.
- Memo EPC-92-014 "NRC Conduct of Emergency Plan Drills" of February 3, 1992
- NRC Inspection "Millstone Station Emergency Preparedness Inspection, Combined Inspection Nos. 50-245/92-07, 50-336/92-07, 50-423/92-07" of February 6, 1992
- Memo NL-92-170 "Emergency Preparedness NRC Enforcement Conference" of March 3, 1992
- NRC Letter "Meeting Report Nos. 50-245/92-07; 50-336/92-07; 50-423/92-07 (Enforcement Conference)" of March 6, 1992
- NRC Letter "Notice of Violation (Combined NRC Inspection Report Nos. 50-245/92-07; 50-336/92-07; 50-423/92-07)" of May 6, 1992
- NU Letter "Response to Inspection Report Nos. 50-245/92-07, 50-336/92-07, 50-423/92-07, 10CFR2.201" of June 4, 1992
- NRC Letter "Combined Inspection Nos. 50-245/92-07, 50-336/92-07, 50-423/92-07" of November 23, 1992
- Meeting minutes MP2 PORC meeting 2-94-063 of April 23, 1994
- Meeting minutes MP2 PORC meeting 2-94-064 of April 23, 1994

9.0 ATTACHMENTS

- Attachment A "Event and Causal Factors Charts"

ATTACHMENT A
EVENTS and CAUSAL FACTORS CHARTS

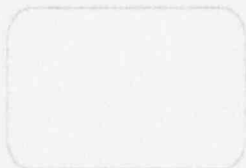
LEGEND FOR EVENT & CAUSAL FACTORS CHARTS



Terminal event -

The reason for an investigation.

Note: A total of four terminal events are included in the following charts.



Event -

An action which led to or followed the terminal event.

Events are shown in chronological order from left to right.



Condition -

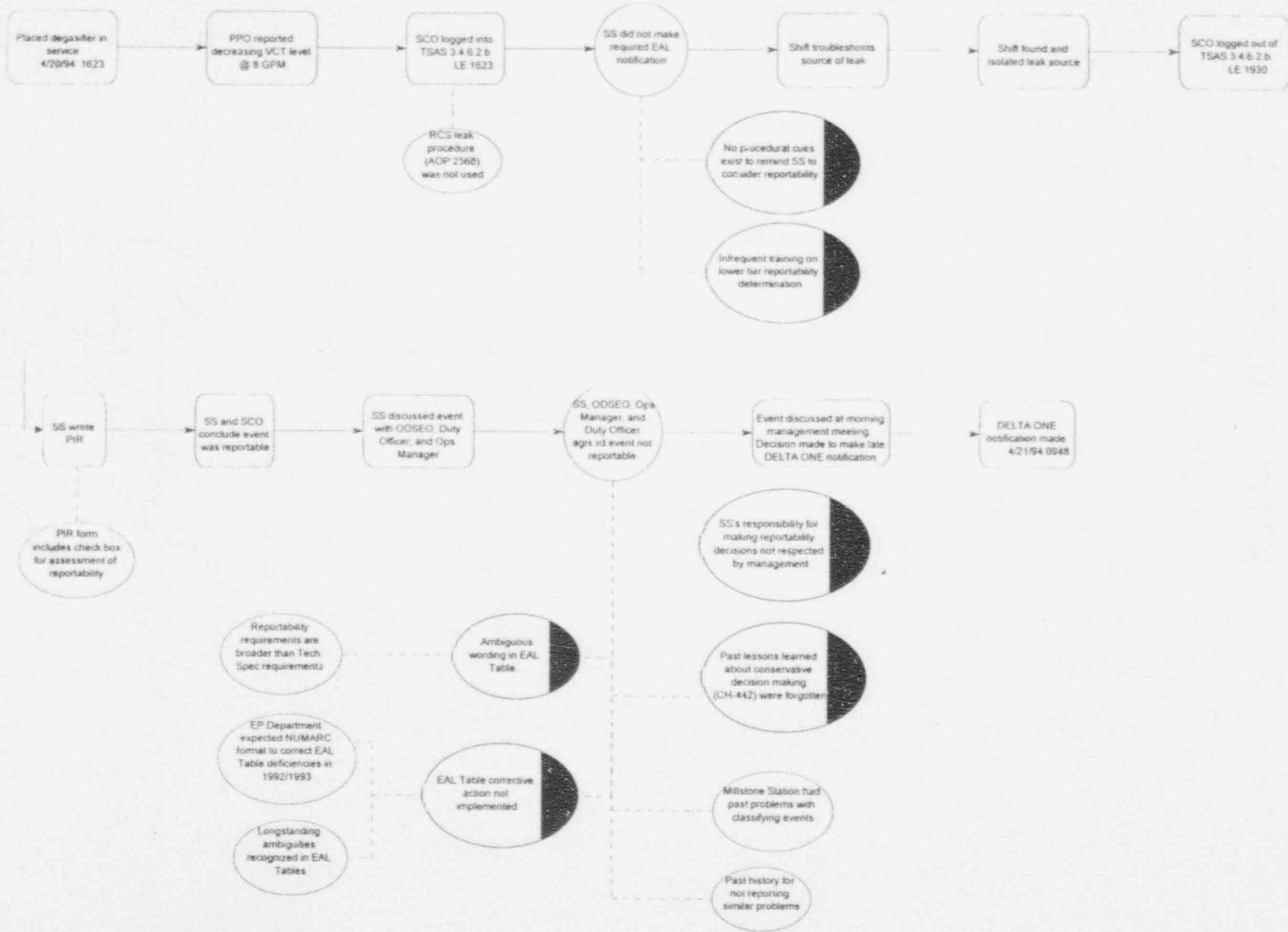
A condition that influenced or shaped an event, or a condition that clarifies the sequence of events.



Causal Factor -

A condition, that if eliminated, would significantly reduce the likelihood of a terminal event.

MILLSTONE UNIT 2 RCS LEAK EVENT OF APRIL 20, 1994



MILLSTONE UNIT 2 STUCK ROD EVENT OF APRIL 22-23, 1994 (PART 2)

