ROCHESTER GAS AND ELECTRIC CORPORATION • 89 EAST AVENUE, ROCHESTER, N.Y. 14649-0001

July 7, 1988

U.S. Nuclear Regulatory Commission
Document Control Desk
Attn: Mr. Carl Stahle
PWR Project Directorate No. 1
Washington, D.C. 20555

Subject: Response to NRC Bulletin 88-04
Potential Safety-Related Pump Loss
R.E. Ginna Nuclear Power Plant
Docket No. 50-244

Dear Mr. Stahle:

The subject Bulletin requested licensees to determine whether conditions may exist which could potentially cause safety-related pump damage due to parallel operation. Damage would be the result of overheating caused by the pump operating deadheaded. The Bulletin also requested an evaluation of the adequacy of the minimum recirculation flow during operation, testing, and accident conditions considering the largest time spent in these modes and the cumulative effects on the pump over the lifetime of the plant. RG&E was initially notified of these concerns by Westinghouse Electric Corporation, which was followed by NRC Information Notice 87-59.

RESIDUAL HEAT REMOVAL AND SAFETY INJECTION SYSTEMS

The results of our evaluations performed and tests run subsequent to these notifications have indicated that the residual heat removal (RHR) pumps, which also serve as the low head safety injection pumps, would be susceptible to the condition described in the Bulletin for three reasons:

1) The RHR system utilizes a minimum flow bypass line which is common to both pumps.

2) The miniflow piping is configured such that an interaction between the two pumps is not precluded during parallel operation.

3) The RHR pump design is characterized by a head-capacity curve which has a relatively flat shape at low flows.

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The three high head safety injection (SI) pumps are each provided with a minimum flow recirculation line which is located upstream of each discharge line check valve. Therefore, each SI pump will receive a minimum flow independent of the other pumps and are not susceptible to the parallel operation concern described in the subject Bulletin. The existing minimum flow (designed for 30 gpm) was based on short term operation and limiting the temperature rise of the pump internal fluid. This system has been re-evaluated as set forth in Attachment A.

Based upon our review of periodic and special test data, and the pump designs and operational modes, we have concluded that the sizing of the minimum flow bypass lines for both the RHR and SI pumps could be considered adequate to provide pump protection for short term operation in the minimum flow mode, for which these lines were intended. However, the parallel operation concern for the RHR pumps necessitated corrective action which was taken on an interim basis by procedural steps and will be taken for the longer term by a plant modification. The safety injection system recirculation system is also undergoing a redesign for a planned plant modification for the purpose of de-sensitizing the safety injection pumps to the potential for long term wear degradation caused by monthly periodic tests in the low flow mode. This planned modification is being combined with a previous modification commitment made in response to IE Bulletin 86-03, Potential Failure of Multiple ECCS Pumps Due to Single Failure of Air Operated Valve in Minimum Flow Recirculation Line, submitted in our letter dated January 8, 1987.

Hardware modifications for both RHR and SI systems are planned during our 1989 annual maintenance and refueling outage. For the RHR system, a redesign is underway which will provide each RHR pump with a minimum flow recirculation line which is independent of the opposite train. The line is being sized to provide sufficient recirculation flow when the pump discharge path is isolated. In the interim, procedures have been modified which require securing one RHR pump if two pumps are operating with a combined flow less than 1200 gpm. This flow was determined as a conservative value above which sufficient flow would be guaranteed through the weaker pump when the pumps operate in parallel. For the SI system, the planned modification will require additional larger diameter recirculation piping with a pressure breakdown orifice in each separate line, sized to allow 100 gpm or about 25% of best efficiency point (BEP) of flow. Each of these designs had the objective of providing sufficient recirculation flow consistent with pump manufacturer recommendations without reduction in the injected flow delivery during accident conditions used in the safety analysis report.

An evaluation of the SI and RHR recirculation redesigns and justification for continued operation is set forth in Attachments A and B.

AUXILIARY FEEDWATER SYSTEMS

The auxiliary feedwater pumps have also been evaluated relative to the Bulletin 88-04 concerns. The Ginna Station main auxiliary feedwater system consists of two 100% capacity motor driven pumps and one 200% capacity turbine driven pump. Two additional standby auxiliary feedwater pumps, each 100% capacity, are also installed in a separate building as a backup to the main auxiliary feedwater pumps. Each of these pumps is provided with an automatically controlled minimum flow recirculation system sized and periodically tested to ensure that sufficient minimum flow will be provided under all accident and normal operating conditions. It has been determined that the minimum flow concerns raised in Bulletin 88-04 have been adequately addressed in the design and testing of these systems at Ginna. An evaluation of the recirculation systems for these pumps is set forth in Attachment C.

There are no other safety-related pumps which are susceptible to the Bulletin 88-04 concerns.

As required by paragraph 5 of the subject bulletin, a written response describing the actions taken will be provided within 30 days following completion of the planned plant modifications described in Attachments A and B.

As required by paragraph 6 of the subject bulletin, this response to the bulletin and our evaluations set forth in Attachments A through C will be maintained at Ginna Station for a minimum of two years.

Very truly yours,

Robert E Smith V.P.
for
Bruce A. Snow
Superintendent
Nuclear Production

Subscribed and sworn to before me
this 7th day of July, 1988.

Lynn I. Hauck
Notary Public

LYNN I. HAUCK
Notary Public in the State of New York
MONROE COUNTY
Commission Expires Nov. 30, 19 88

Attachments

xc: U.S. Nuclear Regulatory Commission
Region I
475 Allendale Road
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xc: Ginna Senior Resident Inspector

ATTACHMENT A

Evaluation of Safety Injection Recirculation System and Justification for Continued Operation

Reference (a): Letter #RGE-87-670 from S.P. Swigert (Westinghouse) to S.M. Spector (RG&E), dated December 8, 1987

Reference (b): Aging and Service Wear of Auxiliary Feedwater Pumps for PWR Nuclear Power Plants, Volume 1, Operating Experience and Failure Identification, NUREG/CR-4597-V1 dated July 1986

NRC Bulletin 88-04 requested an evaluation of two conditions which, if existing, could result in damage or failure of safety-related pumps. First, the concern exists that when two pumps are operated in parallel, the weaker pump may be deadheaded by the stronger pump when the pumps are operating in the minimum flow mode. Second, the concern exists that the amount of minimum flow may not be adequate to preclude pump damage or failure if even a single pump is operating. Should either of these conditions exist, the planned short term and long term modifications are to be identified as well as the justification for continued operation. R.E. Ginna utilizes a two-loop Westinghouse designed reactor coolant system and has three high head safety injection pumps.

The existing safety injection system is depicted on Figure 6.3-1 of the UFSAR. A line diagram depicting the present SI recirculation system is also shown on Figure A-1 of this attachment. Each safety injection pump is provided with a 3/4-inch line containing a pressure breakdown orifice, a check valve and a locked open manual valve. The discharge lines from the "A" pump and "B" pump have train separation, leading to the RCS loop "B" and loop "A" cold legs, respectively. The "C" pump is a swing pump that ensures delivery to both trains will exist in the event that either the "A" or "B" pump fails to start. When all three pumps are operating, the flow from the "C" pump is directed to both trains. The 3/4-inch lines from the three pumps join and form a 1-inch line which eventually leads back to the RWST. However, as noted in Westinghouse letter, Reference (a), the placement of the orifice upstream of this junction reduces the pressure low enough so that a weaker pump will not be prevented from delivering its minimum flow. The orifice in the individual recirculation line essentially desensitizes the system to strong/weak pump miniflow concerns. Since the 3/4-inch recirculation lines are located upstream of the pump's discharge check valves, and the fact that an orifice is located in each miniflow line, the operating pressure of a stronger pump running in parallel does not have the potential to prevent recirculation flow through this line, and deadhead the other pump.

As shown on UFSAR Figure 15.6-12, during the injection phase SI flow will be pumped into the RCS cold legs when pressure drops below 1400 psia. Of the break sizes required to be analyzed in section 15.6 of the UFSAR, only a break size below 4-inch diameter would result in the RCS remaining above 1400 psia for any appreciable time. The 4-inch break transient was the smallest size analyzed and resulted in the RCS pressure falling to 1400 psia in approximately 20 seconds. The elapsed time to generate the safety injection signal, actuate the start sequence and bring the pumps to full speed is on the order of 20 seconds (assuming loss of offsite power). If offsite power remains available, the SI pumps would be brought up to speed in 10 seconds, so that potentially a pump might expect to operate with the designed recirculation capacity for only 10 seconds before the pump discharge pressure would overcome the system pressure. Therefore, for the break sizes analyzed, representing the bounding cases, the pumps would not be expected to operate for an appreciable time in the recirculation mode.

For primary system breaks smaller than 4-inch diameter, secondary side steam breaks, steam generator tube rupture, rod ejection accident, or an inadvertent SI signal, the safety injection pumps may be called upon to operate in the minimum recirculation flow mode for short periods of time. Procedure review and training on the simulator conservatively has shown that the operating time in the recirculation flow mode will not exceed 60 minutes. The designed minimum flow is 30 gpm at shutoff, i.e., when the discharge valve is closed, 30 gpm recirculates continuously through the pump. There are no automatic valves in the individual recirculation lines, so that each line is always open. The safety injection pumps are Worthington Corporation, horizontal, 11 stage, centrifugal pumps driven by Westinghouse 350 hp, 3600 SRPM, A.C. motors. The minimum flow recirculation system for the safety injection pumps was designed to provide pump protection for short term operation and was based on limiting the heat rise of the internal fluid within the pump to acceptable values. Considering the boric acid storage tanks as the source of water for the pumps and the heat tracing applied, the calculated temperature rise is 40°F. This is well within established limits given the operating conditions and the design basis. The allowable temperature rise to saturation conditions is over 100°F. The design of the pump provides for process fluid cooling for the mechanical seals, using separate seal water heat exchangers, using component cooling water and service water jacket cooling for the pump ball thrust bearing. Although the value of 30 gpm (or about 7% of best efficiency point; BEP) would be considered low using current guidelines of minimum flow design, RG&E considers it a conditionally acceptable value based on the following:

1) It provides pump protection for short term operation only

2) Demonstrated performance of these pumps during periodic testing at low flows substantiates acceptability.

Trends in minimum flow design philosophy and, more importantly, developments in the effects of suction recirculation on pump hydraulic performance and impeller wear degradation in the long term, has led pump manufacturers to recommend significantly higher values of recirculation flow. These recommendations are consistent from the perspective that 1) often the specified design operating conditions and duration is not, or cannot, be well defined and, 2) the manufacturers have no control over the users' operation of the pump, yet risk liability by association if the component suffers premature degradation. Consequently, minimum flow recommendations from the manufacturers, unless otherwise noted, apply to continuous long term operation and are on the order of 25% of BEP, depending on pump parameters such as pumped water temperature, rotating speed, single or multi-stage design, horizontal and vertical mounting, wearing ring materials, pump specific speed, brakehorsepower, suction conditions, and others. Operation in the recirculation mode for 24 hours per day or some finite number of hours per month, perhaps on the order of 100 hours per month, has the potential to cause aggravated impeller damage and premature internal wear if ample flow is not provided. Quantifying the operating time to the degree of anticipated wear can only be determined empirically. A report on aging and service wear of auxiliary feedwater pumps, Reference (b), makes reference to the effects of suction recirculation and causes of internal wear. Based on this reasoning, the manufacturer has now recommended a nominal value of 1/3 of BEP (150 gpm) for continuous operation, and stated that operation at lower flows is a function of owner related experience.

While this trend of providing minimum flow recommendations based on long term operation is in the best interest of the owners and suppliers, at the expense of oversizing the pumps and related components, earlier designs, which produced minimum flow consistent with short term operation, can be shown to be adequate.

RG&E's experience with the SI pump performance during periodic testing has been excellent. There have not been any maintenance problems associated with the pumps. Monthly low flow periodic tests are performed at essentially the same conditions as the recirculation mode of operation. Procedure PT-2.1 specifies operation of each pump with flow through a 3/4-inch test line with the flow throttled to 53 gpm (Technical Specification value set in Section 4.5.2.1). This represents the only flow through the pump during the test, because the manual valve in the recirculation line is closed during testing. The value of 53 gpm is not judged to represent a significant increase in flow over the value of 30 gpm, which is the designed flow through the recirculation line.

As a means of substantiating this, a special test was conducted on April 6, 1988. During this test, valve alignments were slightly modified from the standard periodic test procedure in order to operate the "A" pump with a minimum flow of 30 gpm through the test line and compare the pump operation and vibration with that for a flow of 53 gpm as well as a flow in excess of 100 gpm*. A summary of test results is included on page A-5.

Review of this data and periodic test data over the past several years indicates that there is no appreciable difference in pump vibration levels relative to flows from 30 gpm to 100 gpm. The values recorded for each of the 3 pumps are typical of those seen during monthly periodic testing, and are consistent (or lower than) the referenced values established during the initial test program for these pumps. The vibration levels are well within the acceptable range of 0 to 1 mils.

Testing of the safety injection pumps during monthly periodic testing requires low flow operation for periods generally of 30 minutes to 1 hour. The pumps may also be operated at low flows for brief periods to maintain accumulator level or for refilling the accumulators when drained during refueling shutdowns. The total operating time for the 3 pumps combined for the first 18 years of plant operation has been approximately 600 hours. The "C" pump has logged the most number of hours, 280. Therefore, continued plant operation utilizing the present recirculation system does not create a condition which is outside of the original design basis for the system nor does it represent an unacceptable condition in terms of pump protection for the maximum duration that the pumps would be expected to operate in the recirculation mode.

The basis for continued operation is that the minimum recirculation flow piping design with individual lines branched off the pump discharge line upstream of the check valve and an orifice placed in each individual recirculation line prevents a strong/weak pump interaction. Also, the test results conducted for the first 18 years of plant operation demonstrate that pump performance, as reflected by vibration measurements, is not significantly different between 30 gpm and 100 gpm, the latter representing about 25% of BEP.

The remainder of this evaluation is intended to focus on the planned plant modification to provide increased pump recirculation capacity. The basis for this modification is to reduce the potential for pump internal accelerated wear as a result of low flow operation and the required periodic testing. The great majority of pump operating hours have to date occurred during low flow operation. Operation of the pumps during any of the postulated accident conditions will not result in operation in minimum flow mode for more than 1 hour, due to procedural SI termination. By installing new resized recirculation piping presently planned to recirculate 100 gpm when the pump operates at shutoff, a positive long term effect, although unquantified, is expected over the life of the pumps. The modification will provide the capability to perform periodic tests at 150 gpm.

*Existing flowmeter in the test line is 70 gpm full scale. During the testing, the throttle valve was full open and indicated in excess of full scale. Combined with a flow of about 30 gpm through the recirculation line, the flow was determined to be in excess of 100 gpm.

SUMMARY OF TEST RESULTS FOR SPECIAL MINIMUM FLOW TEST CONDUCTED ON "A" SAFETY INJECTION PUMP

"A" SI PUMP FLOW

	30 gpm	53 gpm	>100 gpm	Acceptable Range at 53 gpm	Reference Values at 53 gpm
Developed pressure, psig	1446	1443	1413	1420-1481	1452
Vibration, mils					
IB Vertical	0.057	0.06	0.048	0-1 mils	0.055
IB Horizontal	0.084	0.088	0.082	0-1 mils	0.09
OB Vertical	0.19	0.18	0.17	0-1 mils	0.24
OB Horizontal	0.15	0.14	0.135	0-1 mils	0.11

"B" PUMP @53 GPM

		Acceptable Range at	Reference Values at
Developed pressure, psig	1457	1420-1493	1464
Vibration, mils			
IB Vertical	0.052	0-1 mils	0.065
IB Horizontal	0.096	0-1 mils	0.12
OB Vertical	0.12	0-1 mils	0.21
OB Horizontal	0.11	0-1 mils	0.11

"C" PUMP @53 GPM

		Acceptable Range at	Reference Values at
Developed pressure, psig	1459	1420-1488	1459
Vibration, mils			
IB Vertical	0.081	0-1 mils	0.095
IB Horizontal	0.17	0-1 mils	0.16
OB Vertical	0.088	0-1 mils	0.35
OB Horizontal	0.14	0-1 mils	0.16

IB = Inboard (coupling) end
OB = Outboard

The recirculation rate of 100 gpm represents a value of 25% of BEP. This value was selected based upon four criteria:

1) The value approached the manufacturer's recommendations for long term operation, reducing hydraulic and dynamic forces imposed on the pump. The manufacturer recommended 150 gpm for long term operation, but made no explicit recommendation for shorter term operation since it is dependent upon owner experience. The proposed modification will enable testing at 150 gpm.

2) The value was considered the maximum recirculation flow which will still allow the required SI delivery to the RCS under all accident conditions. The required delivery curve is presented in the UFSAR Figure 15.6-12.

3) The value will reduce the calculated pumped fluid temperature increase through the pump fourfold, i.e., to a 10°F temperature rise.

4) The value will increase the operating life of the pump ball bearings by reducing the bearing loads during periodic testing. The present periodic testing is conducted using a separate test line with the recirculation lines isolated. The test flow is adjusted to 53 gpm and pump performance is monitored in accordance with ASME Section XI Article IWP-3100, with one exception as discussed below.

In order to determine the effect of increased recirculation flow over that of the existing system, 30 gpm per pump, a hydraulic model using the KYPIPE computer code for the ECCS system has been developed.

The pump manufacturer, Worthington Corporation, does not recommend bearing temperature measurements at low flows as a good indication of bearing condition. Vibration readings provide a better indication of their condition. At low flows, bearing temperature measurements are expected to be higher due to increased axial and radial thrust loads in this region. The temperature rise of the pumped fluid is also greater, and this heat is conducted to the bearings through the pump shaft. These factors typically resulted in bearing stabilization time being extended beyond that which would be normally expected for the pump at its rated flow condition. Stabilization under these low flow conditions during previous periodic tests occurred typically after about 1 hour, and sometimes 2 hours. Retests were not uncommon due to temperatures exceeding the 160°F imposed limit, which was, in fact, the manufacturer's recommended limit at the rated condition of 300 gpm.

It has also been shown that bearing stabilization temperature and duration is dependent on other factors, such as ambient air temperature and thrust bearing housing cooling water temperature (service water). This was confirmed during a series of tests performed on each of the 3 pumps during the winter of 1981 and the winter and summer of 1982. Consequently, it is not possible to obtain repeatable, consistent and meaningful results relatable to bearing condition. Obtaining this only marginally useful data was outweighed by the negative impact of subjecting the pump to unnecessarily high loads in the low flow test condition for extended periods of time each month. Overall, this was viewed as having a detrimental effect on bearing life, and ultimately pump serviceability. Consequently, bearing stabilization tests were discontinued in January 1983.

Stabilization temperature was not noticeably changed by test flows between 50 to 80 gpm. The testing performed in 1981 and 1982 did confirm that the bearing temperatures will stabilize in the low flow mode and not reach unacceptable levels considering the design lake temperature of 80°F for summer operation.

The proposed modification will allow a flow during testing in excess of the 150 gpm recommended by the manufacturer for continuous operation by combining the modified recirculation line flow and existing test line flow. Nearly doubling the flow from 80 gpm to 150 gpm will place the pump in an operating region where residual axial thrust can be expected to be reduced. Since the value of 150 gpm represents a flow judged acceptable for long term operation, this condition can be viewed as an improvement to overall bearing life.

The KYPIPE computer code has been verified against actual plant data taken in March 1971 which was performed by Westinghouse to re-evaluate the capability of the safety injection system.

The planned recirculation system will consist of a single recirculation line sized for 100 gpm for each pump with pressure breakdown flow orifice, check valve and manual valve. This configuration was preferred as it represents a passive type system with no active components, and therefore meets the single active failure criteria. It represents a more reliable option than the other active/passive parallel path systems considered which would require control systems with air and/or electrical interfaces. A schematic of the planned system is depicted on Figure A-2.

The criteria used to establish the maximum allowable recirculation flow was the delivery curve shown on Figure 15.6-12 of the UFSAR (attached Figure A-3). The hydraulic model is conservative for the following reasons:

a) The existing pump performance curve was degraded 5 percent to evaluate the ability of the safety injection system to meet the UFSAR SI delivery curve. Periodic test procedure PT-2.1 contains action requirements when the pump performance degrades 3%-4% of the reference pressure.

b) The hydraulic model predicts less SI flow than that which was actually measured during the full flow testing performed in March 1971.

c) The hydraulic model assumed the minimum SI pump suction head for all ranges of SI flow. The minimum suction head is equivalent to the 15% RWST level, the point at which the SI pump suction is transferred to the containment sump via the RHR pumps.

d) The determination of the resultant SI delivery curve, utilizing the modified (100 gpm) recirculation flow, was based upon the highest resistance flow path (pump "C" delivery to loop "A").

The resultant safety injection delivery curve exceeds the requirement shown on Figure 15.6-12 of the UFSAR (attached Figure A-3), utilizing the proposed recirculation design which will allow 100 gpm recirculation flow at shutoff. In order to reduce velocities to acceptable values, each recirculation line will be increased from 3/4-inch to 1-inch, and the recirculation manifold line will increase from 1-inch to 2-inch.

The existing 1-inch manifold line contains 2 air operated valves in series. During the sump recirculation mode, the recirculation manifold line is isolated to preclude radioactive contamination of the RWST. Currently these 2 valves, AOV 897 and AOV 898, are mechanically blocked open to prevent closure on loss of air supply. Closure would block off the miniflow protection for all three SI pumps. They must be manually unblocked and closed prior to the initiation of the sump recirculation phase. As previously reported under RG&E's response to IE Bulletin 86-03, RG&E plans to replace these valves.

The criteria used for the replacement valves is 1) to ensure that no single active failure would prevent the recirculation line from remaining open for pump protection, 2) to ensure that no single active failure will prevent the recirculation line to be isolated prior to the sump recirculation phase, and 3) that valve manipulation can be performed from the Control Room.

The present schedule calls for the new recirculation piping, valves and controls to be installed during the 1989 refueling outage, with pre-operational testing and the modification turned over for use by the end of 1989.

FIGURE A-1.
SIS MINIFLOW RECIRCULATION SYSTEM

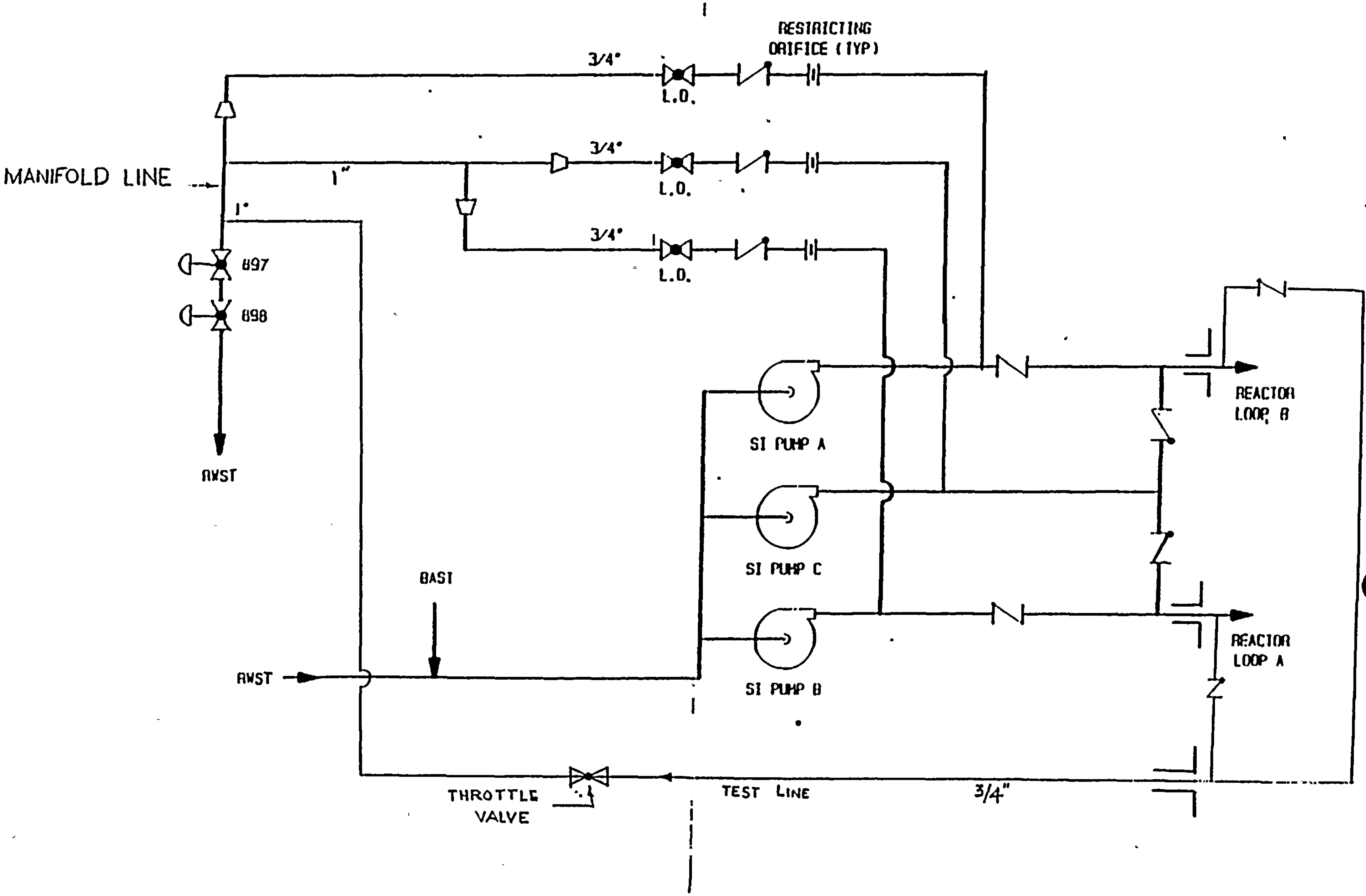


FIGURE A-2

MODIFICATION SCHEMATIC

PRELIMINARY

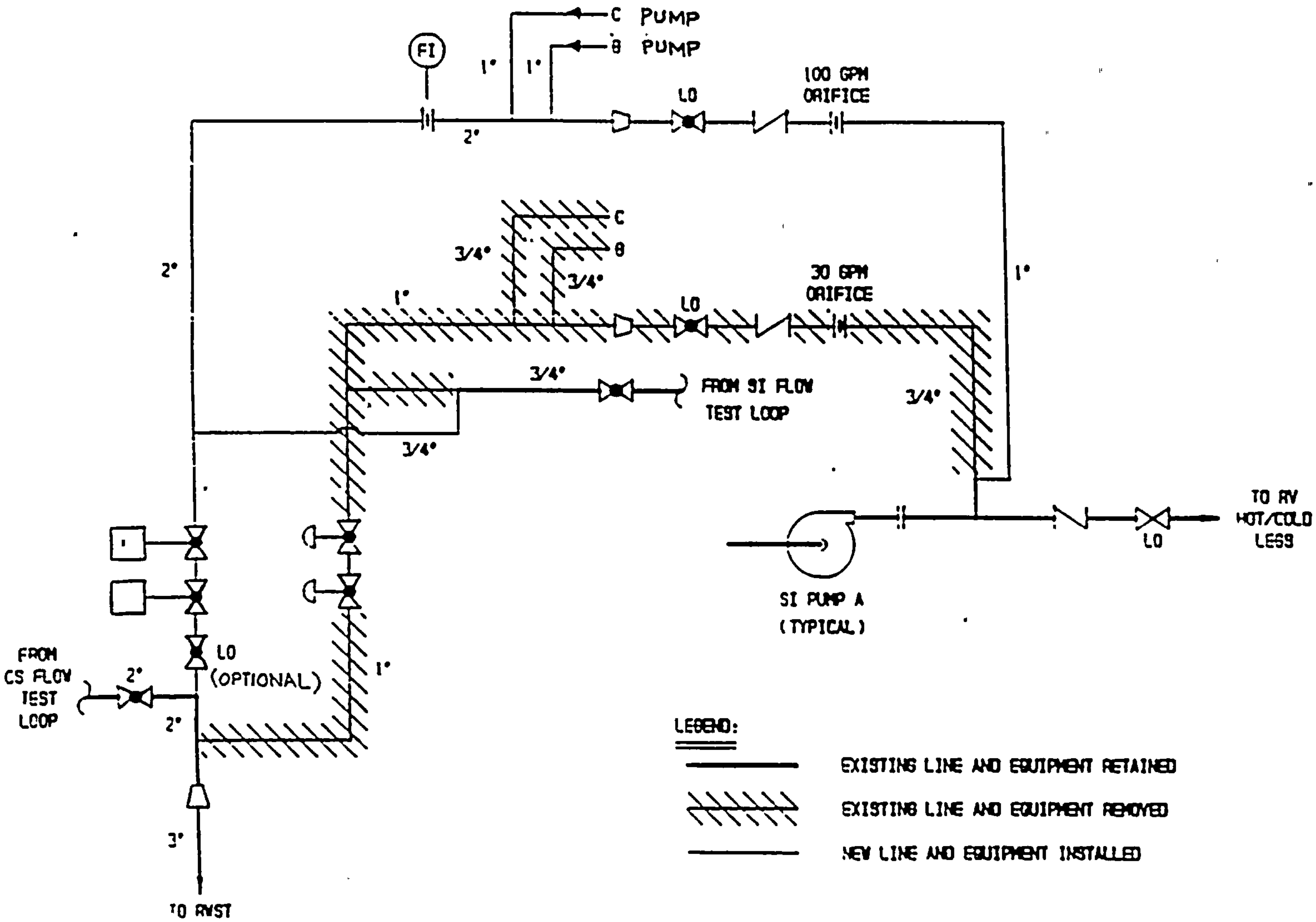
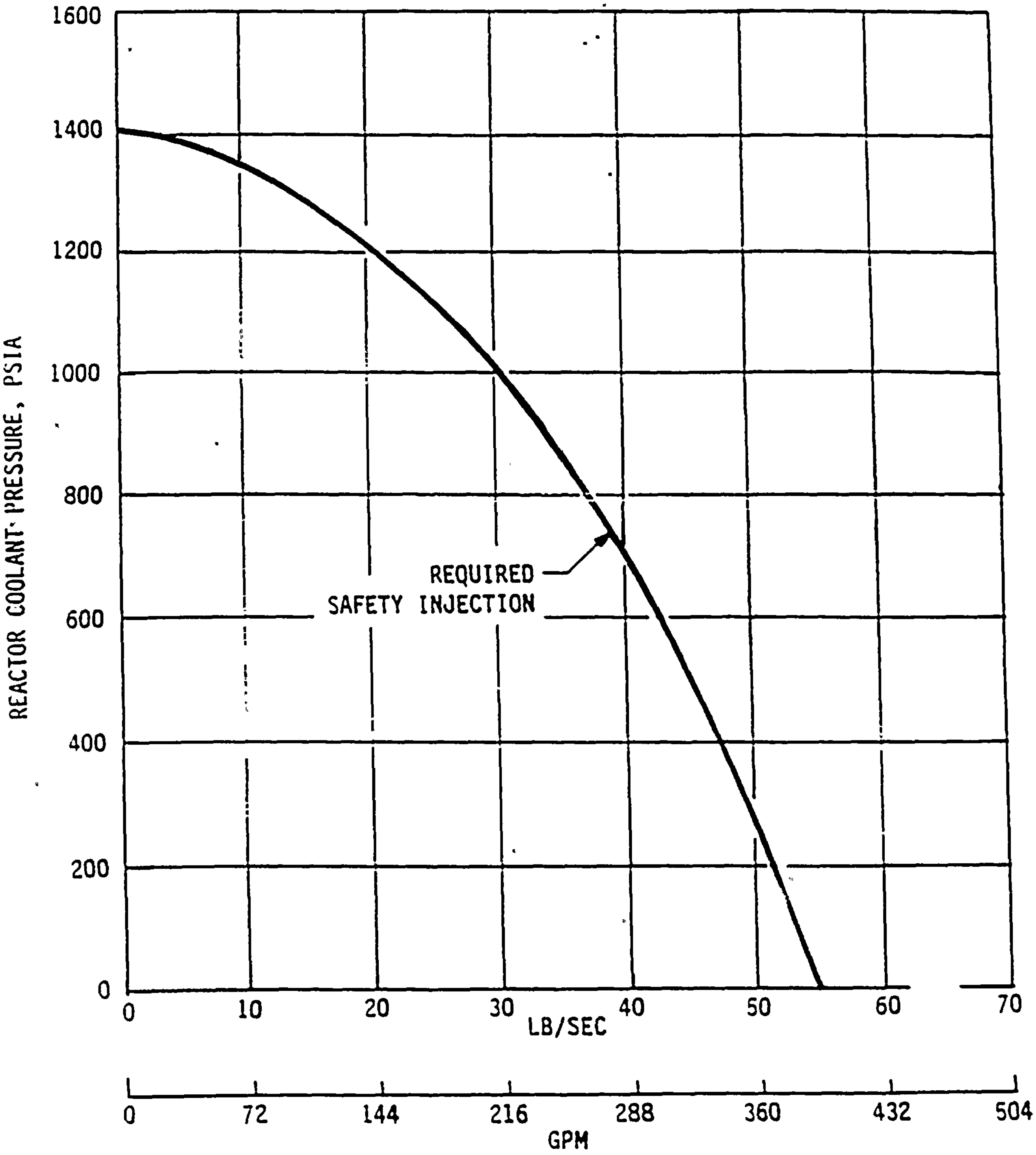


FIGURE A-3

SAFETY INJECTION FLOW



ATTACHMENT B

Evaluation of the Residual Heat Removal (RHR) Recirculation System and Justification for Continued Operation

Reference: (a) Flow Measurement Engineering Handbook, R.W. Miller, McGraw Hill Book Company, New York, 1983, Chapter 4

NRC Bulletin 88-04 requested an evaluation of two conditions which, if existing, could result in damage or failure of safety-related pumps. First, the concern exists that when two pumps are operated in parallel, the weaker pump may be deadheaded by the stronger pump when the pumps are operating in the minimum flow mode. Second, the concern exists that the amount of minimum flow may not be adequate to preclude pump damage or failure if even a single pump is operating. Should either of these conditions exist, the planned short term and long term modifications are to be identified as well as the justification for continued operation.

The RHR pumps at R.E. Ginna serve as the residual heat removal pumps used during normal plant cooldown, heatup and refueling as well as the low head safety injection pumps, functioning as part of the emergency core cooling system (ECCS).

There are 4 modes during which the RHR pumps are placed in operation:

1) Low head safety injection (LHSI) as part of the ECCS, with pumps taking suction from the refueling water storage tank (RWST). This is the injection phase and represents the normal plant alignment upon receipt of an SI signal.

2) Low head safety injection (LHSI) as part of the ECCS, with pumps taking suction from the containment sump. This represents the recirculation phase following depletion of RWST to 15% level.

3) Residual heat removal mode during plant cooldown and during refueling operations. The RHR pumps take suction from the RCS loop "A" hot leg and discharge back to the RCS to loop "B" cold leg. During this mode RCS pressure and temperature are below 350 psig and 350°F. Pump operability testing is also conducted monthly during shutdowns at a pump flow of 700 gpm.

4) Test mode. Monthly periodic testing is performed in accordance with ASME Section XI Article IWP-3100 during normal plant operation. Pumps are operated separately and take suction from the RWST and discharge through the miniflow recirculation line and back to the pump suction.

The RHR system configuration is shown on Figure 5.4-7 of the UFSAR. The pumps discharge into parallel paths each with a check valve, residual heat exchanger, and control valve in primarily 8-inch piping. The discharge lines merge into a common 10-inch section of piping which leads inside containment. This 10-inch line directs the flow through two motor operated valves to the loop "B" cold leg. These normally closed valves are opened for normal RHR operation during plant cooldown. Two 6-inch branch lines leading to the reactor vessel, are automatically aligned for low head safety injection upon receiving an SI signal.

A 2-inch miniflow recirculation line branches off the 10-inch common discharge line and leads to a section of 10-inch RHR suction piping which splits and leads back to each of the RHR pumps. The miniflow recirculation line contains a manual globe valve and flow meter FI-628. The miniflow line is always open. This miniflow line serves both pumps and provides the needed flow through the pumps when the RCS pressure exceeds RHR pump shutoff head. The system is designed to provide 200 gpm minimum flow with one pump running or 100 gpm per pump if operated in parallel.

Westinghouse initially notified RG&E of a potential concern for those plants that had a common recirculation line and identified R.E. Ginna as a plant that was potentially affected (Westinghouse letters to RG&E dated October 26, 1987, November 30, 1987 and December 8, 1987). NRC Information Notice 87-59 dated November 17, 1987 was issued identifying the concerns which were again documented in NRC Bulletin 88-04 dated May 5, 1988. RG&E initiated a Corrective Action Report (CAR 1828) following receipt of the initial Westinghouse correspondence.

The RHR pumps are single stage, horizontal, coupled centrifugal pumps, Model 6-SVC, manufactured by Pacific Pump Division driven by Westinghouse Electric Corporation 200 hp A.C. motors. The pumps are rated for 1560 gpm at 280 ft. total head at 1770 rpm.

Review of the manufacturer's initial pump performance curves indicated that the pumps are well matched for parallel operation, however, due to the flatness of the curves at low flows which is typical of pumps with low specific speed such as these, small differences in the actual pump total developed head or system resistance can cause large differences in the individual pump's operating flow. A review of several months of periodic test data performed in the April-September 1987 timeframe demonstrated that the difference between the two pumps' developed pressure was about 1 or 2 psi at the 200 gpm flowrate. The impact of this was then evaluated.

The RHR system contains one flowmeter (FI-626) located in the 10-inch common discharge line, which measures the total flow from both RHR legs, therefore, confirmation of the actual flow from each pump during parallel low flow operation necessitated a special test. Two tests were conducted, on December 16, 1987 and December 22, 1987, during which an ultrasonic type flowmeter was installed on the "B" RHR discharge leg. By recording simultaneously the flow on the miniflow recirculation line flowmeter FI-628 and the ultrasonic flowmeter in the "B" pump leg, flow in both legs of the RHR piping was determined. Pump bearing housing vibration, casing vibration, seal water piping temperature, casing temperature and motor current were also monitored and recorded during the test. The testing determined that with both pumps operating in parallel at a total flow of 200 gpm, the "A" pump received only about 5 gpm and was, therefore, essentially deadheaded. Operation in the parallel mode was terminated 5 1/2 minutes after start. The total discharge pressure confirmed the "A" pump to be only 2 psi less than the "B" pump at 200 gpm when each pump operated separately. Based upon the shape of the head-capacity curve, however, for these pumps, a 2 psi difference would result in the total flow with both pumps operating in parallel required to be about 500 gpm before the weaker "A" pump would be able to overcome the head at this operating point.

In order to more closely establish the operational limitations while in parallel, a review was made of a larger sample of monthly periodic test data. This testing is conducted during normal plant operation utilizing the miniflow recirculation line. The flowrate is set at 200 gpm by throttling manual globe valve 822B. Each pump is tested separately. Data over the last 24 months has been trended to establish the difference between the differential pressures of the "A" and "B" pumps considering the pressure gage repeatability. The same discharge pressure gage, PI-629, is used for testing each pump. Suction pressure is determined by an elevation head calculation based on RWST water level. Testing is done on both pumps sequentially using the same procedure. The same personnel performed the testing on the "A" as well as "B" pump, hence, gage readings are expected to be consistent for a particular monthly test. Since the same gage is used, the calibration and bias error of the gage would remain unchanged for a particular monthly test, and not be a factor in determining the difference in differential pressures between pumps "A" and "B". The trending, therefore, provides the basis for determination of the mean value of the pressure difference and standard deviation of the data. The trending shows that the mean value for the difference in differential pressures is 1.76 psi.

The data points reviewed over the last 24 months of periodic testing indicate that the pressure indicator produces reasonably repeatable pressure values. The accuracy of the values, that is, the closeness to the true value, which includes the effects of both precision and bias error, is $\pm$ 1.6% for the "A" pump data and $\pm$ 1.2% for the "B" pump data. By determining the difference in pressure readings and accounting for two standard deviations, the adjusted pressure difference was determined to be 3.76 psi for analysis purposes (Reference a).

An analysis of the losses due to piping and components shows that the head loss in the "B" pump and "A" pump discharge sections of piping up to the junction point of the two loops is within 0.2 feet of water or essentially equivalent at the 200 gpm flowrate.

The head loss encompassed piping and component losses such as elbows, reducers, heat exchangers, and valves as well as elevation head losses. Therefore, the difference in pump differential pressures recorded is due to individual pump characteristics, not differences in the individual RHR discharge line resistances.

The purpose of the data review and trending was to establish a value for the difference of pump developed pressure which would provide the basis for establishing operating limitations for parallel pump operation. This adjusted pressure difference resulted in a condition whereby the total flow with both pumps operating in parallel would need to be about 700 gpm before the weaker "A" pump would be assured of overcoming the head at the operating point.

Following RG&E notification of the miniflow concern by Westinghouse, calculations were performed to determine the following:

1) The calculated temperature rise in the fluid within the critical areas internal to the pump versus the flowrate through the pump.

2) The time to saturation of the water within the critical internal areas of the pump after being started in the deadheaded condition.

The RHR pumps are normally aligned to the RWST which is maintained at a minimum water volume by Technical Specification, therefore, the elevation head above the RHR pump suction centerline is known. The maximum water temperature of 80°F for the RWST was used in the calculations. The volume of water within the pump was obtained with the help of the manufacturer.

The temperature rise versus pump flow curve was plotted with the results that a 40 gpm flow would produce a 10°F rise and a 20 gpm flow would produce a 21°F rise in the internal fluid. The results also indicated that if started in a deadheaded condition, the internal fluid could reach saturation conditions in 6.7 minutes, assuming no heat losses from the pump, no heat loss due to the component cooling water jacket cooling which is provided around the pump casing cover, and all the pump brakehorsepower is converted immediately into heatup of the pump fluid.

The miniflow recirculation line was originally sized based upon pump internal temperature rise and was intended to provide pump protection against operation in the recirc mode for short periods of time. The capacity of the miniflow line is in excess of 200 gpm with one pump operating, since V-822B requires some throttling in order to achieve this flow. Consequently, for parallel operation, if both pumps were to equally share this flow (as is the ideal condition in parallel operation), each pump would deliver 100 gpm. Based upon this and the calculated temperature rise curve, the miniflow line was adequately sized and would result in a temperature rise of only 3.9°F.

Regarding the 6.7 minutes to saturation time, during the special test run on December 22, 1987 the "A" pump was determined to be essentially deadheaded for 5.5 minutes while the pump parameters were monitored. Seal return piping surface temperature and casing surface temperature were monitored. The seal return temperature did not show a noticeable increase. The casing surface temperature indicated 85°F when the pump was secured. Bearing housing vibration at the highest location (inboard end vertical) increased from 0.75 mils (normal) to 1.2 mils (deadheaded). Casing vibration increased from 0.20 mils (normal) to 0.32 mils (deadheaded) on the "A" pump. In general, the trend in the bearing housing vibration levels was an increase of 10-20% as flow was reduced from 200 gpm to 50 gpm. On the "A" pump, which was in fact deadheaded during the 5 1/2 minute span, the vibration increased from 0.80 mils at 50 gpm to 1.2 mils (inboard vertical) or 50%, yet, these levels themselves are typical for the equipment and are within the accepted standards.

Consequently, test data recorded in the range of 200 gpm to 50 gpm did not indicate a significant increase in pump vibration, or other monitored parameters, although the casing temperature did indicate the fluid temperature was increasing, as would be expected.

Based upon the foregoing summary of events and information, all procedures which require operation of the RHR pumps have been changed to require that when two pumps are running and the total flow indicated on flow indicator FI-626 is less than 1200 gpm, one pump is stopped. Conversely, if one pump is running with greater than or equal to 1200 gpm, the second pump is started if available. It is acceptable to stop an RHR pump because a single pump will provide all required accident flow. These procedural modifications have been made as an interim measure justifying continued operation until a planned plant modification can be installed which will provide a separate and independent recirculation flow loop for each pump. Additionally, an operator aid tag has been placed on the FI-626 indicator in the Control Room which identifies this operating limitation. Training on these procedure changes is being provided to the operators on an ongoing basis. The procedure changes have been inserted in the immediate action steps of the emergency procedures. Monitoring this trip and restart criteria is performed on a continual basis as required on the procedure foldout page. Combined with the operator training and the operator aid tag, a high confidence exists that operation of the pumps in parallel at a condition which could result in overheating or damage will not occur.

The setpoint of 1200 gpm has been chosen to account for instrument uncertainty and to provide an acceptable flow split during parallel operation. Utilizing the periodic test data, it has been determined that total flows above about 700 gpm will ensure that the weaker pump will overcome the operating head.

Considering the effects of instrument uncertainty of approximately 3%, which would result in an additional required margin of 130 gpm, the value of 1200 gpm will ensure that both pumps will deliver an adequate flow while operating in parallel. It has been determined that an indicated flowrate of 1200 gpm on FI-626 in the Control Room would result in no less than 1070 gpm total flow considering the most limiting instrument uncertainty. If this were the case, the "A" pump would receive 300 gpm and the "B" pump 770 gpm. An actual total flow of 1200 gpm would be split such that the "A" pump would deliver 390 gpm and the "B" pump 810 gpm. Therefore, the setpoint provides a flow split whereby the weaker "A" pump receives nominally about 20 percent of BEP flow and an amount consistent with current manufacturer's recommendations.

The pump manufacturer, Pacific Pump Division, has recommended a recirculation flow of 100 gpm per pump for short durations up to 30 minutes. The recommended value for intermediate range operation, that of 100 hours per month, is 260 gpm (15% of BEP) and long term continuous operation a value of 520 gpm (30% of BEP) is recommended.

The majority of operating time for the pumps is spent in the RHR mode during plant heatup, cooldown, and refueling operations. One or both RHR pumps operate for a total of about 1000 hours per year in the RHR mode. The precise time split between the "A" pump and "B" pump has not been determined. Operation in the test mode of 200 gpm is performed monthly except during annual refueling shutdowns when they are tested at 700 gpm. This would amount to a duration on the order of 25 hours per year (or less) or about 5% of the total operating time (assuming 500 hours per pump). Since the 200 gpm value is sufficiently close to the recommended value of 260 gpm recommended by the manufacturer for operation up to 1200 hours per year (100 hours per month), the approximately 25 hours spent at 200 gpm will not result in accelerated wear on the pump internals.

A safety analysis was performed which supported the procedural modifications which require securing one RHR pump as described above. Parallel low flow operation of RHR pumps at Ginna may occur during:

1. <u>SAFETY INJECTION (INJECTION PHASE)</u>

During the ECCS injection phase 1 of 2 RHR pumps, 2 of 3 high head safety injection pumps and 1 of 2 SI accumulators are assumed to inject water.

2. <u>SAFETY INJECTION (RECIRCULATION PHASE)</u>

During the ECCS recirculation phase, 1 of 2 RHR pumps and heat exchanger will satisfy the long term core cooling requirements of 10CFR50.46.

3. <u>RHR SYSTEMS OPERATION DURING A PLANT COOLDOWN BELOW 350°F</u>

During RCS cooldown below 350°F, only 1 of 2 RHR pumps are procedurally operated at low-flow conditions precluding RHR pump damage. A review of procedures shows that at no time do procedures used to initiate, operate, or shutdown the RHR system in this mode of operation require or recommend the running of RHR pumps with the discharge path isolated. Additionally, there are no automatic isolation signals in the Ginna configuration that would place the RHR pumps in the parallel low-flow operating mode.

4. <u>TEST MODE</u>

A review of periodic test procedures and refueling shutdown surveillance procedures revealed that at no time would there be parallel low-flow operation.

Therefore, for all anticipated normal operating conditions the potential for RHR pump damage is limited such that the RHR pumps availability is assured to the maximum extent possible such that the provisions of 10CFR50 Appendix A GDC 34 Residual Heat Removal are satisfied. In addition, the margin of safety and performance of the ECCS as described in 10CFR50 Appendix A GDC 35 are satisfied.

The procedure changes are intended as an interim measure. A plant modification designed to affect long term corrective action is presently underway. Critical piping tie-ins for the modification are scheduled to be installed during the 1989 Refueling and Maintenance shutdown, with new hardware and piping installation, testing, and the modification turned over for use by the end of 1989. A new recirculation system is being designed which will ensure an increased minimum flow capacity consistent with the manufacturer's recommendations for intermediate term operation under all anticipated normal and accident conditions. The requirements will be met whenever one or both RHR pumps are operating. The new recirculation capacity will not prevent the required delivery to the reactor vessel, as defined on Figure 15.6-13 of the UFSAR, from being met.

Through the use of the computer model KYPIPE developed for the ECCS system at Ginna, the existing system and proposed modification to the recirculation system can be assessed and impact on system delivery determined. The optimum design has not as yet been finalized. Since the criteria requires an increase in recirculation capacity when the discharge path is isolated as well as sufficient capacity to ensure that the UFSAR delivery curve (Figure 15.6-13) is met, a recirculation system with flow or pressure control components may be necessary in lieu of a passive pressure breakdown system as is now employed. The system redesign option which is being given strong consideration for implementation at this time is depicted on Figure B-1. As required by paragraph 5 of Bulletin 88-04, a written response describing the actions taken will be provided within 30 days following completion of the plant modification.

Appropriate conservatism will be applied to the KYPIPE computer code. Sufficient pump performance degradation will also be applied in the model so that pump maintenance will be performed prior to system delivery requirements being reduced below the acceptable limits established in the UFSAR. Pump developed pressure measurements in the monthly periodic test procedures can be used to dictate when corrective action would be warranted. Additionally, the increased capacity of the recirculation system will reduce to a minimum the possibility of accelerated wear due to operation in the periodic test mode.

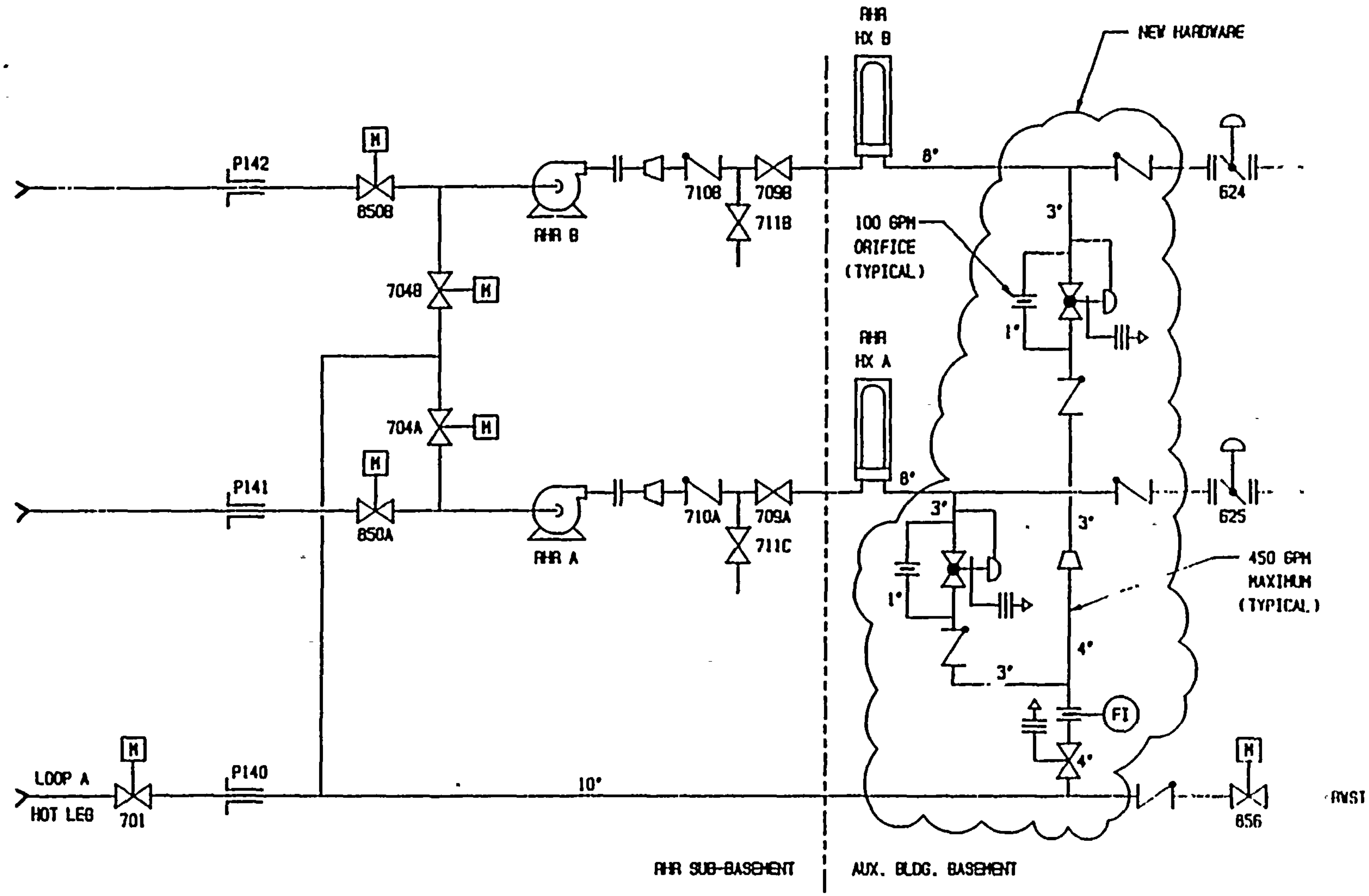


FIGURE B-1
RHR MINIMUM RECIRCULATION FLOW

ATTACHMENT C

EVALUATION OF RECIRCULATION SYSTEMS FOR AUXILIARY FEEDWATER SYSTEM

Reference (a): Letter from J.E. Maier (RG&E) to D.M. Crutchfield (NRC), Subject: NRC Requirements for Auxiliary Feedwater Systems, dated January 8, 1982

Reference (b): Letter from J.E. Maier (RG&E) to D.M. Crutchfield (NRC), Subject: NRC Requirements for Auxiliary Feedwater Systems, dated June 8, 1981

Reference (c): Letter from L.D. White (RG&E) to D.M. Crutchfield (NRC), Subject: NRC Requirements for Auxiliary Feedwater Systems, dated May 28, 1980

These systems have been evaluated under previous Systematic Evaluation Program (SEP) Topic X and TMI-2 Task Action Plan Items II.E.1 (from NUREG-0660). As part of the later task, these pumps underwent a 48 hour endurance test performed at minimum flow conditions. These tests demonstrated continued operability and acceptability of critical parameters at low flow conditions based upon limits established for the pumps at rated conditions.

Monthly periodic tests require that each auxiliary feedwater pump recirculation system operates as designed. Each pump is provided with a separate line equipped with an automatic air operated (fail-open) valve and pressure breakdown orifice. These lines tie in to a common line which leads back to the two 30,000 gallon condensate storage tanks for the main auxiliary feedwater system. The standby auxiliary feedwater system is similar with the common line leading back to the 10,000 gallon condensate supply tank.

MAIN AUXILIARY FEEDWATER SYSTEM

The system is depicted on Figure 10.5-1 of the UFSAR. Each of the three pumps is provided with a 2-inch recirculation line, automatically controlled air operated valve, and pressure breakdown orifice. The valve is designed to fail to the open position. The "A" motor driven AFW pump is capable of discharging 200 gpm to the "A" steam generator and the "B" motor driven AFW pump 200 gpm to the "B" steam generator. The turbine driven AFW pump is capable of providing a total of 400 gpm to both steam generators. Both motor driven pumps automatically start if 1) either steam generator decreases to a low-low level of 17%, 2) an SI signal is present, or 3) trip of both main boiler feed pumps occurs. Since each motor driven pump is aligned to its steam generator, an interaction cannot occur as described in Bulletin 88-04.

The recirculation valves for the motor driven pump system remain closed until the discharge pressure in the discharge line reaches the established setpoint. Recent tests performed on the pumps demonstrated that the valves were fully open at a discharge flow of 80 gpm (32% of BEP). Therefore, the total flow through the pump exceeds 80 gpm, since the recirculation line is also open to provide additional flow. The existing periodic test procedures require verification that the recirculation valve is fully opened when the flow through the discharge is throttled to 50 gpm, or 20% of BEP, which is considered adequate. Therefore, the established setpoints provide margin over and above the acceptable value of 50 gpm. The periodic test also demonstrates that the recirculation valve is fully closed when the discharge flow reaches 125 gpm. The periodic testing also verifies that the valve will fail to open position when air is removed.

The motor driven pumps are designed to provide a minimum of 200 gpm during accident conditions. The discharge valves are automatically throttled to achieve this flow. The discharge valves are only throttled to lower flows during plant startup and low power operation or during periodic testing. During these modes of operation, the flow is procedurally controlled so that a minimum of 50 gpm is always provided. Since the recirculation valve opens automatically, a minimum flow through this line provides assurance that the pump will always receive a recirculation flow.

The turbine driven AFW pump is also equipped with a 2-inch separate recirculation line, automatic air operated valve (fail-open) and pressure breakdown orifice. In this system the valve is controlled by flow in the discharge line, designed to open the valve if the flow decreases to 100 gpm. Periodic testing is performed on a monthly basis and demonstrates that the valve is fully open at 100 gpm. This flow represents 20% of BEP and is therefore adequate. The turbine driven pump would only be throttled back to the 100 gpm condition during test modes.

The turbine driven pump is automatically started on a low-low level of 17% in both steam generators, or on loss of both 4160V buses 11A and 11B. All three main auxiliary feedwater pumps start on loss of offsite power. In this case, each of the "A" and "B" motor driven pumps would be running in parallel with the turbine driven pump supplying water to the "A" and "B" steam generators, respectively. Since these pumps are provided with automatic systems, the recirculation valves would open in the unlikely event that the discharge valves were to be throttled back, thereby providing adequate flow for each pump. Additionally, an orifice is installed in each minimum flow recirculation line upstream of the common line tie-in so that the strong/weak pump interaction noted in Bulletin 88-04 is de-sensitized.

Monthly periodic testing of the pumps performed at rated flow demonstrates that the discharge pressure limits and bearing housing vibration are within the bounds established. This data is trended and provides a means of determining performance changes.

The 48 hour endurance tests on the motor driven AFW pumps were conducted on October 9 through October 11, 1981 ("A" pump) and on November 6 through November 8, 1981 ("B" pump). Test results were reported in Reference (a). The test was run in the recirculation mode of 50 gpm during the test.

The 48 hour endurance test on the turbine driven AFW pump was performed on March 6 through March 8, 1981. Test results were reported by Reference (b) and demonstrated operability and acceptability of critical parameters during the recirculation condition at about 100 gpm.

Consequently, the concerns raised in Bulletin 88-04 have been adequately addressed in the design and are demonstrated during periodic testing of the systems.

STANDBY AUXILIARY FEEDWATER PUMP

This system is depicted on Figure 10.5-2 of the UFSAR. Each of the pumps is rated for 200 gpm. Each pump is provided with a 1.5-inch recirculation line, with automatic flow controlled air operated valve and manufacturer-designed pressure breakdown orifice. The valve is designed to fail in the open position. The valve is designed to open when the discharge flow decreases to 80 gpm. Each pump feeds a separate steam generator and parallel operation as described in Bulletin 88-04 is, therefore, not a concern. The recirculation lines merge to a common line which leads back to the 10,000 gallon condensate supply tank. The standby auxiliary feedwater pumps are provided only for use if all three of the main auxiliary feedwater pumps were unavailable, such as certain steam line breaks and unmitigated fire scenarios. The pumps are manually actuated and controlled. There are no known modes of operation whereby the discharge valves would be throttled back with these pumps running in parallel. However, since the common line tie-in is downstream of each orifice, the line is de-sensitized to the possible effects of the strong/weak pump interaction described in Bulletin 88-04.

Periodic testing of the pumps is performed monthly and demonstrates that each pumps' developed pressure remains within established limits and that at a flow of 50 gpm the recirculation valve is fully open. Testing also confirms that the valve fails to the open position when air is removed.

The best-efficiency point of the pumps is 450 gpm making the recirculation flow of 50 gpm about 11% of BEP. Pump temperature rise of the internal fluid at this condition is calculated to be only 17.3°F. Since the only mode of operation which will result in this low flow is the test mode, this value is acceptable. The pumps are operated in this mode for brief periods of time only, in order to demonstrate that the recirculation valve fully opens. The 48 hour endurance test was conducted on both pumps at the recirculation condition in March and May 1980. Test results were reported in Reference (c) and demonstrated operability and acceptability of critical parameters.

Consequently, the concerns raised in Bulletin 88-04 have been adequately addressed in the design and are demonstrated during periodic testing of the pumps.

TABLE 1

DETAILED TECHNICAL SPECIFICATION CHANGES

Location	Description of Change	Reason for Change
Page 4.5-3	Added 450 gpm at 138 psig for RHR pumps; added square brackets around 200 gpm and 140 psig in Table 4.5-1. Added Note (1).	Reduce the potential for pump accelerated wear due to low flow operation by
Page 4.5-3	Added 150 gpm at 1356 psig for SI pumps; added square brackets around 50 gpm and 1420 psig in Table 4.5-1. Added Note (2).	increasing surveillance test flow equivalent to the minimum flow recommended for continuous operation.
Page 4.5-8	Elaborated the basis for the minimum discharge pressure and pump degradation. Added Reference 2.	Clarify basis in keeping with UFSAR analyses.
Page 4.5-9	No change.	Reformatted on page.
Page 4.5-10	Changed Reference 2 to Reference 3 and Reference 3 to Reference 4.	Renumber references.
Page 4.5-11	Updated References as follows: Reference (1) from FSAR 6.2 to UFSAR 6.3.5.2. Added Reference (2), UFSAR Figs. 15.6-12 & 15.6-13. Changed Reference (2) to Reference (3) and updated it from FSAR 6.3 to UFSAR 6.5.1.2.4. Changed Reference (3) to Reference (4) and updated it from FSAR 14.3.5 to UFSAR 6.4.3.1.	Update the references from the original FSAR to the appropriate section of the UFSAR.