Number:	Symptom/Title:	Revision No./Date
ES-1.2	POST LOCA COOLDOWN AND DEPRESSURIZATION	Basic 1 Sept. 1981

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

Caution *If RWST level reaches (1), align SI system or cold leg recirculation per ES-1.3, TRANSFER TO COLD LEG RECIRCULATION FOLLOWING LOSS OF REACTOR COOLANT.*

NOTE
- *RCP pressure trip criteria does not apply during controlled RCS depressurization. RCP must be tripped if RCS subcooling is less than (2) °F.*
- *RCPs should be run in order of priority to provide pressurizer spray.*
- *Foldout page should be open.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
1	**Check RCP Status:**	
	a. At least one RCP – RUNNING	a. IF no RCP running, THEN try to start one RCP: 1) Establish conditions for running one RCP – [Enter plant specific list.] 2) Start one RCP.
	b. If more than one RCP running, stop all but one RCP	
2	**Reset SI.**	
3	**Reset Containment Isolation Phase A.**	
4	**Compare RCS And Steam Generator Pressures:**	
	a. RCS pressure – GREATER THAN OR EQUAL TO STEAM GENERATOR PRESSURES	a. IF RCS pressure less than steam generator pressures, THEN dump steam to condenser until pressures equal. 1) [Enter plant specific steps.] IF condenser NOT available, THEN use steam generator PORVs.

(1) Enter plant specific value corresponding to RWST switchover alarm in plant specific units.

(2) Enter sum of temperature and pressure measurement system errors translated into temperature using saturation tables.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
5	**Verify Adequate Shutdown Margin.**	Borate as necessary.
6	**Initiate RCS Cooldown:**	
	a. Maintain cooldown rate – LESS THAN 100°F/HR	
	b. Dump steam to condenser: [Enter plant specific list]	b. Dump steam with steam generator PORVs.
	c. Maintain steam generator narrow range level – AT __(1)__ %	c. Throttle AFW flow as necessary.

Caution *RCS subcooling must be maintained greater than __(2)__ °F during any RCS depressurization.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
7	**Try To Restore Pressurizer Level Above 20%:**	
	a. Maintain RCS subcooling – GREATER THAN __(2)__ °F	a. Continue dumping steam.
	b. Reduce pressurizer pressure with normal spray	b. Use one pressurizer PORV. <u>IF</u> pressurizer PORVs <u>NOT</u> available, <u>THEN</u> use auxiliary spray.
	c. Pressurizer level – GREATER THAN 20%	c. Perform steps 9 and 10. <u>WHEN</u> level reaches 20%, <u>THEN</u> do step 8.
8	**Increase Pressurizer Temperature:**	
	a. Energize heaters	
	b. Restore temperature to 50°F above core exit TCs	
	c. Maintain temperature – GREATER THAN 50°F ABOVE CORE EXIT TCs	

(1) Enter plant specific value corresponding to no-load steam generator level including allowances for post accident transmitter errors and reference leg process errors.

(2) Enter sum of temperature and pressure measurement system errors translated into temperature using saturation tables.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
9	**Prevent Accumulators From Injecting:**	
	a. Check power available to isolation valves	a. Restore power to isolation valves.
	b. Close isolation valves	b. Vent any un-isolated accumulator to (1) psig.
10	**Check RCS Pressure:**	
	a. RCS pressure – GREATER THAN 400 PSIG	a. IF pressure less than 400 psig, THEN go to step 15.

Caution *RCP seal cooling (either seal injection or CCW) must be maintained at all times.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
11	**Depressurize RCS By Reducing Charging/SI Flow:**	
	a. Open charging/SI pump miniflow path	
	b. Throttle SI flow from one charging/SI pump	
	c. Maintain pressurizer ~~level~~ pressure with normal spray	c. Use one pressurizer PORV. IF pressurizer PORVs NOT available, THEN use auxiliary spray.
	d. Check charging/SI pump discharge pressure – LESS THAN (2) PSIG	d. IF discharge pressure greater than (2) psig, THEN: 1) Stop pump. 2) IF another charging/SI pump is running, THEN repeat step 11. IF NOT, THEN go to step 12.
	e. Check RCS pressure – LESS THAN 400 PSIG	e. IF RCS pressure greater than 400 psig, THEN repeat step 11.

(1) Enter value such that injection of accumulator water from this pressure will not result in nitrogen injection at low RCS pressure.

(2) Enter charging/SI pump discharge pressure at miniflow.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
12	**Establish Normal Charging Path:**	
	a. Isolate BIT flow path	
	b. Fully open manual throttle valves	
	c. Open normal charging line	
	d. Verify seal injection flow path	
	e. Start one charging pump	
13	**Check RCS Pressure:**	
	a. RCS pressure – LESS THAN 400 PSIG	a. IF pressure greater than 400 psig, THEN throttle charging flow control valve. IF RCS pressure remains above 400 psig, THEN go to step 14.
	b. Go to step 15	

Caution *Do not open high-head SI pump miniflow valves if the SI system is in cold or hot leg recirculation.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
14	**Depressurize RCS By Reducing High-head SI Flow:**	
	a. Throttle flow from one high-head SI pump	
	b. Maintain pressurizer level with normal spray	b. Use one pressurizer PORV. IF pressurizer PORVs NOT available, THEN use auxiliary spray.
	c. Check high-head SI pump discharge pressure – LESS THAN __(1)__ PSIG	c. IF discharge pressure greater than __(1)__ psig, THEN: 1) Stop pump. 2) IF another high-head SI pump is running, THEN repeat step 14. IF NOT, THEN go to step 15.
	d. Check RCS pressure – LESS THAN 400 PSIG	d. IF RCS pressure greater than 400 psig, THEN repeat step 14.

(1) Enter high-head SI pump discharge pressure at miniflow.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
15	**Check RCS Conditions:**	
	a. RCS pressure – LESS THAN 400 PSIG	
	b. RCS hot leg temperature – LESS THAN 350°F	b. Continue dumping steam.
16	**Evaluate Plant Status:**	
	a. Determine if RHR can be placed in service for cooldown.	a. <u>IF NOT</u>, <u>THEN</u> return to E-1, LOSS OF REACTOR COOLANT.

— END —

FOLDOUT FOR E-1 AND ES-1 GUIDELINES

1. <u>RCP TRIP CRITERIA</u>
   - Trip any RCP if component cooling water to that pump is lost.
   - Trip all RCPs if <u>BOTH</u> conditions listed below are met:

     a. SI is ON.

     b. RCS pressure - EQUAL TO OR LESS THAN (1) PSIG.

2. <u>SI TERMINATION CRITERIA FOLLOWING LOSS OF REACTOR COOLANT</u>

   a. Terminate SI when <u>ALL</u> parameter listed below are met:

   (1) RCS Pressure - GREATER THAN 2000 PSIG

   (2) RCS Subcooling - (2) °F

   (3) Pressurizer level - GREATER THAN 50%

   (4) Heat Sink:

   (a) SG Level - (3) % NR

   — OR —

   (b) AFW Flow - (1) GPM

3. <u>SI REINITIATION CRITERIA FOLLOWING LOSS OF REACTOR COOLANT</u>

   a. Reinitiate SI if <u>ANY ONE</u> of the parameters listed below occurs:

   (1) RCS Pressure - LESS THAN (4) PSIG

   (2) RCS Subcooling - LESS THAN (2) °F

   (3) Pressurizer Level - LESS THAN 20%

4. <u>COLD LEG RECIRCULATION SWITCHOVER CRITERION</u>

   <u>IF</u> RWST level less than (5) %, <u>THEN</u> align SI system for cold leg recirculation per ES-1.3, TRANSFER TO COLD LEG RECIRCULATION FOLLOWING LOSS OF REACTOR COOLANT.

5. <u>SYMPTOMS FOR FR-C.1, RESPONSE TO INADEQUATE CORE COOLING</u>

   Go to FR-C.1, RESPONSE TO INADEQUATE CORE COOLING when <u>ALL</u> symptoms in <u>ANY ONE</u> of the following symptom sets occur:

PARAMETER	SYMPTOM SET		
	I	II	III
1. TCs	> 1200 °F	–	> 700 °F
2. Containment Condition	–	ABNORMAL	ABNORMAL
3. RCP Status	–	ANY ON	ALL OFF
4. RVLIS	–	< 100% NR	< (6) % ~~WRNR~~

6. <u>SYMPTOMS FOR FR-H.1, RESPONSE TO LOSS OF SECONDARY HEAT SINK</u>

   Go to FR-H.1, RESPONSE TO LOSS OF SECONDARY HEAT SINK, if AFW flow is <u>NOT</u> AVAILABLE.

(1) Enter plant specific value derived from background document to E-O.

(2) Enter sum of temperature and pressure measurement system errors translated into temperature using saturation tables.

(3) Enter plant specific narrow range value which includes allowance for normal channel accuracy, post-accident transmitter errors, and reference leg process errors.

(4) Enter plant specific value for low pressurizer pressure SI setpoint.

(5) Enter plant specific value corresponding to RWST switchover alarm in plant specific units.

(6) Enter plant specific value which is 3½ feet above bottom of active fuel in core with zero void fraction, plus uncertainties.

BACKGROUND INFORMATION
FOR
WESTINGHOUSE
EMERGENCY RESPONSE GUIDELINES

ES-1.2
POST-LOCA COOLDOWN AND DEPRESSURIZATION
GUIDELINE BASIC REVISION
SEPTEMBER 1, 1981

With the system temperature and pressure established at the allowable values for operation of the residual heat removal system, a decision can be made as to whether to attempt to place the RHR system in service. Depending on the specific plant design, placing the RHR system in operation may require defeat of various interlocks and must be carefully evaluated before proceeding.

The specific objectives of the Post-LOCA Cooldown and Depressurization guideline are as follows:

1. Cool down the secondary side of the steam generators to terminate the transfer of stored heat from the steam generators and to begin the cooldown of the reactor coolant.

2. Maintain the required shutdown margin as the reactor coolant temperature is decreased.

3. Maintain the subcooling of the reactor coolant.

4. Attempt to restore a water level in the pressurizer.

5. Reduce the reactor coolant pressure by venting or quenching the steam bubble and reducing the injection flow rate into the reactor coolant system.

The plant systems may be operating in the injection mode as a result of the automatic actuation signal, with at least one train of safeguards components in operation, or may be in the recirculation mode. It is intended that the post-LOCA instructions be implemented only after the plant has been brought to a relatively stable condition and there is a need to reduce the reactor coolant temperature and pressure. The actions are not to be taken until directed to by E-1.

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I. INTRODUCTION

The system transients applicable during the use of this guideline are contained on the background document for E-1, "Loss of Reactor Coolant".

The required operations to mitigate the consequences of a loss of coolant accident are described in Emergency Guideline E-1. Correct performance of the required actions will bring the reactor plant to a relatively stable condition in which the injection flow approximately equals the leak flow. Depending on the size of the leak, the reactor coolant pressure may be near the containment pressure (large break), near normal operating pressure (small break) or at any intermediate pressure.

The plant is designed to remain in the recirculation mode (either cold or hot leg) for an indefinite period. In this mode of operation, the reactor coolant pressure will remain at a value dependent on the size of the leak and the safety injection system characteristics. Some or all of the residual heat of the core will be carried away with the leak flow and will be dissipated to the environs through heat exchangers in the safeguards systems. For very small breaks in which the leak flow is not sufficient to remove the core heat, the reactor coolant temperature will remain elevated to allow the steam generators to remove some of the heat.

The Post-LOCA Cooldown and Depressurization guideline is provided to describe additional optional actions which will change the status of the reactor plant. The specific purpose of the optional operator actions is to bring the reactor coolant system temperature and pressure to or below 350 degrees F and 400 psig respectively and to attempt to restore an indicated water level in the pressurizer.

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II. RECOVERY DESCRIPTION

Referring to the block diagrams (figure 1), a summary description of this guideline follows. Where a specific plant design must be assumed in developing a step, the standard Westinghouse 412 design was used. The fluid system configuration is shown on figure 2.

A. The initial group of steps establishes "normal" plant conditions for cooldown. These include having one RCP running, resetting SI and containment isolation, reducing secondary side pressure (if required), and verifying adequate shutdown margin.

B. After establishing stable initial RCS conditions, a controlled cooldown is begun by steam dump.

C. The next set of steps attempts to restore pressurizer level so that the heaters can be used to maintain subcooling margin.

D. The next step isolates the accumulators to prevent them from maintaining RCS pressure and injecting nitrogen during the subsequent depressurization steps.

E. The next group of steps begins RCS depressurization if the RCS pressure is above the RHR cut-in pressure of 400 psig. This depressurization is accomplished by throttling the charging pumps. This throttling is terminated when either all charging pumps are stopped (to prevent dead heading the pumps) or the RCS pressure is below 400 psig. The charging pumps are then re-aligned to the normal charging flow path. If the pressure remains above 400 psig, the throttling procedure is repeated with the high-head SI pumps. After the high-head SI pump throttling is complete, the RCS pressure will be below 400 psig.

The guideline describes the W standard 412 arrangement. For plants without charging/SI pumps, the high-head SI pumps would

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be throttled, and the normal charging flow path would be established. For plants with charging/SI pumps but no high-head SI pumps, the steps dealing with high-head SI pumps would be deleted.

F. The final steps verify the plant has been brought to RHR conditions (less than 350°F and 400 psig), and directs the plant staff to determine the long-term plant status.

III. DISCUSSION OF SPECIFIC GUIDELINE STEPS, CAUTIONS AND NOTES

A. Caution before Step 1: This caution warns that, if cooldown and depressurization has begun before transfer to cold leg recirculation, the operator must immediately go to the transfer procedure upon reaching the appropriate RWST level setpoint. This transfer to cold leg recirculation has priority over the cooldown and depressurization operations. For plants with semi-automatic transfer to recirculation, the appropriate RWST level is the automatic transfer setpoint. For plants with manual transfer, the RWST level alarm which alerts the operator to commence transfer is appropriate.

B. Note before Step 1: This note explains that the RCPs do not have to be tripped on low RCS pressure as required in guideline E-1, provided that a controlled RCS depressurization is in progress. This allows use of an RCP during the subsequent steps to achieve RCS pressure control (pressurizer spray) and a homogeneous RCS mixture. However, if RCS subcooling is lost, the RCPs must be stopped for pump protection.

C. Step 1: The intent of this step is to insure that one, and only one, RCP is running. Since this procedure is entered from E-1, it is possible all RCPs were tripped. However, as noted in part B, it is desirable to start a RCP. Therefore, part a of this step first checks if at least one RCP is running. If

all are off, the operator should attempt to start one, after establishing that the necessary support systems (e.g., component cooling water, electrical power, seal cooling) are available. If there is more than one RCP running, all but one should be stopped, as described in Step 1b. This is consistent with normal plant cooldown procedures. One RCP is sufficient for homogeneity and pressure control. More than one RCP running will unnecessarily extend cooldown by adding heat to the RCS.

There is a distinct order of preference for RCP operation. If possible, the RCP in the loop with the surge line should be the running pump. This provides maximum pressurizer spray capability. The second choice is a RCP in a loop with a pressurizer spray line. This would provide some pressurizer spray capability. (On some plants, maximum spray is obtained with either pump in a loop with a spray line. In this case, there is no preference between surge line and spray line loops.) If these pumps are not available, an RCP in a loop without the surge line or a spray line (for 3 and 4 loop plants) should be used. These pumps will not provide normal pressurizer spray, but will insure a homogeneous RCS with respect to temperature and boron gradients.

D. Steps 2 & 3: These steps advise the operator that, before some of the actions to realign the systems can be taken, the automatic actuation signals for safety injection and containment isolation must be reset and blocked. However, these actions do not imply that safety injection flow will be changed or that the containment integrity will be violated. Specific examples of required actions which depend on resetting safeguards signals are establishing compressed air inside containment, opening charging/containment isolation valves, etc.

E. Step 4: For many larger sized breaks, the reactor coolant temperature will decrease rapidly, due to the loss of heat out

the break, and will become lower than the temperature of the water and steam on the secondary side of the steam generators. This differential temperature is undesirable since it will tend to add heat to the reactor coolant. Therefore, if the steam generator pressure is above the RCS pressure, this step directs the operator to immediately dump steam from all steam generators to decrease the differential temperature and consequently the transfer of heat into the reactor coolant. The preferred method to dump steam is through the normal path to the main condenser. If the condenser is not available, the steam generator PORVs may be used. This steam dump is to be controlled such that the resultant steam generator pressure is at or slightly below the RCS pressure. The steam dump must be controlled such that an RCS cooldown will not commence. Since the secondary pressure will not be continuously decreasing at the time, there should be no concern with respect to uncovering the steam generator U-tubes. Should steam generator water level drop significantly during this depressurization, it should be terminated.

F. Step 5: The purpose of this step is to verify that the required reactivity shutdown margin for the expected cooldown operation will be maintained. For small breaks in which little more than the contents of the BIT are injected before the cooldown is to begin, additional boron may be necessary to reach the cold shutdown boron concentration since the BIT contents may not be sufficient to borate to the equilibrium cold shutdown value. For large breaks, the injection of large volumes of borated water from the accumulators and RWST, in addition to the contents of the BIT, will provide the required boron to counter the positive reactivity addition due to the cooldown.

This step does not require sampling if the operator is confident that sufficient shutdown margin exists. If samples are required, the boron samples to determine RCS concentration

should be taken from as many sample points (e.g. hot leg, pressurizer) as practical. This is especially true if there are no RCPs running, since boron gradients might exist in the RCS. When determining the adequacy of the RCS boron concentration, the required concentration should be adjusted, if necessary, to account for any control rods which are not fully inserted. Once boration (if required) is initiated, the operator may proceed to Step 6 (cooldown), since the BIT contents would have already been injected to provide sufficient shutdown margin down to an RCS temperature of 350°F (assuming no more than one control rod not fully inserted).

The boration path chosen is plant specific, and depends on equipment availability. The recommended method is to align the highest boron concentration source available. In most cases, this would be the Boric Acid Tanks, since the contents of the BIT already will have been injected.

G. Step 6. The actions of this step begin the cooldown of the reactor coolant by use of the steam generator steam dump. The steam generator water level must remain above the tops of the U-tubes. This action will assure that all of the tubes will be involved in the heat transfer and there will be no concern for a vapor bubble remaining in the primary side of the U bends and interferring with the circulation of the reactor coolant. This is particularly important if all reactor coolant pumps are stopped and the heat is to be transported to the steam generators by natural circulation.

Under many LCOA conditions the liquid inventory in the primary system will be such that vapor will exist in the reactor vessel head, pressurizer and steam generator U-tubes. The vapor in the reactor vessel head will remain unless the system is repressurized sufficiently or the reactor coolant pumps cause circulation into the head to force the vapor back to liquid or

the vapor is allowed to expand and be condensed in the liquid in the hot legs or steam generator tubes. The vapor in the pressurizer can be vented or quenched by spray at the option of the operator. The vapor in the steam generator U-tubes will be condensed as soon as the water level on the secondary side rises above the U bends and the temperature (pressure) on the secondary side is reduced by the steam dump below the temperature on the primary side.

The steam dump flow rate should be established by manual control of the dump valves (or PORVs if condenser dump is not available) such that the rate of cooldown of the reactor coolant system does not exceed a rate of 100°F/hr, as indicated by the reactor outlet temperature. It should be noted that if the reactor coolant system is in a natural circulation mode, there will be a time delay of many minutes before the steam dump action is reflected by a decrease of the reactor coolant temperature. After the natural circulation has been established, the reactor outlet temperature should trend down with the decreasing steam pressure, but rapid changes in the steam pressure will not result in immediate corresponding changes in the outlet temperature.

The observed loop temperatures and temperature differences (T_H, T_C and ΔT) can be expected to vary from loop-to-loop and may deviate at any single observation. Only the trended valves of these parameters should be utilized to infer the continued existence of the natural circulation flow.

The operator must watch for a change in the trend of the reactor coolant temperature which would indicate a loss of natural circulation flow. One cause of the loss of circulation could be an excessive rate of steam dumping which results in a cold water block in the loop seal under the reactor coolant

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pump. By decreasing the rate of steam dumping the thermal gradient can be reestablished between the hot and cold legs sufficient to sweep out the cold slug from the loop seal.

Once the cooldown operation has been established, the operator should proceed to Step 7. If a reactor coolant pump is in operation this action will occur early in the procedure because the cooldown operation will be established and verified quickly as in a normal cooldown. However, for a natural circulation mode there will be a significant time delay before the cooldown operation can be established and verified.

H. Caution before Step 7: This caution alerts the operator that subcooling must be maintained in the RCS. This caution is placed before Step 7, since a temporary depressurization will take place in this step. In addition, this caution applies to subsequent steps, where permanent pressure reductions will occur.

I. Step 7: This step attempts to restore pressurizer level. For small RCS breaks, pressurizer level will be restored. For larger breaks, the level will not be restored; however, the RCS pressure will also equilibrate below 400 psig.

Part a of Step 7 re-iterates that subcooling must be maintained at all times. Therefore, since the subsequent action of establishing level will cause temporary pressure reductions, subcooling margin must be established. The recommended margin is 50°F. A loss of subcooling during pressurizer steam volume reduction could result in formation of voids in the reactor vessel, and thereby cause a premature and erroneous return of pressurizer water level.

Once subcooling margin is verified, or obtained by waiting for RCS cooling, the action of obtaining pressurizer level by

reducing steam pressure will cause the leak flow out of the system to decrease and also will allow the safety injection flow to increase due to the lower backpressure on the injection system. The combination of lower bleed flow and increased feed flow will result in a net water input to replace the volume of steam removed. The system will tend to return to an equilibrium pressure where the bleed flow is equal to the feed flow but with a larger liquid inventory in the reactor coolant system. The steam volume reduction operation is to be continued, as long as the coolant subcooling is maintained, until the liquid inventory has been increased to bring the water level back into the pressurizer. Note that the prevailing system pressure will not be significantly reduced because the equilibrium pressure is determined by the balance between the leak flow and the injection system characteristics.

The two methods of reducing the steam volume in the pressurizer are by quenching some of the steam by spray or by venting to the PRT. The preferred method is the use of the normal RCP controlled pressurizer spray. If a RCP is not in service, one PORV can be used to vent the steam. The objective is to remove some of the steam from the pressurizer to allow the water level to rise back into the pressurizer by action of the safety injection flow.

Auxiliary spray should not be used unless there is a requirement to depressurize and the normal spray or PORVs are not available. Forcing cold water through the pressurizer spray nozzle would create an excessive thermal transient to the piping, nozzle and pressurizer shell and only a few such thermal shocks can be tolerated.

If a PORV is used, the operator must monitor the PRT parameters, after having utilized the PORV, to detect a leaking PORV. If the PORV does not close tightly after use, the isolation valve can be closed to stop the leakage.

The steam volume should be reduced, until the water level has been restored into the pressurizer with all safety injection pumps in service and the steam dump valves full open. For relatively large size breaks the water level will not return to the pressurizer and the safety injection system will simply make up for the leak flow at the prevailing system pressure. However, for smaller size breaks the water level can be made to return to the pressurizer at a pressure which will be dependent on the size of the leak. If the steam volume reduction operation is continued, the steam bubble will be completely removed and the pressurizer will become filled solid. This should be avoided if possible but it should be recognized that gross control of system pressure is also possible with the pressurizer filled solid.

The safety injection termination criteria established in E-1 does not apply to this subprocedure. That is, safety injection flow must remain in service during the steps in this instruction until the injection flow is deliberately decreased by throttling of the flow paths and selectively stopping individual safety injection pumps.

If level is not achieved and the subcooling limit is being approached, the depressurization operation should be terminated until subcooling margin can be re-established.

J. Step 8: With a water level reestablished in the pressurizer, the water can be heated by the pressurizer heaters to develop a differential temperature between the reactor outlet and the pressurizer water. It should be noted that the reactor coolant system pressure is still being controlled by the bleed and the feed process created by the leak and the safety injection flow. Under these conditions, if the pressurizer were to be heated to saturation conditions and the heating continued, the water would be forced out of the pressurizer by the growing

steam bubble. Therefore, it is not necessary or desirable to take the pressurizer to saturation conditions before proceeding to the following depressurization steps. However, it is recommended that the pressurizer water be maintained at least 50°F higher than the reactor outlet temperature to help assure that the coolant in the reactor remains subcooled.

When the pressurizer heaters are energized and if the a.c. electrical power is being supplied from the emergency diesel-generators, all energized heaters must be supplied from only one diesel generator. The reason for this caution is to avoid arcing between terminals and potential loss of both electrical buses if the generators are not in phase and there is an adverse environment around the heater terminals.

K. Step 9: After the water level has been returned to the pressurizer, the heaters have developed a differential temperature of 50°F and the combined action of the leak flow and injection flow are maintaining a reactor coolant pressure above 400 psig, the sytem depressurization action can begin. To avoid the unnecessary injection of the contents (in particular the compressed gas) of the SI accumulators for certain small breaks as the system pressure is deliberately reduced, the SI accumulators should be isolated by closing the outlet isolation valves. If for some reason the isolation valves cannot be utilized, the gas should be vented off to the containment to reduce the gas pressure to about 400 psig. Some residual gas pressure should remain in the accumulators so they will remain available as a source of borated cooling water. The exact final pressure can be calculated for each plant, considering the accumulator volume, normal nitrogen volume, and normal accumulator pressure.

L. Step 10: Before throttling any pumps, the RCS pressure should be checked. If it is already below 400 psig, there is no need to throttle flow, and the throttling steps are skipped.

M. Caution before Step 11: This caution reminds the operator that charging pumps may be turned off in the next step. Therefore, to insure a RCP seal cooling source, steps may be required to establish component cooling water to the RCP thermal barrier.

N. Step 11: Each section of this step will be discussed separately. This step is modeled after the W standard 412 fluid system configuration, which utilizes both charging/SI and high-head SI pumps as high pressure injection. For plants with only charging/SI pumps, this step is applicable. For plants with only high-head SI (and non-safety grade charging pumps) this step is not applicable. A flow diagram is shown on figure 2 representing the 412 arrangement during the injection phase. The location of valves used for throttling is indicated by an arrow.

The objective this step is to throttle or to terminate the flow from the charging/SI pumps if required to cause the reactor coolant pressure to decrease to 400 psig or less. That is, the injection flow is made to continually balance the leak flow at progressively lower reactor coolant pressures while simultaneously, the steam bubble in the pressurizer is reduced in pressure (by quenching or venting) to maintain the indicated pressurizer water level. For those break sizes for which the high head SI pump subsystem alone can compensate for the break flow, the charging pumps can be stopped.

The charging pumps are selected as the first subsystem to be throttled since they provide the larger share of the injection flow at elevated system pressures. If two pumps are in operation, it is recommended that one pump not be tripped in an attempt to decrease the injection flow. As seen from figure 3, the stopping of flow from one pump can result in a very large change in the value of the equilibrium pressure at which the leak flow and injection flow are balanced. This large change

in pressure would have to be compensated by a significant change in the pressurizer steam bubble, i.e. either quench or vent some of the steam volume, or the water level would recede out of the pressurizer.

a) The charging/SI pump miniflow isolation valves are open to provide pump protection.

b) One charging/SI pump should be throttled using the isolation valve at the discharge of the pump. If another valve, better suited for throttling or located more conveniently exists, it should be used. The operator performing the throttling must be in communication with the control room. The throttling must be done slowly and gradually, since rapid RCS depressurizations may result in inadequate subcooling. The subcooling will tend to increase due to the continuing cooldown of the coolant by the steam dump and the depressurization operation must be coordinated with the cooldown such that the subcooling is not decreased by the coolant pressure being reduced more rapidly than the temperature.

c) Since the reactor coolant pressure is being maintained by the equilibrium between the leak flow and the safety injection flow, the only method available to reduce the system pressure is to throttle the safety injection flow. However, as the injection flow is decreased there will be a net outflow from the system and the pressurizer steam bubble will expand to compensate for the outflow. The bubble expansion will result in a lowering of the system pressure but also will result in a decreasing pressurizer water level. Therefore, concurrent with the reduction in the safety injection flow, the steam bubble in the pressurizer must be prevented from expanding by either quenching by spray or by venting to the PRT. The injection flow decrease and steam volume reduction operations must be accomplished simultaneously and carefully to avoid losing the indicated pressurizer water level.

The heaters can then remain energized to maintain the pressurizer water temperature at least 50°F higher than the reactor outlet temperature.

d) As the charging/SI pump is throttled, RCS pressure will decrease. During throttling, the pump flow must not decrease below its minimum allowed flow. Therefore, as the operator is throttling, he should observe the local pump discharge pressure. If the pressure is approaching the head developed at miniflow, the pump should be stopped. If the pressure is less than the miniflow head, throttling should continue until either the miniflow head is reached, or the RCS pressure is less than 400 psig.

If the charging/SI pump miniflow head is reached, that pump should be shutdown. If a second charging/SI pump is running, that pump should then be throttled. If no charging/SI pumps are running, the operator should proceed to realign the charging system (Step 12).

e) Throttling of the charging/SI pumps continues until either both pumps are stopped (Section d), or until RCS pressure is below 400 psig. This step allows a check to determine if additional throttling is required, or if the desired pressure has been achieved.

D. <u>Step 12:</u> This step aligns the charging/SI pumps from the safety injection mode (through the BIT) to the normal charging path. If both charging pumps were stopped in the previous step and RCS pressure is still above 400 psig, realigning this system will not decrease the RCS pressure. However, this alignment provides remote charging flow contol, and insures seal injection flow without large injection flow which will keep RCS pressure high.

P. Step 13: This step provides another check of RCS pressure once normal charging flow has been established. If the RCS pressure was only slightly above 400 psig before both charging/SI pumps were turned off, it is possible that additional throttling may achieve the desired pressure. If the RCS pressure remains above 400 psig, the charging flow should be throttled in the normal range, and the operator should proceed to Step 14.

Q. Caution before Step 14: This caution warns that the high-head SI pumps should not be allowed to pump sump water to the RWST (and hence the environment). This could occur if the miniflow valves were opened during cold leg or hot leg recirculation.

R. Step 14: This step is identical to Step 11, and would be implemented if RCS pressure remains high. Therefore, the discussion for Step 11 is applicable to this step. For plants without charging/SI pumps, this is the first SI throttling step. For these plants, once RCS pressure is below 400 psig, the normal charging system may be aligned (similar to Step 12) to allow normal charging/pressure control.

S. Step 15: This step verifies that the desired RCS conditions have been achieved. The RCS pressure is maintained less than 400 psig, and the RCS temperature (cooldown has been proceeding throughout this guideline) is less than 350^{o}F. If the temperature is above 350^{o}F, steam dump must be continued.

T. Step 16: The final plant conditions and the time they are reached will depend on many factors; but it is expected that for small breaks, the pressurizer level will be restored on scale and the reactor coolant pressure and temperature can be reduced to below 400 psig and 350^{o}F respectively. If the above conditions are successfully established, consideration can be given to placing the residual heat removal system into service to avoid continual use of the steam dump and auxiliary feedwater systems and thus transfer to a closed loop cooling mode.

It should be noted that a reactor coolant makeup capability must be maintained to compensate for the leak flow. This makeup may be taken from the containment building sump. Some portion (either sump recirculation or RWST injection) of the safety injection path must remain in service. Plant specific designs may or may not allow the simultaneous use of the safety injection low path and the residual heat removal system.

If it is possible in a specific plant to place the RHR system in service and maintain the coolant makeup capability, it may be necessary to defeat or bypass certain interlocks which are provided to specifically prevent having the RHR system inlet valves and sump valves open at the same time.

For those plant designs or under specific accident conditions under which the RHR system cannot be put into service, the safeguards systems can remain in the long term recirculation mode with the core residual heat being dissipated through the safeguards heat exchangers and for small breaks, through the steam generator steam dump system.

Figure 1

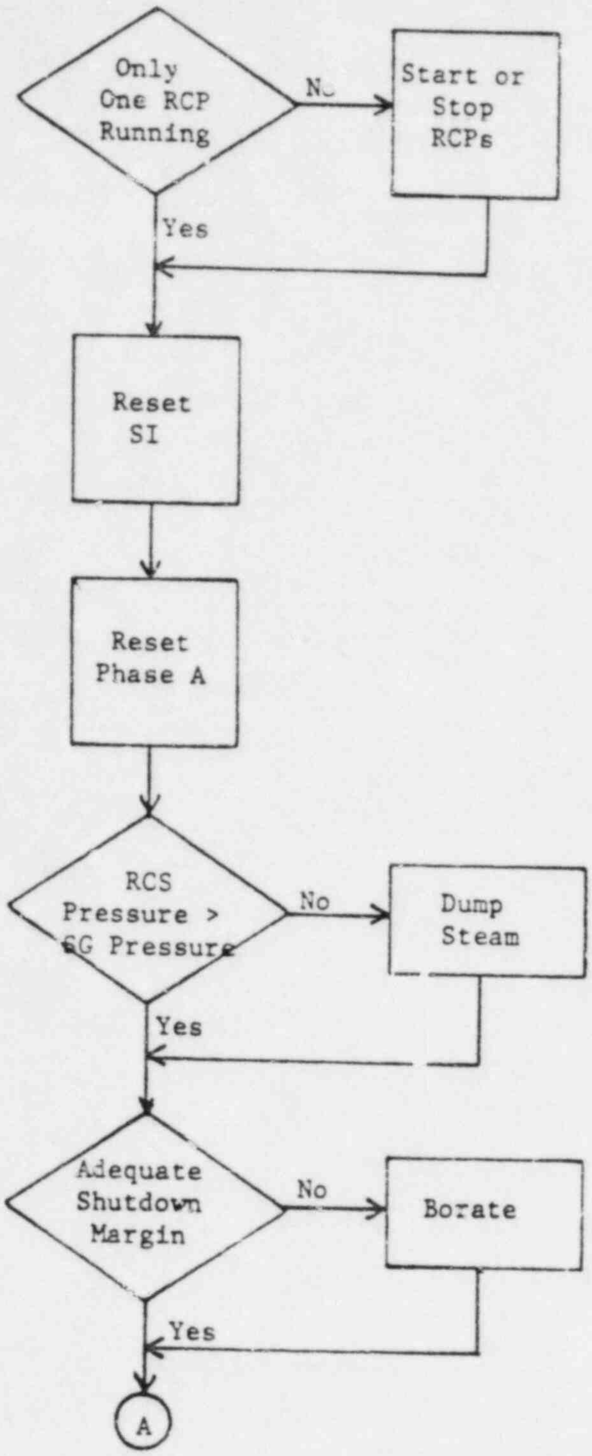
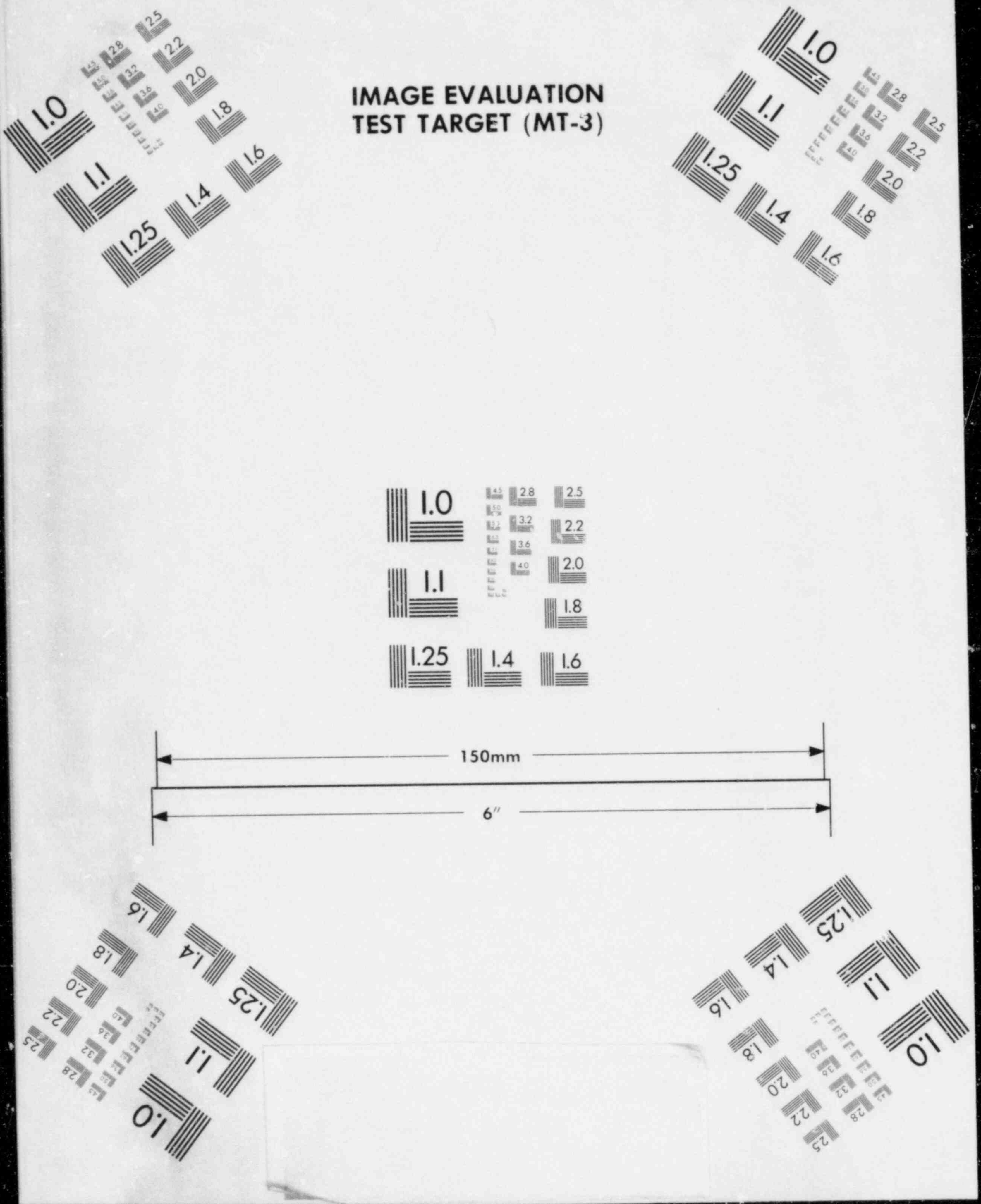

Only One RCP Running
No
Start or Stop RCPs
Yes
Reset SI
Reset Phase A
RCS Pressure > SG Pressure
No
Dump Steam
Yes
Adequate Shutdown Margin
No
Borate
Yes
A

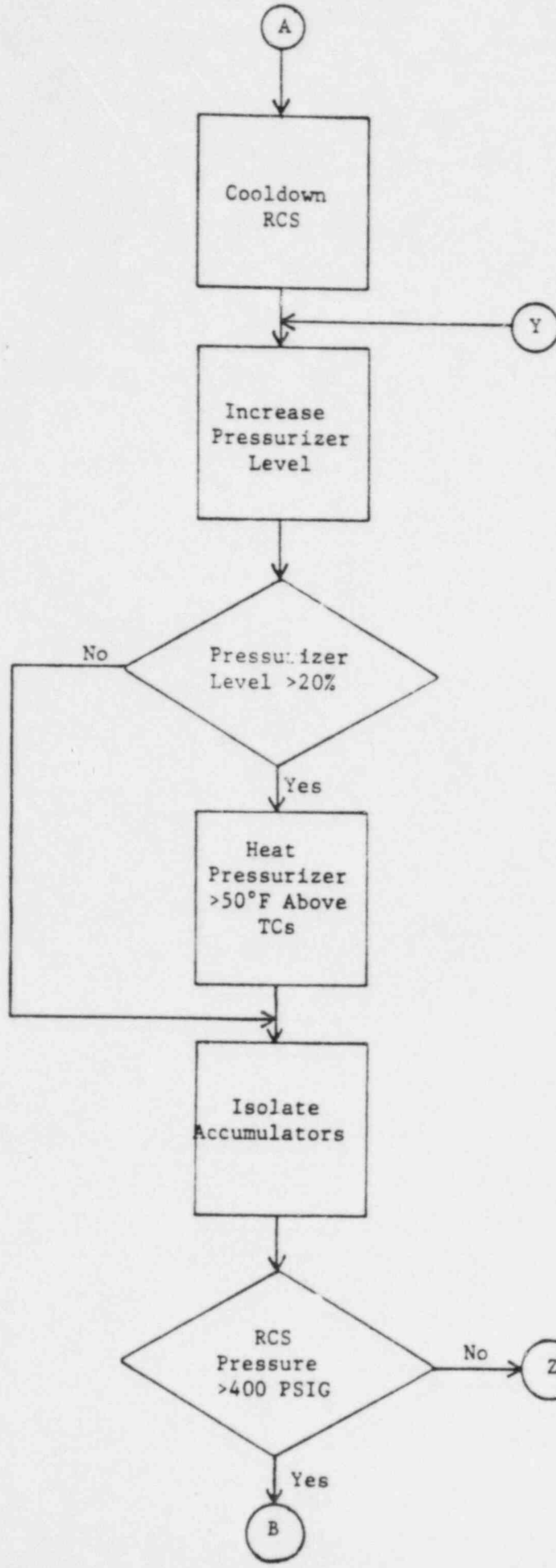
IMAGE EVALUATION TEST TARGET (MT-3)

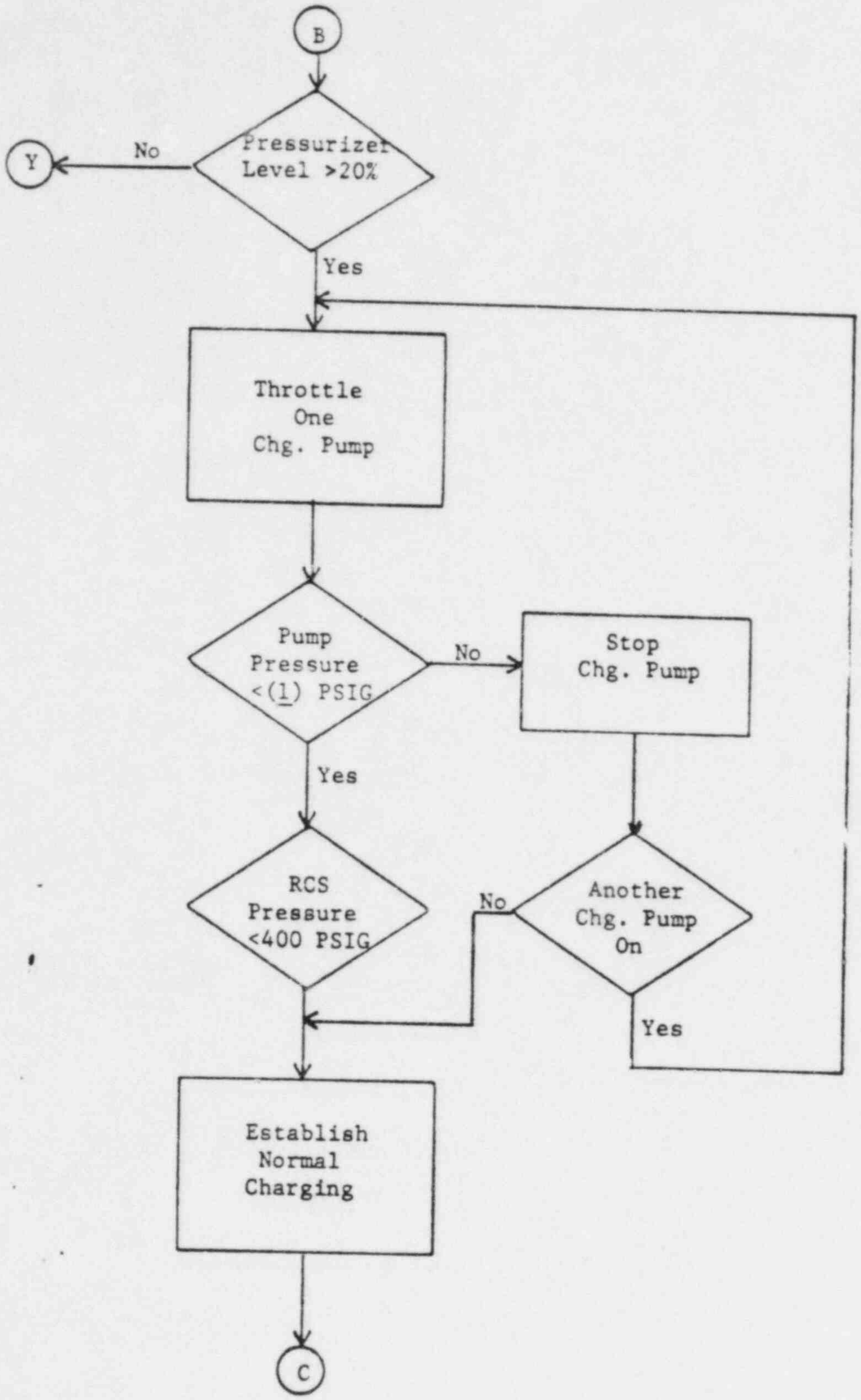
150mm

6″

IMAGE EVALUATION TEST TARGET (MT-3)

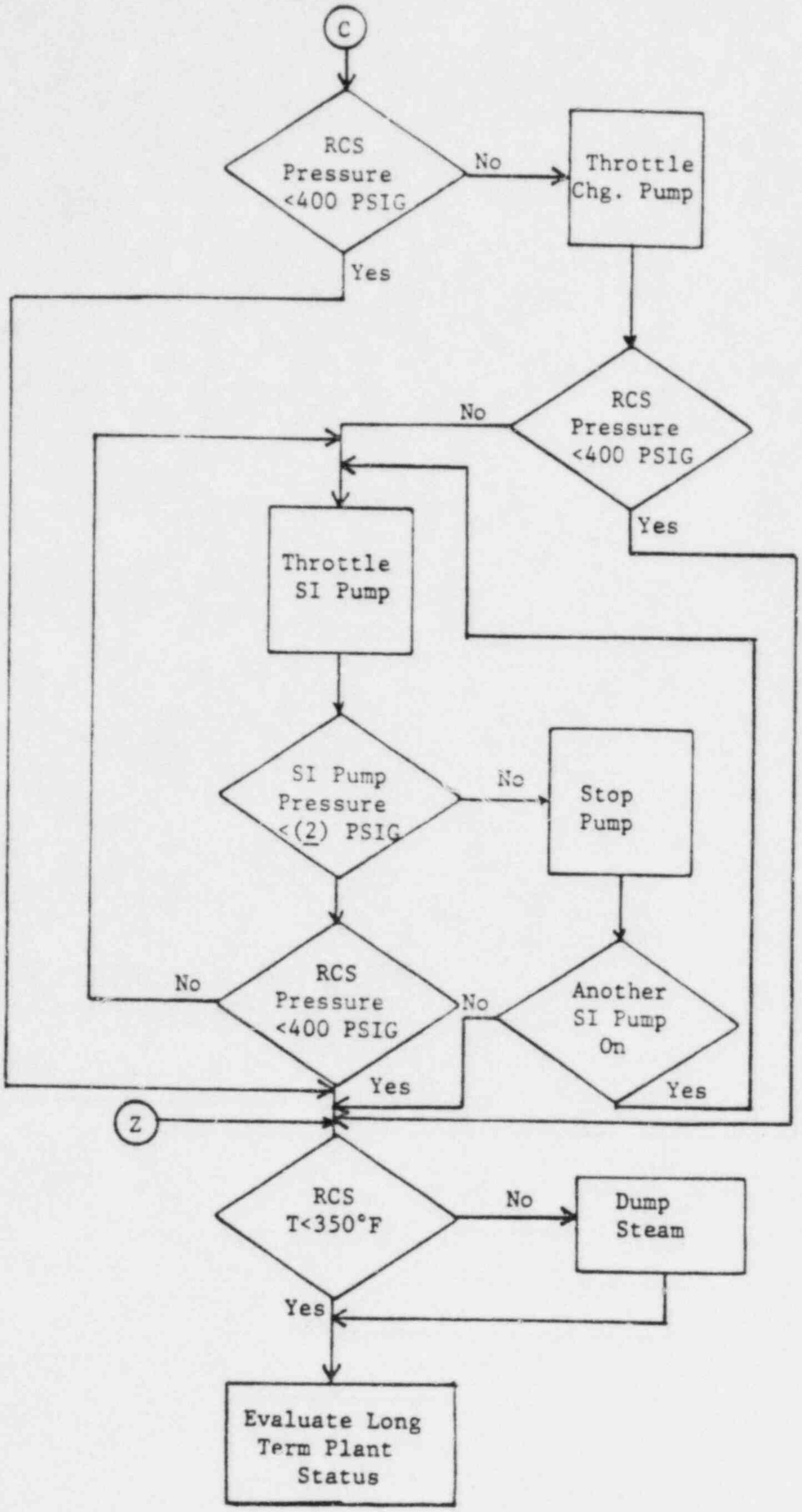



A
Cooldown RCS
Y
Increase Pressurizer Level
Pressurizer Level >20%
No
Yes
Heat Pressurizer >50°F Above TCs
Isolate Accumulators
RCS Pressure >400 PSIG
No
Z
Yes
B



ES-1.2
-20-

(1) Charging Pump head at miniflow

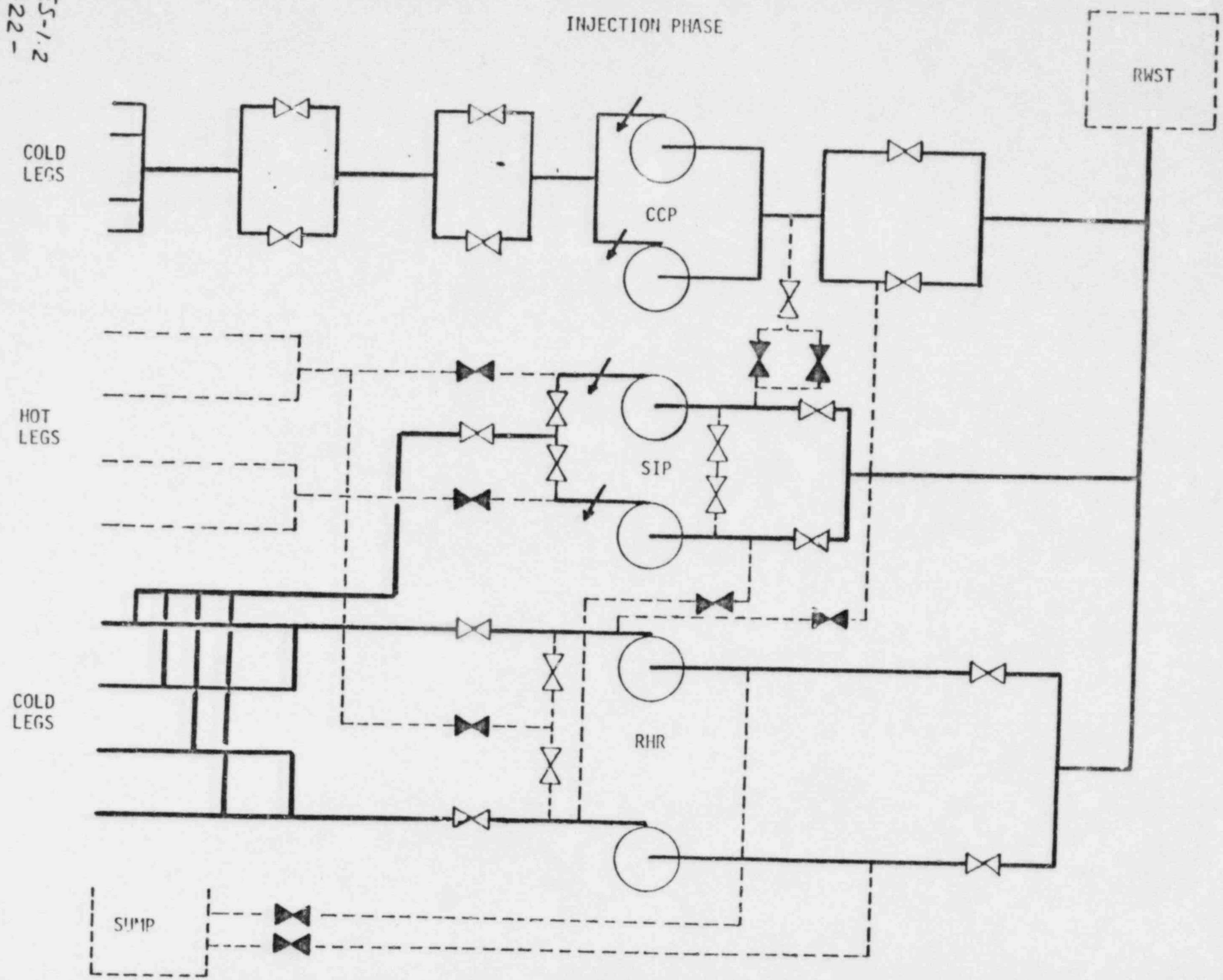


ES-1.2

(2) High head SI pump head at miniflow

FIGURE 2

INJECTION PHASE



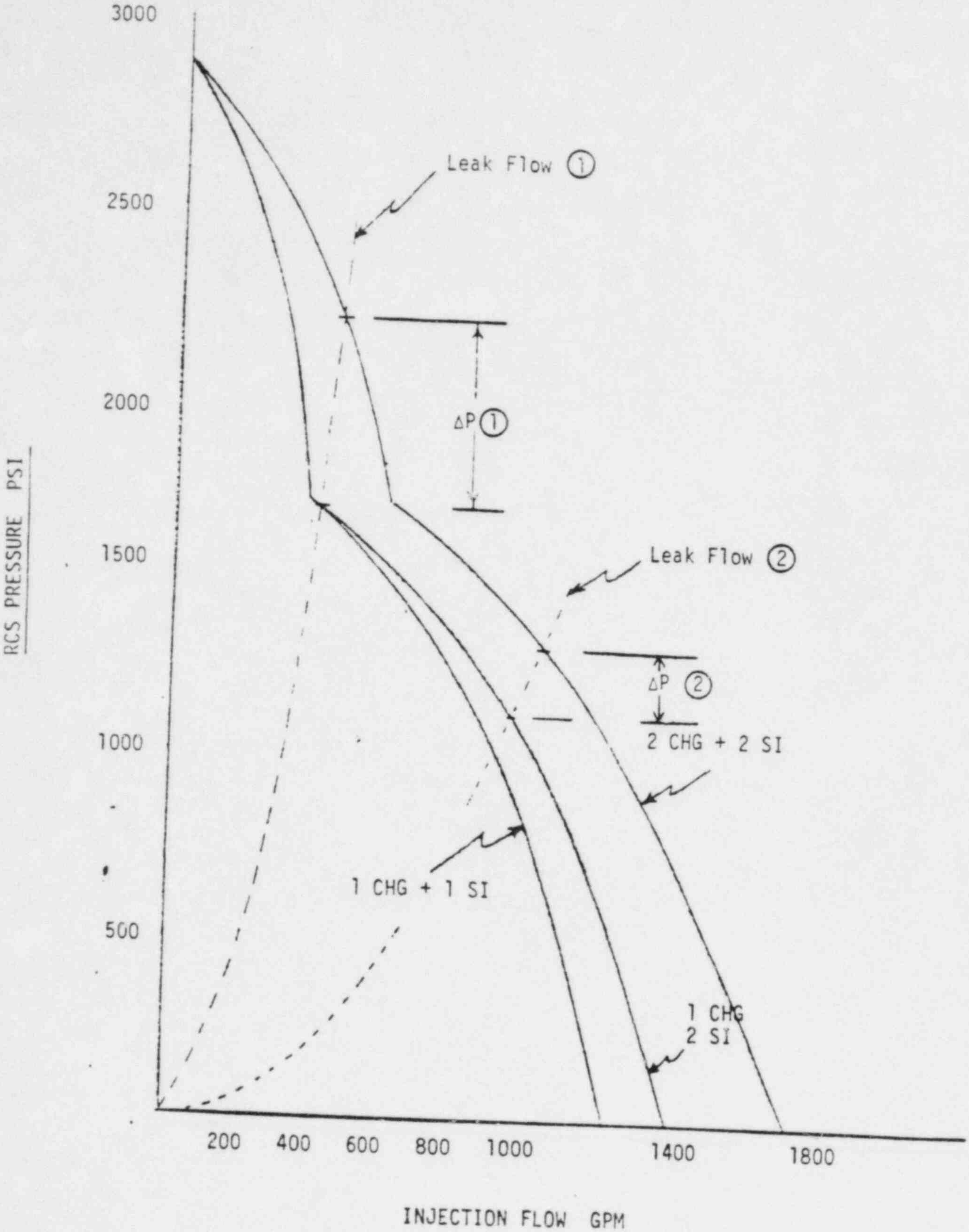


Figure 3. Injection vs Leak Flow Curves

Attachment 4

Technical Bases for Secondary Depressurization (OA-4) or Director Primary Depressurization (OA-5) to Control the Steam Generator Tube Rupture Event in the Millstone - 3 Probabilistic Safety Study

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

Caution *If all steam generators are ruptured, the steam generator with the lowest level should be used for subsequent RCS cooldown. DO NOT isolate this steam generator. Consider it non-ruptured.*

NOTE
- *Foldout page should be open.*
- *Personnel should be available for sampling during this procedure.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
1	**Identify Ruptured Steam Generator(s):** • Unexpected rise in any steam generator narrow range level • High radiation from any steam generator blowdown line 1) [Enter plant specific steps for opening blowdown lines sequentially to check radiation] • High radiation from any steam generator sample • High radiation from any steam generator steamline	IF NOT immediately identified, THEN continue with steps 3 through 9. WHEN ruptured steam generator(s) identified, THEN do step 2.
2	**Isolate Ruptured Steam Generator(s):** a. WHEN in narrow range, THEN stop all AFW flow to ruptured steam generator(s) 1) [Enter plant specific steps]	
	b. Close ruptured steam generator(s) main steamline isolation valve and bypass valve	b. Close non-ruptured steam generator main steamline isolation valves and bypass valves. Use non-ruptured steam generator PORVs for steam dump.
	c. Verify ruptured steam generator(s) PORVs closed	c. Manually close ruptured steam generator(s) PORV.
	d. Close ruptured steam generator(s) steam supply valve to turbine-driven AFW pump	

HP POR

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
3	**Check Pressurizer PORV Block Valves:**	
	a. Power available to block valves	a. Restore power to block valves.
	b. Block valves – OPEN	b. Open block valve unless it was closed to isolate a faulty PORV.
4	**Check Pressurizer PORVs:**	
	a. PORVs – CLOSED	a. Manually close PORVs. <u>IF</u> any valve cannot be closed, <u>THEN</u> manually close its block valve.

Caution

- *IF any pressurizer PORV opens because of high RCS pressure, repeat step 4 after pressure drops below PORV setpoint.*
- *Seal injection flow should be maintained to all RCPs.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
5	**Check If RCPs Should Be Stopped:**	
	a. SI running – CHECK FOR FLOW OR PUMP BREAKER INDICATOR LIGHTS LIT • Charging/SI –OR– • High-head SI	a. DO NOT STOP RCPs. Go to step 6.
	b. RCS pressure – EQUAL TO OR LESS THAN ___(1)___ PSIG	b. DO NOT STOP RCPs. Go to step 6
	c. Stop all RCPs	

(1) Enter plant specific value derived from background document to E-O.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
6	**Check If Low-head SI Pumps Should Be Stopped:**	
	a. Check RCS pressure:	
	1) Pressure - GREATER THAN _(1)_ PSIG	1) IF less than _(1)_ psig, THEN go to E-1, LOSS OF REACTOR COOLANT, STEP 13.
	2) Pressure - STABLE OR INCREASING	2) IF decreasing, THEN go to step 7.
	b. Reset SI	
	c. Stop low-head SI pumps and place in standby	

Caution *IF RCS pressure drops below _(1)_ psig, the low-head SI pumps must be manually restarted to supply water to the RCS.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
7	**Check Electrical Power And Air Supply Available To Essential Equipment:**	Establish power supplies, as necessary.
	a. [Enter plant specific list]	

(1) Enter plant specific shutoff head of low-head SI pumps.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
8	**Check Secondary System Integrity:**	
	a. RCS hot leg temperature - GREATER THAN __(1)__ °F	a. IF any hot leg temperature less than __(1)__ °F and decreasing, THEN close all main steamline isolation valves and bypass valves. IF any steam generator pressure continues to decrease, THEN go to ES-3.3, SGTR WITH SECONDARY DEPRESSURIZATION.
	b. ALL steam generator pressures - GREATER THAN __(2)__ PSIG	b. IF any steam generator pressure less than __(2)__ psig, THEN close all main steamline isolation valves and bypass valves. IF any steam generator pressure continues to decrease, THEN GO TO ES-3.3, SGTR WITH SECONDARY DEPRESSURIZATION.

Caution *Alternate water sources for AFW pumps will be necessary if CST level is low.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
9	**Check Steam Generator Levels:**	
	a. Narrow range level - GREATER THAN __(3)__ %	a. IF less than __(3)__ %, THEN maintain full AFW flow until narrow range level is greater than __(3)__ %
	b. Throttle AFW flow to maintain narrow range level at __(4)__ %	

Caution *DO NOT PROCEED to step 10 until ~~faulted~~ Ruptured steam generator has been identified and isolated.*

(1) Enter plant specific temperature corresponding to lowest expected hot leg temperature following a normal reactor trip.
(2) Enter plant specific value corresponding to 50 psi above maximum Tech Spec accumulator nitrogen pressure.
(3) Enter plant specific value showing level just in the narrow range including allowances for normal channel accuracy, post-accident transmitter errors and reference leg process errors.
(4) Enter plant specific value corresponding to no-load steam generator level including allowances for post-accident transmitter errors and reference leg process errors.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

10 **Cooldown Non-ruptured Steam Generators 50°F Below Ruptured Steam Generator:**

a. Determine required non-ruptured steam generator pressure in table below:

Ruptured Steam Generator Pressure (PSIG)	Required Non-ruptured Steam Generator Pressure (PSIG)	
	Any RCP Running	All RCPs Stopped
1200	780	610
1100	710	550
1000	640	490
900	570	430
800	500	370
700	430	320
600	350	260
500	310	210
400	230	160

b. Rapidly dump steam to condenser from non-ruptured steam generators:

1) [Enter plant specific steps]

Response not obtained: b. Rapidly dump steam with non-ruptured steam generator PORVs.

c. Check ruptured steam generator(s) pressure – STABLE OR INCREASING

Response not obtained: c. <u>IF</u> decreasing, <u>THEN</u> go to ES-3.3, SGTR WITH SECONDARY DEPRESSURIZATION, STEP 8.

Caution
- *If containment conditions are abnormal, go to E-1, LOSS OF REACTOR COOLANT, STEP 9.*
- *Disregard RCP trip criteria for all subsequent steps in this guideline.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
11	**Check RCS Pressure:**	
	a. RCS pressure - AT LEAST 200 PSI GREATER THAN RUPTURED STEAM GENERATOR PRESSURE	a. IF NOT, THEN go to ECA-3, SGTR CONTINGENCIES.
12	**Depressurize RCS Using Normal Spray:**	
	a. Verify normal spray - AVAILABLE	a. Go to step 14.
	b. Open normal spray valves	b. Go to step 14.
	c. Verify RCS pressure - DECREASING	c. Close spray valves and go to step 14.
13	**Check If RCS Depressurization Should Be Stopped:**	
	a. RCS pressure - LESS THAN OR EQUAL TO RUPTURED STEAM GENERATOR PRESSURE -OR- Pressurizer level - GREATER THAN (1) %	a. Continue depressurization until either condition met.
	b. Stop RCS depressurization by closing spray valves	
	c. Check pressurizer level - GREATER THAN (2) %	c. IF level less than (2) %, THEN go to ECA-3, SGTR CONTINGENCIES.
	d. Verify RCS pressure - INCREASING	d. IF RCS pressure decreasing or stable, THEN stop RCPs in loops with spray line connections.
	e. Go to step 16	
14	**Depressurize RCS Using One Pressurizer PORV:**	
	a. Open one pressurizer PORV	a. IF RCS cannot be depressurized using any PORV, THEN use auxiliary spray.

(1) Enter plant specific value corresponding to high pressurizer level reactor trip setpoint.

(2) Enter plant specific value showing level just in span including allowances for normal channel accuracy.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
15	**Check If RCS Depressurization Should Be Stopped:**	
	a. RCS pressure - LESS THAN OR EQUAL TO RUPTURED STEAM GENERATOR PRESSURE -OR- Pressurizer level - GREATER THAN __(1)__ %	a. Continue depressurization until either condition met.
	b. Stop RCS depressurization:	
	1) Close PORV	1) Close PORV block valve.
	2) Close auxiliary spray valve	2) Isolate auxiliary spray line.
	c. Check pressurizer level - GREATER THAN __(2)__ %	c. IF level less than __(2)__ %, THEN go to ECA-3, SGTR CONTINGENCIES.
	d. Verify RCS pressure - INCREASING	d. IF RCS pressure NOT increasing, THEN check PRT conditions. IF PRT conditions indicate RCS leak, THEN go to E-1, LOSS OF REACTOR COOLANT.

Caution *If PRT integrity is lost, abnormal containment conditions may not be reliable indications of a loss of reactor coolant.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
16	**Check If SI Can Be Terminated:**	
	a. RCS pressure - INCREASES BY 200 PSI	a. DO NOT TERMINATE SI. IF pressure has NOT increased by 200 psi AND pressurizer level is stable or decreasing, THEN go to ECA-3, SGTR CONTINGENCIES.
	b. Pressurizer level - GREATER THAN __(2)__ %	b. DO NOT TERMINATE SI. Go to ECA-3, SGTR CONTINGENCIES.
	c. RCS subcooling - GREATER THAN __(3)__ °F	c. DO NOT TERMINATE SI.

Caution *Do not proceed to step 17 until all conditions in step 16 are met.*

(1) Enter plant specific value corresponding to high pressurizer level reactor trip setpoint.
(2) Enter plant specific value showing level just on span including allowances for normal channel accuracy.
(3) Enter sum of temperature and pressure measurement system errors translated into temperature using saturation tables.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
17	**Terminate SI:**	
	a. Go to ES-3.1, SI TERMINATION FOLLOWING STEAM GENERATOR TUBE RUPTURE	
18	**Check If Condenser Can Be Used:**	
	a. Condenser - AVAILABLE	a. IF condenser not available, THEN attempt to restore condenser. IF condenser can NOT be restored, THEN evaluate if releases from ~~faulted~~ ruptured steam generator will exceed 10 CFR 20 limits. IF 10 CFR 20 limits will be exceeded and any RCS running THEN cooldown per ES-3.2 SGTR ALTERNATE COOLDOWN.
19	**Verify Adequate Shutdown Margin**	Borate, as necessary.

Caution *Steps 20 through 23 must be performed simultaneously to avoid loss of pressurizer level control.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
20	**Initiate RCS Cooldown To 350°F:**	
	a. Maintain cooldown rate - LESS THAN 50°F/HR	
	b. Dump steam from non-ruptured steam generators to condenser	b. Dump steam with non-ruptured steam generator PORVs.
	1) [Enter plant specific steps]	

Caution *Charging and letdown flows should be compared to determine if leakage between the RCS and ruptured steam generator is stopped.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
21	**Maintain Pressurizer Level In Normal Operating Range:**	
	a. Operate charging and letdown, as necessary	

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
22	**Depressurize Ruptured Steam Generator(s):**	
	a. Slowly release steam to condenser from ruptured steam generator	a. Slowly release steam to atmosphere with ruptured steam generator(s) PORV.
	1) [Enter plant specific steps]	

Caution • *Maintain RCS pressure and temperature within normal cooldown limits.*
• *IF RCS pressure or pressurizer level drop in an uncontrolled manner, THEN reinitiate SI and return to step 10.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
23	**Depressurize RCS:**	
	a. Reduce RCS pressure to maintain RCS/ruptured steam generator pressures equal	
	1) Use normal pressurizer spray	1) IF letdown is in service, THEN use auxiliary spray. IF NOT in service, THEN use one pressurizer PORV.
24	**Determine If SI Accumulators Should Be Isolated:**	
	a. RCS pressure – LESS THAN OR EQUAL TO (1) PSIG	a. IF RCS pressure greater than (1) psig, THEN return to step 20.
	b. Close all SI accumulator isolation valves	b. Vent any unisolated accumulator.
25	**Check If RHR System Can Be Placed In Service:**	
	a. RCS hot leg temperatures – LESS THAN 350°F IN NON-RUPTURED LOOPS	a. IF greater than 350°F, THEN return to step 20.
	b. RCS pressure – APPROXIMATELY 400 PSIG	b. IF greater than 400 psig, THEN return to step 21.

Caution *Do not collapse the pressurizer bubble.*

(1) Enter plant specific value slightly above normal accumulator pressure.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
26	**Place RHR System In Service Per** [Plant Specific Procedure]	
27	**Continue Cooldown To Cold Shutdown:** a. Cooldown using RHR b. At least one RCP – RUNNING	b. IF all RCPs stopped, THEN continue dumping steam from non-ruptured steam generators until they have stopped steaming.
28	**Check RCS Temperature:** a. Temperature – LESS THAN __(1)__ °F b. Stop all RCPs c. Cooldown pressurizer 1) Spray pressurizer with auxiliary Spray	a. IF greater than __(1)__ °F, THEN return to step 27.
29	**Maintain Cold Shutdown Conditions.**	

—END—

(1) Enter plant specific number for stopping RCPs during normal cooldown.

FOLDOUT FOR E-3 AND ES-3 GUIDELINES

1. RCP TRIP CRITERIA
   - Trip any RCP if component cooling water to that pump is lost.
   - If a controlled cooldown is not in progress, then trip all RCPs when BOTH conditions listed below are met:

     a. SI is ON

     b. RCS pressure - EQUAL TO OR LESS THAN (1) PSIG

2. SI REINITIATION CRITERIA FOLLOWING STEAM GENERATOR TUBE RUPTURE

   Reinitiate SI if ANY ONE of the parameters listed below occurs:

   (1) RCS subcooling - LESS THAN (2) PSIG

   (2) Pressurizer level - LESS THAN 20%

3. SYMPTOMS OF LOSS OF REACTOR COOLANT DURING STEAM GENERATOR TUBE RUPTURE

   Go to E-1, LOSS OF REACTOR COOLANT, if abnormal containment conditions persist AND are not due only to failure of PRT rupture disc.

4. SYMPTOMS OF PRIMARY TO SECONDARY LEAKAGE DURING RECOVERY ACTIONS

   Charging and letdown flows should be compared to determine if leakage between the RCS and the ruptured steam generator exists.

5. SYMPTOMS FOR FR-C.1, RESPONSE TO INADEQUATE CORE COOLING

   Go to FR-C.1, RESPONSE TO INADEQUATE CORE COOLING, when ALL symptoms in ANY ONE of the following symptom sets occurs:

PARAMETER	SYMPTOM SET		
	I	II	III
1. TCs	> 1200 °F	–	> 700 °F
2. Containment Condition	–	ABNORMAL	ABNORMAL
3. RCP Status	–	ANY ON	ALL OFF
4. RVLIS	–	< 100% NR	< (3) % ~~WR~~ NR

6. SYMPTOMS FOR FR-H.1, RESPONSE TO LOSS OF SECONDARY HEAT SINK

   Go to FR-H.1, RESPONSE TO LOSS OF SECONDARY HEAT SINK, if AFW NOT AVAILABLE.

(1) Enter plant specific value derived from background document.
(2) Enter sum of temperature and pressure measurement system errors translated into temperature using saturation tables.
(3) Enter plant specific value which is 3½ feet above bottom of active fuel in core with zero void fraction, plus uncertainties.

BACKGROUND INFORMATION
FOR
WESTINGHOUSE
EMERGENCY RESPONSE GUIDELINES

E-3

STEAM GENERATOR TUBE RUPTURE

Basic Revision

September 1, 1981

DESCRIPTION OF STEAM GENERATOR TUBE RUPTURE TRANSIENT

This is a description of a typical plant response to a postulated steam generator tube rupture accident and the potential actions, manual or automatic, which may occur during recovery. The trends described are only representative and do not reflect exact times expected during the transient since variations in manual actions or operable equipment, as well as specific plant design and tube rupture size, will result in different plant behavior. For this reason, specific time scales have been eliminated from the transient plots presented to emphasize only the general trends.

Loss of offsite power coincident with a steam generator tube rupture is addressed as well as the more likely case of available offsite power. Potential failures compounding a steam generator tube rupture, such as uncontrolled secondary depressurization and/or multiple tube ruptures, have been identified and are presented separately[1,2]. The symptoms which distinguish the simple steam generator tube rupture from the various multiple failure contingencies are discussed in this document.

The transient plots presented of various system conditions are for a double ended rupture of a steam generator tube for a typical 4-loop plant. Table 1 presents the sequence of automatic actions (A) and simulated operator actions (O) modeled in the results presented. For a smaller tube rupture or different plant design - i.e., 2-loop or 3-loop plants - the general sequence of events would be the same. The exact times and responses are plant and event specific. In some cases, the operator may diagnose the event prior to automatic protection functions and may manually operate the protection systems.

The Reactor Coolant System (RCS) pressure transient, Figure 1, initially decreases toward the reactor trip setpoint as flow through the tube rupture, in excess of charging pump capacity, depletes the primary coolant inventory. The rate of pressure decay increases with tube

rupture size and decreases with increased charging pump flow and pressurizer volume. For the case presented, reactor trip occurs on overtemperature delta-T. In other instances, the operator may only receive an alarm indicating the close proximity of the reactor coolant average temperature to the trip. This depends on the relationship between the alarm and actual trip setpoint of the reactor on a plant specific basis. Due to this delay, reactor trip could occur on low pressure first. For smaller tube ruptures, the operator may trip the reactor manually prior to automatic trip.

Following reactor trip the primary pressure decreases more rapidly as sensible energy transfer to the secondary rapidly cools the RCS and tube rupture flow continues to deplete primary inventory. This decrease in RCS pressure results in a low pressure Safety Injection (SI) signal soon after reactor trip. For smaller tube ruptures the operator may manually initiate SI prior to automatic actuation. Normal feedwater flow is automatically terminated on reactor trip and the auxiliary feedwater system is actuated to deliver flow to all steam generators. Eventually, operator action is required to adjust auxiliary feedwater flow to maintain the steam generator water level on the narrow range span, Figure 2.

Secondary pressure will increase rapidly as automatic isolation of the turbine following reactor trip, momentarily stops steam flow from the steam generators trapping the steam in the steamlines. Normally, automatic steam dump to the condenser would be expected to dissipate energy transfered from the primary, thereby limiting the secondary pressure increase and maintaining programmed no-load RCS temperature. In some cases, the steam dump may not adequately control the rapid increase in pressure, which may cause the steam generator relief valves or the steam generator safety valves to lift, releasing steam to the atmosphere. If offsite power is not available, automatic steam dump to condenser will not occur resulting in an increase in secondary pressure to the safety valve setpoint pressure as illustrated in Figure 3. The relief capacity of the safety valves is sufficient to maintain secondary

pressure approximately constant. In the event of an uncontrolled secondary steam release, such as a stuck open safety valve or steamline fracture, secondary pressure will continue to decrease below no-load pressure.

Automatic steam dump control is expected to establish and maintain programmed no-load RCS temperature after reactor trip. If a reactor coolant pump continues running, only a small core delta-T will exist. Consequently, the core inlet and core outlet temperatures will tend to stabilize at no-load temperature until manual cooldown of the RCS is initiated. For the results in Figure 4, all reactor coolant pumps are stopped at reactor trip. Steam dump to condenser is assumed unavailable as a result of a loss of offsite power. SI flow and auxiliary feedwater flow eventually reduce the RCS average temperature to near no load until auxiliary feedwater is manually controlled to maintain steam generator level in the narrow range. In the event of an uncontrolled secondary steam release the average RCS temperature would continue to decrease below no-load temperature.

Initially, pressurizer water level will drop as break flow through the ruptured tube in excess of the charging pump capacity depletes the RCS inventory, Figure 5. The rate at which level decreases is dependent on the size of the tube rupture and the capacity of the charging system since these determine the net mass loss of the primary. After reactor trip, the primary coolant shrinkage associated with the rapid post-trip cooldown and the continued loss of RCS inventory through the tube rupture result in a rapid decrease in pressurizer level until SI flow occurs. Pressurizer level may be offscale low prior to SI actuation. The minimum level is dependent on tube rupture size, SI setpoint and capacity, and steam dump control. Maximum SI flow capacities were assumed for the results presented in Figures 1 through 7.

When the post-trip RCS cooldown subsides, SI flow is expected to begin refilling the pressurizer and increase RCS pressure until SI flow equals

break flow, thus maintaining primary inventory constant. This equilibrium pressure is dependent on the size of the tube rupture and SI capacity as demonstrated in Figure 6. Pressurizer level may not return to span during repressurization of the RCS. For multiple tube ruptures or reduced SI capacity, RCS pressure may continue to decrease toward the ruptured steam generator pressure until equilibrium is established. Manual actions may reduce RCS pressure and SI flow prior to reaching equilibrium.

Extensive operator action is required to mitigate the steam generator tube rupture accident. The optimum recovery guidelines, which form the basis for the actions modeled in the results presented, have been developed through a comprehensive analysis program which investigates the sensitivity of system response to potential operator actions. The logic used to diagnose and recover from a SGTR event is demonstrated in the attached diagram. Detailed recovery steps are presented in the E-3, "STEAM GENERATOR TUBE RUPTURE" emergency operating guidelines. A discussion of each step is provided in the following sections of this report. The typical system response to the recommended operator actions is demonstrated in Figures 1 through 7.

The ruptured steam generator is identified by a high steam generator water level. For a double ended tube rupture, significantly more coolant mass exists in the ruptured steam generator early in the transient as shown in Figure 2, so that identification on high water level is expected. For smaller tube ruptures, high radiation indications may be necessary for positive identification of the ruptured steam generator. However, in such instances, the break flow would be less and, consequently, more time exists to recover.

Once identified, the ruptured steam generator is manually isolated to maintain the ruptured steam generator pressure above the non-ruptured and to minimize activity releases. Auxiliary feedwater flow is terminated to the ruptured steam generator to reduce the chance of filling the steamlines with water.

Steam dump from the non-ruptured steam generators to the condenser, via the steam dump system or through the atmospheric relief valves, is initiated to reduce the RCS temperature to 50^{o}F below the saturation temperature at the ruptured steam generator pressure. This assures adequate subcooling of the RCS after depressurization to the ruptured steam generator pressure. The cooldown of the RCS is demonstrated in Figure 4. The associated shrink in primary coolant momentarily drops the pressurizer level offscale and reduces the RCS pressure as shown in Figures 5 and 1, respectively.

After the primary temperature is reduced, the RCS is depressurized to the ruptured steam generator pressure to terminate break flow. The preferred method of depressurization is the normal pressurizer spray system. When this is not available or not effective, the primary pressure is reduced by opening one pressurizer PORV. This method will cause release to the Pressurizer Relief Tank (PRT), possibly failing the rupture disk, and result in additional primary inventory loss. Consequently, it is presented as an alternative method in the event that normal pressurizer spray does not function. Figure 1 illustrates the rapid decrease in RCS pressure when one pressurizer PORV is opened. Pressurizer water level increases as SI flow in excess of break flow replaces vented steam with water, as shown in Figure 5. For multiple tube ruptures or reduced SI capacity, pressurizer level may not return on span during depressurization to the ruptured steam generator pressure. Note that during this depressurization phase, the break flow, Figure 7, may momentarily reverse.

When the RCS pressure is equal to the ruptured steam generator pressure, the PORV (or spray valve) is closed. In some cases, depressurization of the RCS may be terminated on high pressurizer level to prevent filling of the pressurizer. Pressurizer level and, consequently, RCS pressure continue to increase until safety injection is terminated, after primary pressure increases 200 psi. The 200 psi termination criteria is required to verify the integrity of the pressurizer vapor space and to collapse any voids in the RCS which may have been generated as a result

of the depressurization phase. For multiple tube ruptures or reduced SI flow, a 200 psi increase may not occur before SI flow and break flow equilibrate. After SI flow is terminated, residual break flow will decrease pressurizer level, Figure 5, and tend to equilibrate primary and ruptured steam generator pressures, Figure 1.

Charging and letdown are established to maintain pressure level greater than 20 percent span. Normal pressurizer spray, if available, or auxiliary spray, if heated by letdown, is used to further reduce RCS pressure, if necessary, below the ruptured steam generator pressure to terminate break flow.

During cooldown and depressurization, the ruptured steam generator water level is maintained sufficient to cover the tubes. This is to insure that no condensation of steam on the cold tubes depressurizes the ruptured generator, resulting in loss of pressurizer level control.

Cooldown of the RCS at 50^{0}F/HR is initiated by dumping steam from the non-ruptured steam generators until the Residual Heat Removal System (RHRS) can be placed in service. The ruptured steam generator is slowly depressurized via steam dump to condenser or through a steam generator PORV. The RCS pressure is simultaneously reduced using pressurizer spray to maintain RCS/ruptured steam generator pressure equilibrium.

When the RHRS is in operation and the hot leg temperatures are reduced below 200^{0}F, the pressurizer is cooled using auxiliary spray and charging/letdown flows are balanced to terminate the accident.

Plant response to a postulated steam generator tube rupture accident and operator actions required to bring the primary and secondary system to cold shutdown conditions has been described. The expected system response as well as potential deviations as a result of variations in plant design or coincident failures have been discussed. Symptoms have been addressed which distinguish a simple steam generator tube rupture event from various contingencies, which require significantly different recover procedures.

TRANSIENT SYMPTOMS AND INSTRUMENT RESPONSES FOR STEAM GENERATOR TUBE RUPTURE

The following discussion characterizes the symptoms of a Steam Generator Tube Rupture (SGTR) transient, primarily in terms of several important instrument indications. Several of these instruments are among the minimum set that Westinghouse recommends be environmentally qualified; others are not but are included because of the nature of the information they provide.

It is assumed that reactor trip and safety injection initiation have occurred.

A. CONTAINMENT PRESSURE, CONTAINMENT SUMP LEVEL, CONTAINMENT AIR EJECTOR RADIATION AND CONTAINMENT RADIATION

Once reactor trip and safety injection initiation have occurred, containment instrumentation will show no change over pre-accident conditions for a SGTR transient. All of the above instruments should display readings in their normal operating ranges. In some instances, condenser air ejector exhaust is directed into containment on a high radiation alarm. For that case, containment air ejector radiation and containment radiation may indicate abnormal indications. Since in a SGTR event there is no primary or secondary fluid introduced into containment, no mechanism will be present for initiating abnormal containment pressure or sump level readings.

The absence of abnormal containment indications is one feature which allows the operator to distinguish between a SGTR and a LOCA or secondary system line rupture inside containment. Normal containment indications will not allow the operator to distinguish between SGTR and spurious safety injection initiation or secondary side line breaks outside of containment.

B. SECONDARY PRESSURE

Following a SGTR, pressure in the ruptured steam generator may remain above the non-ruptured steam generator pressure. This symptom is of little diagnostic value for a 2-loop plant or for very small tube ruptures.

C. RCS WIDE RANGE PRESSURE, AND HOT AND COLD LEG TEMPERATURES

Since a SGTR does involve a loss of primary system inventory, RCS pressure and temperature will decrease. For very large tube ruptures the RCS may depressurize to near the secondary pressure and may reach saturation in the hot legs. The decrease in RCS pressure distinguishes the SGTR event from a spurious safety injection. In addition, these reductions in conjunction with normal, pre-event containment indications provide additional confirmation of a SGTR rather than a small LOCA. When safety injection flow matches break flow, the RCS pressure will tend to stabilize.

D. PRESSURIZER WATER LEVEL

Following a SGTR, pressurizer level will initially decrease as break flow in excess of charging flow depletes primary inventory. Volume shrink in the RCS after reactor trip will further decrease level and may drain the pressurizer. Operation of high head SI is expected to eventually re-establish water level on span as SI flow and break flow equilibrate. In some instances, level may not return on span prior to manually depressurizing the RCS. These symptoms may also occur for certain small LOCAs or secondary side breaks, but the absence of containment instrument indications allows SGTR to be distinguished.

E. STEAM GENERATOR WATER LEVEL

Steam generator water level will initially drop out of narrow range as a result of reactor trip. Continued operation of the auxiliary feedwater system will restore level in the narrow range. Eventually, auxiliary

feedwater flow must be throttled to prevent filling of the steam generators. If auxiliary feedwater flow is balanced to all steam generators, water level in the ruptured steam generator will rise more rapidly. For large tube ruptures this is expected to provide early indication of a SGTR event.

F. RWST WATER LEVEL, CST WATER LEVEL, AND BIT WATER LEVEL

These water levels will change only slowly following a SGTR and do not provide any information useful for short term diagnostics.

G. CONDENSER AIR EJECTOR AND SG BLOWDOWN RADIATION

These symptoms are the ones most characteristic of a SGTR event. High secondary radiation alarms will sound following a SGTR. If some leakage (within tech specs) exists prior to the event, the signal will rapidly increase. The high radiation level may drive the response off-scale so rapidly that no useful rate information can be obtained.

These instrument indications can be particularly useful in distinguishing between a SGTR and other small LOCAs. If the LOCA is small enough that immediate indications from containment sump levels and containment radiation do not occur, the absence of steam generator radiation and condenser air ejector radiation should guide the operator to look for alternate indications of a LOCA other than a SGTR.

H. AUXILIARY BUILDING AREA RADIATION MONITORS

These instruments should not exhibit any change from pre-event readings for a SGTR.

I. AUXILIARY FEEDWATER FLOW

Following an SI signal, the Auxiliary feedwater system will deliver to all steam generators. The steam generator with the ruptured tube will

require less auxiliary feedwater flow to maintain water level. Consequently, the ruptured steam generator will require more throttling of auxiliary feedwater flow to prevent filling of the steam lines. For large tube ruptures this can provide additional confirmation of a SGTR.

J. SI/RHR FLOW

These indications are not useful in diagnosing a SGTR. They are necessary to provide verification of safety injection.

K. RCL FLOW

This indication is of no apparent significance in diagnosing a SGTR.

TABLE 1: SEQUENCE OF EVENTS

1. Reactor Trip - pumps lost if offsite power is not available (A)
2. Turbine Trip (A)
3. Loss of Offsite Power (A)
4. Steam Generator Safety Valves Open (A)
5. Safety Injection Actuated (A)
6. Auxiliary Feedwater Actuated (A)
7. Main Steamline Isolation (O)
8. Steam Dump From Non-Ruptured SGs - reduce RCS temperature to 50°F below no-load (O)
9. One Pressurizer PORV Opened - reduce RCS pressure to the ruptured steam generator pressure (O)
10. Terminate SI (O)
11. Reestablish Charging and Letdown - maintain pressurizer level at 20% span (O)
12. Pressurizer Spray Initiated - terminate break flow (O)

(A) Automatic
(O) Operator

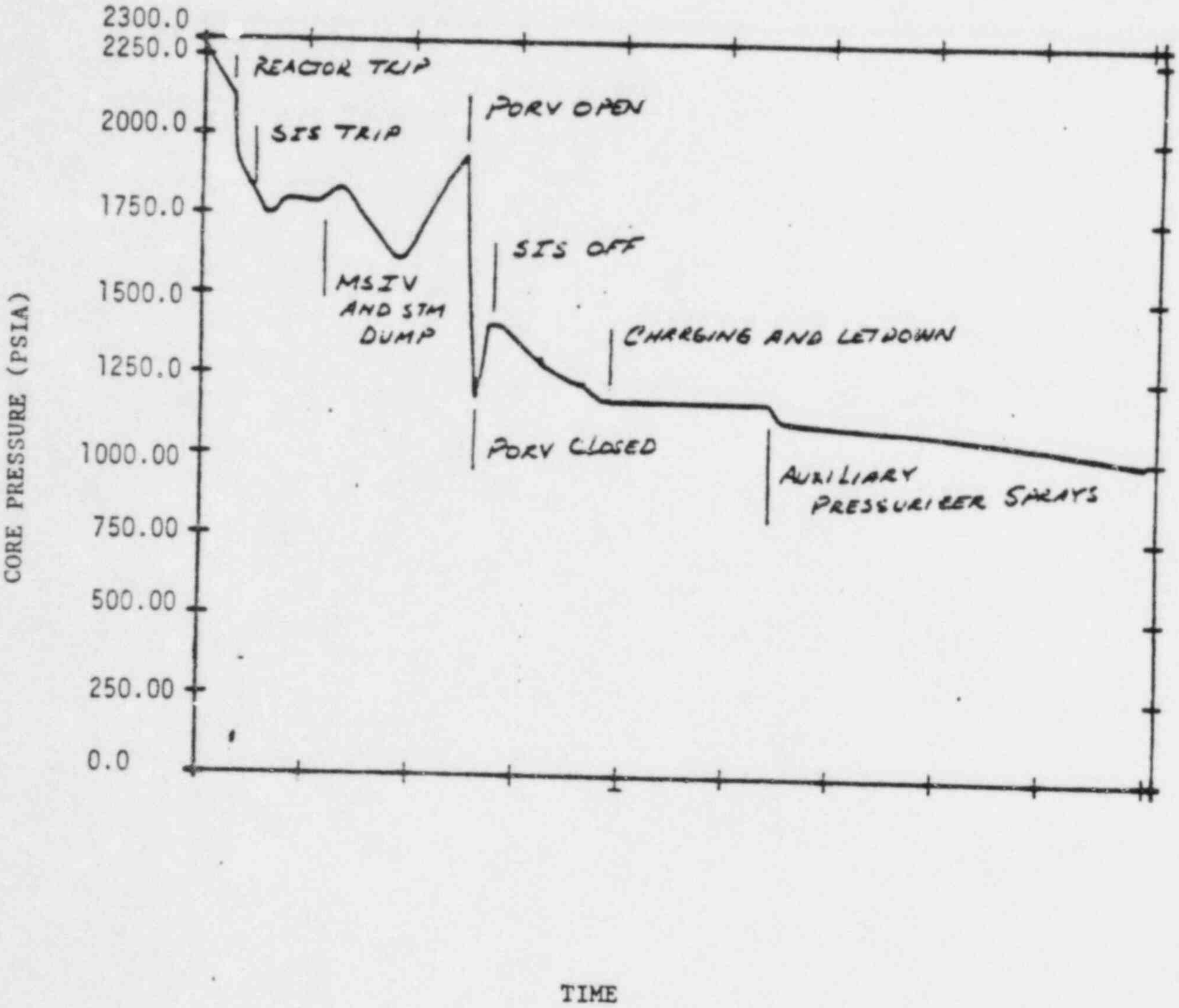


FIGURE 1. REACTOR COOLANT SYSTEM PRESSURE

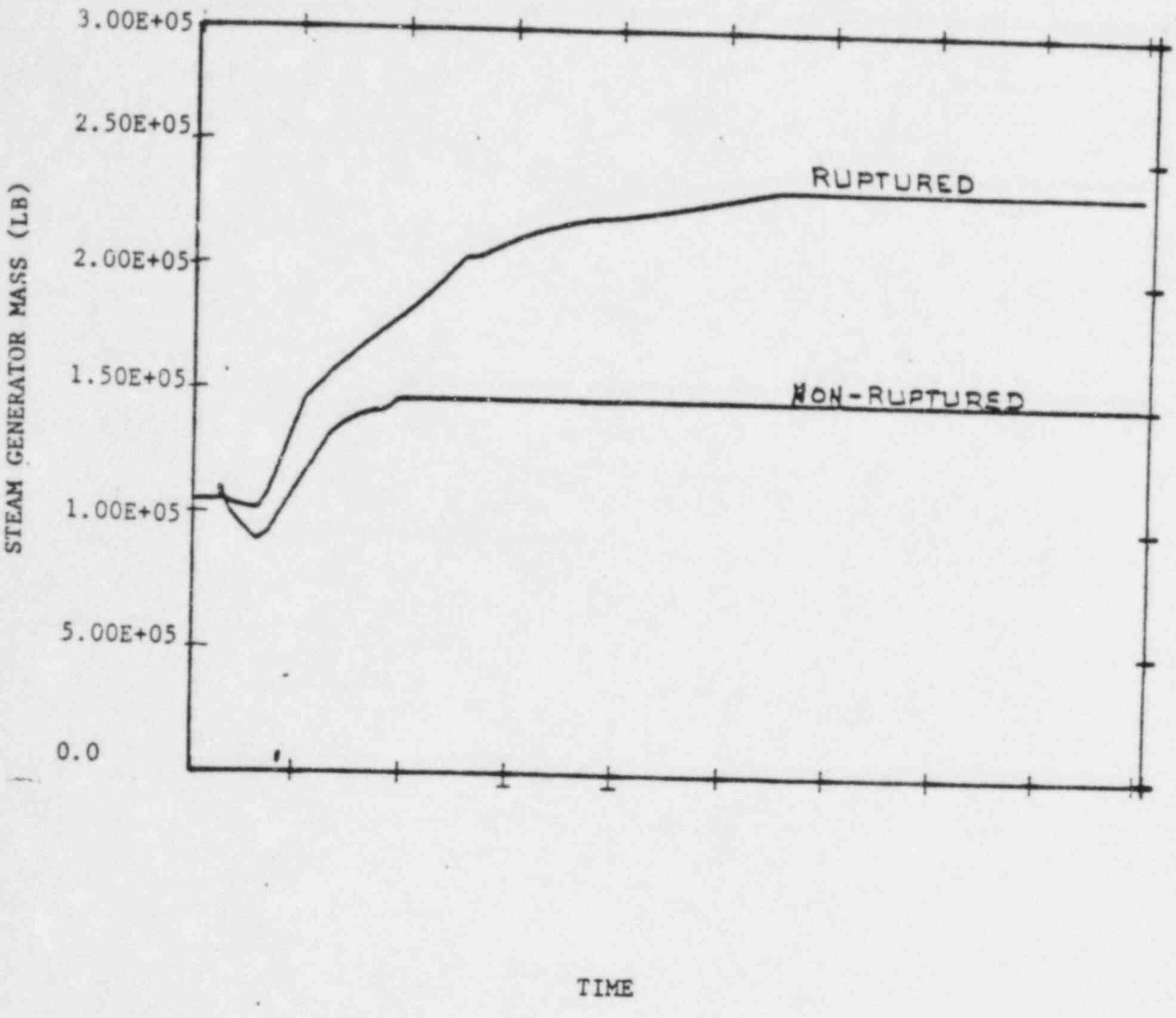


FIGURE 2. STEAM GENERATOR MASS

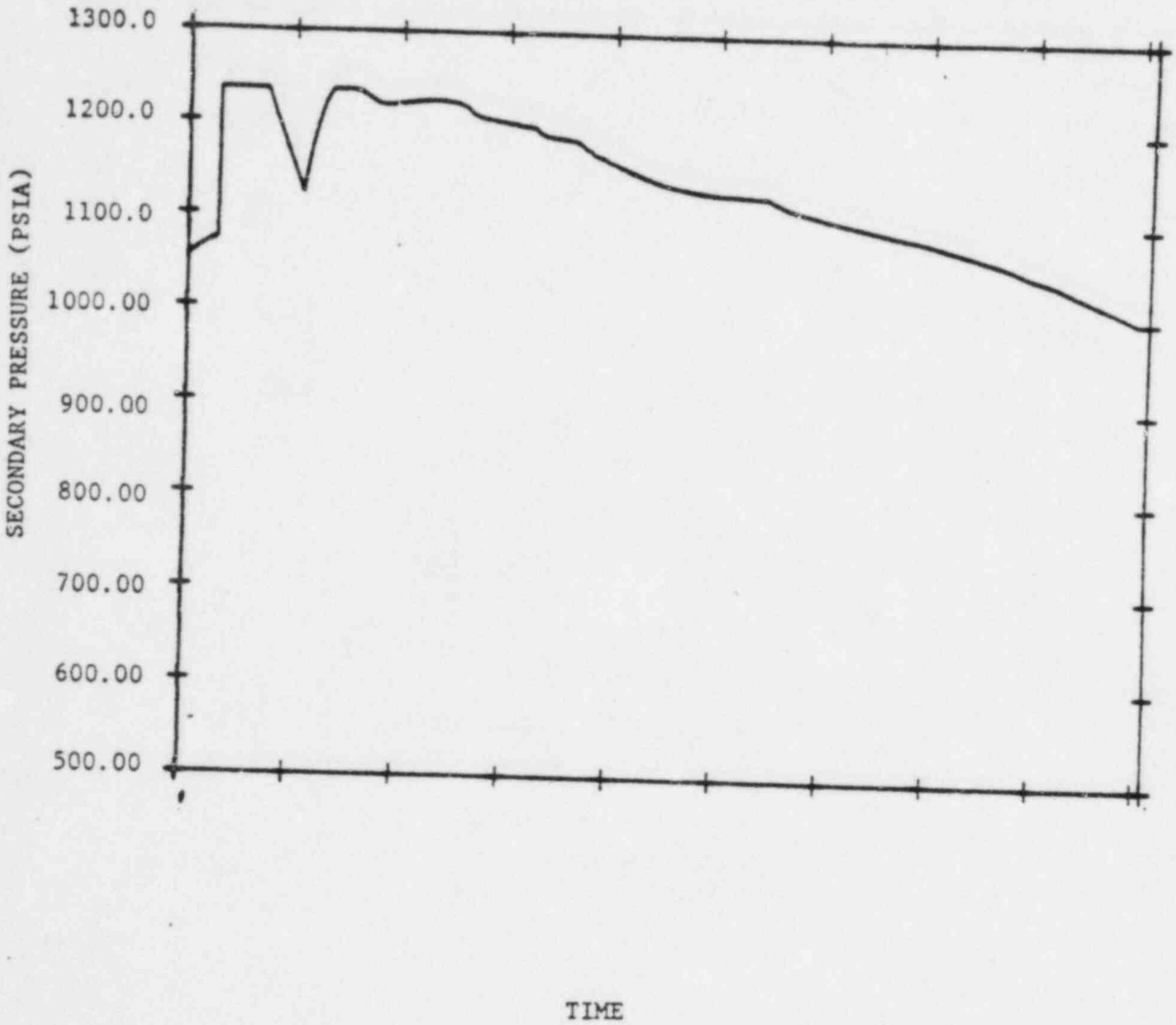


FIGURE 3. SECONDARY PRESSURE

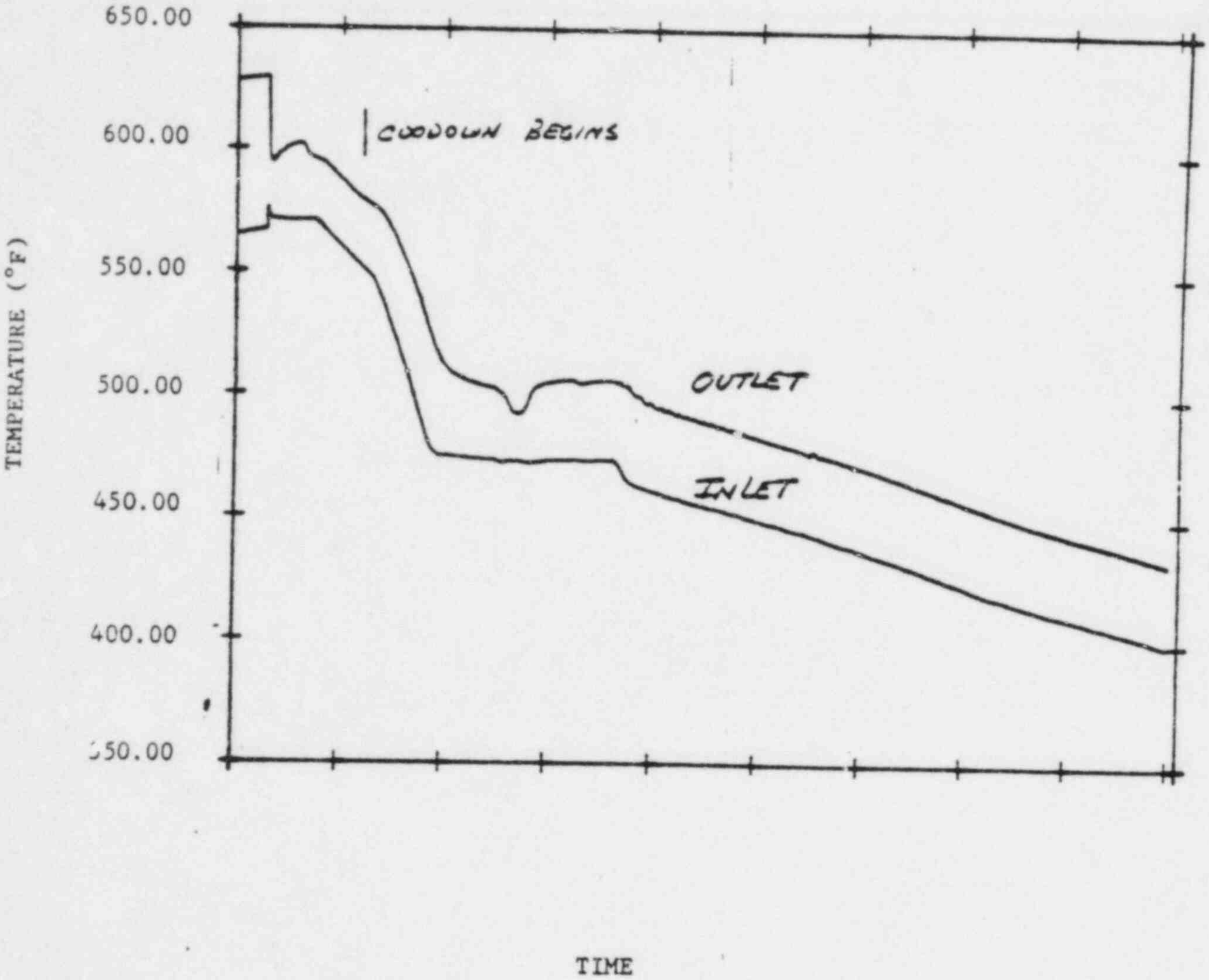


FIGURE 4. REACTOR VESSEL INLET AND OUTLET TEMPERATURE

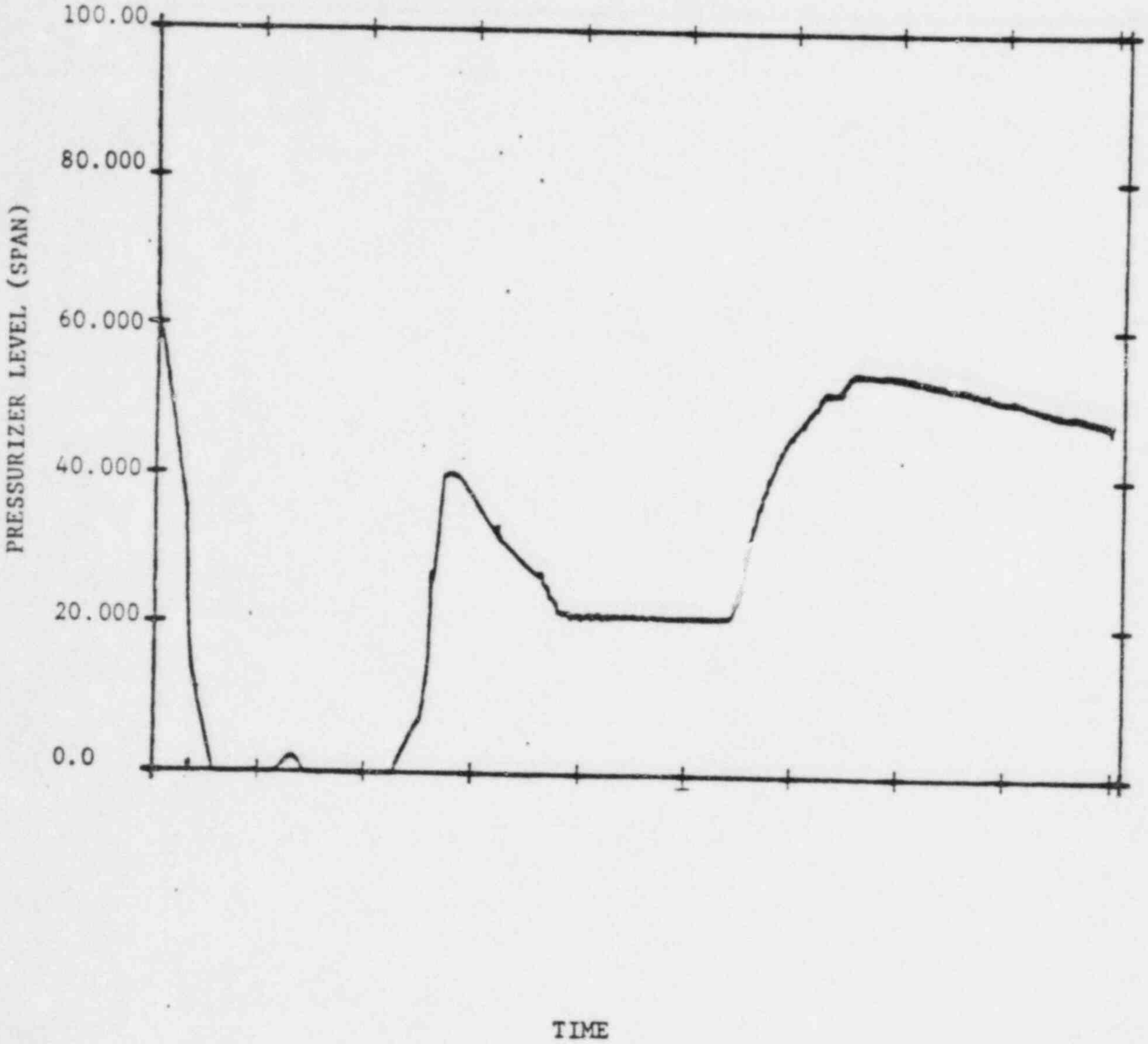


FIGURE 5. PRESSURIZER WATER LEVEL

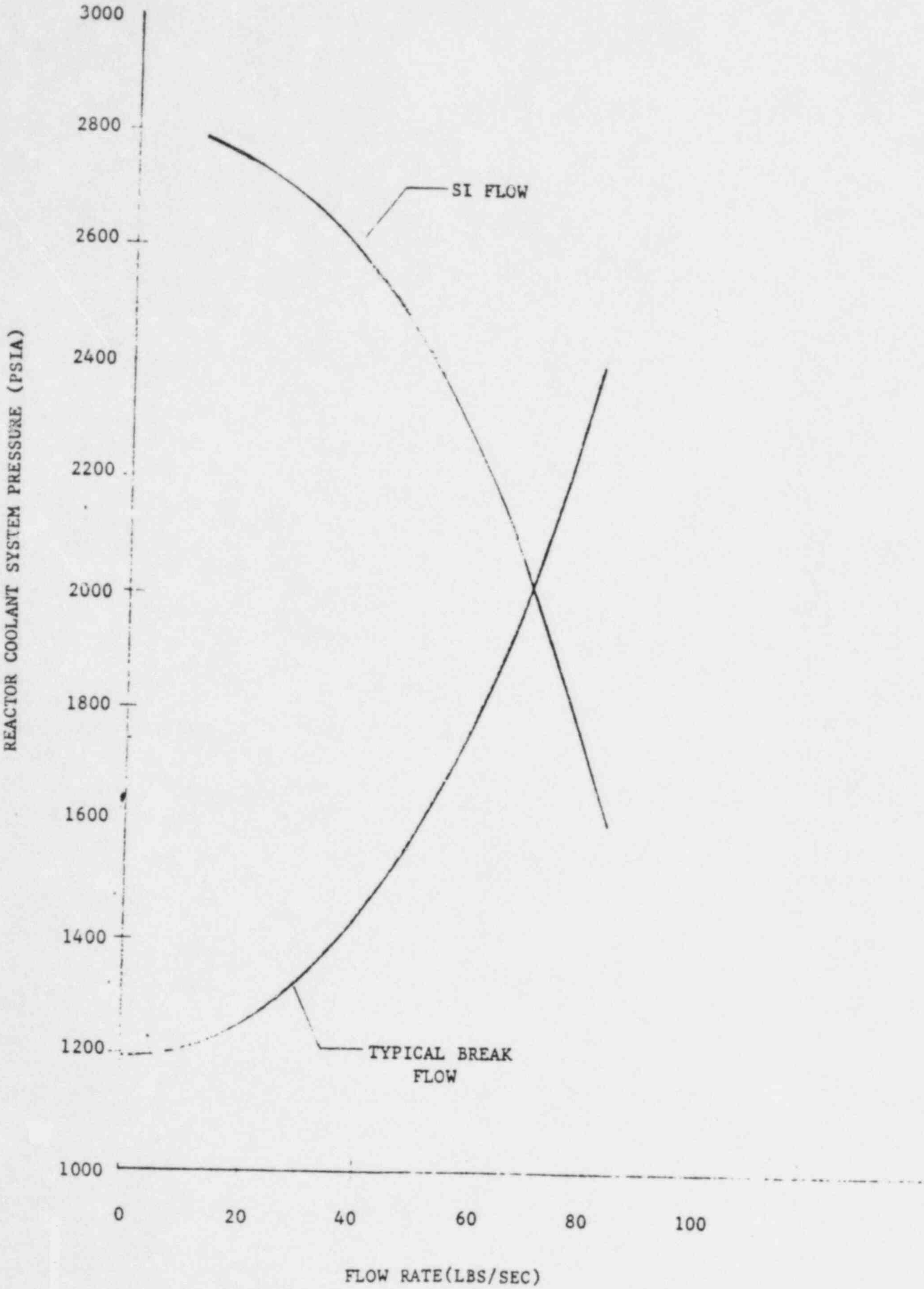


FIGURE 6. TYPICAL BREAK FLOW AND SI FLOW VS. RCS PRESSURE

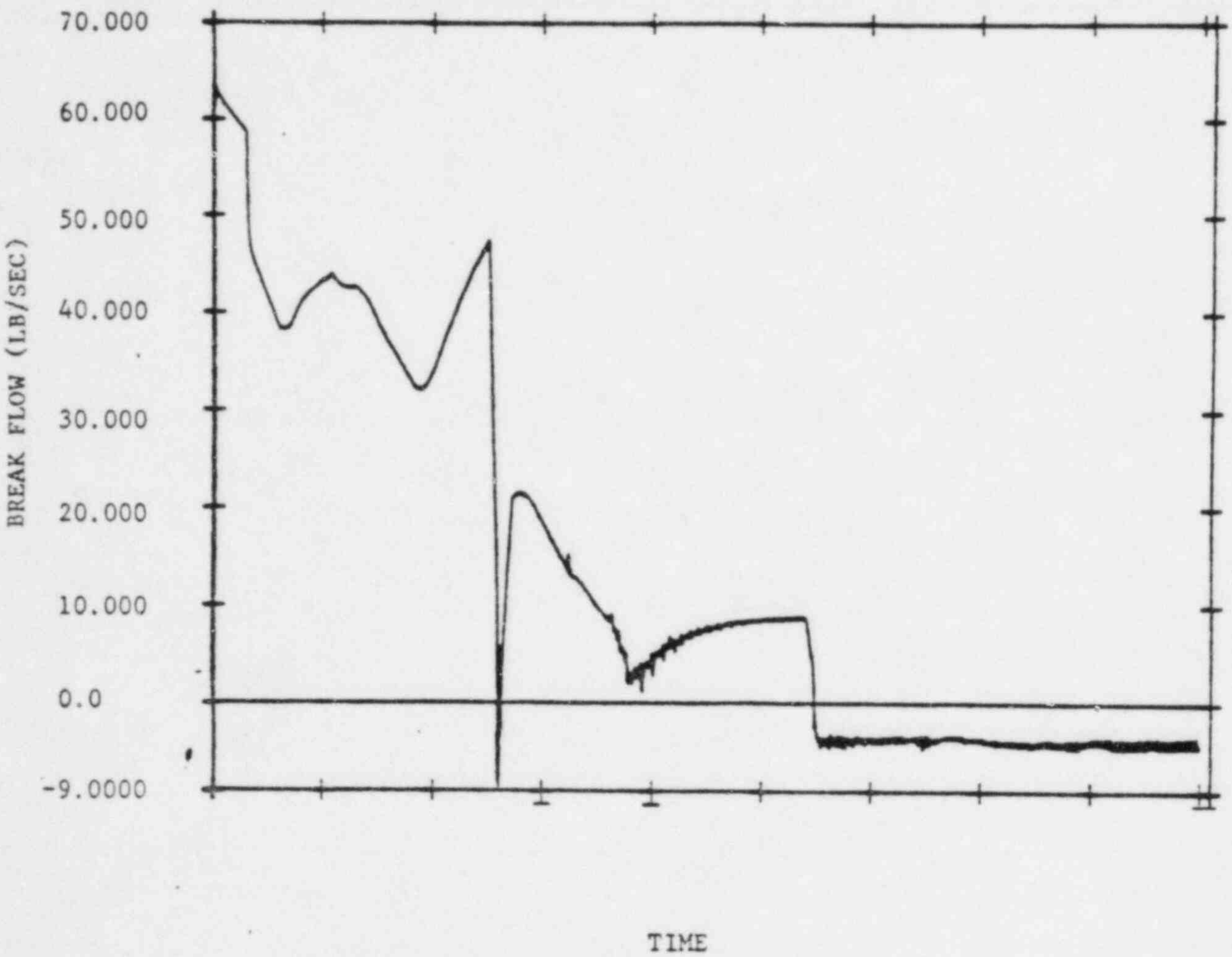


FIGURE 7. BREAK FLOW

BASIS FOR SUBSEQUENT ACTIONS IN E-3
STEAM GENERATOR TUBE RUPTURE

A detailed discussion and explanation of the E-3, "Steam Generator Tube Rupture", emergency operating guidelines is presented on a step by step basis. It is assumed that prior to entering the E-3 guidelines that the operator has noted the cautions(3) concerning emergency diesels operation and the use of loop isolation valves, if available. In addition, it is expected that cross checks will be performed on instrument channels so that inconsistent readings between anomalous and valid indications will be detected.

FIRST NOTE PRECEDING STEP 1

Very small steam generator tube ruptures may appear nearly the same as small LOCA transients as shown by most process variables. During the course of accident recovery, therefore, the operator must assure that a small LOCA has not been misdiagnosed as a tube rupture. This can be accomplished by obtaining a containment atmosphere sample, which should indicate normal readings in the case of a tube rupture. It must be noted that for plant designs in which the condenser air ejector exhaust is directed to the containment building following a high radiation alarm, containment samples would be expected to exhibit abnormal gaseous readings, even for a steam generator tube rupture event. In addition, small steam generator tube ruptures may be difficult to positively identify by secondary side level behavior. Identification of the affected steam generator may require sampling the steam generator shell sides for abnormal radioactivity levels. This step is identified early in the procedure in order to provide maximum time to make available the appropriate personnel to perform these sampling functions.

CAUTION PRECEDING STEP 1

In the unlikely event that tube ruptures have occurred in all steam generators, isolation of all ruptured steam generators is not feasible

since at least one steam generator is required for cooldown of the Reactor Coolant System (RCS). For such a case it is desirable to identify the steam generator with the smallest size tube rupture. Since tube rupture flow is directly related to the size of the rupture, the steam generator with the smallest tube rupture is recognized by the steam generator with the lowest secondary water level. If this steam generator is not readily identified, the operator should select one steam generator to be used for RCS cooldown with priority based on low secondary water level. This steam generator should be considered as non-ruptured for subsequent steps in these guidelines during cooldown to the Residual Heat Removal System. That is, maintain sufficient auxiliary feedwater flow to maintain secondary water level in the narrow range and dump steam from this steam generator as described in the following steps for a non-ruptured steam generator.

Step 1

The indications listed in Step 1 identify the unique features of a ruptured steam generator. In the case of a large rupture, steam generator water level should provide an obvious indication of the affected steam generator(s). For smaller tube ruptures, however, steam generator water level may respond slowly so that identification on high secondary radiation may be required. If rapid secondary steam release should occur, a momentary swell in steam generator water level may result. The operator should verify that the increased water level in a suspect steam generator is not a momentary swell. This step should be completed as quickly as possible to expedite recovery procedures. If the ruptured steam generator(s) is not immediately identified, step 3 through step 9 should be completed while continuing efforts to identify the ruptured steam generator. All steam generators should be inspected for indications of a tube rupture since multiple ruptures may have occurred.

Step 2

Isolation of the ruptured steam generator(s) effectively contains release of radiation from this generator by isolating its associated steam line. If steam release through steam generator safety valves

continues, releases from the ruptured steam generator(s) will continue until manual or automatic actions reduce the secondary pressure below the safety valve setpoint. Feedwater flow is terminated to this generator to minimize the rate of filling with liquid to prevent water from entering the steam lines. The ruptured steam generator(s) power operated relief valves and the isolation valves to the turbine driven auxiliary feedwater pump must be closed as a further effort toward isolating steam release paths. All plant specific release paths should likewise be isolated.

If the Main Steamline Isolation Valve (MSIV) or bypass valve for the ruptured steam generator(s) fail to close properly, the MSIVs and bypass valves for the non-ruptured steam generators must be closed as an alternative method of isolating the ruptured steam generator(s). In this case, steam from the non-ruptured steam generators must be released through the secondary Power Operated Relief Valves (PORV) to prevent unisolating the ruptured steam generator(s).

Isolation of the ruptured steam generator(s) from the non-ruptured must be maintained to prevent steaming of the ruptured generator(s). In addition to minimizing radioactivity releases, this ensures RCS subcooling during depressurization of the primary to the ruptured steam generator pressure. After the initial depressurization phase the RCS pressure is equal to the ruptured steam generator pressure. Since the RCS temperature is reduced using the non-ruptured generators, primary subcooling is determined by the difference in saturation temperatures at the ruptured and non-ruptured generator pressures and the core temperature rise.

Step 3

The pressurizer PORVs must be made available for depressurization of the RCS in the event that normal spray is not available or effective. In addition, PORV block valves must be available to prevent loss of primary inventory and uncontrolled depressurization if a PORV fails to close.

This step is designed to ensure power to the PORV block valves if offsite power is lost and to verify a flow path from the PORVs to the Pressurizer Relief Tank (PRT). If a faulty PORV has been previously isolated using a block valve, that valve must not be opened since it may fail to close on demand, potentially resulting in a small LOCA.

Step 4

Since a steam generator tube rupture exhibits the same RCS primary indications as a small LOCA, the operator must verify that a loss of coolant is not occurring through a pressurizer PORV. This may be accomplished by monitoring PORV position indicators, relief line TCs, and PRT conditions. If a faulty PORV is identified, it must be isolated by closing the associated block valve.

CAUTION FOLLOWING STEP 4

If any pressurizer PORV opens because of high RCS pressure, the operator must verify that the PORV closes properly, after RCS pressure decreases, to prevent continued loss of primary coolant. If a faulty PORV is identified, the associated backup isolation valve must be closed.

CAUTION PRECEDING STEP 5

Seal injection flow must be maintained to prevent additional leakage from the RCS and potential pump seal damage.

Step 5

This step represents the Westinghouse recommendations for Reactor Coolant Pump (RCP) operation during abnormal and emergency events. See the basis document E-0, "Diagnostics", Step 2 for a general explanation of this step. Also, a more detailed discussion of the phenomena experienced with different modes of RCP operation during a LOCA is presented in the Appendix to E-1.

These criteria for RCP trip will be monitored, where indications of a LOCA event are still evident, so that proper LOCA mitigation actions would be performed in the event that a LOCA (other than the diagnosed steam generator tube rupture event) was in progress. Safety analyses have demonstrated that the reactor coolant pumps are not needed to maintain core cooling during LOCA events as long as safety systems are functioning properly, e.g., safety injection. However, for a tube rupture event RCP operation is preferred to provide normal pressurizer spray capability and to reduce thermal gradients within the primary.

Step 6

RCS pressure will not drop below the Low-head safety injection pump shutoff head for a steam generator tube rupture event prior to depressurization of the ruptured steam generator(s) below the Low-head pump shutoff head. Consequently, the Low-head safety injection pumps should be stopped to avoid damage to these pumps caused by running in the miniflow mode for long periods of time (| 30 minutes). This step verifies that Low-head safety injection pumps are not needed. If Low-head pumps are discharging at this time, the operator must go to E-1, "Loss of Reactor Coolant", Step 14 to investigate other indications of a LOCA in progress. If appropriate, Low-head safety injection pumps are stopped and placed in standby.

CAUTION FOLLOWING STEP 6

Automatic restart of the Low-head safety injection pumps will not occur after reset. Consequently, the Low-head pumps must be manually restarted if the RCS pressure drops uncontrolled below the Low-head pump shutoff head.

Loss of offsite power after safety injection is reset results in loading normal blackout loads on the emergency electrical busses rather than safeguards loads, e.g., ECCS. The safeguards loads must be loaded manually on the diesel powered emergency busses.

Step 7

This step instructs the operator to establish electrical and pneumatic power supply to equipment which may be necessary for recovery from a steam generator tube rupture event if offsite power is lost. Essential equipment includes PORVs (primary and secondary) and associated isolation valves, main steam line bypass valves, normal and auxiliary spray valves and cold leg accumulator isolation valves. A plant specific list of equipment should be prepared to ensure that power supplies are established to all available equipment referenced in this guideline if offsite power is lost. Note that if containment isolation also occurs, power supplies to certain equipment, e.g., auxiliary spray valves, pressurizer PORVs may be lost. In these cases, the operator must ensure that power to this equipment can be re-established when containment isolation is reset. During this phase of the transient and recovery, symptoms of a LOCA exist. Therefore, containment isolation must not be reset until necessary to access required equipment.

Step 8

If an unisolated secondary steam release, e.g., a stuck open safety valve or a steam line fracture, exists during or develops as a result of a steam generator tube rupture, the ruptured steam generator may depressurize uncontrollably. Consequently, depressurization of the primary to the ruptured steam generator pressure may not be possible until cold shutdown is achieved. In addition, uncontrolled depressurization of the secondary can potentially result in vessel integrity and reactivity feedback concerns associated with a rapid RCS cooldown if precautionary actions are not taken. In such cases, the E-3, "Steam Generator Tube Rupture" guidelines are not sufficient. Hence, this step checks the secondary pressure to determine if an uncontrolled steam release exists and instructs the operator accordingly.

Decreasing secondary pressure significantly below no-load is an indication of an uncontrolled steam release. Automatic steam dump Tavg control may momentarily reduce secondary pressure below no-load immediately after reactor trip because of the lag in RCS average temperature. However, in such a case, pressure will increase and eventually stabilize near no-load. Consequently, RCS average temperature decreasing below no-load provides additional confirmation.

For sizable steam releases, secondary pressre will rapidly decrease to the automatic main steamline isolation setpoint. Smaller releases, for which secondary pressure stabilizes above the automatic MSI setoint, are of major concern only if they develop in a ruptured steam generator. Those cases will be detected in Step 10.

If the MSIVs or bypass valves have not been closed, an uncontrolled steam release will depressurize all steam generators until isolation occurs (steam line check valves may limit the depressurization to one steam generator depending on the location of the release). If the uncontrolled release is downstream of the MSIVs, closing the MSIVs and bypass valves on all steam generators will terminate the release. In that case, steam generator pressures can be regulated using the secondary PORVs and, hence, E-3 guidelines are adequate.

For an uncontrolled steam release upstream of the MSIVs or if an MSIV or bypass valve fails, closing the MSIVs and bypass valves will limit the depressurization to only the faulted steam generator(s). In this case, E-3 guidelines are not sufficient and the operator is directed to ES-3.3, "SGTR With Secondary Depressurization", for further accident recovery.

It is desireable to maintain the ruptured steam generator pressure above the cold leg accumulator pressures since this will prevent discharge of the accumulators during depressurization of the RCS to the ruptured steam generator pressure. Consequently, the operator is instructed to

close all MSIVs and bypass valves if secondary pressure approaches the cold leg accumulator pressures as a result of an uncontrolled steam release. In some cases automatic MSI may have already occurred.

CAUTION PRECEDING STEP 9

This caution provides a long term instruction to ensure that a water supply is continuously provided to the auxiliary feedwater pumps. For the full spectrum of LOCA events the steam generator level should be maintained above the U-tubes. In addition to the obvious function of providing a heat sink, it also reduces radioactive releases.

Step 9

Assurance must be provided that adequate heat sink exists in the steam generators to provide a continued means of energy removal. Auxiliary feedwater flow must be manually regulated to maintain the proper indicated level since there is no automatic level control in this mode. If the ruptured steam generator has not yet been identified, auxiliary feedwater flow must be regulated to establish and maintain a minimum narrow range level indication in all steam generators until identification is complete. This enables the ruptured steam generator to be detected as early as possible on high steam generator water level. Once identified, auxiliary feedwater flow is regulated to establish and maintain recommended no-load water level in the non-ruptured steam generators. Auxiliary feedwater must be added to the ruptured steam generator only as necessary to ensure that the tubes are covered.

CAUTION PRECEDING STEP 10

The operator must not proceed until the ruptured steam generator(s) has been identified and isolated. Subsequent actions will reduce the RCS temperature below saturation at the ruptured steam generator pressure. Prior to these operations, ruptured steam generator isolation must be

complete in order to ensure primary system subcooling following depressurization to the ruptured steam generator pressure and to prevent additional releases from the ruptured generator during cooldown.

Step 10

In anticipation of subsequent RCS depressurization, the primary temperature must be reduced to ensure subcooling at the ruptured steam generator pressure. If significant bulk voiding occurred, pressurizer level would not be a reliable indication of system inventory. Consequently, the operator would not have sufficient information to justify terminating safety injection.

As previously discussed in Step 2, primary subcooling following depressurization to the ruptured steam generator pressure is determined by the difference in pressure between the ruptured and non-ruptured steam generators and the core temperature rise. A table of the required non-ruptured steam generator pressures is provided in step 10 for various ruptured steam generator pressures. Since the core temperature rise will be significantly greater if no RCPs are running, non-ruptured steam generator pressures are supplied for a) any RCP running, and b) no RCP running. These pressures are designed to ensure 50°F subcooling in the primary loops with non-ruptured steam generators. The 50°F subcooling allows for instrument uncertainties in RCS pressure and temperature measurements and provides additional operating margin.

If offsite power and the condenser are available the non-ruptured steam generators will be depressurized by dumping steam as rapidly as possible to condenser. Steam dump to condenser is the preferred method of depressurization since this minimizes doses and provides smooth cooldown control. If the non-ruptured steam generator MSIVs and bypass valves have been closed to isolate the ruptured steam generator(s) or an uncontrolled steam release, steam dump to condenser will not be available. If a spurious closure of the MSIVs has been identified, then the operator should attempt to open the bypass valves on the non-ruptured steam

generators to establish a flow path to the condenser. If an uncontrolled steam release results, the bypass valves must be closed and steam dump to atmosphere initiated. In some designs, the bypass valve may not provide sufficient flow capacity for a rapid RCS cooldown. In that case, the bypass valves should not be opened and secondary PORVs must be used for steam dump.

If offsite power or the condenser is not available, steam dump must be made to the atmosphere using the non-ruptured steam generator PORVs.

A small, unisolated steam release from a ruptured steam generator may not have been detected and may depressurize the ruptured steam generator following cooldown of the RCS using the non-ruptured generators. In that case, subcooling of the RCS cannot be assured at the ruptured steam generator pressure. In addition, break flow will be reinitiated if the ruptured steam generator continues to depressurize after safety injection is terminated. Therefore, the operator is directed to ES-3.3, "SGTR With Secondary Depressurization," Step 11 if the ruptured steam generator pressure continues to decrease.

No significant cooling of the primary loop with the ruptured steam generator will occur if natural circulation exists during cooldown since there is no heat removal through that steam generator (reverse heat transfer will develop in that loop). Therefore, the operator should expect instrument indications of conditions in that loop(s) to be significantly different than primary loops with non-ruptured steam generators and may indicate oscillatory behavior near saturation conditions.

Step 11

For multiple tube ruptures or reduced safety injection flow capacity, the primary may depressurize to less than 200 psi greater than the ruptured steam generator pressure as a result of the tube rupture. Consequently, primary pressure will not incresae 200 psi after initial depressurization to equilibrium with the ruptured steam generator.

Therefore, safety injection could not be terminated in E-3. This step directs the operator to ECA-3, "SGTR Contingencies", if the primary pressure is less than 200 psi above the ruptured steam generator pressure.

FIRST CAUTION PRECEDING STEP 12

Up to this time, no abnormal containment indications should accompany this transient, with the exception of abnormal gaseous readings if the air ejector exhaust is directed into containment following a high radiation alarm. Therefore, containment indications should be checked for abnormal conditions to verify proper accident diagnosis. If abnormal indications do exist, further accident recovery must be directed to E-1, "Loss of Reactor Coolant", Step 9.

SECOND CAUTION PRECEDING STEP 12

During controlled depressurization of the primary, the RCS pressure criteria for RCP trip, which is based on RCS depressurization during a LOCA, does not apply. Continued RCP operation is preferred to maintain the use of normal pressurizer spray and reduce thermal gradients during cooldown. It should be emphasized, however, that the other criteria for RCP termination, e.g., loss of component cooling water, are appropriate and must be observed.

Step 12

Depressurization of the primary system is necessary to equilibrate primary and ruptured steam generator pressures, thereby terminating break flow. The preferred method of depressurization is normal pressurizer spray since this minimizes thermal stresses and does not deplete RCS inventory. Step 12 and Step 13 provide instructions for this depressurization phase using normal spray. If normal spray is not available, Step 12 and Step 13 do not apply and an alternative method of depressurization provided in Step 14 must be used.

If the RCPs in the loops with pressurizer spray lines are stopped, normal pressurizer spray will not be available. In other instances, normal spray may be available but not effective in depressurizing the primary. In either case, an alternative method described in Step 14 must be used.

If normal spray is available, depressurization of the primary is initiated by opening normal pressurizer spray valves to provide maximum spray capacity which condenses steam in the pressurizer. As the primary pressure is reduced, pressurizer level will increase as safety injection flow in excess of tube rupture flow replaces condensed steam in the pressurizer. For multiple tube ruptures or reduced safety injection capacity, pressurizer level may not return on span during depressurization to the ruptured steam generator pressure.

If the ruptured steam generator pressure is below the cold leg accumulator pressure, the operator should attempt to close the accumulator isolation valves prior to depressurizing the RCS to the ruptured steam generator pressure. If the accumulators cannot be isolated quickly, the operator must commence RCS depressurization prior to isolating the accumulators. In that case, however, pressurizer level may reach off-scale high prior to depressurizing to the ruptured steam generator pressure as accumulator injection replaces condensed steam in the pressurizer. Depressurization of the RCS must be terminated before filling the pressurizer to prevent loss of pressurizer pressure control.

Step 13

This step instructs the operator to stop normal pressurizer spray when the primary pressure is reduced to the ruptured steam generator pressure. With spray stopped, RCS pressure will increase as safety injection flow in excess of break flow compresses the steam bubble in the pressurizer until safety injection flow and break flow equilibrate. If RCS pressure does not increase while pressurizer level continues to

increase, leakage from the spray line into the pressurizer is suspected. The operator should attempt to manually close the pressurizer spray valves. If leakage from the spray line continues, the RCPs connected to spray lines must be stopped to terminate pressurizer spray.

For multiple tube ruptures or reduced safety injection flow, pressurizer level may not return on span prior to depressurizing the primary to the ruptured steam generator pressure. If pressurizer level does not return on span, further recovery must be directed to ECA-3, "SGTR Contingencies".

If the ruptured steam generator pressure is below the cold leg accumulator pressure, then pressurizer level may reach off-scale high prior to depressurizing the RCS to the ruptured steam generator pressure. Depressurization of the RCS must be terminated before filling the pressurizer to prevent loss of pressurizer level control.

If normal pressurizer spray is effective in depressurizing the primary, Step 14 and Step 15 do not apply.

CAUTION PRECEDING STEP 14

If a pressurizer PORV is used to depressurize the RCS, primary coolant will be discharged into the PRT. In some cases, this discharge may be sufficient during controlled depressurization to rupture the PRT, which will result in abnormal containment conditions. Consequently, abnormal containment indications are no longer a reliable indication of a LOCA. If PRT integrity is lost, the operator must carefully evaluate pressurizer level and pressure behavior to verify release from the pressurizer vapor space has been terminated.

Step 14

If normal spray is not available or not effective, RCS pressure is reduced to the ruptured steam generator pressure by opening one pressurizer PORV to vent steam from the pressurizer vapor space. Only one PORV

is used to limit the depressurization rate. If this PORV is not effective because of a faulty PORV or a closed block valve, a different PORV should be used. Use of a PORV to depressurize will result in loss of primary inventory to the PRT as discussed in the previous caution.

RCS pressure will decrease rapidly when a PORV is opened as steam is vented from the pressurizer vapor space. Pressurizer level will increase as safety injection flow in excess of break flow increases primary coolant inventory and begins to replace vented steam with water. For multiple tube ruptures or reduced safety injection flow, pressurizer level may not return on span during depressurization to the ruptured steam generator pressure.

If no RCP is running, voiding in the upper head may occur (depending on the ruptured steam generator pressure) during depressurization of the primary to the ruptured steam generator pressure. This will result in a rapidly increasing pressurizer level as water displaced from the upper head, in addition to excess safety injection flow, replaces vented steam in the pressurizer. In addition, depressurization of the primary will be slowed. Consequently, pressurizer level may approach off-scale high before primary pressure decreases to the ruptured steam generator pressure. Pressurizer level must be monitored to prevent filling the pressurizer.

If normal spray and all pressurizer PORVs are unavailable, auxiliary pressurizer spray must be used to depressurize the RCS. Forcing cold water through the pressurizer spray nozzle creates thermal transients in the piping, nozzle, and pressurizer shell which must be minimized. Consequently, auxiliary spray should not be used unless heated by letdown. Since letdown has been automatically isolated, auxiliary spray must be used for RCS depressurization only when the other methods fail. If auxiliary spray is required, spray should be initiated slowly.

Step 15

After the RCS pressure has been reduced to the ruptured steam generator pressure, via one pressurizer PORV or auxiliary spray, depressurization must be terminated by closing the PORV or auxiliary spray valve. In some cases, depressurization must be terminated on high pressurizer level to prevent filling of the pressurizer and, consequently, loss of pressurizer pressure control.

When depressurization is terminated, RCS pressure will increase as safety injection flow in excess of break flow compresses the steam bubble in the pressurizer until safety injection flow and break flow equilibrate. If RCS pressure does not increase while pressurizer level continues to increase, then leakage from the PORV or auxiliary spray line (depending on the mode of depressurization) is suspected. The operator should monitor PRT conditions to verify leakage from the PORV. If leakage from the PORV continues after closing the PORV isolation valve, then further accident recovery must be directed to E-1, "Loss of Reactor Coolant", Step 9. Note that if the PRT has ruptured, leakage to the PRT may not be detected. In that case the operator must rely on pressurizer level and pressure behavior to detect leakage from the PORV.

For multiple tube ruptures or reduced safety injection capacity, pressurizer level may not return on span prior to depressurizing the primary to the ruptured steam generator pressure. In that case further accident recovery must be directed to ECA-3, "SGTR Contingencies".

Step 16

After depressurization is stopped, safety injection will continue to repressurize the RCS to an equilibrium pressure where break flow again matches safety injection flow. Therefore, safety injection must be terminated in order to stop break flow. The operator must monitor critical system conditions to ensure that an uncontrolled loss of RCS inventory will not occur following termination. Step 16 lists the conditions for which safety injection can be terminated.

An increase in RCS pressure of 200 psi after depressurization has been stopped verifies that safety injection flow is greater than break flow and, consequently, RCS inventory is increasing. In addition, increasing RCS pressure verifies the integrity of the pressurizer vapor space. A 200 psi increase is approximately the minimum increase which can be detected by the operator because of the RCS pressure indicator resolution.

If pressurizer level stabilizes, RCS pressure will no longer increase. Consequently, if RCS pressure has not increased 200 psi before pressurizer level stabilizes, safety injection flow cannot be terminated in E-3. In that case, the operator is directed to ECA-3, "SGTR Contingencies" for further accident recovery.

During periods where a steam vent path is established from the pressurizer vapor space and portions of the RCS have reached saturation conditions, holdup of water in the pressurizer can result in a stable or increasing pressurizer water level while system inventory is decreasing. For these conditions, pressurizer water level may not be a true indication of primary coolant inventory. Therefore, RCS subcooling and pressurizer level are required before safety injection can be terminated. Minimum RCS subcooling, based on wide range temperatures in the hot legs connected to non-ruptured steam generators or core exit thermocouples, must be greater than the sum of the temperature measurement system uncertainties and RCS pressure measurement system uncertainties converted into temperature using the saturation tables in order to ensure subcooling. If pressurizer water level has not returned on span the operator is directed to ECA-3, "SGTR Contingencies", for further accident recovery.

CAUTION FOLLOWING STEP 16

Safety injection must not be terminated if any of the conditions of Step 16 are not satisfied since the status of the RCS is not certain. The operator must not proceed to Step 17 until all the criteria for safety injection termination are satisfied.

Step 17

When all conditions described in Step 16 are satisfied, safety injection must be terminated to stop break flow. The operator is directed to ES-3.2, "SI Termination for Steam Generator Tube Rupture", for guidelines on terminating safety injection. After safety injection flow is terminated, residual break flow will reduce pressurizer water level and RCS pressure until primary and ruptured steam generator pressures equilibrate.

It may be difficult to verify pressure equilibrium between the primary and ruptured steam generator on pressure instrumentation alone because of instrument uncertainties. However, if charging and letdown flows are balanced, residual break flow will decrease the pressurizer level and equilibrate primary and ruptured steam generator pressures. Consequently, charging and letdown flows must be balanced at this time. If pressurizer level continues to decrease, RCS pressure must be reduced using normal spray, or auxiliary spray if heated by letdown, to maintain pressurizer level.

If RCS temperature has not yet stabilized, excess charging flow may be required to compensate for RCS shrinkage. Pressurizer level must be maintained above 20%. However, when temperature has stabilized, charging and letdown flows must be balanced to ensure break flow is stopped.

Step 18

The subsequent recovery actions for this event may result in release of steam from the ruptured steam generator. Since this phase of the recovery consists of a controlled release, the most appropriate release limitations are those provided in 10 CFR 20. If steam dump from the ruptured steam generator to the condenser is not available, an evaluation of potential release from the ruptured steam generator to atmosphere should be performed to determine if these limits will be exceeded. If atmospheric releases may exceed 10 CFR 20 limitations, an

alternative method of depressurizing the ruptured steam generator provided in ES-3.1, "SGTR Alternate Cooldown", must be used. It is likely that the utility will be required to obtain approval for subsequent recovery actions which involve any radioactive releases from the appropriate authorities.

Step 19

Subsequent steps will bring the RCS to cold shutdown. RCS boron concentration should be verified adequate for reactivity control at cold conditions. Boron can be added as necessary through the charging lines.

CAUTION PRECEDING STEP 20

Charging pump capacity may be only slightly greater than that required to compensate for RCS shrinkage during subsequent cooldown. If substantial tube rupture flow develops during cooldown, there may not be adequate charging flow available to maintain pressurizer level. Failure to simultaneously reduce RCS and ruptured steam generator pressures during cooldown will reinitiate break flow.

Step 20

The RCS is cooled to RHRS cut-in conditions by dumping steam from the non-ruptured steam generators. Steam dump to condenser is preferred since this provides smooth cooldown capabilities and minimizes doses. If the condenser is not available, the non-ruptured steam generator PORVs must be used to dump steam. Since break flow has previously been terminated, cooldown should be limited to 50°F/HR.

CAUTION PRECEDING STEP 21

It may be difficult to verify pressure equilibrium between the primary and ruptured steam generator on pressure instrumentation alone because of instrument uncertainties. However, with charging and letdown flows

balanced, tube rupture flow will tend to equilibrate primary and ruptured steam generator pressures. For these conditions, pressurizer level will adjust to accommodate changes in primary coolant volume. During cooldown, shrinkage will decrease pressurizer level and pressure, thereby drawing water through the tube rupture from the secondary. If charging flow is increased to account for RCS shrinkage, pressure equilibrium between the primary and secondary will be maintained.

Excess charging flow will maintain RCS pressure above the ruptured steam generator pressure, resulting in tube rupture flow from primary to secondary. On the other hand, insufficient charging flow indicates flow from the ruptured steam generator into the primary.

Each utility should prepare a plant specific table providing the approximate primary coolant shrink rate for various cooldown rates. The operator can select from this table the expected charging/letdown flow imbalance necessary to maintain pressurizer level constant, with primary and ruptured steam generator(s) in equilibrium.

STEP 21

During subsequent depressurization of the ruptured steam generator(s) and RCS, tube rupture flow will occur, resulting in fluctuations in pressurizer water level. The operator should control charging/letdown flows as necessary to maintain level in the normal operating range.

Step 22

The ruptured steam generator will act like a large pressurizer to the RCS and inhibit RCS depressurization. Therefore, pressure must be reduced in the ruptured steam generator(s) to depressurize the RCS to RHRS operating pressures. The most direct method of depressurization is steam release. Alternative methods are described in ES-3.1, "SGTR Alternate Cooldown". It is possible that the ruptured steam generator(s) is filled with water. Therefore, it is important that depressurization be accomplished slowly to prevent potential valve damage from

water relief. In addition, water in the ruptured steam generator may be highly subcooled. Consequently, the ruptured steam generator may depressurize rapidly as steam is released. The ruptured steam generator(s) pressure must be maintained above the non-ruptured to maintain RCS subcooling.

CAUTION PRECEDING STEP 23

Since this is a controlled cooldown of the RCS, RCS pressure and temperature must be maintained within normal cooldown limits.

If RCS pressure or pressurizer level drop in an uncontrolled manner safety injection must be reinitiated to maintain RCS inventory and re-establish pressurizer level. Since this will pressurize the RCS and increase break flow the operator must return to Step 10 to establish conditions for terminating safety injection.

Step 22

This step is designed to depressurize the RCS to maintain pressure equilibrium with the ruptured steam generator. Normal spray or auxiliary spray, if heated by letdown, can be used to condense steam in the pressurizer. At this time, auxiliary spray is expected to be heated by letdown. If neither normal spray or auxiliary spray is available, one pressurizer PORV must be intermittently opened to vent steam from the pressurizer. Avoid filling the pressurizer with water since this will result in a loss of pressurizer pressure control. If pressurizer heaters have been energized, heater controls must also be adjusted.

It may be difficult to verify pressure equilibrium between the primary and ruptured steam generator on pressure instrumentation alone because of instrument errors. Charging/letdown flows should be adjusted to accommodate primary coolant shrinkage during cooldown as discussed in the caution preceding step 21. If pressurizer water level continues to

drop, tube rupture flow is suspected. In that case, RCS pressure must be reduced further to establish equilibium and maintain pressurizer level.

During the depressurization process, backflow may occur from the ruptured generator. Therefore, RCS boron concentration must be monitored and adequate shutdown margin verified.

If a PORV is used to depressurize the RCS, pressurizer level and pressure, and PRT indications must be monitored to verify that a leak from the pressurizer vapor space has not developed. If a faulty PORV is identified, the associated isolation valve must be close to terminate the leak.

Step 24

When the RCS pressure approaches the cold leg accumulator setpoint pressure the accumulators must be isolated to prevent unnecessary discharge. If the accumulators discharge they will impede depressurization of the RCS and increase carryover into the ruptured steam generator. If the accumulator isolation valves cannot be closed, then any unisolated accumulators must be vented before continuing to depressurizing the RCS and ruptured steam generator.

Step 25 and Step 26

Cooldown and depressurization of the RCS must be continued as described in Steps 20 through 24 until RHRS can be placed in service. When the hot leg temperatures have been reduced below 350°F and RCS pressure is less than 400 psi, the RHRS system can be placed in service using normal procedures. Steam release from the ruptured steam generator should be terminated to minimize doses.

Pressure equilibrium between the RCS and ruptured steam generator must be maintained to prevent loss of primary coolant and boron dilution

caused by backflow from the ruptured steam generator. Charging and letdown flows should be monitored for any mismatch which is not typical of cooldown on RHRS. If leakage through the tube ruptured is detected, pressurizer spray or heaters can be used as appropriate to establish equilibrium.

Step 27

The procedure for cooldown on RHRS is normal with the additional consideration of minimizing rupture flow. If no RCP is running, the operator must continue dumping steam from the non-ruptured steam generators until they stop steaming to aid in cooldown and maintain natural circulation.

Step 28

When the RCS is sufficiently cooled, all RCPs should be stopped. The pressurizer must be cooled using auxiliary spray to relieve any static head difference between the ruptured steam generator and pressurizer. Auxiliary spray may be used if the RCS is below 200^{0}F even if it is not heated by letdown. Charging and letdown flows must be balanced to ensure leakage into the ruptured steam generator is not occurring.

Step 29

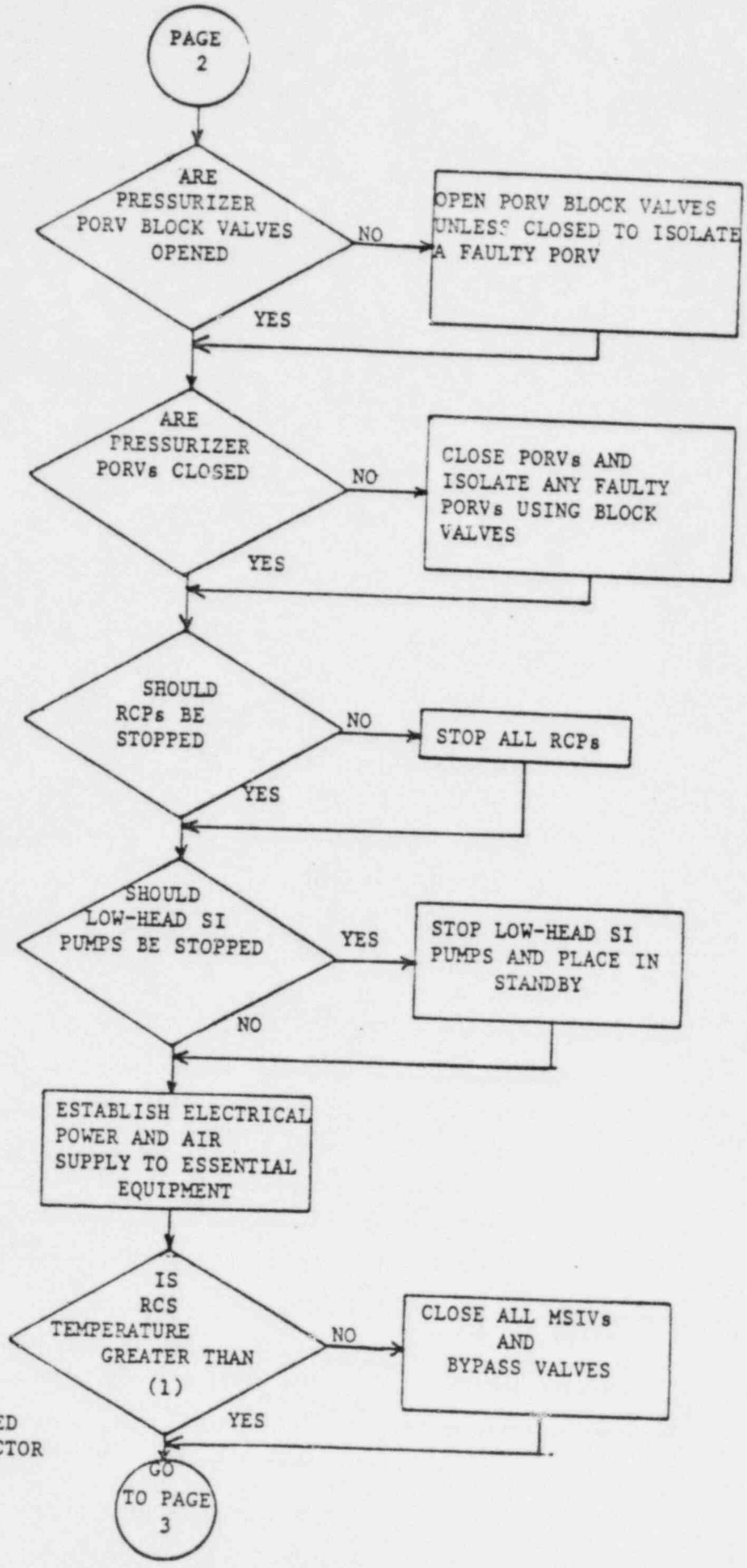
Cold shutdown conditions must be maintained.

References

1. Westinghouse Emergency Resonse Guideline ES-3.2, SGTR With Secondary Depressurization, September 1, 1981.

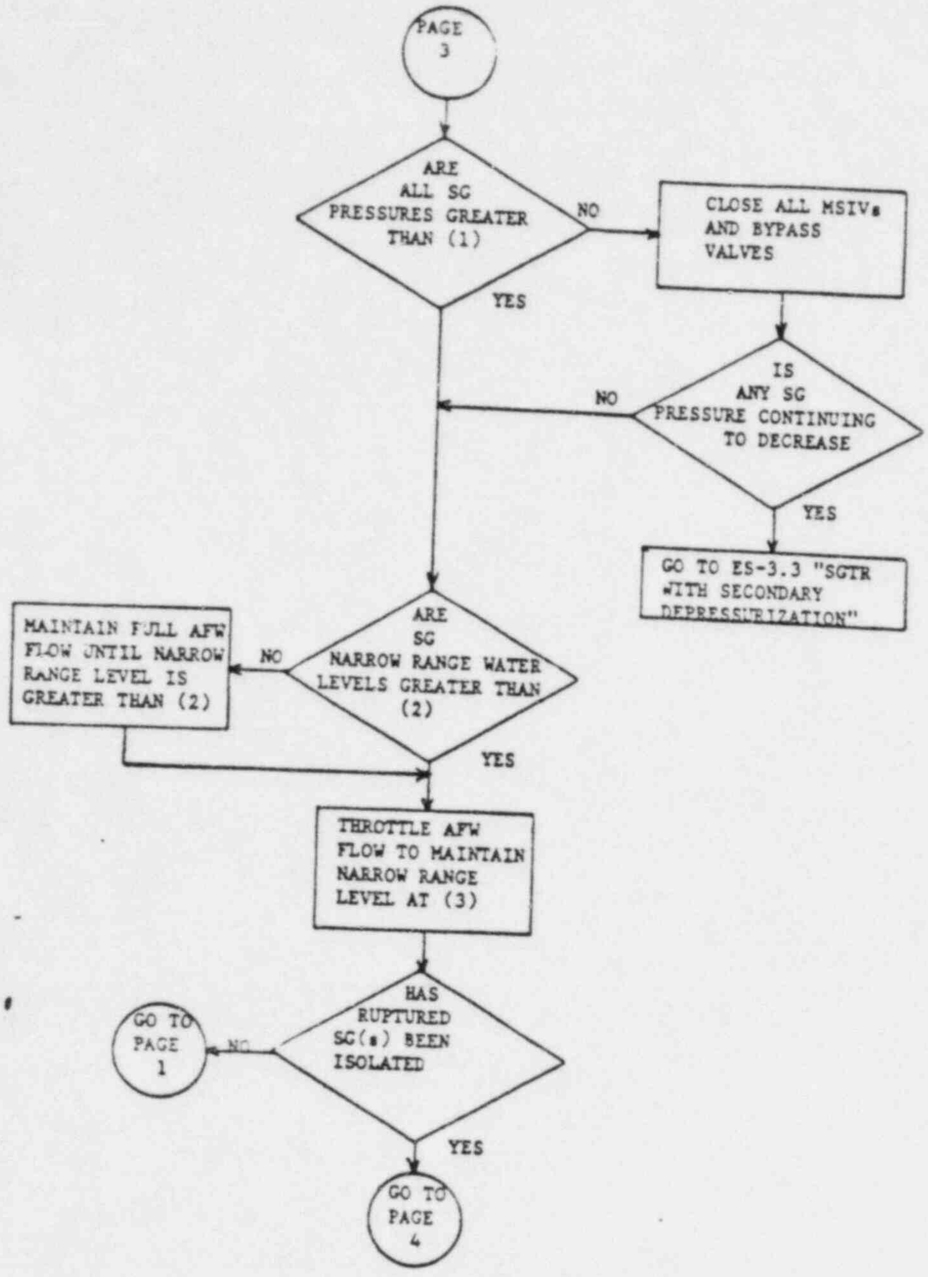
2. Westinghouse Emergency Response Guideline ECA-3, SGTR Contingencies, September 1, 1981.

3. Westinghouse Emergency Response Guidelines E-1, Loss of Reactor Coolant, September 1, 1981.



(1) ENTER PLANT SPECIFIC MINIMUM HOT LEG TEMPERATURE EXPECTED FOLLOWING A NORMAL REACTOR TRIP

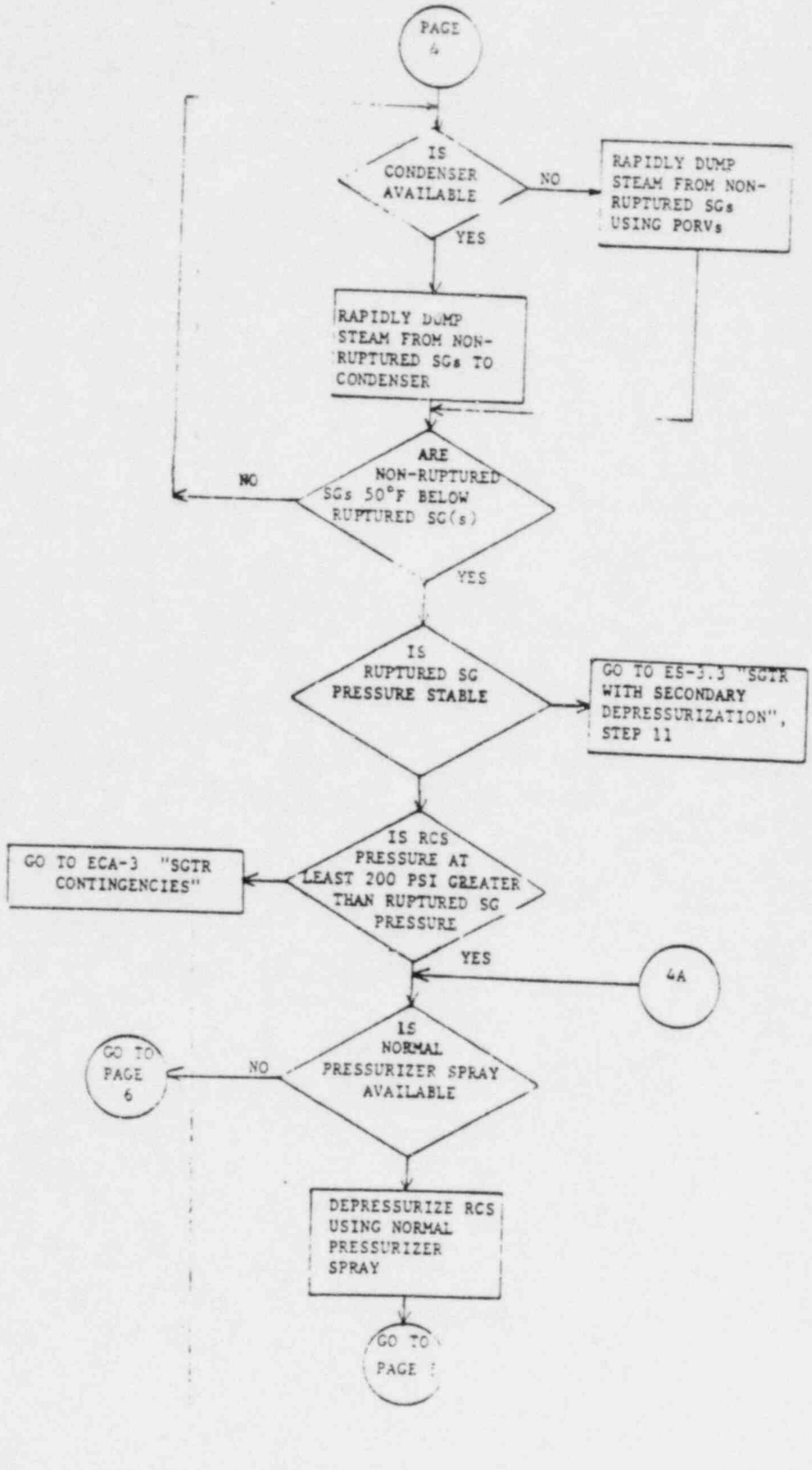
E-3

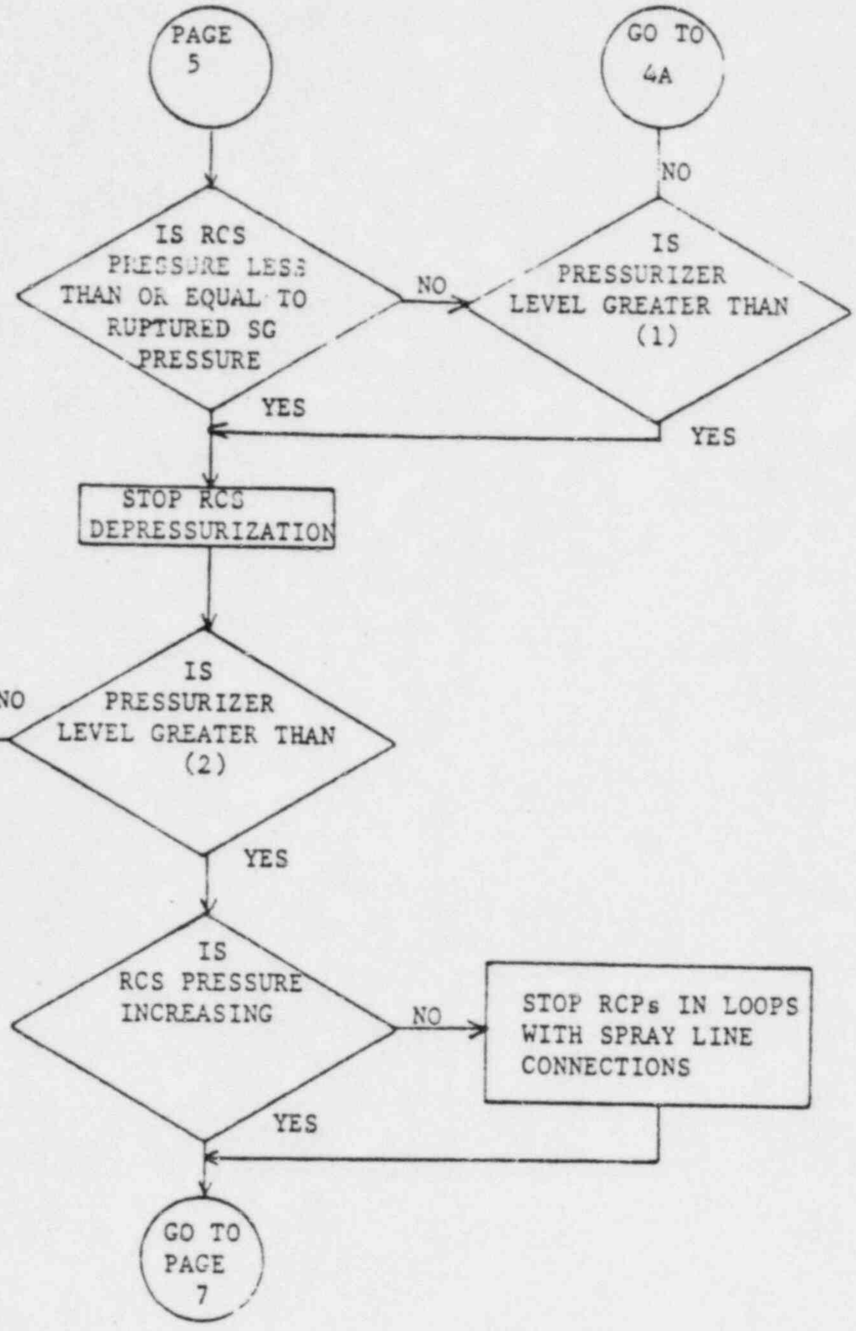


(1) ENTER PLANT SPECIFIC VALUE CORRESPONDING TO MAXIMUM TECH SPEC ACCUMULATOR NITROGEN PRESSURE PLUS 100 PSI.

(2) ENTER PLANT SPECIFIC VALUE SHOWING NARROW RANGE LEVEL JUST ON SCALE INCLUDING ALLOWANCE FOR NORMAL CHANNEL ACCURACY.

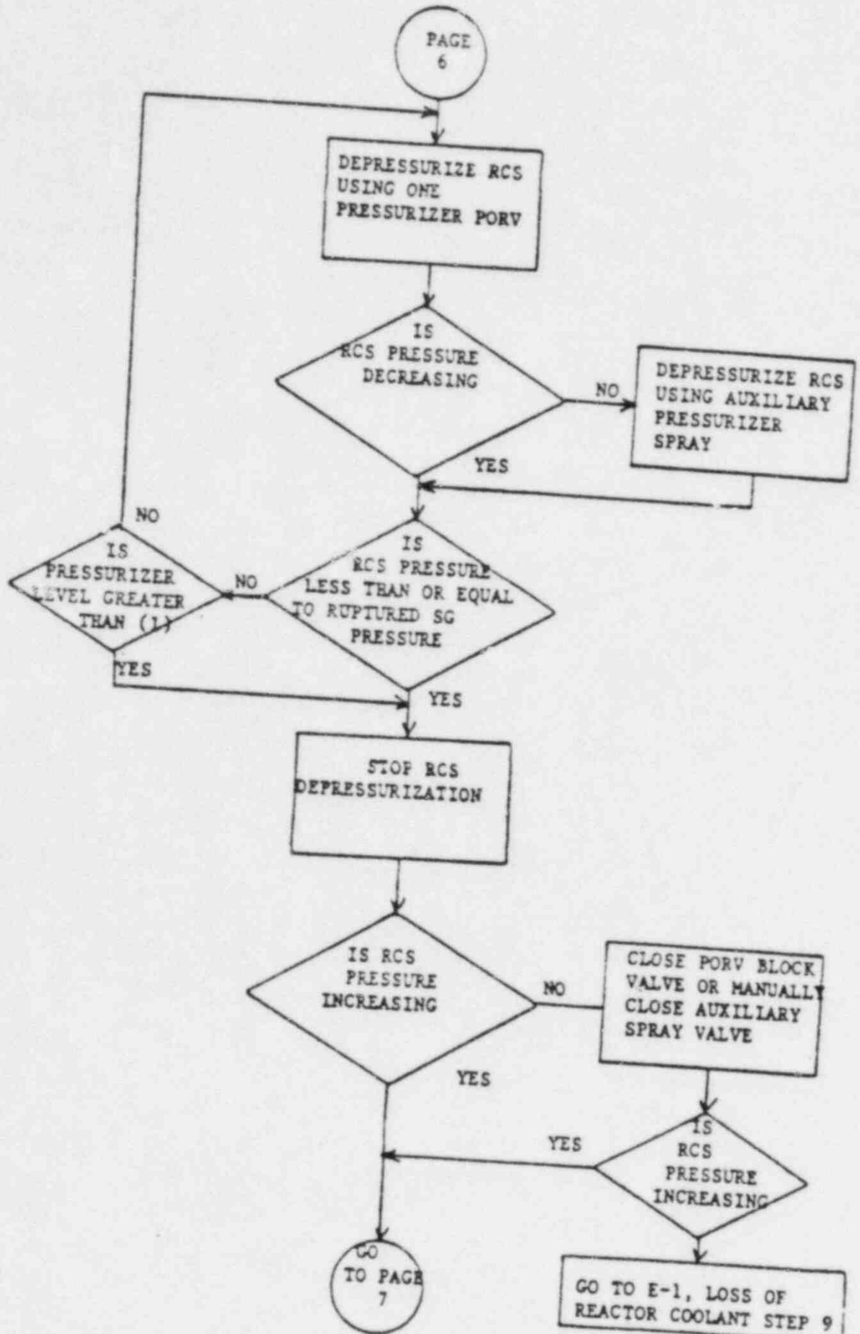
(3) ENTER PLANT SPECIFIC VALUE CORRESPONDING TO PROGRAMMED NO-LOAD NARROW RANGE LEVEL INCLUDING ALLOWANCE FOR NORMAL CHANNEL ACCURACY.


PAGE 4
IS CONDENSER AVAILABLE
NO
YES
RAPIDLY DUMP STEAM FROM NON-RUPTURED SGs USING PORVs
RAPIDLY DUMP STEAM FROM NON-RUPTURED SGs TO CONDENSER
ARE NON-RUPTURED SGs 50°F BELOW RUPTURED SG(s)
NO
YES
IS RUPTURED SG PRESSURE STABLE
GO TO ES-3.3 "SGTR WITH SECONDARY DEPRESSURIZATION", STEP 11
IS RCS PRESSURE AT LEAST 200 PSI GREATER THAN RUPTURED SG PRESSURE
GO TO ECA-3 "SGTR CONTINGENCIES"
YES
4A
IS NORMAL PRESSURIZER SPRAY AVAILABLE
NO
GO TO PAGE 6
DEPRESSURIZE RCS USING NORMAL PRESSURIZER SPRAY
GO TO PAGE

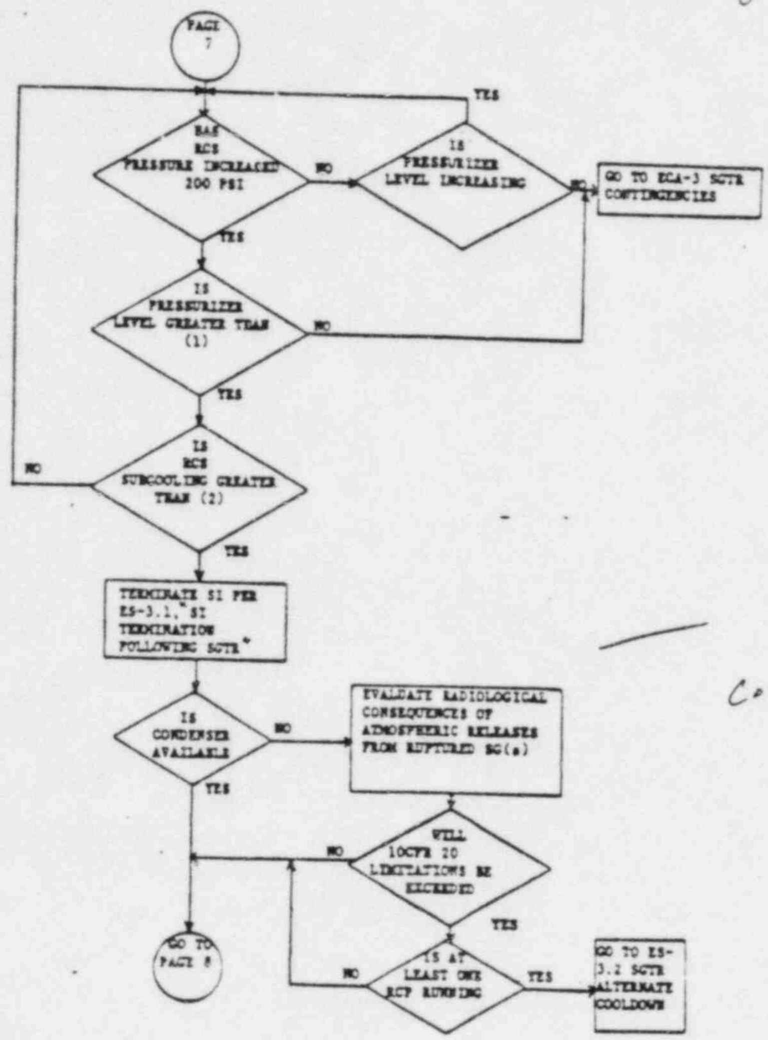


(1) ENTER PLANT SPECIFIC VALUE CORRESPONDING TO HIGH PRESSURIZER WATER LEVEL REACTOR TRIP SETPOINT.

(2) ENTER PLANT SPECIFIC VALUE SHOWING LEVEL JUST ON SPAN INCLUDING ALLOWANCES FOR NORMAL CHANNEL ACCURACY.



(1) ENTER PLANT SPECIFIC VALUE CORRESPONDING TO HIGH PRESSURIZER WATER LEVEL REACTOR TRIP SETPOINT.

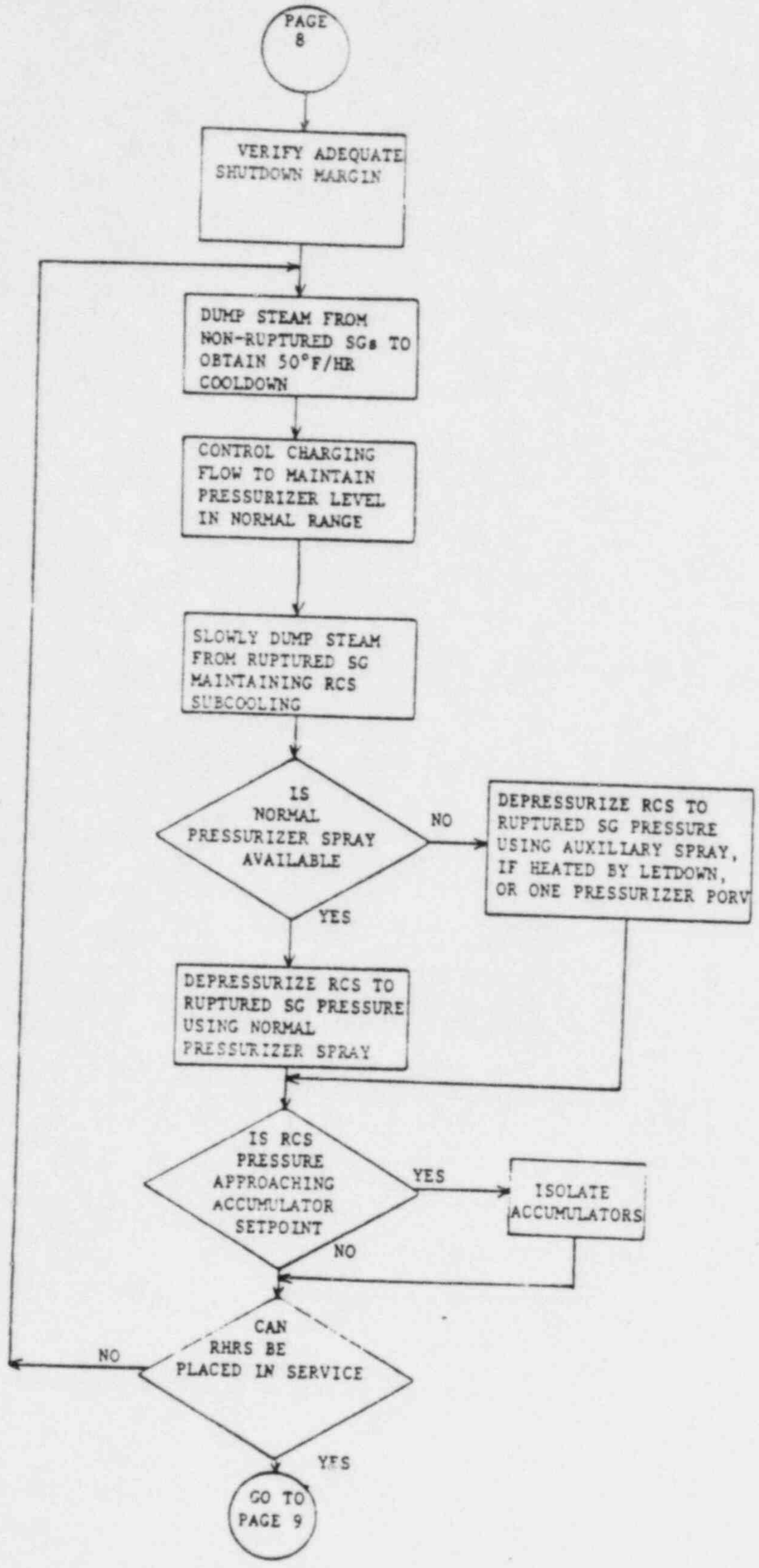


SI Termination check

Cooldown

(1) ENTER PLANT SPECIFIC VALVE SHOWING LEVEL JUST ON SPAN INCLUDING ALLOWANCE FOR NORMAL CHANNEL ACCURACY.

(2) ENTER SUM OF TEMPERATURE AND PRESSURE MEASUREMENT SYSTEM ERRORS TRANSLATED INTO TEMPERATURE USING SATURATION TABLES.


PAGE 8
VERIFY ADEQUATE SHUTDOWN MARGIN
DUMP STEAM FROM NON-RUPTURED SGs TO OBTAIN 50°F/HR COOLDOWN
CONTROL CHARGING FLOW TO MAINTAIN PRESSURIZER LEVEL IN NORMAL RANGE
SLOWLY DUMP STEAM FROM RUPTURED SG MAINTAINING RCS SUBCOOLING
IS NORMAL PRESSURIZER SPRAY AVAILABLE
NO
DEPRESSURIZE RCS TO RUPTURED SG PRESSURE USING AUXILIARY SPRAY, IF HEATED BY LETDOWN, OR ONE PRESSURIZER PORV
YES
DEPRESSURIZE RCS TO RUPTURED SG PRESSURE USING NORMAL PRESSURIZER SPRAY
IS RCS PRESSURE APPROACHING ACCUMULATOR SETPOINT
YES
ISOLATE ACCUMULATORS
NO
CAN RHRS BE PLACED IN SERVICE
NO
YES
GO TO PAGE 9