



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

ENCLOSURE 1

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
EMERGENCY DECLARATIONS RESULTING FROM LOSS OF ALARM SYSTEMS
GENERIC TO ALL NUCLEAR POWER PLANTS

1.0 BACKGROUND

After the Three Mile Island Unit 2 accident on March 29, 1979 the President directed the Nuclear Regulatory Commission and the Federal Emergency Management Agency (FEMMA) to develop an Emergency Plan.

Annunciators were first considered as part of the Emergency Classification System in NUREG-0654 FEMA-REP1 "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants." This document dated January 1980 was developed jointly by FEMA and the NRC and contains the minimum acceptance criteria for radiological emergency planning and preparedness to be used by reviewers in determining the adequacy of state, local and nuclear power plant operator plans and preparedness.

NUREG-0654, FEMA-REP-1, Revision 1 dated October 1980, Emergency Classification System Appendix I has the following Emergency Action Levels:

Notification of Alert

Most or all alarms (annunciators) lost.

Notification of Site Emergency

Most or all alarms (annunciators) lost and plant transient initiated or in progress.

There were fourteen (14) events that involved loss of alarm systems during the past seven and half (7 1/2) years. The causes of this loss were, equipment failure, design errors, or personnel errors. These events are summarized as follows:

- 1.1 On December 28, 1984, Crystal River, Unit 3 was at 91 per cent power when it experienced a loss of the control room annunciators due to an electrical fault. An alert was declared in accordance with the emergency plan. The plant was stable throughout the event, and no safety systems were

rendered inoperable. The annunciators were declared operable ten minutes later and the Alert was terminated.

- 1.2 On January 28, 1988, Beaver Valley Nuclear Station, Unit 2, was in Mode 5, and experienced a small fire in a remote annunciator control cabinet which resulted in the loss of all control room annunciators. Plant parameter indication was available throughout the event from other control room instruments, and the safety parameter display system. However, because of the sustained loss of the annunciators, the license declared an Alert in accordance with the emergency plan.
- 1.3 On February 1, 1988, Calvert Cliffs Nuclear Station, Unit 2, was operating at 100 per cent power and experienced a fire in a remote annunciator control cabinet which resulted in the loss of visual indication of the control room annunciators for 2 hours, and the audible function was not restored for 2 days. All emergency systems, the computer, alarm printer, and safety parameter display system remained functional throughout the event. The unit remained at 100 per cent power during the event, and in accordance with the emergency plan, an Alert was declared.
- 1.4 On February 8, 1988, Rancho Seco Nuclear Plant was in cold shutdown and experienced a fire in the "B" annunciator

control cabinet. The "A" cabinet was located alongside the "B" cabinet and caused the loss of all control room annunciators. The licensee provided compensatory measures and manually monitored vital plant parameters. No emergency was declared.

- 1.5 On June 24, 1989, Zion 2 Nuclear Plant was at 98 per cent power when power was lost to the NSSS annunciators due to a switch failure while checking grounds on a dc power system, and a wiring error (reversed polarity) in a transfer switch for the alternate supply. Additional operators were stationed at the control board to visually observe essential parameters and equipment on the control boards. Since the control room had a total loss of NSSS annunciation, an "Alert" level of Generating Station Emergency Plan (GSEP) was initiated. This event had minimal safety significance since only annunciation in the control room was affected, and the unit operator had other means of status indication available.

- 1.6 On September 9, 1989, Brunswick Steam Electric Plant, Unit 2 was in cold shutdown mode when an electrical short in the annunciator system resulted in the loss of all annunciators. An Alert was declared due to the loss of audible annunciators and the licensee stationed operators to monitor

plant parameters. The plant remained stable and no safety systems were affected.

1.7 On July 26, 1991, Millstone Unit 2 was at 100 per cent power when a short in a dc power supply caused the loss of both supplies to the annunciators for longer than 15 minutes. This condition required an Alert to be declared. Six operators were assigned to the eight main control room panels to monitor plant parameters. The control room instruments were operable, and all those that could be bench-marked were bench-marked to their normal condition. In accordance with their procedures, the operators maintained stable plant conditions and no work was in progress that affected plant power level or switch yard electrical stability.

1.8 On August 13, 1991, Nine Mile Point Nuclear Power Plant, Unit 2, experienced internal failure in the main transformer, that resulted in an automatic reactor protection system scram and a loss of five "uninterruptible" power supplies (UPS). The loss of the UPS caused and the loss of the following equipment:

- A. All indications of reactor control rod position.
- B. Condensate and feedwater system controls.
- C. All control room annunciators (alarms).
- D. In-plant radio communication system.

- E. In-plant page telephone communication system.
- F. Control Room indication of plant fire alarms.
- G. Almost all plant computers that perform monitoring, alarms, protection, and data recording functions.
- H. Multiple control systems resulting in a loss of containment space cooling.
- I. Many main control board balance of plant parameter displays.
- K. The safety parameter display system.
- L. Some plant lighting systems.

A Site Area Emergency was declared by the shift supervisor twelve minutes after the initiating event. However, with the availability of back-up indicators to monitor plant status, the licensee later concluded, and NRC concurred, that the declaration of the site Area Emergency was due to an overly conservative EAL scheme and not directly tied to conditions that existed in the plant at the time of declaration.

- 1.9 On February 18, 1992, Quad Cities, Unit 1 was in a maintenance outage when the unit experienced a power surge due to a lightning strike in the 345 kV switchyard which blew the annunciator main fuses causing the loss of annunciators. Because of the loss of annunciators, the licensee declared an Alert. The Alert was terminated 1:14

hours lat .. The loss of the annunciators had no safety significance.

1.10 April 7, 1992, Quad Cities, Unit 1 was at 100 per cent power when a total loss of the 125 Vdc bus occurred. On April 9, 1992, Unit 1 was at 100 per cent power when a loss of the 125 Vdc bus occurred again. The loss of dc power was due to personnel error for each of these events. Both of these events caused a loss of all Unit 1 and common panel annunciators and caused the 1A recirculation pump to coast down to minimum speed. During the April 7 event, the operator noticed that the reactor was reducing power and reactor water level was increasing. The root cause of the loss of 125V dc power was identified in 44 minutes. The restoring of the dc power caused operational problems and an Alert was declared in 49 minutes due to the "unplanned loss of Most or All annunciators." The Alert was terminated in 54 minutes when the annunciators became operational. On April 9, 1992, 47 minutes after the initial event, an Alert was declared for the same reasons as on April 7. It was terminated 52 minutes later when the lost annunciators became operable. The plant operators maintained the plant stable according to their procedures, and the loss of annunciators had no safety significance.

1.11 On May 4, 1992, at 0436 hours, Palo Verde Nuclear Generating Station, Unit 3 lost the non safety-related annunciator system and plant process computer alarm system because of human error. An electrician caused 480 volts to be applied to the inputs of the annunciator system which are also shared with the plant process computer. Approximately 3.75 hours later the licensee declared an Alert. Upon the loss of the core monitoring computer, power was reduced as required by the Technical Specifications and the licensee increased control room personnel for additional monitoring of control room indicators. Power was held at 70 per cent until May 7, 1992, and at 0420 hours, power was reduced and the unit was tripped from 20 per cent power in order to repair the electrical system damage.

1.12 With the unit at 77 per cent power on July 1, 1992, the Dresden Nuclear Generating Station, Unit 2 experienced a loss of annunciators, three times in five seconds, on four control room panels. Annunciators were lost again momentarily during trouble shooting efforts. The loss was due to a loose connection in a copper link within a fuse holder. During annunciator system modification, when spare electrical cables were being pulled, movement apparently jostled the copper link causing it to momentarily lose continuity. The licensee declared an Alert consistent with

the emergency plan. The unit continued at 77 per cent power during the event which lasted 7 and 1/2 hours.

1.13 On October 16, 1992, the Callaway plant operators noticed that numerous annunciators were in an alarm state. The plant was operating at 99.2 per cent power and continued to operate at that power level. During the replacement of power supply fuses, all the annunciator power supplies failed which resulted in the loss of all annunciators for about one hour. The plant Emergency Response Plan specified that for this condition that an Alert be declared; however, the licensee did not declare an Alert. The annunciator system was not fully operable for a period of about 25 hours. The plant remained in a stable condition and no safety systems were affected.

1.14 On December 13, 1992, Salem, Unit 2 was operating at 100 per cent power when operators discovered that the overhead annunciator system had been lost. The loss was detected when an alarm typewriter was observed to be typing alarms without a corresponding alarm tile light on the overhead annunciator system. The root cause for the loss of the annunciator was determined to be operator error wherein the wrong keystrokes were entered on the computer with the annunciator system switch in the wrong position. The operator error caused a failure in communication between the

plant computer and the overhead alarms. Preliminary findings by the NRC Augmented Inspection Team (AIT) have concluded that the event had no safety consequence and no safety equipment was degraded.

2.0 EVALUATION

2.1 REGION I AND UTILITY CONCERNS REGARDING EMERGENCY ACTION LEVELS (EAL)

By memorandum dated April 8, 1988, to Frank J. Miraglia, Jr., Associate Director for Projects, NRR, William F. Kane, Director of the Division of Reactor Projects, Region I proposed a Task Interface Agreement to further review the EAL "Alert" associated with the loss of annunciator events of January 23, 1988, at Beaver Valley 2, and February 1, 1988, at Calvert Cliffs Unit 2. The Region's major concern centered on the guidance provided by NUREG-0654 regarding the emergency classification for this type of events, the extent of procedural coverage, and the lack of procedures and training for loss of annunciator events.

By memorandum dated May 11, 1988, Bruce A Boger, Assistant Director for Region I Reactors, Division of Reactor Projects I/II, NRR, requested that Jack W. Roe, Director, Division of Licensee Performance and Quality Evaluation, NRR, have his staff consider the Region I concern with respect to lack of

abnormal or emergency operating procedures for handling loss of annunciator events.

By memorandum dated June 22, 1988, to Bruce A. Boger, Assistant Director for Region I Reactors, Division of Reactor Projects I/II, NRR, Jack W. Roe, Director, Division of Licensee Performance and Quality Evaluation, NRR indicated that emergency operating procedures (EOPs) are not the appropriate means for handling loss of annunciators because such events do not result in conditions which would cause entry into EOPs and would not meet the definition of the Owners Group generic technical guidelines for an emergency. Such events may be more appropriately covered by "Procedures for Abnormal, Off-Normal or Alarm Conditions" as a category of Appendix A of Regulatory Guide 1.33, "Quality Assurance Program Requirements." The licensee Technical Specifications, Section 6.8 and subsection 6.8.1, commits them to follow the recommendations of Appendix A of Regulatory Guide 1.33, Revision 2, dated February 1978, which endorse ANSI N18.7-1976/ANS 3.2 "Administrative Controls and Quality Assurance for Operational Phase of Nuclear Power Plants." ANSI N18.7 - 1976/ANS 3.2 is currently being revised and includes loss of annunciators as one of the written procedures that a licensee should establish.

By memorandum dated June 23, 1988, to Bruce A. Boger, Assistant Director for Region I Reactors, Division of Reactor Projects I/II, NRR, Frank J. Congel, Director, Division of Radiation Protection and Emergency Preparedness, NRR, stated that he agreed with the Region I assessment that loss of annunciators should be removed or receive a downgraded classification in EAL for the Site Area Emergency. However, for the time being, he would prefer to retain the loss of annunciator events at an Alert level because of the valuable augmentation of on site resources that accompanies that classification. He, further, indicated that, (1) this issue would be thoroughly considered in the context of an overall revision of the EALs which was being undertaken in response to the Region I request in conjunction with other issues that have surfaced regarding EALs and (2) an interim revision addressing the loss of annunciator EALs is unnecessary because the EAL listings in NUREG-0654 are intentionally conservative and, as guidance, they need not be strictly followed by licensees. Finally, he indicated that he would encourage the Regions to address this issue on a case-by-case basis and to look favorably upon request from licensees to eliminate the loss of annunciators EAL as a Site Area Emergency based upon the rationale provided by Region I.

By memorandum dated August 9, 1988, to William F. Kane, Director of the Division of Reactor Projects, Region I, Bruce A. Boger, Assistant Director for Region I Reactors, Division of Reactor Project I/II, NRR, reiterated the conclusion reached in Jack Roe's June 22, 1988, memorandum that the Division of Licensee Performance and Quality Evaluation (DLPQ) is of the "technical opinion that a procedure for handling loss of annunciator events is necessary.." and that "the (ANSI [N 18.7]/ANS 3.2 and RG 1.33) revision process will address the issue for all plants. However, as with other revised staff guidance, it does not appear the staff will back-fit the revised version of RG 1.33 on those facilities which do not voluntarily upgrade to this revision." With respect to the need for a NUREG-0654 revision, Bruce Boger reiterated Frank Congel's June 23, 1988 memorandum regarding revision to NUREG-0654 by stating that the implementation of a well thought-out loss of annunciator procedure (upon which operators have been trained) would provide to the NRC the minimum justification necessary to reduce the loss of annunciator events [Site Area Emergency] to the Alert EAL.

The review of the fourteen (14) events that are summarized in section 1.0 indicate that for the plants involved, there were no specific procedures in place to handle the loss of annunciators, and there had been no change to plant specific

emergency response guidelines from the guidance given in NUREG-0654 to reduce the loss of annunciators from a Site Area Emergency to an Alert EAL.

By memorandum dated May 19, 1992, to Scott Newberry, Chief, Instrumentation and Control Systems Branch (SICB), Robert Erickson, Chief, Emergency Protection Branch (PEPB) provided information on proposed changes from NUMARC regarding classification of a loss of annunciator events to assist in SICB's assessment of the significance of annunciator failures.

The NUMARC document (9NUMARC/NESP-007) for emergency declaration lists the following definitions for events:

1.0 Notification of Unusual Event

A notification of an Unusual Event is a Unplanned Loss of Most or All Safety System Annunciation or Indication in the Control Room for greater than 15 minutes during power operation, hot-standby (startup in BWRs), and hot shutdown. An Example of this emergency action level is:

- a. Loss of most or all (site-specific) annunciators associated with safety systems for greater than 15 minutes.

AND

- b. Compensatory non-alarming indicators are available.

AND

- c. In the opinion of the Shift Supervisor, the loss of the annunciators or indicators requires increased surveillance to safely operate the unit(s).

AND

- d. Annunciator or indicator loss does not result from planned action.

2.0 Notification of Alert

Unplanned Loss of Most or All Safety System Annunciation or Indication in the Control Room with either (1) a significant transient in progress, or (2) compensatory Non-Alarming Indicators are unavailable during power operation, hot standby (startup in BWRs), and hot shutdown. An example of this emergency action level is:

- a. Loss of most or all (site-specific) annunciators associated with safety systems for greater than 15 minutes.

AND

- b. In the opinion of the Shift Supervisor, the loss of the annunciators or indicators requires increased surveillance to safely operate the unit(s).

AND

- c. Annunciator or indicator loss does not result from planned action.

AND

- d. Either of the following:

- 1. A significant plant transient is in progress.

OR

- 2. Compensatory non-alarming indications are unavailable.

The only difference between the NUMARC definition of an Unusual Event and an Alert is item d. above.

By memorandum dated July 15, 1992, the Director, Office for Analysis and Evaluation of Operational Data (AEOD) to the Director, Office of Nuclear Reactor Regulation, provided a statement of concerns regarding the adequacy of Emergency Operating Procedures and training associated with loss of all control room annunciators. The events at Nine Mile Point, Unit 2, Quad Cities, Unit 1, Palo Verde, Unit 3, and Dresden, Unit 2, summarized in sections 1.8, 1.10, 1.11, and 1.12 of this report respectively were cited in the AEOD memorandum. AEOD stated that in the case of Nine Mile Point Unit 2, and Palo Verde Unit 3, neither licensee had procedures covering the event nor were the operators trained for these events. The AEOD memorandum further stated that the industry (and staff) may have underestimated the probability of occurrence of this type of events. The memorandum also indicated that when a plant experiences a total loss of

annunciators, there seems to be a reasonable likelihood that significant equipment failure or some other event complication will be attendant. AEOD concluded from the above discussion that there is a need for a reassessment of the safety significance of events involving loss of control room annunciators, similar to Nine Mile Point, Unit 2, Palo Verde, Unit 3, and other plant events. This reassessment should include the contribution this type of events could have on the ability of the operators to place and maintain the plant in a safe, shutdown condition and whether the operators should receive additional training (simulator and/or classroom) on the loss of all control room annunciators.

By memorandum dated August 10, 1992, to the Director of AEOD, the Director of the Office of Nuclear Reactor Regulation, indicated that the NRR staff is pursuing the following actions to address the safety significance of loss of annunciator events:

1. The impact of the recent annunciator power supply experience is being considered in the proposed disposition of Generic Issue 76, "Instrumentation and Control Power Interactions."
2. The staff proposed Commission paper on the Advanced Reactors will recommend that annunciator systems in future plants be "more robust" and thereby reduce the likelihood of the types of events noted in the AEOD memorandum of July 15, 1992.
3. NRR is evaluating the recent loss of annunciator events as part of the Nine Mile Point 2 event follow-up actions to

determine the need for any additional generic action beyond the above efforts.

With regard to Generic Issue 76, by memorandum dated February 26, 1992, to Warren Minners, Division of Safety Issue Resolution, Office of Nuclear Regulatory Research (RES), RES, Eric S. Beckjord, Director, Office of Nuclear Regulatory Research stated that the prioritization of Generic Issue No. 76 shows that the safety concern is being addressed in the IPE Program. Therefore, GI 76 will be DROPPED from further pursuit as a separate issue.

By memorandum dated August 20, 1992, to Frank Congel, Director Division of Radiation Protection and Emergency Preparedness, PEPB, Robert Erickson, Chief Emergency Protection Branch (PEPB) provided a summary of the emergency planning perspective on loss of control room annunciators. The memorandum provided the staff's historical position and philosophy on emergency action level classification relating to loss of annunciator events, and how the new NUMARC methodology will help clarify this issue. This memorandum stated that "the ambiguity of these [examples given in Appendix 1 to NUREG-0654 initiating conditions regarding loss of annunciators for an Alert or Site Area Emergency] initiating conditions has elicited varying interpretations by the industry and has resulted in 'over classification' because:

- (1) the annunciators are only used as an aid to draw the operator's attention to off-normal conditions
- (2) information

provided by the annunciators is generally backed-up by other control room equipment, and (3) neither Emergency Operating Procedures nor operator training and response depends upon annunciators to trigger further actions. Thus, loss of annunciators in itself does not pose a significant threat to plant safety and does not meet the threshold of an Alert or Site Emergency, provided other sources of plant data are readily available and usable by the operator."

2.2 LOSS OF ANNUNCIATION SAFETY SIGNIFICANCE

Calvert Cliffs, Unit 2 and Millstone, Unit 2 remained at 100 per cent power, and Quad Cities, Unit 1, and Palo Verde, Unit 3 remained at reduced power during their Alert declaration in order not to impose an additional transient while trouble shooting the problem. Both Millstone and Palo Verde increased the number of operators for surveillance, and Millstone took the extra step to have the operators temporarily mark their key instruments to denote normal conditions as a further aid.

The issue raised by the loss of annunciator events to date, in order to establish their safety significance, is whether the plant operators are able to take the necessary action while operating at 100 per cent power, reduced power or tripped without annunciators and still ensure plant safety. In order to meet the EAL Unusual Event classification definition, an event must reach a point which indicates a potential degradation of level of

safety of the plant. To meet the Alert definition, there must be an indication that events are in process or have occurred which involve an actual or potential substantial degradation of the level of safety of the plant. Given the 14 events cited, is inconsistent to equate the loss of annunciators with a potential or substantial degradation of level of safety. As stated in William F. Kane's April 8, 1988, memorandum to NRR, "the annunciators are only used as an operator aid to draw operator attention to individual off-normal conditions." In all the events to date, the operators had sufficient indication to take the necessary actions to ensure plant safety without reliance on the annunciators consistent with their procedures and training.

Loss of annunciators without a transient (such as at Calvert Cliffs, Unit 2 and Millstone, Unit 2) has no effect on plant performance. The operators rely on other key indications of plant parameters to determine plant status such as:

- A. Reactor parameters - reactor pressure, pressurizer level, power, and neutron flux;
- B. Steam (secondary) parameters - steam pressure, steam flow, steam generator water level, and condenser water levels; and
- C. Electric generator parameters - gross power output, voltage, amperes, station service voltage and loads, and station dc voltage.

3.0 CONCLUSION

Our conclusions regarding loss of annunciators are as follows:

- (1) Most annunciators are non-safety related and will continue to be periodically lost. The cause of the loss is equipment failures, design errors, and personnel errors.
- (2) Annunciators are used as an operator aid to draw operator attention to off-normal conditions and their loss does not cause a degradation in the level of safety of the plant.
- (3) The information provided by annunciators is provided by other control room safety-related instruments e.g. Reactor Protection, Engineering Safety Features, and Post Accident Monitoring systems and non safety-related instruments (plant computer, alarm printer, SPDS, etc.).
- (4) Emergency procedure guidance does not call for operator reliance on annunciators to take action. In most cases neither the plant specific Emergency Operating Procedures nor operator response

guidance rely upon annunciators to trigger further action.

- (5) Certain indicators such as, Post Accident Monitoring (PAM) and Control Rod Position Indication are important and require proper coordination with the Emergency Procedures.
- (6) In the event of a reactor trip or other transients that challenge the plant, so many annunciator alarms go off within such a short period of time that operators do not try to respond to all of them. Instead, they rely upon safety-related control room instrumentation to monitor the functioning of safety-related systems and for deciding what manual action to take.
- (7) The declaration of an Alert or higher level emergency loss of annunciators which are not required for safe shutdown or operation of the plant, appears to be inappropriate considering the possible public alarm and unwarranted activation of emergency response facilities and personnel. The Nuclear Management and Resources Council, (NUMARC) proposed declassification of EAL for loss of annunciators, endorsed by NRC Regulatory Guide

1.101, Revision 3, is an appropriate charge, in that loss of annunciators should only be part of an EAL.

4.0 RECOMMENDATION

Our recommendations regarding loss of annunciators are as follows:

- (1) Licensees should have abnormal procedures covering loss of annunciators and should provide operator training regarding this loss.
- (2) When a plant has a loss of annunciators, the licensee should; (1) increase surveillance of key parameters, and (2) stop all routine surveillance, maintenance activities, and power level changes to preclude possible initiation of a plant transient while the annunciators are being repaired.
- (3) In plants where the Emergency Operating Procedures rely upon the annunciators to trigger further action, the procedures should either be modified to remove that reliance, consistent with approved emergency procedure guidance, or the annunciators should be upgraded to safety grade.