61.0 NRC Inspection Report No. 50-315/316/97-024, Finding E1.1.b and Inspection Report No. 50-315/316/99010, Findings M.2.1.b and O1.2.b.1

Event Description:	Lack of a procedure for manually backwashing the ESW pump discharge strainers
Date of Event:	December 1997 and May 1999
Plant:	Donald C. Cook Nuclear Plant, Units 1 and 2

61.1 Event Summary

During inspections by the NRC staff at Donald C. Cook Nuclear Plant, Units 1 and 2 (Cook 1 and 2) in December 1997 and May 1999, the inspectors identified a violation in which the licensee failed to treat the manual backwashing of the essential service water (ESW) strainers in accordance with quality standards commensurate with the importance of the safety functions to be performed. The inspection reports concluded that (1) the licensee did not have a procedure for manually backwashing the ESW pump discharge strainers, and (2) the evolution would require tools which were not readily available, and (3) the operators had not been trained in how to perform a manual backwash of the strainers. In addition, the inspection reports concluded that there were degraded material conditions that decreased the automatic backwash capability during earthquakes and other events and therefore had the potential to impact CDF sequences relative to seismic and other events.

The estimated change in core damage frequency (CDF) associated with this issue is 3.2×10^{-5}/year.

61.2 Event Description

The NRC staff conducted an inspection at Cook 1 and 2 from November 8, 1997 through December 27, 1997 (Ref. 1). During the inspection, the team questioned the adequacy of the licensee's basis for the ESW system strainers not being a support system required for ESW system operability. Consistent with this treatment, the licensee had classified the ESW strainer backwash system as a non-safety-related system. However, it was possible for the strainers to be manually backwashed if the air system or the relays were to fail, in order to support the continued operability of the ESW system. The licensee supplied additional information to the inspectors, who in turn requested that the NRC's Office of Nuclear Reactor Regulation (NRR) review the licensee's design basis, and reach a conclusion about the need for operable strainers to support an operable ESW train.

In their response to the inspector's request, NRR concluded that the licensee should consider any procedures for manually backwashing the ESW strainers to be safety-related. NRR also concluded that the licensee should ensure that the emergency procedures for responding to a loss of offsite power (LOSP) contain appropriate actions to take if the plant lost the capability to automatically backwash the strainers. However, the inspectors subsequently determined that no procedure for manually backwashing the strainers existed, the evolution would require tools which were not readily available to the operators, and the operators had not been trained in how to perform a manual backwash of the strainers.

As a result of NRR's conclusion, the inspectors determined that the licensee had failed to comply with the basis for Technical Specification 3/4.7.4 for the Cook plant, which states in part, "The OPERABILITY of the essential service water system ensures that sufficient cooling capacity is available for continued operation of safety-related equipment during normal and accident conditions." Consequently, this meant that the licensee was in violation of Criterion V of Appendix B to Title 10 CFR Part 50, which requires in part, "That activities affecting quality shall be prescribed by documented instructions, procedures, or drawings, of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings."

An NRC inspection report issued in 1999 (Ref. 2) noted that the licensee did not perform an operability evaluation to determine the aggregate impact of multiple degraded conditions relating to the ESW strainers. The inspection report identified the following events and conditions:

- Failure of the Unit 1 West left strainer to backwash due to a failed backwash valve;
- Degraded gate seal on the inlet gate of the Unit 1 strainer;
- Rounded key on the motor operator on the inlet gate of the Unit 1 strainer;
- Cracked support pads for both of the Unit 1 strainers;
- Improperly supported air lines to the backwash valves of all four ESW strainers;
- Improperly supported instrument lines to all four ESW strainers; and
- Jerky operation of Unit 2 East ESW strainer basket backwash valve 2-WRV-773

In light of the above, the risk associated with the following three degraded conditions was examined:

- Lack of a procedure of for manually backwashing the strainers;
- Degraded capability of the automatic backwashing system (which is not seismically qualified); in case of a seismic event and
- Potential decrease in the backwash capability due to degraded material conditions.

61.3 Additional Event Related Information

The ESW system at Cook consists of four ESW pumps. Two pumps are sufficient to supply all service water requirements for both units. The ESW system provides cooling water to the component cooling water (CCW) heat exchangers, the residual heat removal system (RHR) heat exchangers, the containment spray (CTS) heat exchangers, and the emergency diesel (EDG) coolers. The CCW is used cool a large number of loads, including high pressure injection (HPI) lube oil. Therefore, in the event of a loss of both trains of ESW, all safety-related systems except the auxiliary feedwater (AFW) system could fail.

The AFW system at each of the Cook units consists of three trains; two motor-driven and one turbine-driven. Two motor-driven trains are powered from safety-related 4 KV buses. The third train is a turbine-driven auxiliary feedwater pump (TDAFP) that does not rely on AC power, except for its room ventilators. The TDAFP room of each unit has doors which are open to the turbine building. The turbine-driven pumps are capable of running for several hours without ventilation. Therefore, even during a station blackout scenario, the turbine-driven auxiliary feedwater pump would remain available.

61.4 Modeling Assumptions

The conditions identified in the inspection reports (lack of procedure to perform manual backwash, degraded material conditions that decreased the automatic backwash capability during events other than earthquakes, degraded material conditions that decreased the automatic backwash capability during an earthquake) had the potential to impact CDF sequences relative to seismic events or events other than earthquakes. The risk associated with events other than earthquakes was determined to be negligible due to the following:

- During normal plant operation, in the absence of stormy weather, the strainers plug up at a relatively low rate. In the absence of stormy weather conditions on the ultimate heat sink (Lake Michigan), the ESW pumps may run for weeks before a strainer plugs (Ref. 3).

- Even if the strainers plug, unless the automatic backwash capability fails, manual backwash is not needed. The inspection reports (Refs. 1, 2) identify one failure of the automatic backwash capability for each Unit and several other degraded conditions. Given that this system is normally running, if these degraded conditions are significant enough to affect the functionality of the system, they will be self-revealing unless the accident condition imposes additional stresses compared to the normal operation.

- The ESW system is shared by both units. The system has many redundancies and capabilities to share ESW pumps between the two units as shown in figure 1. The two Cook units are equipped with four ESW pumps. Only two of the pumps are needed to support normal operation or accident loads of both units. The heat exchangers for the two diesel generator sets on each unit are served by both ESW headers of that unit. As a result of this configuration, any of the four ESW pumps can be aligned to cool a given EDG.

- Lack of a procedure did not eliminate the capability to perform backwashing of strainers in the event of losing automatic backwashing capability. According to discussions with the senior resident inspector at the Cook plant (Ref. 3), because there was no procedure, it may require about 2 hours for the operators to perform manual backwashing. Even if a procedure were available, the backwashing is expected to take 15-30 minutes (Ref. 3).

To illustrate the fact that the CDF increase associated with this issue due to events other than earthquakes is less than 1×10^{-6}, the following sequence was considered. Sequence 1 below is considered limiting, since the initiating event (severe weather induced loss of offsite power) leads to the stormy condition that challenges the automatic backwashing capability. In this analysis, it was conservatively assumed that one of the ESW pumps in each of the two ESW headers is dedicated to the Unit 1 EDGs (i.e., capability to share ESW pumps among units was not credited):

<u>Sequence 1: Loss of offsite power (LOSP) due to stormy conditions</u>

- LOSP from stormy conditions (no earthquake);
- Automatic backwash capability of a train of ESW fails;
- The second ESW train fails to continue to run prior to recovery of the first ESW train by manual backwashing; and
- Loss of ESW leads to core damage.

There are other method of failing two ESW pump trains which could lead to loss of two ESW pump trains after a LOSP beyond the failures considered in Sequence 1 above (e.g., probability of failing to start ESW pumps, ESW pump out of service). However, these failure combination are not considered here since they are not impacted by the degraded condition (lack of a procedure to perform manual backwashing). For example, the probability of both trains of ESW trains failing due to pumps in both trains failing to start after a LOSP is independent of the availability of a procedure to manually backwash the strainers.

LOSP due to stormy conditions (no earthquake) - From Table B-4 of Reference 4, the mean frequency of severe weather-related LOSP events at the Cook site is 5.2×10^{-3}/calendar year

Automatic backwash capability of a train of ESW fails -Since the postulated initiating event is assumed to fail offsite power and associated with stormy conditions, it was assumed that automatic backwashing capability of ESW would be challenged. The Cook Individual Plant Examination (IPE) does not provide a failure probability for automatic backwash. Based on the description of the automatic backwash system, in consideration of its reliance on pressure switches, pressure transmitters, relays, and air-operated valves and the typical failure probabilities for these components (See Table 3.3-1 of Ref. 5), the approximate failure probability of the automatic backwashing system of an ESW train was assumed to be less than 1.0 x 10^{-2}.

The second ESW train fails to continue to run prior to recovering the first ESW train by manual backwashing - Even though the ESW train that failed may be recovered in spite of the fact that a procedure did not exist, there is insufficient basis to credit that capability. Moreover, the ASP program does not credit recovery actions unless a procedure exists to support those recovery actions. Consequently, the second ESW train would be expected to run for its entire mission time of 24 hours.

The running train of the ESW may fail due to a variety of reasons. The dominant failure modes of the running train are (a) ESW pump fails to run, and (b) ESW train fails due to plugging of the strainer and the automatic backwashing (of the second train) fails. Based on Cook IPE (Ref. 5), the probability of the ESW pump failing to run is 3.0 x 10^{-5}/hour. The Cook IPE does not provide a failure probability for the automatic backwashing system. Given that the automatic backwash capability has failed several times (six failures between August 1996 and June 1999 in four ESW strainers), the failure rate based on these known failures is about 0.5 failures/strainer/year. Using Bayesian updating with a non-informative prior, and conservatively assuming 1.0 failures/strainer/year, the failure rate is estimated to be approximately 1.7 x 10^{-4}/hour (= 1.5/8760).

In the absence of a procedure to perform manual backwashing, the probability of failure of the second train of ESW to run over its mission time of 24 hours is 4.8 x 10^{-3} (= 24 hours x 2.0 x 10^{-4}/hour).

Loss of ESW failure leads to core damage - The ESW system provides cooling water to the component cooling water (CCW) heat exchangers, the residual heat removal system (RHR) heat exchangers, the containment spray (CTS) heat exchangers, and the emergency diesel (EDG) coolers. The CCW is used cool a large number of loads, including high pressure injection (HPI) lube oil. Therefore, in the event of a loss of both trains of ESW, all safety-related systems except the auxiliary feedwater (AFW) system could fail. When both ESW pump trains supporting a unit fail (one train fails due to strainer plugging and failure to backwash and the other train fails while running before the first train is recovered), the EDGs cannot be cooled. As a result, the EDGs must be stopped or they would fail. As a result, the plant will not have motive power to run its ESW pumps. Once the ESW pumps stop, the strainers cannot be backwashed (pumps must be running to perform the backwash automatically or manually). Therefore, ESW cannot be recovered. Consequently, the EDGs cannot be recovered.

Even though AFW is initially available, unless the ESW and EDGs can be recovered within several hours, AFW will fail due to loss of ventilation. Therefore, conservatively, this probability was assumed to be 1.0.

Using the above frequencies and probabilities (some of which are conservative upper bounds), the frequency of Sequence 1 was estimated as follows:

(Frequency of LOSP from stormy conditions (no earthquake): 5.2 x 10^{-3}/calendar-year) x

(Criticality factor: 0.79) x
(Probability of failure of the automatic backwash capability of a train of ESW: 1.0×10^{-2}) x
(Probability the second ESW train fails to continue to run prior to recovering the first ESW train by manual backwashing over 24 hours: 4.8×10^{-3}) x
(Probability of loss of ESW failure leading to core damage: 1.0) = 2.5×10^{-7}/year.

Since there are two sequences similar to Sequence 1 (one in which West ESW train fails first and the other in which East ESW train first), the increase in frequency is 5×10^{-7}/year. The above calculation does not credit the capability to share ESW pumps among the two units. When that capability is credited, the increase in frequency will be less than 5×10^{-7}/year.

The frequency estimated above is less than 1×10^{-6}/year. Therefore, this sequence is excluded from further analysis.

The automatic backwashing capability of the ESW strainers is not seismically qualified. In addition, the inspection reports documented several material conditions that indicated degradations in the system (e.g., improperly supported air lines to the backwash valves of all four ESW strainers, improperly supported instrument lines to all four ESW strainers). As a result, it was reasonable to assume that the automatic backwash capability would fail after an earthquake. Two scenarios were considered: (a) an earthquake that failed the automatic backwash capability of both ESW trains, and fails offsite power, and (b) an earthquake that affected the automatic backwash capability without affecting offsite power. Of the above, scenario (a) in which both offsite power and ESW would be affected was limiting, and was analyzed. Probabilistically, scenario (b) is less likely, considering the relatively low seismic fragility of switchyards. In addition, scenario (b) is lower in risk significance compared to (a) since, if offsite power were available, emergency diesel generators (EDGs) that need ESW within minutes would not be needed to mitigate the accident. If offsite power were available, both the turbine-driven and motor-driven AFW pumps could be used to remove decay heat from the core.

The sequence of actions that would lead to a non-recoverable station blackout (SBO)consists of of the following. As a result of a postulated earthquake, offsite power would be lost. Simultaneously, the ESW strainers would plug. The automatic backwashing capability would be expected to fail since that system is not seismically qualified and was in a degraded condition. The manual backwashing capability could not be established, since there was no procedure. The EDGs would fail due to the degraded ESW flow, and consequently an SBO would occur.

The non-recoverable SBO described above would lead to core damage.

Therefore, the second sequence of interest is as follows:

<u>Sequence 2: Loss of Offsite Power and ESW due to earthquake and AFW failure</u>

- An earthquake capable of failing offsite power and automatic backwashing capability of ESW occurs;

- Automatic backwashing capability is demanded due to earthquake stirring up the lake intake with sand and debris and it fails;
- Manual backwashing fails, leading to EDG unavailability; and
- Core damage occurs due to SBO.

Earthquake capable of failing offsite power and ESW automatic backwash capability occurs - The automatic backwash system of ESW is not seismically qualified in that it relies on relays, pressure switches, and air-operated valves which are not qualified. In addition, there were degraded conditions that could have affected the seismic capability (improperly supported air lines to the backwash valves, improperly supported instrument lines). The seismic fragility of the automatic backwash system in this "as-found" condition is unknown.

The seismic fragility of the switchyard is dependent upon the fragility of ceramic insulators. According to Table 3 of the licensee's seismic Individual Plant Examination of External Events (IPEEE) (Ref. 6), the median capacity of the ceramic insulators is 0.2g. Table 5 of Reference 6 and the hazard curves (also in Ref. 6) were used to calculate the frequency of occurrence of an earthquake at the Cook site. The table below shows the contribution of individual earthquake acceleration groups to the seismically induced LOSP frequency. The total LOSP frequency (summation of frequencies from all seismic groups) was approximately 4.0 x 10^{-5}/year

Earthquake acceleration range in 'g's	0.15-0.25	0.25-0.30	0.30-0.35	0.35-0.40	0.40-0.45	>0.45
Frequency (per year)	≈ 4.0 x 10^{-5}	8.6 x 10^{-6}	5.1 x 10^{-6}	2.97 x 10^{-6}	1.75 x 10^{-6}	2.50 x 10^{-6}
Prob. of LOSP in the range	0.5	0.82	0.90	0.96	0.99	1.00
Frequency of seismically induced LOSP	2.0 x 10^{-5}	7.1 x 10^{-6}	4.6 x 10^{-6}	2.9 x 10^{-6}	1.7 x 10^{-6}	2.5 x 10^{-6}

Automatic backwashing capability is demanded due to the earthquake stirring up the lake intake with sand and debris and it fails - The automatic backwashing capability may or be challenged in the aftermath of an earthquake. During an earthquake, due to the ground movement, energy will be added to the lake. It was assumed that the energy added by this means would generate waves and turbulence in the lake similar to those induced during stormy weather conditions and this would result in a challenge to the automatic backwash capability of both ESW trains. From Reference 3, when the licensee last vacuumed out the sand deposited near the pumps, there were sand dunes and piles of sand 10 feet high near the pumps. A likely scenario would be an earthquake causing the sand dunes near the pump to collapse and push a slug of sand into the suction of the pumps (Ref. 3, 7).

Since the automatic backwash capability was not seismically qualified and was degraded, it was assumed to fail. Since the large number of air lines in the plant were not seismically qualified, and since these air lines could fail by themselves or could fail due to objects that fall on them during an earthquake, this is a reasonable assumption. This assumption is used in the IPEEE and other licensing based seismic analyses [e.g., resolution of Unresolved Safety Issue (USI) A-46)]. Therefore, the probability of demanding the automatic backwash system and its subsequent failure was conservatively assumed to be 1.0.

Manual backwashing fails, leading to EDG unavailability - Since there was no procedure to implement manual backwashing of ESW strainers, no credit was given for this action. As a result, EDGs would become unavailable and the ESW pumps would stop running. Therefore, the probability of this event was assumed to be 1.0.

Core damage occurs due to SBO - If a SBO occurs as a result of ESW pumps failing leading to failure of the EDGs and if the ESWs failed due to plugged strainers, the ESWs could not be recovered. The ESW strainer cleaning (automatic or manual) relies on ESW pumps and since the EDGs would be unavailable the strainers could not be recovered. Therefore, the probability of this event was assumed to be 1.0.

Using frequencies and probabilities above, the frequency of Sequence 2 was calculated as follows:

(Frequency of earthquake causing LOSP and failing ESW: 4.0×10^{-5}/calendar-year) x
(Criticality factor: 0.79) x
(Probability of automatic backwashing failure: 1.0) x
(Probability of manual backwashing failure leading to EDG failure: 1.0) x
(Probability of core damage given non-recoverable SBO: 1.0) = 3.2×10^{-5}/year.

61.5 Analysis Results

The estimated total increase in the core damage frequency (ΔCDF) associated with this issue is the sum of frequencies of sequences 1 and 2 above which is 3.2×10^{-5}/year. It is dominated by Sequence 2. In Sequence 2, core damage results due to an earthquake which fails offsite power and ESW due to the degraded automatic backwash capability that is not seismically qualified. The manual backwash capability was not credited due to lack of a procedure to perform that function.

61.6 References

1. Donald C. Cook Nuclear Generating Plant, NRC Inspection Report No. 50-315/97024(DRP); 50-316/97024(DRP), January 23, 1998.

2. Donald C. Cook Nuclear Generating Plant, NRC Inspection Report No. 50-315/99010(DRP); 50-316/99010(DRP), June 11, 1999.

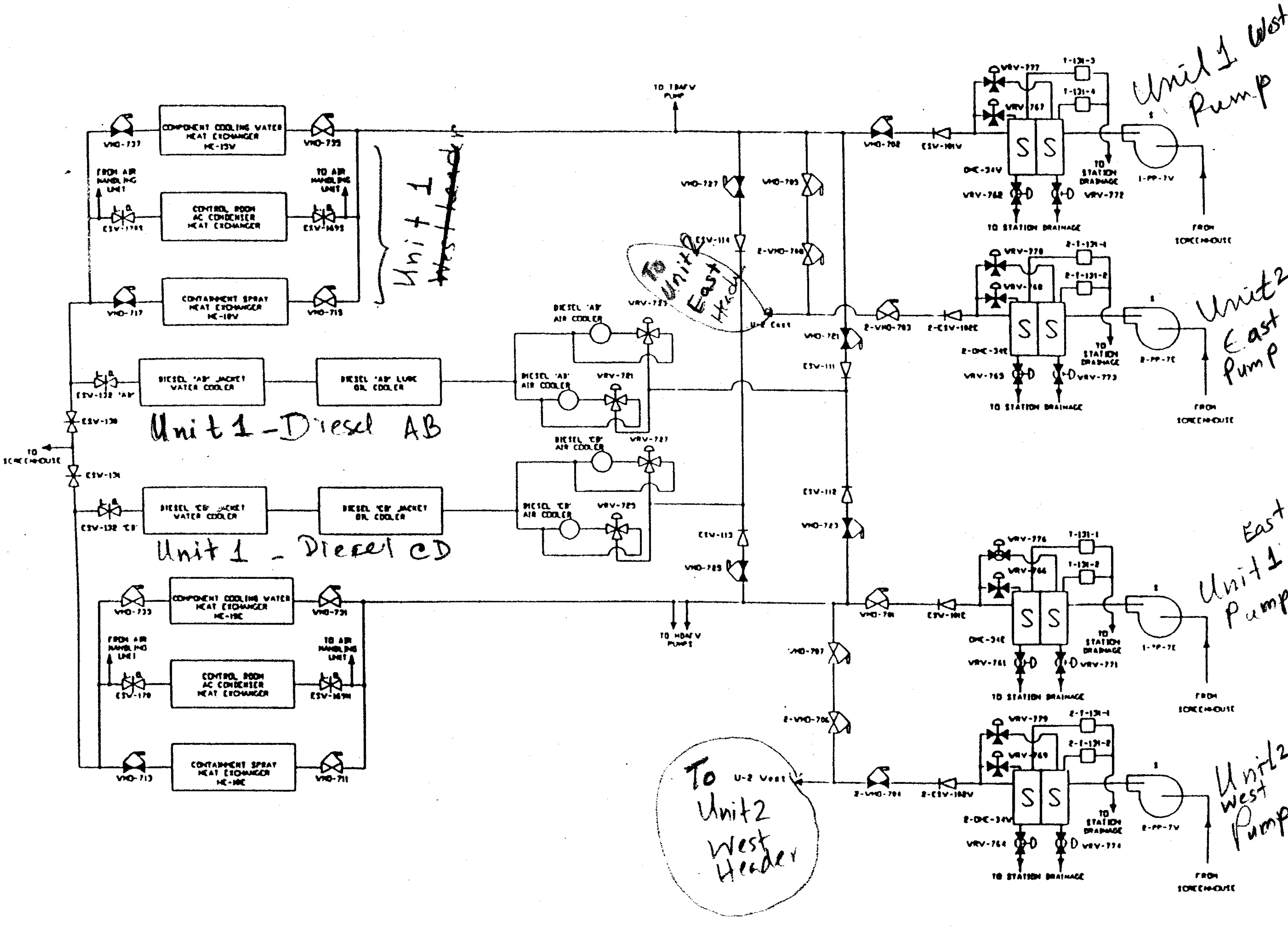
3. Personal communications, B. Bartlett (Senior Resident Inspector at Cook) and S.D. Weerakkody (U. S. Nuclear Regulatory Commission), February 4, 2000.

4. C. L. Atwood, et. al., *Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1980-1996,* NUREG/CR-5496, November 1998.

5. *Donald C. Cook Nuclear Plant Units 1 and 2, Individual Plant Examination, Revision 1*, October 1995.

6. *Donald C. Cook Nuclear Plant Units 1 and 2, Individual Plant Examination of External Events.*

7. Electronic mail communication, R. Wescott (U.S. Nuclear Regulatory Commission) to S.D. Weerakkody (U. S. Nuclear Regulatory Commission), February 9, 2000.



NOTES
1. VALVE NOTATION DEFINITIONS
a) L.O. = LOCKED OPEN
2. STRAINER BACKWASH VALVES (VRV)
CLOSED UPON LOSS OF AIR OR POWER

REFERENCE DRAWINGS
OP-1-5113-20 OP-2-5113-25

Figure 1 (Issue No. 61): ESW System Simplified Flow Diagram