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July 6, 1984
5211-84-2173

Office of Nuclear Reactor Regulation
Attn: J. F. Stolz, Chief
Operating Reactors Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Inadequate Core Cooling (NUREG-0737 II.F.2)

By letter dated June 14, 1983, the NRC provided conceptual design approval of our proposed RCS Inventory Trending System. The NRC further identified several concerns and requested a schedule for providing the requested information. By letter dated January 31, 1984, GPUN provided partial responses to the requested items and provided an interim system design description. The final design description (Attachment 1) is submitted in fulfillment of the first milestone commitment discussed in our response of March 10, 1983 (Drawing will be sent separately). Responses to the remainder of the requested items will be submitted in July, 1984.

Attachment 2, entitled "RCS Coolant Inventory Trending (CIT) with RC Pumps Operating", provides the method for developing void fraction for various RCS pump configurations based on motor power. This attachment replaces Attachment 2 of our submittal on January 31, 1984 which used motor current. Part of the information (as marked) in this submittal is considered proprietary by Babcock & Wilcox Co. under the provision of 10CFR2.790 as sworn by J. H. Taylor, Manager, Licensing, and should be treated as such. Mr. Taylor's affidavit was attached to the submittal for Rev. 0 of this report. Revision 1 contains an additional proprietary section, Section 2.6, not included in Revision 0. The pages Exhibit A and B have been revised to reflect the document revision.

Regs: LPDR, PDR, NTIS, NSIC } Non Prop

A002 1/1

Attachment 3 entitled "ICC Instrumentation Schedule (RCITS)" revises the previous schedule provided in our response of March 10, 1982. The new schedule does not change our commitment to install the RCITS by startup from the Cycle 6 refueling outage (which is postponed until at least August 1985). However, as discussed in our response to Commissioner Gilinsky of November 23, 1983, GPUN plans to complete installation in the fourth quarter of 1984 assuming TMI-1 has not restarted by then. Revision of the scheduled dates is based on more realistic engineering and construction projections and a finalization of the design.

Concerning the status of the RCITS, GPUN has completed both a tap in the DHR dropline and a tie-in to the RV head vent, and is currently installing additional portions of the system inside the TMI-1 Reactor Building.

Sincerely,

RJ Toole for

H. D. Hukill
Director, TMI-1

HDH/LWH/SMO/mle

Attachments

cc: R. Conte
J. Van Vliet

ATTACHMENT 1

Final

System Design Description

For

Three Mile Island Unit 1

Reactor Coolant Inventory

Trending System

1.0 DESIGN DESCRIPTION

1.1 SUMMARY

The purpose of this modification is the addition of a Reactor Coolant Inventory Tracking System (RCITS) to the Three Mile Island Nuclear Generating Station Unit 1.

The RCITS provides a means for the Control Room operator to monitor the water inventory of the reactor coolant system (RCS). The RCITS is operational when the reactor coolant pumps are on or off. Displayed water inventory data with the pumps off is useful as confirmatory information to other instrumentation of conditions which may interrupt natural circulation leading to a potential Inadequate Core Cooling (ICC) event. The following water inventory displays are available for the control room operator when the pumps are off:

a. Hot leg of primary loop 'A' level
b. Hot leg of primary loop 'B' level
c. Reactor vessel '1' level (above Fuel)
d. Reactor vessel '2' level (above Fuel)

Each of these displays is compensated for fluid density variations. This compensation is required to correct the level indications for two conditions. The first is density changes in the fluid in the reactor vessel and reactor coolant piping due to temperature and pressure variations within the RCS. The second condition is density changes in the level transmitter reference legs due to variations in the ambient reactor containment building temperature.

The RCITS also provides a means for the control room operator to monitor the void content of the reactor coolant system when the pumps are running. Displayed void fraction data provided by the RCITS will be useful as anticipatory information of conditions which may interrupt normal circulation. Void fraction displays are provided for each of the four Reactor Coolant Pumps (RCP's).

1.2 REFERENCES

1.2.1 Industry

1.2.1.1	IEEE Standard 323-1974	Qualifying Class 1E Equipment for Nuclear Power Generating Stations
1.2.1.2	IEEE Standard 344-1975	Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations
1.2.1.3	IEEE Standard 383-1974	Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations
1.2.1.4	NRC Regulatory Guide 1.89 Rev. 0	Qualification of Class 1E Equipment for Nuclear Power Plants
1.2.1.5	NRC Regulatory Guide 1.100, Rev. 1	Seismic Qualification of Electric Equipment for Nuclear Power Plants
1.2.1.6	NUREG 0680 Sup. 3	TMI-1 Restart SER
1.2.1.7	NUREG 0700	Human Factors Design Criteria for Control Rooms
1.2.1.8	NUREG 0737 II.F.2	Inadequate Core Cooling
1.2.1.9	USNRC-7590-01 of Dec. 10, 1982	Order for Modification of License for TMI-1 to Accommodate Additional Instrumentation to Detect Inadequate Core Cooling.
1.2.1.10	ASME Section III (latest approved edition)	Boiler and Pressure Vessel Code

1.2.2 GPU Nuclear

1.2.2.1	1000-PLN-7200.01, Rev. 0	GPUN Operational Quality Assurance Plan

1.2.2.2	SP-5616	GAI Specification for Electrical Work at Three Mile Island Nuclear Station Unit 1
1.2.2.3	SP-9000-44-001, Rev. 0	Specification for Instrument and Control Equipment Installation
1.2.2.4	TDR 282, Rev. 2	TMI-1 Qualified Equipment Locations and Environments
1.2.2.5	SDD 662C (DIV. I), Rev. 6	System Design Description No. 662C DIV. I, Reactor Coolant Inventory Tracking System
1.2.2.6	SP-90003-201, Rev. 3	GPUN Specification for Piping and Fittings.
1.2.2.7	SP-1101-43-004	Conduit and Conduit Support Installation Criteria for TMI-1
1.2.2.8	SP-5544	GAI Specification for Plant Piping at Three Mile Island Nuclear Station
1.2.2.9	SP-5661	GAI Specification for Field Fabrication and Erection of Piping at Three Mile Island Nuclear Station Unit 1
1.2.2.10	6150-ADM-3272.01,Rev.0	Inservice Inspection Program Development and Implementation
1.2.3	<u>Burns and Roe, Inc.</u>	
1.2.3.1	Drawing M0002, Rev. 0	Flow Diagram - Reactor Coolant Vents Reactor Coolant Inventory Tracking System
1.2.3.2	Drawing M0003, Rev. 0	Flow Diagram - Decay Heat Removal Reactor Coolant Inventory Tracking System
1.2.3.3	Drawing E002, Rev. 0	TMI Unit 1 Control Room Panel PCL (RCITS)

1.2.3.4	Drawing E003, Rev. 0	Loop Diagram - Hot Leg of Primary Loop 'A' Level (RCITS)
1.2.3.5	Drawing E004, Rev. 0	Loop Diagram - Hot Leg of Primary Loop 'B' Level (RCITS)
1.2.3.6	Drawing E005, Rev. 0	Loop Diagram - Reactor Vessel Loop 'A' Level Above Fuel (RCITS)
1.2.3.7	Drawing E006, Rev. 0	Loop Diagram - Reactor Vessel Loop 'B' Level Above Fuel (RCITS)
1.2.3.8	Drawing E007, Rev. 0	Loop Diagram - Reactor Vessel Level for RCS draindown
1.2.3.9	Drawing E012, Rev. 1	Block Diagram - Reactor Coolant Inventory Tracking System

1.2.4 Gilbert Associates, Inc.

1.2.4.1	Drawing 202-095, Sht. RK-1, Rev. IA-0	Block Diagram - Reactor Coolant Inventory Tracking System
1.2.4.2	Drawing 202-095, Sht. RK-2, Rev. IA-0	Block Diagram - Reactor Coolant Inventory Tracking System
1.2.4.3	Drawing 202-095, Sht. RK-3, Rev. IA-0	Block Diagram - Reactor Coolant Inventory Tracking System

1.3 DETAILED SYSTEM DESCRIPTION

1.3.1 Water Level Trending Subsystem

The water level trending portion of the RCITS is shown on Burns and Roe drawings M0002, M0003, E002, E003, E004, E005, E006, E007 and E012, and Gilbert Associates drawings 202-095, sheets RK-1, RK-2 and RK-3. Drawings M0002 and M0003 are flow diagrams which identify where instrumentation is connected to the reactor coolant system and the decay heat removal system. Drawings E003, E004, E005, E006 and E007 are instrument loop diagrams which

identify the details of each instrument loop. Drawings E012 and 202-095, sheets RK-1, RK-2 and RK-3 are block diagrams which identify the interconnections for the major electrical components. There are five level measurements that are part of the RCITS. y are classified "Important to Safety" and "Nuclear Safety Related." Details of these level measurements are as follows:

1.3.1.1 Hot Leg Level Primary Loop A

Differential pressure transmitter RC-LT-1033 is installed between an upper connection at the top of steam generator RC-H-1A's hot leg and a lower connection upstream of decay heat line isolation valve DH-V-1. This instrument measures the water level from the bottom to the top of reactor coolant loop A hot leg piping.

The upper connection for RC-LT-1033 is equipped with a condensate pot and provides a water column reference leg for the transmitter.

Resistance temperature detector RC-TE-1033 senses the temperature of the water in RC-LT-1033's reference leg to compensate for density changes. The signal provides density correction for both RC-LT-1033 and RC-LT-1035, since both reference legs are routed together, and will be exposed to the same ambient temperature.

Thermocouple RC-TE-1054 senses reactor coolant system core exit temperature which is used to compensate for density changes in the reactor vessel head and hot leg fluids. Resistance temperature detector RC-TE-1052 provides a cold junction reference temperature for thermocouple RC-TE-1054.

RC-TE-1054 is mounted in the existing Incore Detector Instrumentation structure, detector well No. 7. RC-TE-1052 is mounted in terminal box T-1118 on the secondary shield wall near the incore detector rack, Reactor Building elevation 346'-0".

RC-LT-1033 is mounted on existing instrument rack No. TR10A at elevation 281'-0 inside the Reactor Building. RC-TE-1033 is pipe mounted on the reference leg outside the D-Ring. Power and signal conditioning for these instruments is provided by existing Signal Conditioning Cabinet A2 located in the Control Building, El. 338'-6".

The density compensated level output signal is displayed via the plant computer

1.3.1.2 Hot Leg Level Primary Loop B

Differential pressure transmitter RC-LT-1034 is installed between an upper connection at the top of steam generator RC-H-1B's hot leg and a lower connection upstream of decay heat line isolation valve DH-V-1. This instrument measures the water level from the bottom to the top of reactor coolant loop B hot leg piping.

The upper connection for RC-LT-1034 is equipped with a condensate pot and provides a water column reference leg for the transmitter.

Resistance temperature detector RC-TE-1034 senses the temperature of the water in RC-LT-1034's reference leg to compensate for density changes. This signal provides density correction for both RC-LT-1034 and RC-LT-1036, since both reference legs are routed together, and will be exposed to the same ambient temperature.

Thermocouple RC-TE-1055 senses reactor coolant system core exit temperature and is used to compensate for density changes in the reactor vessel head and hot leg fluids. Resistance temperature detector RC-TE-1053 provides a cold junction reference temperature for thermocouple RC-TE-1055.

RC-TE-1055 is mounted in the existing Incore Detector Instrumentation structure, detector well No. 18. RC-TE-1053 is mounted in terminal box T-1119 on the secondary shield wall near the incore detector rack, Reactor Building elevation 346'-0".

RC-LT-1034 is mounted on existing instrument rack No. TR11B at elevation 281'-0" inside the Reactor Building. RC-TE-1034 is pipe mounted on the reference leg outside the D-Ring. Power and signal conditioning for these instruments is provided by existing Signal Conditioning Cabinet B1 located in the Control Building, El. 322'-0".

The density compensated level output signal is displayed via the plant computer.

1.3.1.3 Reactor Vessel Level 1

Differential pressure transmitter RC-LT-1035 installed between an upper connection at the reactor vessel head vent valves and a lower connection upstream of valve DH-V-1. This instrument measures the level from the bottom of the hot leg piping to the top of the vessel head.

The upper connection for RC-LT-1035 is equipped with a condensate pot and provides a water column reference leg for the transmitter.

Density compensation is accomplished by utilizing the signals from temperature sensors RC-TE-1033, RC-TE-1054 and RC-TE-1052 as described in paragraph 1.3.1.1.

RC-LT-1035 is mounted on existing instrument rack No. TR10A at elevation 281'-0" inside the Reactor Building. Power and signal conditioning for these instruments is provided by existing Signal Conditioning Cabinet A2 located in the Control Building, El. 338'-6".

The density compensated level output signal is displayed via the plant computer.

1.3.1.4 Reactor Vessel Level 2

Differential pressure transmitter RC-LT-1036 is installed between an upper connection at the reactor vessel head vent valves and a lower connection upstream of valve DH-V-1. This instrument provides a redundant level measurement for the reactor vessel head.

The upper connection for RC-LT-1036 is equipped with a condensate pot which provides a water column reference leg for the transmitter.

Density compensation is accomplished by utilizing the signals from temperature sensors RC-TE-1034, RC-TE-1055 and RC-TE-1053 as described in paragraph 1.3.1.2.

RC-LT-1036 is mounted on existing instrument rack No. TR11B at elevation 281'-0" inside the Reactor Building. Power and signal conditioning for these instruments is provided by existing Signal Conditioning Cabinet B1 located in the Control Building, El. 322'-0".

The density compensated level output signal is displayed via the plant computer.

1.3.2 Void Fraction Trending Subsystem

The void fraction trending portion of the RCITS is shown by Gilbert Associates block diagram 202-095, sheet RK-3. This drawing shows the RCP power monitor inputs to the plant computer.

Pump power signals from each of four RCP power monitors are transmitted to the plant computer where these signals are converted to void fractions via an empirical algorithm utilizing RCP power, pump status and RCS cold leg temperature data. The void fraction algorithm was developed to yield the desired relationship between RCP power and RCS void fraction at the pump suction.

Four isolated signal transmitters IT-1 are mounted in sections A, B, C and D of the Reactor Coolant Pump Power Monitor Rack A.

For each RC pump the transmitter receives an input from an existing watt-transducer and provides a non-1E RC pump power signal to the plant computer.

Transmitter power and existing watt-transducers are also located in RCP Power Monitor Rack A which is located in the Control Building, elevation 322'-0".

The void fraction measurement subsystem is classified as "Important to Safety".

1.3.3 Single Failure Design

The RCITS is designed so that a single active failure other than the plant computer will not prevent trend displays of the reactor coolant void fraction or water level for at least one hot leg

level measurement, one reactor vessel head level measurement, and one void fraction measurement. The lower connections for all the level transmitters are connected to a single tap on the decay heat drop line. The design philosophy with regard to redundant channels utilizing a common connection is to separate these lines as soon as possible. This philosophy is applied to this modification.

1.3.4 Piping, Valves and Tubing Design

Piping is nuclear class N-2, seismic category S-I up to and including the root valves from the primary pressure boundary. The tubing and instrument valves are nuclear class N-2, seismic category S-I. The piping conforms to the requirements of line specification GP 2500-4 of reference 1.2.2.6. Double valve isolation is maintained. Snubbers and/or thermal loops are used at the tie-in points. Instrument tubing and valves conform to the requirements of reference 1.2.2.3.

1.3.5 Electrical Design

Electrical components of the water level trending portion of the RCITS are class 1E qualified to the applicable requirements of References 1.2.1.1, 1.2.1.2, 1.2.1.3, 1.2.1.4, and 1.2.1.5, and in accordance with the environmental conditions of Reference 1.2.2.4. However, the computer and associated wiring is non-Class 1E.

The RCP current and potential transformers and watt transducers of the void fraction trending subsystem are high quality commercial grade components. RCS cold leg temperature elements and RCS pressure transmitters are original plant equipment qualified in accordance with the TMI-1 licensing basis. Wiring for the void fraction trending subsystem is non-1E.

All electrical work is performed in accordance with Reference 1.2.2.2. Conduit routed inside containment will be supported as seismic Class I using new and existing supports installed in accordance with Reference 1.2.2.7.

1.3.6 Structural Design

Equipment is designed to meet the requirements of Reference 1.2.1.2. Tubing supports are designed in accordance with

Reference 1.2.2.3. Conduit supports are designed in accordance with Reference 1.2.2.7.

1.3.7 Quality Assurance

The RCITS is to be installed, tested and inspected in accordance with the GPUN Operational QA Plan, Rev. 0 (Reference 1.2.2.1). The water level trending subsystem is "Important to Safety" and "Nuclear Safety Related".
void fraction
trending subsystem is "Important to Safety" only.

1.3.8 Computer Displays Design

The primary sources of computer display data are analog points from the system data base which (for RCITS purposes) have been labelled Group A data and Group B data. Their point numbers and descriptors are:

Group A (Level) Data

A1	A466	RC Hot Leg A Level
A2	A468	RC Hot Leg B Level
A3	A467	Reactor Vessel Head Level 1
A4	A469	Reactor Vessel Head Level 2

Group B (Void Fraction) Data

B1	C4018	Void Fraction A1
B2	C4019	Void Fraction A2
B3	C4020	Void Fraction B1
B4	C4021	Void Fraction B2

Other sources of data are the following points:

A427	RCP A Power
A428	RCP B Power
A429	RCP C Power
A430	RCP D Power
C1679	Pump Running Index
L2901	Reactor Trip

The values for Hot Leg and Reactor Vessel Head levels will be derived from signals which have been compensated for primary system temperature and reference leg temperature in the Foxboro Signal Conditioning Cabinets. The values for void fraction will be those calculated by the on-line application software program VOIDF. The program uses RCP power, RCP status (pump running index) and RC inlet temperature as inputs.

RCP power values are derived from watt transducers associated with each RCP motor. The pump running index is calculated by the NSS Application Software (NAS) program PMPIN. PMPIN uses RCP motor breaker status contacts to determine the status of each pump. The reactor trip status is calculated by the Process Computer's Trigger Task TT:RTP. TT:RTP uses isolated reactor trip signals from RPS Channels A through D to determine reactor trip status.

At any given time the operator will view either Group A or Group B data. Depending upon plant operating status, there will be times when the display of Group A or B data on RCITS displays will not be meaningful. Group A (Level) data will be meaningful only when all RCPs are secured. Group B (Void Fraction) data for an RC cold leg will be meaningful only when the associated RCP is running.

To reduce the likelihood of confusion resulting from the viewing of data which is not meaningful when one or more RCPs are running, Group A data will be given a "bad" quality tag, and a request for its value will result in a display of a series of dots (....). This indication of quality and value will be the result of an automatic deletion of Group A points from scan. The deletion from scan (and the return to scan when all RCPs are off) will be performed by the Application Software Program SGHUCD.

The same indications will be used for an RC cold leg's void fraction point when the associated RCP is secured. Assignment of quality in this way is based on a check in VOIDF of the value of

the pump running index. Furthermore, the void fraction for a cold leg will not be calculated if the associated pump is not running. The decision as to whether or not to calculate void fraction is made in the Executive Program VOIDFR.

Table I summarizes the above information and the void fraction calculation frequency.

TABLE I
RCITS DATA INTERPRETATION

PLANT OPERATING CONDITION	GROUP A (LEVEL) DATA MEANINGFUL?	GROUP B (VOID FRACTION) DATA MEANINGFUL?	VOID FRACTION CALC. FREQUENCY
No Rx Trip All RCPs ON (Normal Operation)	No	Yes	6 min.
Rx Trip All RCPs ON	No	Yes	30 sec.
Rx Trip 1-3 RCPs ON	No	Yes-"ON" RCPs No-"OFF" RCPs	30 sec.
Rx Trip No RCPs ON	Yes	No	N/A

The displays which may be used to present RCITS information to the control room operator are described below.

1.3.8.1 Single Point Displays (SPD)

The operator will have available for single point display any of the 14 variables listed above. These variables will be accessible in the usual way via the Single Point Function Select key and point identification numbers.

When accessed by SPD, Group A (Level) data will have an indication as to the meaningfulness via the indicated value and quality for each point. When the data is not meaningful, i.e., when one or more RCPs are on, the quality for all four levels will be indicated as bad and the values will be indicated as a series of dots (....).

When accessed by SPD, Group B (Void Fraction) data will also have an indication as to meaningfulness via the value and quality indications. When an RC pump is secured, the quality indicator for associated cold leg's void fraction point will be set to bad, and the void fraction value will be indicated as a series of dots.

1.3.8.2 Group Displays

The operator will have available the RC Inventory Tracking Group Display shown in Figure 3. This display will be available in the usual way via the Group Function Select Key. The display will be one of the displays in the Reactor Coolant Inventory Group Display Area.

RC pump power is included in the group display because it is the major input to the void fraction calculation and can be used to corroborate an unexpected value for void fraction. Pump Running Index is included because it can indicate or confirm which data, Group A or B, is currently meaningful. The index can also be used as an additional corroborator of an unexpected value for void fraction. Reactor Trip status is included as a reminder of the update rate of the void fraction values. (See Table 1).

The layout of data on the display is somewhat arbitrary and can easily be changed. The layout chosen for Figure 3 was based on the following considerations:

1. Blocks of data are separated to enhance data search and find.

2. The most important data is at the top. Level monitoring (Group A) data is given highest priority, even though most of the time during normal operations the RCPs will be running and the data will not be meaningful.

3. Void fraction (Group B) data is next in importance and position.

4. The major inputs to the void fraction calculations are next, in one block.

5. At the bottom, in an easily found location, is data (pump running index) which indicates whether Group A or Group B data is meaningful.

The display of Group A and B data meaningfulness will be the same as described in Section 1.3.8.1. When meaningful, the data will have a normal appearance; when not meaningful, the quality will be bad and the value will appear as a series of periods.

1.3.8.3 <u>Trend Displays</u>

The operator will have available historical data trend displays which present a history of level and void fraction values (Group A and B data). These displays will be available via the Long Term Storage and Retrieval (LS&R) Function Select key. These displays will only be available on CRT #3.

1.3.8.3.1 <u>Display Content</u>

Two historical data trend displays will be available to the operator. One of the two displays is titled "RC Hot Leg & RV Levels" and will contain four historical data trend graphs, one graph for each of the four level variables in Group A. The other display is titled "RC Cold Leg Void Fractions" and it also contains four graphs, one graph for each of the four void fraction variables in Group B.

When it appears on the screen after it has been requested by the operator, the display will contain historical data which has been recorded during the previous two hours and eight minutes. The display will then be updated with new data at 30 second intervals (post-reactor trip), with the oldest data appearing to slide off the screen as new data is added.

1.3.8.3.2 <u>Display Selection</u>

To obtain the displays, the operator first depresses the LS&R Function Select key, at which time the operator will be presented with a menu (Figure 4) on which a data entry for display selection may be made. On the menu are listed two displays with corresponding display numbers.

To obtain one of the displays the operator presses the numeric key corresponding to the desired display and then presses EXECUTE. If no display number is entered, the screen will default to Display #1 after EXECUTE is depressed.

To cancel the display, the CANCEL button should be depressed. If one of the two displays is on the screen, and the other display is desired, the operator may either use the NEXT PAGE/PREV PAGE

buttons, or cancel the current display and request the other display in the manner described above.

An incorrect entry will result in a yellow reverse video data entry field when EXECUTE is depressed.

1.3.8.3.3 Display Format

The historical data trend display will have a format similar to the Data Trend Function display, or a strip chart recorder output. The displays will appear approximately as shown in Figures 5 and 6. The data will be plotted in four separate vertical rectangular boxes or charts. The boxes and the variable trace inside each box are four different colors. The colors, from left to right, are white, yellow, magenta and cyan.

Located above each box is a name for each trace. Also above each box is displayed the current value for each variable as a floating point decimal number with one digit to the right of the decimal point.

The traces inside each box will consist of full intensity dots or data points at the appropriate location relative to the scale at the bottom of the box. Also, half-intensity shading will be provided from the zero points on the left-hand side of each box to each full-intensity data point. New data points will be added at the top of each box. (The plot rate will be displayed on the bottom line of the display). The older points will be moved down with addition of each new point until they reach the bottom of the chart boxes, where they are finally pushed off the display. The oldest value on the display will be two hours eight minutes old.

In the upper right-hand corner of the display is displayed the current date and time. Directly under the current time, the time associated with the newest data on the display is shown. On the middle right-hand part of the display the mid-point time of the chart is displayed. On the lower right-hand part of the display is displayed the time associated with the display's oldest data.

The point number, description and engineering units for each variable being trended is listed under the rectangular boxes. This information is displayed in the same color and sequence as the boxes that provide the data trend display for each variable. Also listed is the zero and full scale value for each variable.

For variables A1 and A2, zero and full scale values are 0 and 50 feet, respectively. (Only 98.3% of the scale will be used). For variables A3 and A4, zero and full scale values are 0 and 15 feet, respectively. For variables B1-B4, zero and full scale values are, respectively, 0 and 100 percent.

Running lengthways down the middle of each rectangular box is a line the same color as the box which is the half-scale indication for each box.

1.3.8.3.4 Display Data Interpretation

The "meaningfulness" of both Group A and Group B data will be indicated on the historical data trend display. When either Group A or Group B data is not meaningful, a series of dots extending from the left-hand side of the box to the right-hand side will be displayed. The dots will be blue in color. The dots will be spaced apart in the horizontal direction the width of one character position. In the vertical (time axis) direction, the dots will be spaced apart the height of one character position. Also, the value at the top of a box will be replaced by a series of dots when the box's variable is currently not meaningful. An example which illustrates a case where historical data for the most recent hour was not meaningful is shown by the left-most box of Figure 6.

When the quality of Group A or B data is bad, this will be indicated on the trend display by a value of 0.0 and no plotting of data. This treatment of bad data is the same as is performed by the Data Trend Function.

1.4 SYSTEM PERFORMANCE CHARACTERISTICS

1.4.1 Process Data

Equipment connected to the primary pressure boundary is subjected to the following conditions:

Pressure	0-2500 PSIG
Temperature	50°-650°F
Boron Conc.	0-2270 PPM

1.4.2 Environmental Performance

1.4.2.1 Equipment inside the Reactor Building is subject to the following conditions:

Normal Conditions

40 year Base Temperature	130°F
Relative Humidity	100%
Pressure	Atmospheric
Radiation	100 mR/hr 3.5 x 10^4 R/40 years

Accident Conditions

Temperature (Max.)	275°F
Relative Humidity	100%
Pressure (Max)	50.6 PSIA
Radiation	2 x 10^7 Rads total
Chemical Spray	9.5 pH

1.4.2.2 Equipment in the Control Building is subject to both normal and accident conditions as follows:

40 year Base Temperature	75°F
Relative Humidity	65%
Pressure	Atmos.
Radiation	10 mR/hr
R/40 yr	Negligible/40 years

1.5 SYSTEM ARRANGEMENT

The water level subsystem of the RCITS is located within the Reactor Building and Control Building of Three Mile Island Nuclear Station Unit No. 1. System piping and tubing is totally within the Reactor Building. Piping and tubing are routed from the reactor vessel head area and inside the D-rings to instruments on racks located outside the secondary shield wall at elevation 281'-0". Electrical cabling transmits signals from the instruments on the racks inside the Reactor Building to the Control Building. The plant computer is used to indicate RCS hot leg and reactor vessel water levels.

The void fraction trending subsystem is located within the Control Building and the Turbine Building. The RCP current and potential transformers are located in the switchgear room at elevation 322' of the Turbine Building. Electrical cabling transmits these signals to RPS-associated watt transducers in the Control Building. From here Class 1E isolators transmit the signals to the plant computer.

1.6 INSTRUMENTATION AND CONTROLS

A detailed description of instrumentation and controls is included in section 1.3.1 of this SDD. The following are additional details:

Differential pressure transmitters are installed with five valve manifolds.

The design of the indicator, computer displays and location of this instrumentation is subject to a human factors engineering review.

1.6.1 Instrument Ranges

Instrument No.	Use	Operating Range
RC-LT-1033	Hot Leg Level A	0-50 FT
RC-LT-1034	Hot Leg Level B	0-50 FT
RC-LT-1035	Reactor Vessel Level 1	0-15 FT
RC-LT-1036	Reactor Vessel Level 2	0-15 FT
RC-TE-1033 and 1034	Density Compensation of reference leg fluid	70-250°F
RC-TE-1054 and 1055	Density Comp. of RCS fluid	200-700°F
RC-TE-1052 and 1053	Cold Junction Ref. Temp.	40-275°F

1.7 SYSTEM INTERFACES

1.7.1 Electrical Distribution Systems

The interface with the vital busses is via the existing 1E qualified power supplies provided with the (Foxboro) Signal Conditioning Cabinets A2 and B1.

Reactor coolant pump power is obtained from the RCP Power Monitor Rack located at the 322' elevation of the Control Building. Pump status is obtained from the associated switchgear. The Bailey 855 computer is powered from inverter 1E (which receives vital power from either station battery 1C or diesel generator 1A) with backup vital power provided from diesel generator 1B. The ModComp computer receives power from an electrical bus which is backed up by diesel generator 1B.

1.7.2 Connections to the Primary Coolant and Decay Heat Piping

Connections to the primary coolant loops via the High Point Vent piping are made through 1/2" tubing which is within the capacity of the makeup pump in the event of tube line breaks. The tie-in to the decay heat drop line is made through a 3/8" hole drilled into the 12" diameter drop line. The RCITS interfaces with the RCS Loop A and B High Point Vents, and Reactor Vessel head vent modification, the decay heat drop line.

Double root valves are used at these connection points. Stress analyses are performed on the existing piping and the connections to confirm that the components are not overstressed.

1.7.3 Containment Penetrations

Instrument cables for the new water level measurement instruments utilize existing spare conductors in electrical penetrations 204E 205E.

1.7.5 Computer

System level data is input to the plant computer for display purposes. System void fractions are calculated by the computer from RCP power inputs and then retained for display.

2.0 SYSTEM LIMITATIONS, SETPOINTS, AND PRECAUTIONS

2.1.1 The indications for hot leg water level of primary loop 'A', hot leg water level of primary loop 'B', reactor vessel head water level '1', and reactor vessel head water level '2' are useful when the reactor coolant pumps are off. These indications are provided by the plant computer during all modes of plant operation.

2.1.2 During reactor vessel head removal, part of the water level measurement system must be removed. Each of the reactor vessel head water level tubing runs bridge from the service structure to floor elevation 347'0". Removable tubing sections are provided with a break flange on one side and a tubing connector on the other side. These removable sections are located downstream of RC-V62A and 62B and must be removed before the reactor vessel head is removed.

2.1.3 The void fraction trending subsystem is useful when the RCP's are running. These indications are provided by the plant computer during all modes of plant operation.

3.0 OPERATION

The Reactor Coolant Inventory Tracking System (RCITS) is not required to monitor normal operation, heatup or shutdown. Operation of the RCITS is only required during abnormal or emergency conditions and to monitor recovery from such conditions.

3.1 INITIAL FILL

The initial fill of the RCITS system requires that all instrument tubing high points be flooded. Instrument test valves at the instrument racks and fill valves at the reference leg condensate pot have been provided for the initial fill operation.

3.2 START UP

No automatic or manual devices are required to start the RCITS system. This system is continuously operational during all modes of plant operation.

3.3 NORMAL

The RCITS is continuously operational during all modes of operation.

3.4 SHUTDOWN

During plant shutdown the RCITS may be recalibrated to assure correct operation. Each instrument is provided with manifold test valves at their instrument rack location for calibration purposes. Calibration of the electronics portion of the RCITS can be

accomplished at the Foxboro signal conditioning cabinets at any time.

3.5 DRAINING

Instrument blowdown valves are provided at the instrument rack which allow draining of the tubing.

3.6 REFILLING

Refilling is the same as initial fill (paragraph 3.1). High points in the RCITS should be verified filled during each refueling operation.

3.7 INFREQUENT OPERATIONS

The RCITS will provide RCS water level trending following a loss of the Reactor Coolant Pumps. Only one abnormal procedure is affected by the availability of the RCITS. During natural circulation cooldown, the RCITS provides an indication of whether a bubble has formed in the hot leg or vessel head. The following guideline can be used in OP 1102-16 "RCS Natural Circulation Cooling".

"Reactor coolant head voids may be evidenced by a large rapid increase in pressurized level or by an indicated head level less than full".

3.8 TRANSIENT OPERATIONS

The RCITS is designed to monitor RCS inventory transients. Thus, the primary usefulness of the RCITS is during emergency operating conditions. The following guidelines provide confirmatory information to other ICC instrumentation, which is to be evaluated by the control room operator in performing plant recovery operations from abnormal transients.

3.8.1 RCP Bump/Restart Guidelines

If the hot leg level is 6 feet below full or the head level is 3 feet below full and trending downward consider bumping the pumps prior to restarting them.

<u>Basis</u>: Restart of the RCPs with substantial steam voids in the hot leg or head will result in a large pressurizer level and/or pressure response in the plant. When steam voids are indicated, the RCPs should be bumped

first to reduce the void volume. These actions would be taken regardless of the RCS cooldown rate.

Collapse of either a head bubble or hot leg bubbles within these volumes will result in a pressurizer level drop of about 70 inches.

3.8.2 If hot leg level is less than 6 feet from the top of the hot leg evaluate whether primary to secondary heat transfer is available.

<u>Basis</u>: A level of 6 feet below the top of the hot leg indicates that single phase natural circulation is unlikely since the U bend is voided. Attempts should be made to restore primary to secondary heat transfer.

3.8.3 <u>EFW Operation</u>

Evaluate the EFW flow rate if the hot leg level is less than 19 feet below full. Consider if EFW flow should be maintained above 450 gpm (225 per OTSG) until the 95% OTSG level setpoint is reached.

<u>Basis</u>: If hot leg (and hence tube region) level is below the EFW flow injection point, then EFW flow should be established to assure boiler condenser cooling. The use of the hot leg level in this case is a diverse indication from incore thermocouples and subcooling margin.

3.8.4 <u>HPI Operation</u>

a. Evaluate running all available HPI pumps at full flow if hot leg level falls 21 feet below full. Observe all of the HPI throttling criteria.

b. Evaluate running all the HPI pumps if the RCPs are running and RCS void fraction is continuing to increase.

<u>Basis</u>: Three HPI pumps will not be run at all times. If level decreases below the point where boiler-condenser cooling should be effective, then system refill should be aided by additional HPI flow. Running 3 HPIs at too high a level may cause repressurization of the RCS. Three pumps are unde-

sirable during water solid (i.e., feed and bleed) since the RCS pressure will be higher than if only two pumps are operating.

3.8.5 PORV Operation

If hot leg level drops below the surge line elevation, 42 feet below the top of the hot leg, evaluate opening the PORV and leaving it open until LPI is in operation. Do not open the PORV unless a source of water addition is available to the RCS (HPI, LPI or CFTs).

Basis: Once the surge line is uncovered, the PORV will be relieving steam. Steam relief provides the most effective means of cooling and depressurization from a given inventory loss. This action will even be effective under conditions where all HPI has been lost since it maximizes the chances of reaching CFT actuation pressure. If no makeup is available to the RCS, then inventory losses should be minimized while the operators attempt to provide a source of water to the RCS. Note that the PORV is also opened by existing procedures when the RCS pressure reaches 2300 psig and these two actions are complimentary to each other.

3.8.6 The following notes should be added to the Abnormal Transient Procedures:

a. Hot leg level indication is invalid when the hot leg high point vents are open.

b. RCS void fraction is only valid when the RCPs are operating.

4.0 CASUALTY EVENTS AND RECOVERY PROCEDURES

Neither the void fraction nor hot leg level instruments initiate any automatic control actions. Their failure in either the high, low or intermediate position will require detection by comparison with other instruments. This situation is true for the failure of any indication and does not represent a unique situation for the operator to deal with.

Failure of the instrument piping associated with the RCITS does not result in a LOCA, but does represent a substantial leak.

None of the indications provided by the RCITS are required or relied upon to recover from such a failure. For example, a break in the hot leg level instrument tube would result in a leak within the capacity of the normal makeup system requiring a plant shutdown. Level from that loop could read low. However, other plant indications such as saturation margin, makeup tank and pressurizer level, makeup flow, RCS pressure, RB sump level, containment temperature and pressure, and void fraction would indicate that both hot legs were full.

5.0 MAINTENANCE

5.1 MAINTENANCE APPROACH

The RCITS is installed with double isolation valves at each instrument tap location. When these valves are closed access to piping and tubing is provided to allow maintenance of the other valves and connections.

5.2 CORRECTIVE MAINTENANCE

Most corrective maintenance on the RCITS will be with respect to leakage problems. These leaks are expected to occur at flange joints and across valve seats.

As covered in 5.1, above, corrective maintenance which needs to be performed, in most cases, can be performed by closing the isolation valve upstream. This precludes the requirement for draining the RCITS while maintenance is in progress.

5.3 PREVENTIVE MAINTENANCE

No preventive maintenance is normally anticipated for system equipment. Surveillance and associated maintenance shall be performed in accordance with the manufacturer's recommendations. Normal Technical Specification surveillance requirements will be observed.

All valves in the system that provide fluid isolation should be internally inspected at least once every five years to assure integrity of the seating surfaces. The same preventive maintenance interval should be applied to all flange joints. Snubber oil levels should be checked as required by manufacturers maintenance instructions. Normal routine maintenance should be performed in accordance with established procedures and vendor recommendations.

5.4 INSERVICE INSPECTION AND TESTING

Testing/calibrating of the level instrumentation will be performed during each refueling by simulating the compensating signals, as done for existing similar level instrumentation (e.g. pressurizer).

The inservice inspection program requires periodic non-destructive examinations be performed during plant outages. The type extent and frequency of examinations will be specified in accordance with Procedure 6150-ADM-3272.01 of the GPU Nuclear Inservice Inspection Manual (Ref. 1.2.2.10).

6.0 TESTING

The following tests must be accomplished for an acceptable RCITS system.

1. Hydrostatic pressure test of piping and tubing system.
2. Functional test as required by the control system's supplier (Foxboro Spec. 200).

7.0 HUMAN FACTORS

GPUN Human Factors Engineering has reviewed the RCITS design. A review of display type, information and format has been conducted in conjunction with Plant Analysis. Plant Analysis input for the displays has been incorporated into the design and no new hardware interface is involved. All displays recommended by Plant Analysis are in accordance with the principles of human engineering. A post-construction walkdown will be performed to assure that scale, labels, and other man-machine interface items are acceptable.

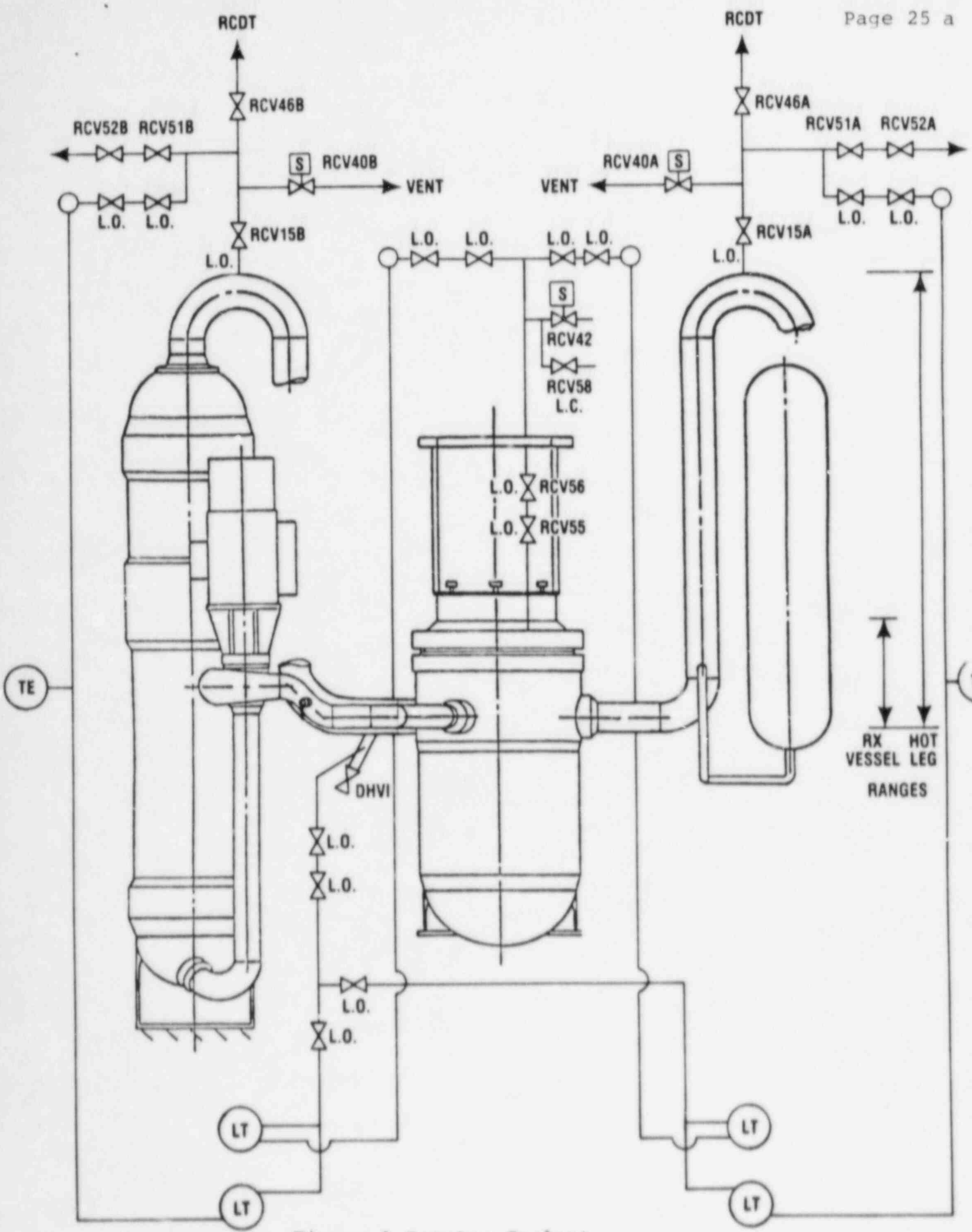

Figure 1 Reactor Coolant Inventory Trending System

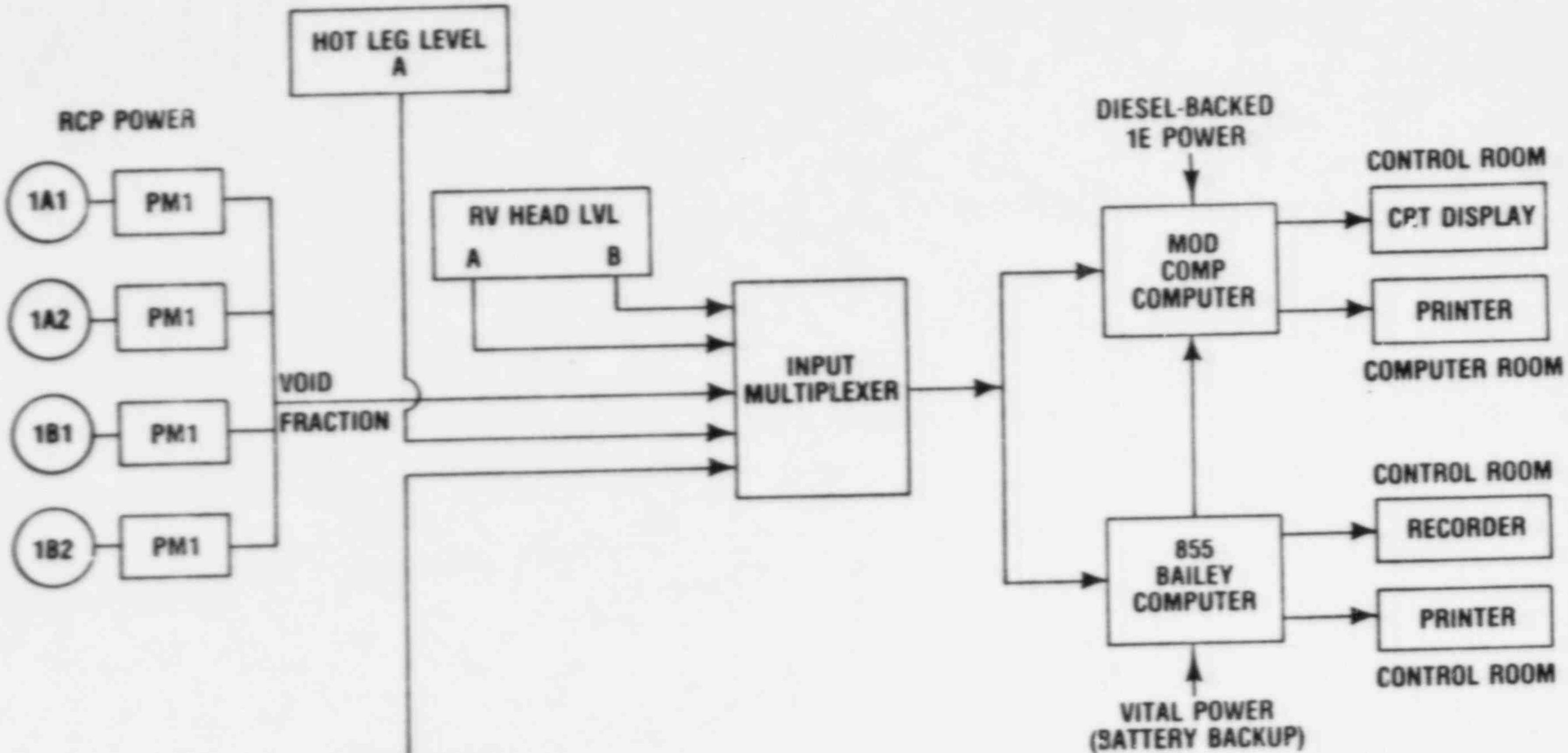

Figure 2 RCITS Display System

AREA 3 GROUP 37 RC INVENTORY TRACKING

A466 RC Hot Leg A Level
A468 RC Hot Leg B Level
A467 Reactor Vessel Head Level 1
A469 Reactor Vessel Head Level 2

C4018 Void Fraction A1
C4019 Void Fraction A2
C4020 Void Fraction B1
C4021 Void Fraction B2

A427 RC-P-1A Power
A428 RC-P-1B Power
A429 RC-P-1C Power
A430 RC-P-1D Power
L2901 Reactor Trip

C1679 Pump Running Index

Figure 3 RC INVENTORY TRACKING GROUP DISPLAY

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LONG TERM STORAGE & RETRIEVAL DISPLAY MENU

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1. RC HOT LEG & RV HEAD LEVELS HISTORICAL DATA TREND

2. RC COLD LEG VOID FRACTIONS HISTORICAL DATA TREND

ENTER
DISPLAY #: ☐ THEN EXECUTE OUTPUT MODE: DISPLAY

Figure 4. LONG TERM STORAGE & RETRIEVAL DISPLAY MENU

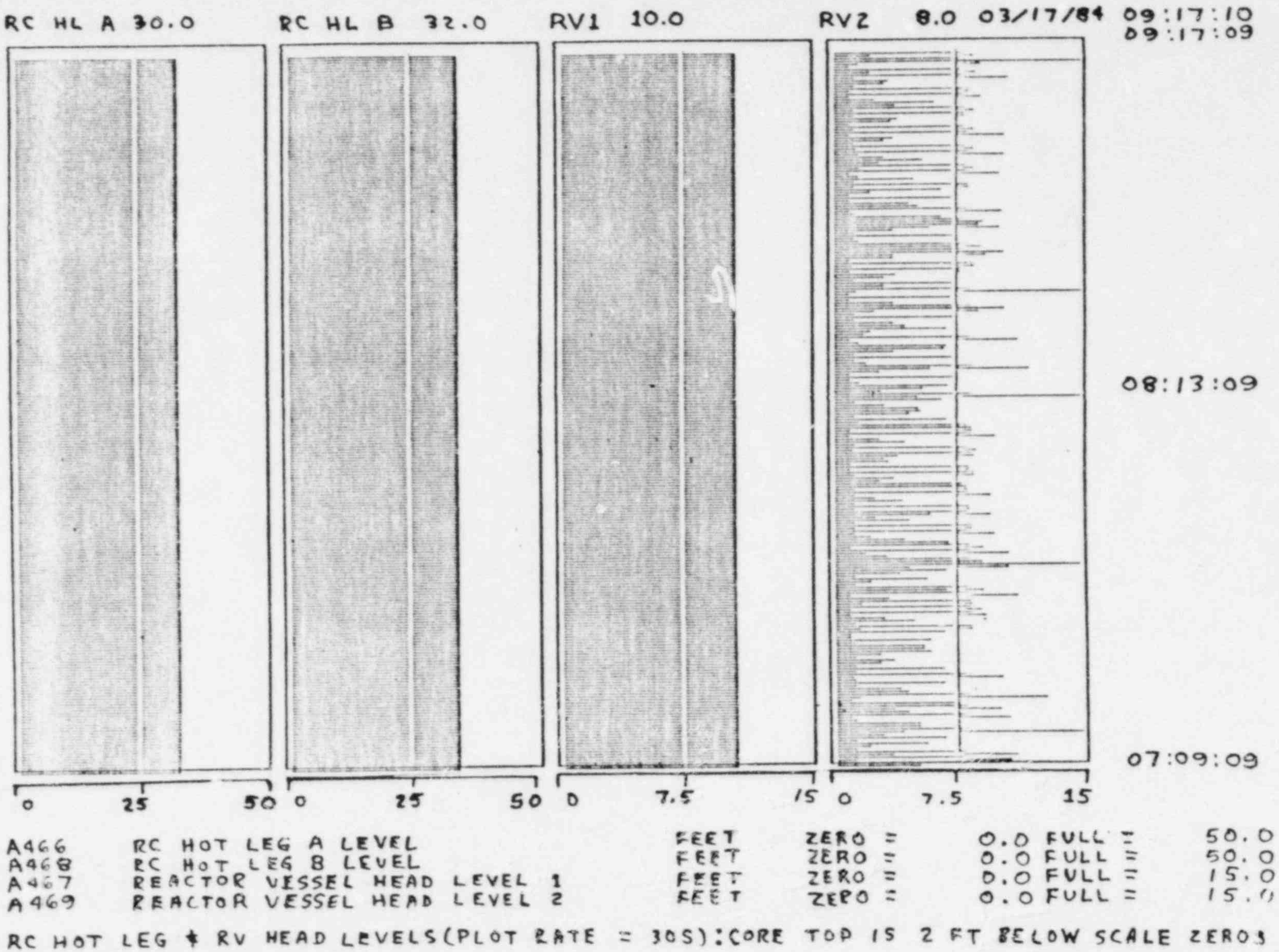

Figure 5. RC HOT LEG & RV HEAD LEVELS HISTORICAL DATA TREND DISPLAY

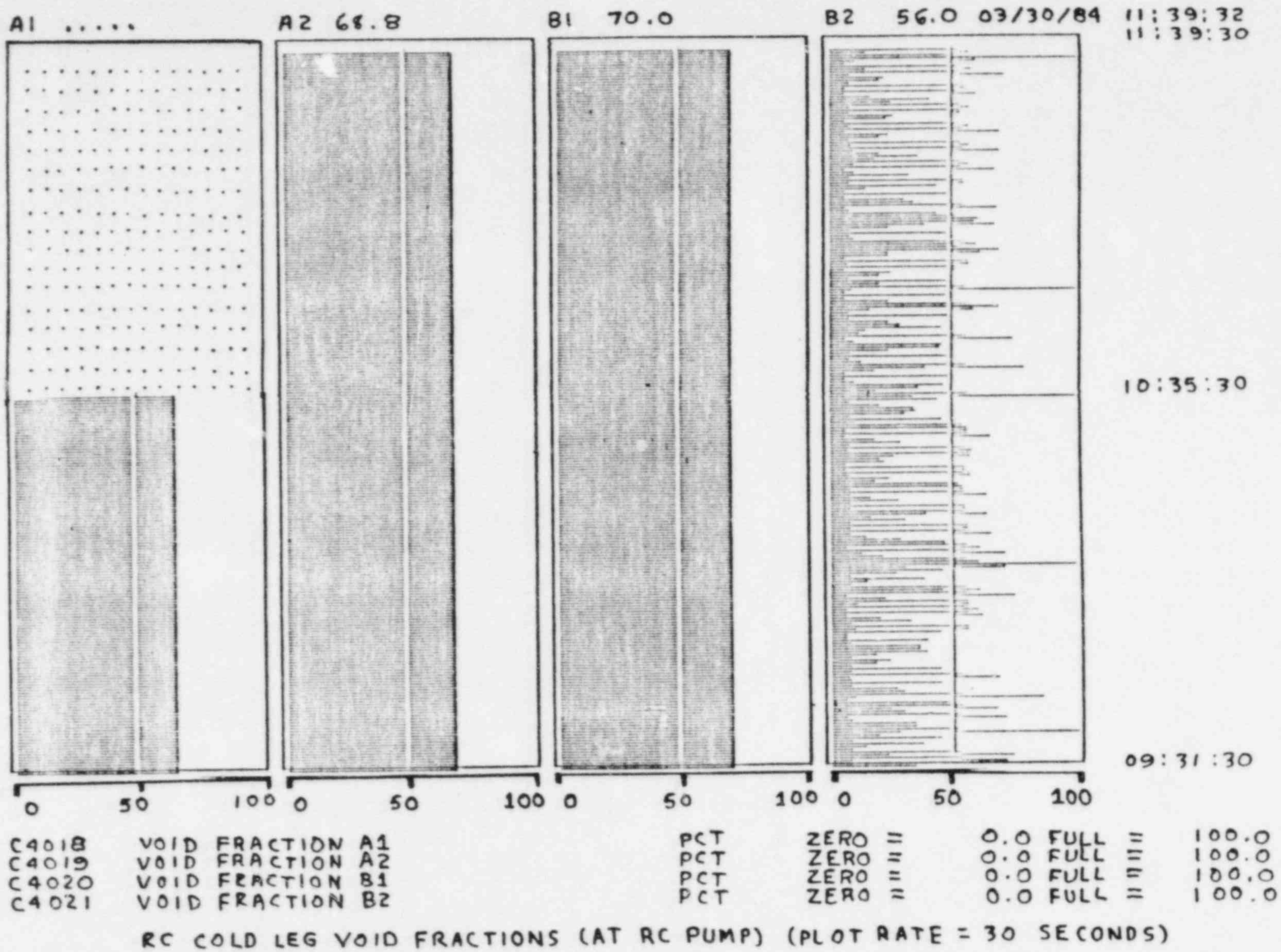

Figure 6. RC COLD LEG VOID FRACTIONS HISTORICAL DATA TREND DISPLAY

Exhibit A

B&W Doc. ID 47-1149188-01 "Summary Information Package RCS Coolant Inventory Trending (CIT) with RC Pumps Operating".

Exhibit B

Description of Material	Applicable Criteria
B&W Doc. ID 47-1149188-01 "Summary Information Package RCS Coolant Inventory Trending (CIT) with RC Pumps Operating"	b, c, d & e

As stamped in the report and as noted below:

Page 6	Section 2.2
Page 7	In its entirety
Page 8	In its entirety
Page 9	In its entirety
Page 10	In its entirety
Page 13	Paragraph 2 of Section 3.1 and Section 3.2
Page 14	Section 3.2
Page 15	In its entirety
Page 16	Table 3.1 and notes
Page 17	Figure 3-1
Page 18	Figure 3-2
Page 19	Figure 3-3
Page 20	Figure 3-4