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SUBJECT: LER 95-006-00:on 950913,analysis showed that CCW exchangers susceptible to damage due to flow-induced vibration.CCW sys has been flow balanced to closer tolerances.W/951012 ltr.

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FPL

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10 CFR 50.73

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Re: Turkey Point Unit 3
Docket No. 50-250
Reportable Event: 95-006
Analysis Shows CCW Heat Exchangers Susceptible to Damage Due to Flow-induced Vibration

The attached Licensee Event Report 250/95-006 is being provided in accordance with 10 CFR 50.73(a)(2)(ii).

If there are any questions, please contact us.

Very truly yours,

D.E. Jernigan for

T. F. Plunkett
Vice President
Turkey Point Plant

CLM

attachment

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC
Thomas P. Johnson, Senior Resident Inspector, Turkey Point Plant, USNRC

230012





IE22

# LICENSEE EVENT REPORT (LER)

| FACILITY NAME (1) | DOCKET NUMBER (2) | PAGE (3) | | |
|---|---|---|---|---|
| TURKEY POINT UNIT 3 | 05000250 | 1 | OF | 13 |

TITLE (4) Analysis Shows CCW Heat Exchangers Susceptible to Damage Due to Flow-induced Vibration

| EVENT DATE (5) | | | LER NUMBER(6) | | | RPT DATE (7) | | | OTHER FACILITIES INV. (8) | |
|---|---|---|---|---|---|---|---|---|---|---|
| MON | DAY | YR | YR | SEQ # | R# | MON | DAY | YR | FACILITY NAMES | DOCKET # (S) |
| 09 | 13 | 95 | 95 | 006 | 00 | 10 | 12 | 95 | | |

| | | |
|---|---|---|
| OPERATING MODE (9) | N/A | 10 CFR 50.73(a)(2)(ii) |
| POWER LEVEL (10) | 0 | |

LICENSEE CONTACT FOR THIS LER (12)

| | TELEPHONE NUMBER |
|---|---|
| C. L. Mowrey, Compliance Specialist | 305-246-6204 |

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

| CAUSE | SYSTEM | COMPONENT | MANUFACTURER | NPRDS? | CAUSE | SYSTEM | COMPONENT | MANUFACTURER | NPRDS? |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

| SUPPLEMENTAL REPORT EXPECTED (14) NO ☒ YES ☐ | EXPECTED SUBMISSION DATE (15) | MONTH | DAY | YEAR |
|---|---|---|---|---|
| (if yes, complete EXPECTED SUBMISSION DATE) | | | | |


ABSTRACT (16)

Florida Power & Light Company (FPL) determined by analysis that the Unit 3 Component Cooling Water (CCW) heat exchangers were susceptible to damage due to vibration, if all components started as designed during an Engineered Safety Features (ESF) actuation.

The causes of the condition were poor communications and teamwork, and a belief that the original safety analyses were bounding (only true for minimum heat load removal, not for maximum flows). Although the potential existed for heat exchanger damage, none has been observed, and probabilistic safety assessment indicates that the impact on core damage frequency is insignificant.

In order to ensure that these high flow conditions are not encountered, several changes were made. These include procedure revisions, resetting the setpoint and time delays for the CCW pump low pressure auto-start, and adding air accumulators to the fail-open Emergency Containment Cooler outlet valves (to prevent inadvertent flow increases). FPL is also investigating other potential long-term modifications.

## I. DESCRIPTION OF THE EVENT

Florida Power & Light Company (FPL) is reviewing Turkey Point Units 3 and 4 design analyses in preparation for a thermal uprate. Among other analyses, the heat loading, and therefore the flow balancing, of the Component Cooling Water (CCW) system [CC] has been reviewed in detail. On September 13, 1995, FPL determined by analysis that the Unit 3 CCW heat exchangers [CC:hx] may be susceptible to damage due to tube vibration resulting from high shell side flow, if all components started as designed during an Engineered Safety Features (ESF) actuation. Specifically, flow is postulated to exceed the specified design limit of the CCW heat exchangers if CCW flow is initiated through both Residual Heat Removal (RHR) heat exchangers [BP:hx] and all three Emergency Containment Coolers (ECCs)[BK:clr], with all three CCW pumps [CC:p] running and all three CCW heat exchangers in service. Flow limits may also be exceeded if only two CCW heat exchangers are in service, as permitted by Turkey Point Technical Specifications, and either two or three CCW pumps are running.

The issue is perhaps more easily understood in the obverse; that is, to avoid exceeding the CCW heat exchanger design flow limits, the following operating limitations apply:

> With three CCW heat exchangers in service, no more than two CCW pumps can be run if all three ECCs and both RHR trains are in service.
>
> With two CCW heat exchangers in service, the number of running CCW pumps must be reduced to one after an ESF actuation. (These two limitations together are known as the N-1 Rule, N being the number of operable CCW heat exchangers; N-1 therefore being the number of CCW pumps allowed to be running.)
>
> If post-accident CCW flow is desired through the non-ESF coolers (Normal Containment Coolers [BK:clr] and the Control Rod Drive Mechanism Coolers [CD:clr]), CCW flow through one of the other five significant loads (3 ECCs, 2 RHR heat exchangers) must first be isolated. (This limitation is known as the Rule of 5, i.e., no more than 5 of the 6 significant loads may be valved in at any one time.)

At the time the issue was recognized as an unanalyzed condition which may have significantly compromised plant safety, Unit 3 was shut down with all fuel offloaded (no Mode). The issue is not applicable to Turkey Point Unit 4, as discussed later in this report. The NRC Operations Center was notified of the event at about 1615 on September 13, 1995, in accordance with 10 CFR 50.72 (b)(2)(i).

## SYSTEM DESCRIPTION

Each unit at Turkey Point has a closed-cycle CCW system composed of a surge tank [CC:tk], three pumps, three heat exchangers, a pump supply header, a header between the pump discharges and the CCW heat exchanger inlets, a heat exchanger outlet header, and piping to and from various loads. The pumps are 100% capacity each and the heat exchangers are 50% capacity each. The headers are normally "open," that is, the pumps share a common supply and a common discharge, and the heat exchangers share a common outlet. Heat is removed from the CCW system by the flow of Intake Cooling Water (ICW) [BI] through the tube side of the CCW heat exchangers. The closed cycle design assures a monitored intermediate barrier between the components handling reactor coolant system fluid, and the ultimate heat sink.

The essential heat loads served by the CCW system are the following ESF components:

1. RHR heat exchangers
2. RHR pump seal coolers [BP:p,clr]
3. High Head Safety Injection (HHSI) pump oil and seal coolers [BQ:p,clr]
4. Containment Spray pump seal coolers [BE:p,clr]
5. Emergency Containment Coolers (ECCs)

and the following non-ESF components:

6. Post Accident Sample System heat exchanger [IP:hx]
7. Spent Fuel Pool (SFP) heat exchangers [DA:hx]
8. Charging pump oil coolers [CB:p,clr]

During normal full power operation one CCW pump and three CCW heat exchangers accommodate the heat removal loads. CCW does not flow through the RHR heat exchangers, and CCW flow through the ECCs is limited to 200 gpm each (about 5% of the maximum flow through each ECC under accident conditions).

## CONDITION DESCRIPTION

The Unit 3 CCW heat exchangers were designed in accordance with the Tubular Exchangers Manufacturers Association (TEMA) standards. These standards provide design guidance to limit shell side flow below the critical flow velocity, at which heat exchanger tube vibration could occur. As the critical flow velocity is approached and exceeded, the tube vibration amplitudes can increase rapidly. Tube-to-tube impacts and accelerated tube wear at support plate locations can occur.

At or above critical flow velocity, possible tube failure mechanisms are fatigue (if tube stresses exceed the endurance limit), and tube wear from tube-to-tube impacts or tube motion at support plates. Rapid tube failure due to fatigue is not expected since the tube alternating stresses are within the range of the endurance limit for the tube material.

Tube wear resulting from tube-to-tube impacts is not significant since the forces occurring at tube impact are small. Because of the tube deflections and the tube-to-support plate forces and relative motions which result, the predominant failure mechanism for the CCW heat exchangers at critical flow velocity has been determined to be tube wear at the tube support plates. Because the predominant failure mechanism is wear, short duration operations at or above critical flow velocities is not expected to result in rapid tube failure. This conclusion has been substantiated by a recent event discussed below.

Turkey Point Condition Report 95-935 identified a high CCW heat exchanger shell side flow condition during recent performance of the CCW pump Inservice Test. The high flow was observed during a step when the CCW headers were "split" to allow recording of data for the 3A CCW pump. The completed procedure indicates that the 3A CCW header flow was approximately 9,000 gpm. Under the test conditions, all of this flow was passing through the shell side of the 3A CCW heat exchanger. Analyses show that 9,000 gpm is high enough to induce vibration of the tubes; such vibration is most likely to occur in the upper rows, where the tubes are exposed to the high bundle and shell entrance and exit velocities.

The majority of the tubes in the top two rows of the Unit 3 CCW heat exchangers were replaced in 1991. Of the top four rows in the 3A CCW heat exchanger, only one tube is plugged. Eddy current test (ECT) results from August, 1995, were reviewed to establish the extent of outside diameter indications prior to the performance of the Inservice Test. In order to assess whether the high flow experienced during the test had caused any damage, the top four rows were tested by ECT on September 27, 1995. The results of the ECT exam were compared to the data taken in August. No new flaws were found. No significant changes in historical flaws were found. Based on these results, the 3A CCW heat exchanger tubes are deemed to have not been affected by the high shell side flow rate, for the estimated duration of about one hour.

## II. CAUSE OF THE CONDITION

### Immediate Cause

The immediate cause of the condition was inadequate procedures, in that they failed to control CCW flow adequately to prevent excessive flow through the heat exchangers.

Intermediate Cause

The intermediate cause was cognitive error on the part of utility personnel in that they failed to recognize the true nature of the design limitations of the CCW heat exchangers. Design basis reconstitution efforts in 1986 identified concerns regarding minimum CCW flow through the RHR heat exchangers, and the potential for pump runout if only one CCW pump is available for post-Loss Of Coolant Accident (LOCA) recirculation phase conditions. These concerns resulted in LER 250/86-009. Flow balance tests were performed in March of 1986, for one pump and two pump operation. These tests demonstrated that with the system properly balanced and procedurally controlled, both the minimum and maximum flow rates to safety-related components were within their design requirements.

Also in 1986, a Justification for Continued Operation (JCO) was issued by the engineering organization to allow the maintenance of flow through a CCW heat exchanger which was out of service, e.g., for cleaning, in order to ensure that flow during normal operations did not exceed 6840 gpm through each of the other two heat exchangers. The JCO would have imposed procedural restrictions intended to ensure that flow was secured to the inoperable heat exchanger in the event of an accident. The JCO was not implemented, apparently for two reasons; (1) the plant had made other procedure changes and valve repairs to limit total CCW system flow, which the plant thought had obviated the need for the JCO, and (2) the plant thought that the 6840 gpm flow limit applied only during normal operations (as reflected in the Precautions and Limitations section of the normal operating procedure for the CCW system). (Note: the JCO is not currently applicable, since the CCW heat exchanger flow limits will not be exceeded during normal or accident conditions.)

Root Causes

The root causes of the condition reported herein were (1) a history in the 1980's of inadequate communications and teamwork between the engineering and plant organizations, and (2) a predisposition to believe that the original plant analyses, based on minimum safeguards equipment (single active failure assumed) were bounding analyses. In fact, those analyses were bounding only in terms of minimum flow requirements, i.e., heat removal capability, and were not bounding in terms of maximum flow capability. The complex engineering analyses to determine the total impact of plant operations and multiple CCW system configurations were not performed until the thermal uprate project; the result was that the maximum CCW flow limit had been defined, but not adequately translated into proceduralized operating guidance.

As described above, during the design basis reconstitution efforts by the engineering organization in 1986-1988, there was recognition of the possibility of excess flow through the CCW heat exchangers. This recognition was captured in the Design Basis Documents, in a draft section titled Component Design Requirements, "Specifically, in the post-accident recirculation mode, the maximum allowable flow could be exceeded should two CCW pumps and two CCW heat exchangers be in service. Consequently, procedures must limit the CCW lineup to running only one CCW pump if less than three CCW heat exchangers are in service during the post-accident recirculation mode" (Unit 3 only). Procedure 3/4-EOP-ES-1.3, Transfer to Cold Leg Recirculation, contained a Caution prior to Step 5, cautioning the operators that "Throttling of the CCW heat exchanger outlet valves may be required to prevent exceeding 7500 gpm per heat exchanger." What was not recognized was the possibility that the CCW heat exchangers could also see excessive flow during the injection phase.

## III. ANALYSIS OF THE CONDITION

The primary safety functions of the CCW System are to provide component cooling water to support normal plant operating modes and for safe shutdown (Hot Standby) while also providing cooling water to safety related equipment during accident conditions to support both reactor heat removal and containment heat removal. Adequate CCW flow is required to remove both normal operating and accident heat loads through ESF equipment, which serves both to prevent and to mitigate the consequences of design basis accidents.

The design basis of the CCW System is to provide sufficient heat transfer from the ESF equipment to the ultimate heat sink (via the ICW System), post accident. The system is designed with sufficient capability to accommodate the failure of any single active component without resulting in undue risk to the health and safety of the public following a Maximum Hypothetical Accident (MHA). The most limiting single failure was the loss of one Emergency Diesel Generator (EDG)[EK:dg], which results in one CCW pump available to mitigate the consequences of the MHA. This assumed single failure also results in the loss of a complete train of ESF, including the inability to open the CCW isolation valve associated with one RHR heat exchanger. Although a complete train of ESF components would be inoperable on loss of an EDG, CCW flow to most of these components will continue.

FPL performed a detailed review of the Unit 3 CCW heat exchangers for the purposes of establishing a maximum shell side (CCW) flow limit. The flow limits for the heat exchangers were reviewed from the aspects of both minimizing the potential for tube vibration (fatigue-type failure) and minimizing accelerated erosion of the tubes. The methodology to determine the maximum flow limits is consistent with that contained in the TEMA standards.

The Unit 3 CCW heat exchangers were installed during plant construction. FPL concluded that the maximum Unit 3 CCW heat exchanger flow limits are as follows:

- 4,063 gpm continuous operation (TEMA limit)
- 6,840 gpm normal plant evolutions (testing, surveillance activities, heat exchanger cleaning, etc.) (manufacturer's limit without vibration concerns)
- 7,200 gpm 31 days (erosion and vibration limit for long-term accident recirculation)
- 7,500 gpm initial safety injection (erosion and vibration limit)

The Unit 4 CCW heat exchangers were replaced in 1988. The replacement Unit 4 CCW heat exchanger design include a tube support design that allows for increased shell side flows. Flow limits for the Unit 4 CCW heat exchangers were determined in the same manner as described above for the Unit 3 heat exchangers. The maximum Unit 4 CCW heat exchanger flow limits are as follows:

- 6,756 gpm continuous operation (TEMA limit)
- 8,000 gpm normal plant evolutions (testing, surveillance activities, heat exchanger cleaning, etc.) (manufacturer's limit without vibration concerns)
- 11,900 gpm 31 days (erosion limit for long term accident operation)

Note that the heat exchanger tube integrity is monitored by the performance of periodic eddy current testing. A small number of tubes have been plugged or replaced based on the results of eddy current testing. Each heat exchanger contains 1625 tubes. Of these 1625 tubes, 21, 38, and 32 are plugged in the 3A, 3B, and 3C heat exchangers, respectively. In the 4A, 4B, and 4C heat exchangers, 9 tubes, 5 tubes, and 2 tubes are plugged respectively.

In summary, for Unit 3 one CCW pump can supply all the flow necessary for accident loads, and two CCW heat exchangers are required to handle both the thermal load and the total CCW system flow. If three CCW heat exchangers are in service, up to two CCW pumps can be running long term. The different spacing of the tube support plates in the Unit 4 CCW heat exchangers renders these limitations not applicable to Unit 4.

ANALYSIS OF UNIT 3 CCW SYSTEM CONFIGURATION

FPL has performed a review of the expected CCW system minimum and maximum flow rates during the past operating cycle. With respect to the minimum CCW system flow requirements, the system flow balancing performed by procedure 3-OSP-030.9, and specified in procedure 3-OP-030, provided assurance that minimum CCW system flow requirements were met.

Maximum CCW system component flows occur during accident conditions when multiple CCW pumps could auto-start and additional flow demands (primarily the ECCs and RHR heat exchangers) are placed on the CCW system. These maximum expected component flow rates were determined by benchmarking the CCW system computer flow model to the actual system balancing that was performed during the 1994 Unit 3 Cycle 14 refueling outage. Once the model was benchmarked, various CCW system configurations were modelled to determine the maximum expected component flow rates. The most limiting components identified during this review were the Unit 3 CCW heat exchangers. CCW heat exchanger flows are maximized when only 2 CCW heat exchangers are available as allowed by Technical Specifications. Individual CCW heat exchanger flows have been calculated during accident conditions, which are in excess of the maximum limit specified for the heat exchanger.

ANALYSIS OF UNIT 4 CCW SYSTEM CONFIGURATION

The maximum expected component flow rates in Unit 4 were determined by benchmarking the CCW system computer flow model to the actual system balancing that was performed during the 1994 Unit 4 Cycle 15 refueling outage. Once the model was benchmarked, various CCW system configurations were modelled to determine the maximum expected component flow rates. The maximum calculated heat exchanger flow is below the 31 day flow limit of 11,900 gpm described above. Therefore, all Unit 4 CCW heat exchanger limits have been satisfied. However, changes to selected emergency operating procedures are being made to retain consistency with the Unit 3 procedures.

PROBABILISTIC SAFETY ASSESSMENT (PSA)

This section summarizes the risk impact of the reported condition. Two initiating events are evaluated. The first is a LOCA followed by a second or third CCW pump starting. If only two CCW heat exchangers are in service, flow in those two heat exchangers may exceed their design limits. FPL conservatively postulated that a rupture of at least one CCW heat exchanger tube occurs due to the resonant vibration. As a result the CCW surge tank inventory would be lost thus the entire CCW system function would be lost (discounts any credit for makeup to the surge tank). The loss of CCW function would include loss of seal and bearing cooling to the ESF pumps, ultimately resulting in failure of the pumps. Failure of the ESF components concurrent with a LOCA is expected to result in core damage.

The scenario is summarized as follows:

A. One CCW heat exchanger out of service for maintenance
B. LOCA occurs
C. Reactor trip and Safety Injection signal occur
D. Two or more CCW pumps start
E. High CCW flows through two heat exchangers cause vibration and finally rupture one or more tubes
F. Operator fails to diagnose and isolate the leak and restore CCW operation
G. Loss of ESF pumps which results in core damage

The initiating event frequency for LOCAs is composed of the following:

1. Small-Small and Small LOCA (frequency of 1.0E-3/Yr, each)
2. Medium LOCA (frequency of 4.0E-4/Yr)
3. Large LOCA (frequency of 1.0E-4/Yr)

Based on the available plant data from the last several years, the probability of any one CCW heat exchanger being out of service is about 3.61E-2. Therefore, the probability of any CCW heat exchanger being out of service is equal to 1.08E-1 (3 trains * 3.61E-2 OOS/train = 1.08E-1 OOS for system). FPL assumed that 70 minutes after the vibration-induced heat exchanger rupture (10 minutes of surge tank depletion and thus loss of CCW pumps, and 60 minutes for subsequent ESF failure due to loss of CCW) the ESF functions would be lost if no operator actions were taken. The failure probability of the operator to makeup and isolate ruptured heat exchanger is obtained as follows:

1. Small-Small (3/8 to 2 inch) and Small (2 to 6 inch) LOCA: (1.0E-3 each)

1.0E-1 for not making up the surge tank from primary makeup water
1.0E-1 for not isolating the ruptured heat exchanger
1.0E-1 for not aligning the other unit's HHSI pumps

2. Medium LOCA: (5.0E-3)

1.0E-1 for not making up the surge tank from primary makeup water
1.0E-1 for not isolating the ruptured heat exchanger
5.0E-1 for not aligning the other unit's HHSI system

3. Large LOCA: (1.0E-2)

1.0E-1 for not making up the surge tank from primary makeup water
1.0E-1 for not isolating the ruptured heat exchanger

The LOCA core damage frequency increase is obtained by:

Frequency of LOCA * probability of heat exchangers out of service * Operator failure probability

$$= (1.0E\text{-}3/Yr * 1.08E\text{-}1 * 1.0E\text{-}3) + (1.0E\text{-}3/Yr * 1.08E\text{-}1 * 1.0E\text{-}3)$$
$$+ (4.0E\text{-}4/Yr * 1.08E\text{-}1 * 5.0E\text{-}3) + (1.0E\text{-}4/Yr * 1.08E\text{-}1 * 1.0E\text{-}2)$$
$$= 5.4E\text{-}7/Yr$$

The second initiating event analyzed was a Loss Of Offsite Power (LOOP) followed by a failure of the Instrument Air system [LD]. Turkey Point's instrument air system has been modified this summer. For the last several years instrument air has been supplied by portable, diesel-driven air compressors [LD:cmp]. A modification is in progress to change the instrument air supply to one electric motor-driven compressor and one diesel-driven compressor, per unit. To be consistent with the basis for other data, the PSA calculation assumes that instrument air is supplied by the portable compressors. The initiating event can occur if the diesel driven instrument air compressors fail to continue running following a LOOP.

The scenario is summarized as follows:

A. One CCW heat exchanger out of service for maintenance
B. A LOOP occurs
C. Both EDGs start
D. At least 2 CCW pumps start automatically
E. The diesel-driven air compressors fail to continue running
F. The operators fail to take action to stop CCW pumps
G. CCW Heat Exchanger tube fails
H. Operator fails to take action to mitigate the tube failure event
I. Operator fails to use available recovery actions including secondary heat removal

Based on the plant data from 1984 to 1994, the probability of LOOP is about 1.0E-01/Yr.

FPL assumed for this analysis that:

1. Both EDGs operate properly, and that the CCW pumps start properly

2. The probability of one diesel-driven air compressor not continuing to run is 1.0E-02. Then the failure of both diesel-driven air compressors is 1.0E-04

3. The probability of an operator failing to stop all but one running CCW pump is 1.0E-01

4. At least one CCW tube ruptures, depleting the CCW surge tank, causing a loss of CCW which leads to a loss of charging pumps and a failure of the reactor coolant pump seals which causes a seal LOCA requiring Safety Injection

5. The probability of an operator failing to mitigate the CCW tube rupture is 1.0E-01

The core damage frequency increase is obtained by:

LOOP Frequency * Probability of CCW HX out for maintenance * probability of two diesel-driven air compressors failing to run * probability of an operator failing to stop CCW pumps * probability of an operator failing to mitigate the CCW rupture.

=1.0E-1 * 1.08E-1 * 1.0E-4 * 1.0E-1 * 1.0E-1 = 1.1E-8

The table below summarizes the Core Damage Frequency (CDF) contribution associated with the potential CCW heat exchanger tube wear issue under various conditions. Two dominant contributors to the CDF increase are included in the scoping estimates for the Mode 1 conditions: LOCAs, and LOOP followed by loss of instrument air. One other scenario is of concern and was scoped in a similar fashion: a Mode 4 LOOP followed by a loss of instrument air. The Mode 4 CDF increase is estimated by multiplying the Mode 1 CDF by 0.1 because of additional time available and probable use of secondary heat removal.

| CDF for Various Conditions | CDF Impact Before Changes | CDF Impact With Operator Action to Stop CCW Pumps, and with ECC Accumulators |
|---|---|---|
| MODE 1: LOCAs | 5.4E-7 | 1.1E-9 |
| MODE 1: LOOP + Instrument Air Loss | 1.1E-8 | 2.16E-10 |
| MODE 1 TOTAL | 5.51E-7 | 1.32E-9 |
| MODE 4 | 1.1E-9 | 2.16E-11 |

The CDF increase for the current configuration is 5.51E-7/Yr in Mode 1 and 1.1E-9/Yr in Mode 4. For the Mode 1 CDF increase, results are very sensitive to the probability of operator failure to shut off CCW pumps. The CDF change, with procedural changes and installation of accumulators for the ECC control valves, is approximately 7 to 70 times lower than without the changes; it varies with the assumptions made regarding operator failure probability.

The Mode 1 total CDF increase of 5.51E-7 is considered not risk significant based on the criterion of 1.0E-6/Yr used in the Nuclear Energy Institute's PSA Applications Guide. Nevertheless, the changes being implemented significantly lower the impact of the identified condition.

## IV. CORRECTIVE ACTIONS

1. To ensure that minimum and maximum CCW component flows are not exceeded, particularly for the CCW heat exchangers, the following administrative and procedural controls have been applied:

   a. The CCW system has been flow balanced to closer tolerances to ensure that maximum flows will not be exceeded at the initiation of any assumed event

   b. Procedural controls are in place to reduce the number of operating CCW pumps to one less than the number of in-service heat exchangers (N-1 criteria, where N is the number of CCW heat exchangers), as part of the normal plant response to a trip or event

   c. The total number of large CCW end-user components that can be valved in or out from the control room is six. Procedural controls now limit operation such that only five of the six would be in service and any one time (Rule of 5)

   These controls ensure that CCW component flows do not exceed recommended limits under any anticipated operating condition.

2. The low pressure automatic start signal for the CCW pumps has the potential to result in more than the desired number of pumps running should the pressure drop momentarily while CCW system configurations are being changed. Therefore the setpoint for the low pressure auto-start is being lowered from 60 psig to 35 psig, and the time delays between autostart signals to successive pumps are being increased. The circuit reliability was also increased by changing the normally energized (de-energize to actuate) state of a relay to a normally de-energized state (energize to actuate). The modification eliminated a circuit failure mode which could have resulted in unnecessary CCW pump starts. Note that the low pressure auto-start is not a safety-related function.

3. The Emergency Containment Cooler CCW outlet isolation valves fail open on loss of instrument air. Accumulators have been added to these three valves on Unit 3 to ensure that they stay closed for at least 20 minutes following a loss of instrument air. This 20 minute time interval is considered sufficient for plant operators to take reasonable action to place the CCW system in an acceptable long term configuration. Plant procedures will be changed such that operators recognize the loss of instrument air event and secure the required number of CCW pumps to assure CCW flow limits are not exceeded.

5. FPL is evaluating other potential long term modifications, such as adding flow limiting devices to the CCW heat exchangers, qualifying the heat exchangers to a higher flow limit by testing in accordance with the TEMA standard, replacing the tube bundles, staking the tubes, etc.

## V. ADDITIONAL INFORMATION

EIIS Codes are shown in the format [EIIS SYSTEM: IEEE component function identifier, second component function identifier (if appropriate)].