50-237

ADDITIONAL INFORMATION
AND
STATUS OF VARIOUS NUREG-0737 ITEMS

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ATTACHMENT

COMMONWEALTH EDISON COMPANY

Dresden Station Units 2 and 3
Quad Cities Station Units 1 and 2
Zion Station Units 1 and 2

Additional Information and Status of Various NUREG 0737 Items

3356N

II.B.3 Post Accident Sampling Capability

Dresden Response:

In Reference (b), we indicated that development of our capability to analyze high radiation samples had caused the implementation schedule to slip to March 1, 1982, for Dresden Unit 2. However, due to the delayed delivery of the gas partitioner, this March 1 date cannot be met. Commission approval is requested to extend this implementation date to April 1, 1982, to accommodate the installation of this equipment.

II.F.1.1 Noble Gas Effluent
and
II.F.1.2 Effluent (I_2) Sampling

Zion Response:

Reference (b) indicated that our projected completion date for these items was March 1, 1982. Recent design changes submitted by the equipment vendors have impacted our construction schedule. We now expect project construction completion by March 31, 1982. However, we do not expect calibration procedures and operating training to be completed until June 30, 1982. Commission approval is hereby requested to extend this implementation due date to accommodate our requirements.

3556N

II.F.1.3 Containment High-Range Rad Monitor

Dresden and Quad Cities Response:

Reference (e) requested our submittal of procedures and correction factors to modify instrument readings to correspond with the actual radiation levels inside containment. The development of these factors is underway and we expect them to be finalized by April 1. At that time, the stations will incorporate this information into their procedures. The process of changing procedures is expected to take six (6) weeks from drafting to approval. Therefore, we expect to be in a position to submit the requested information by May 15, 1982.

II.F.1.5 Containment Water Level

Dresden and Quad Cities Response:

Reference (f) discussed calibrational problems that we are experiencing with our torus water level instruments and stated that we expected to submit a schedule for the resolution of this matter by February 19. The following was discussed with Messrs. J. D. Hegner and P. W. O'Connor on that date. A proposed resolution of the calibrational problems has been discussed and agreed upon with the equipment vendor, ITT Barton. This fix will require a change in location of each level transmittter to a lower elevation along with replacement of the capillary tubing and parts containing capillary fluid. As a result, new supports for the transmitters must be designed and installed, and some capillary re-routing will be required.

A confirmatory test of this proposed fix is currently in progress on one instrument. If the fix proves satisfactory, all instruments (2 per unit) will be changed accordingly. Based upon this approach, construction drawings can be developed by April 2. However, we do not yet know the status of parts availability or when this modification can be scheduled. While making the modification, one (1) instrument will remain operational on each unit, and we estimate approximately one (1) week out of service time for each instrument. We will provide an updated status of this item by April 1, 1982.

In the interim, the indicated level is being treated as a "gross" indication of level as described in Reference (b).

II.F.2 ICC Instrumentation

Zion Response:

Reference (a) requested that the Commonwealth Edison Company submit additional information concerning the Westinghouse summary report on RVLIS. In accordance with our scheduled as presented in Reference (d), attached for your use are seven (7) copies of the requested information.

II.K.3.5 Auto Trip of RCPs

Zion Response:

NUREG 0737 imposes a March 1, 1982, modification schedule for this item. Reference (c) stated that the Westinghouse and Commonwealth Edison position is that automatic RCP trip is not necessary since sufficient time is available for manual tripping of the pumps. The Westinghouse Owners Group schedule to resolve this issue was presented in Reference (c) which involves a three (3) month "study period" after formal NRC approval of the Westinghouse model.

RESPONSES TO NRC REQUEST FOR ADDITIONAL INFORMATION
ON THE WESTINGHOUSE R.V.L.I.S.
SUMMARY REPORT
(7300)(ZION)

Item 1

Justify that the single upper head penetration meets the single failure requirement of NUREG-0737 and show that it does not negate the redundancy of the two instrument trains.

Response

1. Redundancy is not compromised by having a shared tap since it is not conceivable that the tap will fail either from plugging or breaking. Freedom from plugging is enhanced by, 1) use of stainless steel connections which preclude corrosion products and, 2) absence of mechanisms, such as flow, for concentrating boric acid. It is also inconceivable that the tap will break because it is in a protected area. It should also be pointed out that in other cases where sharing of a tap occurs in the RCS, we know of no prior experience reporting deleterious malfunctions of the shared tap. Also, even if the shared tap does fail, it should be recognized that RVLIS is not a Protection System initiating automatic action, but a monitoring system with adequate backup monitoring such as by core exit thermocouples for operator correlation.

Item 2

Describe the location of the level system displays in the control room with respect to other plant instrument displays related to ICC monitoring, in particular, the saturation meter display and the core exit thermocouple display.

Response

See Figure 1

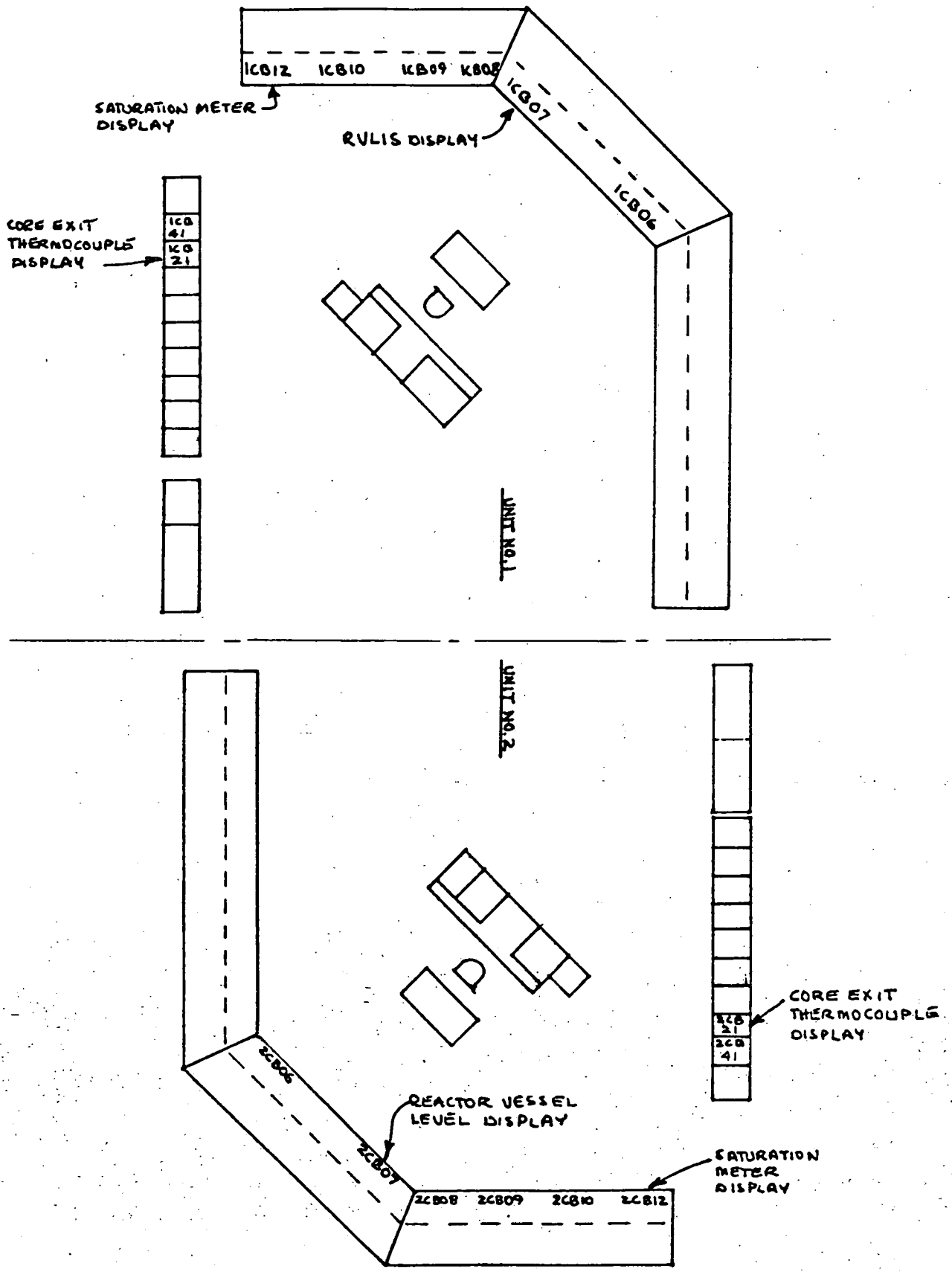
1CB12
1CB10
1CB09
1CB08
1CB07
1CB06
SATURATION METER DISPLAY
RVLIS DISPLAY
CORE EXIT THERMOCOUPLE DISPLAY
1CB 41
1CB 21
UNIT NO.1
UNIT NO.2
2CB06
2CB07
2CB08
2CB09
2CB10
2CB12
REACTOR VESSEL LEVEL DISPLAY
SATURATION METER DISPLAY
CORE EXIT THERMOCOUPLE DISPLAY
2CB 21
2CB 41

Figure 1

Item 3

Describe the provisions and procedures for on-line verification, calibration and maintenance.

Response

3. In general, the system electronics are verified, maintained and calibrated on-line by placing one of the redundant trains into a test and calibrate mode while leaving the other train in operation to monitor inadequate core cooling.

   A general verification is performed before shipment, but plant specific data is not used. The capability exists for the operator to verify the operation of the system. This would involve disconnecting the sensors at the RVLIS electronics, providing an artificial input, and observing the response of the system on the front panel and remote display.

   Online calibration of the system is made possible by the "Card Edge" adjustments. The P.C. Cards are calibrated at the factory; however, if the function is changed or a component on the card is replaced, the calibration procedure is given within the equipment reference manual.

   The RVLIS system requires the normal maintenance given to other control and protection systems within the plant. On-line maintenance is accomplished by placing only one of the two redundant trains into maintenance at a time this will allow continued monitoring of inadequate core cooling.

ATTACHMENT A

SYSTEMS OPERATING PROCEDURES

2-1. PURPOSE

The objectives of these instructions are to establish the requirements for the use of the Reactor Vessel Level Instrumentation System (RVLIS) for various plant conditions and to specify the maintainability requirements of the system equipment.

2-2. PREREQUISITES

- The capillary lines have been vacuum filled, per the instructions of section 4.
- Calibrate the d/p cells per instructions of ITT Barton Manual for Model 764, Level A, transmitters.
- The process equipment must be scaled using the appropriate scaling document.
- Determine the height of the upper tap piping above the inside top of the vessel.

2-3. INITIALIZATION

With the plant less than 200°F and less than 430 psig, obtain the following data for trains A and B:

(1) With an automatic data logger, record the following:

- T_{hot}
- RCS pressure
- d/p transmitter output (filtered)
- Signal to the remote display

(2) Manually record:

- o Level indication readings
- o Reference leg RTD output

(3) Record the above data for the following reactor coolant pump operations:

NOTE

The various configurations should be obtained through the normal startup if possible.

NOTE

Narrow range will read offscale with one or more pumps running.

- o No pumps running

NOTE

A narrow range indication of 100 percent reading represents a level to the inside top of the vessel. The height of the upper tap piping above the inside top of the vessel will result in a reading greater than 100 percent. This added height is plant specific and must be determined prior to adjusting the process equipment (narrow range) for full scale indication.

- o One pump running
- o Two pumps running
- o Three pumps running
- o All pumps running

(4) With all pumps running, increase RCS pressure - temperature to T_{avg} no-load and record data per step (1) every $50^{o}F$ increment. Data of step (2) should be recorded at $350^{o}F$ and at T_{avg} no-load. Review wide range RVLIS data for the entire heatup, and adjust the compersation function so that the wide range indication reads 100 percent with all pumps running.

(5) Trip all pumps and record data per steps (1) and (2). Verify that narrow range indication is in agreement with the reading of step (3) "No pumps running".

(6) Restart pumps in sequence and record wide range readings for both trains for each pump combination.

(7) Record for future reference is the emergency procedures the wide range indications for the various pump combinations.

2-4. NORMAL PLANT OPERATION

With the plant at power, the level readings should be as follows:

Wide range	107 percent (wide range reading will increase from 100 percent to approximately 107 percent with all pumps running, as reactor power is increased from zero to 100 percent)

Narrow range	Off Scale - High

Any reduction in wide range expected readings (with all pumps running) can only be caused by the presence of voids in the circulating water. Voids will not exist without reduced pressure which could trip the reactor, so all accident conditions will proceed from a condition of zero power (100 percent reading on the wide range). Check that the pressure has decreased or that subcooling meter confirms saturation conditions exist; then readings below 100 percent are an indication of voids in the coolant.

If the actual readings differ from the expected readings by 3 percent for a single train, refer to troubleshooting (paragraph 2-10).

If the indication for both trains differs from the expected readings, refer to the emergency operating instructions for immediate and subsequent action.

2-5. REFUELING

After depressurization and prior to lifting the reactor vessel head, perform the following steps to prepare the RVLIS:

(1) Close reactor vessel level head connection isolation valve.

(2) Disconnect piping between the isolation valve and the sensors.

NOTE

Contaminated water residue may be in the pipe.

(3) Provide temporary plugs for the pipe ends of the removable section and stationary sections.

Restore the RVLIS after reactor vessel head installation as follows:

(1) Remove pipe end plugs and reconnect piping section.

(2) With the isolation valve open, backfill the piping from sensors by attaching a water source to the sensor vent

(3) Disconnect waterfill apparatus.

(4) At startup (450 psig, <200°F), visually inspect piping/ coupling of the reinstalled piping for leakage.

(5) At full system pressure, repeat inspection.

2-6. PERIODIC TESTING

2-7. Plant at Power

Perform calibration checks of the process electronics in accordance with the process equipment instruction manual.

2-8. Refueling Outages

(1) With RVLIS isolated from the Reactor Coolant System, open sensor vents and check the position of the sensor bellows with a ruler. Capillary fill volume is verified if sensor bellows position is within ± 1/16 in. of the reading obtained during previous calibrations.

(2) Recalibrate d/p transmitters to ± 0.5% of span by applying the appropriate dp at the sensor vents, using instructions of Barton Instruction Manual (Model 764) and the instructions contained in the RVLIS system manual. Confirm that the d/p transmitter output equals the elevation head between sensors to within ± 2 inches.

(3) Perform the calibration check of the process electronics in accordance with the equipment technical manual.

(4) At the process equipment cabinets, compare the reference leg RTD channel outputs with ambient temperature measurements. Check the RTD resistances and adjust the RTD channel outputs if the temperatures differ by more than $\pm 5^{o}F$.

2-9. Plant Startup

Verify the operability of the RVLIS system during the startup/heatup of the plant following a refueling by tracking the displays of the two trains. Reading should be within $\pm$ 2% of the expected values.

2-10. TROUBLESHOOTING, PLANT AT POWER

Single indication varies from the expected value, check the following:

- Perform a calibration check of the process equipment, per the appropriate instruction manual.

If repairs are required to the capillary lines, the system must be vacuum-filled and calibrated per the instructions contained in the RVLIS System Manual and the appropriate equipment instruction manuals.

Item 4

Describe the diagnostic techniques and criteria to be used to identify malfunctioning components.

Response

The cabinet mounted equipment is designed to facilitate periodic tests to identify malfunctioning components and ensure the equipment functional operability is maintained comparable to the original design standards. Component power supply failure is annunciated in the main control room.

Item 5

Estimate the in-service life under conditions of normal plant operations and describe the methods used to make the estimate, and the data and sources used.

Response

The in-service life of the RVLIS based electronics is dependent upon proper maintenance, including the replacement of individual component parts when necessary. The provisions for this maintenance are included in the technical manual. Based on the assumption of normal conditions and proper maintenance of the components, the only limitation to the in-service life will be the availability of replacement parts. It is estimated that in 20 years, some of the components will be technically obsolete and no longer produced. Consequently, the cards may have to be modified in the future to accommodate the current technology. Thus, any individual component failures are regarded as maintenance considerations and their replacement is necessary to prolong in-service life.

In-Service life which is different than Design Life and Qualified Life is dependent upon implementing a scheduled preventative maintenance program including periodic overhaul of the equipment. In this manner, the equipment is restored to a level that continual operatibility is ensured. In developing the maintenance program, repair costs may necessitate replacement of the equipment.

If the maintenance program is followed there is no apparent reason that operation of the equipment cannot be extended.

Some of the equipment is similar to equipment installed in present Westinghouse plants that have been operating for 10-15 years.

The following valves have been supplied by Westinghouse for the Reactor Vessel Level Instrumentation System for Zion Units 1 and 2:

W Valve ID	Qty	Manufacturer	W Design Specification	Code Applicability
3/4 T 78	4	Rockwell	G-952855; Rev 0	ASME B&PV Class

The 3/4 T78 valve is a stainless steel, manually operated globe valve whose basic function is to isolate the flow of fluid. The valve is designed for a cycle life of 4000 cycles over the 40 year design life, which satisfies the normal plant operating requirements established in the above referenced specification. The valve is a hermetically sealed valve, designed to be maintenance free with no consumable materials making a pressure boundary seal.

Item 6

Explain how the value of the system accuracy (given as +/- 6% was derived. How were the uncertainties from the individual components of the system combined? What were the random and systematic errors assumed for each component? What were the sources of these estimates?

Response

6. The system accuracy of ± 6% water level was a target value established during the conceptual design and was related to the dimensions of the reactor vessel (12% from nozzles to top of core) and core (30%), and the usefulness of the measurement during an accident. Subsequent analyses have established a system accuracy based on the uncertainties introduced by each component in the instrument system, and including the uncertainties resulting from the severe environment imposed on the instrumentation located inside the containment. The individual uncertainties unaffected by the environmental effects and resulting from random effects were combined statistically and then added to the uncertainties resulting from the environmental effects to obtain the overall instrument system accuracy during an accident. Some of the individual uncertainties vary with conditions such as system pressure. The following table identifies the random, individual uncertainties for the narrow range measurement while at a system pressure of 1200 psia.

Component and Uncertainty Definition	Uncertainty % Level
a. Differential pressure transmitter calibration and drift allowance, (± 1.5% of span) multiplied by the ratio of ambient to operating water density.	± 2.08

b.	Differential pressure transmitter allowance for change in calibration due to ambient temperature change (± 0.5% of span for ± 50oF) multiplied by the density ratio.	± 0.7
c.	Differential pressure transmitter allowance for change in calibration due to change in system pressure (± 0.2% of span per 1000 psi change) multiplied by the density ratio.	± 0.33
d.	Differential pressure transmitter allowance for change in calibration due to exposure to long-term overrange (± 0.5% of span) multiplied by the density ratio.	± 0.7
e.	Reference leg temperature instrument (RTD) uncertainty of ± 5oF and an allowance of ± 5oF for the difference between the measurement and the true average temperature of the reference leg, applied to each vertical section of the reference leg where a measurement is made. Stated uncertainty is based on a maximum containment temperature of 420oF, and a typical reference leg installation.	± 0.64
f.	Reactor coolant density based on auctioneering for highest water density obtained from hot leg temperature (± 6oF) or system pressure (+ 60 psi). Magnitude of uncertainty varies with system pressure and water level, with	± 1.06

largest uncertainty occurring when the reactor vessel is full.

g. Sensor bellows displacements due to system pressure changes or reference leg temperature changes will introduce minor errors in the level measurement due to the small volumes and small bellows spring constants. The changes, such as pressure or temperature, tend to cancel, i.e., the bellows associated with each measurement move in the same direction. Maximum expected error due to differences in capillary line volume and local temperatures is equivalent to a level change of about 5 inches, multiplied by the density ratio. ± 1.32

h. Density function generator output mismatch with ASME Steam Tables limited to a maximum of: ± 0.70

i. Electronics system calibration, overall uncertainty limited to less than: ± 1.5

j. Control board indicator resolution. ± 1.1

The statistical combination (square root of the sum of the squares) of the individual uncertainties described above results in an overall system instrumentation uncertainty of ± 3.6% of the level span, before accounting for containment environmental effects. Since the d/p transmitters and the RCS wide range pressure transducers are located inside the containment, the following uncertainties must be considered, evaluated at a system pressure of 1200 psia:

k. Differential pressure transmitter allowance for long-term temperature and radiation effects, multiplied by the density ratio. ± 21.00

l. Reactor coolant density based on wide range pressure transducer allowance for long-term temperature and radiation effects. ± 5.10

These level uncertainties are added directly to determine the total uncertainty including the environmental effects. The total uncertainties over a range of system pressures are as follows:

System Pressure	Uncertainty w/o Environmental Effects	Uncertainty w/ Environmental Effects
400 psia	± 3.4%	± 29%
1200 psia	± 3.6	± 30
2200 psia	± 4.5	± 36

Item 7

Assume a range of sizes for "small break" LOCA's. What are the relative times available for each size break for the operator to initiate action to recover the plant from the accident and prevent damage to the core? What is the dividing line between a "small break" and a "large break"?

Response

7. Inadequate core coolant (ICC) was defined in WCAP-9754, "Indequate Core Cooling Studies of Scenario With Feedwater Available Using the NOTRUMP Computer Code", as a high temperature condition in the core such that the operator is required to take action to cool the core before significant damage occurs. During the design basis small loss of coolant accident, the operator is not required to take any action to recover the plant other than to verify the operable status of the safeguards equipment, trip the reactor coolant pump (RCPs) when the primary side pressure has decreased to a specific point, and initiate cold and hot leg recirculation procedures as required. In the design basis small LOCA, a period of cladding heatup may occur prior to automatic core recovery by the safeguards equipment. The heat up period is dependent upon the break size and ECCS performance.

An ICC condition may arise if there is a failure of the safeguards equipment beyond the design basis. In that case, adequate instrumentation exists in the Zion plant to diagnose the onset of ICC and to determine the effectiveness of the mitigation actions taken. The instrumentation which may be used to determine the adequacy of core cooling consists of a subcooling meter, Core Exit Thermocouples (T/Cs), and the Reactor Vessel Level Instrumentation System (RVLIS).

For a LOCA of an equivalent size equal to approximately six inches or less, an ICC condition can only occur if two or more failures occur in the ECCS. As indicated in WCAP-9754, an ICC condition can be calculated by hypothesizing the failure of all high head safety

injection (HPSI) for LOCAs of approximately one inch in size. For a 4 inch equivalent size LOCA one can hypothesize an ICC condition by assuming the failure of all HPSI as well as the failure of the passive accumulator system (a truly incredible sequence of events).

For LOCAs of sizes of six inches or less, the approach to ICC is unambiguous to the reactor operators. The first indication of a possible ICC situation is the indication that some of the ECCS pumps have failed to start or are not delivering flow. The second indication of a possible ICC situation is the occurrence of a saturation condition in the primary coolant system as indicated on the subcooling monitor. Shortly after the second indication, the RVLIS would start to indicate the presence of steam voids in the vessel. At some point in time the RVLIS will indicate a collapsed liquid level below the top of the core. The core exit thermocouples will begin to indicate superheated steam conditions. If appropriate the RVLIS and core exit T/C behavior will provide unambiguous indications to operator to follow the ICC mitigation procedure.

WCAP-9754 indicates that the selected core exit T/Cs will read 1200°F at approximately 11000 seconds after the initiation of a 1-inch LOCA with the loss of all HPSI. The Generic Westinghouse EOP Guideline instruct operator to pursue ICC mitigation procedures when these conditions are reached. The 4-inch LOCA will indicate 1200°F at about 1350 seconds. By following the Westinghouse recommended Emergency Operating Procedures (EOPs), the operators will have earlier indication of a possible ICC situation. Recovery procedures to depressurize the primary system below the low pressure safety injection shutoff head may be followed. These procedures include correction of the HPSI failure, opening steam dump, or opening pressurizer PORVs. The RCPs may be restarted to provide additional steam cooling flow.

Large break LOCAs consist of LOCAs in which the fluid behavior is inertially dominated. Small break LOCAs, on the other hand, have

the fluid behavior dominated by gravitational effects. For LOCAs which are significantly larger than an equivalent 6-inch break, the ECCS has the maximum potential for flow delivery since the primary coolant system is at low pressure.

No early manual action is useful in recovering from ICC. Analyses for LOCAs in this range indicate ambiguous behavior of the core exit T/Cs and RVLIS early in the accident due to dynamic blowdown effects. This behavior is temporary and the core exit T/Cs and the RVLIS will indicate the progress being made by the ECCS in recovering the core. When the core exit T/Cs and RVLIS may be temporarily providing ambiguous indications, no manual action is needed or useful. Later in the accident when manual action may be useful, the core exit T/Cs and RVLIS will provide an unambiguous indication of ICC if it exists. This unambiguous indication may be present as early as 30 seconds after the initiation of the LOCA for a double ended guillotine rupture or a main coolant pipe.

It follows from the above discussion that, for ICC considerations, a reasonable definition of large breaks are breaks that are significantly larger than an equivalent 6 inch break. All other breaks are small breaks.

Item 8

Describe how the system response time was estimated. Explain how the response times of the various components (differential pressure transducers, connecting lines and isolators) affect the response time.

Response

8. An analysis of the RVLIS hydraulics, an independent analysis of the hydraulics by ORNL, and the results of testing at the Semiscale Test Facility in Idaho generally support a response time (50% response to a step change in level) of 3 seconds or less for the standard RVLIS hydraulics. There are, however, two types of transients which will affect the RVLIS response: a change in level and a change in system pressure. The major factors that influence the RVLIS hydraulics response to these two types of transients are the fluid volume within the RVLIS system and the length of capillary tubing connected to the dp transmitter. For a level transient, the volume required to displace the transmitter bellows and the total length of capillary tubing are the significant parameters. Although the capillary tubing length (approximately 300 feet at Zion) and diameter (0.089 inches) represent a significant resistance to flow, the volume required for a full open deflection of the transmitter bellows is small (0.16 cu. in.). The sensor bellows displacement spring constants will introduce a small error in the measured level but will not impact the response time of the system.

For a system pressure transient, the total fluid volume of the RVLIS system and the difference in length between the two capillary lines connected to the dp transmitter are the significant parameters. In theory, the transmitters would not response to a change in pressure if the two capillary lines were equal in length. In practice, plant layout requirements result in lengths differing by as much as 100 feet. During a system pressure change, the water volume in the RVLIS system will expand or contract a small amount, but measurable pressure drops will develop in the capillary lines as the small

volumes move to equalize pressure. The dp transmitter will indicate a differential pressure or offset caused by one line being longer than the other. For a reasonably rapid transient of 100 psi per second imposed on the standard RVLIS system having a difference in line lengths of 100 feet, the offset or apparent level change would approach about 2 feet of water, and the offset would remain until the pressure transient is terminated. Since the Zion d/p transmitters are located inside the containment and no hydraulic isolators (which account for most of the system volume) are installed, the offset from this transient would be 1/10 of that for a standard system, which is essentially neglibible. Much larger offsets approaching full scale deflection could occur (and have been observed during a large break test at Semiscale) during the initial large break transient, but a RVLIS output during this short period of less than 2 minutes would not otherwise be useful or required for actions associated with ICC.

In addition to the hydraulics response characteristics, the RVLIS electronics incorporate an adjustable lag to filter hydraulic noise when reactor coolant pumps are operating. The lag time constant, adjustable up to 10 seconds, will be set during startup to a value of about 1 to 3 seconds. The response time associated with the rest of the electronics has essentially no impact on the total response time, which is expected to be well within 10 seconds.

Item 9

There are indications that the TMI-2 core may be up to 95% blocked. Estimate the effect of partial blockage in the core on the differential pressure measurements for a range of values from 0 to 95% blockage.

Response

9. Blockage in the core will increase the frictional pressure drop and increase the total differential pressure across the vessel. This will be reflected as a higher RVLIS indication. The increase in the RVLIS will be most significant under forced flow conditions when the reactor coolant pumps are operating.

   In order for blockage to be present, the core would have to have been uncovered for a prolonged period of time. A low RVLIS indication along with a high core exit thermocouple indication would have been indicated during this time. If the RCP's had been operating throughout the transient, there would have been sufficient cooling to prevent significant core damage. Therefore, for significant blockage to exist during pump operation, the operator would have restarted the pumps after an ICC condition had existed for a period of time. Based on the history of the transient, the operator would know that the RVLIS would read higher than expected. Although the RVLIS would read high, it would still follow the trend in vessel inventory. The operator would be able to monitor the recovery with the RVLIS.

   Under natural circulation conditions, the impact of core blockage is not expected to be large. Although the RVLIS indication will read slightly higher than normal, the RVLIS will still trend with the vessel inventory and provide useful information for monitoring the recovery from ICC. ICC will have been indicated at an earlier time; before a significant amount of core blockage has occurred. The operator will know that the RVLIS could read slightly high, based on the history of the transient.

Item 10

Describe the effects of reverse flows within the reactor vessel on the indicated level.

Response

10. Reverse flows in the vessel will tend to decrease the DP across the vessel which would cause the RVLIS to indicate a lower collapsed level than actually exists. The low indication would not cause the operator to take unnecessary actions, since the RVLIS would be used along with the core exit thermocouples to indicate the approach to ICC. It is important to note that large reverse flows are not expected to occur for breaks smaller than 6" in diameter during the time that the core is uncovered. Large reverse flow rates may occur early in the blowdown transient for large diameter breaks but, as is discussed in the response to Item 7, it is not necessary to use the RVLIS as a basis for operator action for breaks in this range.

Item 11

What is the experience, if any, of maintaining D/p cells at 300% overrange for long periods of time?

Response

11. Experience in overranging of D/p Instruments has been obtained in previous applications of D/p capsules similar to those used in RVLIS. In Dual Range Flow (D/p) Applications the "Low Flow" transmitter (and/or gages) are overranged to 300% or greater by normal flow rates yet provide reliable metering when required for startup.

    Also, test data exists on the basic transmitter design showing about 0.5% effect on calibration with 24 hours exposure to 3000 psig overrange. All units are similarly exposed to this overrange for 5 minutes in both directions as a part of factory testing.

    There have been instances involving accidental overrange of these instruments (including RVLIS) as the result of leakage or operator errors where full line pressure overranges have occurred for up to several weeks with minimal effect on instrument accuracy.

    Based upon this experience and test data we expect to prove statistically that reliable measurements can be made by the selected overranged instrument designs used for RVLIS. On line calibration capability is provided if needed to support gathering of statistical data.

Item 12

Five conditions were identified which could cause the DP level system to give ambiguous indications. Discuss the nature of the ambiguities for 1. accumulator injection into a highly voided downcomer, 2. when the upper head behaves like a pressurizer, 3. upper plenum injection, and 4. periods of void redistribution.

Response

12. 1. When the downcomer is highly voided and the accumlators inject, the cold accumulator water condenses some of the steam in the downcomer which causes a local depressurization. The local depressurization will lower the pressure at the bottom of the vessel which will lower the DP across the vessel, causing an apparent decrease in level indication. The lower pressure in the downcomer also causes the mixture in the core to flow to the lower plenum, causing an actual decrease in level. The period of time when the RVLIS indication is lower than the actual collapsed liquid level will be brief.

An example of when this phenomenon may occur is when the reactor coolant pumps are running for a long period of time in a small break transient. After the RCS loops have drained and the pumps are circulating mostly steam, the level in the downcomer will be depressed. A large volume of steam will be present in the downcomer, above the low mixture level, which allows a large amount of condensation to occur. For most small break transients, the reactor coolant pumps will be tripped early in the transient and the downcomer mixture level will remain high, even in cases where ICC occurs. When the downcomer level is high the effect of accumulator injection on the RVLIS indication will be minor.

2. When the upper head begins to drain, the pressure in the upper head decreases at a slower rate than the pressure in the rest of the RCS. This is due to the upper head region behaving much like the pressurizer. The higher resistance across the upper support plate relative to the rest of the RCS prevents the upper head from draining quickly. This situation only exists until the mixture level in the upper head falls below the top of the guide tubes. At this time, steam is allowed to flow from the upper plenum to the upper head and the pressure equilibrates. While the upper head is behaving like a pressurizer, the vessel differential pressure is reduced and the RVLIS indicates a lower than actual collapsed liquid level.

   This phenomenon is discussed in the summary report on the RVLIS* relative to the three inch cold leg break. Since that time, the upper head modeling has been investigated in more detail. It was found that the modeling used at that time assumed a flow resistance that was too high for the guide tubes. Subsequent analyses have shown that the pressurizer effect has less impact on the vessel dp than was originally shown. There is very little impact on the results after the level drains below the top of the guide tubes. The pressurizer effect is still believed to exist and it becomes more significant as break size increases. The interval of time when the upper head behaves like a pressurizer is brief and the RVLIS will resume trending with the vessel level after the top of the guide tubes uncover. The reduced RVLIS indication will not cause the operator to take any unnecessary action, even if a level below the top of the core is indicated since the core exit thermocouples are used as a corroborative indication of the approach to ICC.

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* Westinghouse Electric Corporation, "Westinghouse Reactor Vessel Level Instrumentation System for Monitoring Inadequate Core Cooling," December 1980.

3. Upper plenum injection (UPI) is applied only to two-loop plants; therefore, the effects due to UPI are not applicable to the Zion Plant.

4. During the time when the distribution of voids in the vessel is changing rapidly, there can be a large change in the two-phase mixture level with very little change in collapsed mixture level. The use of the RVLIS, in conjunction with the core exit thermocouples, is still valid for this situation, however. The only event that has been identified which could cause a large void redistribuition is when the reactor coolant pumps are tripped when the vessel mixture is highly voided. After the pump performance has degraded enough that the flow pressure drop contribution to the vessel differential pressure is small, the change in RVLIS indication will be very small when the pumps are tripped. As discussed in the summary report, the approach to ICC would be indicated when the wide range indication read 33 percent. If the pumps were tripped at this time, the core would still be covered. The operator would know that the core may uncover if the pumps were tripped with a wide range indication lower than 33 percent. Prior to pump trip, the core will remain adequately cooled due to forced circulation of the mixture. When the pumps trip the two phase level may equillibrate at a level below the top of the core. The narrow range indication will provide an indication of core coolability at this time.

Item 13

No recommendations are made as to the uncertainties of the pressure or temperature transducers to be used, but the choice appears to be left to the owner or AE. What is the upper limit of uncertainties that should be allowed? Describe the effect of these uncertainties on the measurement of level. What would be the effect on the level measurement should these uncertainties be exceeded?

Response

13. The reactor coolant pressure and temperature signals originate from the existing wide range pressure and hot leg RTD's already installed in the plant, and the uncertainties for these instruments are understood. As indicated in the response to question 6, the pressure uncertainty is ± 60 psi and the temperature uncertainty is under normal operating conditions. Accident environments will degrade the accuracy of the pressure transducer, potentially resulting in an uncertainty of up to ± 300 psi and a somewhat larger contribution to the level measurement uncertainty (see Item 6).

Item 14

Only single RTD sensors on each vertical run are indicated to determine the temperatures of the impulse lines. Where are they to be located? What are the expected temperature gradients along each line under normal operating conditions and under a design basis accident? What is the worst case error that could result from only determining the temperature at a single point on each line?

Response

14. RTD sensors are installed on every independently run vertical section of impulse line, to provide a measurement for density compensation of the reference leg. If the vertical section of impulse line runs through two compartments separated by a solid floor, an RTD sensor is installed in each compartment.

    The RTD is installed at the midpoint of each vertical section, based on the assumption that the temperature in the compartment is uniform or that the temperature distribution is linear in the vicinity of the impulse line. As stated in the response to question 6, an allowance for the true average impulse line temperature to differ from the RTD measurement by 5oF is included in the measurement uncertainty analysis. This allowance permits a significant deviation from a linear gradient, e.g., 20% of the impulse line could be up to 25oF different from a linear gradient without exceeding the allowance. During normal operation, forced circulation from cooling fans is expected to maintain compartment temperatures reasonably uniform. During the LOCA, turbulence within a compartment due to release of steam would also produce a reasonably uniform temperature. Note that the impulse lines are protected from direct jet impingement by metal instrument tubing channels.

Item 15

What is the source of the tables or relationships used to calculate density corrections for the level system?

Response

The relationships used in the analog based RVLIS system, to calculate density corrections are from the ASME steam tables, dated 1967. These relationships are implemented within the system by means of P.C. cards that generate an output signal which is a predetermined function of the input signal. The predetermined functions produce specific slopes which are added together to obtain the required input-output relationships.

Item 16

The microprocessor system is stated to display the status of the sensor input. Describe how is this indicated and what this actually means with respect to the status of the sensor itself and the reliability of the indication.

Response

The Zion plant is provided with the 7300 electronics system; therefore this question is not applicable.

Item 17

Describe the provisions for preventing the draining of either the upper head or hot leg impulse lines during an accident. What would be the resultant errors in the level indications should such draining occur?

Response

17. The RVLIS systems at Zion do not include hot leg connections. The layout of the impulse lines from the upper head and hot leg is arranged to prevent or minimize the impact of drainage during an accident. In general, however, the water in the impulse line will be cooler than the water in the reactor or hot leg, and there will be sufficient subcooling overpressure in the lines so that very little, if any, of the water would flash to steam during a depressurization or containment heatup. Heat conduction along the small diameter piping and tubing would be insufficient to result in flashing in a significant length of piping.

    The connection to the upper head from a spare control rod drive mechanism port drops or slopes down from the highest point of the vessel connection to the sensor bellows mounted on the refueling canal wall, so water would be retained in this piping. Draining of the vertical section immediately above the reactor vessel has no effect on the level measurement, since this section is included in the operating range of the instrument.

    The majority of the impulse line length is in capillary tubing sealed at both ends with a bellows (sensor bellows at the reactor end, transmitter bellows at the instrument end) so water would be retained in this system at all times. The water will be pressurized by reactor pressure, and since the reactor temperature will be higher than containment temperature during an accident, the water in the sealed capillary lines cannot flash.

Item 18

Discuss the effect on the level measurement of the release of dissolved, noncondensible gases in the impulse lines in the event of a depressurization.

Response

18. The majority of the impulse lines are sealed capillary tubes vacuum filled with demineralized, deaerated water. The lines contain no noncondensible gases and are not in a radiation environment sufficient for the disassociation of water.

    The short run of impulse line connected directly to the primary system will behave as described in the response to question 17. Since there is no mechanism for concentration of gases at the top of the reactor vessel during normal operation, the connection to the top of the vessel would contain, at most, the normal quantity of dissolved gases in the coolant, and the subcooling pressure during an accident would maintain this quantity of gas in solution.

Item 19

In some tests at Semi-scale, voiding was observed in the core while the upper head was still filled with water. Discuss the possibility of cooling the core-exit thermocouples by water draining down out of the upper head during or after core voiding with a solid upper head.

Response

19. One of the indicators of an approach to an Inadequate Core Cooling (ICC) situation is the response of the core exit thermocouples (T/Cs) to the presence of super-heated steam. The core exit thermocouples will not provide an indication of the amount of core voiding. Response of the core exit T/Cs provides a direct indication of the existence of ICC, the effectiveness of ICC recovery actions, and restoration of adequate core cooling. The core is adequately cooled whenever the vessel mixture level is above the top of the core and the core may have a significant void fraction and still be adequately cooled.

    Realistically, an indication of an ICC condition would not occur until the primary coolant system has drained sufficiently for the reactor vessel mixture level to fall below the top of the core. Westinghouse has performed analyses which indicate that the upper head will drain below the top of the guide tubes before ICC conditions exist. The guide tubes are the only flow path from the upper head to the upper plenum. In WCAP-9754, "Inadequate Core Cooling Studies of Scenarios With Feedwater Available, Using the NOTRUMP Computer Code", it was found that inadequate core cooling situations woul not result for LOCAs of an equivalent size or equal to approximately 6 inches or less without two or more failures in the ECCS. In both specific scenarios examined in WCAP-9759, a 1-inch and 4-inch small LOCA, the upper head and upper plenum had completely drained before the onset of an ICC condition.

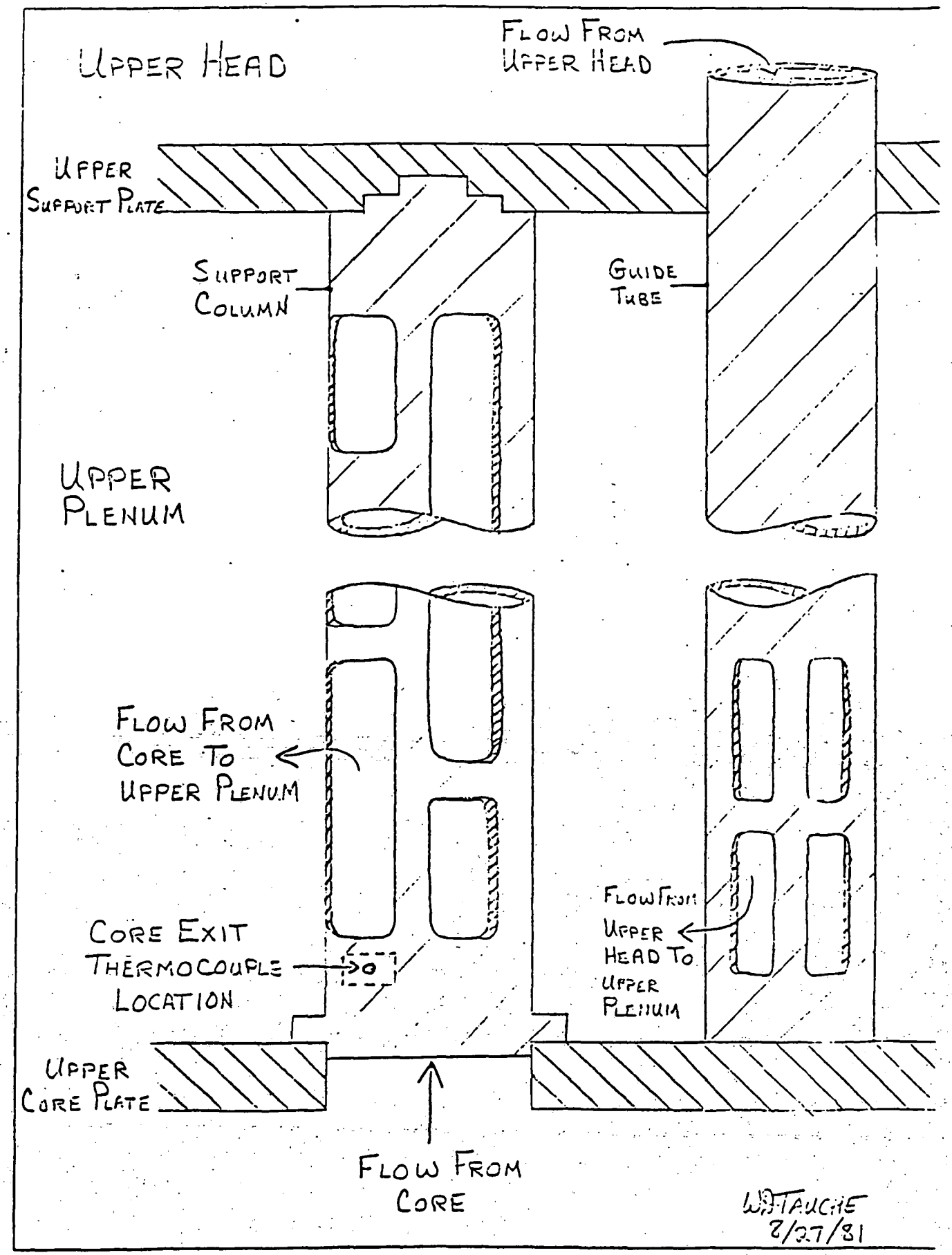
In the Zion plant, the core exit T/Cs protrude slightly from the bottom of the support columns (see attached Figure). In this location, they measure the temperature of the fluid leaving the core region through the flow passages in the upper core plate. Flow from the upper head must enter the upper plenum via the guide tube before being able to enter the upper core plate flow passages. In addition, the LOCA blowdown depressurization behavior must be such that there is a flow reversal for the core exit T/Cs to detect the upper head fluid temperature. The upper head fluid is expected to mix with the upper plenum fluid as it drains from the upper head.

The potential for core exit T/C cooling from colder upper head fluid, while the core has an appreciable void fraction is not viewed as a potential problem for the detection of an inadequate core cooling situation. Although some Semi-scale tests indicated core voiding while the upper head was liquid solid that does not imply that the core exit T/Cs would give an ambiguous indication of ICC calculations for a Westinghouse PWR and consideration of the core exit T/C design would not result in ambiguous ICC indications.

SKETCH SHEET
FORM 28577

NON-UHI CORE EXIT T/C DIAGRAM

WESTINGHOUSE ELECTRIC CORPORATION



W.J. TAUCHE
2/27/81

Item 20

Describe the behavior of the level measurement system when the upper head is full, but the lower vessel is not.

Response

20. During the course of a LOCA transient, the upper plenum will experience voiding before the upper head. The voids in the upper plenum will be indicated by a lower RVLIS reading. The RVLIS will not indicate where the voiding is occurring, but at this point in the transient, it is not necessary to know where the region of voiding is. In the early part of the transient when the mixture level is above the top of the guide tube in the upper head, it is sufficient for the operator to know that the vessel inventory is decreasing, irrespective of the region where voiding is occurring. As discussed in the response to Item 21, the fluid in the upper head does not affect the RVLIS indication after the upper head has drained to below the top of the guide tubes. As discussed in the response to Item 19, the uipper head will drain before the onset of ICC and there will not be an ambiguous indication during the period of time when RVLIS will be used.

Item 21

One discussion of the microprocesor system states that water in the upper head is not reflected in the plot. Does this mean that there is no water in the upper head or that the system is indifferent to water in the upper head under these conditions?

Response

21. The discussion in the system description is contained in the section describing the analysis of the system performance. The statement in question is referring to the WFLASH code calculation of mixture level, rather than how the RVLIS will respond to water in the upper head. The computer code includes calculation of water mass and pressure in the upper head, but this water mass is not included in the calculation of mixture level; hence, the mixture level is indicated only below the elevation of the upper support plate.

    The RVLIS measurement from top to bottom of the vessel will measure the level in the following regions: top of vessel to top of guide tube; inside guide tube from top to upper support plate; upper plenum; reactor core; lower plenum. During a LOCA, the RVLIS will measure the water level in the upper head only until the level drops to the top of the guide tubes; RVLIS would then measure level reduction in the guide tubes and upper plenum. The water remaining in the upper head below the top of the guide tubes would not be measured by RVLIS. This water would eventually drain through small holes into the guide tubes and downcomer, and this draining would be accomplished within a few minutes, depending on the accident. In any case, the water temporarily retained in the upper head would have no effect on the RVLIS indication.

Item 22

Describe the details of the pump flow/Dp calculation. Discuss the possible errors.

Response

22. Calculations are performed to obtain an estimate of the differential pressure that the wide range instrument will measure with all pumps operating, from ambient temperature to operating temperature. The calculations employ the same methods used to estimate reactor coolant flow for plant design and safety analysis. These calculations are used primarily to define the instrument span and to provide an estimate for the function that compensates the differential pressure signal over the full temperature range, i.e., that results in the wide range display indicating 100% over the full temperature range with all pumps operating, pumping subcooled coolant. During the initial plant startup following installation of the instrumentation, wide range differential pressure data would be obtained and used to confirm or revise the compensation function so that a 100% output is obtained at all temperatures. Since the calculated compensation function is verified by plant operating data, any uncertainties in the flow and differential pressure estimates are eliminated.

Item 23

Have tests been run with voids in the vessel? Describe the results of these tests.

Response

23. Test data has been obtained from a Westinghouse RVLIS installed at the Semiscale Test Facility in Idaho. Small break loss-of-coolant experiments have been conducted at this facility by EG&G for the NRC. The results of these tests are used to compare the RVLIS measurements with Semiscale differential pressure measurements, gamma densitometer data and core cladding surface thermocouple indications. After correcting for differences between PWR reactor vessel internals and Semiscale modeling, good correlation between Semiscale level indications and RVLIS measurements has been observed. Both Westinghouse and ORNL (for the NRC) have evaluated the test data and have issued reports summarizing the RVLIS performance during selected Semiscale tests.

Item 24

Estimate the expected accuracy of the system after an ICC event.

Response

24. The accuracy of the system as described in the response to question 6 would be the same for any LOCA-type incident, including an ICC event, causing a temperature increase within the reactor containment. Uncertainties due to reference leg temperature measurements, sensor bellows displacements, and pressure transducer and d/p transmitter degradation are included in this accuracy analysis.

Item 25

Describe how the conversion of RTD resistance to temperature made in the analog level system.

Response

The "7300" RVLIS incorporates P.C. Cards that provide an output proportional to the change in resistance of the RTD. The card contains a resistance bridge driven by a power supply to produce a signal proportional to the changes in resistance of the RTD and a signal characterizer which accommodates linear calibration of non-linear RTD's.