ATTACHMENT D

# EVALUATION OF REACTOR COOLANT PUMP RESTART REQUIREMENTS FOLLOWING A STEAM GENERATOR TUBE FAILURE AT THE R. E. GINNA NUCLEAR POWER PLANT

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# EVALUATION OF REACTOR COOLANT PUMP RESTART REQUIREMENTS FOLLOWING A STEAM GENERATOR TUBE FAILURE OF THE R. E. GINNA NUCLEAR POWER PLANT

An evaluation of the reactor coolant pump restart criteria following a steam generator tube rupture event has been performed for the R.E. Ginna nuclear power plant to assess the potential for coolant flashing and loss of pressurizer pressure control during pump startup. Depressurization of the reactor coolant system during a tube rupture accident may generate a steam bubble in the upper head region of the reactor vessel if no reactor coolant pump is operating. This bubble could rapidly condense during pump startup, drawing liquid from the pressurizer and reducing reactor coolant subcooling. If pressurizer inventory is not sufficient, level may decrease offspan. No direct indication of coolant inventory would exist if this occurred and pressurizer heaters would be unavailable for pressure control. In addition, local flashing of reactor coolant could result in erratic system response. These conditions would make plant control more difficult and may confuse the operator during an accident if such behavior was unexpected.

The reactor coolant system pressure response to the collapse of an upper head void was calculated by modelling the pressurizer as a single, stratified node with thermodynamic equilibrium between phases to determine pressurizer inventory and reactor coolant temperature requirements. Water was assumed to be displaced from the pressurizer to accommodate an instantaneous collapse of a steam bubble occupying the entire upper head (305 $ft^3$). Figure 1 presents the minimum indicated pressurizer level required before starting an RCP to assure that an indicated level remains after pump restart. The level necessary to maintain pressurizer heaters operational is also shown in Figure 1. Calibration effects on the level indication are included in these results. As demonstrated, pressurizer level would remain on span for all primary pressures following RCP restart with an indicated level greater than 86

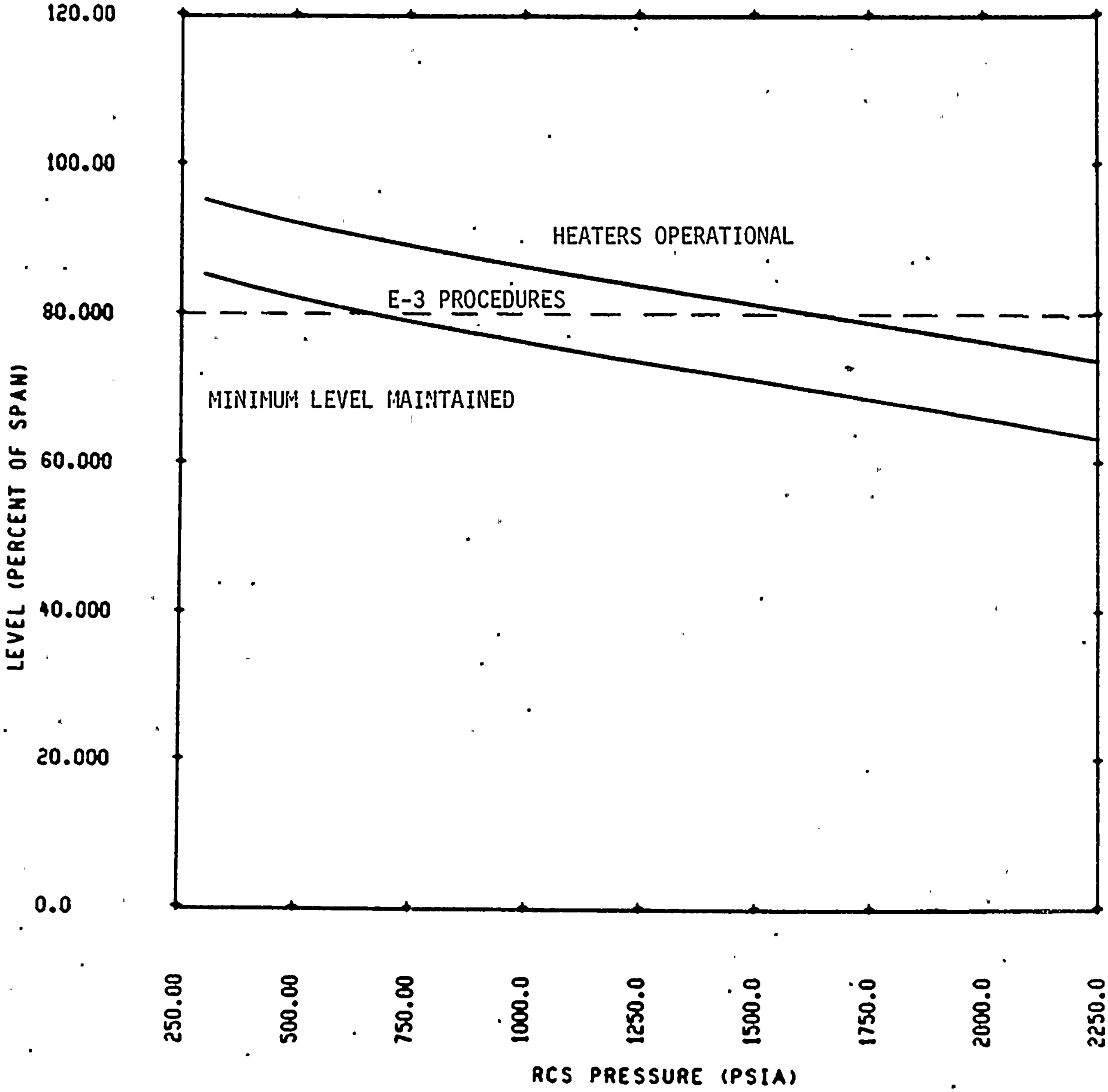



FIGURE 1. MINIMUM INDICATED PRESSURIZER LEVEL FOR RCP RESTART AT GINNA.

percent. An initial level greater than 95 percent would be required to ensure that the pressurizer heaters would remain available.

Emergency operating procedures for Ginna estabish a minimum level of 80 percent before restarting a RCP. Figure 2 shows the minimum indicated level after reactor coolant pump restart with an initial level of 80 percent. This criteria assures that an indicated level will be maintained for initial primary pressures greater than 620 psia. During recovery from a steam generator tube rupture event, RCP restart is permitted after primary and faulted steam generator pressures have been equilibrated. This equilibrium pressure is expected to be between no load steam generator pressure (960 psia) and the steam generator safety valve pressure (1100 psia). For these conditions, pressurizer level would be maintained following RCP restart with the Ginna criteria. However, for large voids (> 240 $ft^3$) pressurizer heaters may not remain available. In that case, charging flow would be increased in an effort to restore level above the minimum value necessary for heater operation. Safety injection reinitiation criteria within the emergency operating procedures direct the operator to start safety injection pumps, if necessary, to supplement the normal makeup system.

The minimum reactor coolant subcooling requirement, consistent with an initial pressurizer level of 80 percent, is presented in Figure 3. These results show that primary pressure will remain above saturation for an indicated subcooling greater than 55°F. For reactor coolant system pressures less than 1100 psia, the required subcooling is less than 49°F. These results include normal instrument uncertainties. Emergency procedures following a steam generator tube rupture are designed to establish and maintain a minimum of 50°F subcooling. Hence, the primary system would remain subcooled following RCP restart with the Ginna criteria.

In addition to the pressurizer inventory requirement, normal RCP prestart limits are enforced to prevent potential pump damage.

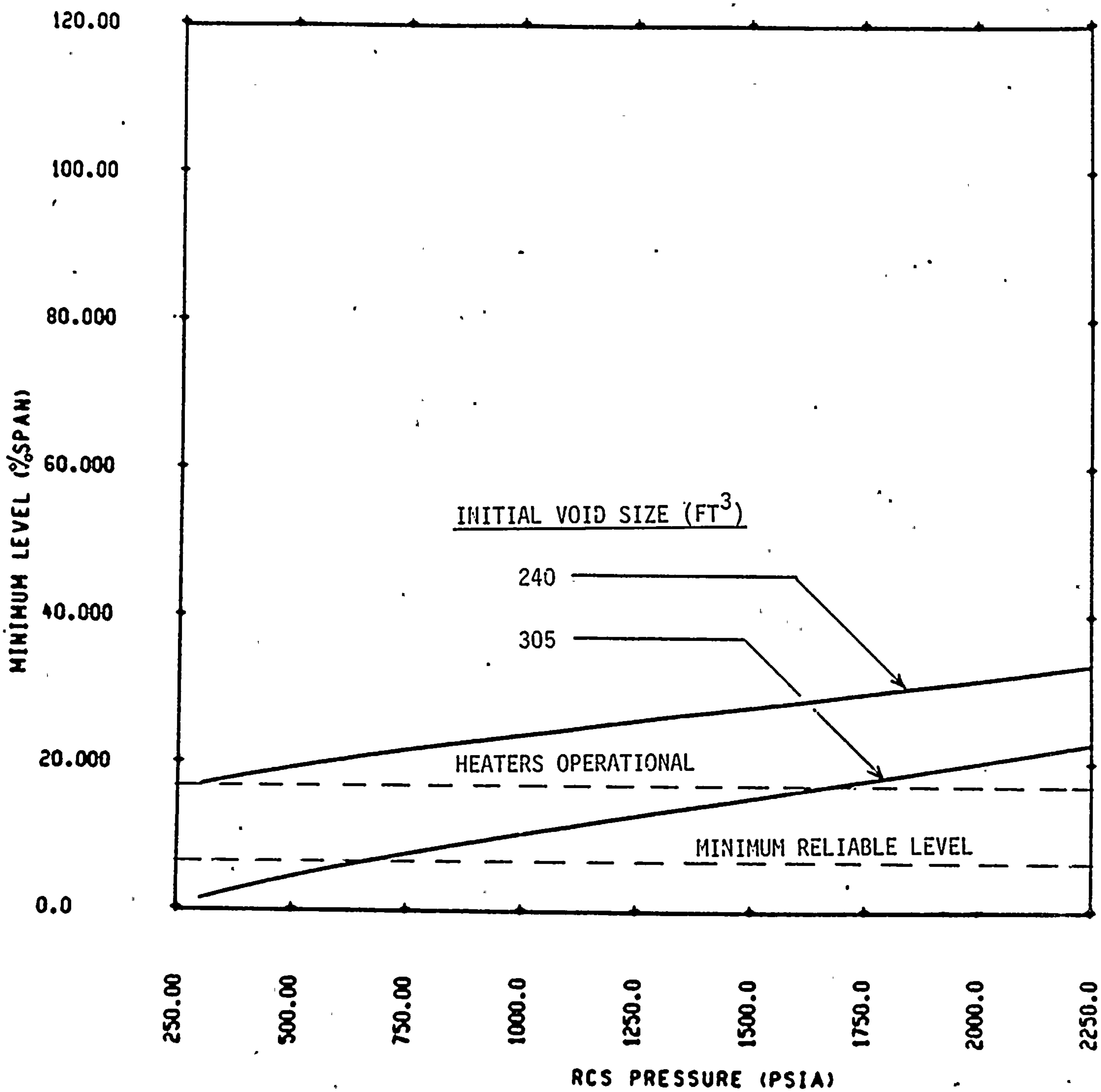



FIGURE 2. MINIMUM INDICATED PRESSURIZER LEVEL FOLLOWING RCP RESTART AT GINNA.

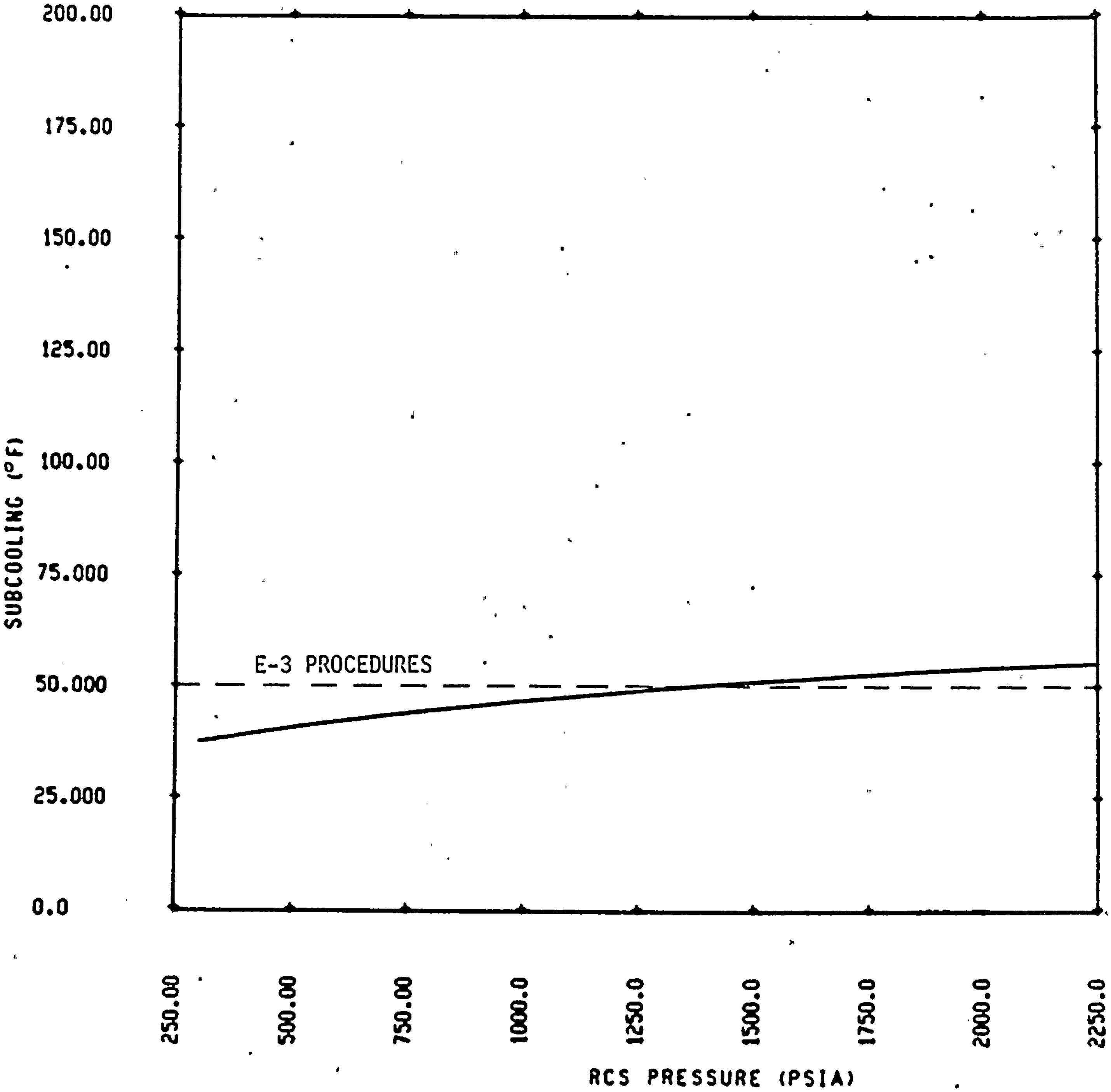



FIGURE 3. MINIMUM REACTOR COOLANT SUBCOOLING FOR RCP RESTART AT GINNA.

The Ginna reactor coolant pump restart criteria are sufficient within the context of the steam generator tube rupture emergency operating procedures to ensure that an indicated pressurizer level and reactor coolant subcooling would be maintained. In some cases, the level may dcrease below the minimum value for operation of the pressurizer heaters. However, in such instances, sufficient guidance on the operation of normal charging and safety injection pumps is provided to restore level. A caution is recommended preceeding reactor coolant pump restart which alerts the operator to the expected pressurizer pressure and level response if an upper head steam bubble exists. Additional instructions should also be provided to assure that water in the pressurizer is saturated to minimize the potential decrease in primary system pressure. These criteria address operational problems which may develop following reactor coolant pump restart during recovery from a steam generator tube rupture event. They may not be appropriate for other accidents or multiple failure events where safety concerns exist, such as during a tube rupture event with a failed open safety valve.

Attachment E
Loose Parts Monitoring System

The loose parts monitoring system provides the operator with continuous data concerning the possible presence of a loose part in the coolant system of Steam Generator 1A and 1B.

The microprocessor based metal impact monitor provides continuous, readily understandable data to the operator about the amplitude and frequency of impacts potentially caused by loose metallic objects striking the interior surface of Steam Generator 1A and Steam Generator 1B. The system detects the acoustic waves generated when a steam generator is struck by metallic debris within the primary or secondary coolant. Such debris may be introduced into the coolant during plant construction, maintenance, or refueling, and may, when carried or agitated by the coolant, attain sufficient velocity to strike and eventually damage steam generator components.

The system employs multiple microprocessors, with one device processing each active transducer signal, and a separate central processor unit (CPU) providing data collection and presentation services. An alphanumeric flat panel display and event printer are provided to present system operating parameters and the results of automated data analysis. On-line data reduction assists the operator in making judgements as to the significance of the impacts, and in determining the proper course of action.

The event recorder (printer) functions under control of the CPU to provide a hard copy record of the functioning of the system. An operator can request a printout of events that occurred that day or that resulted in alarms. At the end of each day, the CPU automatically commands a printout which summarizes the day's activity. The summary lists all detected impacts and their intensity and duration. A self test is performed of the system under CPU control at this time and the results of the self test are also recorded by the printer.

A tape recorder output and audio output are available to monitor all sensor channels. The alarm output interfaces with the plant computer which alarms in the control room.

The system sensitivity is such that impacts caused by objects which strike the interior surface of the coolant boundary within three feet of a sensor, and with a kinetic energy of 0.5 ft-lb or greater, can be detected. Signal processing algorithms discriminate between most background noise and actual impacts. Metal impacts caused by hydraulic and mechanical equipment, and electrical noise, increase significantly during plant startup and shutdown conditions, therefore, the number of signals capable of causing false loose part impact indications is high at these times.

The sensor locations on each Steam Generator are illustrated on the attached figures and listed below:

a. Sensor no. 1 is located 90° from the tubelane on the tubesheet centerline on the hot leg side of the generator.

b. Sensor no. 2 is located on the channel head at the divider plate approximately 24 inches above the support pad bearing surface.

c. Sensor no. 3 is located on the tubesheet centerline directly above sensor no. 2.

d. Sensor no. 4 is located on a vertical line above sensors 2 and 3 and the same distance from no. 3 as it is from no. 2.

Information which is accumulated and recorded on a daily basis and, available to the plant operator concerning impacts that have been detected includes the following:

a. Sensor location and channel number.

b. Time of the first and most recent impacts.

c. The channel alarm setpoint (expressed as an acceleration of the coolant vessel in units of g, the acceleration due to gravity), and the number of impacts with amplitudes greater than that setpoint.

d. The number of impacts with amplitudes less than the alarm setpoints.

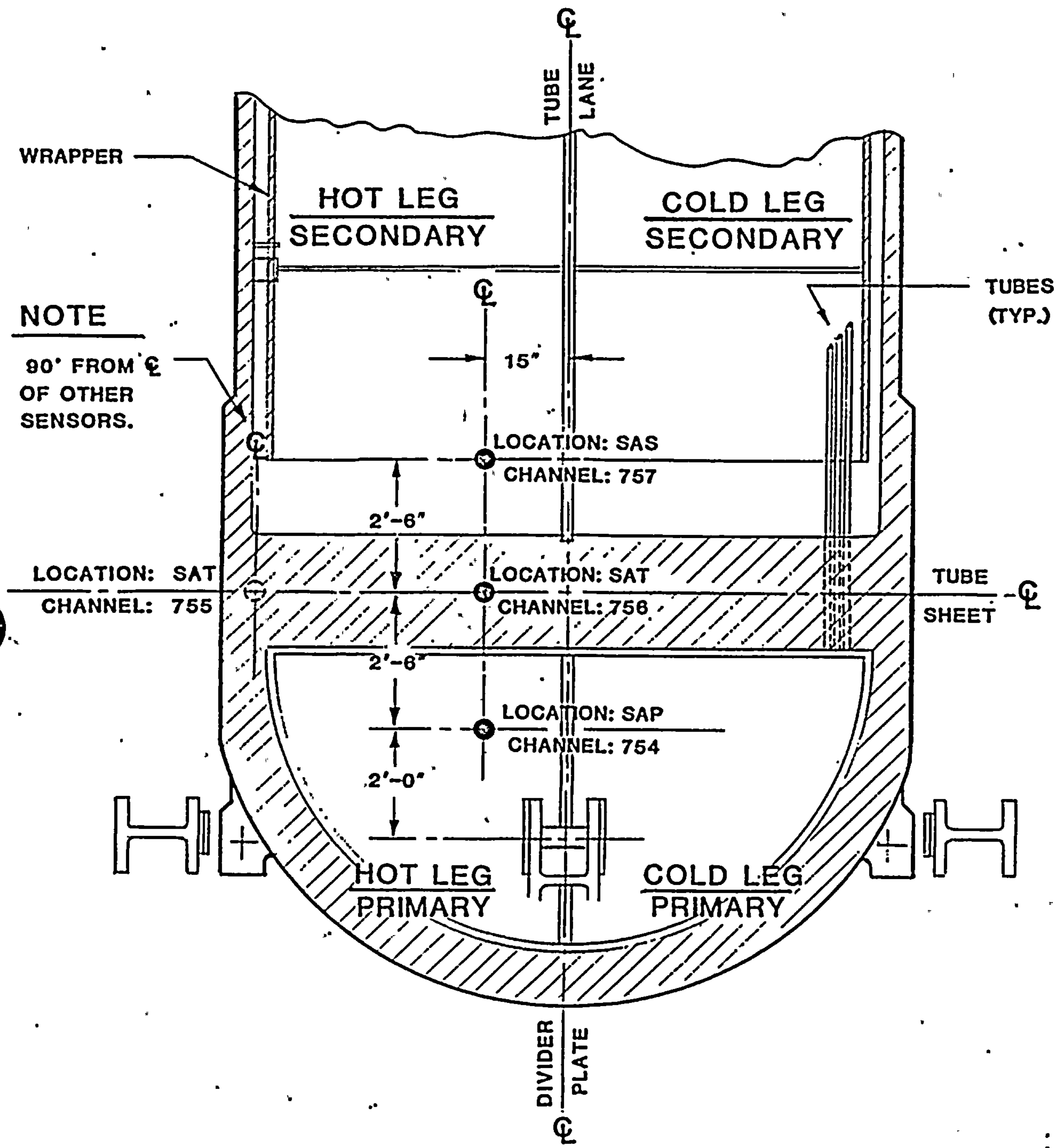
e. The maximum and average impact amplitudes (measured in g), and the implitude of the most recent impact.

f. The maximum and average impact rates (measured in impacts per minute).

g. The number of one minute periods during which impacts have been detected. This figure provides an indication of whether impacts are occurring continuously or intermittently.

h. The number of impacts detected at each location which are known from the time of arrival sequence to have occurred elsewhere in the primary piping.

# STEAM GENERATOR 1A



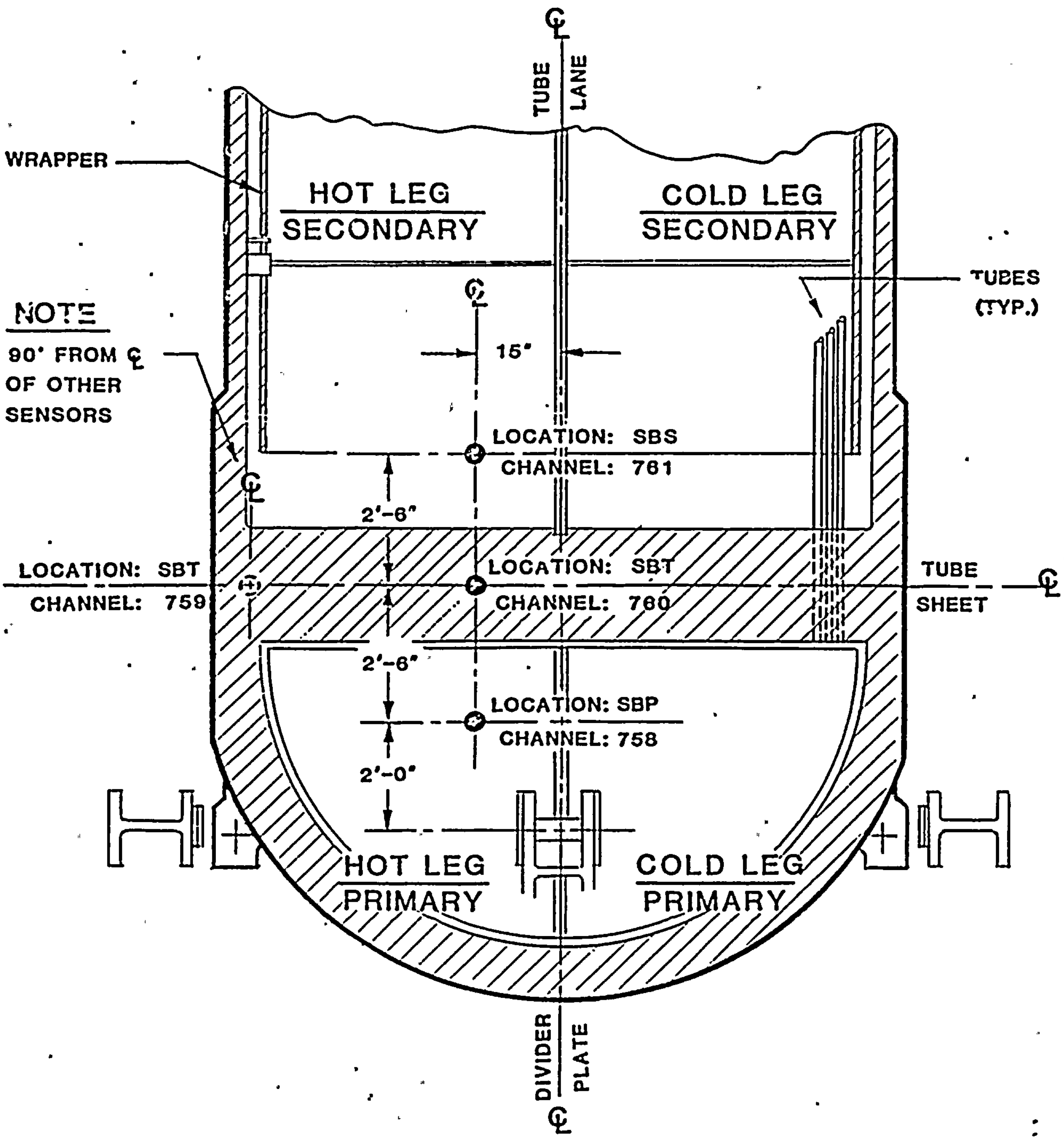

## DIGITAL METAL IMPACT MONITORING SYSTEM

# ACCELEROMETER LOCATIONS

ROCHESTER GAS AND ELECTRIC CORP.

R. E. GINNA STATION - 5/24/82

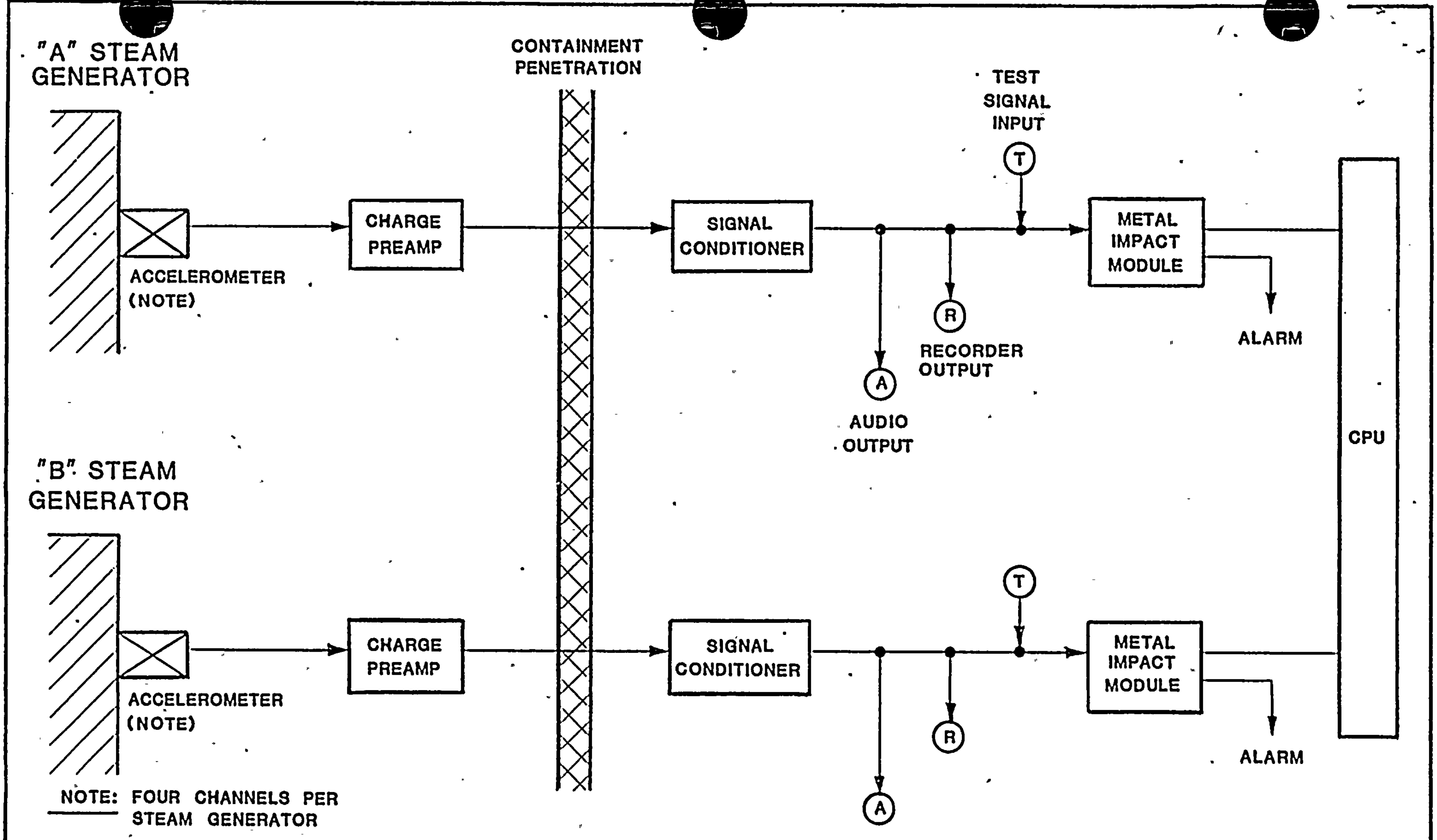
# STEAM GENERATOR 1B




DIGITAL METAL IMPACT MONITORING SYSTEM

## ACCELEROMETER LOCATIONS

ROCHESTER GAS AND ELECTRIC CORP.
R. E. GINNA STATION - 5/24/82




DIGITAL METAL IMPACT MONITORING SYSTEM

# ELECTRICAL ONE LINE

ROCHESTER GAS AND ELECTRIC CORP.

R. E. GINNA STATION - 5/24/82

ATTACHMENT F

# EVALUATION OF POTENTIAL STAGNATION TRANSIENTS AND SCENARIOS FOR THE R. E. GINNA NUCLEAR POWER PLANT

NOVEMBER, 1982

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# EVALUATION OF POTENTIAL STAGNATION TRANSIENTS AND SCENARIOS FOR THE R. E. GINNA NUCLEAR POWER PLANT

In the case where all reactor coolant pumps are tripped, natural circulation flow will develop in the RCS if at least one steam generator is available in order to transfer decay heat out of the core. Natural circulation flow is driven through each loop by the thermal head resulting from the density difference between the hot and cold sides of the RCS. Mechanisms which significantly alter the necessary temperature distribution or pressure drops through a loop have the potential to impede flow in one or both loops. A summary of the potential ways by which natural circulation flow may be stopped leading to the possibility of relatively stagnant loop conditions is provided in the following discussion.

## I. INADEQUATE CORE HEAT GENERATION (low decay heat)

At very low decay heat fractions (less than 0.5 percent of full power) the capability to maintain natural circulation flow may be more difficult. Since decay heat generation is the heat source which drives flow to the steam generators, very low decay heat levels will decrease the magnitude of the flow rates through the loops. In addition, the susceptability of the system to some of the mechanisms to follow will be increased under low decay heat conditions.

## II. LOSS OF RCS INVENTORY

A loss-of-coolant accident of a large enough size (greater than approximately 1-2 inches in equivalent diameter) may result in a draining of the RCS such that subcooled or two phase natural circulation may give way to reflux cooling or pool boiling in the core. In this case the primary concern is to continue safety injection operation to replace RCS mass losses and prevent or miminize the possibility of core uncovery.

For breaks smaller than approximately 1-2 inchs in diameter natural circulation flow will continue as long as secondary inventory is maintained.

## III. INADEQUATE SYMMETRIC HEAT REMOVAL

The failure of all auxiliary feed pumps after a plant trip and the inability to establish an alternate feed source using either main feed or condensate pumps will lead eventually to steam generator dry-out. At that time the RCS will undergo a heat-up and the inability to transfer a significant amount of heat to the steam left in the secondary will lead to a reduction in natural circulation flow.

The major concern in this situation is to establish an alternate heat removal method in order to prevent core uncovery. The recommended mode is to use "bleed and feed" where at least two pressurizer PORVs are opened and safety injection is initiated. This mode, if initiated in a timely manner, can prevent core uncovery and maintain core cooling for a long period. Relatively stagnant conditions may be present in the cold legs, however, but the primary concern is to prevent core uncovery and possible fuel damage while continuing steps to re-establish a secondary heat sink to complete plant recovery.

## IV. NON-SYMETRIC HEAT REMOVAL

### A. Steaming Imbalance

A large steaming imbalance that results in an overcooling of one steam generator in relation to the other steam generator may cause a cessation of natural circulation in the loop that is not adequately cooled. As the secondary steam temperature becomes equal to or greater than the core exit temperature the flow will decrease significantly or stop due to the loss of the flow driving temperature difference through that loop. There are three basic scenarios that could lead to this situation.

1. A steam break will result in an uncontrolled steam release from one steam generator and could result in an RCS cooldown large enough that the other steam generator would not be able to remove heat. In that case, flow might stop in the intact loop until the faulted steam generator is isolated and heat removal capability re-established in the intact generator. Analysis of small steam breaks has shown this to be a concern only for low decay heat conditions.

2. During a steam generator tube rupture event recovery, the ruptured steam generator will be isolated by the closing of its MSIV and the termination of auxiliary feed to it. A rapid cooldown using only the intact generator is then performed to lead to a depressurization of the RCS, termination of safety injection and the equilibration of RCS and ruptured steam generator pressure to stop primary to secondary leakage. The action to cooldown with the ruptured generator isolated may result in loss of natural circulation flow through that loop. However, in order to terminate primary to secondary leakage in an expeditious manner it is necessary that this action be taken. It is recognized that a relatively stagnant loop may result and that a subsequent SI termination under the proper conditions is important not only to minimize leakage, but also to minimize the possibility of thermal shock.

3. Any situation which results in a significant cooldown in one steam generator versus the other can lead to loss of natural circulation flow in one loop. For example, unavailability of equipment or manual operator action that does not cool down both steam generators together may result in a problem if the difference is significant. In particular, it is necessary that the steam temperature in a generator be equal to or greater than the average core outlet temperature to approach stagnation in a loop. Background information to the emergency guidelines recommends checking the trends of hot and cold leg temperature and core outlet temperature to verify the establishment of natural circulation throughout the RCS.

B. Feed Imbalance

A feed imbalance itself should not lead to a loss of natural circulation flow through a loop. However, an imbalance which results in the uncovery of the tubes may cause a loss of flow through that loop. There are three situations in which this may occur.

1. A feedline break will remove the ability to provide feedwater flow to the faulted steam generator and also may result in a significant loss of inventory if the break is not isolable.

2. During recovery from a steam break the auxiliary feedwater is isolated from the faulted generator to prevent RCS overcooling. If unisolable, the steam break will eventually lead to steam generator dry-out and loss of adequate heat removal for natural circulation flow through the faulted loop.

3. A significant feed imbalance due to operator action or equipment unavailability that leads to a significant uncovery of the steam generator tubes can lead to loss of circulation in a loop. The emergency procedures specify a minimum non-faulted steam generator level to be just in the narrow range span including uncertainties. This level will assure the tubes are covered and that natural circulation flow capability will be maintained.

# SUMMARY OF MECHANISMS TO DRAW COLD WATER INTO VESSEL

After a period of flow stagnation long enough to build up a quantity of relatively cold water in the cold leg or crossover leg, there are several actions which may draw the water into the vessel downcomer.

1. Starting an RCP in a loop that has been relatively stagnant will result in the moving of the contents of that loop into the downcomer. Starting an RCP in another loop will cause reverse flow to occur in the inactive loop and, therefore, will not draw the water into the vessel. The impact of any cold water flow into the downcomer will be minimal due to the short duration of this cold flow.

2. The opening of a pressurizer PORV to depressurize the RCS can result in a flow into the downcomer if the PORV is on the loop other than the stagnant loop. Without SI on any cold flow would be of short duration and have minimal impact. With SI on the cold flow would be continuous, however, the opening of PORVs directed by procedures is only necessary for a short period until depressurization to the necessary level is completed.

3. With a stagnant loop a subsequent break in the system either in the hot leg or upper head region could result in a drawing of cold SI water into the vessel downcomer. In this situation the highest priority is to maintain RCS inventory to assure adequate core cooling.