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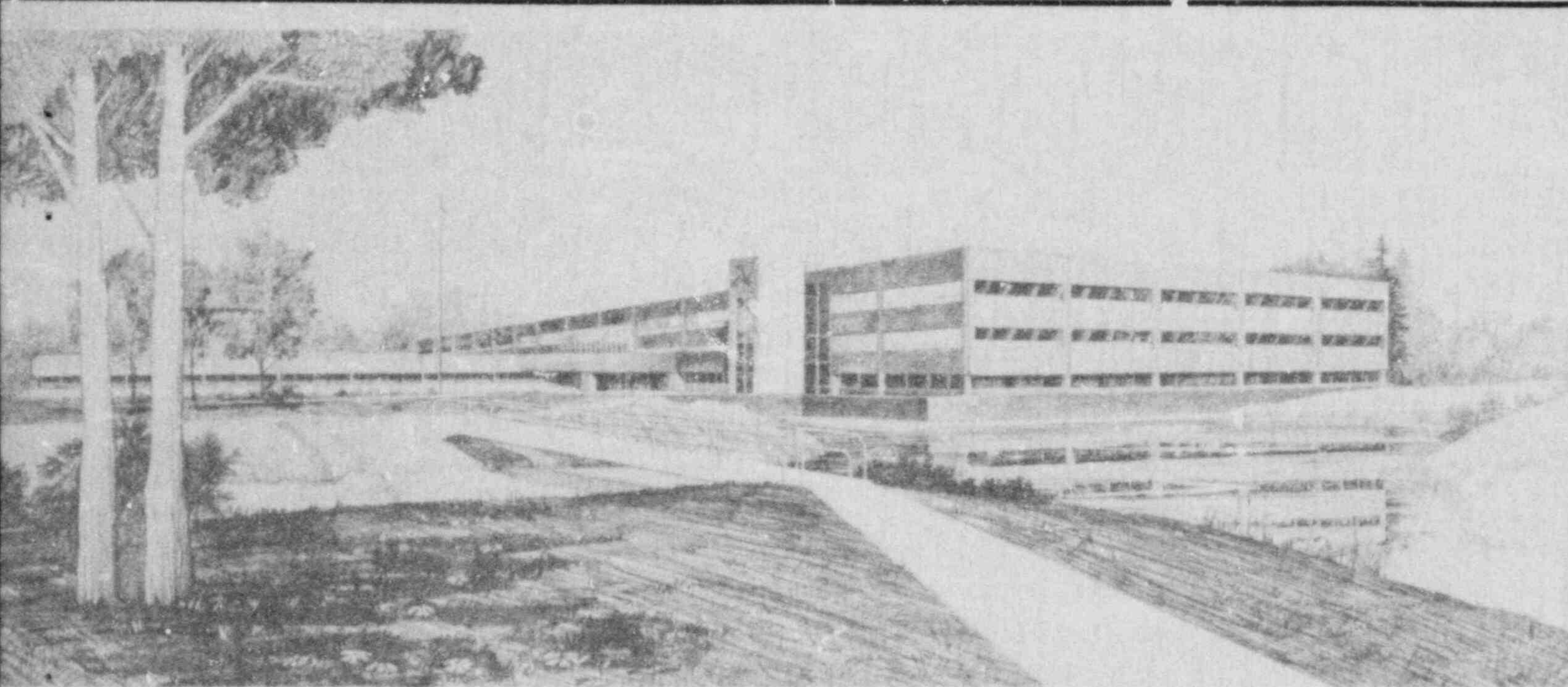

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LOFT Experimental Measurements Uncertainty Analysis Volume XVII Process Instruments Recorded on DAVDS

Robert P. Evans
Kenneth D. McKnight

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ABSTRACT

An uncertainty analysis of the Loss-of-Fluid Test process instruments which are recorded on the Data Acquisition and Visual Display System was performed to document the accuracy of these channels under steady state operating conditions.

FIN No. 6043—LOFT Instrumentation

SUMMARY

Uncertainty analyses are presented to quantify the uncertainty bounds for the Loss-of-Fluid Test (LOFT) process measurements. The process instruments are those used to control the plant operation and safety. The uncertainties presented are of two types: objective uncertainties (basically random) which can be duplicated in the laboratory and for which data are available, and subjective uncertainties (basically systematic) for which no specific data are available.

Subjective uncertainties are based on engineering judgment. The actual measurements are made within a water-cooled nuclear reactor environment of the primary, secondary, and support systems. Environmental conditions include high pressure high temperature water and steam and moderate-to-high radiation levels. This analysis is valid only during steady state normal operating conditions.

The process instruments which are recorded on the Data Acquisition and Visual Display System (DAVDS) are used to supplement the experimental instrumentation for the analysis of LOFT experiments. Since the process measurements were designed for measurement of steady state conditions, the response time for a measurement channel is typically 70 ms or greater. The signal from the instrument to the DAVDS is electrically buffered from the process recording and display system so that there is no cross-talk between the two systems.

The objective uncertainties are derived, in most cases, for a measurement channel by the root-sum-square (RSS) total of all the manufacturers' specifications (Appendix A). These specifications are summarized in Appendix B. It has been assumed that the manufacturers' specifications have been normalized to the measurand "percent of range" (RG) and are statistically 2σ values. This is a conservative assumption since most suppliers quote a 3σ value.

The subjective uncertainties are derived from engineering experience and judgment when no objective data are available on which to base an uncertainty in a specific area. These uncertainties include such parameters as radiation effects or vibration sensitivity. No attempt will be made to break down these uncertainties into their parameters; they will be listed as single numbers with an explanation of the type of parameters that were assumed for the estimate.

The total uncertainty for the measurement channel is given as the RSS sum of the objective and subjective uncertainties. These uncertainties, along with a diagram of the measurement channel components, are documented in Appendix A Figures A-1 through A-55. The uncertainties quoted include a DAVDS uncertainty of +0.13% of range.[1]

FOREWORD

Analyses are performed to evaluate the anticipated performance uncertainty for each experimental measurement in the LOFT system. Results of these analyses are reported in a series of volumes designated NUREG/CR-0169, EGG-2037.[a] Volume I of this series describes the LOFT experimental measurement systems and the techniques used for calculating the uncertainties. The remaining volumes in the series present detailed results from the uncertainty analysis performed for each experimental measurement system. The following volumes were previously published.

1. G. L. Biladeau, *LOFT Experimental Measurements Uncertainty Analyses, Volume VI, LOFT Linear Variable Differential Transformer Displacement Transducer Uncertainty Analysis*, TREE-NUREG-1089, February 1978.

2. G. D. Lassahn, *LOFT Experimental Measurements Uncertainty Analyses, Volume XVI, LOFT Three-Beam Gamma Densitometer System*, TREE-NUREG-1089, February 1978.

3. L. D. Goodrich, *LOFT Experimental Measurements Uncertainty Analyses, Volume XV, LOFT Primary Coolant Pump Speed Measurement Uncertainty Analysis*, TREE-NUREG-1089, April 1978.

4. G. L. Biladeau, *LOFT Experimental Measurements Uncertainty Analyses, Volume IX, LOFT Strain Gage Uncertainty Analysis*, TREE-NUREG-1089, June 1978.

5. G. D. Lassahn, *LOFT Experimental Measurements Uncertainty Analyses, Volume VII, LOFT Self-Powered Neutron Detector Uncertainty Analysis, NUREG/CR-0169*, TREE-1089, August 1978.

6. G. D. Lassahn and P. A. Quinn, *LOFT Experimental Measurements Uncertainty Analyses, Volume VIII, LOFT Traversing In-Core Probe Uncertainty Analysis, NUREG/CR-0169*, TREE-1089, August 1978.

7. P. A. Quinn, G. L. Biladeau, and R. Y. Maughan, *LOFT Experimental Measurements Uncertainty Analyses, Volume V, LOFT External Accelerometer Uncertainty Analysis*, NUREG/CR-0169, TREE-1089, October 1978.

8. S. Silverman, *LOFT Experimental Measurements Uncertainty Analyses, Volume XIV, LOFT Drag-Disc Turbine Transducer Uncertainty Analysis*, NUREG/CR-0169, TREE-1089, November 1978.

9. G. D. Lassahn, *LOFT Experimental Measurements Uncertainty Analyses, Volume XVIII, Radiation-Hardened Gamma Densitometer System*, TREE-NUREG-1089, February 1978.

10. G. D. Lassahn, *LOFT Experimental Measurements Uncertainty Analyses, Volume XII, Differential Pressure Measurements*, NUREG/CR-0169, EGG-2037, March 1982.

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a. Volumes VI, IX, XV, and XVI were published prior to implementation of the NUREG/CR numbering system. Volumes V, VII, VIII, and XIV were published as NUREG/CR-0169, TREE-1089 (TREE was the former designation for formal reports prepared by EG&G Idaho, Inc.). The remaining volumes in this series will be published as NUREG/CR-0169, EGG-2037.

11. G. D. Lassahn, *LOFT Experimental Measurements Uncertainty Analyses, Volume XIX, Small-Pipe MCA Densitometer*, NUREG/CR-0169, EGG-2037, August 1981.

12. S. Ploger, *LOFT Experimental Measurements Uncertainty Analyses, Volume X, Absolute Pressure Measurement Uncertainty Analysis*, NUREG/CR-0169, EGG-2037, September 1981.

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14. L. D. Goodrich and G. D. Lassahn, *LOFT Experimental Measurements Uncertainty Analyses, Volume XI, Free-Field Pressure Transducer*, NUREG/CR-0169, EGG-2037, June 1982.

15. G. D. Lassahn, *LOFT Experimental Measurements Uncertainty Analyses, Volume III, Data Acquisition and Recording System*, NUREG/CR-1069, EGG-2037, August 1982.

16. T. R. Meachum, *LOFT Experimental Measurements Uncertainty Analyses, Volume IV, Liquid Level Transducer*, NUREG/CR-1069, EGG-2037, August 1982.

17. G. D. Lassahn and D. J. N. Taylor, *LOFT Experimental Measurements Uncertainty Analyses, Volume XX, Fluid Velocity Measurement Using Pulsed Neutron Activation*, NUREG/CR-1069, EGG-2037, August 1982.

18. G. C. Cheever, *LOFT Experimental Measurements Uncertainty Analyses, Volume XXI, Modular Drag-Disc Turbine Transducer*, NUREG/CR-1069, EGG-2037, February 1983.

ACKNOWLEDGMENTS

Some of the information presented in this report was derived from D. H. Van Haaften, LOFT Instrumentation Accuracy Analysis, LO-81-81-013 Rev. 1, April 1984.

CONTENTS

LOFT EXPERIMENTAL MEASUREMENTS UNCERTAINTY ANALYSIS VOLUME XVII PROCESS INSTRUMENTS RECORDED ON DAVDS

INTRODUCTION

Some of the process instruments on the Loss-of-Fluid Test (LOFT) system are recorded on the Data Acquisition and Visual Display System (DAVDS) to supplement the experimental instrumentation during steady state operation to establish pre-loss-of-coolant experiment (LOCE) conditions. This avoids instrument duplication. These process instruments supply both parametric (temperature, pressure, density, etc.) and supplemental (time, position, etc.) measurements. Parametric measurements supply essential information regarding the nuclear, hydraulic, and thermal state of the test assembly prior to a LOCE. Supplemental measurements provide information concerning timing of events.

INSTRUMENT CHANNEL DESCRIPTION

The process instrumentation records on DAVDS originate from ten systems in three broad categories. These categories are: (a) Plant Protection System, (b) Plant Operating System, and (c) Monitor and Surveillance System.[2,3] The ten systems in these categories are:

1. Secondary Coolant System
2. Emergency Core Coolant System
3. Primary Coolant System
4. Blowdown System
5. Primary Coolant Addition and Control System
6. Primary Component Cooling System
7. Primary Coolant Purification System
8. Pressure Reduction and Decontamination Spray System
9. Process Nuclear System
10. Component Measurement System.

Process instruments recorded on DAVDS are paralleled from all three categories. This instrumentation consists of absolute and differential pressure, temperature, flow, liquid level, valve position (continuous and open or closed), nuclear, pump parameters, and hydrogen concentration. Over 200 of these process measurements are recorded on DAVDS for use in experiment analysis. The uncertainty, response, and range for each instrument channel are summarized in Table 1. The uncertainty reported is the root-summed-squared (RSS) sum of the objective uncertainty (that derived from the manufacturers' specifications and LOFT testing) and the subjective uncertainty (that derived through engineering experience and judgment). These uncertainties are reported as a percent of range (RG), percent of reading (RD), or in actual units of measurement (i.e., m/s, K, etc.).

In many cases, the subjective portion is much larger than the objective portion of the uncertainty, since the unknowns of the measurement installation and environment are very large. Factors such as the effect of ambient pressure, temperature, radiation, vibration, etc. are virtually unknown for most of these channels. Figures 1 through 14 indicate the approximate location of each measurement; Figures A-1 through A-55 show how various components are connected, along with specific component uncertainties.

Pressure

Approximately 27 process pressure measurements are recorded on DAVDS, depending on the test being performed. The uncertainties in these measurements arise from installation and mounting effects and from inherent measurement channel uncertainties. The inherent measurement channel uncertainties are generally derived from manufacturers' specifications and are detailed in Figures A-1 through A-5 and in the summaries of the specifications in Appendix B. The installation effects dominate the response time. Typically, manufacturers' specifications quote response times of 7 ms; however, long piping lengths and snubbers increase the response time significantly. Where direct measurement of the response time was not feasible, the response time was estimated by comparison with instruments with similar mountings for which direct measurement was feasible.

Differential Pressure

Seven process differential pressure measurements are recorded on DAVDS. Three of these are used for level measurements, three are for flow measurements, and one is for completion of the loop sum differential pressure measurement. The differential pressure outputs of the first six are recorded, as are the corresponding level or flow measurements. The uncertainties in the differential pressure measurements are similar in source to those for the pressure measurements. In addition, the absolute line pressure effects on the differential pressure transducer must be explained. The instruments comprising the differential pressure measurement channels, with their manufacturers and uncertainties, are shown in Figures A-6, A-7, and A-8.

Flow

Twenty-eight process flow measurements are recorded on DAVDS. These flow measuring instruments include venturis and orifices with differential pressure transmitters, vortex shedding-type transducers, Pitot tubes with differential pressure transmitters, and ultrasonic flow transducers. The specific components for a specific measurement channel, with their manufacturers and uncertainties, are shown in Figures A-9 through A-21. The response times of these transducers depend upon the measurement principle and measurement location. For those measurements using differential pressure transmitters, the response time is adversely affected by long tubing lengths and snubbers.

The primary loop flow measurement has a microprocessor-based instrument which takes inputs from temperature, pressure, and differential pressure transmitters to produce a more accurate flow measurement.[4] The response time of the system, disregarding the pressure transmission lines, is $\sim$1 s.

Temperature

The process temperature measurements recorded on DAVDS use either type-J (iron v. copper-nickel) thermocouples (TCs) or resistance temperature detectors (RTDs). Forty process temperature measurements are recorded on DAVDS.

The measurement channels are shown in Figures A-22 through A-34. The response time of the temperature measurement is limited by the installation and mounting, and has been determined, by analysis of LOFT data, for each measurement channel.

Liquid Level

The 21 process liquid level measurements recorded on DAVDS, with one exception, use differential pressure transmitters as level indicators. The one exception uses a buoyancy transducer. Figures A-6 and A-35 through A-40 provide the channel layout, with components and uncertainties, for the specific liquid level measurement channels.

The response time for the differential pressure transmitter-based measurements is dominated by the effects on the differential pressure transmitter discussed above. To increase the accuracy of the pressurizer level system, a microprocessor-based computer is used in the measurement channel. This system accepts, in addition to the differential pressure input, inputs from pressure and temperature transmitters. These additional inputs are used to compensate for the pressure and temperature effects on the level measurement. The time response for this channel is $\sim$1 s.

Valve Position

Positions are recorded on DAVDS for 82 valves. These consist of either open or closed indication (65 valves) or continuous position indication (17 valves). The open or closed indication is provided by two limit switches, one at each end of the valve travel. Continuous position indication is provided through linear potentiometers or linear variable differential transformers (LVDTs) which allow the valve stem position to be monitored throughout the valve stem travel. Figures A-41 and A-42 show typical open or closed and continuous valve position measurement channels. Figures A-43 and A-44 represent the only channels for which complete information is available.

Nuclear

The process nuclear instrumentation consists of two source range, two intermediate, and three power range detectors, plus one power range spare. All of the nuclear detectors are thermal neutron detectors. Figures A-45 through A-48 provide component interconnection diagrams along with the component manufacturers and uncertainties. The response time of the measurement channel varies from less than 10 ms for the power range channels to 30 s for the source range channels.

Hydrogen Concentration

Three hydrogen concentration measurements are obtained in the LOFT containment building. The measurement channel description is shown in Figure A-49. No additional information is available on these measurements and they should be considered highly uncertain.

Pump Parameters

Seven parameters for each of the two primary coolant pumps are recorded on DAVDS. These include frequency, current, root-mean-squared (RMS) current, reactive power, pump power, voltage, and RMS voltage. Figures A-50 through A-55 show the components and their interconnections for each type of measurement.

DISCUSSION OF UNCERTAINTIES

The uncertainties derived in this analysis are of two types: those for which backup data (objective) are available, and those which are based on engineering judgment (subjective). The objective uncertainties for each measurement channel are shown in Figures A-1 through A-55, with backup information in Appendix B. The subjective uncertainties are shown below with some basis for the estimates.

Pressure

The pressure transmitters are subjected to environmental and mounting effects which are not addressed by the manufacturers' specifications. These include such effects as vibration and acceleration, aging (both radiation and cycling), line effects, and recalibration. The combined effects are estimated at 0.5% of range.

Differential Pressure

Differential pressure transmitters are subjected to many of the same effects as the pressure measurements. Because the differential pressure transmitters require two input sensing lines, the line effects are much greater than for the pressure instruments. These transmitters are unidirectional and are, therefore, reliable only for positive differential pressures. The estimated subjective uncertainty for these measurements is 0.8% of range.

Flow

The outputs of five types of process flow transducers are recorded on DAVDS. Although each has its particular uncertainties, those utilizing differential pressure transmitters are combined in this section, since the differential pressure transmitter provides the majority of the uncertainty.

Differential Pressure-Based Flow Transducers. The uncertainties for these transducers include those discussed in "Flow" above, plus the effects caused by the changing flow conditions of the fluid. The combined effects on the measurement uncertainty are estimated at 1.0% of range.

Vortex Shedding Flow Transducers. Fluid viscosity changes, as well as aging effects, contribute to the subjective uncertainty for this transducer. This uncertainty is estimated at 0.5% of range.

Ultrasonic Flow Transducers. For maximum accuracy, this transducer should be matched to the specific location. Uncertainties in pipe wall thickness, fluid properties, and flow regimes, as well as calibration and aging, contribute to the measurement uncertainty. The estimated effects contribute 0.5% of range to the measurement uncertainty.

Temperature

Two types of process temperature measurement instruments are recorded on DAVDS, i.e., TCs and RTDs. Uncertainties for these measurements are in Kelvin; therefore, the range must be adjusted by 255 K, i.e., (RG - 255).

Thermocouples. TCs are sensitive to a wide range of environmental conditions which affect their output, as well as to hardware and calibration uncertainties which include the extension cable, calibration equation, cold work of the thermal elements during installation, aging, radiation, and the reference junction. The reference junction for the thermocouples is contained in the temperature transmitter. The thermocouples used are standard grade. The estimated effect of these uncertainties is 2.7 K + 0.7% of the reading, i.e., (RD - 255).

Resistance Temperature Detectors. RTDs have a slower response time than TCs but are usually more accurate. Some additional factors affecting the uncertainty of the RTD measurements include interchangeability between RTDs, linearity, self-heating, repeatability, long term stability, insulation resistance, thermal e.m.f., and radiation. The combined estimate of these uncertainties is 1.0% (RG - 255). This term can become as great as 10% if the transducer is left in operation for long periods of time, due to the radiation effect on the platinum in the RTD.

Liquid Level

The majority of the liquid level measurements are based on differential pressure measurements. One measurement uses a float transducer.

Differential Pressure-Based Liquid Level Transducers. The uncertainties for this measurement include those covered in "Flow" above, plus the effects of calibration, volume, shape, and temperature of the vessel. These will vary for each application, but a general estimate for the subjective uncertainties for this type of measurement is 1.5% of range.

Float-Type Liquid Level Transducer. Changes in fluid conditions, as well as transducer aging and calibration changes, affect the measurement uncertainty. An estimate of these effects is 0.5% of range.

Valve Position

Valve position monitors are either the open or closed type or the continuous position monitor.

Open or Closed Monitor. The only uncertainty of this transducer is the uncertainty of total failure. For this analysis, uncertainty is not applicable.

Continuous Position Transducer. The uncertainty in this measurement is that of the transducer monitoring the valve position. Some of the factors which can affect the uncertainty are stability, temperature, calibration changes, and ripple. These are estimated at 1.0% of range.

Nuclear

The primary factors affecting the subjective uncertainty of the nuclear detectors are aging and calibration. The power range output is standardized to the secondary calorimetric, which is based on temperature and pressure and has an uncertainty of $\sim$2% of range. The uncertainties on the intermediate and source range channels are slightly higher (3% of range for the intermediate range and 3.6% of range for the source range channels), according to the manufacturer.

Hydrogen Concentration

Since no information has been found, the subjective uncertainty on this measurement is considered to be large, i.e., on the order of 10% of range.

Pump Parameters

Four basic types of pump parameter measurements are obtained: power, current, voltage, and frequency. The current (I), voltage (V), and frequency (F) are used to calculate the power, using the equation:

$$\text{Power} = \sqrt{3} \times I \times V \times F$$

where I and V are the RMS values of current and voltage, respectively.

Power is also measured independently using a wattmeter. Comparisons of the measured power and calculated power from actual tests show inaccuracies of 13-15%. It is believed that the majority of this error is in the current measurement. This determination was based on an observation of the actual installation. The shunting resistor in the current transducer was poorly installed, giving rise to the uncertainty in the measurement.

The subjective uncertainties, based on engineering judgment of the inconsistencies observed in the power measurement, for each type of measurement are:

Current	12% of range
Voltage	3% of range
Frequency	1% of range
Power	1% of range.

Included in these uncertainties are the uncertainties due to the secondary circuit burden (load).

SUMMARY OF UNCERTAINTIES

Table 1 summarizes the uncertainties for each measurement channel. The number given is the RSS sum of the objective and subjective uncertainties.

CONCLUSIONS

The uncertainties derived in this analysis are estimates based on manufacturers' specifications, LOFT testing, and engineering judgment. The largest source of uncertainty, in all of the process measurements recorded on DAVDS, is contributed by mounting and environmental factors. This is largely due to the many unknowns in these areas.

The process measurements are intended only for steady state operation. Any data obtained during transient conditions must be carefully considered for response limitations.

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1. G. D. Lassahn, *LOFT Experimental Measurement Uncertainty Analysis, Volume III, Data Acquisition and Recording System*, August 1982.

2. *LOFT Integral Test System, System Design Description 1.4.4B, Primary Coolant Instrumentation and Control System,* January 1982.

3. *LOFT Integral Test System, System Design Description 1.4.6B, Secondary Coolant Instrumentation and Control System*, October 30, 1981.

4. K. R. Quirl, *Pressurizer Level Instrumentation Upgrade*, LO-90-81-022, March 1981.

Table 1. LOFT process measurements uncertainty list

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
AH2E-T55-C01	H2 CONCENTRATION IN CONTAINMENT	0 - 4.0%		10RG	N/A	A49
AH2E-T55-C02	H2 CONCENTRATION IN CONTAINMENT	0 - 4.0%		10RG	N/A	A49
AH2E-T55-C03	H2 CONCENTRATION IN CONTAINMENT	0 - 4.0%		10RG	N/A	A49
CV-P004-008	FEEDWATER FLOW CONTROL VALVE	0 - 100%	10MS	2.34RG	11	A42
CV-P004-010	SCS STEAM FLOW CONTROL VALVE	0 - 100%	10MS	2.34RG	11	A42
CV-P004-011	STEAM STOP VALVE	0 - 100%	10MS	2.34RG	11	A42
CV-P004-073	FEEDWATER ISOLATION VALVE, 0=CLOSED 1=OPEN	OPEN OR CLOSED	10MS	N/A	11	A41
CV-P004-090	MAIN STEAM BYPASS VALVE	0 - 100%	10MS	2.34RG	11	A42
CV-P004-091	MAIN FEED BYPASS VALVE	0 - 100%	10MS	2.34RG	11	A42
CV-P120-019	BWST FILL LINE	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-032	ACC B DISCHARGE LINE	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-033	ACC B DISCHARGE BYPASS	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-035	ACC B DISCHARGE ISOLATION COMMON	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-037	ACC B RECIRCULATION TO BWST	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-042	ACC A INLET LINE	0 - 100%	10MS	2.34D + 3RG	13	A42
CV-P120-047	ACC A DISCHARGE LINE	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-048	ACC A DISCHARGE BYPASS	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-050	ACC A DISCHARGE ISOLATION COMMON	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-051	ACC A RECIRCULATION TO BWST	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-052A	BWST TO LPIS PUMPS	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-052B	BWST TO LPIS PUMPS	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-053	HOT LEG INJECTION VALVE	OPEN OR CLOSED	10MS	N/A	12	A41

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
CV-P120-054	VALVE POSITION - UPPER PLENUM INJECTION	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-063	COLD LEG ISOLATION VALVE	OPEN OR CLOSED	10MS	N/A	13,14	A41
CV-P120-066	VALVE POSITION - LOWER PLENUM ISOLATION	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-067-1	BLOWDOWN RECIRCULATION LINE FOR SHUTDOWN COOLING	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-067-2	BLOWDOWN RECIRCULATION LINE FOR SHUTDOWN COOLING	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-070-1	LPIS PUMP B ISOLATION AROUND LOCE ORIFICE	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-071-1	LPIS PUMP A ISOLATION AROUND LOCE ORIFICE	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-071-2	LPIS PUMP A BYPASS ISOLATION	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-076	LPIS PUMP B INLET FROM BWST	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-077	LPIS B INLET FROM DECONTAMINATION SUMP	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-078	LPIS A INLET FROM DECONTAMINATION SUMP	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-079	BLOWDOWN LOOP RECIRCULATION TO LPIS PUMP B	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-080	BLOWDOWN LOOP RECIRCULATION TO LPIS PUMP A	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-081	BWST TO LPIS PUMP A	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-090	COLD LEG INJECTION ISOLATION VALVE	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-091	N2 TO MTA CONTROL VALVES	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P120-092	N2 TO BASEMENT CONTROL VALVES	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P120-097	LPIS PUMP A DISCHARGE ISOLATION	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-098	LPIS PUMP A TO BWST	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-099	LPIS PUMP B TO BWST	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-105	BLOWDOWN RECIRCULATION LINE TO LPIS PUMP INLET	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-106	BOST TO LPIS PUMP SUCTION	OPEN OR CLOSED	10MS	N/A	13	A41

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
CV-P120-107	LPIS DISCHARGE CROSSTIE	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-108	LPIS DISCHARGE CROSSTIE	OPEN OR CLOSED	10MS	N/A	13	A41
CV-P120-109	ACC B TO UPPER PLENUM	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-110	DOWNCOMER ISOLATION VALVE	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-113	N2 SUPPLY TO MTA VALVES	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P120-114	N2 SUPPLY TO BASEMENT VALVES	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P120-115	N2 SUPPLY TO BASEMENT VALVES	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P120-119	LPIS PUMP B DISCHARGE ISOLATION	OPEN OR CLOSED	10MS	N/A	12	A41
CV-P120-142	VALVE POSITION CONTAINMENT ISOLATION	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P128-005	MIX TANK TO HPIS PUMP A	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-006	MIX TANK TO HPIS PUMP B	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-007	BATCH TANK TO HPIS PUMP A	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-008	BATCH TANK TO HPIS PUMP B	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-011	BWST TO HPIS PUMP A	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-014	BWST TO HPIS PUMP B	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-063	BATCH TANK FILL VALVE	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-086	HPIS DISCHARGE TO BWST	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-105	HPIS PUMP CROSSTIE	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-106	HPIS TO PURIFICATION SYSTEM	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-109	HPIS PUMP CROSSTIE	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-116	HPIS PUMP B DISCHARGE ISOLATION	OPEN OR CLOSED	10MS	N/A	14	A41
CV-P128-117	HPIS PUMP A DISCHARGE ISOLATION	OPEN OR CLOSED	10MS	N/A	14	A41

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
CV-P138-001	QOBV IN COLD LEG (ZT-P138-109)	0 - 100%	10MS	2.34RG	1	A42
CV-P138-002	BLOWDOWN SYSTEM COLD LEG ISOLATION VALVE	OPEN OR CLOSED	10MS	N/A	1	A41
CV-P138-015	QOBV IN HOT LEG (ZT-P138-108)	0 - 100%	10MS	2.34RG	1	A42
CV-P138-070A	BLOWDOWN SYSTEM BYPASS VALVE(A)	0 - 100%	10MS	1.88RG	1	A43
CV-P138-071A	BLOWDOWN SYSTEM BYPASS VALVE	0 - 100%	10MS	1.88RG	1	A43
CV-P138-098	COLD LEG DUMP VALVE	OPEN OR CLOSED	10MS	N/A	N/A	A43
CV-P138-099	QOBV COMMON DUMP VALVE	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P138-100	HOT LEG DUMP VALVE	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P138-123	20 GPM SPRAY HEADER CONTROL VALVE	0 - 100%	10MS	2.34RG	9	A44
CV-P138-124	60 GPM SPRAY HEADER CONTROL VALVE	0 - 100%	10MS	2.34RG	9	A44
CV-P138-125	220 GPM SPRAY HEADER CONTROL VALVE	0 - 100%	10MS	2.34RG	9	A44
CV-P139-005-4	PRESSURIZER POWER OPERATED RELEASE	OPEN OR CLOSED	10MS	N/A	N/A	A41
CV-P139-025	PRIMARY HOT LEG DRAIN ISOLATION VALVE	OPEN OR CLOSED	10MS	N/A	1	A41
CV-P139-026	PPS PRIMARY SYSTEM DRAIN (POSITION)	0 - 100%	10MS	2.34RG	1	A42
CV-P139-031-2	PPS PRIMARY SYSTEM DRAIN (POSITION)	0 - 100%	10MS	2.34RG	1	A42
CV-P139-051	PRESSURE STANDARD VENT VALVE	OPEN OR CLOSED	10MS	N/A	1	A41
CV-P139-087	TEST PORV	OPEN OR CLOSED	10MS	N/A	3	A41
CV-P140-002	PURIFICATION SYSTEM DRAIN VALVE	0 - 100%	10MS	2.34RG	14	A42
CV-P140-005	PURIFICATION SYSTEM FLOW CONTROL VALVE	0 - 100%	10MS	2.34RG	14	A42
FE-P138-138	SUPPRESSION TANK FLOW IN 2 INCH LINE	0 - 6 L/S	50 MS	2.91 RG	1,9	A9
FE-P138-139	TOTAL SUPPRESSION TANK SPRAY FLOW	0 - 25 L/S	50 MS	2.91 RG	1,9	A9
FE-P138-140	SUPPRESSION TANK FLOW IN 3 INCH LINE	0 - 20 L/S	50 MS	2.91 RG	1,9	A9

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
FE-P138-153	BYPASS SUPPRESSION TANK SPRAY FLOW	0 - 10 L/S	50 MS	2.91 RG	1,9	A9
FT-P004-012A	STEAM FLOW - CONDENSER INLET ,LOW RANGE	0 - 3.8 KG/S	50 MS	3.17 RG	11	A10
FT-P004-012	STEAM FLOW - CONDENSER INLET	0 - 37.8 KG/S	50 MS	3.17 RG	11	A10
FT-P004-062A	AUX. FEEDWATER PUMP FLOW RATE	0 - 1.3 L/S	30 MS	4RD +1.1 RG	11	A11
FT-PC04-062B	SECONDARY MAKEUP PUMP RATE	0 - 1.3 L/S	30 MS	4RD +1.1 RG	11	A11
FT-PC04-072A	DIFFERENTIAL PRESS. ACROSS FEEDWATER FLOW VENTURI	0 - 25 KPA	50 MS	4400KG/S+3.37RG	11	A12
FT-PC04-072-2	FEEDWATER PUMP DISCHARGE FLOW RATE	0 - 38 KG/S	50 MS	4400KG/S+3.37RG	11	A12
FT-PC04-090	MAIN STEAM VALVE BYPASS FLOW	0 - 3.8 KG/S	50 MS	2.2 RG	11	A13
FT-PC04-091	FEEDWATER VALVE BYPASS FLOW	0 - 5.0 L/S	50 MS	2.5 RG	11	N/A
FT-P120-031-1	ACC B FLOW RATE LOW RANGE	0 - 38 L/S	70 MS	1.7RD + 2.05RG	12	A14
FT-P120-031-5	ACC B FLOW RATE HIGH RANGE	0 - 126 L/S	70 MS	1.7RD + 2.05RG	12	A14
FT-P120-036-1	ACC A FLOW RATE HIGH RANGE	0 - 126 L/S	70 MS	1.7RD + 2.05RG	1,13	A14
FT-P120-036-5	ACC A FLOW RATE, LOW RANGE	0 - 38 L/S	70 MS	1.7RD + 2.05RG	1,13	A14
FT-P120-072A	LPIS PUMP B FLOW RATE	0 - 25 L/S	70 MS	2.77RG	12	A15
FT-P120-072B	LPIS PUMP B FLOW RATE	0 - 25 L/S	70 MS	2.77RG	12	A16
FT-P120-085A	LPIS PUMP A FLOW RATE	0 - 25 L/S	70 MS	2.77RG	1,13	A15
FT-P120-085B	LPIS PUMP A FLOW RATE	0 - 25 L/S	70 MS	2.77RG	1,13	A16
FT-P128-085	HPIS PUMP B FLOW RATE	0 - 1.89 L/S	70 MS	.5RD + 2.05RG	14	A17
FT-P128-104	HPIS PUMP A FLOW RATE	0 - 1.89 L/S	70 MS	.5RD + 2.05RG	14	A17
FT-P138-017	ION EXCHANGER	0 - 10 L/S	70 MS	.5RD + 2.05RG	N/A	A18
FT-P139-027-1	PRIMARY COOLANT FLOW CHANNEL A	0 - 630 KG/S	70 MS	.25RD + 3.44RG	1,2	A19
FT-P139-027-2	PRIMARY COOLANT FLOW CHANNEL B	0 - 630 KG/S	70 MS	.25RD + 3.44RG	1,2	A19

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
FT-P139-027-3	PRIMARY COOLANT FLOW CHANNEL C	0 - 630 KG/S	70 MS	.25RD + 3.44RG	1,2	A19
FT-P139-086	PORV VALVE FLOW MONITOR	UNKNOWN		5RG		N/A
FT-P140-010A	PURIFICATION FLOW, HIGH RANGE	0 - 4.7 L/S	1 SEC	.5RD + 2.05RG	14	A20
FT-P141-022	TOTAL PRIMARY COMPONENT COOLANT FLOW RATE	0 - 22 L/S	70 MS	.5RD + 2.05RG	14	A21
LD-P139-006	PRESSURIZER LEVEL COMPUTER CHANNEL A	0 - 1.8 M	1 SEC	.02M + 3.86RG	1,2,5	A35
LD-P139-007	PRESSURIZER LEVEL COMPUTER CHANNEL B	0 - 1.8 M	1 SEC	.02M + 3.86RG	1,2,5	A35
LD-P139-008	PRESSURIZER LEVEL COMPUTER CHANNEL C	0 - 1.8 M	1 SEC	.02M + 3.86RG	1,2,5	A35
LIT-P120-013	BWST LEVEL A	0 - 2.5 M	70 MS	2.56RG	12	A6
LIT-P120-014	BWST LEVEL B	0 - 2.5 M	70 MS	2.56RG	12	A6
LIT-P120-030	ACCUMULATOR B, LEVEL A	0 - 3 M	70 MS	2.56RG	6	A6
LIT-P120-044	ACCUMULATOR A, LEVEL A	0 - 3 M	70 MS	2.56RG	1,6	A6
LIT-P120-087	ACCUMULATOR A, LEVEL B	0 - 3 M	70 MS	2.56RG	6	A6
LIT-P120-089	ACCUMULATOR B, LEVEL B	0 - 3 M	70 MS	2.56RG	6	A6
LIT-P128-029	BORIC ACID MIX TANK LEVEL A	0 - 2.5 M	70 MS	2.38RG	14	A6
LIT-P128-030	BORIC ACID MIX TANK LEVEL B	0 - 2.5 M	70 MS	2.38RG	14	A2
LIT-P128-045	PRIMARY COOLANT BATCH TANK LEVEL A	0 - 1.3 M	70 MS	2.38RG	14	A6
LIT-P128-046	PRIMARY COOLANT BATCH TANK LEVEL B	0 - 1.3 M	70 MS	2.38RG	14	A6
LT-P004-008AA	STEAM GENERATOR NARROW RANGE LEVEL	-.2 - 1.5 M	70 MS	2.16RG	4	A36
LT-P004-008A	STEAM GENERATOR FEEDWATER LEVEL	-1 - 1.5 M	70 MS	2.16RG	4	A37
LT-P004-008BB	STEAM GENERATOR WIDE RANGE LEVEL	-2.2 - 1.5 M	70 MS	2.16RG	4	A36
LT-P004-008B	STEAM GENERATOR FEEDWATER LEVEL	-3.7 - 1.5 M	70 MS	2.16RG	4	A37
LT-P004-042	CONDENSATE RECEIVER LEVEL	0 - 1.2 M	100 MS	1.59RG	11	A36

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
LT-P122-036	PRESSURE REDUCTION AND DECONTAMINATION SUMP LEVEL	0 - 3.8 M	70 MS	2.52RG	14	A39
LT-P138-033	SUPPRESSION VESSEL LEVEL A	0 - 3.5 M	70 MS	2.36RG	9	A40
LT-P138-058	SUPPRESSION VESSEL LEVEL B	0 - 3.6 M	70 MS	2.36RG	9	A40
PCP-1-F	PRIMARY COOLANT PUMP FREQUENCY - PUMP NO.1			NONE		A50
PCP-1-I-AC	PRIMARY COOLANT PUMP CURRENT - PUMP NO.1		N/A	NONE		A51
PCP-1-I-RMS	PRIMARY COOLANT PUMP RMS CURRENT - PUMP NO. 1			NONE		A52
PCP-1-P-VAR	REACTIVE POWER					A53
PCP-1-P	PUMP POWER - PCP NO. 1			NONE		A53
PCP-1-V-AC	PRIMARY COOLANT PUMP VOLTAGE - PUMP NO.1		N/A	NONE		A54
PCP-1-V-RMS	PRIMARY COOLANT PUMP RMS VOLTAGE - PUMP NO. 1			NONE		A55
PCP-2-F	PRIMARY COOLANT PUMP FREQUENCY - PUMP NO.2			NONE		A50
PCP-2-I-AC	PRIMARY COOLANT PUMP CURRENT - PUMP NO.2		N/A	NONE		A51
PCP-2-I-RMS	PRIMARY COOLANT PUMP RMS CURRENT - PUMP NO. 2			NONE		A52
PCP-2-P-VAR	REACTIVE POWER					A53
PCP-2-P	PUMP POWER - PCP NO. 2			NONE		A53
PCP-2-V-AC	PRIMARY COOLANT PUMP VOLTAGE - PUMP NO.2		N/A	NONE		A54
PCP-2-V-RMS	PRIMARY COOLANT PUMP RMS VOLTAGE - PUMP NO. 2			NONE		A55
PDT-P139-06	DIFF PRESS FOR LEVEL ACROSS PRESSURIZER,CHAN A	0 - 17.5 KPA	70 MS	3.18RG	2,5	A6
PDT-P139-07	DIFF PRESS FOR LEVEL ACROSS PRESSURIZER,CHAN B	0 - 17.5 KPA	70 MS	3.18RG	2,5	A6
PDT-P139-08	DIFF PRESS FOR LEVEL ACROSS PRESSURIZER,CHAN C	0 - 17.5 KPA	70 MS	3.16RG	2,5	A6
PDT-P139-27-1	DIFF PRESS FOR PRIMARY COOLANT FLOW CHAN A	0 - 200 KPA	70 MS	3.24RG	2	A7
PDT-P139-27-2	DIFF PRESS FOR PRIMARY COOLANT FLOW CHAN B	0 - 200 KPA	70 MS	3.16RG	2	A7

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
PDT-P139-27-3	DIFF PRESS FOR PRIMARY COOLANT FLOW CHAN C	0 - 200 KPA	70 MS	3.16RG	2	A7
PDT-P139-30	REACTOR VESSEL DIFFERENTIAL PRESSURE	0 - 350 KPA	70 MS	1.66RG	1,2	A6
PT-PC04-010A	ABS PRESS,10 INCH LINE FROM STEAM GENERATOR	0 - 8 MPA	70 MS	1.16RG	11	A1
PT-PC04-022	CONDENSATE RECEIVER PRESSURE	0 - 3 MPA	70 MS	1.19RG	11	A1
PT-P004-034	ABS PRESSURE, SECONDARY COOL.SYSTEM FEEDWATER	0 - 10 MPA	70 MS	1.16RG	11	A1
PT-P004-085	ABS PRESSURE, 12 INCH CONDENSOR	0 - 3 MPA	70 MS	1.16RG	11	A1
PT-P120-029	ABS PRESSURE ECCS ACCUMULATOR B	0 - 7 MPA	70 MS	1.34RG	6	A2
PT-P120-043	ABS PRESSURE ECCS ACCUMULATOR A	0 - 7 MPA	70 MS	1.34RG	1,6	A2
PT-P120-055	ABS PRESSURE HOT LEG INJECTION	0 - 21 MPA	70 MS	1.36RG	N/A	A3
PT-P120-056	ABS PRESSURE UPPER PLENUM INJECTION	0 - 21 MPA	70 MS	1.36RG	12	A2
PT-P120-059	ABS PRESSURE ACCUMULATOR B TO DOWNCOMER INJECTION	0 - 21 MPA	70 MS	1.36RG	12	A3
PT-P120-061	ABS PRESSURE COLD LEG INJECTION	0 - 21 MPA	70 MS	1.36RG	2,13	A3
PT-P120-064	ABS PRESSURE ACCUMULATOR A TO DOWNCOMER INJECTION	0 - 21 MPA	70 MS	1.24RG	13	A2
PT-P120-074	ABS PRESSURE LPIS INJECTION PUMP B DISCHARGE	0 - 7 MPA	70 MS	1.36RG	12	A3
PT-P120-083	ABS PRESSURE LPIS INJECTION PUMP A DISCHARGE	0 - 7 MPA	70 MS	1.36RG	13	A3
PT-P128-102	ABS PRESSURE CHARGING PUMP B DISCHARGE	0 - 21 MPA	70 MS	1.36RG	14	A3
PT-P128-103	ABS PRESSURE CHARGING PUMP A DISCHARGE	0 - 21 MPA	70 MS	1.36RG	14	A3
PT-P138-023	BLOWDOWN HEADER PRESSURE	0 - 1.4 MPA	70 MS	1.36RG	9	A3
PT-P138-055	ABS PRESSURE SUPPRESSION VESSEL CHANNEL A	0 - 700 KPA	70 MS	1.36RG	9	A3
PT-P138-056	ABS PRESSURE SUPPRESSION VESSEL CHANNEL B	0 - 700 KPA	70 MS	1.36RG	9	A3
PT-P138-057	ABS PRESSURE SUPPRESSION VESSEL CHANNEL C	0 - 700 KPA	70 MS	1.36RG	9	A3
PT-P139-002	PRIMARY COOLANT HOT LEG PRESSURE CHANNEL A	0 - 21 MPA	70 MS	1.36RG	1,2	A3

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
PT-P139-003	PRIMARY COOLANT HOT LEG PRESSURE CHANNEL B	0 - 21 MPA	70 MS	1.36RG	1,2	A3
PT-P139-004	PRIMARY COOLANT HOT LEG PRESSURE CHANNEL C	0 - 21 MPA	70 MS	1.36RG	1,2	A3
PT-P139-005-1	ABS PRESSURE,PRESSURIZER CHANNEL A	0 - 21 MPA	70 MS	1.23RG	1,5	A4
PT-P139-041	ABS PRESSURE,CONTAINMENT PRESSURE CHANNEL A	.08481 - 200 KPA	70 MS	1.44RG	N/A	A5
PT-P139-042	ABS PRESSURE,CONTAINMENT PRESSURE CHANNEL B	.08481 - 200 KPA	70 MS	1.44RG	N/A	A5
PT-P139-043	ABS PRESSURE,CONTAINMENT PRESSURE CHANNEL C	.08481 - 200 KPA	70 MS	1.44RG	N/A	A5
RE-T-77-1A1	POWER RANGE CHANNEL A - PEAK	0 - 125% PWR		3.4 RG	10	A45
RE-T-77-1A2	POWER RANGE CHANNEL A - LEVEL	0 - 62.5 MW		3.2 MW	10	A46
RE-T-77-2A1	POWER RANGE CHANNEL B - PEAK	0 - 125% PWR		3.4 RG	10	A45
RE-T-77-2A2	POWER RANGE CHANNEL B - LEVEL	0 - 62.5 MW		3.2 MW	10	A46
RE-T-77-3A1	POWER RANGE CHANNEL C - PEAK	0 - 125% PWR		2.4 RG	10	A45
RE-T-77-3A2	POWER RANGE CHANNEL C - LEVEL	0 - 62.5 MW		3.2 MW	10	A46
RE-T-85-1	SOURCE RANGE CHANNEL 1		30 S	0 - 500 KHZ		A47
RE-T-85-2	SOURCE RANGE CHANNEL 2		30 S	0 - 500 KHZ		A47
RE-T-85-3	SOURCE RANGE CHANNEL 3		30 S	0 - 500 KHZ		A47
RE-T-86-3	INTERMEDIATE RANGE CHANNEL 3	0.2 - 1.0 VOLT		7.7 RG	10	A48
RE-T-86-4	INTERMEDIATE RANGE CHANNEL 4	0.2 - 1.0 VOLT		7.7 RG	10	A48
RE-T-86-5	INTERMEDIATE RANGE CHANNEL 5	0 - 1 VOLT		7.7 RG	10	A48
RE-T-86-6	INTERMEDIATE RANGE CHANNEL 6	-.20 - +.20 DOLLARS		7.7 RG	10	A48
RE-T-87-4A1	POWER RANGE CHANNEL D - PEAK	0 - 125% PWR		3.4 RG	10	A45
RE-T-87-4A2	POWER RANGE CHANNEL D - LEVEL	0 - 125% PWR		3.4 RG	10	A46
TDM-P004-077	CONDENSATE SUBCOOLER DELTA TEMPERATURE	0 - 28 DEG K		.56K+1RD+2.1RG	11	N/A

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
TE-P004-054	CONDENSATE RECEIVER TEMPERATURE	250 - 500 DEG K	50 MS	4.9K+1.18(RG-255)	11	A22
TE-P120-001	BWST TEMPERATURE A	250 - 370 DEG K	50 MS	4.9K+1.56(RG-255)	12	A23
TE-P120-002	BWST TEMPERATURE	250 - 370 DEG K	50 MS	4.9K+1.56(RG-255)	12	A23
TE-P120-027	LIQUID TEMP ACCUMULATOR B	250 - 370 DEG K	50 MS	4.9K+1.56(RG-255)	6	A24
TE-P120-041	LIQUID TEMP ACCUMULATOR A	250 - 370 DEG K	50 MS	4.9K+1.56(RG-255)	1,6	A24
TE-P120-100	LIQUID TEMP LPIS HEAT EXCHANGER A OUTLET	250 - 480 DEG K	0.25 S	1.74(RG-255)	13	A25
TE-P120-101	LIQUID TEMP LPIS HEAT EXCHANGER A INLET	250 - 480 DEG K	0.25 S	1.74(RG-255)	13	A25
TE-P120-102	LIQUID TEMP LPIS HEAT EXCHANGER B OUTLET	250 - 480 DEG K	0.25 S	1.74(RG-255)	12	A25
TE-P120-103	LIQUID TEMP LPIS HEAT EXCHANGER B INLET	250 - 480 DEG K	0.25 S	1.74(RG-255)	12	A25
TE-P122-003	PRESSURE REDUCTION SPRAY PUMP TEMP.	280 - 450 DEG K	1 S	4.9K+1.2(RG-255)	14	A26
TE-P138-034	TEMP.@ TOP OF SUPPRESSION VESSEL	280 - 480 DEG K	1 S	4.9K+1.5(RG-255)	9	A24
TE-P138-056	TEMPERATURE AT OUTLET OF HOT QOBV	280 - 480 DEG K	200 MS	4.9K+1.5(RG-255)	7	N/A
TE-P138-059	TEMPERATURE AT OUTLET OF COLD LEG QOBV	280 - 480 DEG K	200 MS	4.9K+1.5(RG-255)	7	N/A
TE-P138-063	TEMPERATURE AT INLET TO COLD LEG ISOLATION VALVE	280 - 620 DEG K	6 S	1.54(RG-255)	7	A27
TE-P138-065	TEMPERATURE AT INLET TO HOT LEG ISOLATION VALVE	280 - 620 DEG K	6 S	1.54(RG-255)	7	A27
TE-P138-137	TEMPERATURE AT HEAT EXCHANGER BS- H-32	250 - 480 DEG K	6 S	4.9K+1.8(RG-255)	9	A28
TE-P138-141	TEMP.@ SUPPRESSION VESSEL SPRAY HEADER,60 GPM	250 - 480 DEG K	6 S	4.9K+1.8(RG-255)	9	A28
TE-P138-142	TEMPERATURE OF SUPPRESSION VESSEL SPRAY FLOW	250 - 480 DEG K	50 MS	4.9K+1.8(RG-255)	9	A26
TE-P138-143	TEMP.@ SUPPRESSION VESSEL SPRAY HEADER ,220 GPM	250 - 480 DEG K	6 S	4.9K+1.8(RG-255)	9	A28
TE-P138-170	TEMP OF WARM UP LINE BROKEN LOOP HOT LEG	132 - 662 DEG K	NONE	4.9K+1.7(RG-255)	1	A29
TE-P138-171	TEMP OF WARM UP LINE BROKEN LOOP COLD LEG	134 - 672 DEG K	NONE	4.9K+1.7(RG-255)	1	A29
TE-P139-019	PRESSURIZER VAPOR TEMPERATURE	280 - 640 DEG K	50 MS	4.9K+1.5(RG-255)	1,2,5	A30

Table 1. (continued)

MEASUREMENT IDENTIFICATION	MEASUREMENT DESCRIPTION	MEASUREMENT RANGE	RESPONSE	MEASUREMENT ACCURACY	MEAS. LOCATION FIGURE	MEAS. SCHEM. FIGURE
TE-P139-020-1	PRESSURIZER LIQUID TEMP	280 - 640 DEG K	50 MS	4.9K+1.5(RG-255)	1,2,5	A30
TE-P139-020	PRESSURIZER LIQUID TEMP	280 - 640 DEG K	50 MS	4.9K+1.5(RG-255)	1,2,5	A30
TE-P139-028-2	INTACT LOOP COLD LEG TEMP	530 - 620 DEG K	6 S	1.97(RG-255)	1,2	A31
TE-P139-029	INTACT LOOP COLD LEG TEMP	280 - 620 DEG K	6 S	1.97(RG-255)	1,2	A31
TE-P139-032-1	INTACT LOOP HOT LEG TEMP	280 - 620 DEG K	6 S	1.74(RG-255)	1	A25
TE-P141-094	PCCS HEAT EXCHANGER HOT LEG TEMPERATURE	275 - 350 DEG K	6 S	1.74(RG-255)	14	A32
TE-P141-095	PCCS HEAT EXCHANGER COLD LEG TEMPERATURE	275 - 350 DEG K	6 S	1.74(RG-255)	14	A32
TE-T055-002	CONTAINMENT TEMPERATURE	250 - 400 DEG K	6 S	1.74(RG-255)	N/A	A33
TT-P004-004	FEEDWATER TEMPERATURE	370 - 500 DEG K	6 S	.56K+1.66(RG-255)	11	A34
TT-P004-007	STEAM LINE TEMPERATURE	280 - 620 DEG K	200 MS	6.0K+5(RD-255)	N/A	N/A
TT-P120-057	HOT LEG INJECTION TEMP	280 - 620 DEG K	5 S	1.74(RG-255)	12	A25
TT-P120-058	UPPER PLENUM INJECTION LINE TEMP	280 - 620 DEG K	5 S	1.74(RG-255)	12	A25
TT-P120-060	DOWNCOMER INJECTION TEMPERATURE	280 - 620 DEG K	5 S	1.74(RG-255)	12	A25
TT-P120-062	COLD LEG INJECTION TEMP	280 - 620 DEG K	5 S	1.74(RG-255)	13	A25
TT-P120-065	LOWER PLENUM INJECTION TEMPERATURE	280 - 620 DEG K	5 S	1.74(RG-255)	13	A25
TT-P139-032	PRIMARY COOLANT HOT LEG TEMP CHANNEL A	530 - 620 DEG K	6 S	1.74(RG-255)	1,2	A25
TT-P139-033	PRIMARY COLLANT HOT LEG TEMP CHANNEL B	530 - 620 DEG K	6 S	1.74(RG-255)	1,2	A25
TT-P139-034	PRIMARY COOLANT HOT LEG TEMP CHANNEL C	530 - 620 DEG K	6 S	1.74(RG-255)	1,2	A25

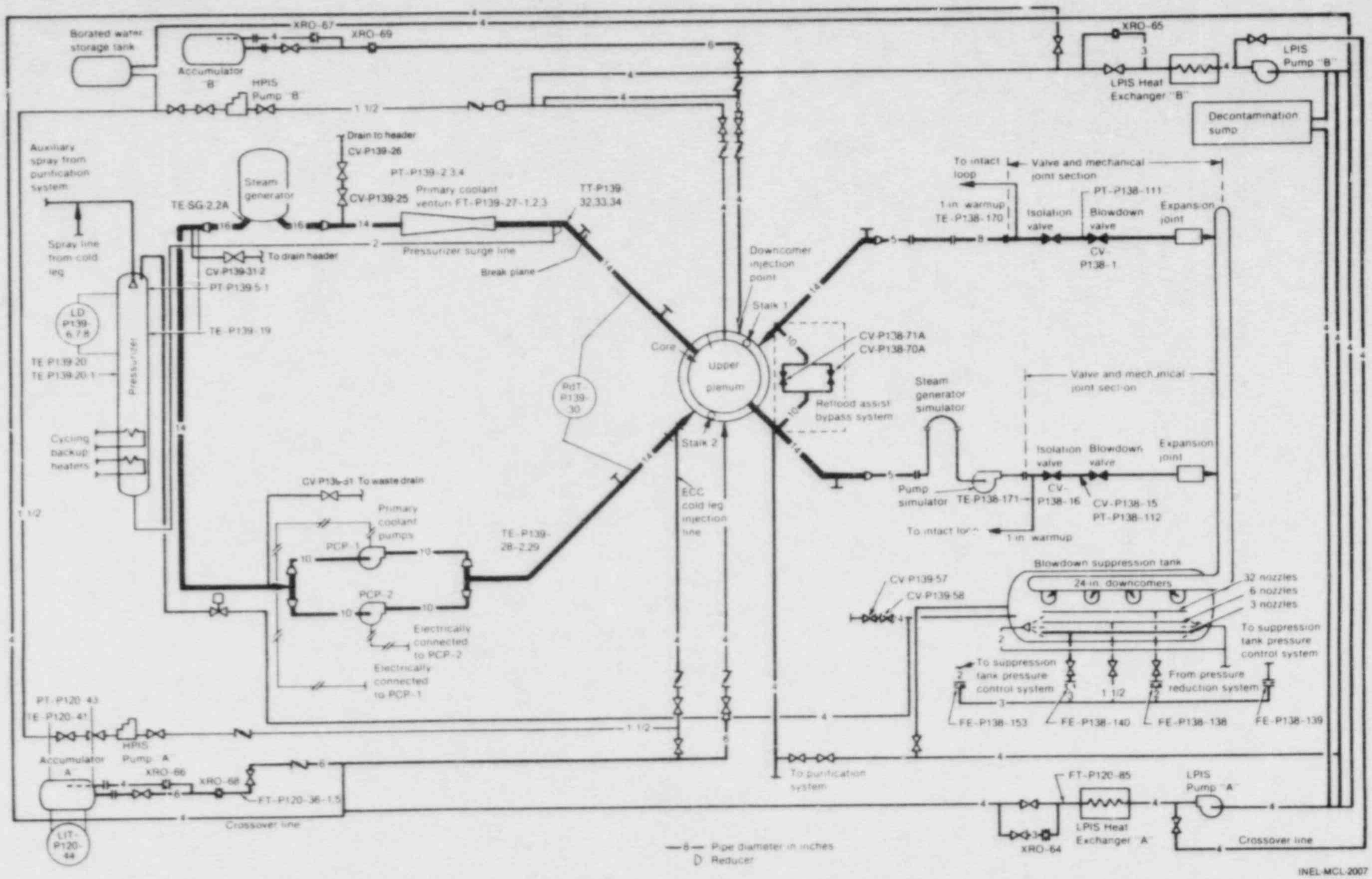

Figure 1. LOFT piping schematic with instrumentation.

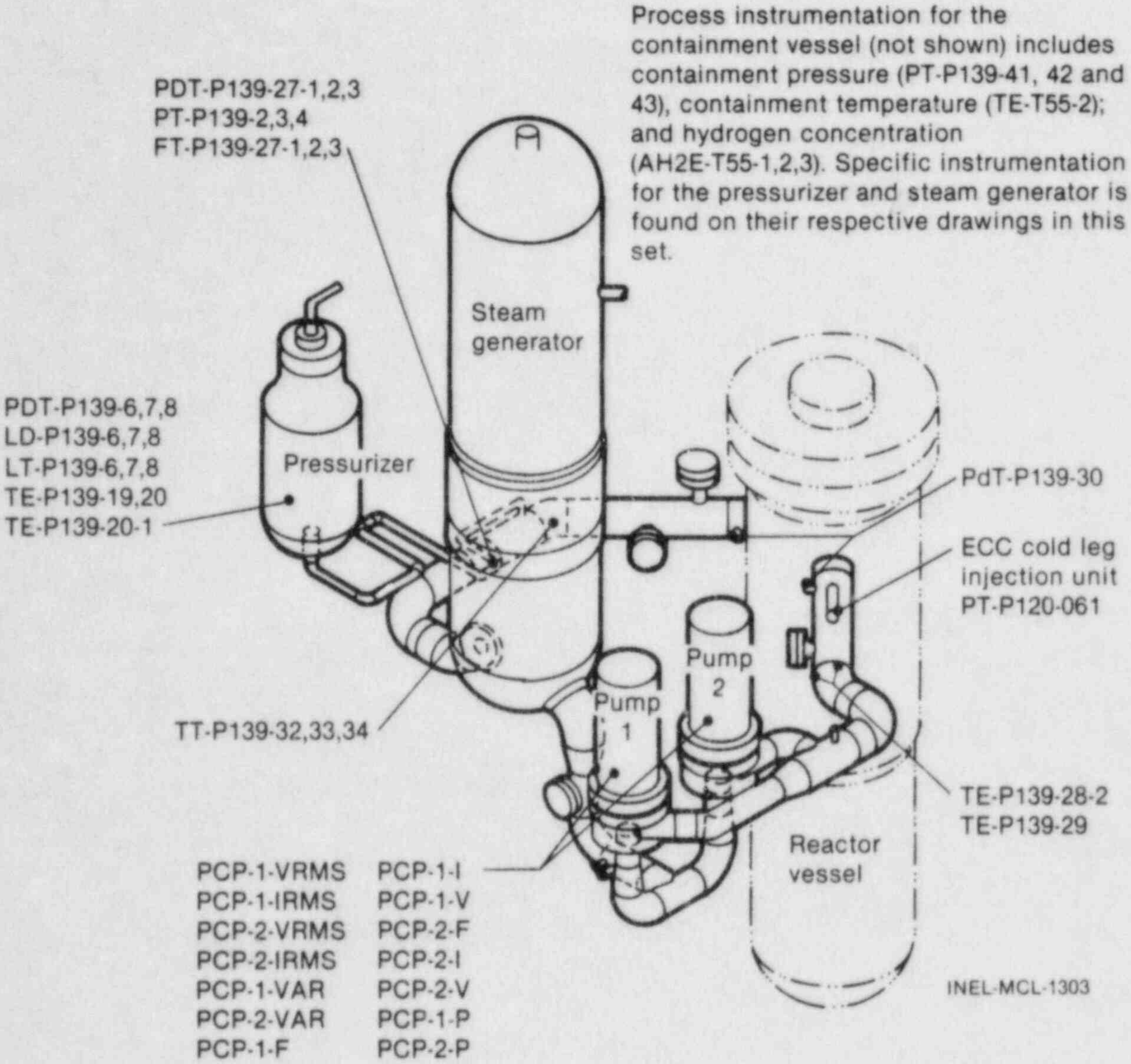

Figure 2. LOFT intact loop process instrumentation locations.

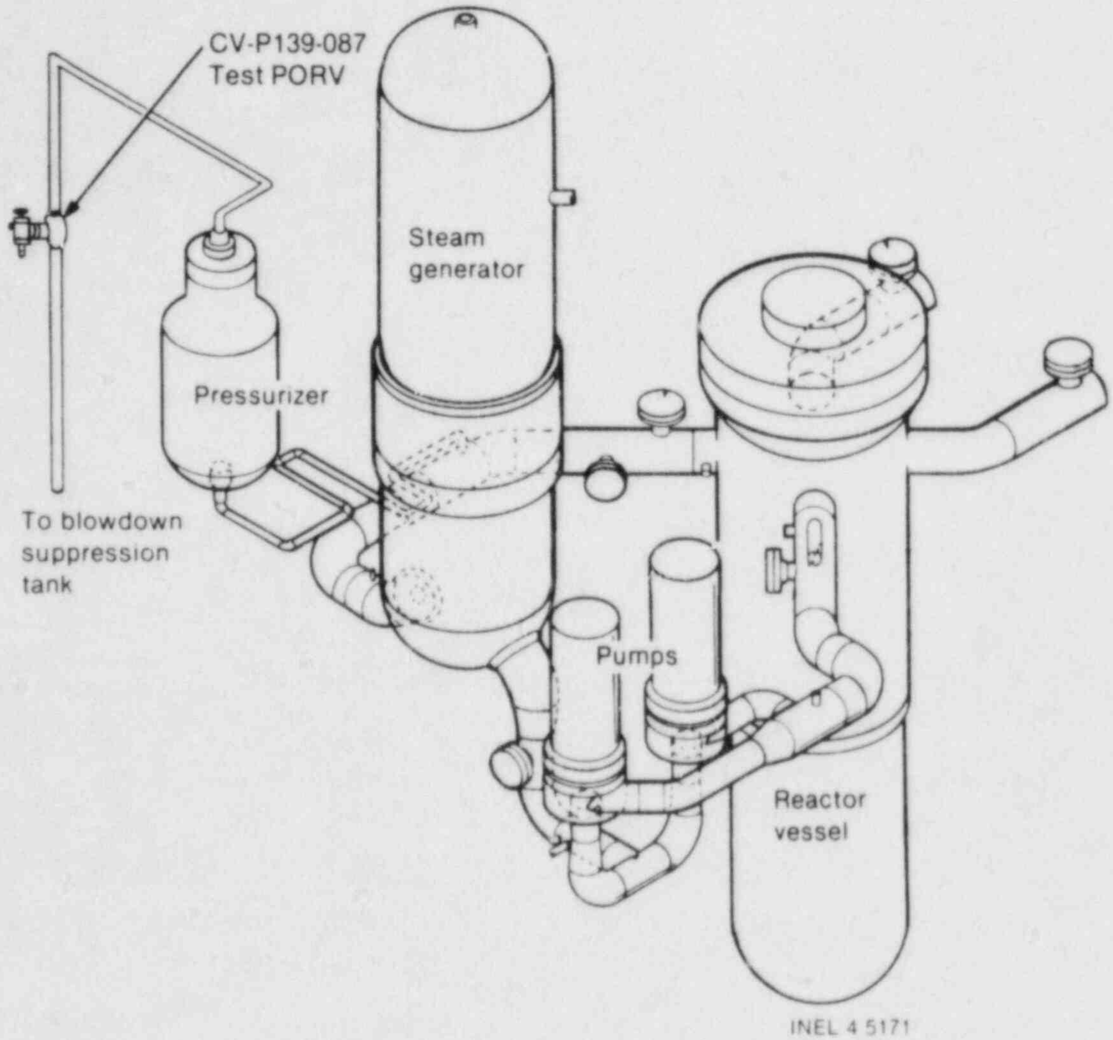

Figure 3. Test PORV and break line.

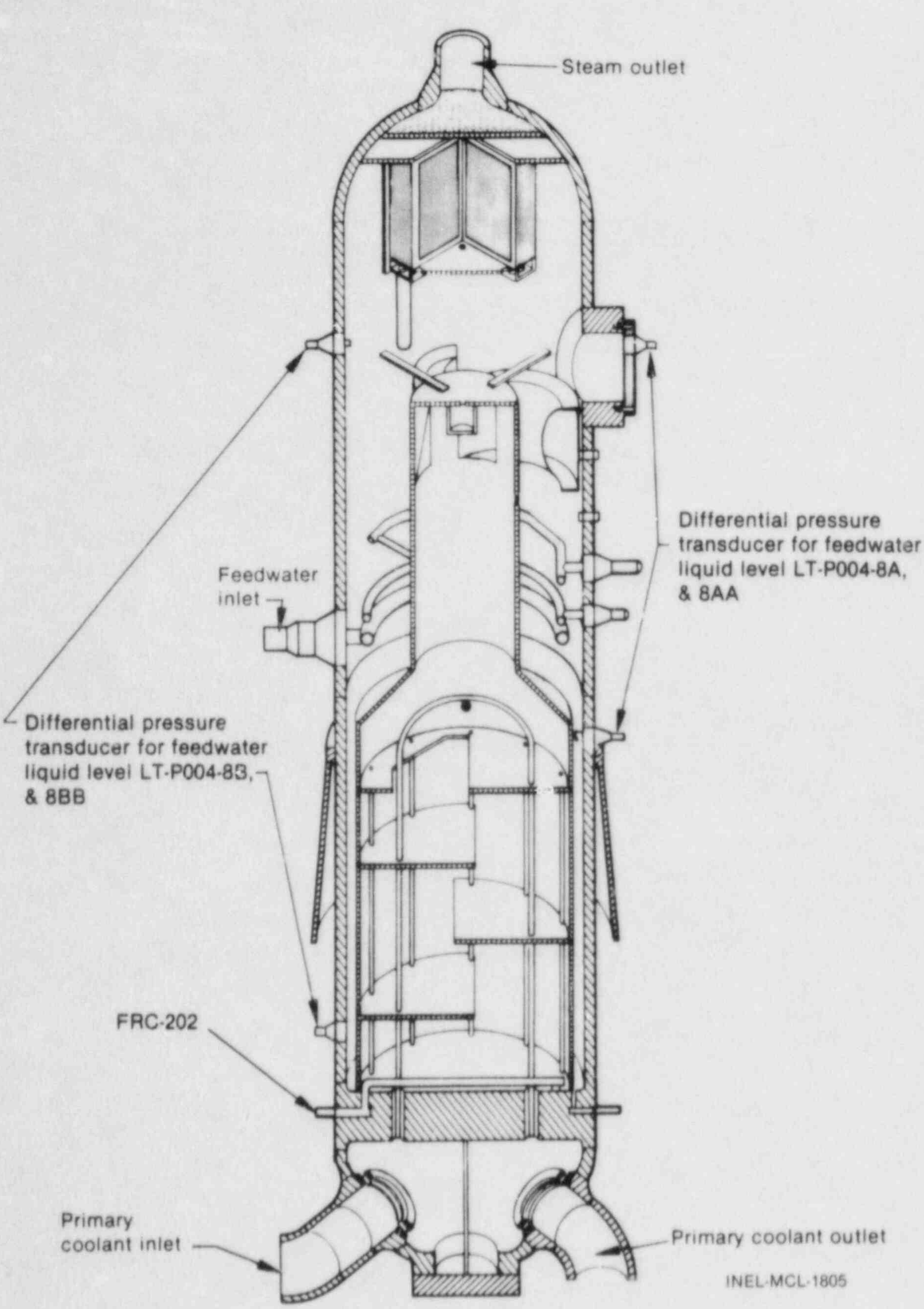

Figure 4. Steam generator process instrumentation locations.

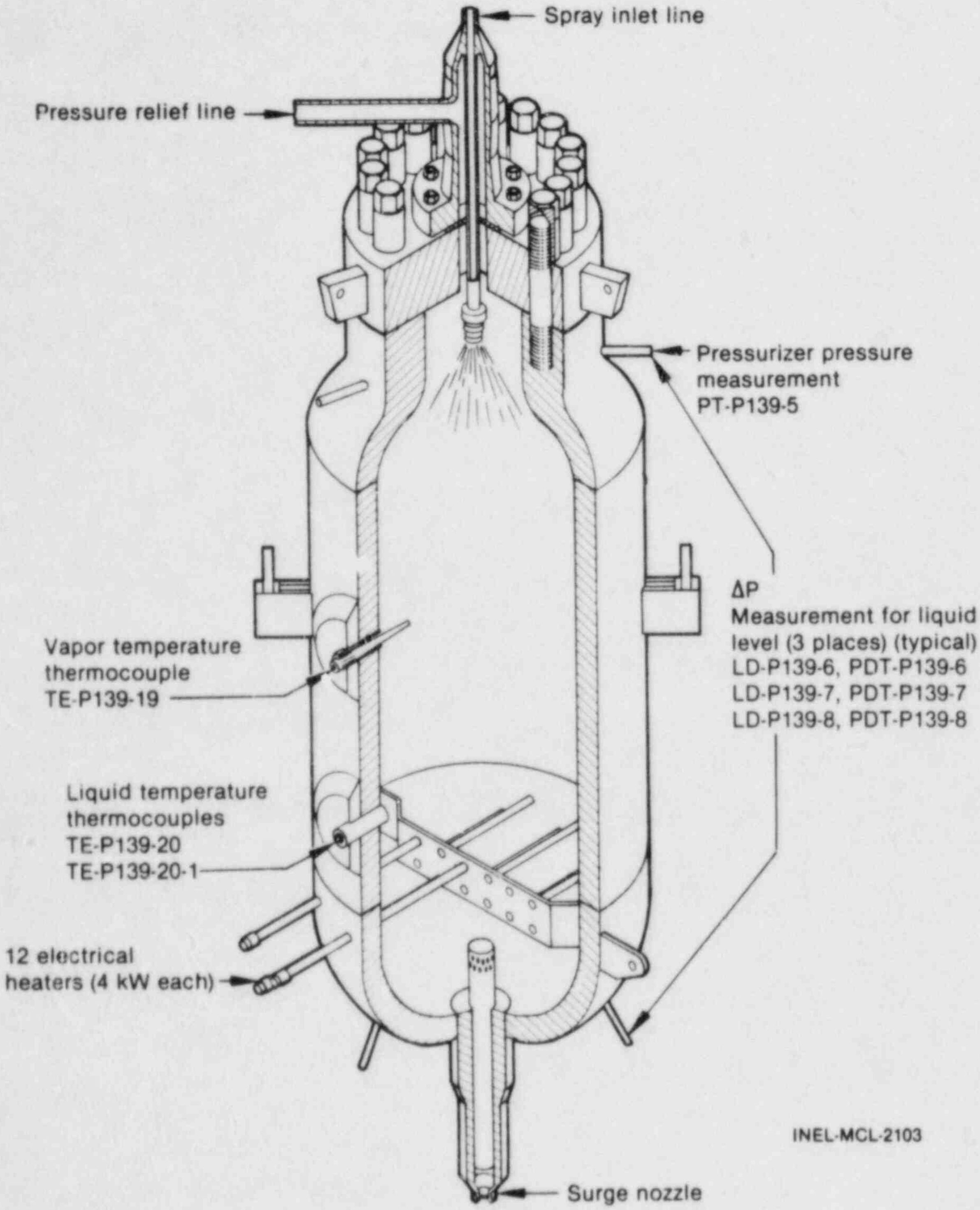

Figure 5. Pressurizer process instrumentation locations.

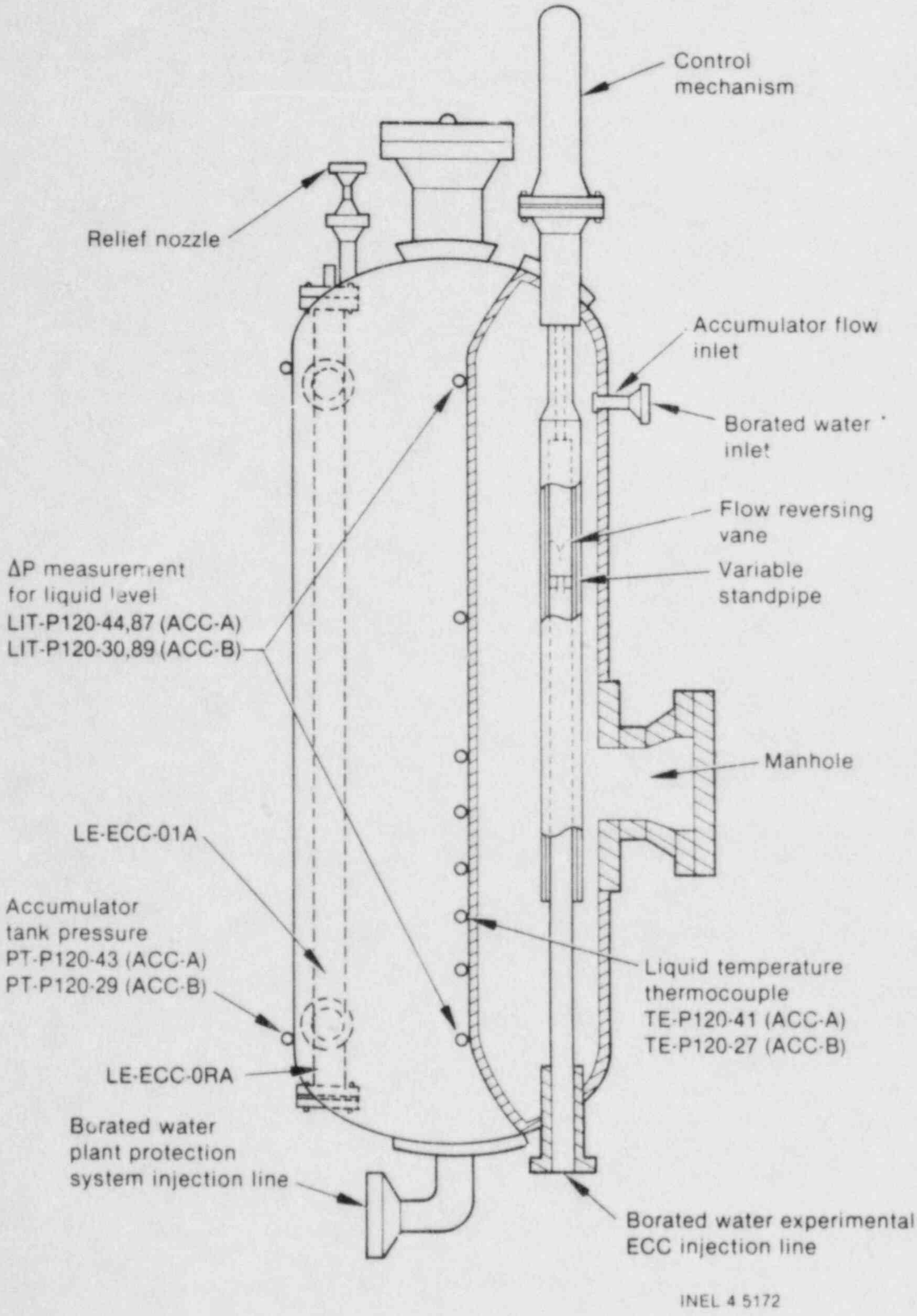

Figure 6. Accumulator process instrumentation locations.

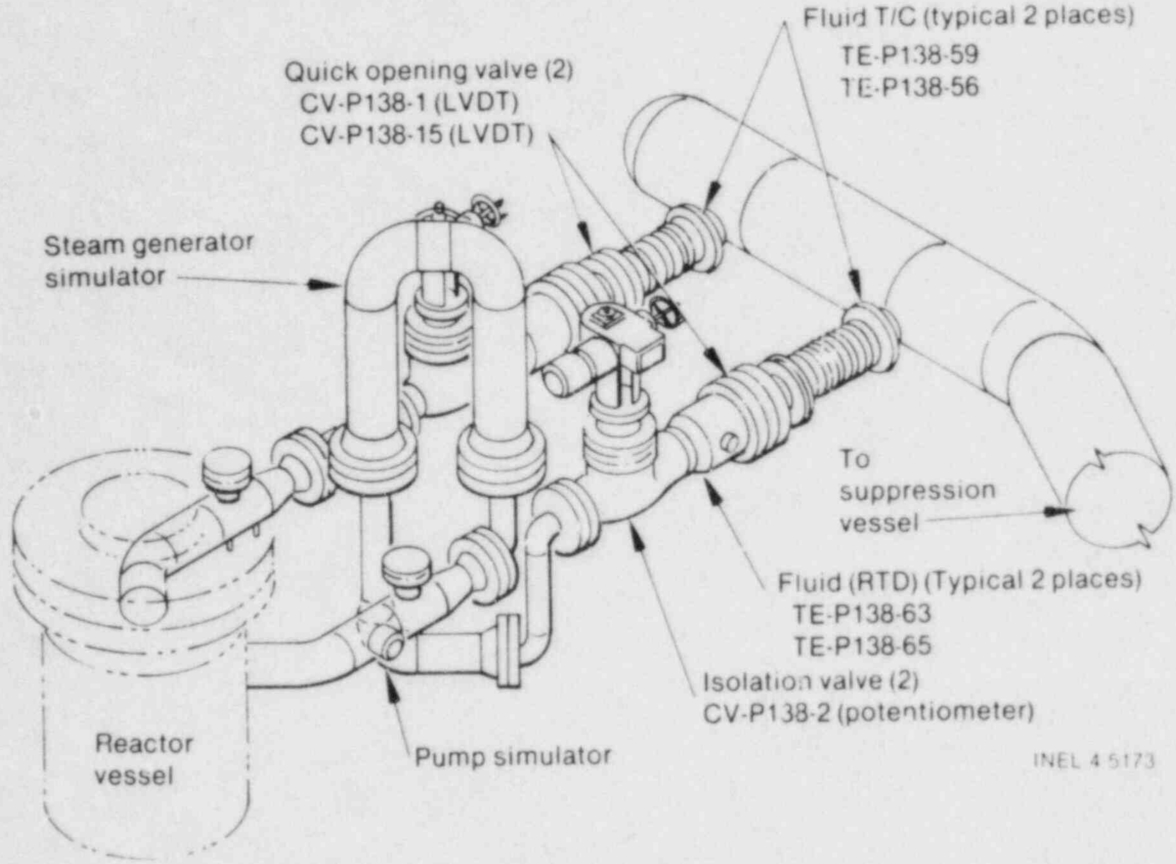

Figure 7. LOFT broken loop process instrumentation locations.

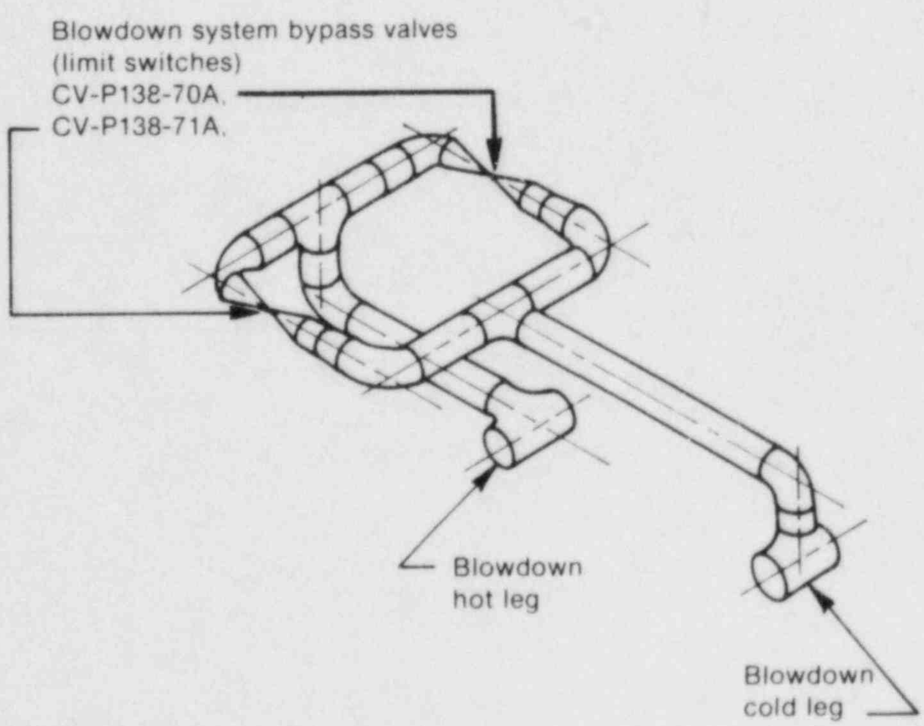

Figure 8. Process instrument location on reflood assist bypass system.

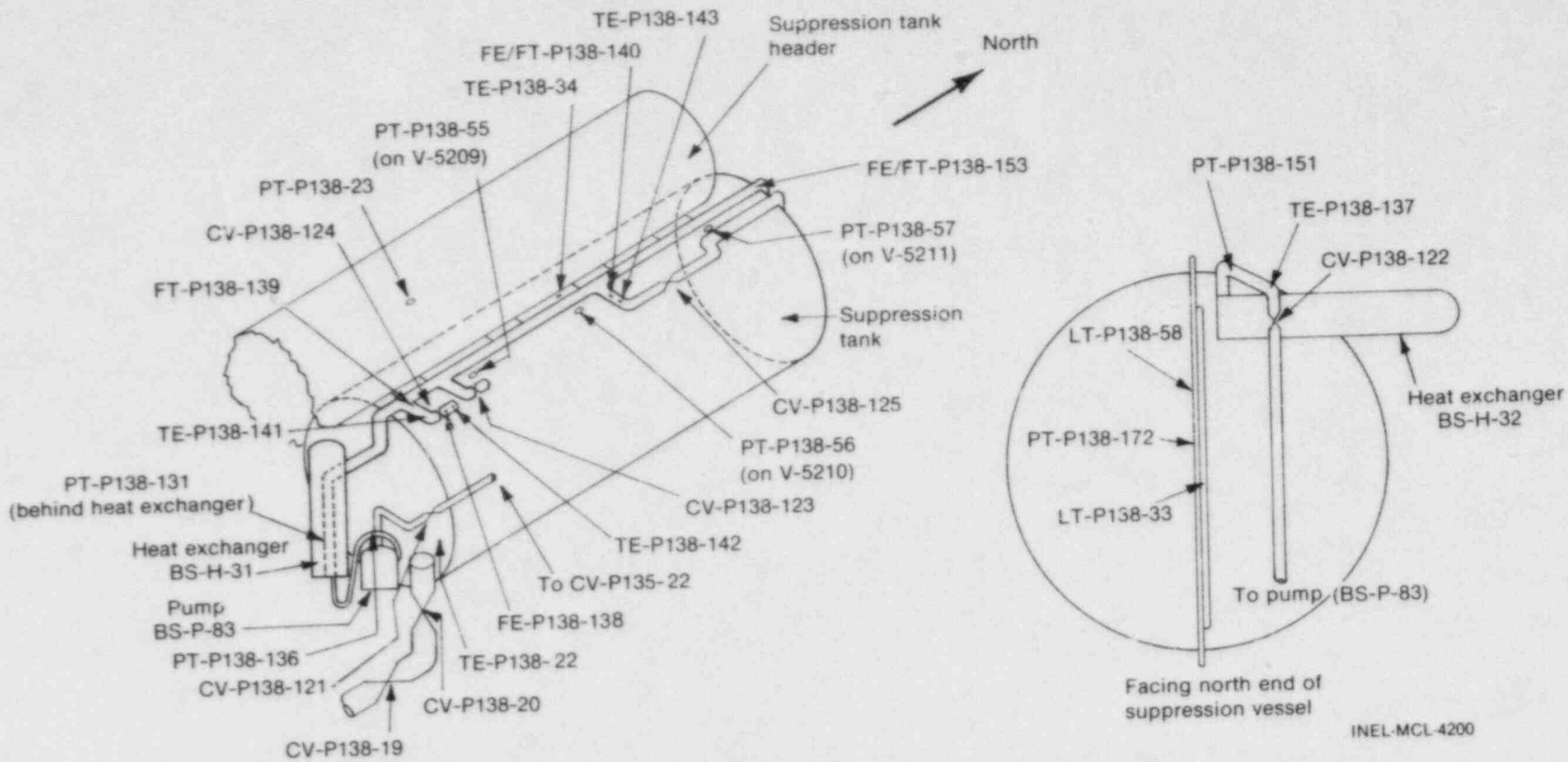

Figure 9. Suppression vessel process instrument locations.

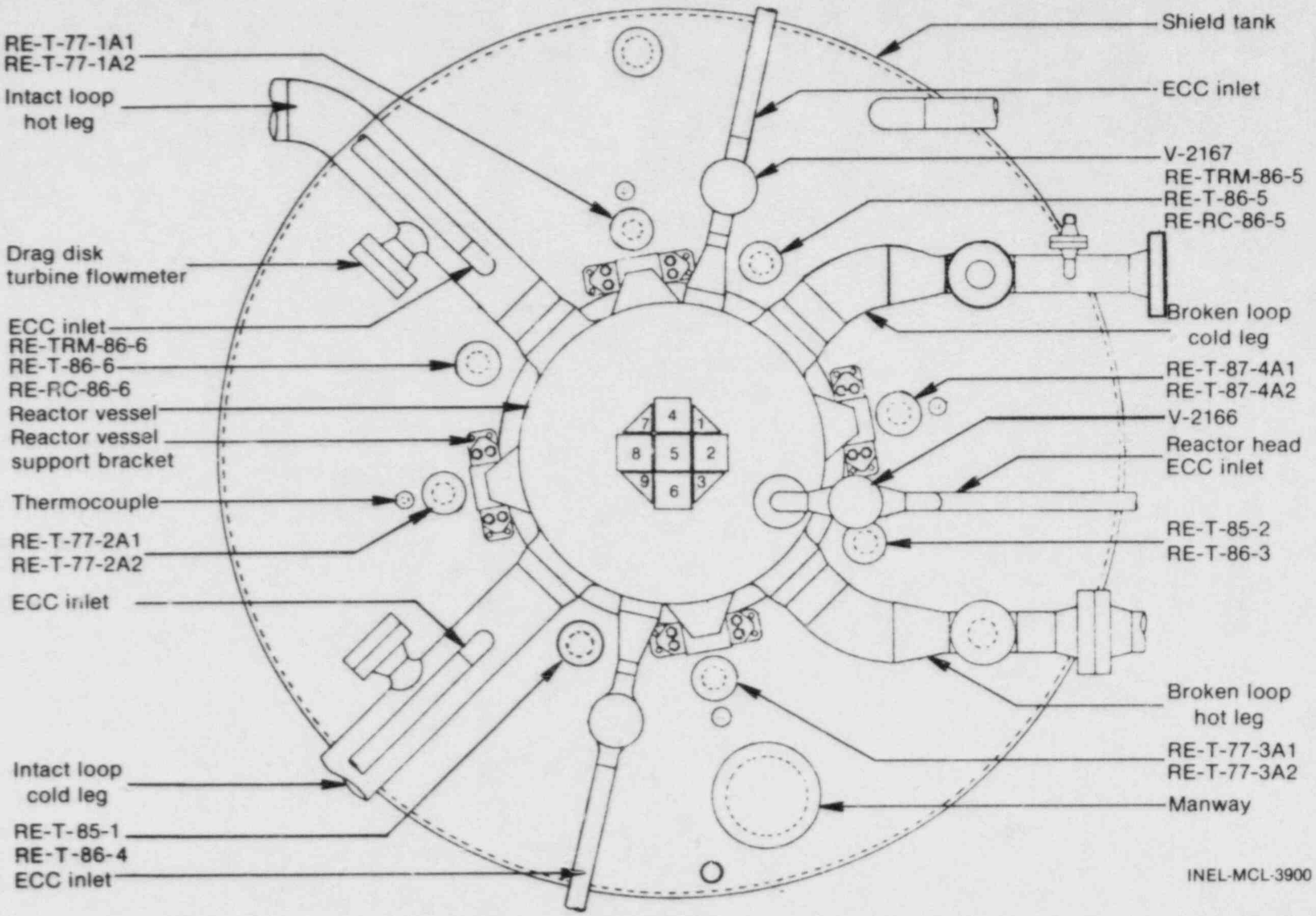

Figure 10. Reactor vessel process instrumentation locations.

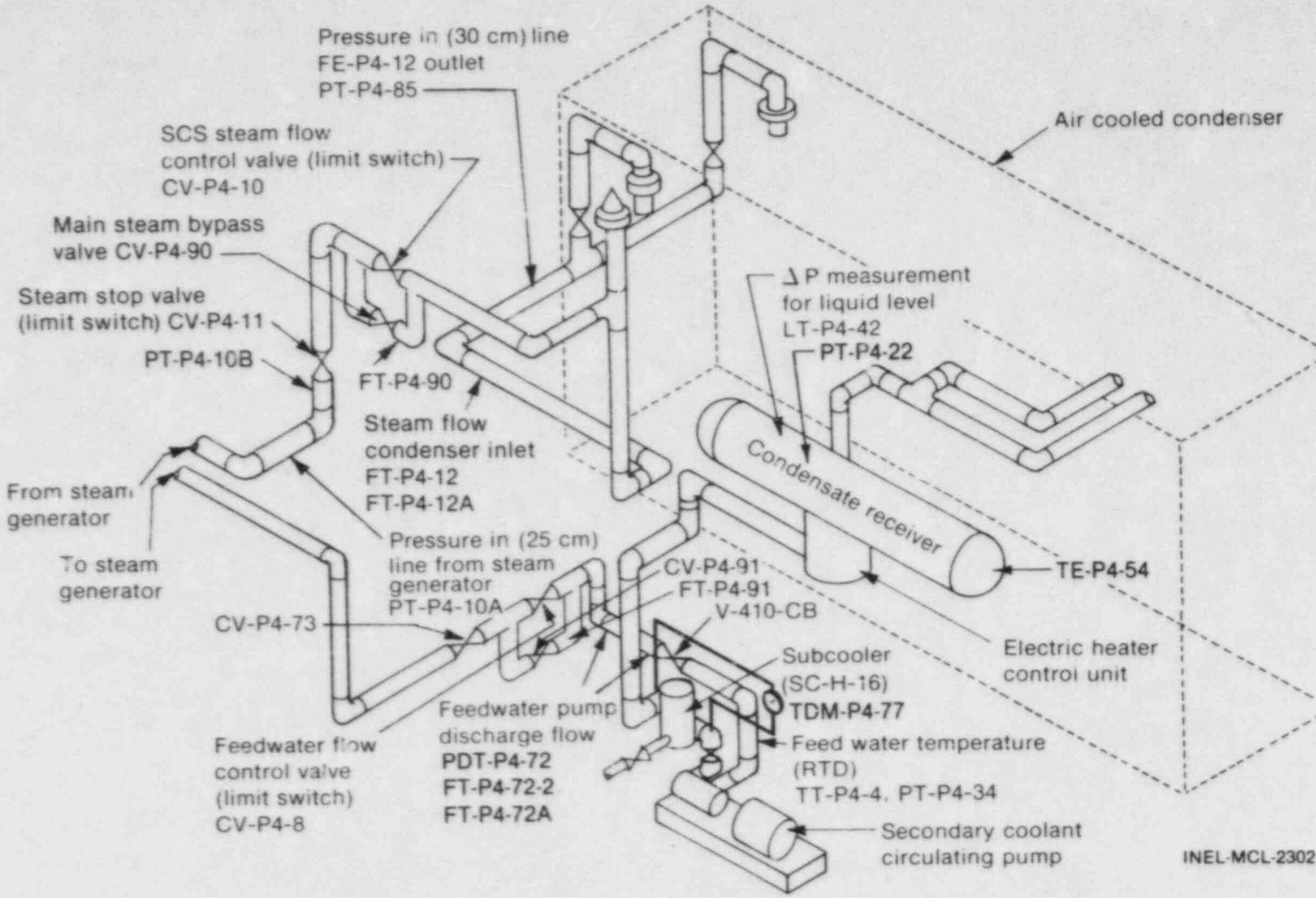

Figure 11. Secondary coolant system instrument locations.

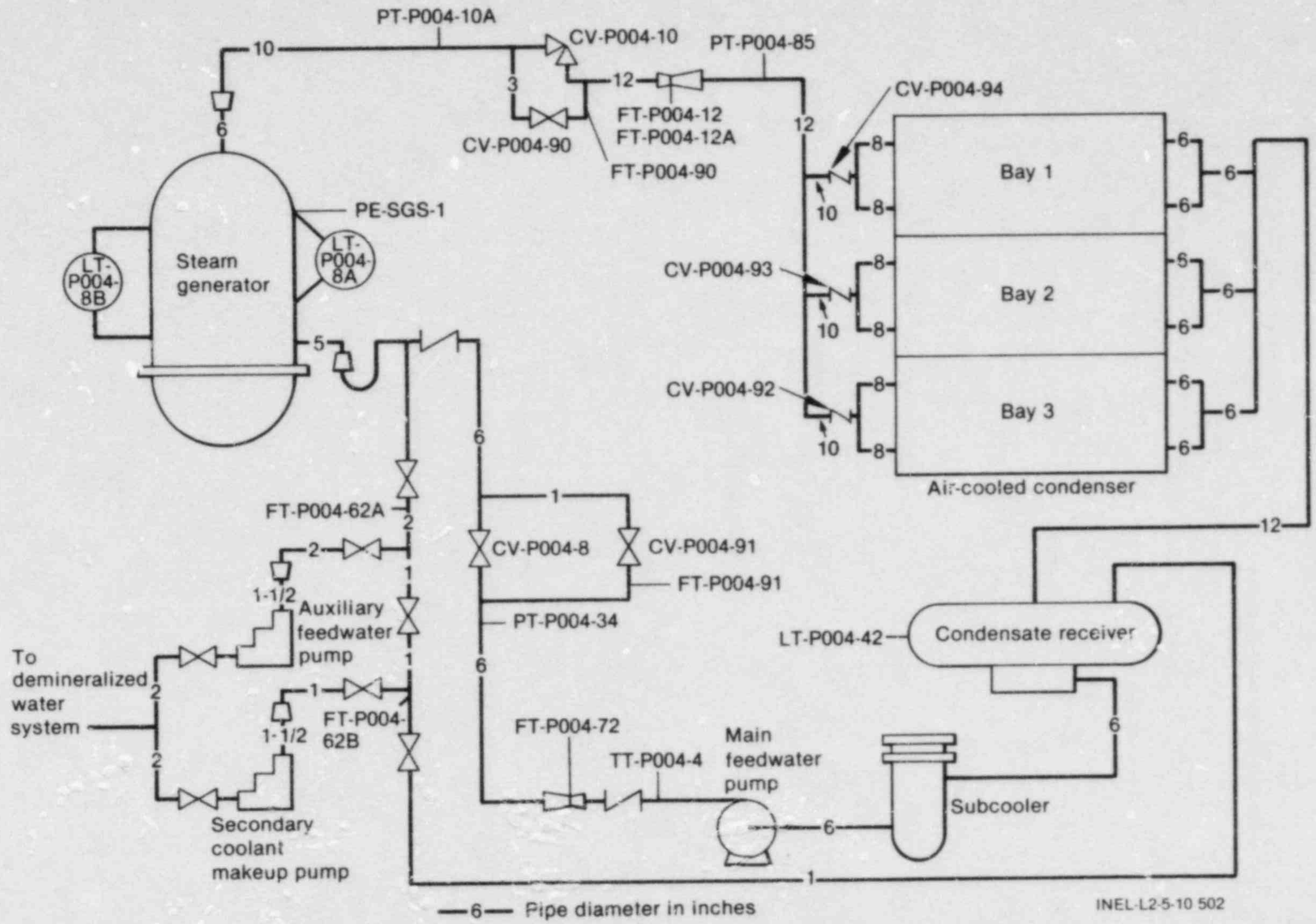

Figure 11a. instrument locations on secondary coolant system.

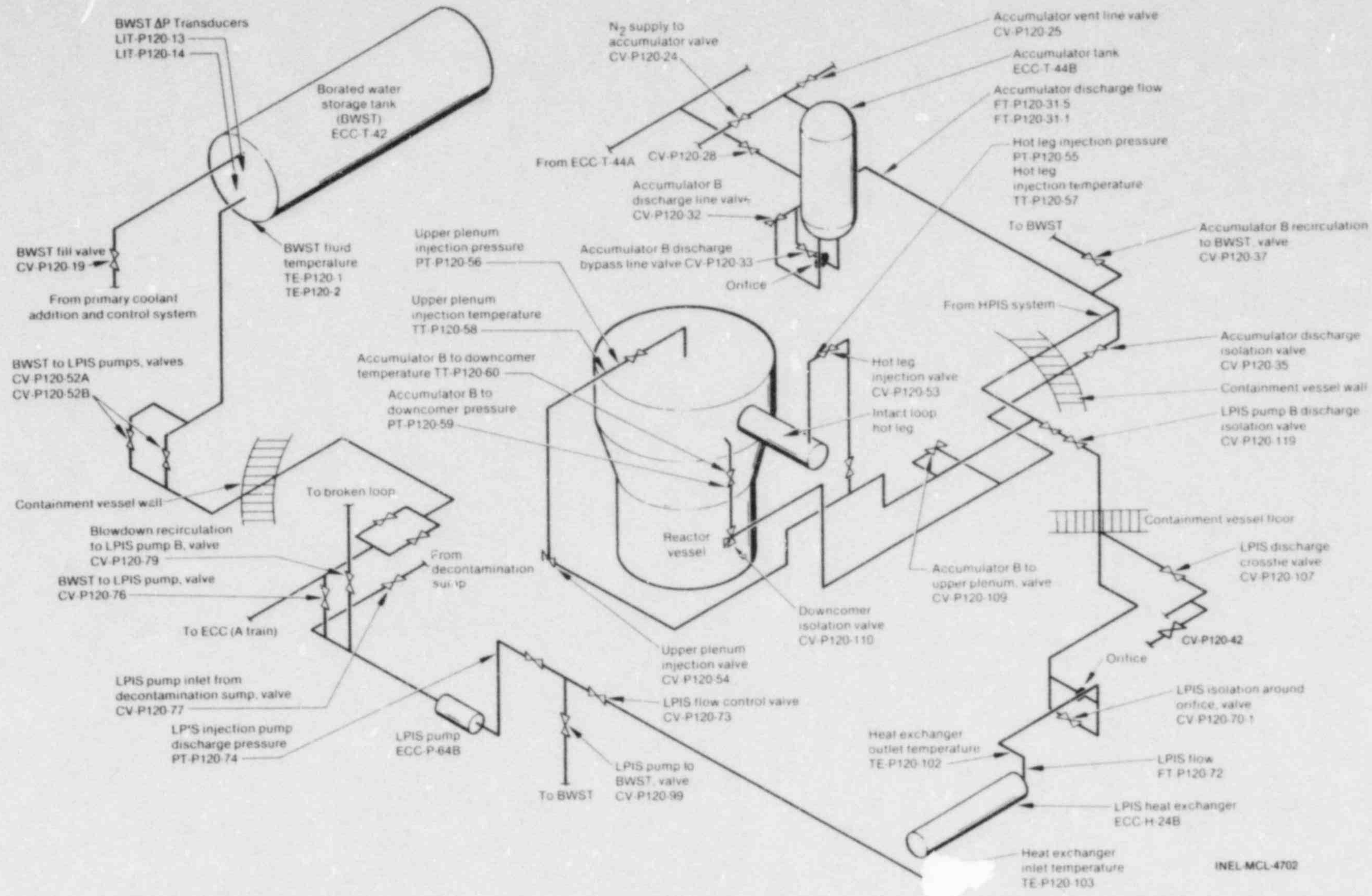

Figure 12. Emergency core cooling system instrument locations

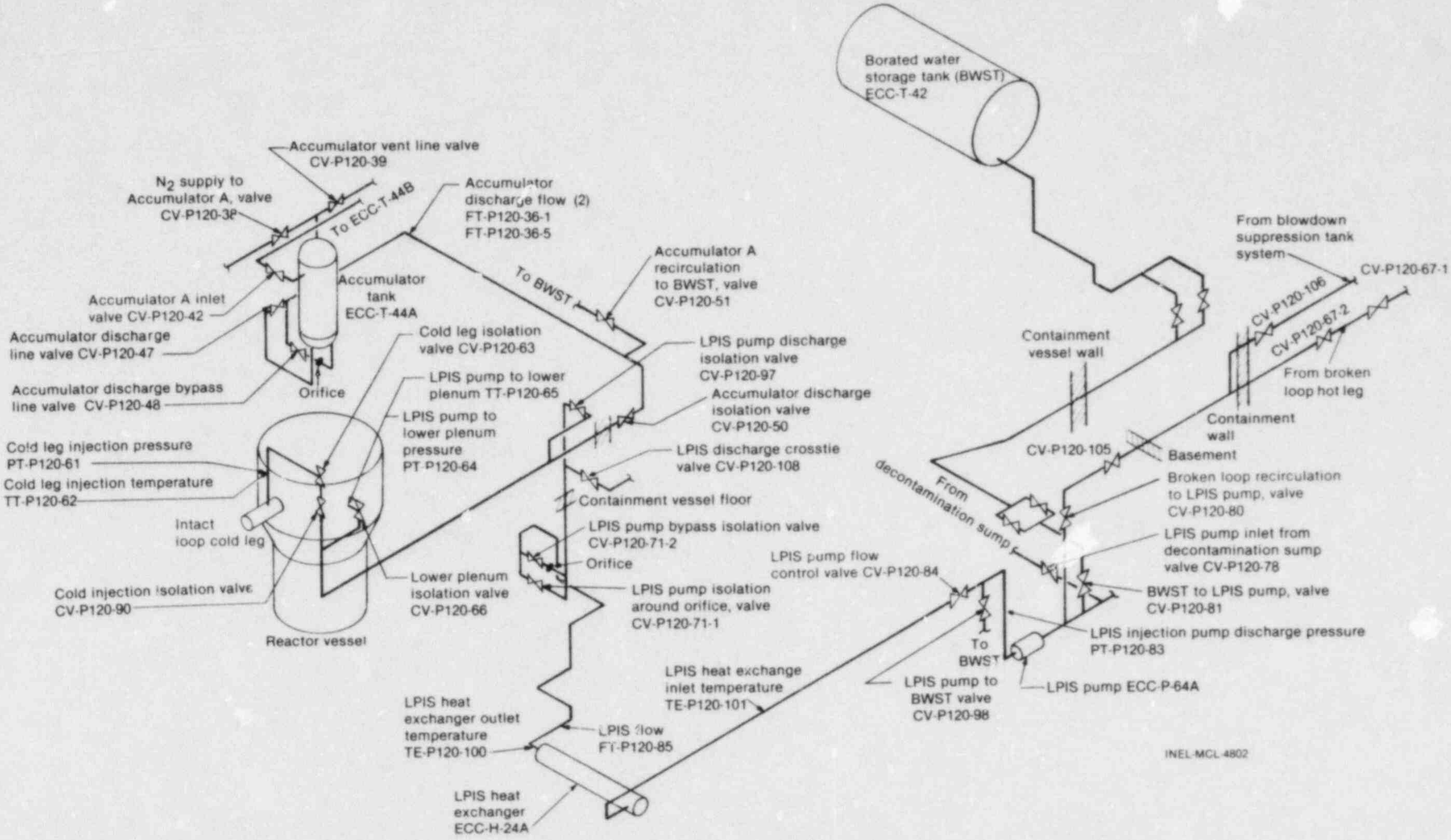

Figure 13. Instrument locations for the emergency core cooling system.

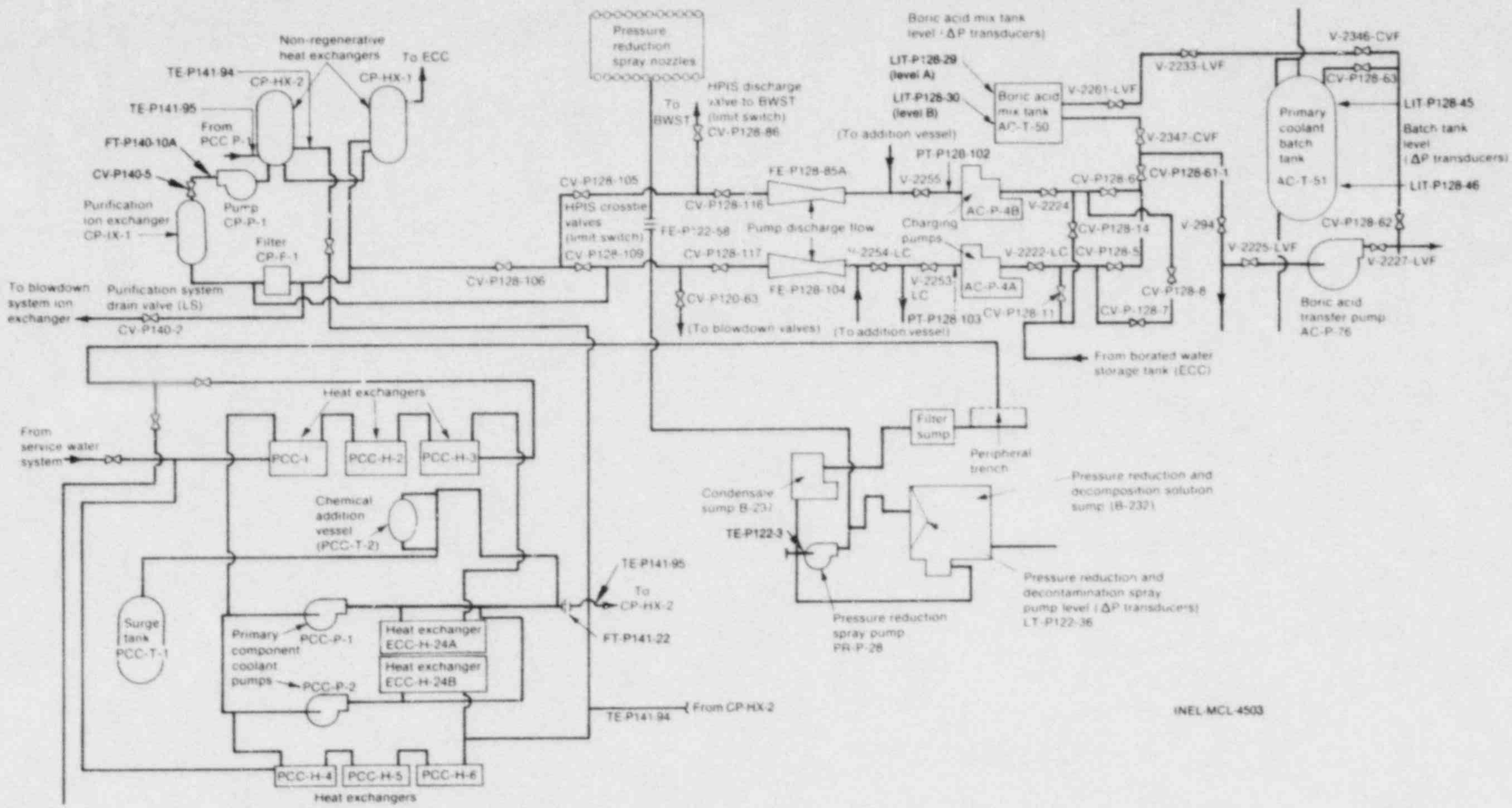

Figure 14. Primary coolant addition and control and coolant purification systems instrument locations.

APPENDIX A

MEASUREMENT CHANNEL INTERCONNECTIONS

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MEASUREMENT CHANNEL INTERCONNECTIONS

This appendix lists the measurement channel interconnections, along with the components, their manufacturers, and uncertainties. Where the uncertainty is given by the manufacturer in the specification, the number to the side refers to the summary in Appendix B, where the backup data can be found. In cases where no manufacturer's uncertainty is given, an "E" is placed next to the uncertainty to indicate that it is an engineering estimate based on the best available information. The figures containing this information are on microfiche inside the back cover.

No information is available on the following channels:

1. FT-P4-91
2. FT-P139-86
3. TT-P4-7
4. TE-P138-56
5. TE-P138-59.

APPENDIX B

MANUFACTURERS' SPECIFICATION SUMMARY

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MANUFACTURERS' SPECIFICATION SUMMARY

This appendix contains a summary of the specifications for the components used in the process measurement channels recorded on DAVDS. The uncertainties for each component are calculated using an RSS technique.

The manufacturers' estimates of uncertainty were assumed to be 2σ values. Although there is no published justification for the manufacturers' uncertainty estimates, this is the only estimate available in many cases. This estimate may be biased, but the manufacturer, as manufacturer, is still the best source for this estimate. In cases where no uncertainty estimate was available from the manufacturer or any other source, an estimate was assigned based on similar types of instruments.

1. Adder-Subtracter

Manufacturer	Honeywell
Model	38502
Accuracy	0.5% RG
Repeatability	0.1% RG
Dead band	0.1% RG
Uncertainty	0.5% RG

2. Amplitude Discriminator

Manufacturer	Moore Industries
Model	N/A
Accuracy	0.25% RG
Temperature effect	0.25% RG per 14 K
Uncertainty	0.[illegible]% RG

3. Buffer Amplifier

Manufacturer	Action Instruments
Model	AP4300

The buffer amplifier conditions a dc input signal and provides a proportional dc output that is fully isolated from the input, line power, and ground.

Input range = Output range	4-20 mA dc
Accuracy	0.1% RG
Temperature effect	0.35% RG per 14 K
Uncertainty	0.36% RG

4. Buffer Amplifier

Manufacturer	General Atomic
Model	BA-1A
Uncertainty	0.5% RG

5. Buffer Amplifier

Manufacturer	General Atomic
Model	BA-2
Input range = Output range	4-20 mA dc
Linearity	0.1% RG
Offset	0.25% RG
Hysteresis	0.2% RG
Temperature effect	0.35% per 14 K
Uncertainty	0.5% RG

6. Combustible Gas Alarm

Manufacturer	J and W
Model	CD-800W
Range	0-100% of lower limit
Uncertainty	None stated

7. Compensating Computer

Manufacturer	EG&G Idaho, Inc.
Uncertainty	1.0% RG

8. Current Transducer

Manufacturer	Ohio Semitronics
Model	CT50LT
Accuracy	0.5% RG
Temperature effect	1.0% RG
Uncertainty	1.1% RG

9. Differential Pressure Transmitter

Manufacturer	Fischer and Porter
Model numbers	10B2495, 13D2495K, 10B2496
Input range	Dependent on application
Output range	4-20 mA dc
Accuracy	0.5% RG
Repeatability	0.1% RG
Temperature effect	0.25% RG per 14 K
Uncertainty	0.6% RG

10. Differential Pressure Transmitter

Manufacturer	Honeywell
Model	29215
Uncertainty	0.5% RG

11. Differential Pressure Transmitter

Manufacturer	Rosemount Engineering
Models	1152 HP and 1152 DP Alphaline
Input range	0-17.23 MPa
Output range	4-20 mA dc

This differential pressure transmitter converts pressure, transmitted through an isolating diaphragm and silicone oil to a sensing diaphragm, to a 4-20 mA dc signal. The position of the sensing diaphragm is detected by capacitor plates on both sides of the sensing diaphragm. The transmitter is designed for nuclear application.

Accuracy (including linearity, hysteresis and repeatability)	0.25% RG
Dead band	None
Stability	0.25% RG per 6 months
Temperature effect—zero error	0.13%RG per 14 K
Overpressure effect	<5.0% RG
Static pressure effect	
Zero error	2.0% RG per 31.0 MPa
Span error	0.25% RG per 6.89 MPa
Power supply effect	<0.005% RG per volt
Uncertainty	2.3% RG

12. Flowmeter

Manufacturer	Controlotron Corporation
Model	Clampitron 240 N

This flowmeter senses liquid flow from the outside of the pipe. The Clampitron 240 N transducer transmits a beam of ultrasonic sound through the pipe wall and liquid and into the receiver transducer. The beam velocity changes proportionally to the fluid velocity.

Flow range	0-9.14 m/s
Linearity	1.0% RD
Calibration	1.5% RD
Accuracy	4.0% RD
Uncertainty	4.4% RD

13. Flowmeter

Manufacturer	Dieterich Standard Corp.
Model	Annubar Flow Sensor 115DPE22B1A2

Pitot tube differential pressure flowmeter.

Range	0-54 kPa
Uncertainty	Manufacturer's specification contains no uncertainty.

14. Flowmeter

Manufacturer	Fischer and Porter Company
Model	10LV Liquid Vortex Meter

The flowmeter is the enhanced vortex shedding type. Standard output is 4-20 mA dc proportional to flow rate. The electronics are integral to the flowmeter body.

Uncertainty 2.25% RG

15. Flow Nozzle Venturi

Manufacturer B.I.F. Industries
Model 13257-1

Input range 0-5 x 10^6 kg/s
Output range 0-200 kPa
Uncertainty 0.25% RD

16. Flow Nozzle Venturi

Manufacturer Vickery Simms
Model V3-403

Input range 0-2.19 l/s
Output range 0-20 kPa
Uncertainty 0.5% RD

17. Flow Nozzle Venturi

Manufacturer Vickery Simms
Model V4-397

Input range 0-29.2 l/s
Output range 0-45 kPa
Uncertainty 1.3% RD

18. Flow Nozzle Venturi

Manufacturer Vickery Simms
Model V6-400

Input range 0-146 l/s
Output range 0-154.7 kPa
Uncertainty 1.7% RD

19. Intermediate Range Detector

Manufacturer Reuter-Stokes
Model RSN 15A

Uncertainty 0.5% RG

20. Level Transmitter

Manufacturer Masoneilan International
Model 12523

Uncertainty No information available

21. Linear Amplifier

Manufacturer General Atomic
Model LA-xx

Uncertainty 0.5% RG

22. Logarithmic Amplifier

Manufacturer General Atomic
Model LIA-5

Uncertainty 0.5% RG

23. Logarithmic Count-Rate Circuit

Manufacturer General Atomic
Model LSM-4

Uncertainty 0.5% RG

24. Multiplier

Manufacturer Fischer and Porter Company
Model 50EX3000

Input range = Output range 4-20 mA dc

Accuracy 1.0% RG
Temperature effect 0.25% RG per 14 K
Uncertainty 1.1% RG

25. MV/I Transmitter

Manufacturer Honeywell
Model 39511

Thermocouple input converted to current output.

Uncertainty 0.1% RG

26. Position Transmitter

Manufacturer Markite
Model SL20

Input range 0-100%
Output range 0-2000Ω
Uncertainty 0.5% RG

27. Position Transmitter

Manufacturer	Rochester Instrument Systems, Inc.
Model	SC-300R

The SC-300R is a standard slidewire position transducer that provides a direct linear dc current or voltage output.

Linearity	0.5% RG
Repeatability	0.1% RG
Stability and drift	0.5% RG per 14 K
Calibration accuracy	0.1% RG
Response time	<10 ms
Temperature range	255-333 K
Uncertainty	0.72% RG

28. Power Amplifier

Manufacturer	General Atomic
Model	ELA294-0222B
Input range	0.0013-0.16 mA
Output range	0-10 V dc
Uncertainty	0.5% RG

29. Power Averager

Manufacturer	General Atomic
Model	SA1
Input range = Output range	0-10 V dc
Uncertainty	0.2%

30. Power Range Neutron Detector

Manufacturer	Reuter-Stokes
Model	RSN-304
Input range	3×10^7 to 3.6×10^9 nV
Output range	0.0013 to 0.16 mA
Uncertainty	0.5% RG

31. Power Transducer

Manufacturer	Scientific Columbus
Model	Exceltronic XLWV

Combination of the XL Watt Transducer and the XLV Var Transducer.

Uncertainty	0.2% RD + 0.01% RG

32. Pressure Transmitter

Manufacturer	Fischer and Porter
Model	50EN1000 Absolute

Pressure transmitter converts a pressure input to a proportional current signal.

Accuracy	0.5% RG
Repeatability	0.1% RG
Dead band	0.1% RG
Frequency response	Flat to 5 Hz
Temperature effects	0.25% RG per 14 K
Uncertainty	0.72% RG

33. Pressure Transmitter

Manufacturer	Fischer and Porter
Model	50EP1000
Output range	4-20 mA dc
Accuracy	0.5% RG
Temperature effect	0.25% RG per 14 K
Uncertainty	0.6% RG

34. Pressure Transmitter

Manufacturer	Honeywell
Model	Vutronik PP/I 30201
Uncertainty	0.5% RG

35. Pressure Transmitter

Manufacturer	Rosemount, Inc.
Model	1152 GP Alphaline

Gage-type pressure transmitter converts pressure, transmitted through an isolating diaphragm, to a 4-20 mA dc signal. The position of the sensing diaphragm is detected by capacitor plates on both sides of the sensing diaphragm. The transmitter is designed for nuclear application.

Accuracy (including linearity, hysteresis, and repeatability)	0.25% RG
Stability	0.25% RG per 6 months
Temperature effect	0.25% RG per 14 K
Uncertainty	0.43% RG

36. R/I Converter

Manufacturer	Fischer and Porter
Model	50ER3000
Output range	4-20 mA dc
Accuracy	0.3% RG
Temperature effect	0.23% RG per 14 K
Uncertainty	0.4% RG

37. R/I Converter

Manufacturer	Honeywell
Model	Vutronik 39521
Uncertainty	1.0% RG

38. Position Transmitter

Manufacturer	Rochester Instrument Systems
Model	SC-300R

The SC-300R is a standard slidewire position transducer that provides a direct linear dc current or voltage output.

Linearity	0.5% RG
Repeatability	0.1% RG
Stability and drift	0.5% RG per 14 K
Calibration accuracy	0.1% RG
Response time	<10 ms
Temperature range	255-333 K
Uncertainty	0.72% RG

39. R/I Converter

Manufacturer	Rosemount Engineering
Model	4401.3
Input range	92.92 - 149.4Ω
Output range	4-20 mA dc
Uncertainty	2.0% RG

40. RMS Converter

No information available

41. RTD

Manufacturer	H. E. Sostman
Model	4106-260-11978C
Input range	283-617 K
Output range	103.97-229.55Ω
Uncertainty	0.1% (RG-255)

42. RTD

Manufacturer	Rosemount Engineering
Model	78-99-42
Input range	283-617 K
Output range	Dependent on application
Uncertainty	0.06 K

43. RTD

Manufacturer	Rosemount Engineering
Model	104MA
Input range	255-400 K
Output range	92.92-149.4Ω
Uncertainty	1.2 K

44. Signal Isolator

Manufacturer	Honeywell
Model	Vutronik 38543-4060-0110-000
Uncertainty	0.25% RG

45. Signal Isolator

Manufacturer	Rochester Instrument Systems
Model	SC302
Input range	4-20 mA dc
Output range	0-1 V dc

Linearity	0.5% RG
Repeatability	0.1% RG
Temperature effect	0.5% RG per 14 K
Uncertainty	0.8% RG

46. Signal Isolator

Manufacturer	Rochester Instrument Systems
Model	SC1302

The isolation signal transmitter is an interface instrument designed for making most process control instruments electrically compatible. Isolation is maintained between input and output signals.

Input range	4-20 mA dc
Output range	0-1 V dc

Accuracy	0.1% RG
Repeatability	0.1% RG
Temperature effect	0.25% RG per 14 K
Uncertainty	0.3% RG

47. Signal Transmitter

Manufacturer	Rochester Instrument Systems
Model	SC1300

The signal transmitter is a solid state standard process signal interface instrument designed to accept voltage or current inputs and provide a current or voltage output.

Linearity	0.3% RG
Repeatability	0.1% RG
Stability	0.25% RG per 14 K
Power supply effect	0.3% RG per 20% power variation
Uncertainty	0.4% RG

48. Source Range Detector

Manufacturer	Reuter-Stokes
Model	RSN 326

Uncertainty	0.5% RG

49. Square Root Extractor

Manufacturer	Fischer and Porter
Model	50ES3000

Input range = Output range	4-20 mA dc

Accuracy (for 0-10% of range)	2.0% RG
Accuracy (for 10-100% of range)	0.5% RG 0.5% RG
Temperature effect	0.25% RG per 14 K
Uncertainty (for 0-10% RG)	2.1% RG
Uncertainty (for 10-100% RG)	0.6% RG

50. Square Root Extractor

Manufacturer	Honeywell
Model	Vutronik 38506

Uncertainty (0-15% RG)	2.0% RG
Uncertainty (15-100% RG)	0.5% RG

51. Summer

Manufacturer	Fischer and Porter
Model	50AS3000

Input range = Output range	4-20 mA dc

Accuracy	0.5% RG
Temperature effect	0.25% RG per 14 K
Uncertainty	0.6% RG

52. Tachometer

No information available.

53. Thermocouple

Manufacturer	Honeywell
Model	Type J, Megopak

Uncertainty	2.2 K or 0.75% (RG-255), whichever is greater

54. Thermocouple

Manufacturer	Honeywell
Model	Type J, 9J30

Input range	0-200°F
Output range	-0.89 to 4.91 mV dc

Uncertainty	2.2 K or 0.75% (RG-255), whichever is greater

55. Thermocouple

Manufacturer	Omega
Model	Type J, TJ36-ICSS-14V-16
Input range	50-700°F
Output range	0.5-20.26 mV dc
Uncertainty	2.2 K or 0.75% (RG-255), whichever is greater

56. Thermocouple

Manufacturer	Pyco
Model	Type J

Input range and output range depend on application.

Uncertainty	2.2 K or 0.75% (RG-255), whichever is greater

57. Thermocouple Cable

Model	Type J
Uncertainty	2.2 K

58. Thermocouple Transmitter

Manufacturer	Rochester Instrument Systems
Model	SC306W
Linearity	0.5% (RG-255)
Repeatability	0.1% (RG-255)
Temperature effect	0.5% RG per 14 K
Response time	<10 ms
Uncertainty	0.71% (RG-255)

59. Thermocouple Transmitter

Manufacturer	Rochester Instrument Systems
Model	SC1306W
Linearity	0.5% RG
Repeatability	0.1% RG
Stability and drift	0.5% RG per 14 K
Calibration accuracy	0.1% RG
Response time	<10 ms
Temperature range	255-333 K
Uncertainty	0.72% RG

60. Voltage Transmitter

Manufacturer	Ohio Semitronics
Model	CTA-112
Accuracy	0.1% RG
Temperature effect	0.7% RG per 14 K
Uncertainty	0.7% RG

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