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MEMORANDUM FOR: Jack E. Rosenthal, Chief
Reactor Operations Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

FROM: Jose G. Ibarra, Senior Instrumentation
and Control Engineer
Reactor Systems Section CE and GE
Reactor Operations Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

SUBJECT: LOSS OF ANNUNCIATOR AND COMPUTER SYSTEM EVENTS

The Technical Review Report describing our study of annunciator problems since 1985 is enclosed. We prepared this report to preserve the data and analysis which was the basis for the response to the Commission provided in the memorandum from J. M. Taylor to the Chairman and Commissioners, "Role of AEOD Oversight of Operating Reactors" (June 4, 1993).

Based on available data, we found that during normal power operations, annunciator systems are quite reliable and failures of annunciators contribute little additional risk. However, we note that operable annunciators are essential to maintaining high availability and safety over the long term. Consequently, we believe that the current high reliability of annunciator systems should be preserved.

One area where problems were identified was licensee emergency classification and emergency response to loss of annunciator events. However, current NRC guidance in this area appears sufficient. At this time, we believe that no further NRC action is needed regarding annunciators.

Original signed by
George Lanik for:

Jose G. Ibarra, Senior Instrumentation
and Control Engineer
Reactor Systems Section CE and GE
Reactor Operations Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

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SUBJECT: LOSS OF ANNUNCIATOR AND COMPUTER SYSTEM EVENTS

1. Summary

This report documents the data collection on loss of annunciator and computer system failures that was utilized to assess industry experience. The data used for calculations in this report was the bases for the response to the Commission staff requirements memorandum (SRM) dated January 16, 1992 (Ref. 1). The staff is developing a technical position on the advanced design of control room annunciators, and is evaluating the recent loss of annunciator events as part of the Nine Mile Point Unit 2 Staff Actions for any additional generic requirement. NRR, in its routine licensing and inspection activities, will continue to monitor the licensees dealing with loss of control room annunciators.

This data has been collected from various databases. Failure of these systems are not necessarily reported to the NRC since the annunciator and computer systems are not safety related. The various data sources used by Office for Analysis and Evaluation of Operational Data (AEOD) in its analyses indicate that the annunciators are failing more often than are reported in the LERs. Losses of the safety parameter display system (SPDS) and the plant process computer are less likely to be reported when lost than the control room annunciators.

The issue of loss of control room annunciators and computer systems raise two issues: (1) the adequacy of the remaining instrumentation to provide information in order to assess the status of plant systems; and (2) the impact of losing information that may be required to declare and assess the level of the emergency. On the first issue, the Augmented Inspection Teams (AITs) (Refs. 2, 3, and 4) have concluded that the loss of annunciators was not safety significant, and AEOD analyses, using current probabilistic risk assessment (PRA) techniques, has determined that loss of annunciators does not pose a serious risk to plant safety. Independent analyses by the Office of Nuclear Reactor Regulation (NRR) has reached a similar conclusion. On the second issue, NRR and AEOD concluded that sufficient guidance had been given to the licensees by the Agency for the development of the emergency action level (EAL) procedures. However, the AITs found inadequacies in the licensees' emergency classification/notification.

The AEOD analyses does not include shutdown conditions which currently are being evaluated by the Office of Nuclear Regulatory Research (RES); and AEOD recognizes the lack of human reliability modeling in these analyses. Shutdown and low power operations are a concern because over 50 percent of the loss of annunciator events were in this reactor state.

2. Introduction and Background

Within the last two years, four events involving total loss of main control room annunciators have prompted three AITs and one Incident Investigation Team (IIT) (Ref. 5). The IIT at Nine Mile Point Unit 2 was in August of 1991, whereas, all the AITs were in 1992. These high level inspections were conducted because the NRC viewed these events as potentially serious events. AEOD, Division of Safety Programs (DSP), Reactor Operations Analysis Branch (ROAB), provided members for the Nine Mile Point Unit 2 IIT in 1991, and all three AITs in 1992 that involved the total loss of control room annunciators. This involvement initiated the data collection on annunciator losses in the last quarter of 1992. During the data collection, AEOD maintained contact with other NRC divisions that had a interest in this issue and were responding internally to the problem of loss of control room annunciators.

In a memorandum dated July 15, 1992 (Ref. 6), AEOD identified the need to reassess the safety significance of events involving a total loss of control room annunciators. On August 10, 1992 (Ref. 7), NRR responded stating the power supply loss was being considered for impact on Generic Issue 76, "Instrumentation and Control Power Interaction."

On December 13, 1992, the Commissioners requested additional information on the loss of control room annunciator events. There had been two AITs in 1992 dealing with the loss of control room annunciators, and the third event of the year was in progress (i.e., Salem Unit 2, December 13, 1992). The Commissioners wanted to know if there was a method available which could calculate the difference in operator performance with and without the annunciators available. AEOD responded on June 4, 1993, stating that AEOD was not aware of any applied methods to calculate the difference in operator performance with and without annunciators available (Ref. 8). However, a survey of operating experience was performed which was used to estimate the impact on frequency of scrams and increased risk due to the loss of control room annunciators.

For this response, AEOD utilized the accident sequence precursor (ASP) computer program to estimate the conditional core damage probability (CCDP) of human errors. In addition, risk calculations based on PRA techniques were performed to estimate the impact of loss of annunciators events. After all of these calculations, AEOD concluded that the overall additional risk due to loss of annunciator events is small. AEOD review of the automatic reactor scrams identified no reactor scrams resulting from failure of operator to take action because an annunciator did not alert the operator of the need to respond. In shutdown conditions, many of the automatic features are not available and manual actions are required to perform safety functions. Therefore, the analyses did not attempt to address the impact of loss of annunciators during shutdown.

On December 28, 1992, the Deputy Executive Director for Nuclear Reactor Regulation, Regional Operations & Research, requested that NRR and AEOD evaluate the current classification for loss of annunciators after the Callaway AIT. Inasmuch as the AIT found no safety significance to the event, it was questioned whether a loss of annunciators should be classified as an Alert, and it did not appear appropriate to take enforcement action for failure to make such a declaration. On February 4, 1993, a joint NRR and AEOD evaluation concluded that the current guidance for treating loss-of-annunciator events in EAL schemes is adequate (Ref. 9). In August 1992, Regulatory Guide 1.101, Rev. 3, endorsed NUMARC/NESP-007 (Ref. 10). Alternate guidance had existed in NUREG-0654/FEMA-REP-1. With the August Regulatory Guide Revision, the NRC issued more information to all licensees regardless of the method they use to devise their EALs schemes.

On February 2, 1993, NRR's Instrumentation & Controls Branch (ICB) issued its assessment of the EAL regarding loss of annunciation (Ref. 11). ICB concluded annunciators are operator aids, and the loss of annunciators does not cause a degradation in the level of plant safety. The information provided by the annunciators is also provided by other control room instruments. Emergency procedures do not depend on annunciators before taking action. ICB further states, "an Alert or higher emergency declaration for loss of annunciators which are not required for safe shutdown or operation of the plant, appear to be inappropriate." ICB recommends licensees have an abnormal procedure covering loss of annunciators and operator training. When a plant has a loss of annunciators, the licensee should increase surveillance of key parameters, and stop all activities and power level changes.

3. Discussion

In the events at Palo Verde, Callaway, and Salem, the AITs concluded the incidents were of minimal safety significance but identified several deficiencies in the annunciator systems. The AITs found lack of annunciator system knowledge and/or training; inadequate work practice/control; and inadequate notification and classification, either to the management or external to the licensee. Two AITs, Salem and Callaway, also, found the licensee had not taken adequate compensatory measures when they lost the complete annunciator system. Appendix A is a summary of the pertinent AITs and the IIT.

The loss of main control room annunciators can be divided into two main issues of concern. One issue is technical in assessing the safety significance of the annunciator loss and assuring remaining instrumentation is adequate for safety assessments. Despite initial concern at the time of the event occurrence, all of the AITs have found no safety significance to the total loss of annunciators. The second issue is the classification and notification of the event by the licensee. On this issue, the AITs found the licensees' responses were inadequate in either the external notification and classification of the event, or the licensee's internal notification process.

The main control room has hundreds of indications, many of which can function as alternate indications. Each indication signals operators of a specific abnormal condition. Qualification of these indications is either nonsafety-related, or safety-related. Closely tied with the nonsafety-related annunciator system in assessing the emergency plant status is the nonsafety-related plant process computer and the nonsafety-related SPDS. The largest data gathering system is the plant process computer. This information includes digital and analog information over a wide-range of parameters. The large amount of information does not lend itself to using this system to operate but instead, the system is used as a recorder of the plant parameters. These recording function is important in determining exact plant parameters and sequence of events used in post trip reviews.

The main objective of the annunciator system is to cue the operator to an abnormal condition usually under normal operations. Annunciator audio and visual alarms prompt the control room operator to take actions that prevent further degradation of the alarming condition. During normal operation, this capability to catch abnormalities before a serious problem develops is very important to the continuous safe operation of the plant. The annunciators change in importance when the reactor enters a transient or a reactor trip. This is due to the fact that too many signals become abnormal. Under these conditions, the operators become more concerned with maintaining the safety functions rather than correcting the abnormal conditions. The emphasis switches to more qualified systems, and systems like the plant process computer become less important. The plant process computer can become backlogged with information depending on the scenario. SPDS, classified important to safety, becomes the main computer in collecting and assessing the safety status of the plant. It is also at this point that the safety related instruments become the main indicators relied upon. In the 1992 AITs, the continued operability of the safety-related instruments was crucial in determining that the safety significance of the event was minimal.

Event assessment level classifications rely on the annunciators operability. Loss of most or all the annunciators concurrent with a transient will place licensees in an Alert. In some plants, the event classification systems also includes the plant process computer and SPDS. The inspections found that the word 'most' was interpreted differently by various operators. The new guidance by NUMARC says 'most' is 75 percent of the total annunciators. This new guidance will relax the need for the licensees to classify and declare events.

A critical situation exists when the three systems, annunciators, plant process computer, and SPDS are totally inoperable during power operations with the possibility of a subsequent transient. Theoretically, the operators can operate the plant with the available equipment without the use of these three systems. However, operating experience has shown that the control room operators can be initially confused without the aid of the annunciators. During shutdown conditions, many of the automatic safety systems may not be available and operator action is required to perform safety functions.

Current PRA and ASP analysis do not specifically model operator and annunciator interactions during shutdown. Unavailability of automatic safety system response coupled with loss of annunciators to alert operators to initiate action may result in increased risk of core damage when shutdown. Annunciator systems may be degraded more often during shutdown conditions because of maintenance activities. The risk associated with shutdown is currently being addressed by NRR and RES, and this evaluation does not address annunciator losses during shutdown.

Errors of omission are factored broadly into the existing PRA methodologies. However, errors of commission have not been factored into the methodologies due to lack of human reliability modelling capability. Efforts are planned by RES to attempt to model errors of commission as an extension of the PRA shutdown risk analyses. Procedures, training, and effective command and control mitigate errors of commission but we have no specific insight on how to treat errors of commission with respect to loss of annunciators.

Some loss of annunciators events have occurred and the control room operators were not aware of the loss. We have no specific insight on how this might affect risk except to note that if another perturbation were to occur, it is likely that the operator would be immediately aware of the loss of annunciators, except in the case of loss of individual annunciators. Also, most operating procedures (especially emergency operating procedures) rely on indications other than annunciators for cues to operator action. Review of reactor trips over a 2-year period did not find any undisclosed loss of annunciator events which were subsequently revealed. Extended loss of annunciator events which are known to the operator can probably be discounted. Once a loss of annunciators is known, compensatory actions are usually taken and the control room operators rely on alternate indications.

The risk associated with the loss of alarms function may be expected to depend on the extent, frequency, duration, and abnormal conditions during the loss. Data on partial and total loss of annunciators, plant process computers, SPDS, alarm panels, and control room instrumentation losses were collected from Licensee Events Reports, IIT Reports, AIT Reports, NUDOCS, SCSS, and Emergency Notification System reports. Partial losses, including substantial failure of the annunciators as defined by the licensee, that could impact the safety of the plant. While most of these alarm functions have alternate alarms or indications, each has a unique function that is not duplicated elsewhere in the control room. Pre-planned system outages during shutdown conditions were excluded from this collection on the expectation that adequate compensatory measures would have been in place.

4. Analysis

The data source documents were sometimes missing relevant information on the loss of annunciators. This scarcity of information is more likely to apply to the process computer and SPDS. In some cases, some of the information was deduced from other sources of data which described the same event. A total of 110 loss of annunciator or computer events were identified from January 1985 to March 1993. A duration of inoperability was calculated for 76 events, the duration of inoperability was estimated for 19 events, but for 15 events a duration of inoperability could not be estimated or calculated due to insufficient information. Appendix B is a list of compiled events.

The compiled data corresponds to a frequency of loss of annunciator occurrence of approximately 0.14 per reactor year. This is computed by dividing 110 events by 800 reactor years. Four events coincided with a reactor trip. Nine events involved the simultaneous loss of annunciators and the plant process computers. For 36 events which included information on the duration, the average loss of annunciators was about 2 hours. Similarly, 44 loss of computer events averaged about 4 hours. The number of events per year and number of events versus duration are shown in Figures 1 and 2.

Based on data reported to the NRC, annunciators systems are highly reliable. There were a total of 110 events of substantial loss that lasted an average of 2 hours versus total operating time of approximately 6 million hours (8 years of operating time minus outage time). This calculation means annunciator systems are available greater than 99 percent of the time. According to their EAL procedures, the licensees have declared only 30 emergencies (i.e., 1 site area emergency, 8 unusual events, and 21 alerts) in the 110 loss of annunciator and computer events. This indicates that the licensees did not consider most events to be significant enough for the activation of any emergency plans.

Lack of complete reporting could be a factor in this data, since only 20 of 110 events were reported in LERs. Single loss of annunciator events are not reportable. These 110 events are compiled using several databases and include only events with a substantial loss of annunciators.

More complicated loss of alarm function events occurred rarely and usually were of very short duration. Four events involved the simultaneous loss of annunciators, plant process computers, and SPDS for up to 1-¼ hours, while another plant took 70 hours to recover during this period. Five events involved a plant transient coupled with the loss of annunciators for less than ½ hour. Two events involved a plant transient coupled with the loss of annunciators, plant process computer, and SPDS for less than 3 hours. These 12 events occurred on a frequency on the order of 0.02 per reactor year.

Loss of a single annunciator window is not considered, since this kind of failure is rarely reported. Compiling this kind of loss would greatly increase the number of events. As a measure of the potential impact of loss of a single annunciator on operator performance, 319 LERs which reported reactor trips were reviewed (years 1991-1992). The review identified no reactor trips that were attributed to an inoperable annunciator window panel leading to lack of operator action which could have prevented the trip.

The power levels of the reactor when the loss of annunciators occurred is shown in Figure 3. Since many automatic functions are bypassed at shutdown and low power operations, the chart showing this configuration in over 50 percent of the loss of annunciator events causes concern. Many factors would mitigate these concerns such as the availability of the safety-related instruments and control room operator awareness. However, the operating data and human reliability modelling are insufficient in this reactor configuration. Current efforts by RES to study shutdown and low power operations, especially human reliability modelling, will assist in determining more accurately the risk in this reactor state.

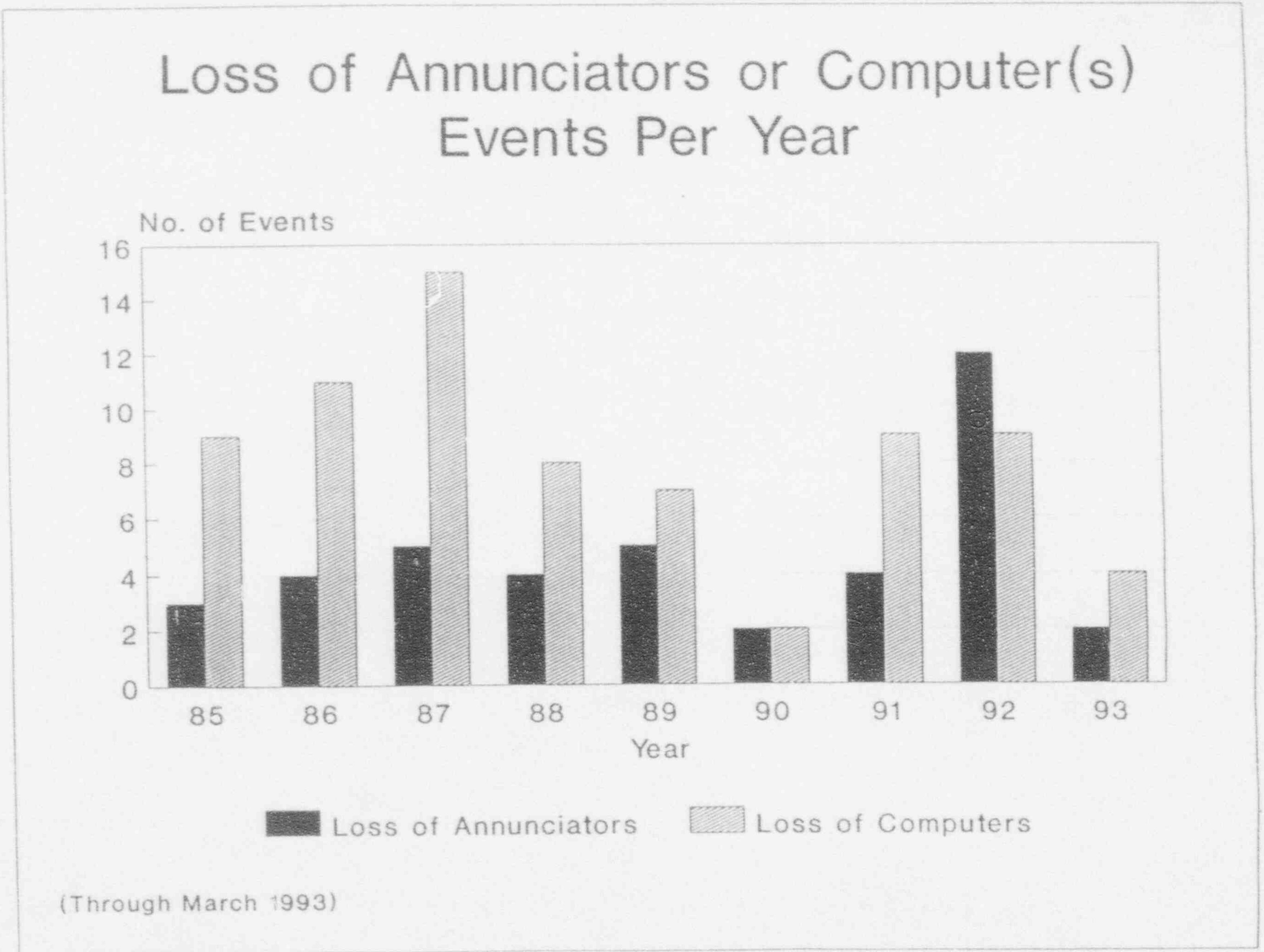

Figure 1 Loss of annunciators or computer(s) Events per year

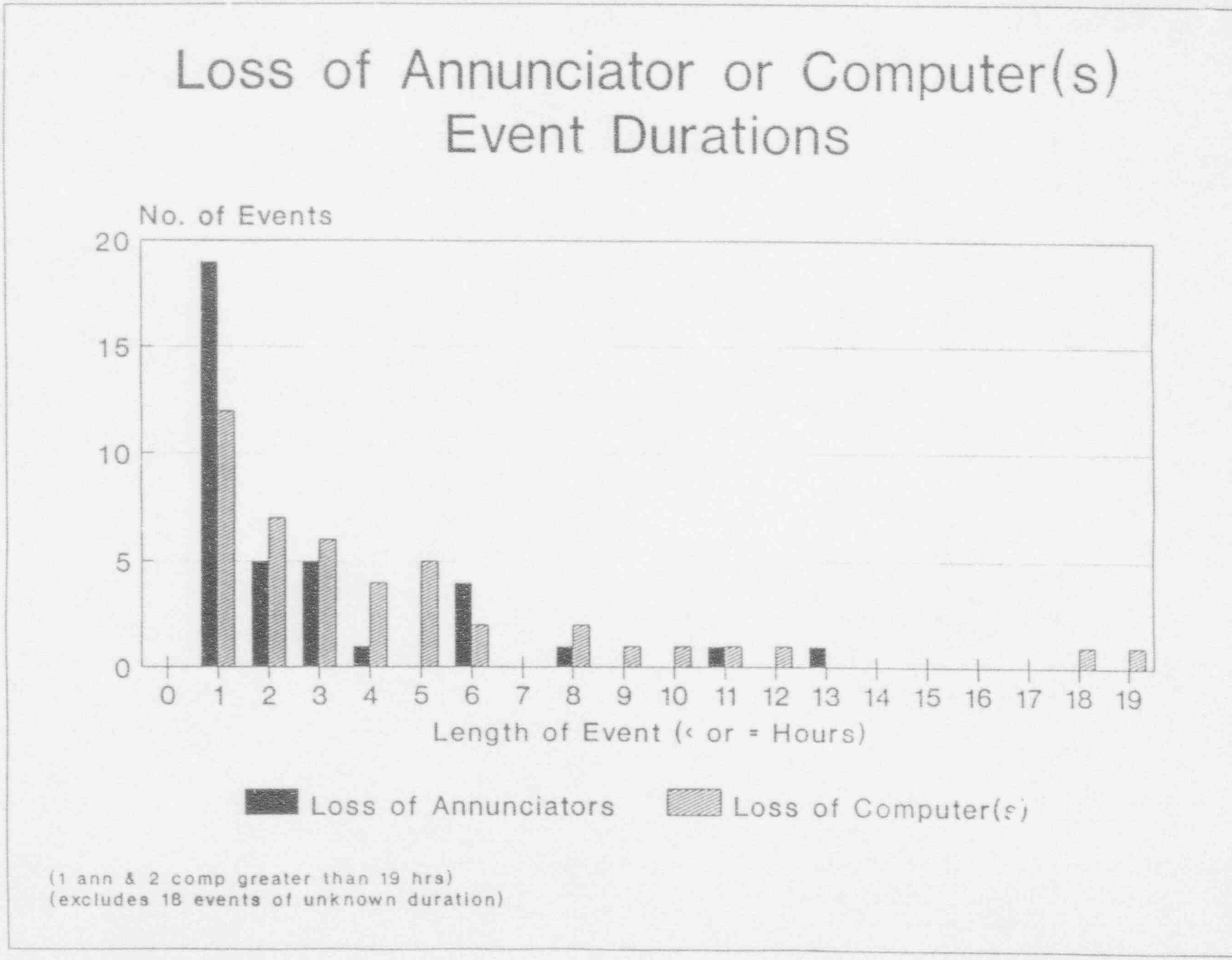

Figure 2 Loss of Annunciator or Computer(s)
Event duration

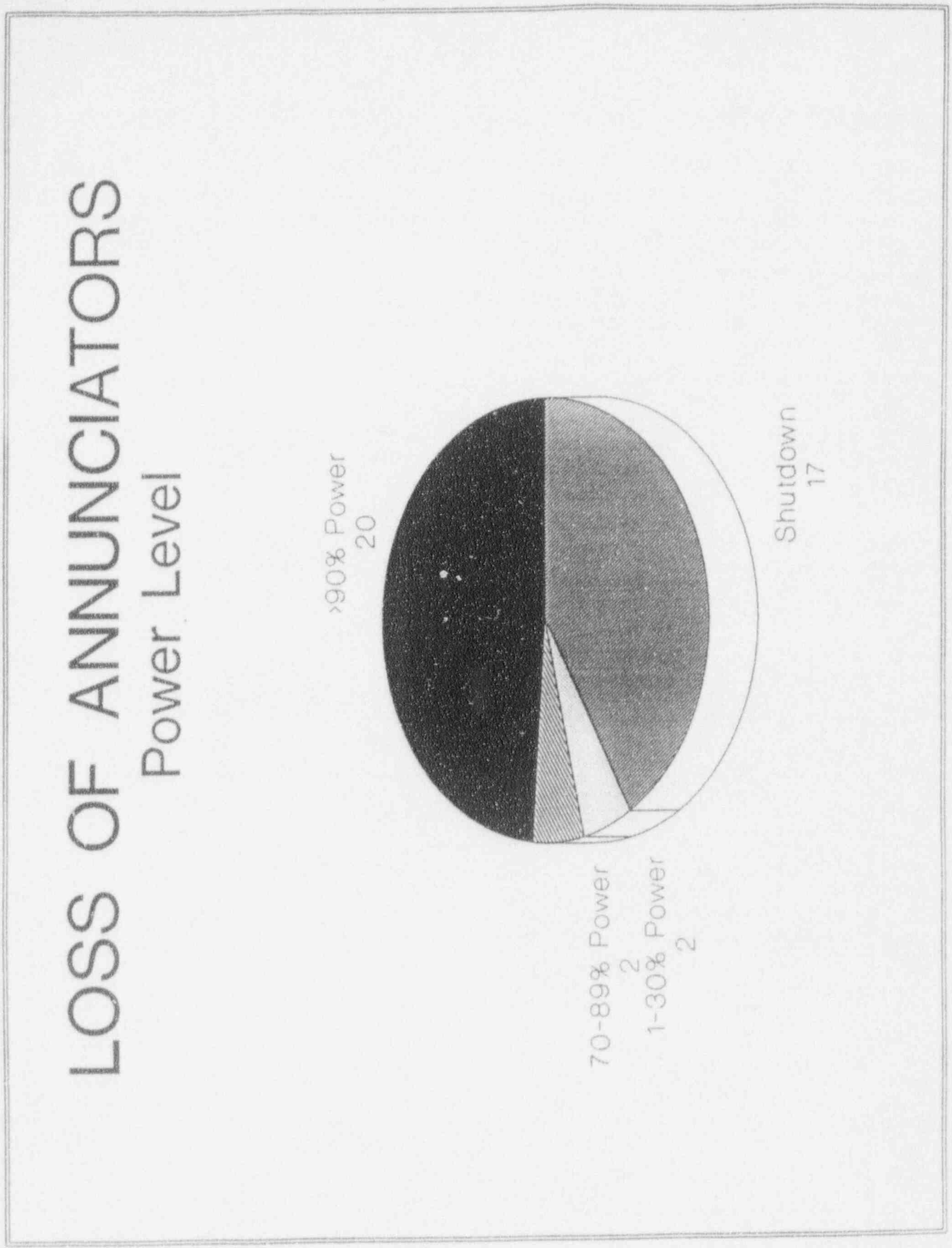

Figure 3 Loss of Annunciators
Power level

5. Calculations

The ASP computer program was utilized to estimate CCDP for trips, loss-of-offsite power (LOOP), and loss-of-coolant accidents (LOCA) by varying the duration of time annunciators were inoperable from 1 hour to 20 hours and varying the nonrecovery factors in the event branches from the existing nonrecovery factor to complete failure. That is, we assumed that the operators would not actuate equipment or recover failed equipment during transient or accident if the annunciators were unavailable. The CCDP magnitude ranged from E-10 to E-05.

The following calculations use nominal probability and risk values from various PRA and ASP calculations to estimate the potential core damage risk per year for various scenarios to try to understand the potential consequences of loss of annunciators events. By equating the estimated core damage risk of an event to the same accompanied by a loss of annunciators in the compiled data, a measure of the impact of human error due to loss of annunciators can be calculated. Event scenarios can be dependent on the loss of annunciators while other events are independent of the loss of annunciators. The coupling factor will influence the method used in the calculations. Note that the following calculations do not include shutdown events.

The calculations for LOOP and reactor trip are cases where the data and logic indicate that the occurrence of the event and the loss of annunciators may be dependent. For example, in some cases, LOOP results in a greater likelihood of loss of power to the annunciators.

However, certain events are likely to be independent of loss of annunciator events. For example, in most cases, the occurrence of a LOCA would not be expected to either cause or be caused by a loss of annunciators. This same logic holds for other events such as anticipated transient without scram, intersystem LOCAs, steam generator tube ruptures, and others.

Increase Risk Calculations:

Reactor Trip

ASP calculates the CCDP for a simple trip to be 3E-07, and an average plant sees about two trips per year. This risk of core damage per reactor year resulting from these trips is estimated to be 2 x 3E-07 per reactor year. On the other hand, operating data shows that 4 trips in the past 800 reactor years of operation have occurred concurrent with loss of annunciators. The risk of core damage per rector year resulting from trips with loss of annunciators can then be estimated to be (4/800) x 3E-07 x A, where A is a factor by which the probability of human error leading to core damage must be multiplied due to loss of annunciators. If for purposes of comparison of risk, we equate the risk per year due to normal trips and the risk per reactor year due to trips accompanied by loss of annunciators, we have the following:

$$2 \times 3E\text{-}07 = 3E\text{-}07 \times 4/800 \times A$$

Solving for A equals 400. This means to achieve a level of risk equal to that of normal trips, operators must be almost 400 times more likely to damage the core without annunciators that with annunciators. Even with a multiple of 400, the resultant risk due to trips accompanied by loss of annunciators is approximately E-07 per reactor year.

Another way of looking at this comparison is that if the operator is twice as likely to make an error which results in core damage due to loss of annunciators, the increase in overall risk per reactor year due to reactor trips is approximately 0.25 percent. This is expected because operating experience shows that approximately 0.25 percent of reactor trips are accompanied by loss of annunciators.

Loss of Offsite Power

Using a calculation similar to above, ASP calculates the CCDP for a single LOOP event to be 5E-04 and the frequency of a LOOP is 1E-01 per year. On the other hand, operating data shows that 2 LOOPs in the past 800 reactor years of operation have occurred concurrent with loss of annunciators. The risk of core damage per year resulting from LOOPs with loss of annunciators can then be estimated to be (2/800) x 5E-04 x B, where B is a factor by which the probability of human error leading to core damage must be multiplied due to loss of annunciators. Again, for purposes of comparison of risk, we equate the risk per reactor year due to normal LOOPs and the risk per year due to LOOPS accompanied by loss of annunciators, we have the following:

$$1E\text{-}01 \times 5E\text{-}04 = 5E\text{-}04 \times 2/800 \times B$$

Solving for B equals 40. This means to achieve a level of risk equal to that of normal LOOPs, operators must be about 40 times more likely to damage the core without annunciators than with annunciators. Again, with a multiplier of 40, the resultant risk due to LOOPS accompanied by loss of annunciators is approximately 5E-05 per year.

Again, if the operator is twice as likely to make an error which results in core damage due to loss of annunciators, the increase in overall risk per reactor year due to LOOPs is approximately 2.5 percent. This is expected because operating experience shows that approximately 2.5 percent of LOOPs are accompanied by loss of annunciators.

Independent Events

Loss-of-Coolant Accident

The assumption that the loss of annunciators and the event of concern are independent changes the calculation such that the risk of a concurrent event and loss of annunciators is the product of the risk per reactor year of the event times the probability of loss of annunciator. The independent probability of loss of annunciators is the ratio of hours lost in 1 year of operation compared to hours of operation in 1 year.

It is possible to calculate risk numbers similar to those above for trips and LOOPs, but with loss of annunciators assumed to be independent. ASP calculates the CCDP for a single LOCA event to be 1E-05 and the frequency of 1E-02 per year. On the other hand, operating data shows that annunciators are lost 0.1375 times per year for a duration of 2 hours average. The risk of core damage per reactor year resulting from LOCAs with loss of annunciators can then be estimated to be (.275/8760) x 1E-05 x 1E-02 x C, where C is a factor by which the probability of human error leading to core damage must be multiplied due to loss of annunciators. Again, for purposes of comparison of risk, we equate the risk per reactor year due to normal LOCAs and the risk per reactor year due to LOCAs accompanied by loss of annunciators, we have the following:

$$1E\text{-}02 \times 1E\text{-}05 = 1E\text{-}05 \times (0.275/8760) \times 1E\text{-}02 \times C$$

Solving for C equals 32,000. This means to achieve a level of risk equal to that of normal LOCAs, operators must be about 32,000 time more likely to damage the core without annunciators than with annunciators. Again, even with a multiplier of 32,000, the resultant risk due to LOCAs accompanied by loss of annunciators is approximately 1E-07 per reactor year.

Another way of looking at this comparison is that if the operator is twice as likely to make an error which results in core damage due to loss of annunciators, the increase in overall risk per reactor year due to LOCAs is approximately 0.003 percent. This is expected if LOCAs are independent of loss of annunciator events such that one in 32,000 LOCAs would be accompanied by loss of annunciators.

The primary reasons for the risk probability due to loss of annunciators is small are: (1) low frequency of high risk events, (2) low frequency of loss of annunciators (high availability), and (3) low risk of core damage even with degraded operator action because many important safety functions are automatic.

6. Conclusions

This report documents the data collection by AEOD/ROAB of the loss of 110 annunciator and computer events which was used as the bases for the SRM response on loss of annunciators. NRR evaluation, AEOD risk calculations, and three AIT reports have concluded that the loss of annunciator is of minimal safety significance. The AEOD risk calculations do not address the impact of losses during low power and shutdown conditions.

The present risk assessment models do not have the capability to model the human performance factor. However, AEOD used techniques to bound the risk calculations that concluded the contributions by inoperable annunciators and human performance would contributes little to the core damage frequency during power operations.

The AIT reports found problems with the classification and notification of the emergencies. A joint evaluation by AEOD and NRR concluded that the NRC has provided the licensees adequate guidance to develop the emergency procedures.

7. References

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2. U.S. Nuclear Regulatory Commission, Augmented Inspection Team Report, Inspection Report 50-530/92-19, Palo Verde Nuclear Generating Station Unit 3, "Loss of Annunciator Event," May 8-14, 1992.

3. U.S. Nuclear Regulatory Commission, Augmented Inspection Team Report, Inspection Report 50-483/92-18 (DRP), Callaway Nuclear Generating Station, "Loss of Annunciator Event," October 16-19, 1992.

4. U.S. Nuclear Regulatory Commission, Augmented Inspection Team Report, Inspection Reports 50-272/92-81 and 50-311/92-81, Salem Nuclear Generating Station Unit 2, "Loss of Annunciator Event," December 14-23, 1992.

5. U. S. Nuclear Regulatory Commission, "Transformer Failure and Common-Mode Loss of Instrument Power at Nine Mile Point Unit 2 on August 13, 1991," NUREG-1455, October 1991.

6. U.S. Nuclear Regulatory Commission, memorandum from E. L. Jordan to T. E. Murley, "Adequacy of Emergency Operating Procedures and Training Associated With Loss of All Control Room Annunciators," July 15, 1992.

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8. U.S. Nuclear Regulatory Commission, memorandum from J. M. Taylor to The Chairman and Commissioners, "Role of AEOD in Oversight of Operating Reactors," June 4, 1993.

9. U.S. Nuclear Regulatory Commission, memorandum from T. E. Murley, E. L. Jordan, "Declaration of alert for Loss of Annunciators," February 4, 1993.

10. Nuclear Management and Resources Council, "Methodology for Development of Emergency Action Levels," NUMARC/NESP-007, Rev. 2, January 1992.

11. U.S. Nuclear Regulatory Commission, memorandum from Jared Wermiel to B. A. Boger, "Emergency Action Level Regarding Loss of Annunciation," February 2, 1993.

APPENDIX A

AIT/IIT LOSS OF ANNUNCIATOR SUMMARY

APPENDIX A

AIT/IIT Loss of Annunciator Summary

SALEM UNIT 2 AITS

Report Nos. 50-272/92-81 and 50-311/92-81

On December 13, 1992, a Salem Unit 2 control room operator discovered that the overhead annunciators had not been updating for about 1-½ hours. The system was promptly restored within 2 minutes of discovery. The operating crew discussed the annunciator loss and concluded that an emergency declaration was not required because the problem had been corrected within 15 minutes after discovery. The control room operators had been using the remote work-station computer and had entered a keystroke combination that prevented the system from displaying alarms. During this event the process computer and SPDS were operable. Power was at 100 percent at the time of the annunciator loss.

The AIT found no safety consequences due to the loss of the overhead annunciators. However, the undetected loss of the annunciator system could delay operator response or increase the likelihood of errors while responding to abnormal plant conditions. Control room operators failed to abide by station operating practice when they tried to use password-protected software. The overhead annunciator system was a new digital system that was a replacement for an outdated analog system. The modification to install the new system had little software review. The plant did not have a loss of annunciator procedure nor were the operators trained in the simulator on loss of annunciators.

PALO VERDE UNIT 3 AIT

Report No. 50-530/92-19

On May 4, 1992, with unit at 100 percent power, an electrician working on a 480 V ac load center dropped an electrical lead. The lead was energized from a 24 V dc power supply in the plant annunciator system. The loose lead came in contact with the 480 V ac. This short circuit caused a loss of the plant annunciator system and a slow degradation of the computer alarm system. Three hours after the short circuit, the operators reduced reactor power to comply with Technical Specifications. An Alert was declared after losing the remaining process computer alarm functions. The plant remained at 70 percent power until the annunciator and computer systems were fixed to a confidence level for reactor shutdown which occurred 4 days later.

The AIT found no significant nuclear safety matters identified during this inspection. They concluded that the work planner and the electrician failed to follow procedures. The resultant short circuit significantly degraded the ability to monitor plant parameters, impacted the plant computer calculations of plant safety limits, and raised the issue of adequate separation between safety-related and nonsafety-related equipment. The operating procedures and training did not cover the total loss of nonsafety-related annunciators, or annunciators and computer systems. The annunciator system was totally inoperable, as was the process computer which impacted the SPDS operability.

CALLAWAY AIT

Report No. 50-483/92018(DRP)

On October 19, 1992, engineers reviewing operating data discovered that at 1:00 a.m. on October 17, all main control room annunciators had failed without the operators knowledge. On October 16, with the reactor at 100 percent power, 76 annunciator windows illuminated. Problems with the annunciator system were identified and corrected during most of the October 17 day shift. The system was not completely operable until 25 hours after the initial problem was identified. Lack of annunciator system knowledge hampered the operators in correcting the problems. Operators considered the annunciator system partially operable when in fact, the system was completely inoperable.

The AIT determined that the actual safety significance was minimal and determined four main root-causes. Communication and teamwork was inadequate. There was a lack of a questioning attitude. The operators did not know the annunciator system well enough to know its failure modes and operability status. Work performance was less than adequate. Plant procedures and training did not address the symptoms for a partial or total loss of the plant annunciator system or the partial loss of the plant computer. There was no procedure guidance on the maintenance of a steady-state reactor power level after the loss of annunciators. There was no simulator training similar to this event.

NINE MILE POINT UNIT 2 IIT

"Transformer Failure and Common-Mode Loss of Instrument Power at Nine Mile Point Unit 2 on August 13, 1991," NUREG-1455, October 1991

On August 13, 1991, a main transformer internal fault caused a reactor scram. Before automatic protective features actuated, the fault depressed voltages on the electrical distribution system. The degraded voltage resulted in a simultaneous common-mode loss of five uninterruptible power supply (UPS) units that powered important control room instrumentation. All the safety related systems were available. However, control rod position indication was lost, and operators took conservative actions as if there had been a failure to scram. The operators experienced difficulty because of the loss of many normally available indications. Some of the lost equipment included control rod position, condensate and feedwater system controls, all control room annunciators, in-plant communications systems, plant fire alarms, plant computer systems, and plant lighting.

The IIT concluded that the event did not pose a threat to plant safety, because the scram functioned properly. The significance of the event lies in the challenge that it presented to the operators and the potential that severe challenges and resultant stress may cause errors of omission or commission. The event was also significant because of the simultaneous failure and common-mode vulnerability of the multiple UPSs. The simultaneous loss of five UPSs was unexpected and presented a unique challenge to both equipment and operators. Failure of the UPS units was due to internal design deficiency and inadequate preventative UPS maintenance.

APPENDIX B

SUMMARY OF COMPILED EVENTS

LOSS OF ANNUNCIATOR OR COMPUTER
(JANUARY 1985-MARCH 1993)

PLANT	ENS NO.	LER NO.	POWER LEVEL	EMER CLASS	TRANS	EVENT TIME	START DATE	EVENT TIME	END DATE	EVENT LENGTH (HRS)	ANN	COMP	SPDS
BEAVER VALLEY 2	11357	NONE	0	ALERT	N	1908	01/28/88	2245	01/28/88	3.3	T	N	N
BRAIDWOOD 1	7620	NONE	0	NONE	N	1815	01/38/87	2047	01/28/87	2.5	N	T	?
BRAIDWOOD 1	7997	NONE	0	NONE	N	2038	03/09/87	2130	03/09/87	1.0	N	P	P
BRAIDWOOD 1	8461	NONE	0	NONE	N	0915	04/23/87	1250	04/23/87	3.6	N	P	T
BRAIDWOOD 1	9576	NONE	22	NONE	N	0137	08/07/87	0355	08/07/87	2.3	N	T	T
BRAIDWOOD 1	10002	NONE	2	NONE	N	0306	09/16/87	0415	09/16/87	3.2	N	T	T
BRAIDWOOD 1	24980	NONE	100	NONE	N	0240	01/30/93	0650	01/30/93	4.2	N	T	T
BRAIDWOOD 1	22060	NONE	99	NONE	N	1313	10/21/91	1627	10/21/91	3.2	N	T	T
BRAIDWOOD 1	24608	NONE	66	NONE	N	1725	11/14/92	?	?	>2.0	N	T	T
BRAIDWOOD 1	21783	NONE	90	NONE	N	0924	09/07/91	?	?	?	N	?	T
BRAIDWOOD 2	22455	NONE	99	NONE	N	0727	12/14/91	?	?	>2.0	N	N	T
BRAIDWOOD 2	13735	NONE	88	NONE	N	2306	10/17/88	?	?	>2.0	N	T	T
BRUNSWICK 2	17411	NONE	0	ALERT	N	1525	12/22/89	1644	12/22/89	2.3	P	N	N
BRUNSWICK 2	16655	NONE	0	ALERT	N	0830	09/21/89	1053	09/21/89	2.4	T	N	N
BYRON 1	11993	NONE	0	NONE	N	2012	04/11/88	2110	04/11/88	0.9	N	T	T
BYRON 1	3323	NONE	97	NONE	N	0020	01/13/86	?	?	?	N	T	T
BYRON 1	7279	NONE	94	NONE	N	2139	12/22/86	2347	12/28/86	2.1	N	T	T
BYRON 1	10188	NONE	98	NONE	N	0601	10/02/87	0740	10/02/87	1.6	N	T	T
BYRON 1	3319	NONE	97	NONE	N	1650	01/11/86	1130	01/12/86	18.7	N	T	T
BYRON 1	3310	NONE	96	NONE	N	1600	01/10/86	2100	01/10/86	5.0	N	T	T
BYRON 1	16469	NONE	100	NONE	N	2007	09/01/89	?	?	?	N	T	T
BYRON 1	16922	NONE	93	NONE	N	0552	10/24/89	0727	10/24/89	1.6	N	P	T
BYRON 1	20079	NONE	100	NONE	N	2227	12/14/90	0358	12/15/90	5.5	N	T	T

LOSS OF ANNUNCIATOR OR COMPUTER
(JANUARY 1985-MARCH 1993) (CONT.)

PLANT	ENS NO.	LER NO.	POWER LEVEL	EMER CLASS	TRANS	EVENT TIME	START DATE	EVENT TIME	END DATE	EVENT LENGTH (HRS)	ANN	COMP	SPDS
BYRON 1	24466	NONE	100	NONE	N	2130	10/20/92	0014	10/21/92	0.2	N	T	T
BYRON 1	14325	NONE	100	NONE	N	0030	12/23/88	0745	12/23/88	7.3	N	T	T
BYRON 2	24604	NONE	97	NONE	N	0127	11/14/92	0554	11/14/92	4.4	N	T	T
BYRON 2	7029	NONE	0	NONE	N	2303	11/27/86	?	?	>2.0	N	T	T
BYRON 2	12371	NONE	94	NONE	N	1556	05/24/88	2330	05/24/88	7.6	N	T	T
BYRON 2	16908	NONE	81	NONE	N	0603	10/22/89	1012	10/22/89	4.1	N	T	T
BYRON 2	20731	NONE	93	NONE	N	1231	03/29/91	?	?	>2.0	N	T	T
BYRON 2	21551	NONE	85	NONE	N	0814	08/06/91	2015	08/06/91	12.0	N	T	T
BYRON 2	9057	NONE	23	NONE	N	0125	06/20/87	?	?	>2.0	N	T	T
BYRON 2	12055	NONE	94	NONE	N	0545	04/19/88	?	?	?	N	T	T
CALLAWAY 1	24453	92-011	100	NONE	N	0100	10/17/92	0156	10/17/92	0.9	T	N	N
CALLAWAY 1	24681	NONE	100	NONE	N	1356	12/01/92	1908	12/01/92	5.1	P	N	N
CALVERT CLIFFS 2	11389	NONE	100	ALERT	N	1646	02/01/88	1918	02/01/88	2.5	T	N	N
COMANCHEPEAK	0	NONE	100	NONE	N	1054	08/25/92	1157	08/25/92	1.1	P	N	N
CRYSTAL RIVER 3	10365	87-025	0	NONE	N	2130	10/16/87	2210	10/16/87	0.7	T	T	T
DRESDEN 2	23768	92-022	77	ALERT	N	1130	07/01/92	1905	07/01/92	7.6	T	N	N
DRESDEN 2	15117	NONE	97	ALERT	N	0435	03/25/89	0440	03/25/89	0.1	P	N	N
DRESDEN 3	23173	NONE	0	ALERT	N	2025	04/04/92	0155	04/05/92	5.5	T	N	N
DRESDEN 3	21880	91-011	0	ALERT	N	1053	09/23/91	1113	09/23/91	0.3	T	N	N
FITZPATRICK	4795	NONE	0	NONE	N	0310	05/25/86	0325	05/25/86	0.2	P	N	N
HADDAM NECK	9366	NONE	0	UE	N	0756	07/20/87	0828	07/20/87	0.6	P	N	N
HARRIS	20458	NONE	99	UE	N	0312	02/15/91	2110	02/15/91	18.0	N	T	T

LOSS OF ANNUNCIATOR OR COMPUTER
(JANUARY 1985-MARCH 1993) (CONT.)

PLANT	ENS NO.	LER NO.	POWER LEVEL	EMER CLASS	TRANS	EVENT TIME	START DATE	EVENT TIME	END DATE	EVENT LENGTH (HRS)	ANN	COMP	SPDS
HARRIS	25030	NONE	100	UE	N	0411	02/06/93	1230	02/06/93	8.3	N	T	?
HARRIS	7612	NONE	7	NONE	N	2153	01/27/87	2216	01/27/87	0.4	N	T	T
HARRIS	13170	NONE	0	ALERT	N	0950	08/12/88	0959	08/12/88	0.2	P	N	N
HOPE CREEK	0	DAILY	100	NONE	Y	0650	11/21/92	?	?	?	N	T	?
KEWAUNEE	8386	NONE	98	NONE	N	1245	04/15/87	1251	04/15/87	0.1	P	N	N
LASALLE 1	2819	NONE	0	NONE	N	0100	11/21/85	?	?	?	N	T	T
LASALLE 1-2	9524	NONE	95	NONE	N	2338	08/02/87	0008	08/03/87	0.5	N	T	T
LASALLE 1-2	12432	NONE	92	NONE	N	0138	06/01/88	?	?	?	N	T	T
LASALLE 1-2	17469	NONE	0	NONE	N	1105	12/31/89	?	?	?	N	T	T
LASALLE 1-2	5746	NONE	0	NONE	N	1340	08/04/86	1505	08/04/86	1.2	N	T	T
LASALLE 1-2	5612	NONE	0	NONE	N	1510	07/24/86	1600	07/24/86	0.8	N	T	T
LASALLE 1-2	9517	NONE	76	NONE	N	1808	08/01/87	?	?	?	N	T	T
MILLSTONE 2	21467	NONE	100	ALERT	N	1255	07/26/91	2345	07/26/91	10.8	T	N	N
NINE MILE POINT 1	11485	NONE	0	NONE	N	1306	02/11/88	?	?	>8.0	N	T	T
NINE MILE POINT 1	7314	NONE	100	NONE	N	2040	12/26/86	?	?	>4.0	N	T	T
NINE MILE POINT 1	9868	NONE	90	NONE	N	2000	09/03/87	?	?	>4.0	N	T	T
NINE MILE POINT 1	10016	NONE	90	NONE	N	1350	09/16/87	0130	09/16/87	36.3	N	T	T
NINE MILE POINT 1	3064	NONE	75	NONE	N	1300	12/14/85	?	?	>4.0	N	T	N
NINE MILE POINT 1	11505	NONE	0	NONE	N	1035	02/14/88	?	?	>4.0	N	T	T
NINE MILE POINT 1	16449	NONE	0	NONE	N	0429	08/31/89	1435	08/31/89	10.1	N	T	T
NINE MILE POINT 1	18355	NONE	0	NONE	N	1811	04/28/90	?	?	>4.0	N	T	T
NINE MILE POINT 1	20385	NONE	97	NONE	N	0450	02/05/91	?	?	?	N	T	T

LOSS OF ANNUNCIATOR OR COMPUTER
(JANUARY 1985-MARCH 1993) (CONT.)

PLANT	ENS NO.	LER NO.	POWER LEVEL	EMER CLASS	TRANS	EVENT TIME	START DATE	EVENT TIME	END DATE	EVENT LENGTH (HRS)	ANN	COMP	SPDS
NINE MILE POINT 1	24159	NONE	100	NONE	N	1927	09/01/92	2000	09/02/92	>4.0	N	T	T
NINE MILE POINT 1	4702	NONE	0	NONE	N	1036	05/18/86	?	?	>4.0	N	T	T
NINE MILE POINT 1	2976	NONE	97	NONE	N	0527	12/07/85	?	?	>4.0	N	T	N
NINE MILE POINT 1	561	NONE	100	NONE	N	1120	04/23/85	?	?	>4.0	N	T	N
NINE MILE POINT 1	503	NONE	85	NONE	N	2315	04/17/85	0515	04/18/85	6.0	N	T	N
NINE MILE POINT 2	23078	92-006	0	ALERT	N	1008	03/23/92	1131	03/23/92	1.4	T	T	T
NINE MILE POINT 2	21546	NONE	99	UE	N	0629	08/06/91	0830	08/06/91	10.0	N	T	N
NINE MILE POINT 2	21602	NONE	100	SAE	Y	0600	08/13/91	0622	08/13/91	2.0	T	T	T
NINE MILE POINT 2	23096	92-007	0	NONE	N	0820	03/26/92	0832	03/26/92	0.2	P	P	N
NORTH ANNA 1	4879	86-009	100	NONE	Y	2131	05/31/86	1232	05/31/86	0.1	T	N	N
NORTH ANNA 1-2	24663	NONE	100	NONE	N	0845	11/26/92	?	?	?	N	N	T
OCONEE 1	574	85-007	100	ALERT	Y	0512	04/25/85	0531	04/25/85	0.3	P	N	N
PALISADES	8509	87-014	99	NONE	N	1758	04/27/87	2100	04/27/87	3.0	N	P	N
PALO VERDE 2	25123	NONE	100	NONE	N	0415	02/23/93	1700	02/23/93	12.7	P	N	N
PALO VERDE 3	23396	NONE	100	ALERT	N	0436	05/04/92	0230	05/07/92	69.9	T	T	T
PERRY 1	8064	87-002	29	ALERT	Y	2114	03/16/87	2119	03/16/87	0.1	T	N	N
PRAIRIE ISLAND 1	19187	NONE	100	UE	N	1443	08/23/90	1745	08/23/90	3.0	T	N	N
PRAIRIE ISLAND 1	21003	NONE	79	UE	N	0858	05/14/91	0932	05/14/91	0.6	N	T	?
QUAD CITIES 1	23211	92-010	100	ALERT	Y	2258	04/09/92	2310	04/09/92	0.2	T	N	N
QUAD CITIES 1	23190	92-010	100	ALERT	Y	1256	04/07/92	1310	04/07/92	0.2	T	N	N
QUAD CITIES 1	22818	92-006	0	ALERT	N	2235	02/14/92	2358	02/14/92	1.4	T	N	N
QUAD CITIES 2	22681	NONE	0	ALERT	N	0620	01/25/92	?	?	?	T	N	T
QUAD CITIES 2	8726	87-007	90	NONE	N	0450	05/20/87	?	?	?	P	N	N

LOSS OF ANNUNCIATOR OR COMPUTER
(JANUARY 1985-MARCH 1993) (CONT.)

PLANT	ENS NO.	LER NO.	POWER LEVEL	EMER CLASS	TRANS	EVENT TIME	START DATE	EVENT TIME	END DATE	EVENT LENGTH (HRS)	ANN	COMP	SPDS
RANCHO SECO	11455	NONE	0	NONE	N	1847	02/08/88	?	?	?	T	N	N
RANCHO SECO	2688	NONE	0	NONE	N	1330	11/08/85	1134	11/08/85	0.1	P	P	T
RANCHO SECO	2678	NONE	15	NONE	N	1513	11/07/85	1410	11/07/85	0.4	P	P	T
RANCHO SECO	2587	85-028	0	NONE	N	1545	10/30/85	?	?	?	N	P	N
RANCHO SECO	2526	NONE	0	NONE	N	2000	10/24/85	2224	10/24/85	2.4	N	P	T
SAINT LUCIE 2	3943	NONE	100	UE	N	1610	02/17/86	1620	02/17/86	0.2	P	N	N
SALEM 1	24895	NONE	0	NONE	N	1209	01/16/93	1231	01/16/93	0.4	N	P	N
SALEM 2	24752	92-017	100	NONE	N	1946	12/13/92	2123	12/13/92	1.6	T	N	N
SURRY 1	4585	86-014	0	NONE	N	0841	05/11/86	0905	05/11/86	0.4	P	N	N
SUSQUEHANNA 1	7262	NONE	0	NONE	N	1421	12/20/86	1814	12/20/86	3.9	N	T	T
WATERFORD 3	16557	NONE	100	NONE	N	1025	09/10/89	?	?	>1.0	N	P	T
WATERFORD 3	24533	NONE	0	NONE	N	2156	10/29/92	2303	10/29/92	1.1	N	T	T
WATERFORD 3	9127	NONE	100	NONE	N	2045	06/26/87	2203	06/26/87	1.3	N	T	T
WATERFORD 3	6024	NONE	100	NONE	N	2045	08/27/86	0120	08/28/86	4.6	N	T	T
WATERFORD 3	25176	NONE	90	NONE	N	0816	03/04/93	?	?	>1.0	N	T	T
YANKEE ROWE	21205	91-002	88	ALERT	Y	2350	06/15/91	0235	06/16/91	2.8	P	P	T
ZION 1	16771	89-017	0	NONE	N	1330	10/04/89	1522	10/04/89	<2.0	N	T	?
ZION 1	16032	NONE	99	UE	N	0125	07/06/89	0715	07/06/89	5.8	P	N	N
ZION 2	18849	NONE	0	ALERT	N	0345	07/07/90	0400	07/07/90	0.2	T	N	N
ZION 2	15950	89-008	99	ALERT	N	1515	06/24/89	2033	06/24/89	5.3	T	N	N