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RECIP.NAME RECIPIENT AFFILIATION
EISENHUT,D.G. Division of Licensing

SUBJECT: Responds to Generic Ltr 81-21, "Natural Circulation Cooldown." Description of cooldown method, including discussion of steps in generic natural circulation procedure guidelines encl.

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FLORIDA POWER & LIGHT COMPANY

December 4, 1981
L-81-513

Office of Nuclear Reactor Regulation
Attention: Mr. Darrell G. Eisenhut, Director
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Eisenhut:

Re: Turkey Point Units 3 & 4
Docket Nos. 50-250 and 50-251
Natural Circulation Cooldown

Florida Power & Light has reviewed the NRC letter dated May 5, 1981 (Generic Letter 81-21) which requested that we assess the Turkey Point procedures and training programs which address natural circulation cooldown. A description of the method to be used for Turkey Point Units 3 & 4 to cooldown on natural circulation from operating conditions to cold shutdown is attached. Included with this description is a discussion of the steps in the generic natural circulation procedure guidelines. This method will not result in reactor vessel voiding. Also included in the attachment is a discussion of the adequacy of condensate grade auxiliary feedwater. There is a sufficient quantity of this water to support our cooldown method.

Training on natural circulation cooldown will be included in the January 1982 operator requalification cycle. This training will present the results of this study and will review the draft revised procedures that will prescribe the cooldown method. The procedures will be revised to include the results of this assessment and these procedures will be implemented by the first refueling outage after January 1, 1982 as required by NUREG-0737.

Very truly yours,

John A DeMastry
for

Robert E. Uhrig
Vice President
Advanced Systems & Technology

REU/PLP/ras

cc: Mr. J. P. O'Reilly, Region II
Harold F. Reis, Esquire

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ATTACHMENT

Re: Turkey Point Units 3 & 4
Docket Nos. 50-250 and 50-251
Natural Circulation Cooldown

DESCRIPTION OF COOLDOWN METHOD

At Turkey Point Units 3 & 4, the full power, full flow steady state design reactor coolant system conditions are a hot leg temperature of 602.1 deg F, a cold leg temperature of 546.2 deg F, an average temperature of 574.1 deg F and a system pressure of 2235 psig. The design conditions for switching to the residual heat removal (RHR) system are a reactor coolant temperature below 350 deg F and a system pressure 450 psig. On loss of reactor coolant pumps, cooldown to RHR entry conditions is by natural circulation. The pumps can be lost by two basic means. The first is a loss of offsite power and therefore electrical power to the reactor coolant pumps and the second is by some common failure of the pumps (ie: loss of component cooling water). Under both of these conditions the pumps would coast down and they would not be available to circulate the reactor coolant. Natural circulation tends to isolate the fluid in the reactor vessel head from the bulk of the primary fluid. A controlled cooldown of the bulk of the primary fluid is necessary to reduce the lag in the cooling of the reactor vessel head and to avoid void formation upon depressurization.

Westinghouse nuclear power plants were analyzed for natural circulation cooldown without upper head voiding by the Westinghouse Owner's Group and the analysis was submitted to the NRC on April 20, 1981 (reference Westinghouse Owner Group letter OG-57). A sensitivity study was performed to apply the generic analysis to the specific plants (see enclosure 1). In the sensitivity study, the Turkey Point Units are classified as T-hot plants with flat upper support plate. The natural circulation cooldown was investigated with control rod driven mechanism (CRDM) cooling fans operating. The procedures recommended by Westinghouse were checked for their applicability to the Turkey Point Units and for their compliance with the cooldown limitations in the Technical Specification cooldown curves. The recommended procedure with the CRDM cooling fans operating was found acceptable for both units.

With a loss of offsite power or with just a loss of reactor coolant pumps, the capability still exists to safety cooldown the plant to cold shutdown. The CRDM cooling fans, which can be manually loaded onto the diesel generator, provide an effective mean of cooling the reactor vessel head. In the procedure we will prepare, the reactor coolant system is cooled at a rate of 25 deg F/Hr until it reaches a temperature below 350 deg F (see figure 1). The reactor coolant system pressure is gradually reduced while maintaining a minimum subcooling of 50 deg F. The operator will maintain RCS pressure between the technical specification curves and the RCS pressure curve as shown in figure 1. This will ensure an adequate amount of subcooling during the natural circulation cooldown procedure. This method takes approximately 9 1/2 hours before residual heat removal entry conditions are reached. Heat is removed during this cooldown by the auxiliary feedwater provided to the steam generators. The generic outline of the procedure is attached. (See Enclosure 2).

EVALUATION OF CONDENSATE REQUIREMENT

The condensate requirement for the procedure discussed above, is estimated to be 135,000 gallons (see enclosure 3). The figure in this enclosure showns the condensate requirement versus time. At Turkey Point each unit's condensate storage tank has a capacity of 250 000 gallons, with a minimum of 185,000 gallons reserved at all times for cooldown to cold shutdown conditions. The 185,000 gallon amount is maintained by technical specifications. This amount of condensate is sufficient to provide cooling water for 19 hours of sensible and decay heat removal to cool the RCS temperature to below 350 deg F. With the CRDM cooling fans it takes 9 1/2 hours to cool the reactor vessel head to the RHR system entry conditions, which is well within the capacity of the safety grade condensate supply.

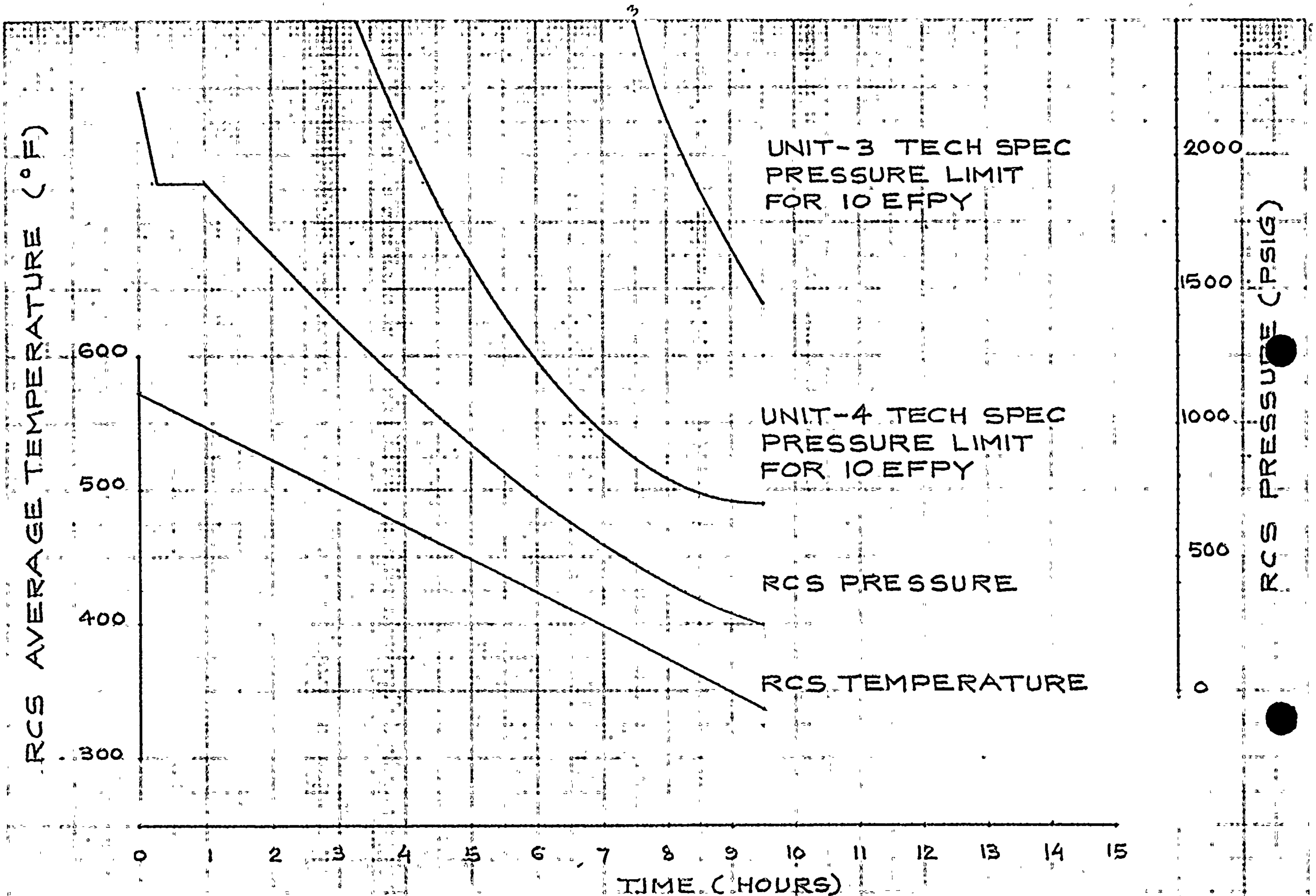


FIG. 1 NATURAL CIRCULATION COOLDOWN WITH CRDM FANS FOR TURKEY POINT UNITS 3 & 4

SKM 11-2-81

NATURAL CIRCULATION COOLDOWN

BACKGROUND INFORMATION FOR

EMERGENCY RESPONSE GUIDELINES

NOVEMBER 16, 1981

ENCLOSURE 1

NATURAL CIRCULATION COOLDOWN

1. INTRODUCTION

Following verification of natural circulation in the RCS the method described in this study is used to cool down and depressurize the plant to cold shutdown conditions by steam dump with natural circulation and subsequent RHR system operation. The following conditions are established prior to commencing this procedure:

a. The reactor plant is stable in a free convection heat transfer mode;

b. Pressurizer pressure is being maintained at 2235 psig;

c. Pressurizer level is being maintained at programmed no-load level;

d. RCS average temperature is being maintained at programmed no-load temperature;

e. Charging, letdown, and seal injection flow are normal;

f. Reactor coolant boron concentration in the active portion of the system is that concentration necessary to provide the shutdown reactivity margin required by the Plant Technical Specifications when calculated on the basis of homogeneous boron distribution with the total coolant mass;

g. Reactor makeup control is in Automatic and set to deliver flow at the required boron concentration;

h. The Control Rod Drive Mechanism cooling fans are in operation;

i. The Auxiliary Feedwater System is in operation and maintaining no-load water level in all steam generators;

j. All ESF busses are being energized from the diesel-generators, if necessary.

If the reactor will remain shutdown for an extended period of time and a plant cooldown is in order, then this method of natural circulation cooldown is to be used at this time.

II. DESCRIPTION OF EVENT TRANSIENT

The objective of the "Natural Circulation Cooldown" subprocedure is to permit cooldown and depressurization of the RCS without forming voids in the higher-temperature portions of the system (e.g, upper head region and steam generator U-tubes). Based on the cooldown/depressurization transient analysis performed for Westinghouse plants as a result of the St. Lucie Unit 1 plant cooldown using natural circulation, certain limitations were determined concerning the maximum cooldown rate and minimum subcooling requirements necessary to prevent void formation. The remainder of this section is devoted to a brief description of the St. Lucie cooldown transient analysis. Further details can be obtained from the St. Lucie Report which was provided to the NRC by a Westinghouse Owners Group letter (OG-57) dated April 20, 1981.

At St. Lucie it was evident from pressurizer level and primary system pressure response that void formation occurred in the upper head region during the natural circulation cooldown. Though the measured hot and cold leg temperatures at the time of voiding were highly subcooled, it appeared that the fluid in the upper head was much hotter, relatively stagnant and in poor communication with the rest of the primary system. It was postulated that the steam bubble in the upper head area was produced when the steam pressure dropped below the saturation pressure corresponding to the temperature of the fluid in the upper head.

There are several parameters which can have a significant effect on the formation of voids in the upper head region during naural circulation.

cooldown/depressurization transients. One such parameter is the magnitude of the flow communication between the upper downcomer and the upper head. This flow is at a temperature equivalent to that of the cold leg fluid. Hence, this flow directly affects the steady state upper head fluid temperature, which is a second factor which has an effect on the formation of voids in the upper head region. Most currently operating Westinghouse plants have an amount of flow into the upper head region which results in an upper head fluid temperature between the cold leg temperature (T_{COLD}) and the core outlet temperature (T_{HOT}). For the St. Lucie cooldown analysis the initial upper head temperature for these plants was conservatively chosen as T_{HOT}. Other Westinghouse plants operate with sufficient flow from the upper downcomer to the upper head region to make the upper head fluid temperature equal to the cold leg fluid temperature (T_{COLD}). Both types of plants were analyzed. Another parameter affecting void formation in the upper head which was analyzed is the cooldown/depressurization rate of the primary system. Natural circulation cooldown rates of 25°F/hr and 50°F/hr were analyzed for T_{HOT} and T_{COLD} plants, respectively. A final parameter important in the formation of voids in the upper head is the heat removal rate from the upper head. The two primary means of heat loss are ambient heat losses and heat removal by the control rod drive mechanism (CRDM) fans. The CRDM cooling system consists of fans which maintain a suitable atmosphere within the CRDM shroud to protect and prolong the life of the CRDM motors. The system induces cooler containment air into the CRDM shroud and exhausts through the fans. The effect of ambient heat losses through the reactor vessel on upper head temperature is small compared to the effect of the CRDM fans and was neglected in the analysis. The cooloff rate of the upper head due to ambient heat losses is less than 1°F/hr. Metal heat addition to the upper head area from the reactor vessel and upper internals was taken into account.

In the analysis, natural circulation cooldown was assumed to be initiated at 720 seconds into the transient. With the exception of the pressurizer, the primary system was subcooled when the natural circulation

cooldown was initiated. At 720 seconds the difference between the hot and cold leg temperatures was approximately 30^{0}F, the primary system loop flow was approximately 500 lb/sec, and the reactor power (due to decay heat) was 2.3 percent of full power (nominal). The loop flow rate of 500 lb/sec was approximately 5 percent of full power loop flow. Natural circulation flow was observed to be 4.5 percent to 5.0 percent of full power flow at 2.3 percent of nominal power for a Westinghouse 4-loop plant based on 4-loop calculations and tests.

With forced flow (i.e., with the reactor coolant pumps running) the flow goes from the upper downcomer through the upper head spray nozzles into the upper head region. From the upper head region the flow goes down through the guide tubes into the upper plenum/core region. With the reactor coolant pumps running the vessel pressure distribution is such that flow is forced up the upper head spray nozzles. Within 2 to 4 minutes after the reactor coolant pumps are tripped this flow reverses and goes up the guide tubes into the upper head region and down through the upper head spray nozzles into the upper downcomer. This flow reversal occurs due to the downcomer density being greater than the upper plenum/core density, and the upper plenum/core density being greater than the upper head density. This density variation forces flow up the guide tubes. Because of this flow reversal, upper head temperature rises early in the transient (see Figure 1). The upper head temperature is initially equivalent to the cold leg temperature. When the spray nozzle/guide tube flow reversal occurs, hotter water from the core is introduced into the upper head area and causes the upper head temperature rise. After this early increase, the upper head temperature steadily decreases.

Other detailed temperature and pressure transients obtained from the St.Lucie cooldown analysis are described in the owner's group (OG-57) report. However, the conclusions drawn from the analysis are presented below for completeness of this section, while the results have been incorporated into the steps of the subprocedure itself (see Enclosure 2, Discussion of Specific Guideline Steps, Cautions and Notes).

Conclusions for T_{HOT} Plants:

The average cooldown rate of the upper head fluid due to the 25°F/hr natural circulation cooldown rate is about 10°F/hr for a T_{HOT} plant. The total upper head cooldown rate due to both the natural circulation cooldown and the CRDM fans varies from 42°F/hr initially to around 27°F/hr when the upper head temperature is cooled to 350°F. Thus, with the CRDM fans operating during the cooldown, a T_{HOT} plant could be cooled and depressurized at a natural circulation cooldown rate of 25°F/hr to the point where the RHRS could be used for further cooldown with no void formation occurring in the upper head area. The operator should maintain 50°F subcooling during the depressurization.

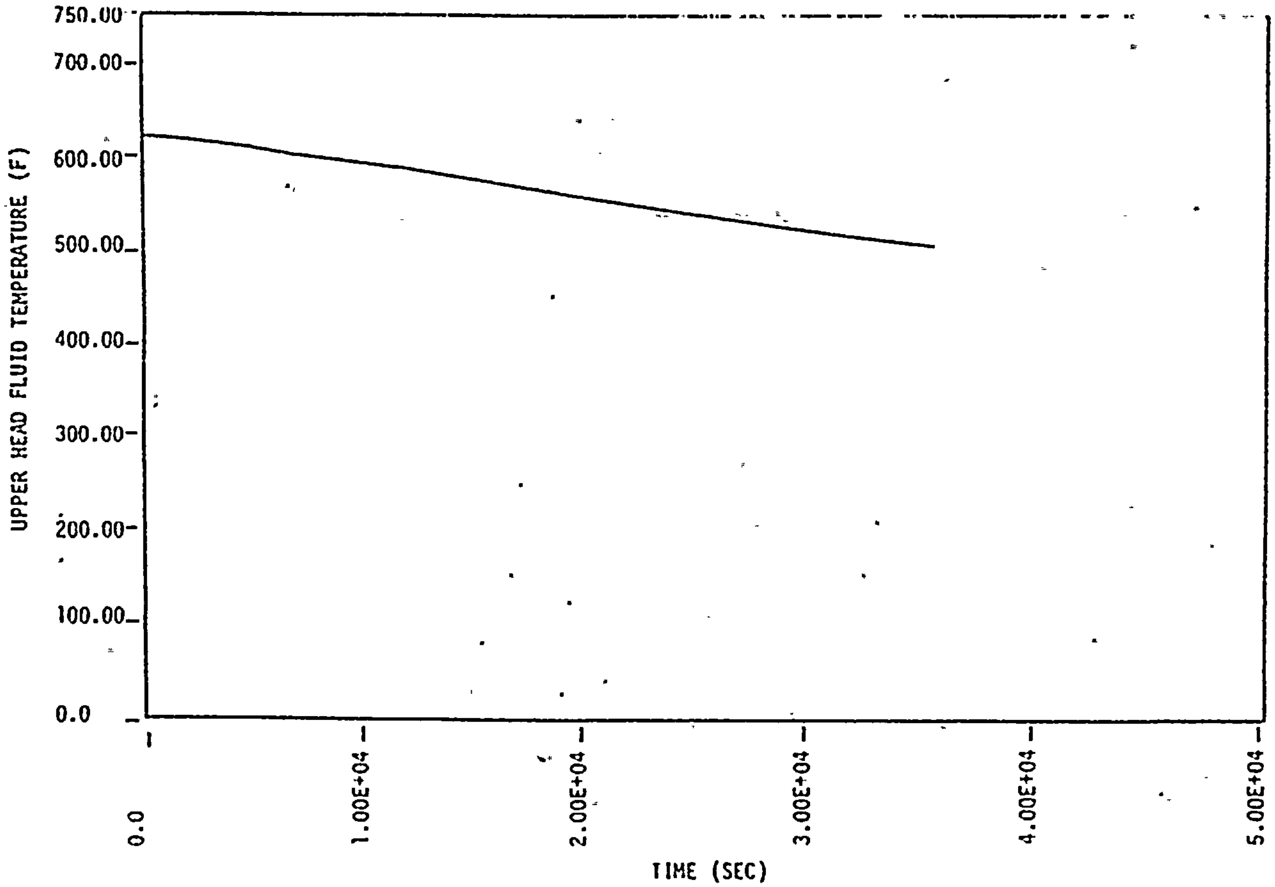


FIGURE 1

UPPER HEAD FLUID TEMPERATURE
T_{HOT} -25°F/HR - COOLDOWN

III. RECOVERY DESCRIPTION

A summary of the recovery technique contained in the "Natural Circulation Cooldown" subprocedure, ES-0.2, is given below. In addition, a block diagram description of the subprocedure steps is shown in Figure 2.

For natural circulation cooldown without void formation:

a. An RCS cooldown is initiated through dumping steam and a maximum cooldown rate is maintained depending upon the type of plant (T_{HOT} vs. T_{COLD});

b. At the permissive setpoints the automatic SI signals are blocked;

c. A minimum subcooling is established and maintained during subsequent cooldown and depressurization. It is dependent upon the type of plant (T_{HOT} vs. T_{COLD}) and the operation of the CRDM fans (all running vs. not all running);

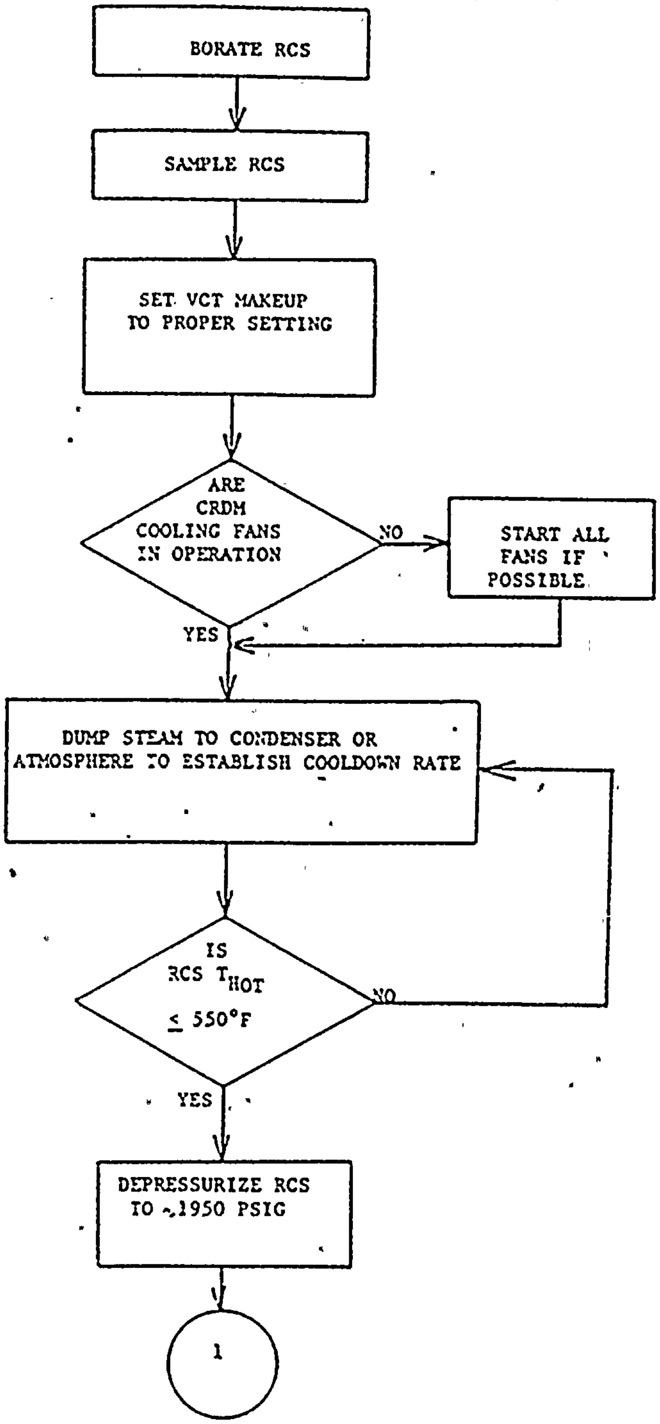
d. At the permissive setpoint the SI system is locked out;

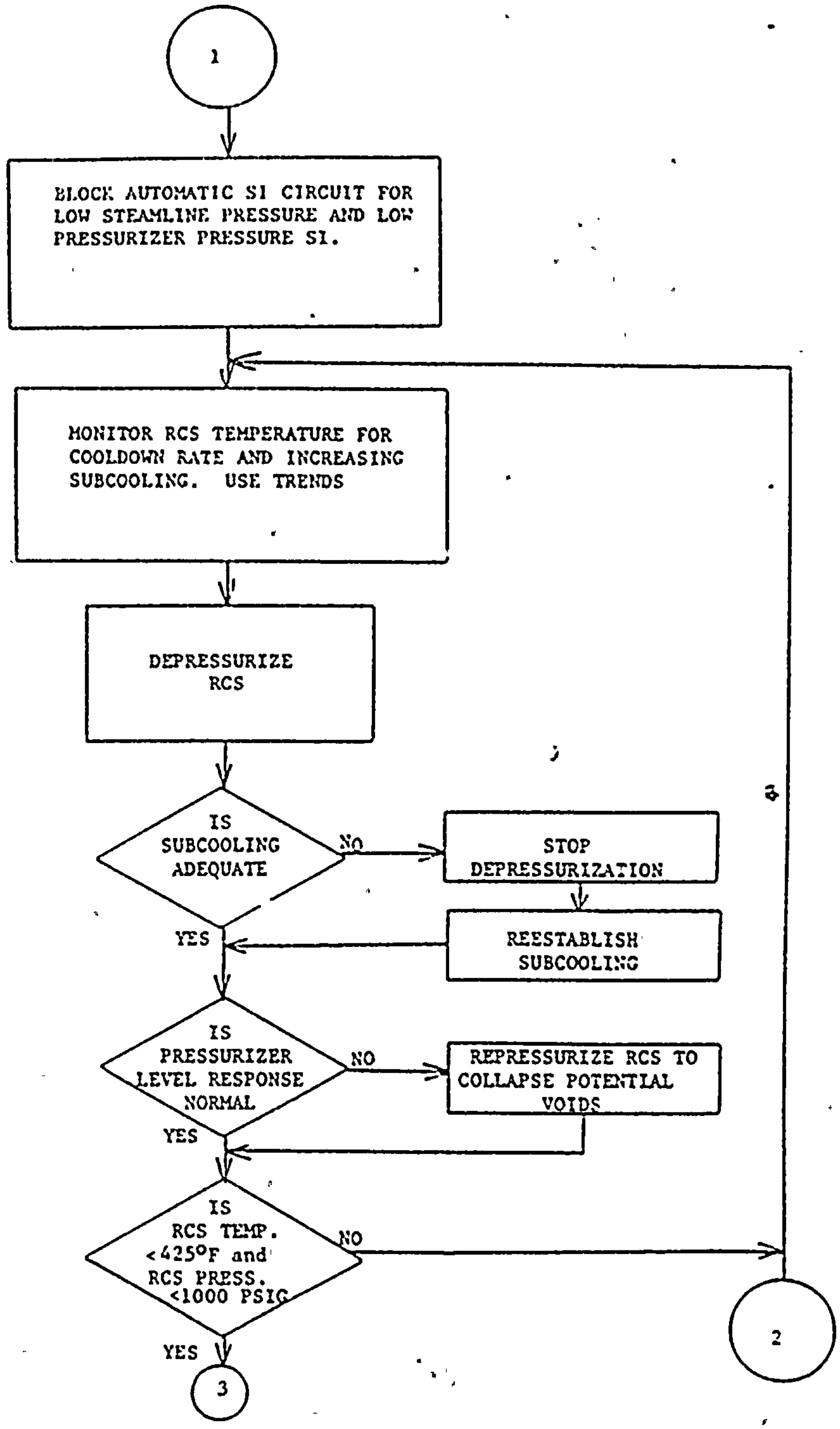
e. The RCS cooldown and depressurization are continued while maintaining the required cooldown rate and subcooling until the RHR system can be placed into service.

f. The cooldown of the entire RCS is continued to less than 200°F using the RHR system, steam dumping and CRDM fans.

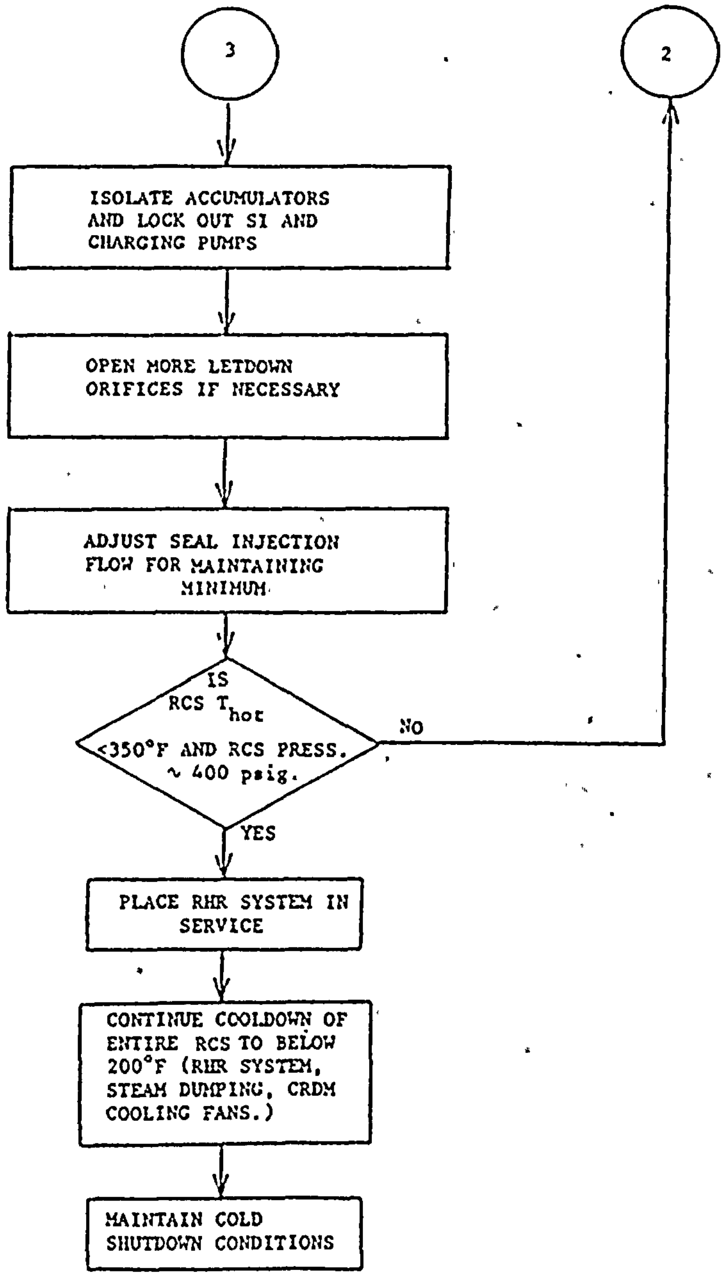
g. Cold shutdown conditions are then maintained while the plant staff investigates repairs necessary for a plant restart.

FIGURE 2 NATURAL CIRCULATION COOLDOWN (ES-0.2)





1
BLOCK AUTOMATIC SI CIRCUIT FOR LOW STEAMLINE PRESSURE AND LOW PRESSURIZER PRESSURE SI.
MONITOR RCS TEMPERATURE FOR COOLDOWN RATE AND INCREASING SUBCOOLING. USE TRENDS
DEPRESSURIZE RCS
IS SUBCOOLING ADEQUATE
NO
STOP DEPRESSURIZATION
REESTABLISH SUBCOOLING
YES
IS PRESSURIZER LEVEL RESPONSE NORMAL
NO
REPRESSURIZE RCS TO COLLAPSE POTENTIAL VOIDS
YES
IS RCS TEMP. <425°F and RCS PRESS. <1000 PSIG
NO
YES
3
2


3
2
ISOLATE ACCUMULATORS AND LOCK OUT SI AND CHARGING PUMPS
OPEN MORE LETDOWN ORIFICES IF NECESSARY
ADJUST SEAL INJECTION FLOW FOR MAINTAINING MINIMUM
IS RCS T_{hot} <350°F AND RCS PRESS. ∿ 400 psig.
NO
YES
PLACE RHR SYSTEM IN SERVICE
CONTINUE COOLDOWN OF ENTIRE RCS TO BELOW 200°F (RHR SYSTEM, STEAM DUMPING, CRDM COOLING FANS.)
MAINTAIN COLD SHUTDOWN CONDITIONS

IV. DISCUSSION OF SPECIFIC GUIDELINE STEPS, CAUTIONS AND NOTES

Steps 1 and 2.

Following stabilization of plant conditions and the determination that a plant cooldown is necessary during natural circulation mode, the coolant boron concentration should be corrected to provide for the required shutdown reactivity margin on a total coolant system mass basis. In other words, the RCS boron concentration in the active portions of the system should be such that it provides the shutdown reactivity margin required by plant Technical Specifications when calculated on the basis of homogeneous distribution of boron within the total plant mass. This will provide reasonable assurance that even a fairly rapid temperature drop, which results in a large outsurge of relatively dilute pressurizer liquid into the active (loop) portion of the reactor coolant system, will not cause problems with loss of core shutdown margin. Without reactor coolant pump-driven pressurizer spray, no adequate means of mixing the loop coolant with pressurizer liquid exists. This means that the active (loop + core) portions of the system must be over-borated to some extent to provide for attainment of the required boron concentration on an overall basis.

To borate, follow the normal procedures for boration using the VCT make-up control system set in the BORATE mode. Care must be taken to ensure homogeneity of boron in the coolant and, therefore, a slower rate of boration may be necessary corresponding to the decreased flow rate of natural circulation.

After completing the boration, it is important that the operator determine the system boron distribution by obtaining samples from available sample points, particularly the pressurizer liquid. The pressurizer liquid boron concentration will remain at or near the original coolant boron concentration prior to the loss of forced flow event. As mixing occurs in the active portions of the reactor coolant system, the boron concentration in the loop(s) with no charging connection should rise to meet the boron concentration in the loop with the charging connection.

The boron concentration measured in the hot legs, and in the letdown line should approach a common value as boron mixing in the active portions of the reactor coolant system proceeds. The ultimate shutdown condition of the reactor must be judged from the response of core nuclear supervisory instrumentation.

Step 3.

Following a successful boration by the use of the BORATE mode of the VCT makeup control system, the system should be returned to AUTOMATIC makeup operation, at a boron concentration which matches that in the active portions of the RCS (not the target overall boron concentration). This boric acid/reactor makeup water blend should be reset into the flow controllers. With the system in automatic operation, verify that the normal level is being maintained in the volume control tank during the coolant contraction.

Step 4.

From the analyses performed for the natural circulation cooldown at St. Lucie (See the W Owner's Group Report OG-57.) it was determined that the Control Rod Drive Mechanism (CRDM) cooling fans aided significantly in removing heat from the upper head area, and it was essential for them to be in operation, if possible.

The CRDM fans remove 12 kw/drive train at full power. As in the St. Lucie 4-loop plant with 57 full-length and 8 part-length rods, the CRDM fans remove 12 kw *(57+8) = 780 kw. For a 3 or 2-loop plant, multiply the total number of full-length plus part-length rods by 12 kw/rod to obtain the heat removal comparable to the 4-loop 780 kw. The ratio of heat removal by the CRDM fans to the upper head total energy (or upper head volume) is essentially the same for 2 and 3-loop plants as for 4-loop plants. Thus the cooldown rates determined for 4-loop plants (32^0F/hr at 600^0F and 17^0F/hr at 350^0F, see step 10) are applicable to 2 and 3-loop plants.

Further calculations show that a 3-loop plant with an inverted top hot upper support plate requires 47 drive trains for the CRDM fans to remove the same MWt per ft^3 of upper head volume as in the St. Lucie case. The corresponding number of drive trains for a 2-loop plant is 33. While CPL and FPL don't have 47 or more drive trains (or NOK, 33 or more), these plants have flat upper support plates instead of inverted top hat. Therefore the total upper head volume (as well as the total initial heat in the upper head) will be significantly less, and the heat removal from the upper head per unit of upper head volume (kw/ft^3) for these plants should be as good as or better than that used in the St. Lucie analyses. Thus the St. Lucie CRDM fan cooler heat removal rates are valid for all 2 and 3-loop plants.

St. Lucie results will also be applicable to TVA, DAP and WAT plants which have upper head injection with a 7.5 percent bypass flow. For TBX, SCP and PBJ, which are T_{COLD} (see Step 5) inverted top hat plants, utilities involved may have to revise the heat removal rate from the upper head as that used in the St. Lucie calculations. In St. Lucie, the maximum upper head temperature for a T_{COLD} plant was 572°F and the upper head removal rate at this temperature was 30°F/hour. If it is assumed that the maximum upper head temperature is the same for TBX and PBJ and these plants have 53 drive trains being cooled at 12 kw/drive train by the CRDM fans, the heat removal rate from the upper head for the CRDM fans would be:

$$30^{\circ}F/hr * \frac{53}{65} = 24.5^{\circ}F/hr \text{ at } 572^{\circ}F$$

Similarly, OHI and TGX (T_{HOT} inverted top hat) would require revisions from St. Lucie results due to having less heat removal from the upper head by the CRDM fans.

Step 5.

To establish the cooldown of the RCS, steam must be released through the condenser steam dump valves. However, if the main condenser is not

available for steam dump, the cooldown must be established by use of the steam generator power-operated relief valves, releasing steam to the atmosphere. With control air pressure available and <u>no</u> main condenser, the plant steam pressure will be controlled at the set pressure of the PORVs on the steam generators. The plant cooldown is initiated by decreasing the pressure setpoint of the PORVs. The cooldown rate should be controlled and maintained less than the plant-specific maximum cooldown rates obtained from the Appendix to this document. The cooldown rate depends upon whether the plant is a T_{COLD} or T_{HOT} plant. Turkey Point Units 3 & 4 are defined to be T_{HOT} plants. Steam dump must be discontinued if the actual cooldown rate exceeds these permissable values.

Auxiliary feedwater flow is regulated to maintain steam generator level. In addition to the obvious function of providing a heat sink for small break LOCA, it is also necessary to maintain water level in the steam generators for small and large break LOCAs so that radioactive doses can be minimized. Any increasing level in one steam generator should be attributed to control system response or manual flow regulation. If one steam generator water level is not reacting as expected, a steam generator tube rupture may be present. To prevent uneven RCS temperature distributions, the pressure difference between steam generators must be minimized. This ensures that decay heat removal is evenly distributed to each active coolant loop and that automatic initiation of safety injection does not occur on a high steam line P signal.

The caution is a long-term instruction to ensure that an alternate water supply is continuously provided to the auxiliary feedwater pumps in the event that the condensate storage tank water level is low or the main condenser is unavailable and the secondary cooling system working fluid cannot be reused.

<u>Steps 6, 7 and 8.</u>

The low steamline pressure and low pressurizer pressure safety injection circuitry must be blocked during the plant cooldown and depressurization.

Therefore, the RCS pressure must be reduced below the pressure at which SI normally unblocks (e.g., 2000 psig) to permit this blocking of SI circuitry. A pressure 50 psi below this pressure where SI normally unblocks is used here (e.g., 1950 psig). However, in order to guarantee a minimum of 50°F subcooling, the RCS hot leg temperature must be less than approximately 550°F. This value of 550°F was chosen to allow for the initial RCS temperature rise within the first several minutes after the reactor coolant pumps are tripped (from spray nozzle/guide tube flow reversal, as explained in section II, Description of Event Transient).

The depressurization should be accomplished through the use of pressurizer auxiliary spray if letdown is available to heat the charging flow in the regenerative heat exchanger. This will minimize the thermal shock to the auxiliary spray nozzle. If letdown is not in service, then the PORVs should be opened intermittently to decrease the pressurizer pressure.

The caution indicates that the automatic actuation circuit will be unblocked if RCS pressure is increased above the pressure at which SI normally unblocks (e.g.,2000 psig). The manual blocking of the circuit would have to be repeated, when the permissive is energized, in order to cooldown and depressurize.

The low pressure safety injection circuitry must be blocked when RCS pressure decreases below the permissive setpoint. Prior to blocking automatic safety injection actuation, the RCS boron concentration should be verified to provide the adequate cold shutdown reactivity margin.

Step 9.

At this point it must be assured that the RCS conditions established in the previous steps are being maintained. The RCS pressure is maintained at 50 psi below the pressure at which SI normally unblocks during the ensuing cooldown to guard against possible void formation. In addition, the pressurizer level should be maintained at approximately no-load

level. However, if voids are present in the RCS, the pressurizer will exhibit large variations in level. Therefore, the pressurizer level should be monitored during subsequent RCS cooldown and depressurization (see step 13).

As explained previously in step 5, the RCS cooldown rate must be maintained at less than the plant specific rate obtained from the Appendix to this document.

Step 10.

Monitor the core exit thermocouples (TCs) and the reactor coolant hot leg temperatures to verify that the reactor coolant is being cooled by the discharge of steam from the steam generators at the cooldown rate previously described in steps 5 and 9. In addition, verify that the subcooling of the reactor coolant is increasing (see step 11 for more detail). This ensures that adequate core cooling is being provided. The subcooling is determined by use of wide range pressure, wide range hot leg RTDs and core exit thermocouples.

Trended readings for core coolant exit thermocouple readings, loop T_H readings, and loop ΔT readings should be used to monitor cooldown and subcooling with readings at 10-15 minute intervals recommended. The observed loop temperatures and temperature differences (T_H, T_C, ΔT) can be expected to vary from loop-to-loop and may deviate at any single observation. These variations of individual readings from the nominal responses are normal, and therefore trended values only are useful for diagnoses of possible problematic conditions in natural circulation flow.

After the natural circulation cooldown has been established, the reactor coolant hot leg temperature should trend down with the decreasing steam pressure.

Steps 11 and 12.

The pressurizer pressure should periodically be decreased to maintain the reactor coolant and pressurizer pressure-temperature relationship in accordance with the Technical Specifications and the figures shown in the Appendix to this document (described below). The depressurization should be accomplished as described in step 9, using pressurizer auxiliary spray or pressurizer PORVs, depending upon whether letdown is in service.

To prevent possible void formation in the upper head, the plant-specific maximum cooldown rates and minimum subcooling, as described in the Appendix to this document, must be maintained. With the availability of the CRDM cooling fans, the total upper head cooldown rate for T_{COLD} plants varies from a maximum of 64^{o}F/hr to about 51^{o}F/hr when the upper head temperature is cooled to 350^{o}F (34^{o}F/hr from the natural circulation cooldown rate of 50^{o}F/hr plus 30^{o}F/hr from the CRDM fans when the upper head temperature is at its highest, 572^{o}F, to 17^{o}F/hr when the upper head temperature is 350^{o}F). For T_{HOT} plants, the total upper head cooldown rate due to both the natural circulation cooldown rate of 25^{o}F/hr (upper head cooldown rate of 10^{o}F/hr) and the availability of CRDM fans (upper head cooldown rate from 32^{o}F/hr at 600^{o}F to 17^{o}F/hr at 350^{o}F) varies from 42^{o}F/hr initially to about 270^{o}F/hr when the upper head temperature is cooled to 350^{o}F. With CRDM fans available, a subcooling margin of only 50^{o}F should be maintained for both types of plants during depressurization.

The figures included in the Appendix illustrate the acceptable operating region, from the pressure-temperature relationship, depending upon the type of plant (T_{COLD}, T_{HOT}) and availability of CRDM fans. It should be noted that the plant-specific Technical Specification curve should be inserted in these figures to replace the typical curve shown. Since the guidelines are written on a generic basis, any problems that may arise due to a plant's more restrictive Technical Specification curve will have to be resolved on a plant specific basis.

If at any time the required subcooling cannot be maintained, the RCS depressurization must be stopped until the required subcooling is reestablished in order to prevent possible void formation in the upper head

Steps 11 and 12.

The pressurizer pressure should periodically be decreased to maintain the reactor coolant and pressurizer pressure-temperature relationship in accordance with the Technical Specifications and the figures shown in the Appendix to this document (described below). The depressurization should be accomplished as described in step 9, using pressurizer auxiliary spray or pressurizer PORVs, depending upon whether letdown is in service.

To prevent possible void formation in the upper head, the plant-specific maximum cooldown rates and minimum subcooling, as described in the Appendix to this document, must be maintained. With the availability of the CRDM cooling fans, the total upper head cooldown rate for T_{COLD} plants varies from a maximum of 64°F/hr to about 51°F/hr when the upper head temperature is cooled to 350°F (34°F/hr from the natural circulation cooldown rate of 50°F/hr plus 30°F/hr from the CRDM fans when the upper head temperature is at its highest, 572°F, to 17°F/hr when the upper head temperature is 350°F). For T_{HOT} plants, the total upper head cooldown rate due to both the natural circulation cooldown rate of 25°F/hr (upper head cooldown rate of 10°F/hr) and the availability of CRDM fans (upper head cooldown rate from 32°F/hr at 600°F to 17°F/hr at 350°F) varies from 42°F/hr initially to about 270°F/hr when the upper head temperature is cooled to 350°F. With CRDM fans available, a subcooling margin of only 50°F should be maintained for both types of plants during depressurization.

If at any time the required subcooling cannot be maintained, the RCS depressurization must be stopped until the required subcooling is reestablished in order to prevent possible void formation in the upper head

region. See Reference 1, the St. Lucie Report, for more detail on the determination of these limits for natural circulation cooldown.

Step 13.

If abnormal RCS conditions such as large variations in pressurizer level during normal charging or spraying operations occur, a steam void may be present in the reactor vessel upper head. If so, repressurize the RCS to collapse the voids. Extra care must be taken during subsequent cool-down.

Step 14.

The safety injection accumulator isolation valves should be closed (by whatever plant specific means necessary) and their power supplies locked out to prevent the dumping of the accumulator borated water into the RCS when RCS pressure drops below accumulator pressure. The safety injection pumps and the non-operating charging/SI pump should be locked out to prevent any spurious startings. The pressure and temperature criteria given for locking out the SI system are only representative values and, therefore, the appropriate Technical Specifications for the plant should be used to lock out SI at this time. It should be noted that the average RCS temperature (average of hot leg and cold leg temperatures) is checked and not the RCS average temperature (T_{ave}) since RTD readings are unreliable during natural circulation.

Step 15.

As reactor coolant pressure decreases, the ΔP across the letdown orifice will drop and result in decreased letdown flow. Action should be taken to increase letdown flow to maintain a constant RCS inventory.

Step 16.

Reactor coolant pump seal injection flow will increase as RCS pressure decreases. Adjust the hand controlled throttle valve in the charging

line as necessary to maintain the seal injection flow within the required limits of the RCP operation instructions.

Step 17.

In order for the RHR system to be placed in service, these conditions for RCS temperature (less than or equal to 350^{O}F) and pressure (approximately 400 psig) must be met through the preceding process of cooldown and depressurization. The RCS pressure criterion of approximately 400 psig is used as the setpoint at which the operator first attempts to open the appropriate valves for RHR system service. It may be necessary to clear certain interlocks which prevent proper alignment of the RHR system valves. Only when the above conditions are attained, should the RHR system be placed into service according to the plant specific procedures.

Steps 18 and 19.

To obtain cold shutdown conditions, the RCS cooldown must continue with the RHR system to less than 200^{O}F. However, the caution warns that depressurizing the RCS before the entire RCS (including the upper head region and steam generator U-tubes) is less than 200^{O}F could result in void formation. Therefore, while using the normal plant cooldown instructions after the RHR system has been placed into service, steps to cooldown these inactive portions of the RCS must also be performed due to the following:

a) The core flow during RHR system operation is less than 2 percent of full flow. The RHR system flow is even less than the natural circulation flow, and the upper head will, therefore, remain stagnant compared to the rest of the RCS (i.e., the RHR system will not force cooling flow into the upper head). Two options are then available: 1) run the CRDM fans during RHR system operation to cool the upper head, or 2) wait for the upper head to cool by conduction before depressurizing the RCS with the RHR

APPENDIX

Maximum Permissable Cooldown Rates to Avoid Upper Head Void Formation (Steps 5a, 9c, 12a)

1. Maximum permissable cooldown rate for all plants that are classified as T_{COLD} plants is 50°F per hour.

2. Maximum permissable cooldown rate for all plants that are classified as T_{HOT} plants is 25° per hour. (Turkey Point Units 3 & 4)

Minimum Indicated Subcooling to Avoid Upper Head Void Formation (Step 11a)

If all CRDM fans are in operation, both T_{HOT} and T_{COLD} plants must maintain at least 50°F indicated subcooling. See Figure 1 or the cooldown description in the first attachment for the acceptable operating region.

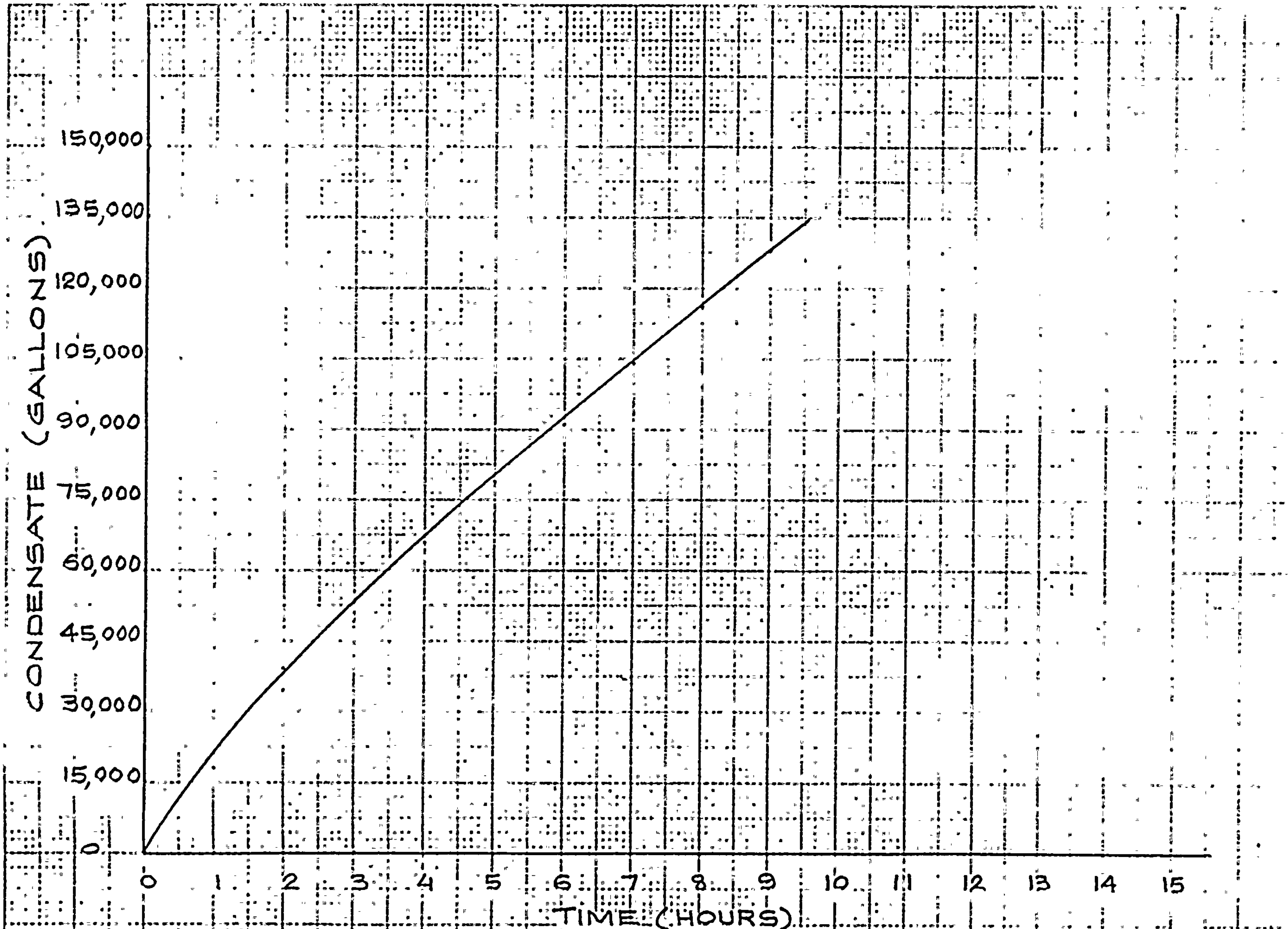


FIG 4. CONDENSATE REQUIRED IN NATURAL CIRCULATION COOLDOWN WITH CRDM FANS FOR TURKEY POINT UNITS 3 & 4 SKM 11-20-81

Enclosure 3

STATE OF FLORIDA)
) ss.
COUNTY OF DADE)

John A. DeMastry, being first duly sworn, deposes and says:

That he is Manager, Nuclear Licensing of Florida Power & Light Company, the herein;

That he has executed the foregoing document; that the statements made in this said document are true and correct to the best of his knowledge, information, and belief, and that he is authorized to execute the document on behalf of said

John A. DeMastry
John A. DeMastry

Subscribed and sworn to before me this 4 day of December, 1981

Cheryl L. Fredrick
NOTARY PUBLIC, in and for the County of Dade, State of Florida

My commission expires: Notary Public, State of Florida at Large My Commission Expires October 30, 1983 ~~Bonded thru Maynard Bonding Agency~~