PSE&G

Public Service Electric and Gas Company 80 Park Plaza Newark, N.J. 07101 Phone 201/430-7000

February 6, 1981

RECEIVED FEB 19 1981 U.S. NUCLEAR REGULATORY COMMISSION

Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Mr. Frank J. Miraglia, Chief
Licensing Branch 3
Division of Licensing

Mr. S. A. Varga, Chief
Operating Reactors Branch 1
Division of Licensing

Gentlemen:

REACTOR VESSEL LEVEL INSTRUMENTATION
NO. 1 AND 2 UNITS
SALEM NUCLEAR GENERATING STATION
DOCKET NOS. 50-272 AND 50-311

PSE&G hereby submits additional information required by NUREG-0737, concerning Item II.F.2, "Instrumentation for Detection of Inadequate Core Cooling." This information supplements our submittal of December 31, 1980 and addresses specifically the Reactor Vessel Level Indicating System.

As this submittal contains information proprietary to Westinghouse Electric Corporation, it is supported by an affidavit signed by Westinghouse, the owners of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in Paragraph (b)(4) of Section 2.790 of the Commission's Regulations.

Accordingly, it is respectfully requested that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR Section 2.790 of the Commission's Regulations. Correspondence with respect to the proprietary aspects of this application for withholding or the supporting Westinghouse affidavit should reference CAW-81-12, and should be addressed to R. A. Wiesemann, Manager, Regulatory and Legislative Affairs, Westinghouse Electric Corporation, P. O. Box 355, Pittsburgh, Pennsylvania 15230.

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This submittal consists of (5) copies each of the proprietary and non-proprietary versions of this report and (1) copy of the supporting affidavit.

Should you have any questions in this regard, do not hesitate to contact us.

Very truly yours,

R. L. Mittl
General Manager -
Licensing and Environment

CC: Mr. Leif Norrholm
Senior Resident Inspector

DD02 1/2

Westinghouse
Electric Corporation

Water Reactor
Divisions

Nuclear Technology Division

Box 355
Pittsburgh Pennsylvania 15230

February 3, 1981
CAW-81-12

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Phillips Building
7920 Norfolk Avenue
Bethesda, Maryland 20014

ATTENTION: Mr. F. J. Miraglia, Chief
License Branch 3

Mr. S. A. Varga, Chief
Operating Branch 1

SUBJECT: Public Service Electric and Gas Company, Salem Units 1 and 2, Reactor Vessel Level Instrumentation

REF: Application for Withholding, Mittl to Miraglia and Varga, February 1981

Dear Messrs. Miraglia and Varga:

The proprietary material for which withholding is being requested by Public Service Electric and Gas Company is of the same technical type as that proprietary material recently provided by Westinghouse in response to the concern given in NUREG-0737 for vessel level instrumentation. The previous application for withholding, AW-77-18, was accompanied by an affidavit signed by the owner of the proprietary information, Westinghouse Electric Corporation.

Further, the affidavit submitted to justify the previous material is equally applicable to the subject material. The subject proprietary material is being submitted in support of Public Service Electric and Gas Company, Salem Units 1 and 2. Accordingly, this letter authorizes the utilization of the previously furnished affidavit in support of Public Service Electric and Gas Company. A copy of the affidavit, AW-77-18 dated April 20, 1977, is attached.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference CAW-81-12 and should be addressed to the undersigned.

Very truly yours,

Robert A. Wiesemann

Robert A. Wiesemann, Manager
Regulatory & Legislative Affairs

/bek
Attachment

cc: E. C. Shomaker, Esq.
Office of the Executive Legal Director, NRC

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Robert A. Wiesemann, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Corporation ("Westinghouse") and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

Robert A. Wiesemann, Manager
Licensing Programs

Sworn to and subscribed before me this 20 day of April 1977.

Notary Public

(1) I am Manager, Licensing Programs, in the Pressurized Water Reactor Systems Division, of Westinghouse Electric Corporation and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing or rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Water Reactor Divisions.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse Nuclear Energy Systems in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(g) It is not the property of Westinghouse, but must be treated as proprietary by Westinghouse according to agreements with the owner.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition in those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information is not available in public sources to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is attached to Westinghouse Letter Number NS-CE-1403, Eicheldinger to Stolz, dated April 6, 1977. The letter and attachment are being submitted in support of the Westinghouse emergency core cooling system evaluation model.

Public disclosure of the information sought to be withheld is likely to cause substantial harm to the competitive position of Westinghouse, taking into account the value of the information to Westinghouse, the amount of effort and money expended by Westinghouse in developing the information, and considering the ways in which the information could be acquired or duplicated by others.

Further the deponent sayeth not.

DOCKET NO. 50-272/311

DATE: 2-23-81

NOTE TO NRC AND/OR LOCAL PUBLIC DOCUMENT ROOMS

The following item submitted with letter dated 2-6-81

from PSE+G is being withheld from public disclosure in accordance with Section 2.790.

PROPRIETARY INFORMATION

INFO IN RESPONSE TO NUREG-0737

D. Johnson

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Distribution Services Branch

FILES

1(a) Design Description of Reactor Vessel Level Instrumentation System

1.1 GENERAL DESCRIPTION

The reactor vessel level instrumentation system (RVLIS) uses differential pressure (d/p) measuring devices to measure vessel level or relative void content of the circulating primary coolant system fluid. The system is redundant and includes automatic compensation for potential temperature variations of the impluse lines. Essential information is displayed in the main control room in a form directly useable by the operator.

The functions performed by the RVLIS are:

1. Assist in detecting the presence of a gas bubble or void in the reactor vessel.

2. Assist in detecting the approach to ICC.

3. Indicate the formation of a void in the RCS during forced flow conditions.

1.2 DETAILED SYSTEM DESCRIPTION

1.2.1 HARDWARE DESCRIPTION

1.2.1.1 Differential Pressure Measurements

The RVLIS (Figure 1-1) utilizes two sets of three d/p cells. These cells measure the pressure drop from the bottom of the reactor vessel to the top of the vessel, and from the hot legs to the top of the vessel. This d/p measuring system utilizes cells of differing ranges to cover different flow behaviors with and without pump operation as discussed below:

1. Reactor Vessel - Upper Range (ΔP_a)
   The d/p cell ΔP_a shown in Figure 1-1 provides a measurement of reactor vessel level above the hot leg pipe when the reactor coolant pump (RCP) in the loop with the hot leg connection is not operating.

2. Reactor Vessel - Narrow Range (ΔP_b)
   The measurement provides an indication of reactor vessel level from the bottom of the

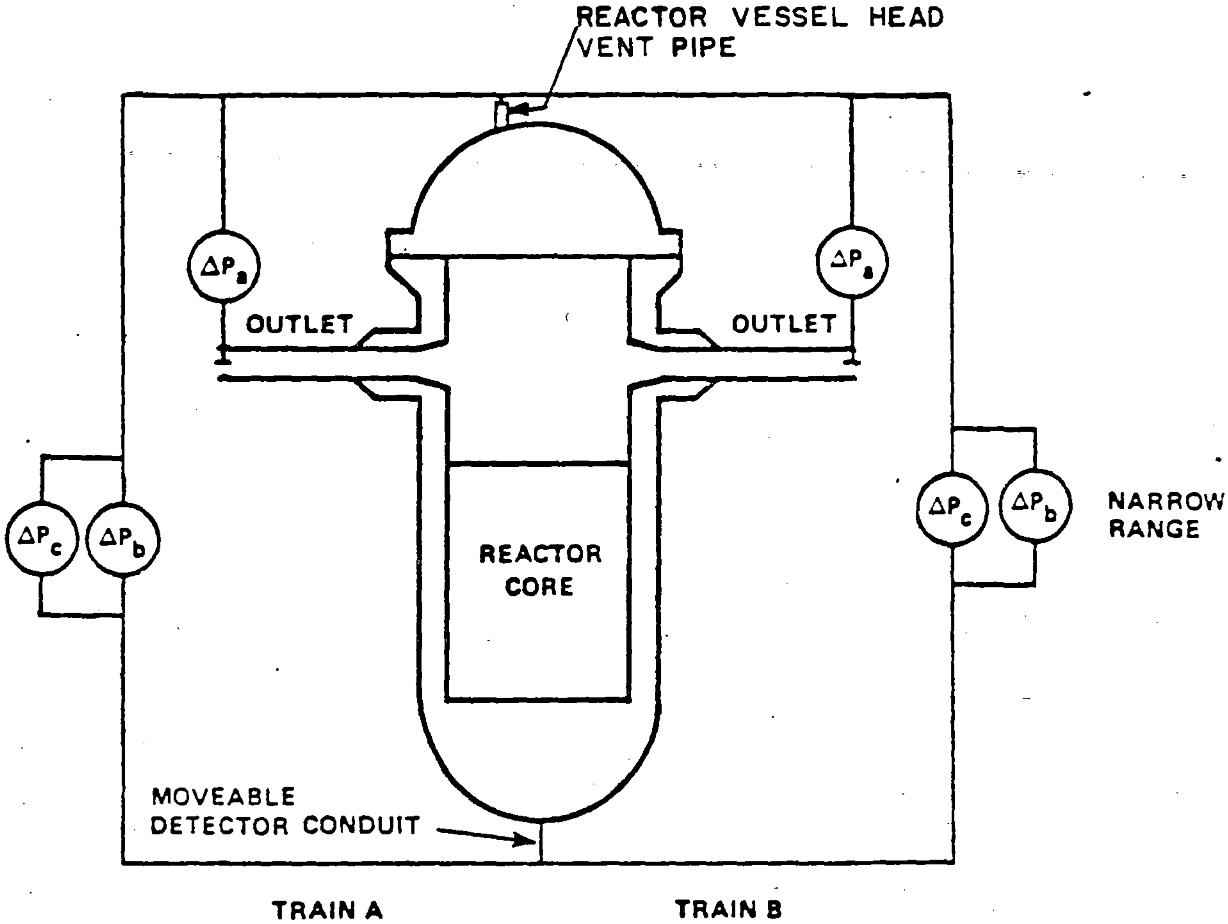


Figure /-/ Reactor Vessel Level Instrument System reactor vessel to the top of the reactor during natural circulation conditions.

3. Reactor Vessel - Wide Range (ΔP_c)
This instrument provides an indication of reactor core and internals pressure drop for any combination of operating RCPs. Comparison of the measured pressure drop with the normal, singlephase pressure drop will provide an approximate indication of the relative void content or density of the circulating fluid. This instrument will monitor coolant conditions on a continuing basis during forced flow conditions.

To provide the required accuracy for level measurement, temperature measurements of the impulse lines are provided. These measurements, together with the existing reactor coolant temperature measurements and wide range RCS pressure, are employed to compensate the d/p transmitter outputs for differences in system density and reference leg density, particularly during the change in the environment inside the containment structure following an accident.

The d/p cells are located outside of the containment to eliminate the large reduction (approximately 15 percent) of measurement accuracy associated with the change in the containment environment (temperature, pressure, radiation) during an accident. The cells are also located outside of containment so that system operation including calibration, cell replacement, reference leg checks, and filling is made easier.

1.2.1.2 System Layout

A schematic of the system layout for the RVLIS is shown in Figure 1-2. There are four RCS penetrations, one connection in the reactor vessel head vent pipe, one connection to an incore instrument conduit at the seal table, and connections into the side of the two RCS hot leg pipes.

The pressure sensing lines extending from the RCS penetrations will be a combination of 3/4 inch Schedule 160 piping and 3/8 inch tubing and will include a 3/4 inch manual isolation valve as described in Section 2.2. These lines connect to six

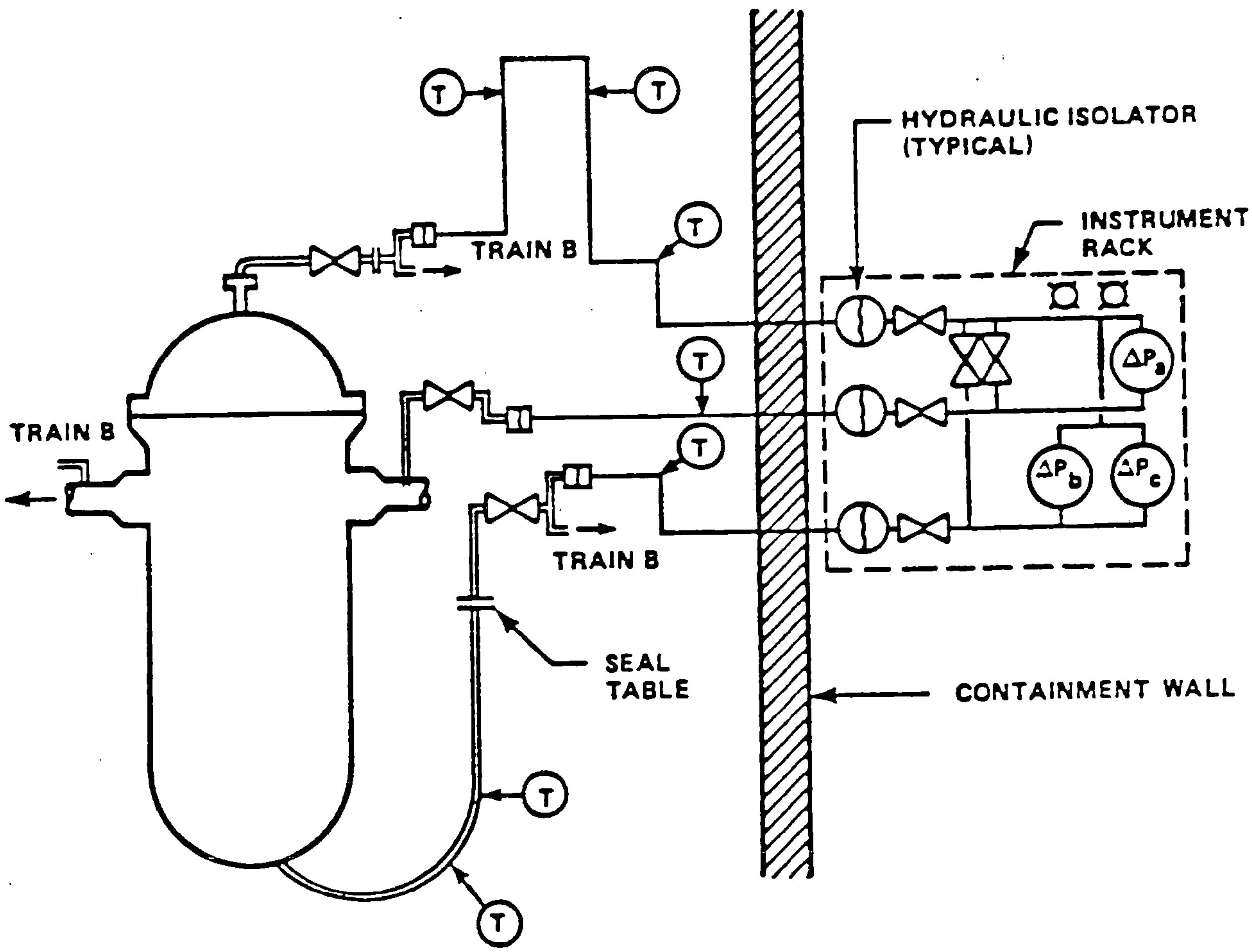


Figure 1-2 Process Connection Schematic, Train A

sealed capillary impulse lines (two at the reactor head, two at the seal table and one at each hot leg) which transmit the pressure measurements to the d/p transmitters located outside the containment building. The capillary impulse lines are sealed at the RCS end with a sensor bellows which serves as a hydraulic coupling for the pressure measurement. The impulse lines extend from the sensor bellows through the containment wall to hydraulic isolators, which also provide hydraulic coupling as well as a seal and isolation of the lines. The capillary tubing extends from the hydraulic isolators to the d/p transmitters, where instrument valves are provided for isolation and bypass.

Figure 1-3 is an elevation plan of a typical plant showing the routing of the impulse lines. The impulse lines from the vessel vent connection must be routed upward out of the refueling canal to the operating deck, then radially toward the seal table and then to the containment penetration. The connection to the bottom of the reactor vessel is made through an incore detector conduit which is tapped with a T connection at the seal table. The impulse

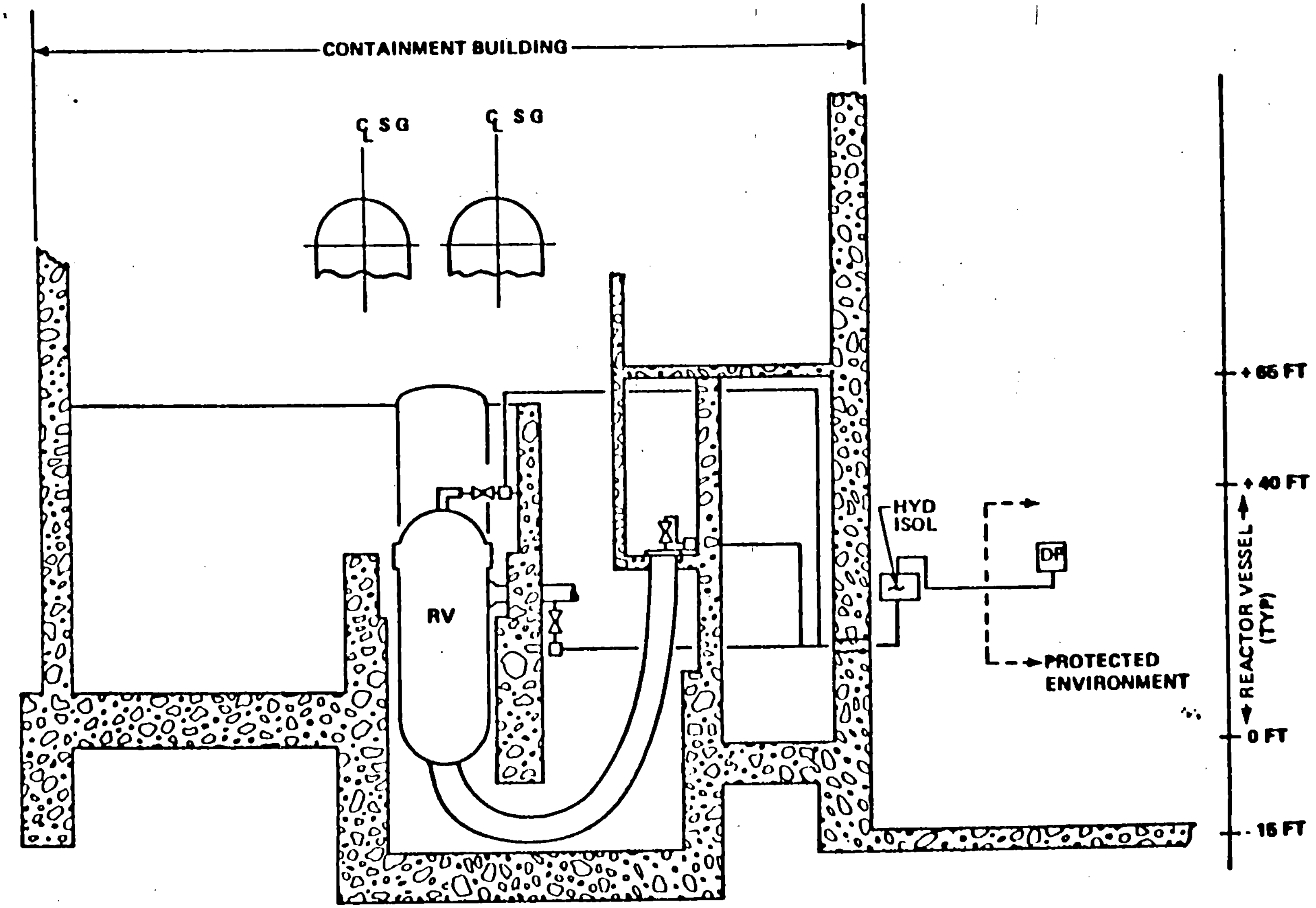


Figure 1-3 Plant Arrangement for RVLIS

line from this connection is routed axially and radially to join with the head connection line in routing to the penetrations. Similarly, the hot leg connection impulse lines are routed toward the seal table/penetration routing of the other two connections.

The impulse lines located inside the containment building will be exposed to the containment temperature increase during a LOCA or HELB. Since the vertical runs of impulse lines form the reference leg for the d/p measurement, the change in density due to the accident temperature change must be taken into account in the vessel level determination. Therefore, a strap-on RTD is located on each vertical run of separately routed impulse lines to determine the impulse line temperature and correct the reference leg density contribution to the d/p measurement. Temperature measurements are not required where all three impulse lines of an instrument train are routed together. Based on the studies of a number of representation plant arrangements, a maximum of 7 independent vertical runs must be measured to adequately compensate for density changes.

2. Following is the design analysis including the evaluation of various instruments employed in monitoring water level.

2.1 RESISTANCE TEMPERATURE DETECTORS (RTD)

The resistance temperature detectors (RTD) associated with the RVLIS are utilized to obtain a temperature signal for fluid filled instrument lines inside the containment during normal and post-accident operation. The temperature measurement for all vertical instrument lines is used to correct the vessel level indication for density changes associated with the environmental temperature change.

The RTD assembly is a totally enclosed and hermetically sealed strap-on device consisting of thermal element, extension cable, and termination cable as indicated in Figure 2-1. The sensitive portion of the device is mounted in a removable adapter assembly which is designed to conform to the surface of the tubing or piping being monitored. The materials are all selected to be compatible with the normal and post-accident environment. Randomly selected samples

a,b,c

Figure 2-1 Surface Type Clamp-On Resistance Temperature Detector from the controlled (material, manufacturing, etc.) production lot will be qualified by type testing. Qualification testing will consist of thermal aging, irradiation, seismic testing and testing under simulation high energy line break environmental conditions. The specific qualification requirements for the RTDs are as follows:

1. Aging

   The thermal aging test will consist of operating the detectors in a high temperature environment: either 400°F for 528 hours or per other similar Arrhenius temperature/time relationship.

2. Radiation

   The detectors shall be irradiated to a total integrated dose (TID) of 1.2×10^8 rads gamma radiation using a Co^{60} source at a minimum rate of 2.0×10^6 rads/hours and a maximum rate of 2.5×10^6 rads/ hour. Any externally exposed organic materials shall be evaluated or tested to 9×10^8 rads TID beta radiation. The energy of the beta particle shall be 6 MEV for the first 10 MRad, 3 MEV for 340 MRad, and 1 MEV for 150 MRad.

3. Seismic

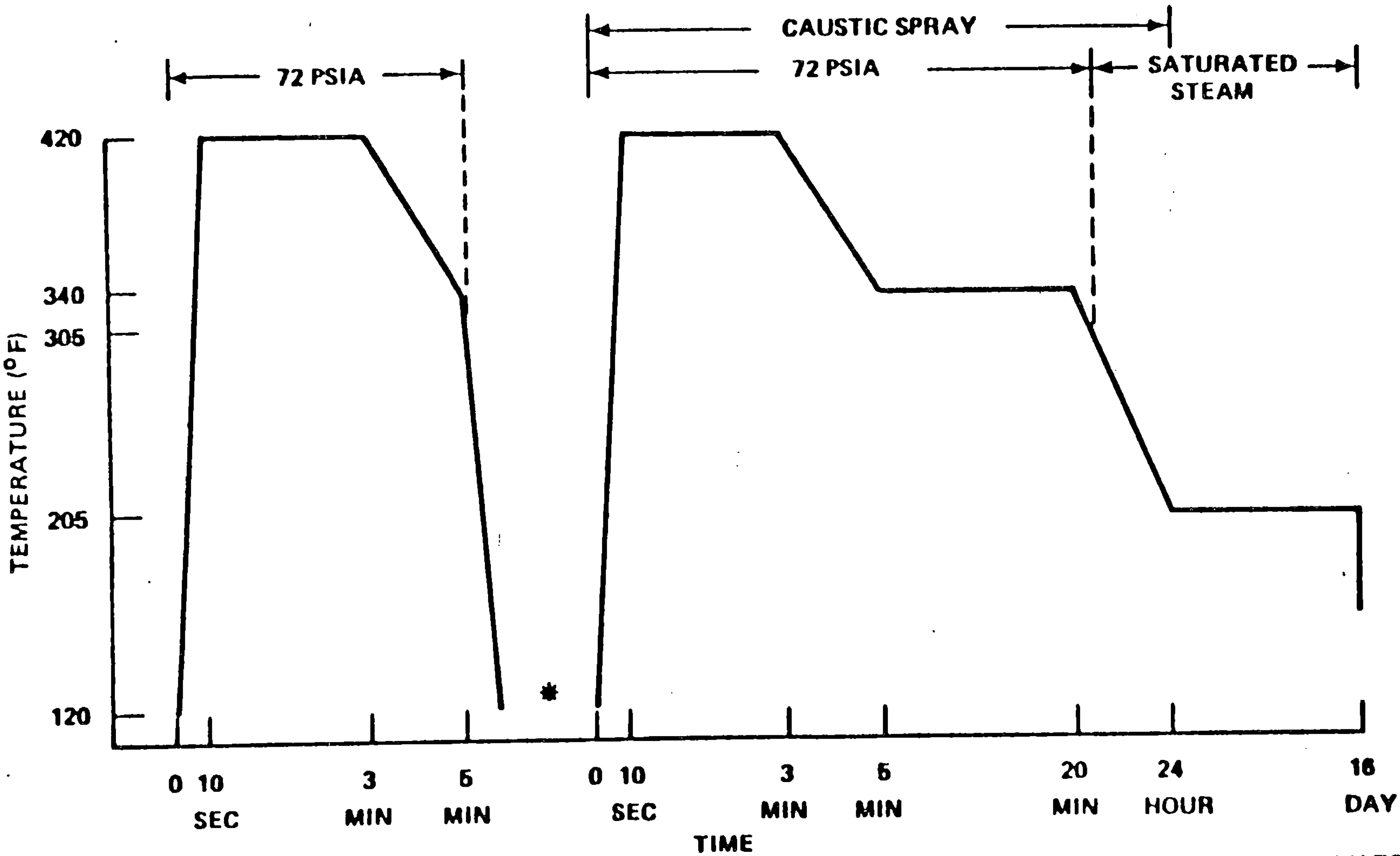
The detectors will be tested using a biaxial seismic simulation. The detectors shall be mounted to simulate a plant installation and will be energized throughout the test.

4. High Energy Line Break Simulation

The detectors shall be tested in a saturated steam environment using the temperature/pressure curve shown in Figure 2-2.

Caustic spray, consisting of 2500 ppm boric acid dissolved in water and adjusted to a pH 10.7 at 25°C by sodium hydroxide, shall be applied during the first 24 hours. The test units will be energized throughout the test.

The RTD device is designed to operate over a temperature range of -58° to 400°F (the normal temperature range is 50° to 130°F).



*TIME BETWEEN TEMPERATURE TRANSIENTS MUST BE AT LEAST ONE HOUR OR UNTIL TEST UNITS RETURN TO A STEADY STATE OUTPUT. TIME ABOVE 340°F MUST BE FIVE MINUTES OR LESS.

Figure 2-2 HELB Simulation Profile

2.2 REACTOR VESSEL LEVEL INSTRUMENTATION SYSTEM VALVES

Two types of valves are used for the RVLIS. The 3/4" root valves are ASME Class 1, stainless steel, globe valves. The basic function of the valve is to isolate the instrumentation from the RCS. The other valves (3/8" Anderson-Greenwood), are an instrumentation-type valve. It is a manually actuated globe valve used to provide isolation in the fully closed position.

2.3 TRANSMITTERS, HYDRAULIC ISOLATORS, AND SENSORS

2.3.1 Differential Pressure Transmitter

The d/p transmitters are of a seismically qualified design. In the RVLIS application, accuracy considerations dictate a protected environment, consequently transmitters are rated for 40 to 130^{o}F and 10^4 rad TID.

The special requirements for these transmitters are as follows:

1. Must withstand long term overloads of up to 300 percent with minimal effect on calibration.

2. High range and bi-directional units required for pump head measurements.

3. Must displace minimal volumes of fluid in normal and overrange operating modes.

The first two requirements are related to the vernier characteristic of the pumps off level measurements and the wide range measurements, respectively. The third is related to the limited driving displacement of the hydraulic isolator when preserving margins for pressure and thermal expansion effects in the coupling fluid.

The d/p transmitters are rated 3000 psig working pressure and all units are tested to 4500 psig. Internal valving also provides overrange rating to full working pressure.

2.3.2 Hydraulic Isolators

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Figure 2-3 ITT Barton Hydraulic Isolator Internal Scheme

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High Volume Sensors

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Figure 2-4 ITT Barton "High Volume" Sensor Bellows Check Valve

3. The following is a description of the test programs to be and being conducted for evaluation, qualification, and calibration of the RVLIS.

3.1 TEST PROGRAMS

A variety of test programs are in progress or will be carried out to study the static and dynamic performance of the RVLIS at two test facilities, and to calibrate the system over a range of normal operating conditions at each reactor plant where the system is installed. These programs will provide the appropriate verification of the system response to accident conditions as well as the appropriate procedures for proper operation, maintenance and calibration of the equipment. A description of these programs is presented in the following section:

3.1.1 Forest Hills Test Facility

A breadboard installation consisting of one train of a RVLIS was installed and tested at the Westinghouse Forest Hills, PA. Test Facility. The system consisted of a full single train of RVLIS hydraulic components (sensor assemblies, hydraulic isolators, isolation and bypass valves and d/p transmitters) connected to a simulated reactor vessel. Process connections were made to simulate the reactor head, hot leg and seal table connections. Capillary tubing which in one sensing line simulated the maximum expected length (400 feet) was used to connect the sensor assemblies to the hydraulic isolators and all joints were welded. Connections between the hydraulic isolators, valves and transmitters utilized compression fittings in most cases. Resistance temperature detectors, special large volume sensor bellows and volume displacers inside the hydraulic isolator assemblies which are normally part of a RVLIS installation were not included in the installation since elevated temperature testing was not included in the program.

The hydraulic isolator assemblies and transmitters were mounted at an elevation slightly below the simulated seal table elevation.

The objectives of the test were as follows:

1. Obtain installation, filling, and maintenance experience.

2. Prove and establish filling procedures for initial filling and system maintenance.

3. Establish calibration and fluid inventory maintenance procedures for shutdown and normal operation conditions.

4. Prove long term integrity of hydraulic components.

5. Verify and quantify fluid transfer and makeup requirements associated with instrument valve operations.

6. Verify leak test procedures for field use.

3.1.1.1 <u>Reactor Vessel Simulator</u>

The reactor vessel simulator consisted of a 40 foot long 2-inch diameter stainless steel pipe with taps at the top, side and bottom to simulate the reactor head, hot leg, and incore detector thimble conduit penetration at the bottom of the vessel. Tubing (0.375 inch diameter) was used to connect this lower tap to the sensor at the simulated seal table elevation and the hot leg sensor to the head connection was simulated by 1-inch tubing which connected the sensor to the vessel.

The reactor vessel simulator was designed for a pressure rating of 1400 psig to comply with local stored energy and safety code considerations.

3.1.1.2 Installation

The system was installed in the high bay test area of the Westinghouse Forest Hills Test Facility by Westinghouse personnel under the supervision of Forest Hills Test Engineering. All local safety codes were considered in the construction.

3.1.1.3 Filling Operation

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3.1.2 SEMISCALE TESTS

In order to study the transient response of the RVLIS during a small-break LOCA and other accident conditions, the hydraulic components of the RVLIS have been installed at the Semiscale Test Facility in Idaho. Vessel level measurements will be obtained during the current semiscale test program series which runs from December 1980 to March 1982. The tests scheduled to be completed by July 1981 are expected to provide the desired transient response verification; additional data will be obtained from the tests scheduled for completion by November 1981.

The Semiscale Test Facility is a model of a 4-Loop pressurized water reactor coolant system with elevation dimensions essentially equal to the dimensions of a full-size system. The reactor vessel contains an electrically heated fuel assembly consisting of 25 fuel rods with a heated length of 12 feet. Two reactor coolant loops are provided, each having a pump and a steam generator with a full height tube bundle. One loop models the loop containing the pipe break, which can be located at any point in the loop. The other loop models the three intact loops. A blowdown tank collects and cools the fluid discharged from the pipe break during the simulated accident. Over 300 pressure, temperature, flow, level and fluid density instruments are installed in the reactor vessel and loops to record the fluid conditions throughout the test run. Test results are compared with predictions for verification of computer code models of the transient performance.

The Westinghouse level measurements obtained during a test run will be compared with data obtained from existing instrumentation installed on the semiscale reactor vessel. The semiscale facility has two methods of measuring the level or fluid density: d/p measurements are obtained over 11 vertical spans on the reactor vessel to determine level within each span, and gamma densitometers are installed at 12 elevations on the reactor vessel to determine the fluid density at each elevation.

This data establishes a fluid density profile within the vessel under any operating condition, and this information will be compared with the data obtained from the Westinghouse level instrumentation. Other semiscale facility instruments (loop flows and fluid densities when pumps are operating, and pressure and temperatures for all cases) will provide supplemental information for interpretation of the test facility fluid conditions and the level measurement.

Specific tests included in the semiscale test program during which Westinghouse RVLIS measurements will be obtained are as follows:

1. Miscellaneous steady state and transient tests with pumps on and off, to calibrate test facility heat losses.

2. Small-break LOCA test with equivalent of a 4-inch pipe break.

3. Repeat of small-break LOCA test with test facility modified to simulate a plant with upper head injection (UHI).

4. Several natural convection tests covering subcooled and saturated coolant conditions and various void contents.

5. Tests to simulate a station blackout with discharge through relief valves.

6. Simulation of the St. Lucie cooldown incident.

3.1.3 PLANT STARTUP CALIBRATION

During the plant startup, subsequent to installing the RVLIS, a test program will be carried out to confirm the system calibration. The program will cover normal operating conditions and will provide a reference for comparison with a potential accident condition. The elements of the program are described below:

1. During refilling and venting of the reactor vessel, measurements of all 6 d/p transmitters would be compared to confirm identical level indications.

2. During plant heatup with all reactor coolant pumps running, measurements would be obtained from the wide range d/p transmitters to confirm or correct the temperature compensation provided in the system electronics. The temperature compensation, based on a best estimate of the flow and pressure drop variation during startup, corrects the transmitter output so that the control panel indication is maintained at 100 percent over the entire operating temperature range.

3. At hot standby, measurements would be obtained from all transmitters with different combinations of reactor coolant pumps operating, to provide the reference data for comparison with accident conditions. For any pump operating condition, the reference data, represents the

normal condition, i.e., with a water-solid system. A reduced d/p during an accident would be an indication of voids in the reactor vessel.

4. At hot standby, measurements would be obtained from the reference leg RTDs, to confirm or correct reference leg temperature compensation provided in the system electronics.

4. The following is an evaluation on the conformance of the RVLIS to NUREG-737.

4.1 OPERATING PERFORMANCE

Each train of the RVLIS is capable of monitoring coolant mass in the vessel from normal operation to a condition of complete uncovery of the reactor core. This capability is provided by the three d/p transmitters, each transmitter covering a specific range of operating conditions. The three instrument ranges provide overlap so that the measurement can be obtained from more than one display under most accident conditions. Capabilities of each of the measurements are described below:

1. Reactor Vessel - Upper Range

   The transmitter span covers the distance from the hot leg piping connection to the top of the reactor vessel. With the reactor coolant pump shut down in the loop with the hot leg connection, the transmitter output is an indication of the level in the upper plenum or upper head of the reactor vessel. The measurement will also provide a confirmation that the level is above the hot leg nozzles.

When the pump in the loop with the hot leg connection is operating, the d/p would be greater than the transmitter span, and the transmitter output would be deleted from the digital panel. An invalid status statement would be indicated.

2. Reactor Vessel - Narrow Range

The transmitter span covers the total height of the reactor vessel. With pumps shut down, the transmitter output is an indication of the collapsed water level, i.e., as if the steam bubbles had been separated from the water volume. The actual water level is slightly higher than the indicated water level since there will be some quantity of steam bubbles in the water volume. Therefore, the RVLIS provides a conservative indication of the level effective for adequate core cooling.

When reactor coolant pumps are operating, the d/p would be greater than the transmitter span, and the transmitter output would be deleted from the digital display panel. An invalid status statement would be indicated.

3. Reactor Vessel - Wide Range

The transmitter span covers the entire range of interest, from all pumps operating with a water-solid system to a completely empty reactor vessel and, therefore, covers the measurement spans of the other two instruments. Any reduction in d/p compared to the normal operating condition is an indication of voids in the vessel. The reactor coolant pumps will circulate the water and steam as an essentially homogeneous mixture, so there would be no distinct water level in the vessel. When pumps are not operating, the transmitter output is an additional indication of the level in the vessel, supplementing the indications from the other instruments.

The output of each transmitter is compensated for the density difference between the fluid in the reactor vessel and the fluid in the reference leg at the initial ambient temperature. The compensation is based on a wide range hot leg temperature measurement or a wide range system pressure measurement, whichever results in the highest value of water density, and, therefore, the lowest value of indicated level. Compensation based on temperature is applied when the system is subcooled, and compensation based on pressure (saturated conditions) is applied if superheat exists at the hot leg temperature measurement point.

The output of each transmitter is also compensated for the density difference between the fluid in the reference leg during an accident with elevated temperature in the containment and the fluid in the reference leg at the initial ambient temperature. The compensation is based on temperature measurements on the vertical sections of the reference leg.

The corrected transmitter outputs are shown on a digital display installed in the control room, one statement for each measurement in each train. A three-pen recorder is also provided in the control room to record the level or relative d/p and to display trends in the measurements. The display would also indicate which reactor coolant pumps are operating, and which level measurements are invalid due to pump operation.

During normal plant heatup or hot standby operation with all reactor coolant pumps operating, the wide range d/p display would indicate 100 percent on the display, an indication that the system is water-solid. If less than all pumps are operating, the display would indicate a lower d/p (determined during the plant startup test program) that would also be an indication of a water-solid system. With pumps operating, the narrow range and upper range displays would indicate off-scale.

If all pumps are shut down, at any temperature, the narrow range and upper range displays would indicate 100 percent, an indication that the vessel is full. The wide range d/p display would indicate about 33 percent of the span of the display, which would be the value (determined during the test program) corresponding to a full vessel with pumps shut down.

In the event of a LOCA where coolant pressure has decreased to a predetermined setpoint, existing emergency procedures would require shutdown of all reactor coolant pumps. In these cases, a level will eventually be established in the reactor vessel and indicated on all of the displays. The plant operator would monitor the displays and the recorder to determine the trend in fluid mass or level in the vessel, and confirm that the ECCS is adequately compensating for the accident conditions to prevent ICC.

Future procedures may require operation of one or more pumps for recovery from certain types of accidents. When pumps are operating while voids are developing in the system, the pumps will circulate the water and steam as an essentially homogeneous mixture. In these cases, there will be no discernible level in the reactor vessel. A decrease in the measured d/p compared to the normal operating value will be an indication of voids in the system, and a continuously decreasing d/p will indicate that the void content is increasing, that mass is being lost from the system. An increasing d/p will indicate that the mass content is increasing, that the ECCS is effectively restoring the system mass content.

4.2 RVLIS ANALYSIS

In order to evaluate the usefulness of the RVLIS during the approach to ICC, it was decided to determine the response of the RVLIS under a variety of fluid conditions. The RVLIS response was analytically determined for a number of small break transients. The response was determined by calculating the pressure difference between the upper head and lower plenum and converting this to an equivalent vessel head in feet. (Note that RVLIS indications will actually be represented by percent of span). Saturation density at the fluid temperature in the upper plenum was used for this conversion. This approximates the calibration that will be used for the RVLIS.

This indication corresponds to the RVLIS configuration used for non-UHI plants. The indication of the upper span (hot leg to upperhead) is not included in this analysis.

When the reactor coolant pumps are not operating, the RVLIS reading will be indicated on the narrow range scale ranging from zero to the height of the vessel. A full scale reading (100 percent of span) is indicated when the vessel is full of water. This reading represents the equivalent collapsed liquid level in the vessel which is a conservative indication of the approach to ICC. The RVLIS indication can alert the operator that a condition of ICC is being approached and the existance of ICC can be verified by checking the core exit thermocouples. When the reactor coolant pumps are operating, the narrow range RVLIS meter will be pegged at full scale.

When the reactor coolant pumps are operating, the RVLIS reading will be indicated on the wide range scale which reads from 0 to 100 percent. The 100 percent reading corresponds to a full vessel with all of the pumps in operation.

With the pumps running, the RVLIS reading is an indication of the void fraction of the vessel mixture. As the void content of the vessel mixture increases, the density decreases and the RVLIS reading will decrease due to the reduction in static head and frictional pressure drop. The latter effect will be enhanced by degradation in reactor coolant pump performance. When this reading drops to approximately 33 percent, there will also be an indication on the narrow range scale. This fraction approximately corresponds to a vessel mass which would just cover the core if the pumps were tripped.

A small break transient (1 inch cold leg break - no high head safety injection; NOTRUMP) for a 4 loop, non-UHI, 3411 MWT plant is discussed in the next section. This case was obtained from the ICC analysis using NOTRUMP. A description of NOTRUMP can be found in References 1 through 6 in Section A.

A discussion of this transient is provided in the next section. Figures 4-1 through 4-4 provide plots of vessel two phase mixture level, RVLIS narrow range reading, mixture and vessel void fraction.

The two-phase mixture level plotted is that which was predicted by the codes for the mixture height below the upper support plate. Water in the upper head is not reflected in this plot. The RVLIS reading that would be seen is plotted on the same figure for ease of comparison.

a,b,c

Figure 4-1 Case D 1 Inch Cold Leg Break, ICC Case, RVLIS Reading and Mixture Level.

a,b,c

Figure 4-2 Case D 1 Inch Cold Leg Break, ICC Case, Mixture Level, RVLIS Reading and Measured Inventory.

a,b,c

Figure 4-3 Case D 1 Inch Cold Leg Break, ICC Case, RVLIS Reading and Mixture Level.

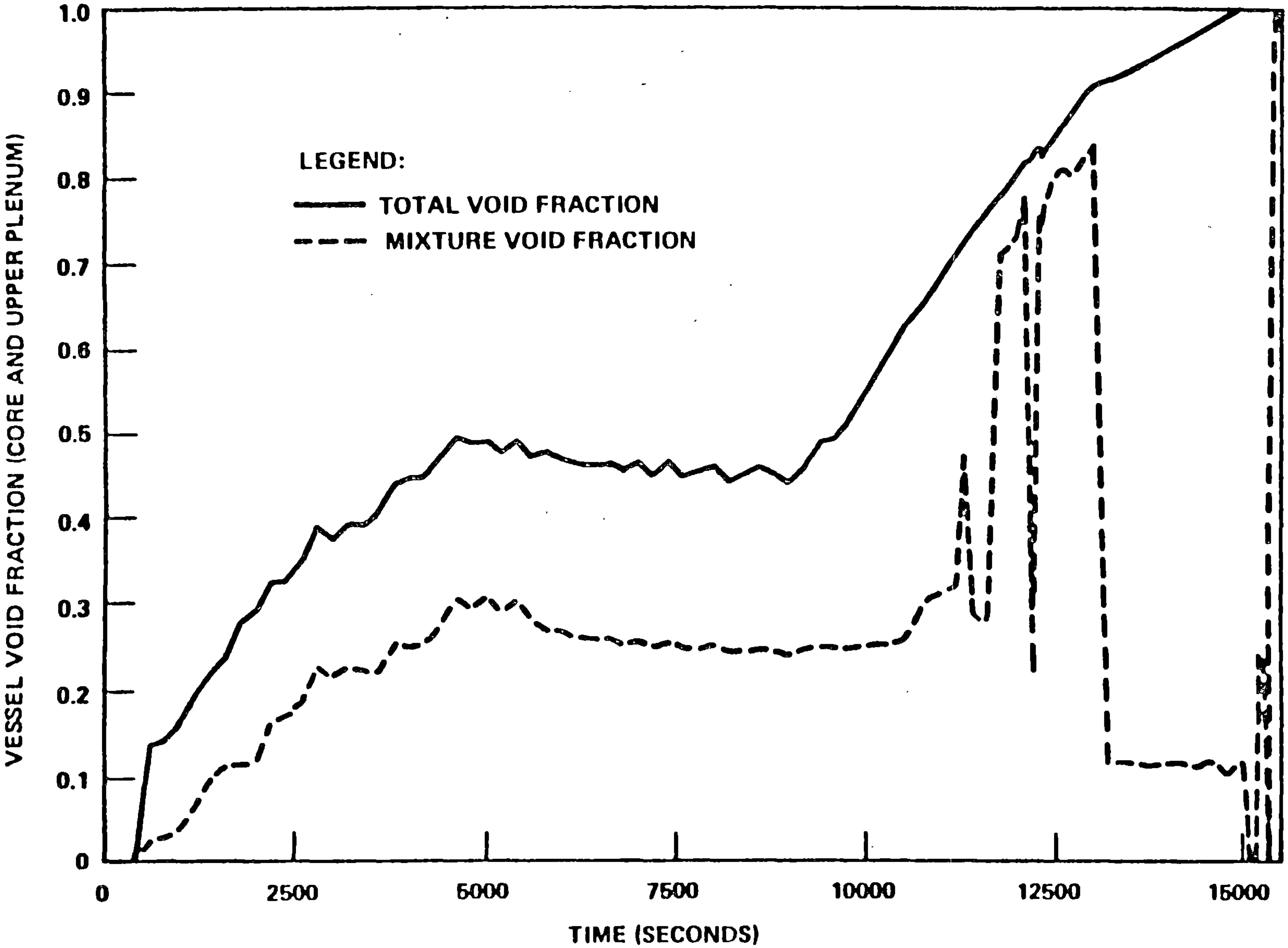

Figure 4-4 Case D 1 Inch Cold Leg Break, ICC Case, Void Fraction

17917-33

The void fraction plots are for the core and upper plenum fluid volumes. The mixture void fraction includes the volume below the two phase mixture level while the total void fracture also includes the steam space above the mixture level.

4.2.1 Investigated Transient

This case (4Loop, non-UHI, 3411 MWT plant, 1 inch cold leg break-no high head safety injection) is one of the transients investigated for the ICC study using NOTRUMP. A more detailed discussion of this transient can be found in Reference 1.

The RVLIS reading is below the vessel mixture level throughout most of the transient and is therefore a conservative indication. The RVLIS reading follows the same trend as the vessel mixture level, except for early in the transient when the mixture void fraction is fluctuating.

4.2.2 Observations Of The Study

The RVLIS will provide useful information for breaks in the system ranging from small leaks to breaks in the limiting small-break range. For breaks in this range, the system conditions will change at a slow enough rate that the operator will be able to use the RVLIS information as a basis for some action.

For larger breaks, the response of the RVLIS will be more erratic, due to rapid pressure changes in the vessel, in the early portion of the blowdown. The RVLIS reading will be useful for monitoring accident recovery, when other corroborative indications of ICC could also be observed.

Very few instances have been identified where the RVLIS may give an ambiguous indication. These include a break in the upper head, accumulator injection into a highly voided downcomer, periods of time when the upper head behaves like a pressurizer, and periods of void redistribution.

A break in the upper head may cause a much lower pressure to exist in the upper head compared to the rest of the RCS.

Because of this, the pressure difference between the lower plenum and the upper head is much larger than is seen for an equivalent vessel level when the break is located elsewhere in the system. The reading, in fact, may never reach the narrow range scale. If the narrow range reading remains at full scale and the wide range reading is greater than that reading which would indicate a full vessel with the reactor coolant pumps tripped, a break in the upper head is indicated. This situation should not cause a problem in detecting ICC because of the parallel logic for the "kickout" to the ICC procedures. If the RVLIS indication is erroneous due to a break in the reactor vessel upper head, the operator will begin following the ICC procedure if the selected core exit thermocouples read 1200°F.

This situation only exists, however, when the break discharge is large enough to cause a large d/p through the flow paths connecting the upper head to the rest of the system. These flow paths become the limiting factor in the depressurization rate.

The time, when ambiguous indications due to accumulator injection and upper head pressurizer behaviour is brief. The situation corrects itself and the RVLIS resumes giving a good indication of the trend in level. Both situations result in an indication of vessel level that is low. The operator must know that a brief period of erratic RVLIS indication may occur when accumulators are injecting. This effect is partially real in that the vessel level may depress for a moment when accumulator injection occurs. Unlike accumulator injection, the operator will not know when the indicated vessel level is being affected by the upper head pressurizer phenomena. However, no premature indication of ICC will occur since the core exit thermocouples will still read saturation temperature.

During periods when the void distribution in the vessel is changing rapidly, there may be a large change in two-phase mixture level with very little change in mass inventory in the vessel. This could happen if the reactor coolant pumps (RCPs) were tripped when the mixture in the vessel was highly voided. This could cause the mixture level to drop from the hot leg elevation to below the top of the core. The operator would expect this to happen based on the fact that the RVLIS reading was within the narrow range indication.

The operator should know in general that, for a brief period of time after tripping the RCPs, transient RVLIS response will occur.

Flow blockage is not expected to decrease the usefulness of the RVLIS indication. The increased d/p due to the flow blockage will be small during natural circulation. The RVLIS will continue to follow the trend in vessel level. When the reactor coolant pumps are operating, flow blockage is not expected to occur unless the pumps had previously been tripped and are being restarted after an ICC situation already exists. If flow blockage were present when the pumps were running, the RVLIS indication would still be useful and, although the indication would be somewhat higher, would continue to follow the trend in vessel inventory.

4.2.3 Conclusions

1. With the RCPs tripped, the Westinghouse RVLIS will result in an underpredicted indication of vessel level while providing an unambiguous indication of the mass in

the vessel. The Westinghouse RVLIS will also measure the vessel level trend reasonably well.

2. With the RCPs tripped, it is feasible to determine a setpoint for the RVLIS to warn the operator that the system is approaching an uncovered core.

3. The RVLIS should be used along with the core exit thermocouples to detect ICC.

4. With the RCPs running, the RVLIS is an indication of the mass in the vessel.

5. When the RCPs are running, and the RVLIS reading drops to the narrow range scale, there is significant voiding in the vessel and the core would just be covered if the pumps were tripped.

6. A break of sufficient size in the upper head could cause the RVLIS to give an ambiguous indication of vessel mass. The core exit thermocouples, however, will provide an indication of ICC if appropriate.

7. Accumulator injection when the downcomer is highly voided could result in a temporarily erratic indication.

8. The RVLIS may significantly underpredict the vessel mass while fluid in the upper head is flashing. However, use of the core exit thermocouples will preclude a premature entry to the ICC procedures.

9. Rapid void redistributions will not be detected by the RVLIS.

5. Following is a description of the computer functions associated with RVLIS.

5.1 MICROPROCESSOR FOR RVLIS

The microprocessor RVLIS indications include equivalent reactor vessel level on redundant flat panels with alphanumeric displays provided for control room installation in addition to having this information available for display at the microprocessor chassis. RVLIS is configured as two protection sets in separated sections of a single instrument rack. The envelope of an instrument rack occupies a space at the base of [ ]. The block diagram of the RVLIS using microprocessor equipment is shown in Fugure 5-1. This diagram shows that in addition to the reactor vessel level (d/p) transmitter input, there are also temperature compensating signals, reactor pump running status inputs, and RCS parameter inputs to each a,c

a,c

Figure 5-1 Reactor Vessel Level Instrument System Block Diagram (One Set of Two Redundant Resets Shown) chassis of the two redundant sets. The output of each set will be to displays and to a recorder, as well as an output for a serial data link. A general display arrangement is shown in Figure 5-2.

Conformance with Regulatory Guide 1.97 for the processor display system is given in Table 5.1.

5.1.1 RVLIS Inputs

The microprocessor system inputs are as follows:

5.1.1.1 Differential Pressure Transmitters

The three d/p transmitters per set are used to measure the d/ps between the three pressure tap points on the primary system, as discussed below:

1. [ ] a,c

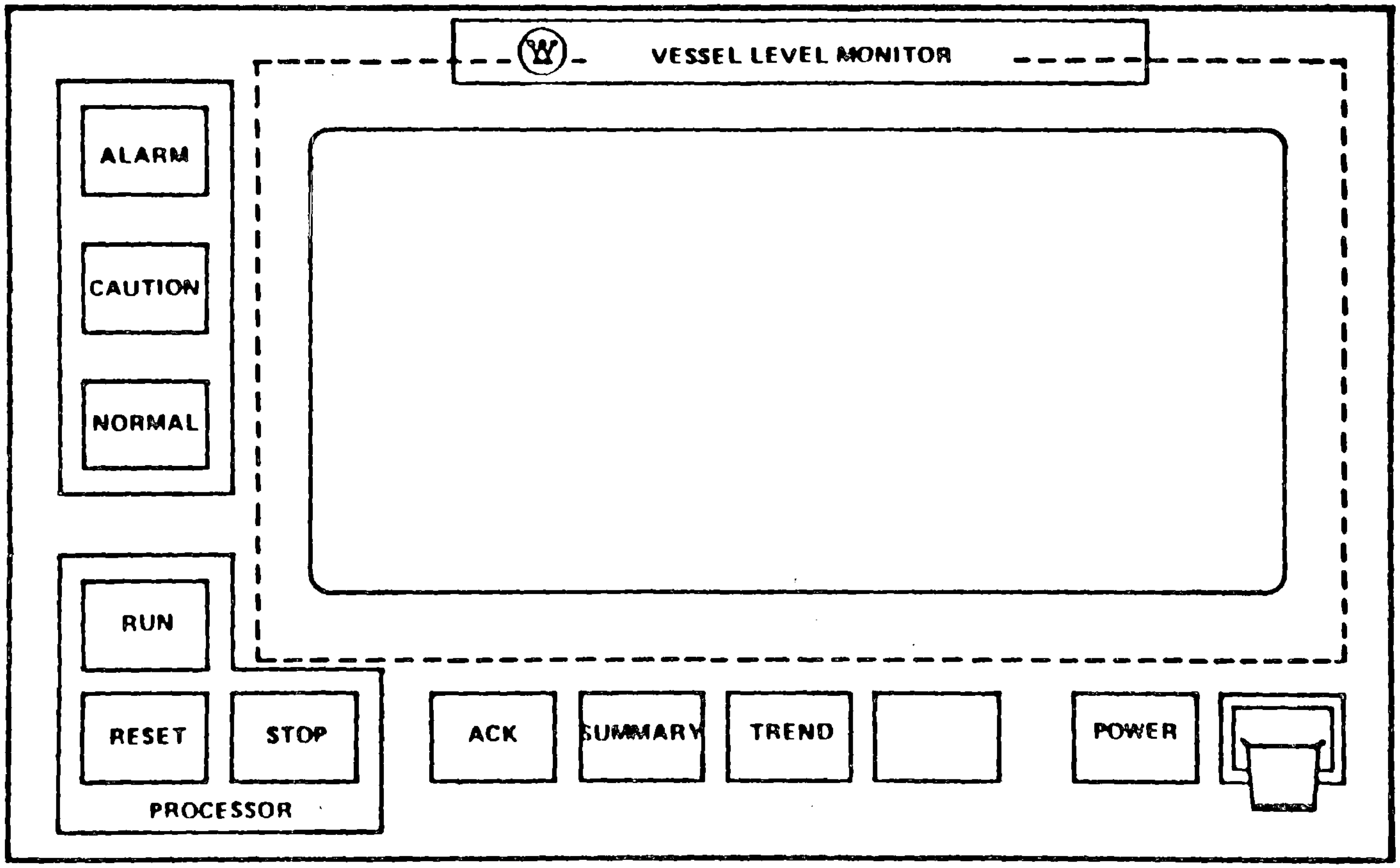

Figure 5-2 Remote Display Modu.. (Control Boarc)

[ ]a,c

The direction of this transmitter's output is full scale (20 ma) with the vessel full and zero scale (4 ma) with the vessel emptied to the hot leg tap.

TABLE 5.1

CONFORMANCE WITH REGULATORY GUIDE 1.97, DRAFT 2
REV. 2 (6/4/80) FOR THE MICROPROCESSOR DISPLAY SYSTEM

Seismic qualification	Yes
Single failure criteria	Yes
Environmental qualification *[IEEE-323-1971 applicability]	Yes
Power Source	Vital
Quality Assurance 10CFR50 Appendix B applicability	Yes
Display type and method	Vertical scale voltage processed in addition to a recorder
Unique identification	Yes
Periodic Testing	Yes

* In some cases IEEE-323-1974 is applicable.

These endpoints are nominal and are for low coolant temperatures. If no pumps are operating, ΔP_a gives an indication of level in the region above the hot leg.

If the pump is running in the loop with the hot leg connection, this indication will be invalid and most likely off-scale. The reading would be flagged as "invalid" under these conditions. The effect on the indication from the pump not running in this loop, but running in other loops, is less than 10 percent of the range.

a,c

2.

ΔP_b gives an indication of reactor vessel level when no pumps are running. If one or more pumps are running, ΔP_b will be off-scale and the reading invalid.

The sense of the ΔP_b output is such that a 20 ma signal is a nominally full vessel and a 4 ma signal is for a nominally empty vessel.

3. [ ] a,c

The sense of the ΔP_c output is that 20 ma represents all pumps running and 4 ma is empty vessel. With all pumps running and no void fraction, the ΔP_c should read 100 percent at zero power. The reading at full power is slightly higher.

5.1.1.2 Reference Leg Temperature RTD

The reference leg temperature RTDs are used to measure the temperature of the coolant in the capillary tube reference legs. This is used to compute the density of the reference leg fluid.

The arrangement of the reference leg temperature RTDs is shown in Figure 5-3.

The conversion of RTD resistance to temperature shall cover the temperature range of 32° to 450°F.

The RTDs are 100 ohm platinum four wire RTDs as shown in Figure 2-1.

5.1.1.3 Hot Leg Temperature

Existing hot leg temperature sensors are used to measure the coolant temperature. These sensors are being replaced yearly. This temperature is used to calculate coolant density.

a,b,c

Figure 5-3 Typical Plant Arrangement For RVLIS

5.1.1.4 Wide Range Reactor Coolant Pressure

Existing or new wide range pressure sensors will be used to measure reactor coolant pressure. The pressure is used to calculate reactor coolant density. The block diagram of the compensation functions is shown in Figure 5-4.

5.1.1.5 Digital Inputs

The reactor coolant pump status signals indicate whether or not pumps are running. Recognizing that hydraulic isolators are provided on each impulse line for containment isolation purposes, each hydraulic isolator has limit switches to indicate they have reached the limit of travel.

5.1.1.6 Density Compensation System

To provide the required accuracy for vessel level measurement, temperature measurements of the impulse line are provided. These

a,b,c

Figure 5-4 Block Diagram of Compensation Function measurements, together with the existing reactor coolant temperature measurements and wide range RCS pressure, are employed to compensate the d/p transducer outputs for differences in system density and reference leg density, particularly during the change in the environment inside the containment structure following an accident. A simplified schematic of the density compensation system is shown in Figure 5-5. The d/p cells are located outside the containment.

The reference leg fluid density calculation covers a range of 32° to 450°F. The fluid is assumed to be compressed liquid water at 1200 psia.

Each of the three d/p measurements will have density corrections from certain temperature measurements. Some of these will have a positive correction and some negative depending on the orientation of the

a,c

Figure 5-5 Simplified Schematic of Density Compensation System impulse line where the temperature is being measured.

5.1.1.7 Vessel Liquid Density Calculation

a,c

[ ]

5.1.1.8 Vessel Vapor Phase Density Calculation

a,c

[ ]

a,c

5.1.1.9 Vessel Level Calculation

a,c

5.1.1.10 Pump Flow d/p Calculation

a,c

a,c

The lower of the two calculated d/p corrections is divided into the measured d/p. The result is the percent of expected d/p and should read 100 percent will all pumps operating and no circulating voids.

5.1.1.11 Scaling of Displayed Values

Each of the three d/p measurements after the preceding calculations shall be scaled to read in percent. With the vessel full of water and no pumps running, the outputs of ΔP_a and ΔP_b should read 100 percent.

5.1.2 <u>Plant Operator Interface and Displays</u>

Information displayed to the operator for the RVLIS is intended to be unambiguous and reliable to minimize the potential for operator error or misinterpretation. The redundant control room displays provide the following information:

a,c

1.

2.

a,c

3.

All signals are input to a microprocessor-based data analysis system. The control room display format utilizes an alpha-numeric display located remotely from the computational system.

Redundant displays are provided for the two sets. Level information based on all three d/p measurements is presented. Correction for reference leg densities is automatic. Any error conditions such as out-of-range sensors or hydraulic isolators are automatically displayed on the affected measurements.

There are two display formats for reactor vessel level: the first is a summary format, and the second is a trending of the three vessel level indications.

a,c

5.1.3 Display Functions for Remote Control Panel

The prime display unit for the vessel level monitor is the 8 line, 32 character per line alphanumeric display which is located in the control room.

5.1.3.1 Vessel Level Monitor Summary Display

Figures 5-2, 5-6, and 5-7 give example displays. General arrangement is shown on Figure 5-2. The vessel level summary display is shown on Figure 5-6. The following is a description of the display.

REACTOR VESSEL LEVEL SUMMARY

	VALUE	NORMAL	STATUS
PLENUM LEVEL	73%	100%	ALARM
VESSEL LEVEL	47%*	0%	INVALID
FLOW HEAD	>110%*#	100%	OFF SCA

PUMPS RUNNING: 41, 42, 43, 44

• ISOLATOR ALARMS: LI3

DISABLED: T3 TH1

Figure 5-6 Vessel Level Summary Display

REACTOR VESSEL LEVEL TREND

TIME MIN	PLENUM LEVEL	VESSEL LEVEL	FLOW HEAD
00	73%	47% I	>110% OS
-15	78%	49% I	98%
-30	79%	52% I	97%
-45	82%	56% I	98%
-60	97%	99% I	99%

Figure 5-7 Vessel Level Trend Display

1. The first line gives the title of the display as shown. The use of the underbar feature delineates this line from the rest of the display.

2. The second line gives column headings as shown. Again, the use of the underbar clarifies the display.

3. The third line gives the measured and normally expected values from the ΔP_a measurement. The first field gives the title, the second gives the measured level, the third gives the normal value for the current status, and the last field gives the validity status and is blank under normal conditions.

4. The fourth line gives the ΔP_b measurement results using the same format as in line 3.

5. The fifth line gives the ΔP_c measurement results using the same format as

in line 3. The use of underbar in line 5 delineates this line from the next.

6. The sixth line gives the status of the pumps as seen by the unit. The running pumps are identified.

7-8. The seventh line and eight line are normally left blank and are reserved for hydraulic isolator limit switch indicators, out of range sensors and operator disabled sensors.

5.1.3.2 Trend Display

The trend display for the vessel level monitor shall use the format shown in Figure 5-7.

5.1.3.3 Displays on Main Processing Unit

The one-line forty character alphanumeric display on the front panel of the main processing unit is used to display individual sensor inputs. The sensor is selected with a two digit thumbwheel switch.

The following information is given for each sensor:

1. Sensor identification
2. Input signal level
3. Input signal converted to engineering units
4. Status of sensor input

5.1.4 Disabled Inputs

Any inputs can be disabled by the operator. This action is under the control of a keyswitch on the front panel of the main computational unit and causes the processor to disregard the analog input for that variable.

6. The current schedule for installing, testing, and calibrating the R VLIS is during the first refueling outage for this unit.

7. Guidelines for the use of the RVLISA and analyses used to develop these procedures.

7.1 Reference Owners Group Procedures

Based on the analyses defined in Section 7.1.1 below and Section 4.2 of this report, Westinghouse Owners Group have developed a Reference Emergency Operating Instruction to address recovery from ICC conditions caused by a small break LOCA without high head safety injection. This instruction has been transmitted to the NRC via Westinghouse Owners Group letter OG-44, dated 11/10/80.

7.1.1 Conditions or Events which Describe the Approach to ICC

The most obvious failure that would lead to ICC during a small break LOCA, although highly unrealistic since multiple failures are required is the loss of all high pressure safety injection. The approach to ICC conditions and the analyses of this event sequence are provided in Section A, References 1 and 2.

7.2 Sample Transient

The response of the vessel level indications and system response during these ICC events and recovery actions are described in Section A, References 1 and 2.

A. REFERENCES

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