OCT 0 2 1984

MEMORANDUM FOR: C. J. Heltemes, Director
Office for Analysis and Evaluation
of Operational Data

FROM: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

SUBJECT: PROPOSED ABNORMAL OCCURRENCE - LOSS OF OFFSITE AND ONSITE AC ELECTRICAL POWER

Your memorandum of September 7, 1984, requested our comments and concurrence on the proposed abnormal occurrence write up for the loss of offsite and onsite AC electrical power at Susquehanna Unit 2 on July 26, 1984.

We concur with your findings that this event represents an abnormal occurrence (AO); however, we have four recommendations regarding the proposed write up:

1. The potential consequences of the event be discussed and put in better perspective.

2. The cause section be strengthened to focus on the human engineering aspects of the event and to include specifics on the causes for the problems with manual start of the emergency diesel generators, and the loss of some control room indications.

3. The possible generic implications listed at the end of the write up be summarized (rather than detailed) since NRC evaluation is still in progress.

4. A simplified electrical distribution sketch be included (if not in this Federal Register Notice, in the quarterly report to Congress).

Enclosure 1 provides proposed write ups which address recommendations 1, 2, and 3. Additional comments of an editorial nature are provided for your consideration on a marked-up copy of your proposed write up (Enclosure 2). Questions should be addressed to Scott Newberry (x28932).

Original Signed by
H. R. Denton
Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosures:
As stated

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IDHR-5-1
OPERATING EXPERIENCE
RD-7-2-1

*PREVIOUS CONCURRENCE SEE DATE

ORAB:DL*	ORAB:DL*	C:ORAB:DL*	AD/SA:DL*	D/DL*	DD/NRR	D/NRR
SNewberry:dm	EButcher	GHolahan	DCrutchfield	DEisenhut	ECase	HDenton
09/25/84	09/25/84	09/25/84	09/26/84	09/27/84	10/3/84	10/3/84

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ENCLOSURE 1

1. Add at the end of "Nature and Probable Consequences"

The High Pressure Coolant Injection (HPCI) and Reactor Core Isolation Cooling (RCIC) systems were available to provide makeup water to protect the core until power was restored. For the initial operation at 30% power, about two hours would be available before the collapsed water level reached the top of the active fuel if these systems are postulated to fail (no reactor coolant makeup at all). The automatic initiation level for HPCI and RCIC would be reached in about 20 to 25 minutes after the reactor trip so that time would exist for one of these systems to be manually started by the operator(s).

2. Add at the end of "Cause or Causes"

The difficulties associated with manually starting the diesel generators was due primarily to operator error. The errors are attributed, however, to the lack of procedures and training regarding manual voltage adjust settings and diesel trip reset features.

Some control room indicators were lost for longer than necessary due to lack of training and procedures on how to reset equipment after a loss of power.

3. Revise Possible Generic Implications as follows:

The NRC investigation, while not fully documented at the time of this report, has identified several possible generic implications from this event which may require further review. These include:

1. Adequacy of annunciation and control room indications.
2. Restart capability of emergency diesel generators under abnormal conditions.
3. Adequacy of human engineering aspects including labels, administrative controls and independent verification requirements.

Enclosure 2

Proposed editorial Comments

DRAFT

For: The Commissioners

From: William J. Dircks
Executive Director for Operations

Subject: ABNORMAL OCCURRENCE RECOMMENDATION - LOSS OF OFFSITE AND ONSITE AC ELECTRICAL POWER

Purpose: Approval of an abnormal occurrence determination

Discussion: Enclosed is a draft Federal Register notice of an abnormal occurrence (AO) in regard to an event at Susquehanna Unit 2 on July 26, 1984, during a startup test, which involved a temporary loss of all AC power including failure of the emergency diesel generators to supply power to the engineered safety system busses.

This item is proposed for abnormal occurrence (AO) reporting based on one of the general criteria of the AO policy statement, i.e., major degradation of essential safety-related equipment can be considered an AO.

Recommendation: That the Commission:

1. Approve the subject proposed abnormal occurrence recommendation together with its associated Federal Register notice, and

CONTACT:
Paul Bobe, AEOD
492-4426

Recommendation: (Cont'd)

2. Note that following approval, the Office of Congressional Affairs will notify the appropriate Congressional committees of the intent to publish the Federal Register notice, and

3. Note that it is planned to include the item in the third quarter CY 1984 AO report, which is presently under preparation.

Scheduling: While no specific circumstances require Commission action by a particular date, it is desirable to disseminate abnormal occurrence information to the public as soon as possible. It is expected that Commission action within two weeks of receipt of this draft proposal would permit publication in the Federal Register about ten days later.

William J. Dircks
Executive Director for Operations

Enclosure:
Draft Federal Register
Notice

DRAFT

NUCLEAR REGULATORY COMMISSION

ABNORMAL OCCURRENCE

LOSS OF OFFSITE AND ONSITE AC ELECTRICAL POWER

Section 208 of the Energy Reorganization Act of 1974, as amended, requires the NRC to disseminate information on abnormal occurrences (i.e., unscheduled incidents or events which the Commission determines are significant from the standpoint of public health and safety). The following incident was determined to be an abnormal occurrence using the criteria published in the Federal Register on February 24, 1977 (42 FR 10950). One of the general criteria notes that major degradation of essential safety-related equipment can be considered an abnormal occurrence. The following description of the incident also contains information on the remedial actions planned and taken.

Date and Place - On July 26, 1984, Susquehanna Steam Electric Station (SSES) Unit 2 experienced an event involving a temporary loss of all AC power including failure of the emergency diesel generators (EDGs) to supply power to the engineered safety system (ESS) busses. SSES Units 1 and 2 are boiling water reactor nuclear power plants operated by Pennsylvania Power and Light Company (the licensee) and located in Luzerne County, Pennsylvania. Unit 2 had received a full power operating license on June 27, 1984. With the unit operating at 30% power, the licensee was conducting planned startup testing at the time of the event. Unit 1 operated at 100% power throughout the event at Unit 2.

Nature and Probable Consequences - The purpose of the startup test ("Loss of Turbine Generator and Offsite Power") was to demonstrate that the dynamic response of Unit 2 was in accordance with design. Initial conditions of the test required Unit 2 to be at approximately 30% power and its electrical distribution system to be separated and isolated from the Unit 1 system. The test would be initiated by opening the Unit 2 turbine-generator output breakers and simultaneously opening the Unit 2 output breaker from the startup transformer (i.e., load reject and loss of offsite power). Thirty minutes after the test initiation, the test would be terminated. The test results would then determine whether test acceptance criteria are satisfied, i.e., (1) all safety systems such as the reactor protection system (RPS), EDGs, reactor core isolation cooling (RCIC) system and high pressure coolant injection (HPCI) system, must function properly without manual assistance, and (2) HPCI and/or RCIC action, if necessary, shall keep reactor water level above the initiation level of the core spray system, low pressure coolant injection (LPCI) system, and automatic depressurization system (ADS).

Separation and isolation of electrical supplies required (1) feeding all Unit 1 4160V ~~ESS~~ ESF busses from the Unit 1 startup transformer, (2) feeding all Unit 2 4160V ~~ESS~~ ESF busses from the Unit 2 startup transformer, (3) racking out all cross-tie feeder breakers from the Unit 1 startup transformer to the Unit 2 4160V ~~ESS~~ ESF busses, (4) racking out the 13.8 kV cross-tie breaker between Unit 1 and Unit 2 auxiliary busses, and (5) placing all common loads on Unit 1 supplies. This electrical configuration and other test prerequisites were established by 1:05 a.m on July 26, 1984.

The startup test was initiated at 1:37 a.m. by manually tripping, (opening) the Unit 2 main generator output breakers and the Unit 2 startup transformer feeder breaker to the Unit 2 startup bus. This resulted in a reactor scram due to turbine trip from control valve fast closure on the simulated load reject, deenergization of the 13.8 kV busses and deenergization of the four Unit 2 4160V ~~ESS~~ ESF busses. The turbine bypass valves properly opened automatically to limit the initial pressure transient, and the loss of power to the RPS motor generator sets properly initiated primary and secondary containment isolations. The above sequence was as expected; however, the operator at the electrical distribution panel noted that none of the four EDGs ~~did not~~ started and that the feeder breakers from the two Unit 2 ~~ESS~~ ESF transformers to the four 4160V ~~ESS~~ ESF busses remained closed. These breakers should have automatically opened and the diesels started upon ~~ESS~~ ESF bus deenergization due to the de-energized startup transformer. ~~Therefore, all AC power for Unit 2 was lost.~~ As a result of the diesels not starting, and providing emergency AC power, all AC power for Unit 2 was lost.

As discussed later, this total loss of AC power resulted in most instrumentation in the control room failing downscale which complicated operator response to the event. Also as discussed later, simultaneously with the total loss of AC power, the plant was further degraded due to the total ~~loss~~ lack of DC power to the ESS logic circuitry. The operators were unaware of this DC power loss since the plant design did not provide control room annunciation of this loss of function. The consequences of the degraded ESS logic circuitry resulted in the following loss of functions: (1) automatic transfer capability of ESS busses to alternate power sources, (2) automatic diesel generator start on loss of bus sources, (3) ability to re-energize 4160V ESS busses from an offsite source from the control room, (4) automatic bus load shedding, (5) degraded grid and undervoltage protection, (6) 4160V bus feeder breaker overcurrent or differential current protection, and (7) core spray or residual heat removal (RHR) pump automatic or manual start capability even with bus power available; hence the low pressure emergency core cooling systems (ECCS) were disabled.

Upon noting that the EDGs did not start, the operator opened the feeder breakers from the two Unit 2 ESS transformers to the four 4160V ESS busses. When the EDGs still did not start, the operator manually started all four diesels. EDG D tripped on overvoltage and B tripped on overvoltage and underfrequency. EDG C stabilized at an idle. EDG A exhibited large frequency oscillations and was manually tripped by the operator. The operator tried to manually close the EDG C breaker onto the associated ESS bus, but the breaker did not close (operator error). The operator then reenergized the startup bus by closing the Unit 2 startup transformer feeder breaker to the startup bus and reenergized the two Unit 2 ESS transformers. The operator next attempted to close the Unit 2 ESS transformers feeder breakers to the 4160V ESS busses, but the feeder breakers would not close. The Unit Supervisor then instructed a Nuclear Plant Operator (non-licensed) in the Unit 2 reactor building to rack in the feeder breakers from the Unit 1 startup transformer to the four Unit 2 4160V ESS busses.

As the Unit 1 feeder breakers to the Unit 2 4160V ESS busses were racked in and restored to operability, the preferred Unit 1 and 2 ESS transformer feeder breaker to each 4160V ESS bus closed, reenergizing the bus, and the tripped EDGs B, D, and A automatically started at 1:48 a.m., 1:50 a.m., and 1:54 a.m., respectively. At 1:50 a.m., the licensee declared an Unusual Event (the least severe category in the NRC's emergency classification system).

Power was restored to the first bus within 11 minutes and the last bus 17 minutes into the event. When power was restored to all four Unit 2 ~~ESS~~ ESF busses, EDGs A, B, and D had High Priority alarms and were remote-manually shut down. The operator in the EDG building reset the Hi Priority alarm on EDG A, but could not reset the High Priority alarm on EDGs B & D (operator error).

As mentioned previously, during the loss of all AC power to Unit 2, most instrumentation in the control room failed downscale. However, operators could monitor reactor water level on two narrow range instruments (0-60 inches) and reactor pressure on the HPCI and RCIC supply pressure indicators. The full core display provided erroneous indication that all rods had not inserted into the core, which initially confused the operators, but operators did believe the reactor was shut down because the source range monitor instrumentation indication and reactor pressure trends supported that conclusion. The control room operators had no indication of suppression pool temperature and no indication of reactor water level, below narrow range instrument zero. Personnel stationed at the local instrumentation racks, as part of the startup test, ~~were able to~~ provide*d* information to the control room when reactor water level dropped below this zero reading.

At 2:18 a.m., *25 minutes into the event*, RCIC was manually initiated at -27" reactor water level *on the narrow range instrument* (a level above the automatic initiation level of -31") to restore reactor vessel level. During the event, one safety relief valve had controlled reactor pressure and removed decay heat by lifting eight times. At 2:30 a.m., the licensee terminated the Unusual Event declaration.

There was no direct impact on public health or safety by the event. However, ~~essential~~ safety-related equipment designed to mitigate the consequences of design basis accidents, in the unlikely event that one occurred, was significantly degraded. *[Add consequence writeup]*

Cause or Causes - The cause of this event is attributed to *inadequate human engineering of local control panels*, ~~operator error, inadequate operator training, imprecise procedures, ineffective independent verification, and~~ inadequate implementation of corrective action for previously identified problems, *ineffective independent verification, imprecise procedures, inadequate operator training, and operator error.*

The process utilized to rack out each of four Unit 1 startup transformer supplies to Unit 2 4160V ~~ESS~~ ESF busses (one of the steps necessary before initiating the startup test) was identified to have been incorrectly performed. The normal practice for racking out a 4160V breaker is to ensure the breaker is open, enter the breaker cubicle and open the DC knife switch supplying DC control power for the breaker, and then to rack out the breaker. However, the operator was confronted with two DC knife switches and, due to a lack of adequate procedural information, mistakenly opened the wrong switch, thereby removing DC power to the ~~ESS~~ ESF logic circuitry for the bus rather than the DC control power to the breaker. The operator repeated the above error on all four 4160V ~~ESS~~ ESF busses. As discussed previously, one of the consequences of removing DC power to ~~the ESS~~ this ESF logic circuitry was to prevent EDG start on loss of bus sources.

The Unit 1 startup transformer ~~supply~~ cross-tie breakers to the Unit 2 4160V ~~ESS~~ ESF busses are located in the 01 cubicle of each bus. The 01 cubicle has two knife switches whereas all other breakers in the 4160V ESS bus have only one knife switch. The labels on the single knife switch breakers read "BREAKER CONTROL SWITCH AND TRIP CIRCUIT FUSES". This knife switch removes DC control power for the breaker. The operators commonly refer to this knife switch as "DC control power". The 01 cubicle breaker labels for the two knife switches read: "BREAKER CONTROL SWITCH AND TRIP CIRCUIT FUSES" (for the knife switch that removes DC control power for the breaker) and "DC CONTROL" (for the knife switch that provides DC power to the ~~ESS~~ ESF logic circuitry for the bus). When the non-licensed operator opened the first 4160V ~~ESS~~ ESF 01 cubicle door, he called the control room, informed them he was at the breaker and requested confirmation that they desired the breaker be racked out and DC control power removed. After receiving confirmation from the control room, the operator subsequently opened the knife switch labeled "DC CONTROL" and racked out the breaker. An experienced startup test engineer was with the operator to verify the adequacy of his actions, but ~~failed~~ did not to detect the error. The same operator and startup test engineer repeated the same action at each of the 4160V ~~ESS~~ ESF busses. No alarm indication of these actions was available in the control room, although an examination of local indicator lights on the front of the cubicle door would have shown an abnormality, namely ~~no~~ the bus feeder protection relay power light would have been extinguished. Also, an examination of the breaker position lights in the control room and the breaker cubicle door ~~should~~ could have alerted operators that the correct knife switch was not open. (Opening the knife switch labeled "BREAKER CONTROL SWITCH AND TRIP CIRCUIT FUSES" would have deenergized all indicating lights associated with the breaker.) During the investigation of the event by the licensee and NRC, two previous events were identified involving improper operations of the "DC CONTROL" knife switch during the preoperational test program in June and October, 1983. The licensee action following the second event was special operator training. The non-licensed operator who performed the breaker alignments on July 26, 1984 did not receive this particular training nor had he previously, according to his recollection, racked out a 4160V double knife switch breaker. He was, however, an experienced operator who had performed numerous breaker rackouts.

[Add causes of diesel start difficulties and loss of control room indications]

Actions Taken to Prevent Recurrence

Licensee - Immediately after the incident, the licensee initiated an investigation into the cause and instituted immediate and long-term corrective actions. Immediate corrective actions included: revising labeling of knife switches, adding ~~addition of~~ caution labels for ESF logic circuitry knife switches and painting the ~~ESS~~ ESF logic circuitry knife switch handles red; providing training in the proper rackout operation; revising procedures to include status of breaker position indicating light checks; performing seven successful starts on EDG A; revising procedures and providing training in EDG operation and alarm reset; successfully testing the EDG C's capability to close manually on a dead bus; examining all fuses in the DC control system for adequacy (size and type); revising the reset procedure for the full core display and training operators in the methods to get rod position information; revising procedures to reset the suppression pool temperature monitoring system after a loss of power; and revising surveillance procedures to assure monthly surveillance procedures do not adversely affect EDG automatic start capability.

The long-term corrective actions include: review and determination of adequacy of the station program for independent verification; review of station standard electrical operating practices for acceptability; development of operating instructions for each type breaker rackout, including light observance during the manual sequence; incorporation of proper terminology into training procedures; revise procedures drawings and checkoff lists; review and evaluation of the EDG testing program to determine adequacy; determination of adequacy of procedures for remote emergency start of EDGs; development of procedures for remote manual emergency start of EDGs; evaluation of overvoltage protection; determination if instrumentation available on loss of AC power is sufficient in number, location, and range for on-shift staff to safely handle a loss of AC power; performance of as-built verification of fuse size, type, and labeling on all 13.8 kV, 4160V, 480V load centers and DC power circuits; review of all surveillance, preventive maintenance, startup test, and operating procedures that require entry into the 13.8 kV, 4160V, 480V, and DC cubicles for technical adequacy and adequacy of control; and evaluation of the present design for compliance with Regulatory Guide 1.47 with respect to annunciation of loss of DC control power.

The licensee's immediate corrective actions were completed prior to NRC permission to restart the plant. The licensee plans to identify to the NRC the status and/or schedule for completing the long-term items.

NRC - NRC resident inspectors and a region-based specialist were in the control room witnessing the conduct of this test. On July 26, 1984, a team of NRC technical specialists were sent to the site to investigate the circumstances of the event. On July 26, 1984, a Confirmatory Action Letter was issued by the NRC Region I Administrator documenting his discussions with the licensee's Senior Vice President-Nuclear to bring Unit 2 to a cold shutdown condition and to not restart Unit 2 until a thorough investigation of the cause, implication, and deficiencies identified are corrected, and the Regional Administrator or his designee has been briefed and has approved the Unit restart. NRC issued a Confirmatory Order on July 27, 1984, confirming, effective immediately, the actions that were the subject of the Confirmatory Action Letter of July 26, 1984.

On July 30, 1984, the licensee briefed the NRC team on the results of the licensee's investigation, the implications, and the corrective actions taken and planned. The NRC investigation results were consistent with the licensee's. On July 31, 1984, the NRC witnessed the successful testing of EDG C's ability to manually load on a dead bus. Subsequently to these two actions, and following the conditions of the Order, the Regional Administrator approved restart of

Unit 2 on July 31, 1984. The NRC investigation, while not fully documented at the time of this report, has identified several possible generic implications from this event which may require further review. These include:

[Modify as proposed]

1. Adequacy of annunciation on loss of DC control power for undervoltage relays, EDG start relays, ECCS load start permissive relays, and bus protection relays.

2. Adequacy of control room instrumentation for blackout (loss of all AC power) in terms of the parameters, range, failure mode, and confusion factor.

3. Training on restart of EDGs, ability to manually start and load a diesel on a dead bus, ability to recognize abnormal switchgear indications, and adequacy of training program tracking.

4. Adequacy of corrective action system relative to human factor consideration.

5. Labeling, caution tags, or administrative control to disable DC control power.

6. Operator-induced common-mode failures.

7. Emergency manual EDG start capability from the control room.

8. Reliability of EDGs since all four were operable per surveillance procedures, but three out of the four were not immediately available.

An NRC inspection report is being prepared. Apparent violations of license technical specifications, together with the licensee's management and procedural controls, are being reviewed. Any deficiencies will be noticed to the licensee.

Dated in Washington, D.C. this day of 1984.

Samuel J. Chilk
Secretary of the Commission