REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

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FACIL: 50-305 Kewaunee Nuclear Power Plant, Wisconsin Public Servic 05000305
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RECIP. NAME RECIPIENT AFFILIATION
LEAR, G. E. PWR Project Directorate 1

SUBJECT: Forwards addl info re inadequate care cooling instrumentation, including revised sys description & revised error analysis, in response to NRC 850522 request. W/one oversize drawing.

DISTRIBUTION CODE: A002D COPIES RECEIVED: LTR 1 ENCL 3 SIZE: 34+1
TITLE: OR Submittal: Inadequate Core Cooling (Item II.F.2) GL 82-28

NOTES: See Drawings Jacket. 05000305
OL: 12/21/73

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WISCONSIN PUBLIC SERVICE CORPORATION
P.O. Box 19002, Green Bay, WI 54307-9002

January 7, 1986

Director of Nuclear Reactor Regulation
Attention: Mr. G. E. Lear, PWR Project Directorate-1
Operating Reactors Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
TAC #45143
Inadequate Core Cooling Instrumentation

References: 1) Letter from Mr. S. A. Varga to Mr. D. C. Hintz dated May 22, 1985

2) Letter from Mr. D. C. Hintz to Mr. S. A. Varga dated July 29, 1985

Reference 1 transmitted a request for additional information concerning specific aspects of our ICC instrumentation. In Reference 2 we advised you of an independent review of our system and that your questions would be answered based on the outcome of that review.

Attached you will find:

--A revised system description
--The response to your request for additional information
--A revised error analysis
--ICC display drawing WSK-146, Rev. 3

I trust that this information is sufficient for your purposes.

Aperture Card Dist
Drawings
TO: Reg File
M. Fairtile
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This letter is due January 7 as was mutually agreed to by WPSC and our Project Manager.

Sincerely,

D. C. Hintz
Manager - Nuclear Power

DWS/jms

Attach.

cc - Mr. Robert Nelson, US NRC

Attachment 1

Mr. D. C. Hintz to Mr. G. E. Lear

January 7, 1986

System Description

REACTOR INVENTORY TRACKING SYSTEM

SUMMARY

The Reactor Inventory Tracking System (RITS) was designed to provide a direct indication in the control room of the water level in the reactor vessel. With both Reactor Coolant Pumps off, water level indication will be continuous from the top of the vessel head to the bottom of the hot legs. With one or both Reactor Coolant Pumps on, the system will indicate Reactor Coolant System void fraction. The level system was designed to meet the requirements of NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations", and NUREG-0737, "Clarification of TMI Action Plan Requirements".

RITS is based on measurement of the differential pressure between the top of the reactor vessel and the bottom of the hot legs. It contains a top fluid connection to a plutonium recycle port on the reactor vessel head and a bottom fluid connection to a coupling in an incore detector thimble guide tube. The top and bottom fluid connections are connected via 3/8 inch diameter tubing to four differential pressure transmitters. Two of the transmitters are "PUMPS ON" and intended for use when one or both of the reactor coolant pumps are running. They will not provide indication with the pumps off. Two of the transmitters are "PUMPS OFF" and intended for use when no pumps are operating. A reference chamber is located at the high point of the system to keep the fluid line to the transmitters full of water. Each pair of "PUMPS ON" and "PUMPS OFF" transmitters is independently powered by Class 1E instrumentation power.

The Inadequate Core Cooling (ICC) Monitoring System, a microprocessor based system, will be used to process the outputs of the differential pressure

transmitters. The system will compute water level when the reactor coolant pumps are off and will determine reactor coolant void fraction when pumps are on. The output signals provided by the ICC Monitoring System are Class 1E to the control room and non-class 1E to the plant process computer. Isolation is provided via fiber optic data link.

In order to compensate the differential pressure signals, the ICCMS utilizes resistance temperature detectors (RTDs) mounted on vertical sections of the tubing, core exit thermocouples, RCS cold leg RTDs, RCS pressure, pressurizer pressure and reactor coolant pump status.

A conceptual drawing of the system is shown in Figure 1. Individual parts of the system are described in the following paragraphs.

TOP FLUID CONNECTION

The top fluid connection (top tap) will be made to a plutonium recycle port on the head of the reactor vessel. This is penetration number 2 in the head. The design of the top tap will be performed by our Architect/Engineer. The fabrication and installation will be performed by WPS contractor personnel. Design includes a one-half inch diameter pipe welded to the head adapter plug for the spare instrumentation port with a 3/8 inch diameter hole drilled through the adapter plug to provide the fluid connection. One inch pipe will then be routed to a 1" manual isolation valve mounted on the CRDM cooling shroud. 3/8" tubing will be routed from the outlet of this valve.

BOTTOM FLUID CONNECTION

The bottom fluid connection (bottom tap) will be made to an existing coupling in an incore detector thimble guide tube. The guide tube selected leads to position G-2 in the reactor core. The connection will be made to the bottom of the coupling which is located in the horizontal portion of the guide tube run.

The bottom tap and the procedures for installation of the bottom tap were developed by NUS Corporation. The bottom tap consists of a half coupling welded to the guide tube coupling with 3/8 inch diameter tubing connecting the half coupling to an isolation valve mounted on the wall of the keyway. A 1/4 inch diameter hole is drilled in the guide tube coupling to provide the fluid connection. The isolation valve is a 1" inch manual globe valve. One inch to 3/8 inch adapters will be welded between the valve and tubing.

REFERENCE CHAMBER

At the high point of the system, a reference chamber will be installed to ensure that the upper fluid line to the differential pressure transmitters remains full of water. The reference chamber is a water reservoir only. It will be sized such that it contains enough water to refill the fluid line to the transmitters once. The reference chamber will be mounted on the outside of the refueling cavity wall.

Design of the reference chamber has determined that a length of four inch diameter stainless steel pipe approximately eight inches long with end caps will meet the refill requirements. The axis of the reference chamber will be mounted horizontally parallel with the wall. There will be three penetrations in the reference chamber, one at the top for connection to a vent valve, one at the bottom to connect to the fluid line to the transmitters and one at the centerline on one end to connect to the fluid line to the reactor vessel. The centerline of the reference chamber will be at approximately the 631'-11" elevation in containment.

REMOVABLE SECTION OF FLUID LINE

A removable section of 3/8 inch stainless steel tubing will be installed between the reactor vessel top tap and the reference chamber. This tubing will slope upward from the top tap to the reference chamber. The tubing will contain Swagelock fittings at each end to permit removal during refueling.

SUPPORT FOR REMOVABLE SECTION OF FLUID LINE

A removable support for the removable section of 3/8 inch tubing between the reactor vessel top tap and the reference chamber will be installed. This support will be attached to the refueling cavity wall. This structure will extend approximately 3-1/2 feet and will provide a seismic support for the 3/8 inch tubing.

DIFFERENTIAL PRESSURE TRANSMITTERS

Differential pressure transmitters will be used to measure the differential pressure signals. Four transmitters will be installed; two "PUMPS ON", and two "PUMPS OFF". One "PUMPS ON" and one "PUMPS OFF" transmitter will receive power from the Safeguard 5 instrumentation racks and the other pair will receive power from the Safeguard 6 racks. Thus, there will be two pair of independently powered transmitters.

The transmitters will be mounted inside containment at El. 611'-0". This elevation places them below the top of the vessel core and above LOCA flood level.

The "PUMPS OFF" transmitters will be calibrated for approximately 450 inches water adjusted for temperature. This span is the difference between a full vessel and level at the elevation of the hot legs for various operating conditions. Reactor vessel elevations are shown in Figure 2. During operation with the one or both reactor coolant pumps on, the "PUMPS OFF" transmitter output will be driven off scale.

The "PUMPS ON" transmitters will be calibrated to a span of approximately 1400 in. This span is the difference between 0% and 100% void fraction differential pressure at various operating conditions plus the flow friction differential pressure generated when one or both reactor coolant pumps are on. With zero reactor coolant pumps running, the "PUMPS ON" transmitter output will be invalid.

RESISTANCE TEMPERATURE DETECTORS (RTD'S)

RTD'S will be installed along the vertical sections of tubing from the reactor vessel taps to the differential pressure transmitters. The signals from the RTD'S are routed to the microprocessors in the relay room. An average of the temperatures is computed in the microprocessors. Five (5) RTD'S will monitor leg temperatures on each train for a total of ten (10) RTD'S.

INADEQUATE CORE COOLING MONITORING SYSTEM

The ICC Monitoring System provides two-channel, seismically qualified, Class 1E display of selected safety parameters in the control room. Among these parameters are reactor vessel liquid level and reactor coolant system void fraction. In addition, the ICC Monitoring System satisfies criteria set forth in NUREG-0696 regarding uninterrupted performance during and subsequent to events expected to occur during the life of the plant including earthquakes. Human factors engineering and man-machine interface considerations are integral to the ICC Monitoring System display design.

The RITS portion of the ICC monitoring system provides a continuous display of reactor coolant system void fraction when reactor coolant pumps are on and continuous indication of reactor vessel collapsed liquid level when reactor coolant pumps are off.

To derive these displays, the system reads the differential pressure from the transmitters and compensates for the temperature and pressure of the reactor coolant system, temperature of the sensing legs, and the differential pressure generated by reactor coolant pump flow friction across the reactor core. The inputs used to accomplish the compensation are listed in Tables 1 and 2.

The ICC Monitoring System chassis are located in independent, seismically qualified cabinets in the relay room.

CONTROL ROOM INDICATION

Redundant Class 1E indication will be provided to the control room from the ICC chassis (See Figure 1). Non Class 1E indication will be provided to the control room and the Technical Support Center from the Honeywell 4500 Computer. Reactor Vessel Level RCS void fraction indication will be placed in near proximity to the displays of the core exit thermocouples and saturation margin monitor. (See attached Dwg. WSK-146.)

The Reactor Vessel Level display is operational with the Reactor Coolant Pumps off. When one or two pumps are running it is driven off scale low. An analog meter is dedicated to reactor vessel level. It graphically correlates percent level to the reactor vessel. A permanently marked mimic of the vessel which shows the reactor core is utilized for this correlation.

When one or two Reactor Coolant Pumps are running, the Reactor Coolant System void fraction trend recorder monitors percent voiding of the RCS system. This pen recorder is used as a relative indication of RCS void fraction trend only. This recorder is outside the boundary of the Reactor Vessel Level display and is not to be associated with the Reactor Vessel mimic. When both pumps are off, the RCS void fraction indicator is driven off scale low.

These displays will be provided independently for Train A and Train B vessel level.

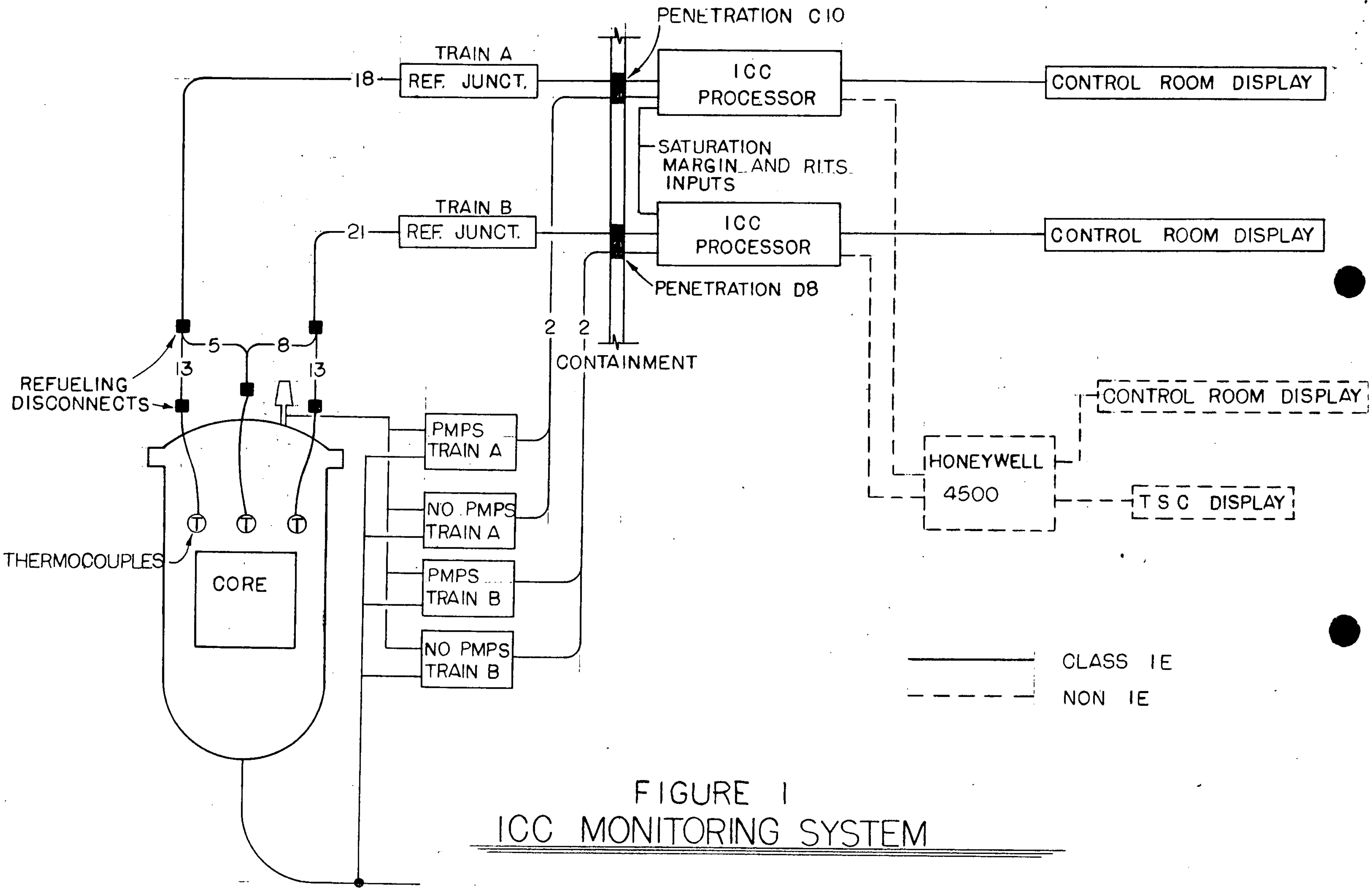


FIGURE 1
ICC MONITORING SYSTEM

TABLE 1

ICC MONITORING SYSTEM INPUTS

TRAIN A

	Parameter	Number of Inputs	Type of Input	Range	Engineering Units
1.	Core Exit Temperature	21	Type K Thermocouple	See comment	°F
2.	Thermocouple Reference Junction Temperature (Train A, Channel 1, 2)	2	200 ohm at 32°F Plat. RTD 4 wire	70-300	°F
3.	Pressurizer Pressure (Channel 1)	1	10-50 mA	1700-2500	psig
4.	Reactor Coolant System Pressure (Channel 1)	1	10-50 mA	0-3000	psig
5.	Reactor Vessel P (Pumps ON, Train A)	1	4-20 mA	-900 to +500	inches of water column
6.	Reactor Vessel P (Pumps OFF, Train A)	1	4-20 mA	-50 to +400	inches of water column
7.	Reactor Coolant Pump Status (Loop A, Channel 1)	1	Dry Contact	N/A	On/Off
8.	Reactor Coolant Pump Status (Loop B, Channel 1)	1	Dry Contact	N/A	On/Off
9.	RVLIS Sensing Leg Temperature (Train A, Channel 1A, 1B, 4, 5A, 5B)	5	100 ohm at 32°F Plat. RTD 4 wire	70-300	°F
10.	RCS Cold Leg Temperature (Loop A, B; Channel 1)	2	4-20 mA	50-650	°F

TABLE 2

ICC MONITORING SYSTEM INPUTS

TRAIN B

	Parameter	Number of Inputs	Type of Input	Range	Engineering Units
1.	Core Exit Temperature	18	Type K Thermocouple	See comment	°F
2.	Thermocouple Reference Junction Temperature (Train B, Channel 1, 2)	2	200 ohm at 32°F Plat. RTD 4 wire	70-300	°F
3.	Pressurizer Pressure (Channel 2)	1	10-50 mA	1700-2500	psig
4.	Reactor Coolant System Pressure (Channel 1)	1	10-50 mA	0-3000	psig
5.	Reactor Vessel P (Pumps ON, Train B)	1	4-20 mA	-900 to +500	inches of water column
6.	Reactor Vessel P (Pumps OFF, Train B)	1	4-20 mA	-50 to +400	inches of water column
7.	Reactor Coolant Pump Status (Loop A, Channel 2)	1	Dry Contact	N/A	On/Off
8.	Reactor Coolant Pump Status (Loop B, Channel 2)	1	Dry Contact	N/A	On/Off
9.	RVLIS Sensing Leg Temperature (Train B, Channel 1A, 1B, 4, 5A, 5B)	5	100 ohm at 32°F Plat. RTD 4 wire	70-300	°F
10.	RCS Cold Leg Temperature (Loop A, B; Channel 2)	2	4-20 mA	50-650	°F

Attachment 2

Mr. D. C. Hintz to Mr. G. E. Lear

January 7, 1986

Response to the Request for
Additional Information
Dated May 22, 1985

1. Elaborate on the indications of the reduced flow and full flow transmitters during various flow conditions (e.g. 0, 1, 2 pumps running).

RESPONSE:

The reduced flow transmitters have been renamed the "Pumps Off" transmitters and are utilized during zero pump operation. The full flow transmitters have been renamed the "Pumps On" transmitters and are utilized during one or two pump operation.

Refer to attached drawing WSK146 Revision 3 for the Control Room indication of the RITS system. The indication for a "Pumps Off" situation will be found on the redundant "RXCP 1A and 1B Off" meters associated with the Reactor Vessel mimic. At this condition, the "RCS VOID FRACTION %" trend recorder will be driven off scale low. The indication for "one or two pumps on" is provided by the "RCS VOID FRACTION %" trend recorder. At this condition, the "RXCP 1A and 1B OFF" meters will be driven off scale low. The void fraction trend recorder is scaled from -100 to +200 and is to be used as a trending device only.

2. Explain the full flow suppression technique and the expected indications with various void fractions or equivalent collapsed vessel water levels.

RESPONSE:

The expected indications are as follows: During normal operating conditions with both Reactor Coolant Pumps running, the "RCS VOID FRACTION %" trend recorder will show approximately a 0% void fraction. The "RXCP 1A and 1B OFF" will be driven off scale low. During no pump operation (e.g. post LOCA), the "RCS VOID FRACTION %" will be driven off scale low and the "RXCP 1A and 1B OFF" meter will indicate the collapsed vessel water level.

Full flow suppression occurs in the microprocessors. Here, the differential pressure sensed by the transmitters is compensated for the number of pumps operating (one or two). The compensated display signal is then sent to the "RCS VOID FRACTION %" trend recorder.

3. Describe the calibration procedures for the system for the various flow conditions.

RESPONSE:

The system calibration will be done in two phases. The first will be calibration of the system for 0-pump operation. Initially the system will be tested with simulated inputs for various levels. The 0-pump differential pressure transmitters will be calibrated in place to ensure accuracy. As a final check, actual vessel level will be determined by the system with pumps off during RCS heating and verified to be correct within overall system error limits.

The second phase will be calibration of the system for 1 and 2 pump operation. This will occur as the RCS is heated up from 350°F to operating temperature (547°F). During the heatup, data from the RITS will be recorded with one and two pumps operating. This will occur after venting of the RCS. Any deviations from 0% void readings on the

RITS will be analyzed and if necessary corrected by replacing the void fraction compensation tables in the microprocessor.

4. The full flow transmitter is said to indicate 4 ma when the vessel is full and 20 ma when the level is at the transmitter elevation. This appears to be reversed from the previous submittal. How will this indication be presented and interpreted for the operator?

RESPONSE:

The full flow transmitter has been renamed the "Pumps On" transmitter and it will indicate 4 ma with zero percent void fraction and 20 ma with 100 percent void fraction. This information is interpreted and presented to the operator as discussed in items 1 and 2 above.

This signal is processed by the ICC microprocessor and presented to the control operators as a trend of void fraction.

5. Why are the transmitters now located 3 feet below the top of the core, instead of at the bottom of the core as indicated in the June 20, 1984 submittal?

RESPONSE:

The intent of the range for the transmitters in the June 20, 1984 submittal was to monitor the collapsed vessel water level from the top of the head to the bottom of the core. It was felt the transmitters had to be at an elevation no higher than the bottom of the core to properly function.

The lower limit of the monitoring range has been changed to the bottom of the hot legs in order to reduce instrument error. The elevation of 3 feet below the top of the core is above the submergence elevation (El. 600 ft.) and at an elevation which provides ease of maintenance.

6. Explain how the reduced flow transmitter will indicate level with one pump running and the dynamic pump head added to the static head indication. How will the operator interpret the 2-pump, 1-pump, 0-pump indications?

<u>RESPONSE:</u>

The reduced flow transmitter has been renamed the "Pumps Off" transmitter and is utilized during no pump operation. The "Pumps On" transmitter will be utilized during one or two pump operation.

The dynamic pump head plus the static head are input in the microprocessor from a computer generated model of the reactor vessel. The differential pressure across the "Pumps On" transmitter is compensated for head due to the instrument tubing and then compared to this model. With additional inputs of pump status and RCS temperature, the microprocessor then calculates a void fraction to display to the operator. Operator interpretation is discussed in items 1 and 2 above.

7. What is the dynamic head with one or two pumps running.

<u>RESPONSE:</u>

The differential pressure across the reactor vessel (flow friction plus static head) has been developed from a computer simulator of the reactor vessel. This differential pressure and the average RCS pressure determine the Void Fraction of the RCS. Two tables to perform this function have been generated (one pump and two pump operation) and are attached.

8. The accuracy Tables (Table 1) for the full flow transmitters are apparently based on a span of 180 inches, while the text indicates a span of 150 inches. Please explain this discrepancy.

RESPONSE:

Design review meetings have changed the name and operating span of the transmitters. The "Pumps Off" transmitters have a span of 450 inches. The "Pumps On" transmitters have a span of 1400 inches. The accuracy tables for the "Pumps Off" situation have been reanalyzed and are attached. The accuracy for the "Pumps On" situation has not been tabulated because the algorithim utilizes a computer generated model of the vessel with unknown uncertainty limits. During the "Pumps On" pre-operational testing, the system will be calibrated to account for the actual differential pressure across the vessel for 0% void fraction at various RCS temperatures.

9. How is the temperature correction for the reference leg computed for normal, LOCA, or SGTR conditions? Please explain the relationship of the 6% transmitter output shift and the reference leg RTD ±6% shift in connection with expected accuracy during LOCA conditions.

RESPONSE:

The temperature correction for the reference leg is computed in the same manner, regardless of plant conditions (normal, LOCA, Post-LOCA, SGTR, etc.). The method is as follows:

1. The density of the fluid in the leg is determined from the average temperature of the RTD's mounted on that leg.

2. The height of the leg multiplied by the density divided by a reference density (62.31#/ft^3) provides the head in the reference leg that has to be compensated.

The transmitter uncertainty and RTD uncertainty are independent of each other. They are indeterminant errors used in calculation of the system expected accuracy and are not related.

10. It is not clear in Table 1 what "output shift" is referenced to in each case. Please clarify the accuracy calculations and assumptions.

RESPONSE:

See revised error analysis (attached).

11. Discuss the effect on the reference leg of gas collecting in the seal chamber. How will gas in the seal chamber be detected during operation?

RESPONSE:

The reference chamber is constructed from an eight inch long length of four inch diameter pipe. There are three penetrations, one at the top for connection to a vent valve, one at the bottom leading to the transmitters, and one at the center line on one end to connect to the reactor vessel.

The head of water above the centerline of the side reference chamber tap will balance across the transmitters through the bottom reference chamber tap and the reactor vessel reference chamber tap. As the water level in the reference chamber falls this balance is maintained until the level falls below the center line of the side tap. Until this time there is no effect on measured level. If the chamber continues to empty there will be an uncompensated effective decrease in reference leg density which would result in a maximum indicated level of 102% at worst conditions with zero void fraction. The case considered above is not assumed to occur because there is no driving force counteracting gravity to drain the remaining inventory from the reference chamber.

Therefore, there is no effect on measured level due to noncondensable gases.

12. Describe the qualification, upgrade and redundancy of the subcooling Margin Monitoring system.

<u>RESPONSE:</u>

The answer to this question has been previously provided in our March 29, 1985, letter to Mr. S. A. Varga.

13. During LOCA conditions, the total uncertainty is estimated as $\pm 26"$ for vessel level approaching recovery. However, at vessel levels close to full the

uncertainty seems to be larger. Please indicate the uncertainty during LOCA conditions at levels other than at the top of the core.

RESPONSE:

See the attached uncertainty analysis.

Table 1

TWO PUMPS OPERATION, P (RV) (psid)

Void Fraction	T_3(ave) °F 350	400	450	500	550	600
0	42.60	40.92	39.19	37.17	34.81	31.83
0.1	27.53	27.85	24.30	24.41	22.93	22.01
0.2	18.38	19.66	16.06	16.90	15.81	15.57
0.3	13.27	14.85	12.00	12.81	11.82	11.55
0.4	10.62	12.15	10.20	10.72	9.66	9.16
0.5	9.23	10.55	9.24	9.53	8.37	7.73
0.6	8.19	9.36	8.20	8.52	7.29	6.79
0.7	6.98	8.09	6.71	7.31	6.11	5.96
0.8	5.38	6.57	4.85	5.90	4.86	5.08
0.9	3.49	4.85	3.29	4.64	3.86	4.11
1	1.78	3.28	2.46	3.85	3.14	3.17

Table 2

ONE PUMP OPERATION, P (RV) (psid)

Void Fraction	T_3(ave) °F 350	400	450	500	550	600
0	21.58	20.77	19.93	18.92	17.76	16.26
0.1	16.64	16.37	15.10	14.72	13.89	13.10
0.2	13.33	13.33	12.06	11.92	11.22	10.67
0.3	11.09	11.22	10.12	10.02	9.36	8.82
0.4	9.48	9.67	8.77	8.65	7.99	7.45
0.5	8.17	8.36	7.64	7.52	6.86	6.41
0.6	6.89	7.11	6.47	6.42	5.80	5.58
0.7	5.52	5.78	5.15	5.24	4.72	4.78
0.8	4.00	4.33	3.71	3.99	3.61	3.88
0.9	2.37	2.80	2.30	2.73	2.52	2.68
1	0.79	1.33	1.23	1.65	1.58	1.03

KEWAUNEE NUCLEAR POWER PLANT

REACTOR INVENTORY TRACKING SYSTEM

UNCERTAINTY ANALYSIS

Revision 1

Prepared by:

WISCONSIN PUBLIC SERVICE CORPORATION

December, 1985

This analysis provides a summary of expected system uncertainties in the Reactor Inventory Tracking System (RITS) at the Kewaunee Nuclear Power Plant (KNPP). Overall system uncertainty is expressed in terms of s, the standard deviation. This revised analysis reflects the changes to the design as outlined in the attached system description.

System Description

The RITS at KNPP is a differential pressure based system. Foxboro differential pressure transmitters, located in Containment, provide a 4-20 mA signal to a microprocessor based inadequate core cooling (ICC) monitor. The ICC monitor compensates this signal for density of the RCS system as a function of temperature. This compensation is achieved by incorporation of other inputs such as tubing leg temperature, average core exit thermocouple temperature, average cold leg temperature, and reactor coolant pump status. This resultant reactor vessel level is output in the Control Room on an analog display of the reactor vessel. This display is expressed in units of percent, where 100% = a full vessel and 0% = level at the elevation of the bottom of the hot legs.

Analysis Method

The total system uncertainty presented in Figures 1-3 included individual component errors and errors introduced by the calculation of vessel level in the ICC monitor. The suppliers' published maximum errors for each component were used as standard deviation figures in the analysis with the exception of the differential pressure transmitter LOCA uncertainty. For the LOCA uncertainty, actual data from the Foxboro qualification test reports were used to calculate a standard deviation. (Note: T1 = containment ambient temperature. T3 = RCS average temperature.)

The combined error of a component was determined through use of the root-sum-squares (RSS) method. Table 1 lists all uncertainties considered along with the combined error for each component. Individual component errors are represented in terms of output shift. For instance, an example of output shift for core exit thermocouples would be:

1) Actual Temperature = 550°F
2) Output Shift = ±0.625%
3) Measured Temperature = 550°F ±3.44°F

The accumulation of error in the ICC system calculations was determined using the relationship

$$S_y = (S_a^2 + S_b^2 + S_c^2 + \ldots + S_n^2)^{\frac{1}{2}}$$

for a sum or difference, and the relationship

$$S_y/y = \left[(S_a/a)^2 + (S_b/b)^2 + (S_c/c)^2 + \ldots + (S_n/n)^2 \right]^{\frac{1}{2}}$$

for multiplication and division where; S_y is the standard deviation of the calculated result, y is the calculated result, and s_n is the absolute standard deviation of the term n in the equation.

Assumptions

To perform the analysis, the suppliers' published maximum error limits were used as standard deviations.

For the LOCA case, it was assumed that the event occurred on the last day of the operating cycle and the transmitters had received full radiation exposure of 5×10^7 RADS prior to the LOCA temperature peak. In addition, the test data used from the Foxboro test reports were for 320°F peak (KNPP peak = 293°F) and 180°F post accident (KNPP post accident = 120°F).

All of the above assumptions tend to increase the uncertainty valves shown in figures 1-3.

Summary

During normal operating conditions, the total system uncertainty for the Reactor Vessel Level System in ±19.1". During the most severe LOCA conditions, the total system uncertainty is ±27.4" for vessel level approaching core uncovery. See Figures 1-3 for additional detail.

Attachment 3

Mr. D. C. Hintz to Mr. G. E. Lear

January 7, 1986

Error Analysis

TABLE 1

COMPONENT ERRORS

1. Differential Pressure Transmitters - output shift in percent of calibrated span:

a.	Accuracy	±0.75
b.	Repeatability	±0.10
c.	Hysteresis	±0.10
d.	Deadband	±0.05
e.	Reproducibility	±0.15
f.	Power Supply	±0.50
g.	Drift/Year	±0.25
h.	LOCA	
	1. 320°F	±1.35
	2. 240°F	±0.17
	3. 180°F	±0.32
i.	Radiation	±2.25
j.	Thermal Aging	±0.26

COMBINED ERROR:

1.	320°F	±2.81 (±15.46")
2.	240°F	±2.47 (±13.59")
3.	180°F	±2.48 (±13.64")
4.	Normal Operating	±0.99 (±5.45")

TABLE 1 - cont'd

2. Reference Leg RTDs - output shift in percent of measured temperature:

a. Accuracy	±0.50
b. Thermal Gradient on reference leg	±6.00
COMBINED ERROR:	±6.02

3. Core Exit Thermocouples - output shift in percent of measured temperature:

a. Accuracy	±0.375
b. Reference junction compensation	±0.50
COMBINED ERROR:	±0.625

4. ICC Monitoring System - output shift in percent of measured parameter

a. A/D Converter	
1. Linearity	±0.03
2. Temperature	±0.06
3. Calibration	±0.03
COMBINED ERROR:	±0.07
b. RTD Converter	
1. Repeatability	±0.50
2. Linearity	±0.25
3. Power Supply	±0.25
4. Temperature	±2.00
COMBINED ERROR:	±2.09
c. System Calculator	±0.01

TABLE 1 - cont'd

d. D/A Converter

1. Linearity	±0.03
2. Temperature	±0.06
3. Calibration	±0.03
COMBINED ERROR:	±0.07

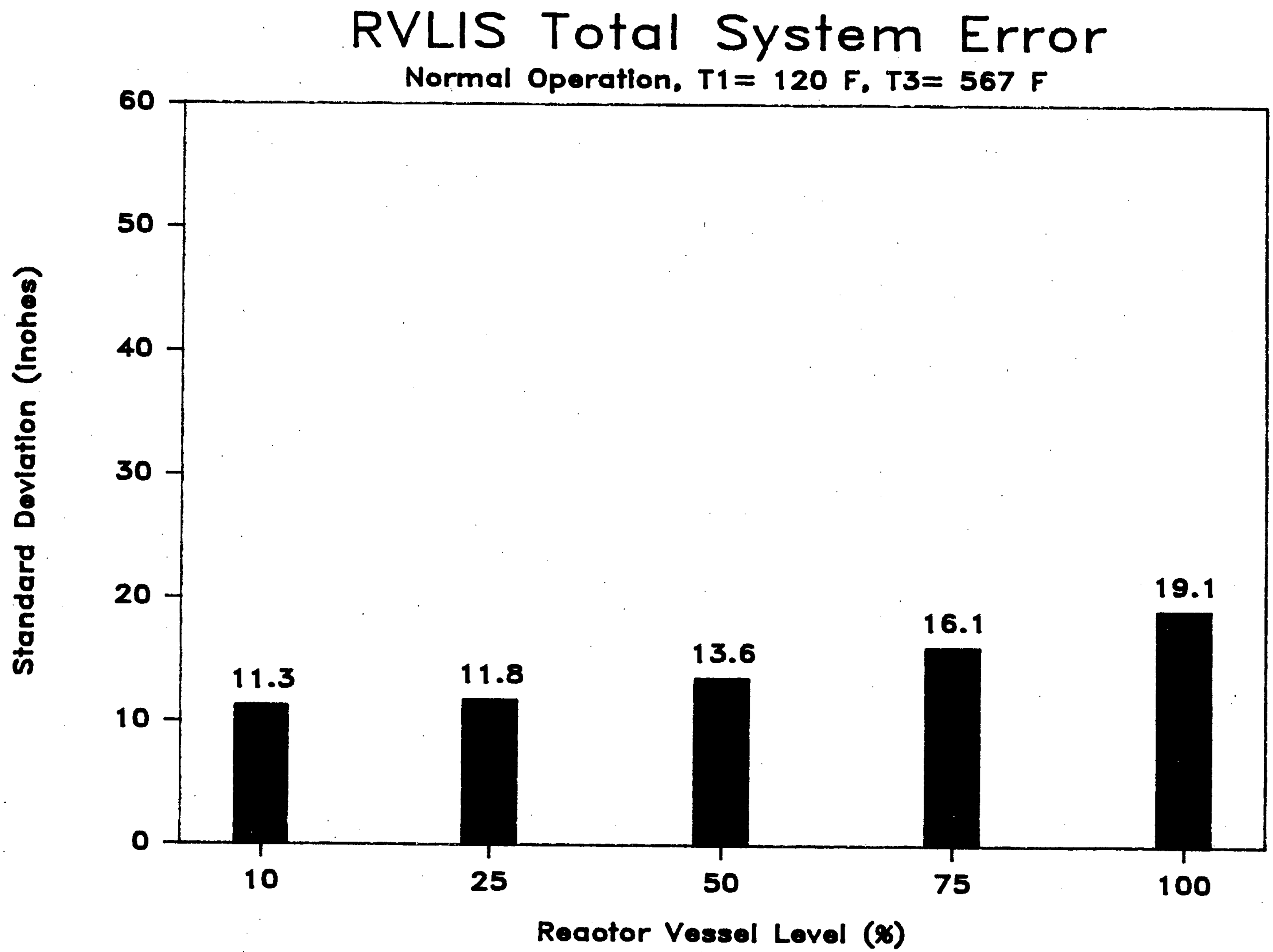
e. Display

1. Repeatability	±1.00
2. Temperature	±0.66
COMBINED ERROR:	±1.20

5. RCS Cold Leg RTDs - output shift in percent of measured temperature

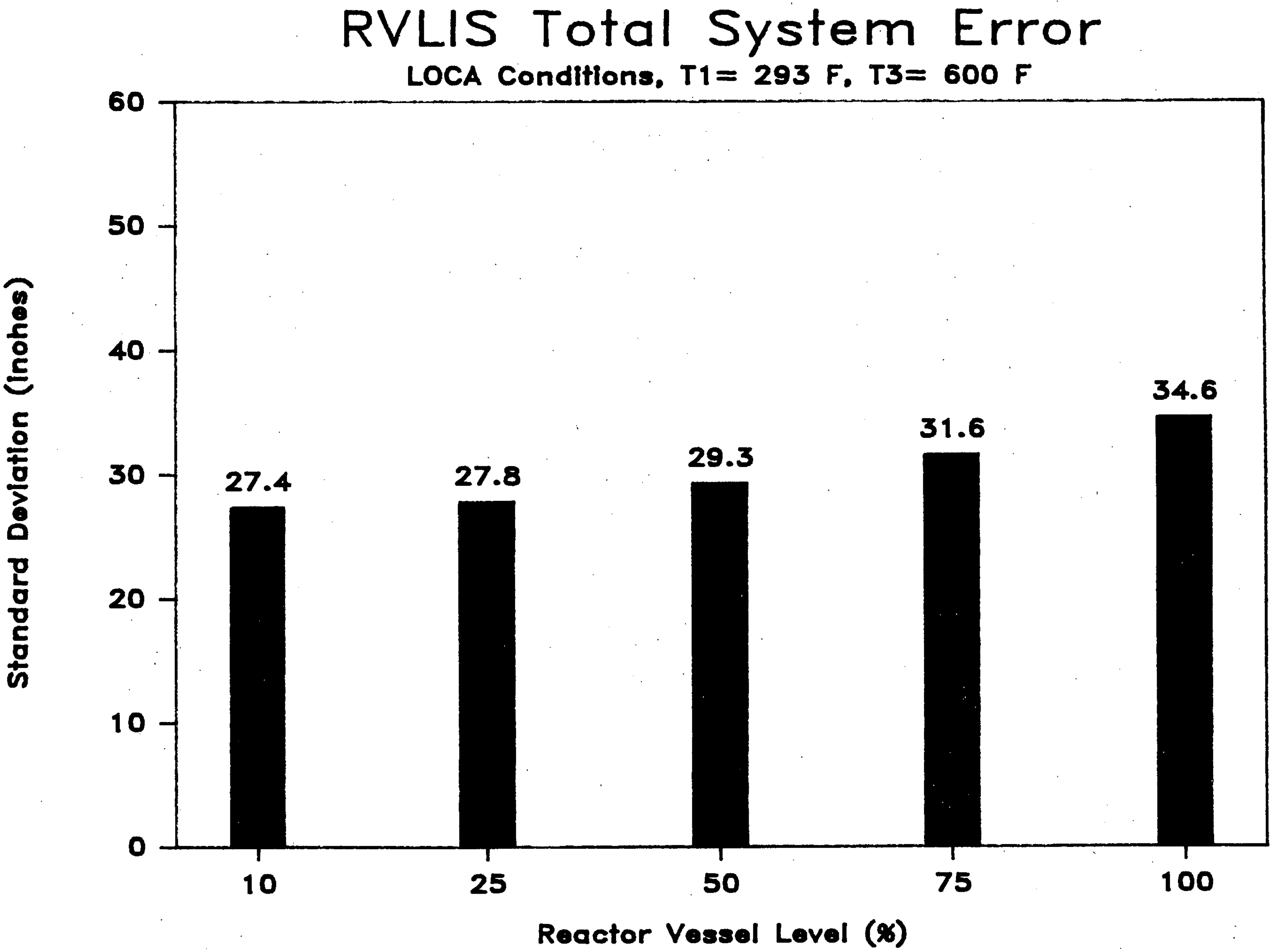
ERROR: ±0.5

FIGURE 1



RVLIS Total System Error
Normal Operation, T1= 120 F, T3= 567 F
60
50
40
30
20
10
0
Standard Deviation (Inches)
11.3
11.8
13.6
16.1
19.1
10
25
50
75
100
Reactor Vessel Level (%)

FIGURE 2



RVLIS Total System Error
LOCA Conditions, T1= 293 F, T3= 600 F
60
50
40
30
20
10
0
Standard Deviation (Inches)
27.4
27.8
29.3
31.6
34.6
10
25
50
75
100
Reactor Vessel Level (%)

FIGURE 3

RVLIS Total System Error

Post LOCA, T1= 120 F, T3= 350 F