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ACCESSION NBR:8104200264 DOC.DATE: 81/04/17 NOTARIZED: NO DOCKET #
FACIL:50-361 San Onofre Nuclear Station, Unit 2, Southern Californ 05000361
50-362 San Onofre Nuclear Station, Unit 3, Southern Californ 05000362

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| MIRAGLIA,F. | Licensing Branch 3 |

See Report

SUBJECT: Forwards revised responses to Item II.F.2 of NUREG-0737 re instrumentation for detection of inadequate core cooling. Instrumentation will not be fully implemented until first refueling outage.Info includes response to NUREG-0660.

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April 17, 1981

K. P. BASKIN
MANAGER OF NUCLEAR ENGINEERING,
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TELEPHONE
(213) 572-1401

Director of Nuclear Reactor Regulation
Attention: Mr. Frank Miraglia, Branch Chief
Licensing Branch No. 3
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Gentlemen:

Subject: Docket Nos. 50-361 and 50-362
San Onofre Nuclear Generating Station
Units 2 and 3

SCE's letter of February 2, 1981, provided responses to the NRC requirements identified in NUREG-0737, Clarification of TMI Action Plan Requirements dated November, 1980, which included a response to item II.F.2, Instrumentation for Detection of Inadequate Care Cooling. SCE met with the NRC staff on March 5, 1981, to discuss item II.F.2. Consistent with the information presented during the meeting enclosed, please find sixty-three copies of revised item II.F.2 which includes the following specific clarifications requested by the NRC.

1. A detailed tabular comparison with the requirements of Attachment 1 of item II.F.2.

2. Schedular information for the remaining ICC instrumentation which will not be fully implemented until the first refueling outage.

3. Adequacy of existing instrumentation, procedures and training to facilitate safe plant operation until the first refueling outage.

If you have any questions or comments concerning this matter, please contact me.

Very truly yours,

KP Baskin

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Enclosures

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## II.F.2 - NUREG 0737 INSTRUMENTATION FOR DETECTION OF INADEQUATE CORE COOLING

### REQUIREMENT

### Position

Licensees shall provide a description of any additional instrumentation or controls (primary or backup) proposed for the plant to supplement existing instrumentation (including primary coolant saturation monitors) in order to provide an unambiguous, easy-to-interpret indication of inadequate core cooling (ICC). A description of the functional design requirements for the system shall also be included. A description of the procedures to be used with the proposed equipment, the analysis used in developing these procedures, and a schedule for installing the equipment shall be provided.

### Clarification

1. Design of new instrumentation should provide an unambiguous indication of ICC. This may require new measurements or a synthesis of existing measurements which meet design criteria (item 7).

2. The evaluation is to include reactor-water-level indication.

3. Licensees and applicants are required to provide the necessary design analysis to support the proposed final instrumentation system for inadequate core cooling and to evaluate the merits of various instruments to monitor water level and to monitor other parameters indicative of core-cooling conditions.

4. The indication of ICC must be unambiguous in that it should have the following properties:

   a. It must indicate the existence of inadequate core cooling caused by various phenomena (i.e., high-void fraction-pumped flow as well as stagnant boil-off); and,

   b. It must not erroneously indicate ICC because of the presence of an unrelated phenomenon.

5. The indication must give advanced warning of the approach of ICC.

6. The indication must cover the full range from normal operation to complete core uncovery. For example, water-level instrumentation may be chosen to provide advanced warning of two-phase level drop to the top of the core and could be supplemented by other indicators such as incore and core-exit thermocouples provided that the indicated temperatures can be correlated to provide indication of the existence of

ICC and to infer the extent of core uncovery. Alternatively, full-range level instrumentation to the bottom of the core may be employed in conjunction with other diverse indicators such as core-exit thermocouples to preclude misinterpretation due to any inherent deficiencies or inaccuracies in the measurement system selected.

7. All instrumentation in the final ICC system must be evaluated for conformance to Appendix B, "Design and Qualification Criteria for Accident Monitoring Instrumentation," as clarified or modified by the provisions of items 8 and 9 that follow. This is a new requirement.

8. If a computer is provided to process liquid-level signals for display, seismic qualification is not required for the computer and associated hardware beyond the isolator or input buffer at a location accessible for maintenance following an accident. The single-failure criteria of item 2, Appendix B, need not apply to the channel beyond the isolation device if it is designed to provide 99% availability with respect to functional capability for liquid-level display. The display and associated hardware beyond the isolation device need not be Class IE, but should be energized from a high-reliability power source which is battery backed. The quality assurance provisions cited in Appendix B, item 5, need not apply to this portion of the instrumentation system. This is a new requirement.

9. Incore thermocouples located at the core exit or at discrete axial levels of the ICC monitoring system and which are part of the monitoring system should be evaluated for conformity with Attachment 1, "Design and Qualification Criteria for PWR Incore Thermocouples," which is a new requirement.

10. The types and locations of displays and alarms should be determined by performing a human-factors analysis taking into consideration:

    a. the use of this information by an operator during both normal and abnormal plant conditions,

    b. integration into emergency procedures,

    c. integration into operator training, and

    d. other alarms during emergency and need for prioritization of alarms.

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    b. integration into emergency procedures,

    c. integration into operator training, and

    d. other alarms during emergency and need for prioritization of alarms.

ATTACHMENT 1

DESIGN AND QUALIFICATION CRITERIA FOR PRESSURIZED-WATER REACTOR INCORE THERMOCOUPLES

1. Thermocouples located at the core exit for each core quadrant, in conjunction with core inlet temperature data, shall be of sufficient number to provide indication of radial distribution of the coolant enthalpy (temperature) rise across representative regions of the core. Power distribution symmetry should be considered when determining the specific number and location of thermocouples to be provided for diagnosis of local core problems.

2. There should be a primary operator display (or displays) having the capabilities which follow:

   a. A spatially oriented core map available on demand indicating the temperature or temperature difference across the core at each core exit thermocouple location.

   b. A selective reading of core exit temperature, continuous on demand, which is consistent with parameters pertinent to operator actions in connecting with plant-specific inadequate core cooling procedures. For example, the action requirement and the displayed temperature might be either the highest of all operable thermocouples or the average of five highest thermocouples.

   c. Direct readout and hard-copy capability should be available for <u>all</u> thermocouple temperatures. The range should extend from 200°F (or less) to 1800°F (or more).

   d. Trend capability showing the temperature-time history of representative core exit temperature values should be available on demand.

   e. Appropriate alarm capability should be provided consistent with operator procedure requirements.

   f. The operator-display device interface shall be human-factor designed to provide rapid access to requested displays.

3. A backup display (or displays) should be provided with the capability for selective reading of a minimum of 16 operable thermocouples, 4 from each core quadrant, all within a time interval no greater than 6 minutes. The range should extend from 200°F (or less) to 2300°F (or more).

4. The types and locations of displays and alarms should be determined by performing a human-factors analysis taking into consideration:

   a. the use of this information by an operator during both normal and abnormal plant conditions.

   b. integration into emergency procedures,

   c. integration into operator training, and

   d. other alarms during emergency and need for prioritization of alarms.

5. The instrumentation must be evaluated for conformance to Appendix B, "Design and Qualification Criteria for Accident Monitoring Instrumentation," as modified by the provisions of items 6 through 9 which follow.

6. The primary and backup display channels should be electrically independent, energized from independent station Class IE power sources, and physically separated in accordance with Regulatory Guide 1.75 up to and including any isolation device. The primary display and associated hardware beyond the isolation device need not be Class IE, but should be energized from a high-reliability power source, battery backed, where momentary interruption is not tolerable. The backup display and associated hardware should be Class IE.

7. The instrumentation should be environmentally qualified as described in Appendix B, item 1, except that seismic qualification is not required for the primary display and associated hardware beyond the isolator/input buffer at a location accessible for maintenance following an accident.

8. The primary and backup display channels should be designed to provide 99% availability for each channel with respect to functional capability to display a minimum of four thermocouples per core quadrant. The availability shall be addressed in technical specifications.

9. The quality assurance provisions cited in Appendix B, item 5, should be applied except for the primary display and associated hardware beyond the isolation device.

# DESIGN AND QUALIFICATION CRITERIA FOR ACCIDENT MONITORING INSTRUMENTATION

## Applicability

To the extent feasible and practical (in conformance with the stipulations of Appendix B and ancillary requirements), equipment is to be installed by the specified implementation dates. Where equipment is unavailable, precluding conformance with equipment qualification and schedular requirements, the implementation dates are to be met by installation of best available equipment. In such cases, deviations are to be described and a schedule for the feasible installation of equipment in conformance with the stipulations of Regulatory Guide 1.97 (when the guide is used) is to be provided.

Appendix B is consistent with our current draft version of Regulatory Guide 1.97. We expect no further revisions to our requirements.

## Criteria

(1) The instrumentation should be environmentally qualified in accordance with Regulatory Guide 1.89 (NUREG-0588). Qualification applies to the complete instrumentation channel from sensor to display where the display is a direct-indicating meter or recording device. Where the instrumentation channel signal is to be used in a computer-based display, recording and/or diagnostic program, qualification applies to and includes the channel isolation device. The location of the isolation device should be such that it would be accessible for maintenance during accident conditions. The seismic portion of environmental qualification should be in accordance with Regulatory Guide 1.100. The instrumentation should continue to read within the required accuracy following, but not necessarily during, a safe shutdown earthquake. Instrumentation, whose ranges are required to extend beyond those ranges calculated in the most severe design basis accident event for a given variable, should be qualified using the following guidance.

The qualification environment shall be based on the design basis accident events, except the assumed maximum of the value of the monitored variable shall be the value equal to the maximum range for the variable. The monitored variable shall be assumed to approach this peak by extrapolating the most severe initial ramp associated with the design basis accident events. The decay for this variable shall be considered proportional to the decay for this variable associated with the design basis accident events. No additional qualificaton margin needs to be added to the extended range variable. All environmental envelopes except that pertaining to the variable measured by the information display channel shall be those associated with the design basis accident events.

The above environmental qualification requirement does not account for steady-state elevated levels that may occur in other environmental parameters associated with the extended range variables. For example, a sensor measuring containment pressure must be qualified for the measured process variable range, but the corresponding ambient temperature is not mechanistically linked to that pressure. Rather, the ambient temperature value is the bounding value for design basis accident events analyzed in

Chapter 15 of the final saety analysis report (FSAR). The extended range requirement is to ensure that the equipment will continue to provide information should conditions degrade beyond those postulated in the safety analysis. Since variable ranges are nonmechanistically determined, extension of associated parameter levels is not justifiable and has, therefore, not been required.

(2) No single failure within either the accident-monitoring instrumentation, its auxiliary supporting features or its power sources concurrent with the failure that are a condition or result of a specific accident should prevent the operator from being presented the information necessary for him to determine the safety status of the plant and to bring the plant to a safe condition and maintain it in a safe condition following that accident. Where failure of one accident-montoring channel results in ambiguity (that is, the redundant displays disagree) which could lead the operator to defeat or fail to accomplish a required safety function, additional information should be provided to allow the operator to deduce the actual conditions in the plant. This may be accomplished by: (a) providing additional independent channels of information of the same variable (addition of an identical channel), or (b) providing an independent channel which monitors a different variable bearing a known relationship to the multiple channels (addition of a diverse channel), or (c) providing the capability, if sufficient time is available, for the operator to perturb the measured variable and determine which channel has failed by observation of the response on each instrumentation channel. Redundant or diverse channels should be electrically independent, energized from station Class 1E power source, and physically separated in accordance with Regulatory Guide 1.75 up to and including any isolation device. At least one channel should be displayed on a direct-indicating or recording device. (NOTE: Within each redundant division of a safety system, redundant monitoring channels are not required.)

(3) The instrumentation should be energized from station Class 1E power sources.

(4) An instrumentation channel should be available prior to an accident except as provided in Paragraph 4.11, "Exemption," as defined in IEEE Std 279 or as specified in technical specifications.

(5) The recommendations of the following regulatory guides pertaining to quality assurance should be followed:

1.28 "Quality Assurance Program Requirements (Design & Construction)

1.30 "Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment"

1.38 "Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants"

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| 1.58 | "Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel" |
| 1.64 | "Quality Assurance Requirements for the Design of Nuclear Power Plants" |
| 1.74 | "Quality Assurance Terms and Definitions" |
| 1.88 | "Collection, Storage, and Maintenance of Nuclear Power Plant Quality Assurance Records" |
| 1.123 | "Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants" |
| 1.144 | "Auditing of Quality Assurance Programs for Nuclear Power Plants" |
| Task RS 810-5 | "Qualification of Quality Assurance Program Audit Personnel for Nuclear Power Plants" (Guide number to be inserted.) |

Reference to the above regulatory guides (except Regulatory Guides 1.30 and 1.38) are being made pending issuance of a regulatory guide endorsing NQA-1 (Task RS 002-5), now in progress.

(6) Continuous indication (it may be by recording) display should be provided at all times. Where two or more instruments are needed to cover a particular range, overlapping of instrument span should be provided.

(7) Recording of instrumentation readout information should be provided. Where trend or transient information is essential for operator information or action, the recording should be analog stripchart or stored and displayed continuously on demand. Intermittent displays, such as data loggers and scanning recorders, may be used if no significant transient response information is likely to be lost by such devices.

(8) The instruments should be specifically identified on the control panels so that the operator can easily discern that they are intended for use under accident conditions.

(9) The transmission of signals from the instrument or associated sensors for other use should be through isolation devices that are designated as part of monitoring instrumentation and that meet the provisions of the document.

(10) Means should be provided for checking, with a high degree of confidence, the operational availability of each monitoring channel, including its input sensor, during reactor operation. This may be accomplished in various ways; for example:

(a) By perturbing the monitored variable

(b) By introducing and varying, as appropriate, a substitute input to the sensor of the same nature as the measured variable

(c) By cross-checking between channels that bear a known relationship to each other and that have readouts available.

(11) Servicing, testing, and calibrating programs should be specified to maintain the capability of the monitoring instrumentation. For those instruments where the required interval between testing will be less than the normal time interval between generating station shutdowns, a capability for testing during power operation should be provided.

(12) Whenever means for removing channels from service are included in the design, the design should facilitate administrative conrol of the access to such removal means.

(13) The design should facilitate administrative control of the access to all setpoint adjustments, module calibration adjustments, and test points.

(14) The monitoring instrumentation design should minimize the development of conditions that would cause meters, annunciators, recorders, alarms, etc., to give anomalous indications potentially confusing to the operator.

(15) The instrumentation should be designed to facilitate the recognition, location, replacement, repair, or adjustment of malfunctioning components or modules.

(16) To the extent practical, monitoring instrumentaton inputs should be from sensors that directly measure the desired variables.

(17) To the extent practical, the same instruments should be used for accident monitoring as are used for the normal operations of the plant to enable the operator to use, during accident situations, instruments with which the operator is most familiar. However, where the required range of monitoring instrumentation results in a loss of instrumentation sensitivity in the normal operating range, separate instruments should be used.

(18) Periodic testing should be in accordance with the applicable portions of Regulatory Guide 1.118 pertaining to testing of instruments channels.

RESPONSE

Since early 1980 the C-E Owners Group (in which SCE has been actively participating) has conducted an evaluation of response characteristics of instrumentation under conditions of inadequate core cooling (ICC). An outline of this evaluation was discussed with the NRC staff at a meeting in Bethesda, Maryland on May 28, 1980. The instruments whose response characteristics have been evaluated are the subcooled margin monitor, the heated junction thermocouple system, core exit thermocouples, in-core thermocouples, self-powered neutron detectors, hot leg resistance temperature detectors, and ex-core neutron detectors. The evaluation was completed in December 1980, and the results have recently been distributed to members of the C-E Owners Group. SCE has evaluated these results and has decided to implement a three-element ICC detection instrumentation system which is detailed in the attached report. In addition, SCE's ICC detection instrumentation was described to members of the NRC Staff on March 5, 1981.

SCE has participated over the past year in the C-E Owners Group development of a technique for measurement of water level in the reactor vessel. The technique which has been selected by the C-E Owners Group is use of heated junction thermocouples (HJTC) distributed at various radial and axial locations in the reactor vessel above the fuel alignment plate. The design objective of this system is to provide a measurement of the water inventory in the reactor vessel above the fuel alignment plate. The details of this design activity were discussed with the NRC Staff at meetings in Bethesda, Maryland on May 28, 1980 and March 4, 1981. SCE is procuring the HJTC System as a component of an instrumentation system for monitoring inadequate core cooling as described in the attached report.

Attached is a Status Report on C-E Owners Group inadequate core cooling activities as supplemented by San Onofre specific design/hardware implementation efforts. The Status Report includes a design description of an Inadequate Core Cooling (ICC) Detection System. Although additional specific engineering and testing is required, SCE feels sufficient design and test information has been generated to allow SCE to proceed with procurement of the Subcooled Margin Monitor and Heated Junction Thermocouple Systems. In addition, SCE is upgrading the in-core instrument assemblies which contain the 56 Core Exit Thermocouples (CET). Also, SCE is procuring an integrated processing and display system which is described in the attached report.

The Status Report has been expanded from the initial submittal by SCE in Amendment 23 to include the following items.

1. A comparison of the documentation requirements of Position II.F.2, Attachment 1 and Appendix B with the Status Report.

2. A summary of the major design, procurement, testing and implementation activities associated with the ICC Detection System for San Onofre Units 2 and 3.

3. A description of the instrumentation, training and procedures which SCE intends to rely on for interim (Cycle 1) operation of San Onofre Unit 2 before the remaining ICC equipment is implemented.

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# SAN ONOFRE UNITS 2 AND 3

# INADEQUATE CORE COOLING DETECTION SYSTEM

## SUMMARY STATUS REPORT

APRIL, 1981

## 1.0 INTRODUCTION

### 1.1 SUMMARY OF ACTIVITIES

This report responds to the requirements in Section II.F.2 of NUREG-0737 (Ref. 1). The report describes the status of design and development activities being conducted by the C-E Owners Group as supplemented by plant specific efforts by SCE to define and implement a system of instrumentation to be used to detect inadequate core cooling (ICC). The report also provides information specific to San Onofre 2 & 3 in order to demonstrate the applicability of the generic activity to San Onofre 2 & 3.
Results of initial studies by the C-E Owners Group are documented in reports CEN-117 (Ref. 2) and CEN-125 (Ref. 3). These results were considered in the preparation of the four emergency operating instructions which SCE transmitted to the NRC by letter dated November 12, 1980. All studies have been based on the requirement to indicate the approach to, the existence of, and the recovery from ICC.

A three step process has been used to define the ICC Detection System. First, a definition for the state of ICC has been selected. Second, typical accident events which progress toward the defined state of ICC have been analyzed. Third, instruments which indicate the progression of these events have been selected and evaluated.

### 1.2 DEFINITION OF ICC

The definition of ICC and the functional requirements for the ICC Detection System have been established within the bounds of the following core conditions:

1. The reactor is tripped so only decay power is considered.

2. The coolant level falls below the top of the core, which can occur only with a loss of coolant mass from the Reactor Coolant System (RCS).

3. The event proceeds slowly enough so that the operator has time to observe and to make use of the instrument displays.

These conditions provide the boundaries for a range of sizes of small break loss of coolant accident (LOCA) caused by either RCS ruptures or primary coolant expansion.

The following definitions of ICC have been considered:

1. First occurrence of saturation.

2. Core uncovery.

3. Fuel clad temperature of 900°F (below which return to normal operation may be permissible).

4. Fuel clad temperature of 1100°F (below which clad rupture is not expected to occur).

5. Fuel clad temperature of 2200°F (which is the licensing limit for design basis events using approved analytical models).

It has been concluded that the events can progress too rapidly for the instrumentation to reliably display the approach of ICC if one of the first four definitions is used. Therefore, it is concluded that definition 5, a fuel clad temperature of 2200°F, should be selected as the criterion for existence of ICC.

## 1.3 DESCRIPTION OF EVENT PROGRESSION

A typical small break LOCA illustrates the progression of an event which causes the approach to ICC. Figure 1-1 shows a representative behavior for the two phase mixture level and the RCS pressure vs. time for the event. The event progression is divided into four intervals which are shown in Figure 1-1 and are defined in Table 1-1.

## 1.4 SUMMARY OF SENSOR EVALUATIONS

Several sensors have been evaluated for use in an ICC Detection System. The instruments considered are listed in Table 1-2, where their capabilities are summarized. Significant conclusions about each instrument are given below.

### 1.4.1 Subcooled Margin Monitor

The Subcooled Margin Monitor (SMM), using input from existing Resistance Temperature Detectors (RTD) in the hot and cold legs and from the pressurizer pressure sensors, is adequate to detect the initial occurrence of saturation during LOCA events and during loss of heat sink events.

The usefulness of the SMM can be significantly increased by also feeding into it the signals from the fluid temperature measurements from the HJTCS and the signals from selected core exit thermocouples and by modifying the SMM to calculate and display degrees superheat (up to about 1800F) in addition to degrees subcooling. The signals from the HJTCS temperature measurements provide information about possible local differences in temperature between the reactor vessel upper head/upper plenum (location of the HJTCS) and the hot or cold legs (location of the RTDs). The core exit thermocouples respond to the coolant temperature at the core exit and their signal indicates superheat after the coolant level drops below the top of the core and, thus, provide an approximate indication of the depth of core uncovery.

With these modifications, the SMM can be used for detection of the approach to ICC, namely Interval 1 (loss of subcooling), Interval 3 (core uncovery) and Interval 4 (core recovery). Even with the modifications, the SMM will not be capable of indicating the existence of Interval 2 when the coolant is at saturation conditions and the level is between the top of the vessel and the top of the core.

The recovery interval may occur at low system pressure and temperature. Since the errors in the existing SMM calculations increase with lower temperature and pressure, required subcooling margins need to be revised for this situation.

### 1.4.2 Resistance Temperature Detectors (RTD)

The RTD are adequate for sensing the initial occurrence of saturation. The hot leg RTD range is sufficient to sense saturation for events initiated at power. The cold leg RTD, which have a wider range, are sufficient to sense saturation for events initiated from zero power or shutdown conditions.

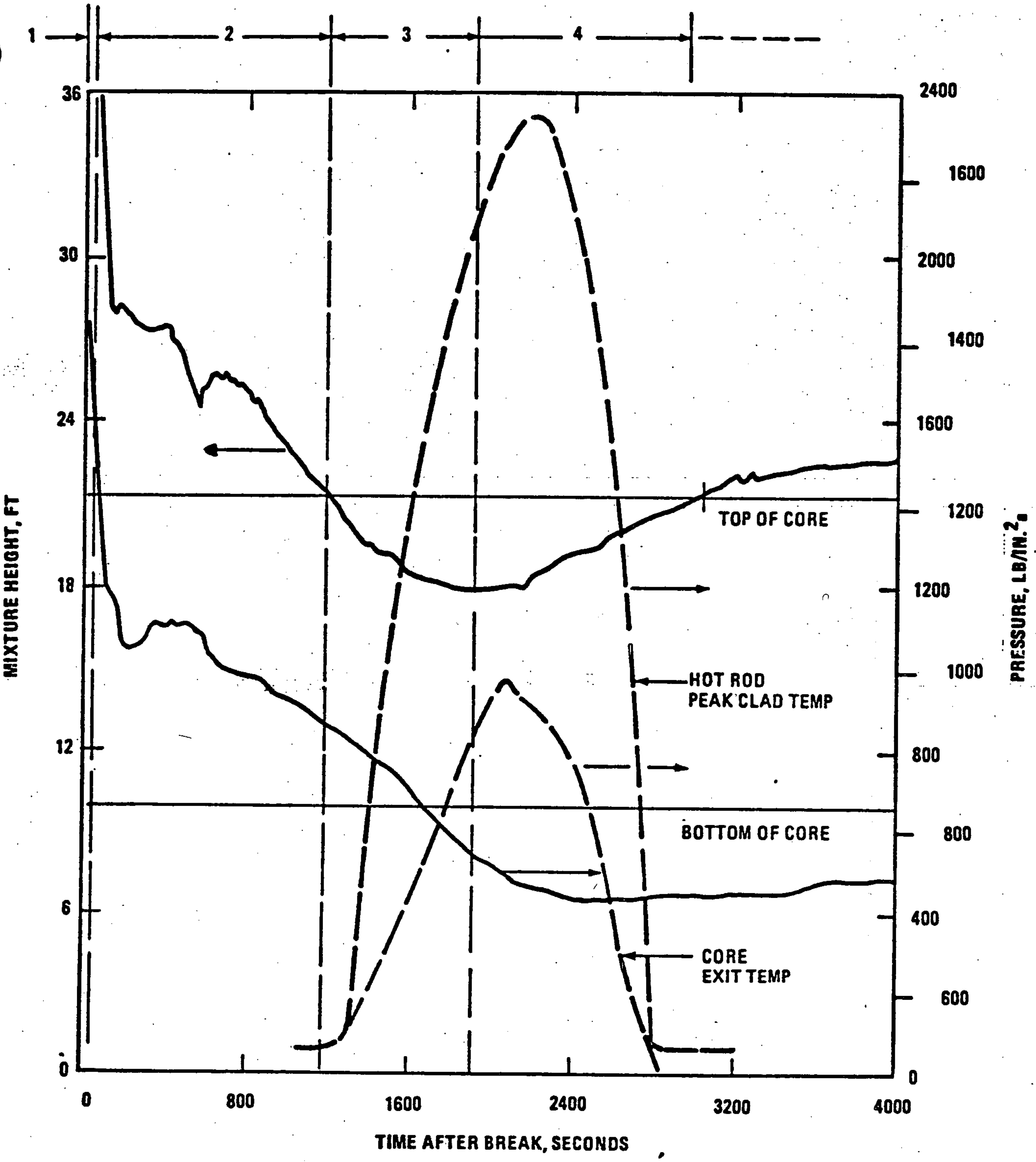
The RTD range is not adequate for ICC indications during core uncovery. For depressurization LOCA events, the core may uncover at low pressure, when the saturation temperature is below the lower limit of the hot leg RTD. Initial superheat of the steam will therefore not be detected by the hot leg RTD. As the uncovery proceeds, the superheated steam temperature may quickly exceed the upper limit of the RTD range. In order to be useful during the core uncovery interval, the range of RTD needs to be increased to cover a temperature range from 100F to 1800F.

### 1.4.3 Heated Junction Thermocouple System (HJTCS)

The HJTCS is being designed to
show the liquid inventory of the mixture of liquid and vapor coolant above the core. It is an instrument which shows the approach to ICC and is the only one which functions in Interval 2, namely the period from the initial occurrence of saturation conditions until the start of core uncovery.

### 1.4.4 Core Exit Thermocouples

The core exit thermocouples are adequate to show the approach to ICC after core uncovery for the events analyzed provided that the signal processing and display does not add substantial time delay to the thermal delay at the thermocouple junction. As mentioned above, the core exit thermocouples respond to the coolant temperature at the core exit and indicate superheat after the core is no longer completely covered by coolant. Except for a




DEFINITION OF INTERVALS IN EVENT PROGRESSION
FIGURE 1-1

time delay of about 200 to 400 seconds, depending on event, the trend of the change in superheat corresponds to the trend of core uncovery as well as to the accompanying trend of the change in cladding temperature.

### 1.4.5 Self Powered Neutron Detectors (SPND)

The SPND yield a signal caused by high temperature as the two-phase level falls below the elevation of the SPND. However, testing is required to identify the phenomena responsible for the anomalous behavior of the SPND at TMI-2. At the present, their use is limited to low temperature events (less than 1000F clad temperature) or to only the initial uncovery portion of an event.

### 1.4.6 Ex-Core Neutron Detectors

Existing source range neutron detectors are sensitive enough to respond to the formation of coolant voids within the vessel during the events analyzed. However, the signal magnitude is ambiguous because of the effects of varying boron concentration and deuterium concentration in the reactor coolant.

A stack of ex-core detectors gives less ambiguous information on voids and level in the vessel. The relative shape of the axial distribution of signals from a stack of five detectors shows promise as an ICC indicator, but additional development is needed.

### 1.4.7 In-Core Thermocouples

It appears in general feasible that in-core thermocouples may be added to or substituted for some SPND in the in-core instrument string. They respond more quickly to core uncovery than the core-exit thermocouples. Also, due to thermal radiation from the fuel rods, they see temperatures closer to the cladding temperatures than to the steam temperature seen by the core exit thermocouples.

For top mounted in-core instrumentation, the core exit thermocouples may survive longer for deep uncovery events because the thermocouples and their leads see only core exit steam temperature which is less than the fuel clad temperature. For bottom mounted in-core instrumentation, those in-core thermocouples which are located below the two-phase level will survive longer than the core exit thermocouples because the core exit thermocouple leads pass down through the high temperature region during core uncovery.

Using a synthesis approach, similar to the one described for core exit thermocouples, it is expected that the in-core thermocouple temperature can be related more directly to the adjacent fuel clad temperature than is possible with a synthesis which uses core-exit thermocouples. However, additional work is required to study the temperature response of in-core thermocouples as well as to develop the mechanical design for incorporating the thermocouples into the in-core instrument string and to develop a synthesis method for calculating fuel cladding temperatures.

Table 1-1

Definition of Intervals in ICC Event Progression

| Interval No. | ICC Phase | Bounding Parameter | Description |
|---|---|---|---|
| 1 | Approach to | Reduction in RCS subcooling until saturation occurs. | Depressurization of RCS to saturation pressure at hot leg temperature or heatup to saturation temperature at safety valve pressure. |
| 2 | Approach to | Falling two phase mixture level in upper plenum, down to top of active fuel. | Net loss of coolant mass from RCS accompanied by boiling from continued depressurization and/or decay power. |
| 3 | Approach to and/or Existence of | Two phase level falls from top of active fuel until minimum level during event progression occurs or until 2200F clad temperature occurs. | Two phase level drops in core causing clad heatup and producing superheated steam at core exit. |
| 4 | Recovery from | Two phase level rises above top of core. | Coolant addition by ECCS raises level and quenches fuel. ICC progression is defined to terminate when vessel is full or when stable, controllable conditions exist. |

## Table

## Instruments Included in Evaluations for ICC Instrumentation System

| Instruments | Development Status | Post-Accident Qualification Status | Indication Provided by Instrument | Non-Ambiguity of Signal | Portion of ICC Event Indicated |
|---|---|---|---|---|---|
| Subcooled Margin Monitor | Exists | Qualified | Degree of Subcooling in RCS | Good | Approach |
| Heated Junction Thermocouples | Under Development | Will be Qualified | 1) Liquid inventory in upper head<br>2) Liquid inventory in upper plenum<br>3) Axial temperature distribution in head and plenum | Good<br>Good<br>Good | Approach<br>Recovery |
| Core Exit Thermocouples | Exists | Can be done | 1) Liquid temperature at core exit<br>2) Infer with synthesis<br>a) Calculated mixture level in-core<br>b) Calculated Clad temperature | Good<br><br>Fair<br>Uncertain | Approach<br><br>Existence<br>Recovery |
| In-Core Thermocouples | Concept Stage | Can be done | 1) Metal temperature inside guide tube when RCP off<br>2) Infer:<br>a) Effective mixture level in-core<br>b) Clad temperature | Good<br><br>Uncertain | Approach<br>Existence<br>Recovery |
| Self Powered Neutron Detectors | Exists | Can be done | Indirect measure of mixture level (Low-pressure uncovery) | Poor | Approach Only |
| Hot Leg RTD (5 each) | Exists | Qualified | Fluid temperature in hot leg<br>Infer calculated mixture level and Clad temperature | Good<br>Fair<br>Uncertain | Approach<br>Existence<br>Recovery |
| Ex-Core Neutron Detector (One, Source range) | Exists | Can be done | Indirect measure of gross voiding<br>Indirect indication of mixture level in-core RCP off | Fair | Approach<br>Existence<br>Recovery |
| Ex-Core Neutron Detector (Stack of 5, Source range) | Concept | Can be done | Same as one ex-core detector, but more axial resolution | Fair | Approach<br>Existence<br>Recovery |

## 2.0 SYSTEM FUNCTIONAL DESCRIPTION

In the following sections a functional description of the instruments of the ICC Detection System is given and the function of the instruments is related to the ICC intervals which were described in Section 1.0.

## 2.1 SUBCOOLING AND SATURATION

The parameters measured to detect subcooling and saturation are the RCS coolant temperature and the pressurizer pressure. Temperature is measured in the hot legs for typical LOCA type events and is measured in the vessel upper head region for cooldown events. The measurement range extends from the shutdown cooling conditions up to saturation conditions at the pressurizer safety valve setpoint. The response time needs to be such that the operator obtains adequate information during those events which proceed slowly enough for him to observe and to act upon the information from the instrument display. Plant specific analyses for San Onofre will be performed for a selection of small break LOCA events in order to establish the required response times. Generic analyses done to date show that existing or planned instruments have adequate range and response.

The information which is derived from the reactor vessel temperature and pressure measurements is the amount of subcooling during the initial approach to saturation conditions and the occurrence of saturation during Interval one. During Interval four, the reestablishment of subcooled conditions is obtained.

## 2.2 COOLANT LEVEL MEASUREMENT IN REACTOR VESSEL

The Reactor Coolant System is at saturation conditions until sufficient coolant is lost to lower the two-phase level to the top of the active core. During this interval there are no existing instruments which would measure directly the coolant inventory loss. A Heated Junction Thermocouple System provides a direct measurement during this period. The parameter which is measured is the collapsed liquid level above the fuel alignment plate. The collapsed level represents the amount of liquid mass which is in the reactor vessel above the core. Measurement of the collapsed water level was selected in preference to measuring two-phase level, because it is a direct indication of the water inventory while the two phase level is determined by water inventory and void fraction.

The collapsed level is obtained over the same temperature and pressure range as the saturation measurements, thereby encompassing all operating and accident conditions where it must function. Also, it is intended to function during Interval four, the recovery interval. Therefore it must survive the high steam temperature which may occur during the preceeding core uncovery interval.

The level range extends from the top of the vessel down to the top of the fuel alignment plate. The response time is short enough to track the level during small break LOCA events. The resolution is sufficient to show the initial level drop, the key locations near the hot leg elevation and the lowest levels just above the alignment plate. This provides the operator with adequate indication to track the progression during Intervals two and four and to detect the consequences of his mitigating actions or the functionability of automatic equipment.

## 2.3 FUEL CLADDING HEATUP

The overall intent of ICC detection is understood to be the detection of the potential for fission product release from the reactor fuel. The parameter which is most directly related to the potential for fission product release is the cladding temperature rather than the uncovery of the core by coolant.

Since clad temperature is not directly measured, a parameter to which cladding temperature may be related is measured. This parameter is the fluid temperature at the core exit. After the core becomes uncovered, the fluid leaving the core is superheated steam and the amount of superheat is related to the fuel length exposed and to the cladding temperature.

The amount of superheat of the steam leaving the core will be measured by the core exit thermocouples. The time behavior of the superheat temperature is, with the exception of an acceptably small time delay, similar to the time behavior of the cladding temperature. Thus, from the observation of the steam superheat, the behavior of the cladding temperature can be inferred. Observation of the cladding temperature trends during an accident is considered to be of more value to the operator than information on the absolute value of the cladding temperature.

The core exit steam temperature is measured with the thermocouples included in the In-Core Instrument (ICI) string. They are located inside the ICI support tube, at an elevation a few inches above the fuel alignment plate. Generic calculations of a similar installation for representative uncovery events show that the thermocouples respond sufficiently fast to the increasing steam temperature. Plant specific calculations on the San Onofre configuration will be made to verify this response.

The required temperature range of the thermocouples extends from the lowest saturation temperature at which uncovery may occur up to the maximum core average exit temperature which occurs when the peak clad temperature reaches 2200F. The required thermocouple range is therefore 200F to about 1800F, which is the approximate upper service temperature limit. Thermocouples are expected to function with reduced accuracy at even higher temperatures, so the range for processing the thermocouple output extends to about 2300F.

## 3.0 SYSTEM DESIGN DESCRIPTION

The following sensors have been selected by SCE as the basic instruments to meet the functional requirements described in Section 2.

1. The Subcooled Margin Monitor (SMM) (Reference 1)
2. The Heated Junction Thermocouple (HJTC) System (Reference 2) and
3. The Core Exit Thermocouple (CET) System.

The conceptual design of each ICC instrument is described in this section which addresses:

1. Sensors design
2. Signal processing and display design

Figure 3-1 is the functional diagram for the ICC instrument systems. Each instrument system consists of two safety grade channels from sensors through signal processing equipment. The outputs of processing equipment systems feeding the primary display are isolated to separate safety grade and non-safety grade systems. Channelized safety grade backup displays are included for each instrument system. The following sections present details of the design.

### 3.1 SENSORS DESIGN

#### 3.1.1 SUBCOOLED MARGIN MONITORING SYSTEM

The specific subcooled margin monitor design configuration being implemented by SCE or San Onofre Unit 2 prior to fuel load is detailed in Appendix A. The final SMM includes the same RCS temperature and pressure inputs as described in Appendix A plus the maximum unheated junction thermocouple temperature (UHJTC) described in Section 3.1.2 and 3.2.2 and the representative core exit thermocouple (CET) temperature. (Sections 3.1.3 and 3.2.3) The UHJTC and CET inputs come from the outputs of the HJTCS and CET processing units. In summary, the sensor inputs to the SMM are

| Input | Range |
|---|---|
| Pressurizer Pressure | 0-3000 psia |
| Cold Leg Temperature (CH A Loop 1B, 2A) (CH B, Loop 1A, 2B) | 0-710°F |
| Hot Leg Temperature (Ch A Loop 1) (Ch B Loop 2) | 0-710°F |
| Maximum UHJTC Temperature (from HJTC processing) | 100-1800°F |
| Representative CET Temperature (from CET processing) | 200-2300°F |

Figure 3-1
Sheet 1 of 2

ICC DETECTION INSTRUMENTATION:
SENSORS, PROCESSING AND DISPLAY

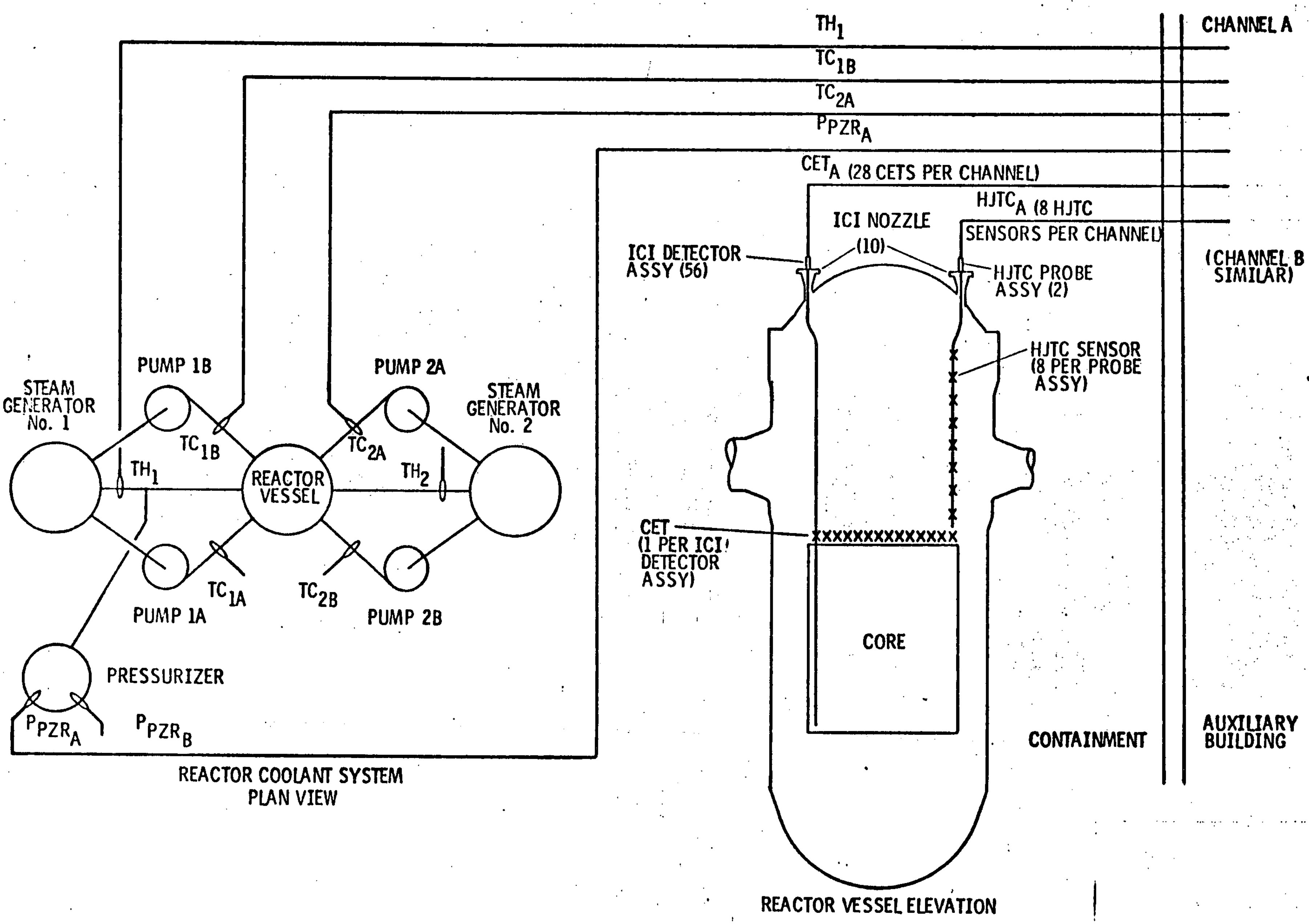
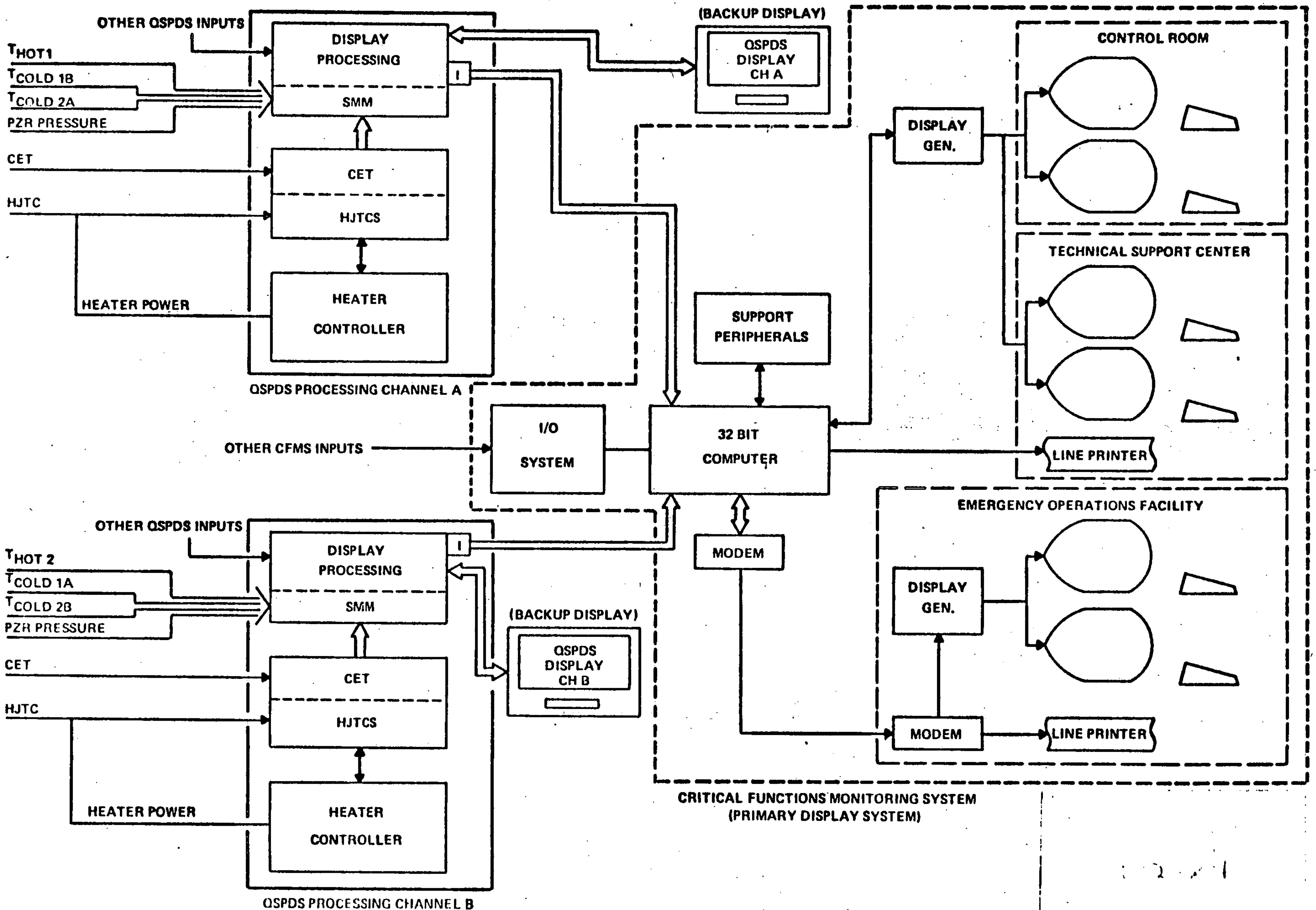


Figure 3-1
Sheet 2 of 2

ICC DETECTION INSTRUMENTATION:
SENSORS, PROCESSING AND DISPLAY



### 3.1.2 HEATED JUNCTION THERMOCOUPLE (HJTC) SYSTEM

The HJTC System measures reactor coolant liquid inventory with discrete HJTC sensors located at different levels within a separator tube ranging from the top of the core to the reactor vessel head. The basic principle of system operation is the detection of a temperature difference between adjacent heated and unheated thermocouples.

As pictured in Figure 3-2, the HJTC sensor consists of a Chromel-Alumel thermocouple near a heater (or heated junction) and another Chromel-Alumel thermocouple positioned away from the heater (or unheated junction). In a fluid with relatively good heat transfer properties, the temperature difference between the adjacent thermocouples is very small. In a fluid with relatively poor heat transfer properties, the temperature difference between the thermocouples is large.

Two design features ensure proper operation under all thermal-hydraulic conditions. First, each HJTC is shielded to avoid overcooling due to direct water contact during two phase fluid conditions. The HJTC with the splash shield is referred to as the HJTC sensor (See Figure 3-2). Second, a string of HJTC sensors is enclosed in a tube that separates the liquid and gas phases that surround it.

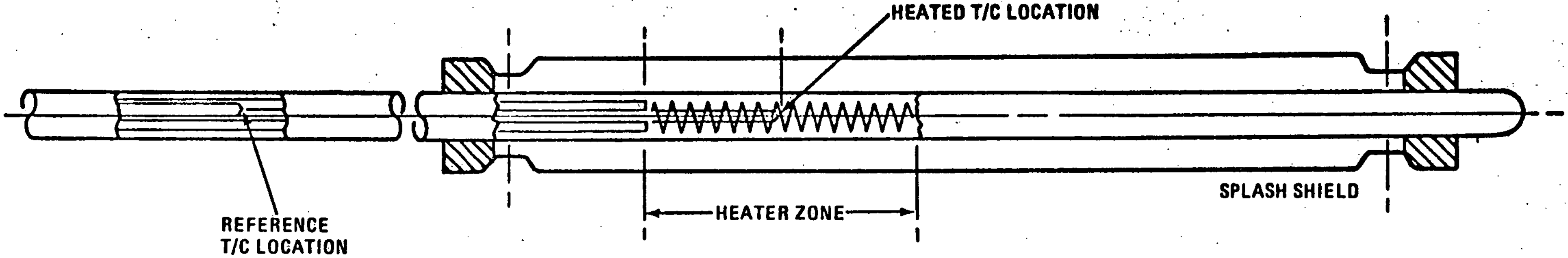
The separator tube creates a collapsed liquid level that the HJTC sensors measure. This collapsed liquid level is directly related to the average liquid fraction of the fluid in the reactor head volume above the fuel alignment plate. This mode of direct in-vessel sensing reduces spurious effects due to pressure, fluid properties, and non-homogeneities of the fluid medium. The string of HJTC sensors and the separator tube is referred to as the HJTC instrument.

The HJTC System is composed of two channels of HJTC instruments. Each HJTC instrument is manufactured into a probe assembly. The probe assembly includes eight (8) HJTC sensors, a seal plug, and electrical connectors (Figure 3-3). The eight (8) HJTC sensors are electrically independent and located at eight levels from the reactor vessel head to the fuel alignment plate.

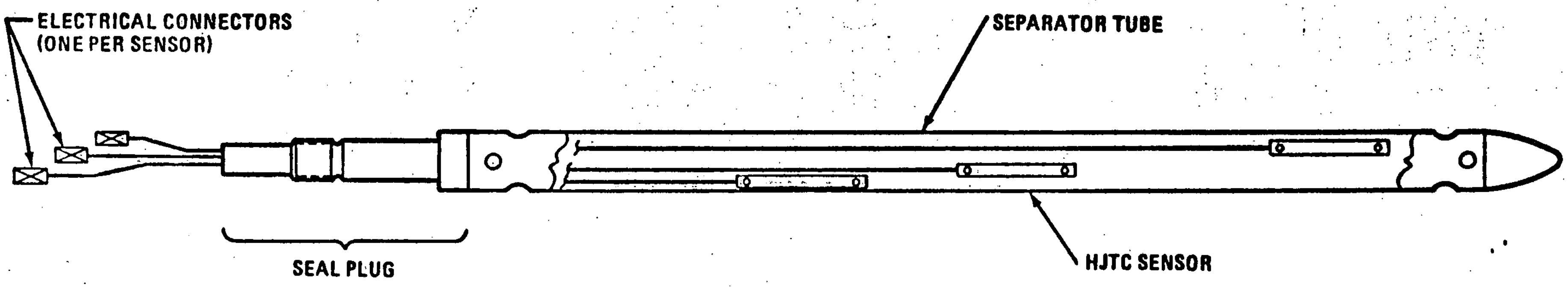
The probe assembly is housed in a stainless steel structure that protects the sensors from flow loads and serves as the guide path for the sensors. Figure 3-4 describes the locations of the HJTC probe assemblies. Installation arrangements have been developed for San Onofre Units 2 and 3; details of which are provided in Appendix B.

### 3.1.3 CORE EXIT THERMOCOUPLE (CET) SYSTEM

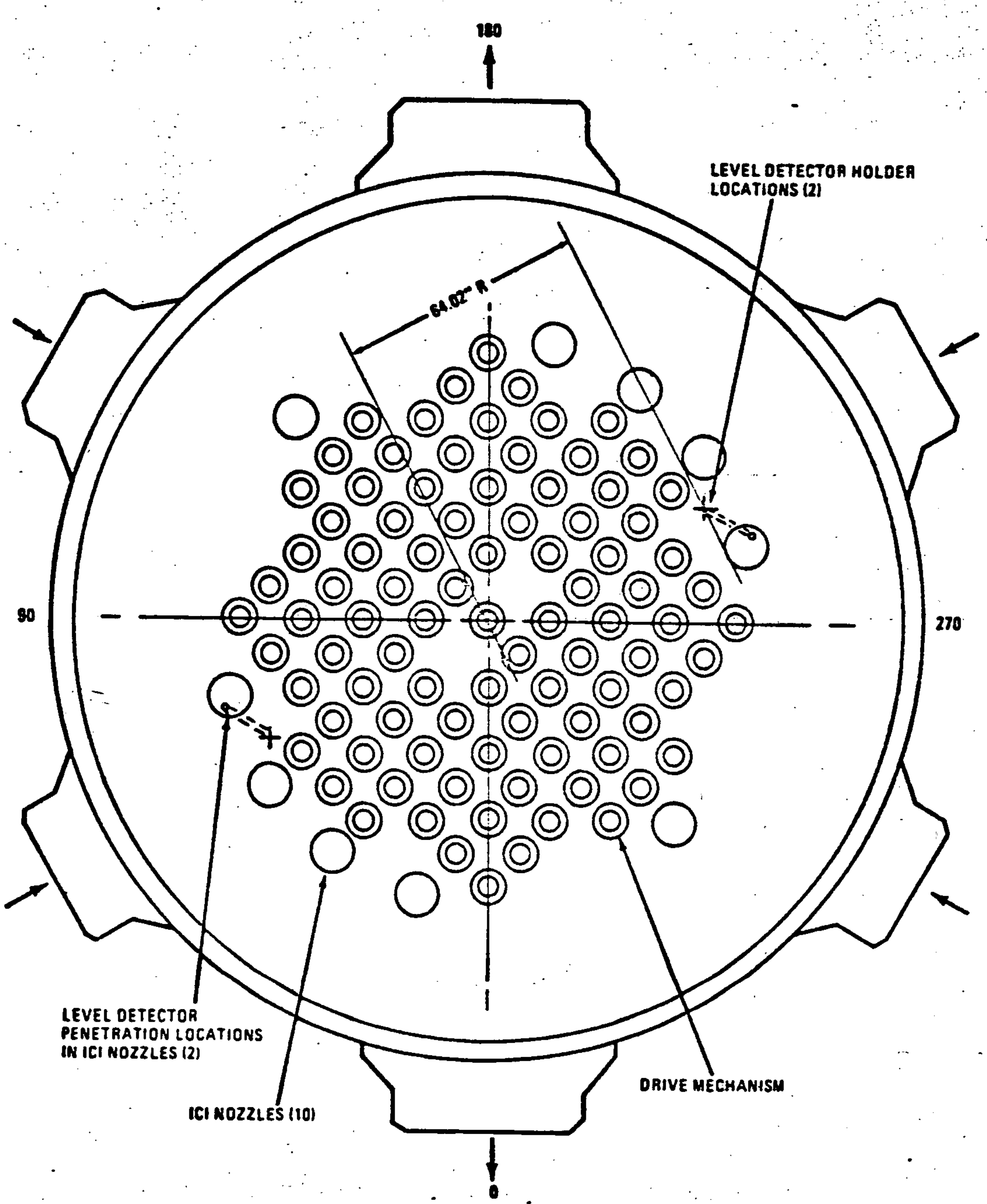
The design of the San Onofre 2 and 3 In-core Instrumentation (ICI) system includes a Type K (Chrome-Alumel) thermocouple within each of the 56 ICI detector assemblies.




HJTC SENSOR — HJTC/SPLASH SHIELD
FIGURE 3-2




HEATED JUNCTION THERMOCOUPLE
PROBE ASSEMBLY
FIGURE 3-3




HJTC HOLDER ASSEMBLY LOCATIONS
FIGURE 3-4

The junction of each thermocouple is located a few inches above the fuel assembly inside a structure which supports and shields the ICI detector assembly string from flow forces in the outlet plemum region. These Core Exit Thermocouples (CET) monitor the temperature of the reactor coolant as it exits the fuel assemblies. Figure 3-4A depicts a typical ICI detector assembly, showing the CET. The core locations of the ICI detector assemblies are shown in Figure 3-4B.

Appendix C describes the present design of the CET system which will be used for the first cycle of San Onofre Unit 2. The basic design of the CET system will not change for the final ICC Detection System; however, modifications to the ICI detector assemblies will be performed to upgrade the CETS to meet environmental qualification requirements (see Section 5.0). The following describes the CET improvements to be made at the first refueling outage of San Onofre Unit 2 and prior to fuel load of Unit 3.

Improved ICI detector assemblies are physically and functionally similar to those of the original San Onofre design; however, an environmentally qualified Class 1E connector is used. In addition, the seal plug is larger and the seal plug-to-connector subassembly is a hermetic unit. Environmental qualification testing of the seal plug-to-connector subassembly will be performed to meet the qualification requirements of Section 5.0.

The CETs have a usable temperature range from 200$^{o}$F to up to 2300$^{o}$F (Reference 4) although accuracy is reduced at temperatures above 1800$^{o}$F.

The signal processing and display for the CET portion of the ICC detection instrumentation is described in Section 3.2.4.3 below.

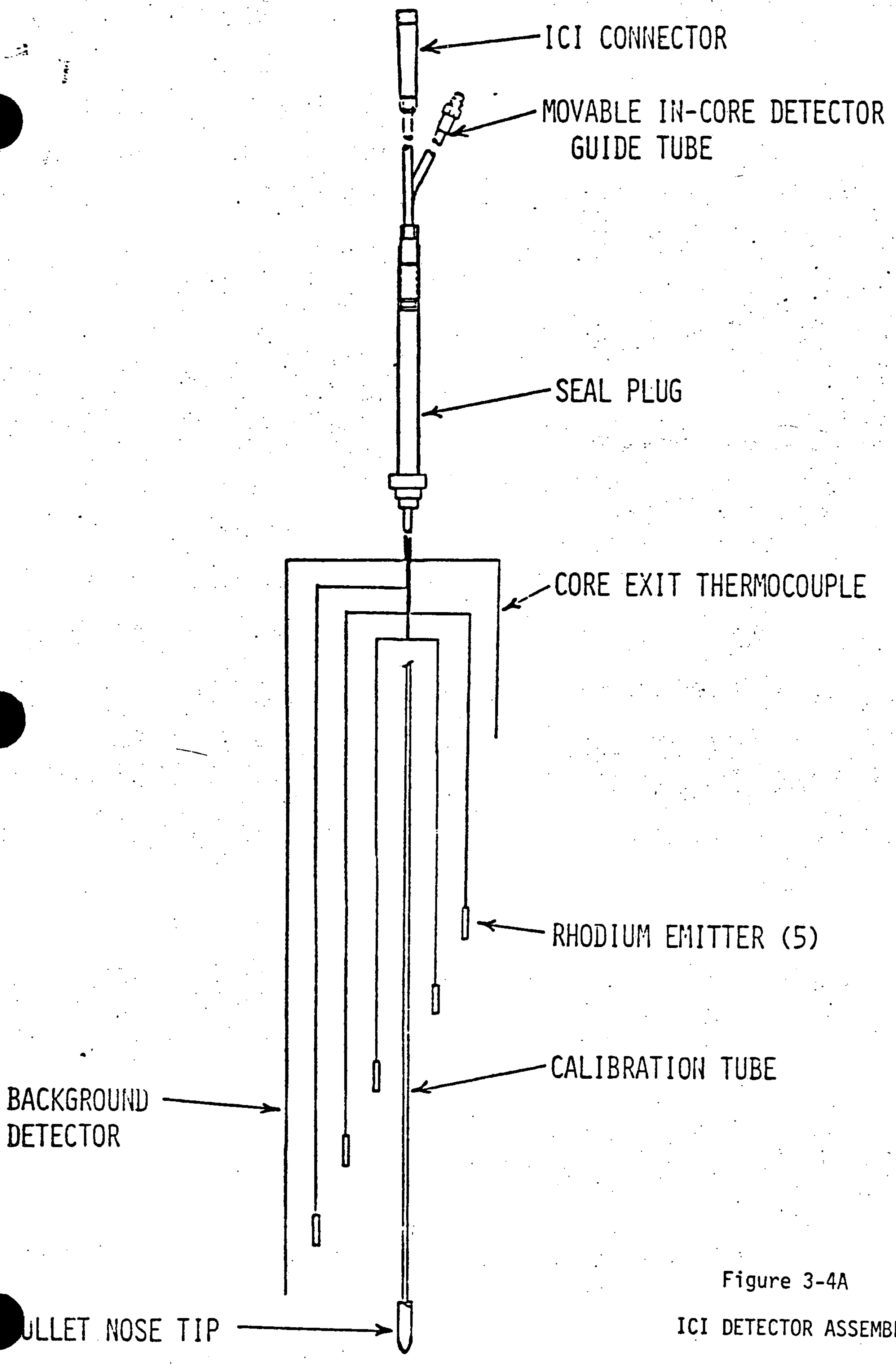
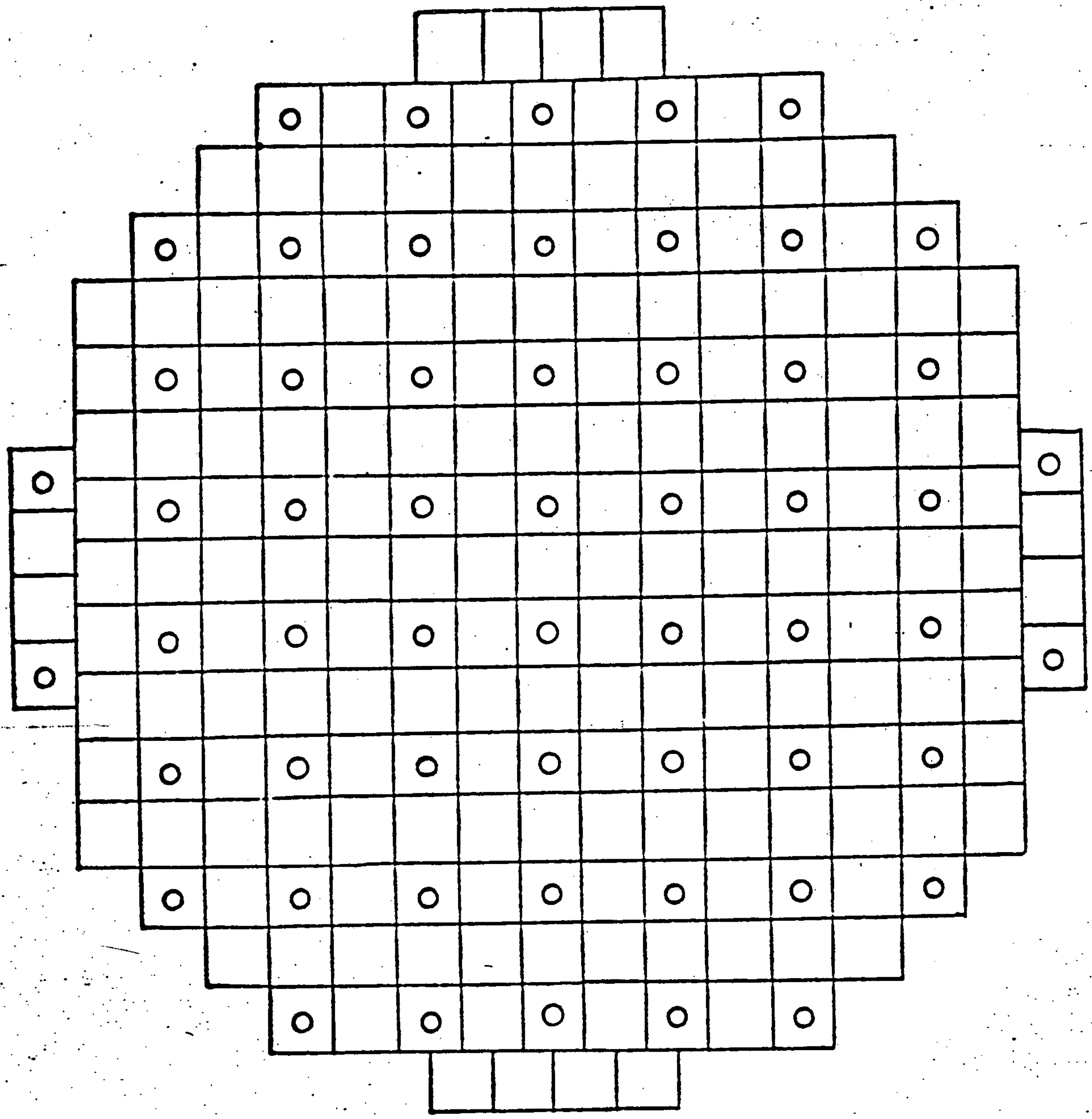



Figure 3-4A

ICI DETECTOR ASSEMBLY



ICI Detector Assembly/Core Exit Thermocouple Location

Figure 3-4B

ICI DETECTOR ASSEMBLIES/CORE EXIT THERMOCOUPLES CORE LOCATIONS

## 3.2 SIGNAL PROCESSING AND DISPLAY EQUIPMENT DESIGN

The processing and display hardware depicted in Figure 3-1 is divided into two major hardware groups - the Qualified Safety Parameter Display System (QSPDS) and the Critical Function Monitoring System (CFMS). The equipment groups process and display the ICC detection sensor inputs as well as sensor inputs to meet other NRC requirements. The QSPDS provides the safety grade processing and display for the ICC detection instruments. The CFMC is the non-safety grade primary display system which has full human factors engineering display capabilities. The design objective for the equipment is to address the NUREG-0737 criteria, including the criteria for Attachment 1 to II.F.2 and Appendix B.

### 3.2.1 QSPDS

As depicted in Figure 3-1, the QSPDS is a two-channel system which displays the ICC instrument outputs to the control room. The QSPDS uses a microprocessor-based design for the signal processing equipment in conjunction with an alphanumeric display and associated keyboard for each of the two channels. Each channel will accept and process ICC input signals and transmit its output to the alphanumberic display. In addition, each channel will transmit its output to the CFMS.

The two QSPDS channels are powered by Channel A & B station vital busses. Each QSPDS is electrically independent and physically separated according to the Regulatory Guide 1.75 up to and including the isolation for the deta links to the CFMS. The QSPDS is qualified to the seismic and environmental standards described in Section 5.0.

The QSPDS consists of two redundant channels to avoid interruptions of display due to a single failure. This two safety grade channel configuration provides QSPDS availability greater than 99%. If in the remote chance that one complete QSPDS channel fails, the operator has

1. Additional channels of ICC sensor inputs for cold leg temperature, hot leg temperature, and pressurizer pressure on the control board separate from the QSPDS.

2. The HJTCS and CET have multiple sensors in each channel for the operator to correlate and check inputs.

3. The HJTCS sensor output may be tested by adjusting the heater power.

The QSPDS is available during normal operation and availability will be addressed in the Technical Specifications.

The QSPDS has two functions:

1. Sensor input processing
2. Display of safety parameters

The sensor input processing consists of:

1. Checking that the sensor inputs are within range.
2. Converting sensor inputs into display units.
3. Calculating parameters from the sensor inputs (if required).
4. Calculating alarms when a parameter exceeds setpoint.

The QSPDS processing equipment includes operator interfaces for equipment testing, setup, and maintenance. The processing for the ICC instrumentation will have surveillance testing and diagnostic capabilities. Automatic on-line surveillance tests will continuously check for specified hardware and software malfunctions. The on-line automatic surveillance tests as a minimum will indicate inputs that are out of range and computer hardware malfunctions. The malfunctions will be indicated through the operator interface. A manual on-line diagnostic capability will be incorporated to aid the operator in locating the source of these malfunctions.

The QSPDS displays present the most reliable basic information for each of the ICC instrument systems. The QSPDS displays are designed:

1. To give primary instrument indications in the remote chance that the CFMS display becomes inoperable.
2. To provide confirmatory indications to the CFMS display.
3. To aid in surveillance tests and diagnostics.

The QSPDS displays (located in the Control Room) will also incorporate human factors engineering. The alphanumeric display is a liquid plasma display with paging capabilities to display all the ICC instrument outputs. The two channels of QSPDS display present direct and continous safety grade indication of the ICC detection parameters. The CFMS provides trending capability for all ICC parameters. The QSPDS displays the following types of information:

1. Safety paramaters according to safety function.

2. Additional safety parameter information on other pages (such as sensor inputs needed to calculate safety parameters).

3. Alarm indication.

Specific display descriptions for each ICC detection instrument is discussed later in Section 3.0.

### 3.2.2 CRITICAL FUNCTIONS MONITORING SYSTEM

The CFMS (also see Response to NUREG-0737 Item III.A.1.2) is the primary display for ICC detection. The CFMS is a dedicated, computer based display system that monitors critical plant functions:

1. Core reactivity control

2. Core heat removal control

3. RCS inventory control

4. RCS pressure control

5. RCS heat removal control

6. Containment pressure/temperature control

7. Containment isolation

If any of the critical functions are violated, (by exceeding logic setpoints) a Critical Function Alarm (CFA) is initiated. The ICC instruments outputs will be incorporated in this critical function alarm logic.

As depicted in Figure 3-1, the CFMS man/machine interface includes two color-graphic CRT's in the Control Room, two color-graphic CRT's and a line printer in the TSC and two color-graphic CRT's and a line printer in the EOF. A keyboard is associated with each supplied CRT.

The data has three levels of information:

Level 1 Critical functions status (very general)

Level 2 System overview (general, on system)

Level 3 System detail (specific information)

This hierarchy allows the operator to progress from an overall system view to a detailed diagnostic view.

The ICC detection displays are incorporated in all three levels of displays as part of the core heat removal control function. The detailed ICC information such as the CET map is displayed on the Level 3 display. Specific display descriptions for each ICC detection instrument is discussed later in Section 3.0. The Historical Data Storage and Retrieval (HSDR) system allows all the ICC information to be recorded, stored and recalled by the operator. With the trending display, the parameter inputs and time scales can be adjusted by the operator. The operator can select a preselected ICC trend display for quick access to vital ICC trend information.

The CFMS is designed to meet the 99% availability criteria. The CFMS is powered from an uninterruptible power supply that is battery backed to provide power if the primary power source fails. The CFMS is electrically independent and physically separate (by Reg. Guide 1.75) from the QSPDS. The safety grade ICC inputs to CFMS are isolated through qualified isolators in the QSPDS and transmitted over a fiberoptic data link.

### 3.2.3 CABLING SYSTEMS

The in-containment cabling system for the CETs and HJTCs uses environmentally qualified mineral insulated cabling and Class 1E connectors. The cabling and connectors are hermetically sealed. Qualified containment penetrations route the CET and HJTC signals through the containment wall to the auxiliary building using similar mineral insulated cabling and hermetic connectors. Separation of the two CET/HJTC channels is initiated below the missile shield and maintained to the signal processing equipment in accordance with the requirements of Regulatory Guide 1.75. Section 5.0 discusses the qualification testing of the cabling.

The SMM inputs are routed from the sensors to the processing equipment via existing safety grade cabling and containment penetrations.

### 3.2.4 PROCESSING AND DISPLAY DESCRIPTION

The following sections describe the processing and display for each of the ICC detection instruments.

### 3.2.4.1 SUBCOOLED MARGIN MONITOR

The SMM processing equipment will perform the following functions:

1. Calculate the subcooled margin.

   The saturation temperature is calculated from the minimum pressure input and the saturation pressure is calculated from the maximum temperature input (See Secton 3.1). The temperature subcooled margin is the difference between saturation temperature and the maximum temperature input. The pressure subcooled margin is the difference between saturation pressure and the minimum pressure input.

2. Process all outputs for display.

3. Provide an alarm output when subcooled margin reaches a preselected setpoint.

The SMM processes the temperature and pressure inputs over the following ranges: CEF temperature from 200°F to 2300°F, the unheated HJTC temperature from 100°F to 1800°F, the hot leg and cold leg RTD temperatures from 0°F to 710°F, and the pressurizer pressure from 0 psia to 3000 psia. The saturation temperature and pressure are calculated from a saturation curve derived from the 1967 ASME steam tables and an interpolation routine.

The following information is presented on the primary display:

1. Pressure margin to saturation
2. Minimum temperature margin to saturation
3. Temperature margin to saturation for each temperature source (i.e., RTD, HJTC or CET)
4. Minimum pressure

The following information is presented on the backup displays:

1. Pressure margin to saturation
2. Temperature margin to saturation
3. Temperature inputs
4. Pressure inputs

The processing equipment for the HJTC performs the following functions:

1. Determine if liquid inventory exists at the HJTC positions.

   The heated and unheated thermocouples in the HJTC are connected in such a way that absolute and differential temperature signals are available. This is shown in Figure 3-5. When water surrounds the thermocouples, their temperature and voltage output are approximately equal. $V_{(A-C)}$ on Figure 3-5 is, therefore, approximately zero. In the absence of liquid, the thermocouple temperatures and output voltages become unequal, causing $V_{(A-C)}$ to rise. When $V_{(A-C)}$ of the individual HJTC rises above a predetermined setpoint, liquid inventory does not exist at this HJTC position.

2. Determine the maximum upper plenum/head fluid temperature from the unheated thermocouples for use an an input to the SMM. (The temperature processing range is from 100$^{o}$F to 1800$^{o}$F.)

3. Process all inputs and calculated outputs for display.

4. Provide an alarm output to the plant annunciator system when any of the HJTC detects the absence of liquid level.

5. Provide control of heater power for proper HJTC output signal level. Figure 3-6 shows a single channel design which includes the heater power controller.

The following information is displayed on the primary (CFMS) display:

1. Two channels of eight discrete HJTC positions indicating liquid inventory above the fuel alignment plate.

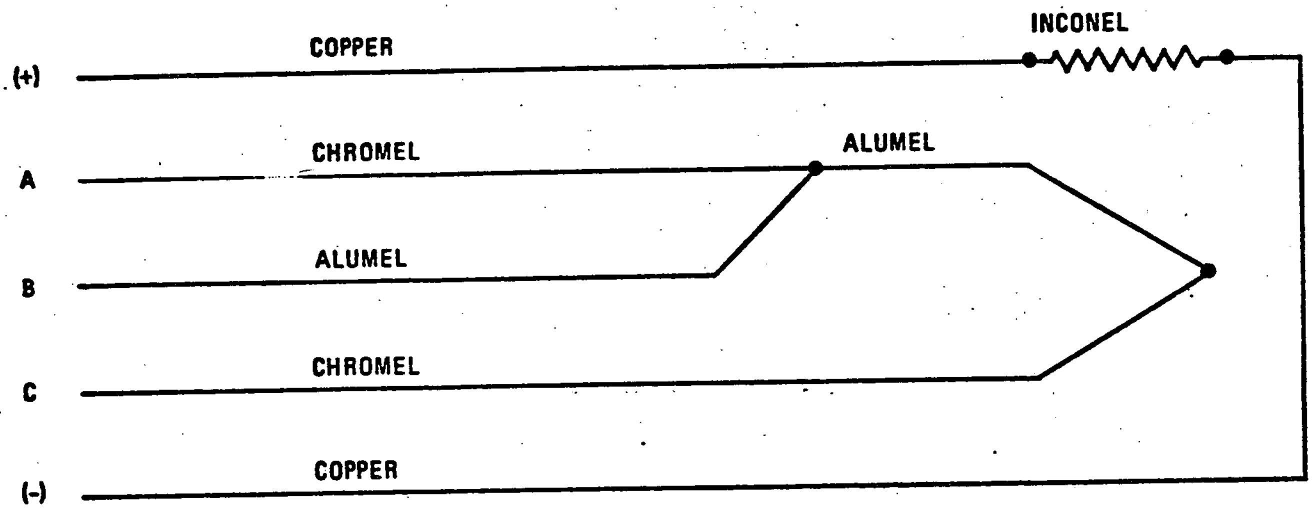
2. Maximum unheated junction temperature of each of the two channels which is provided to the SMM.

The following information is displayed on the backup (QSPDS) displays:

1. Liquid inventory level above the fuel alignment plate derived from the eight discrete HJTC positions

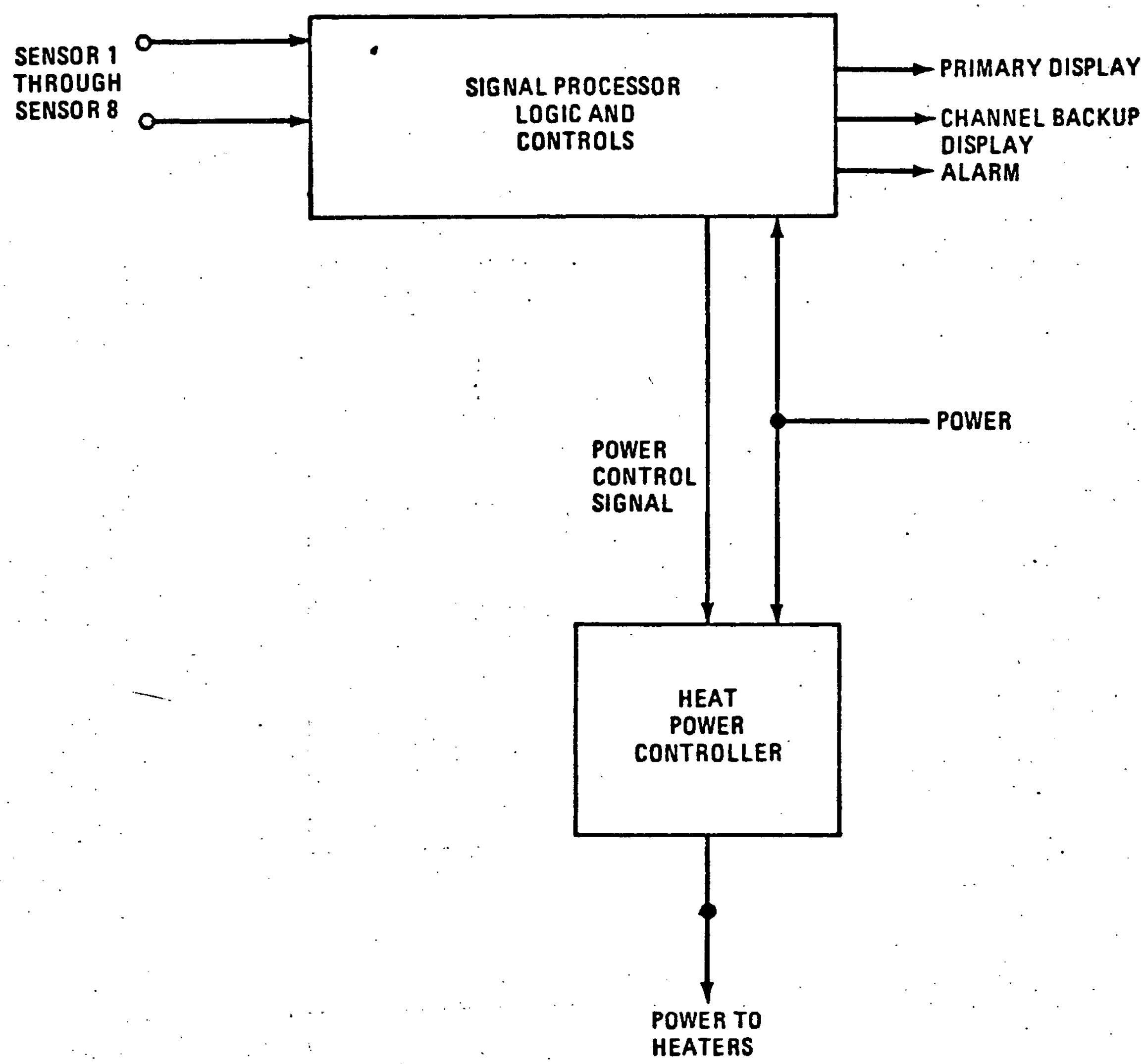
2. Unheated junction temperature at the eight positions

3. Heated junction temperature at the eight positions




V (A-B) = ACTUAL TEMPERATURE, UNHEATED JUNCTION
V (C-B) = ACTUAL TEMPERATURE, HEATED JUNCTION
V (A-C) = DIFFERENTIAL TEMPERATURE

ELECTRICAL DIAGRAM OF H.J.T.C.
FIGURE 3-5




HJTC SYSTEM PROCESSING CONFIGURATION
(ONE CHANNEL SHOWN)
FIGURE 3-6

### 3.2.4.3 CORE EXIT THERMOCOUPLE SYSTEM

The processing equipment for the CETs will perform the following functions:

1. Process all core exit thermocouple inputs for display. Half of the available CET inputs (28 CET per channel) will be processed in each channel.
2. Provide an alarm output to the plant annunciator system when the temperature from any of the CET's exceeds a preselected setpoint.
3. Determine the CET temperature to be supplied to the SMM. The processed temperature range will be from 200°F to 2300°F.

These functions are intended to meet the design requirements of NUREG-0737, II.F.2 Attachment 1.

The following information is displayed on the primary (CFMS) display:

1. A spatially oriented core map indicating the temperature at each of the CET locations.
2. A selective representative CET temperature

   The maximum CET temperature or an average of the five highest CET temperatures of each of the two channels (which is provided to the SMM) will be presented.

The following information is displayed on the QSPDS displays:

1. All CET temperatures for each channel (or 28 CET temperatures)
2. A selective representative CET temperature (see definition above)

## 4.0 SYSTEM VERIFICATION TESTING

This section describes tests and operational experience with ICC instruments.

### 4.1 RTD AND PRESSURIZER PRESSURE SENSORS

The hot and cold leg RTD temperature sensors and the pressurizer pressure sensors are standard NSSS instruments which have well known responses. No special verification tests have been performed nor are planned for the future. These sensors provide basic, reliable temperature and pressure inputs which are considered adequate for use in the SMM and other additional display functions.

### 4.2 HJTC SYSTEM SENSORS AND PROCESSING

The HJTC System is a new system developed to indicate liquid inventory above the core. Since it is a new system, extensive testing has been performed and further tests are planned to assure that the HJTC System will operate to unambiguously indicate liquid inventory above the core.

The testing is divided into three phases:

Phase 1 - Proof of Principle Testing
Phase 2 - Design Development Testing
Phase 3 - Prototype Testing

The first phase consisted of a series of five tests, which have been completed. The testing demonstrated the capability of the HJTC instrument design to measure liquid level in simulated reactor vessel thermal-hydraulic conditions (including accident conditions).

Test 1 Autoclave test to show HJTC (thermocouples only) response to water or steam.

In April 1980, a conceptual test was performed with two thermocouples in one sheath with one thermocouple as a heater and the other thermocouple as the inventory sensor. This configuration was placed in an autoclave (pressure vessel with the capabilities to adjust temperature and pressure). The thermocouples were exposed to water and then steam environments. The results demonstrated a significant output difference between steam and water conditions for a given heater power level.

Test 2 Two phase flow test to show bare HJTC sensitivity to voids.

In June 1980, a HJTC (of the present differential thermocouple design) was placed into the Advanced Instrumentation for Reflood Studies (AIRS) test facility, a low pressure two phase flow test facility at Oak Ridge National Laboratory (ORNL). The HJTC was exposed to void fractions at various heater power levels. The results demonstrated that the bare HJTC output was virtually the same in two phase liquid as in subcooled liquid. The HJTC did generate a significant output in 100% quality steam.

Test 3 Atmospheric air-water test to show the effect of a splash shield

A splash shield was designed to increase the sensitivity to voids. The splash shield prevents direct contact with the liquid in the two phase fluid. The HJTC output changed at intermediate void fraction two phase fluid. The results demonstrated that the HJTC sensor (heated junction thermocouple with the splash shield) sensed intermediate void fraction fluid conditions.

Test 4 High pressure boil-off test to show HJTC sensor response to reactor thermal-hydraulic conditions.

In September 1980, a C-E HJTC sensor (HJTC with splash shield) was installed and tested at the ORNL Thermal-Hydraulics Test Facility (THTF). The HJTC sensor was subjected to various two phase fluid conditions at reactor temperatures and pressures. The results verified that the HJTC sensor is a device that can sense liquid inventory under normal and accident reactor vessel high pressure and temperature two phase conditions.

Test 5 Atmospheric air-water test to show the effect of a separator tube

A separator tube was added to the HJTC design to form a collapsed liquid level so that the HJTC sensor directly measures liquid inventory under all simulated two phase conditions. In October, 1980, atmospheric air-water tests were performed with HJTC sensor and the separator tube. The results demonstrated that the separator tube did form a collapsed liquid level and the HJTC output did accurately indicate liquid inventory. This test verified that the HJTC instrument, which includes the HJTC, the splash shield, and the separator tube, is a viable measuring device for liquid inventory.

The Phase 2 test program will consist of high pressure and temperature tests on the HJTC instrument. These tests will provide input for the C-E HJTC instrument design and manufacturing effort. The Phase 2 test program is expected to be completed in mid 1981.

The Phase 3 test program will consist of high temperature and pressure testing of the manufactured prototype system HJTC probe assembly and processing electronics. Verification of the HJTC system prototype will be the goal of this test program. The Phase 3 test program is expected to be completed by the end of 1981.

## 4.3 CORE EXIT THERMOCOUPLES

No verification testing of the CETs is planned. A study at ORNL was performed to test the response of CETs under simulated accident conditions (Reference 4). This test showed that the instruments remained functional up to 2300F. This test along with previous reactor operating experience verify the response of CETs.

## 5.0 SYSTEM QUALIFICATION

The qualification program for the ICC Detection System instrumentation has not been completely defined. However, plans are being developed based on the following three categories of ICC instrumentation:

1. Sensor instrumentation within the pressure vessel
2. Instrumentation components and systems which extend from the primary pressure boundary up to and including the primary display isolator and including the backup displays.
3. Instrumentation systems which comprise the primary display equipment.

A preliminary outline of the qualification program for each classification is given below.

The in-vessel sensors will meet the NUREG-0737, Appendix B guide to install the best equipment available consistent with qualification and schedular requirements. Design of the equipment will be consistent with the guidelines of Appendix B as well as the clarification and Attachment 1 to Item II.F.2 in NUREG-0737. Specifically, instrumentation will be designed such that they meet appropriate stress criteria when subjected to normal and design basis accident loadings. Seismic qualification to safe shutdown conditions will verify function after being subjected to the seismic loadings.

The out-of-vessel instrumentation system, up to and including the primary display isolator, and the backup displays will be environmentally qualified in accordance with IEEE-323-1974. Plant-specific containment temperature and pressure design profiles will be used where appropriate in these tests. This equipment will also be seismically qualified according to IEEE-STD-344-1975. CEN-99(S), "Seismic Qualification of NSSS Supplied Instrumentation Equipment, Combustion Engineering, Inc." (August 1978) describes the methods used to meet the criteria of this document.

SCE is evaluating what is required to augment the out-of-vessel Class 1E instrumentation equipment qualification program to NUREG-0588. Consistent with Appendix B of NUREG-0737, the out-of-vessel equipment under procurement is the best available equipment. SCE expects to complete this evaluation in July 1981.

The primary display will not be designed as a Class 1E system, but will be designed for high reliability; thus it will not be qualified environmentally or seismically to Class 1E requirements nor will it meet the single failure criteria of Appendix B, Item 2. Post-accident maintenance accessibility will be included in the design. The quality assurance provisions of Appendix B, Item 5 do not apply to the primary display according to NUREG-0737. However, the computer driven primary display system will be separated from the Class 1E sensors, processing and backup display equipment by means of an isolation device which will be qualified to Class 1E criteria.

## 6.0 OPERATING INSTRUCTIONS

Guidelines for reactor operators to use to detect ICC and take corrective action have been developed by the C-E Owners Group and submitted to NRC for review (Ref. 5). These guidelines have been used to review and revise the plant emergency procedures for San Onofre Units 2 and 3. In addition, the C-E Owners Group has developed reactor operator training materials concerning ICC. The training staff attended a training seminar conducted by C-E in November, 1979, to initiate the San Onofre ICC training program.

The C-E Owners Group is defining a program for development of further emergency procedure guidelines and operator training materials associated with the ICC Detection System described in Section 3. This program is expected to provide these guidelines and training materials during the fourth quarter of 1981.

## 7.0 COMPARISON OF DOCUMENTATION REQUIREMENTS OF POSITION II.F.2, ATTACHMENT 1 AND APPENDIX B WITH STATUS REPORT

Tables 7-1 through 7-3 provide a point by point comparison of the documentation required by NUREG-0737, Item II.F.2, the requirements of Attachment 1 of Item II.F.2, and the Criteria of Appendix B of NUREG-0737 with the inadequate core cooling detection instrumentation to be installed in San Onofre Units 2 and 3.

TABLE 7-1

EVALUATION OF ICC DETECTION INSTRUMENTATION TO DOCUMENTATION REQUIREMENTS OF NUREG-0737 ITEM II.F.2

| ITEM | RESPONSE |
|---|---|
| 1.a. | Description of the ICC Detection Instrumentation is provided in Section 3.0. The instrumentation to be added includes the modified SMM, the HJTC Probe Assemblies, Improved ICI (CET) Detector Assemblies, Qualified Cabling, and the QSPDS. |
| 1.b. | The existing instrumentation systems are described in Appendices A, B and C and NUREG-0737, Item III.A.1.2. This includes the SMM (unmodified). HJTC Probe Holders, ICI (CET) Detector Assemblies (with existing) and the CFMS. Section 9.0 justifies first cycle operation of San Onofre Unit 2 with the existing instrumentation. |
| 1.c. | The planned modifications to the existing Unit 2 instrumentation will be made during the first refueling (prior to fuel load for Unit 3) as discussed in Section 8.0. Modifications include changes to the SMM, design, procurement and installation of the HJTC probe assemblies, improved ICI Detector Assemblies (which necessitate installation of improved ICI Nozzle Flanges), Qualified CET and HJTC Cabling and Containment Penetrations, QSPDS, and interface and software modifications to the CFMS. The final ICC Detection instrumentation will be as described in Section 3.0. |
| 2. | The design analysis and evaluation of the ICC Detection Instrumentation is discussed in Sections 1.0 and 2.0. Testing is discussed in Section 4.0. |
| 3. | Additional instrumentation testing is discussed in Section 4.0. Qualification testing is discussed in Section 5.0. |

| ITEM | RESPONSE |
|---|---|
| 4. | This table evaluates the ICC Detection Instrumentation's conformance to the NUREG-0737, Item II.F.2 documentation requirements. Table 7-2 evaluates conformance to Attachment 1 of Item II.F.2. Table 7-3 evaluates conformance to Appendix B of NUREG-0737. |
| 5. | Sections 3.1 and 3.2 describe the computer functions associated with ICC monitoring and address the availability (i.e., 99%) of the computers. Section 3.2.4 describes the processing and display functions which will be incorporated into the QSPDS and CFMS software. A further description of the CFMS functions is described in the response to NUREG-0737, Item III.A.1.2. |
| 6. | Section 8.0 discusses the schedule for installation and implementation of the complete ICC Detection Instrumentation. |
| 7. | Guidelines for use of the ICC Detection Instrumentation are discussed in Section 6.0. |
| 8. | Section 9.0 discusses key operator actions in the current emergency procedures for ICC. Section 6.0 discusses the emergency procedures to be implemented upon.incorporation of the complete ICC Detection System. |
| 9. | The following describes additional submittals that will be provided to support the acceptability of the final ICC Detection Instrumentation. The schedule for submittal of this documentation will be provided in July, 1981.<br>1) Qualification Testing of the HJTCS.<br>2) Environmental and Seismic Qualification of the in-vessel and out-of vessel instrumentation equipment.<br>3) Modifications to emergency procedures.<br>4) Proposed Changes to Technical Specification. |

| ITEM | RESPONSE |
|---|---|
| 3. | The QSPDS displays fulfills the requirements for the safety grade backup displays. Both channels of QSPDS displays together displays all CET temperatures. All CET temperatures can be displayed within 6 minutes. (See Section 3.2.4.3). |
| 4. | The types and locations of displays and alarms are determined by performing a human-factors analysis. The CFMS (Section 3.2.2 and Response to NUREG-0737, Item III.A.1.2) incorporates extensive human-factors engineering. The QSPDS (Section 3.2.1) also incorporates human factors engineering. The use of these display systems will be addressed in operating procedures, emergency procedures, and operator training. |
| 5. | The CET display is evaluated with the other ICC instruments in the Appendix B evaluation in Table 7-3. |
| 6. | The CFMS meets the primary display requirements (See Section 3.2.2) and the QSPDS meets the backup display requirements (See Section 3.2.1). |
| 7. | The ICC detection instrumentation is environmentally and seismically qualified as specified in Section 5.0. The CFMS is not seismically qualified past the isolation devices in the QSPDS. The isolation devices in the QSPDS are accessible for maintenance following an accident. |
| 8. | The CFMS and QSPDS are designed to provide 99% availability. The availability of the QSPDS will be addressed in the Technical Specifications. |
| 9. | The quality assurance provision of Appendix B, Item 5, will be applied to the ICC detection instruments as described in the Appendix B evaluation in Table 7-3. |

## TABLE 7-2
## EVALUATION OF ICC DETECTION INSTRUMENTATION
## TO ATTACHMENT 1 OF II.F.2

| ITEM | RESPONSE |
|---|---|
| 1. | San Onofre 2 & 3 have 56 core exit thermocouples (CETs) distributed uniformly over the top of the core. Section 3.1.3 has a description of the CET sensors. Figure 3-4B depicts the locations of the CETs. |
| 2. | The CFMS meets the primary display requirements for CET temperatures. Section 3.2.2 describes the CFMS and Section 3.2.4.3 describes the CFMS displays for the CET temperatures. |
| 2.a. | A spatial CET temperature map is available on demand. |
| 2.b. | A selective reperentative CET temperature will be displayed continuously on demand. This temperature is either the maximum CET temperature or the average of the five highest CET temperatures. |
| 2.c. | The CFMS provides direct readout of CET temperatures. The line printer provides the hard-copy capability for recording CET temperatures. |
| 2.d. | The CFMS has extensive trend and hidtorical data storage and retrieval system. (See Section 3.2.2). |
| 2.e. | The CFMS has alarm capability through the Critical Functions Alarm (See Section 3.2.2). |
| 2.f. | The CFMS is extensively human-factor designed (see Section 3.2.2 and Response to NUREG-0737, Item III.A.1.2). |

TABLE 7-3

EVALUATION OF ICC DETECTION INSTRUMENTATION
TO APPENDIX B OF NUREG-0737

| ITEM | RESPONSE |
|---|---|
| 1. | The ICC detection instrumentation is environmentally and seismically qualified as specified in Section 5.0. The CFMS is not seismically qualified past the isolation devices in the QSPDS. The isolation devices in the QSPDS are accessible for maintenance following an accident. |
| 2. | The ICC detection instrumentation through the QSPDS meets the single failure requirement as described in Section 3.2.1. |
| 3. | The ICC detection instrumentation through the QSPDS is powered from the Class 1E Vital Busses for Channels A and B. |
|  | The ICC detection instrumentation through the QSPDS is designed to operate during normal operation as well as emergency conditions. The availability will be addressed in the Technical Specifications. The CFMS is designed to operate during normal operations with an availability of 99%. |
| 5. | The ICC detection instrumentation through the QSPDS incorporates the recommendations of Regulatory Guides 1.28, 1.30, 1.38, 1.58, 1.64, 1.74, 1.88 as discussed in the San Onofre Units 2 and 3 FSAR, Appendix 3A. Regulatory Guides 1.123 and 1.144 and Task RS 810-5 are under review by SCE. |
| 6. | The ICC Detection Instrumentation outputs are continuously displayed on the QSPDS displays. (See Section 3.2.1). |
| 7. | The CFMS provides trending display and historical data storage and retrieval (HDSR) capabilities to meet this requirement. (See Section 3.2.2). |

| ITEM | RESPONSE |
|---|---|
| 8. | The QSPDS displays are clearly identified on the control panel. The CFMS displays equipment are appropriately placed for effective man-machine interface. |
| 9. | The signals transmitted to the CFMS from the QSPDS are isolated with isolation devices qualified to the provisions of Appendix B. |
| 10. | The operational availability of the ICC instruments of each channel can be checked according to the description addressing single failure in Section 3.2.1. |
| 11. | Servicing, testing, and calibrating programs shall be specified for the ICC detection instruments through the QSPDS. |
| 12. | The means for removing channels from services is being considered in the design of the ICC equipment. |
| 13. | The design facilitates administrative control of the access to all setpoint adjustments, calibration adjustments, and test points. |
| 14. | The design meets this requirement. |
| 15. | The design meets this requirement (See Section 3.2.1). |
| 16. | The design incorporates this requirement to the extent practical. |
| 17. | The design incorporates this requirement to the extent practical. |
| 18. | The ability to perform periodic tests is being considered in the design of the ICC equipment. |

## SECTION 8.0

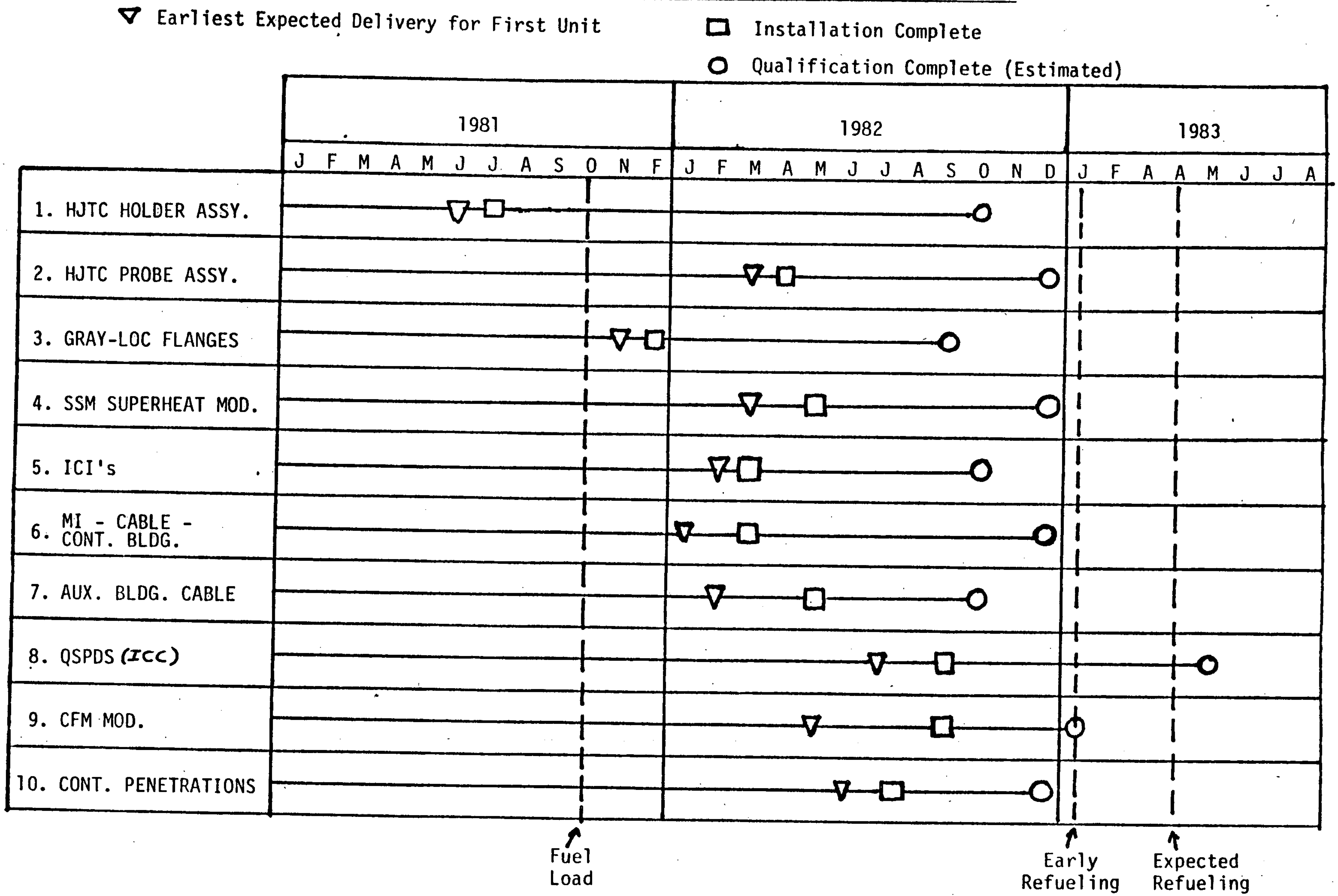
### Schedule for ICC Instrumentation

Item II.F.2 of NUREG-0737, "Clarification of TMI Action Plan Requirements" dated October 31, 1980, requires installation of additional ICC instrumentation by January 1, 1982. During a meeting with the NRC staff on March 5, 1981 SCE informed the NRC that the January 1, 1982 implementation schedule for the additional ICC instrumentation was not realistic for SONGS 2 and that adequate instrumentation is currently available to facilitate safe plant operation until the first refueling outage when the full spectrum of ICC instrumentation can be implemented. Consistent with the NRC request during the meeting, a schedule for installation of ICC has been prepared. The schedule attached shows the difficulty of meeting the January, 1982 schedule requirement on SONGS 2. The last part of a nine package proposal set for the ICC instrumentation was provided by CE on April 1 1981. This ICC instrumentation system was previously presented conceptually to the NRC on March 5, 1981 and to the ACRS on March 13, 1981. The earliest expected delivery dates for the ICC instrumentation are reflected in Figure 8-1 and 2 indicating that most equipment can be delivered by the first half of 1982.

Installation and startup times were estimated for each of the ten equipment packages listed in Figure 8-1. Installation required from two weeks to three months after delivery with the auxiliary building cable (Item #7) requiring the longest time for installation. The QSPDS is delivered last and takes one month to install. An additional month was added to permit startup testing of the system showing completion in September 1982. The CFM modification is tested at the same time so Figure 8-1 also shows completion in September 1982. Qualification testing, to be run in parallel is expected to be completed toward the end of 1982. However, SONGS 2 is scheduled to load fuel in October, 1981. If installation is delayed to first refueling, a portion of the installation work can be completed during Cycle 1 plant operation. Then, at first refueling, installation of ICC equipment can be completed on an accelerated schedule during plant down-time while refueling is in progress.

Based upon the information developed recently as summarized above, the most realistic time frame for full implementation of ICC instrumentation is during the first refueling outage for SONGS 2. This schedule is considered acceptable because sufficient existing instrumentation is available that when integrated with operating procedures and operator training will facilitate detection of ICC as discussed in Section 9.0.

FIGURE 8-1 EARLIEST POSSIBLE ICC INSTALLATION SCHEDULE - SONGS 2



## SECTION 9.0

## Operations with Interim ICC Instrumentation

Procedures and training for identification of an approach to ICC on SONGS 2 have been developed using existing instrumentation. These procedures have been reviewed and accepted by the NRC PTRB at a meeting on April 10, 1981. The discussion herein pertains to these existing procedures and plans for training.

With final ICC instrumentation installation scheduled for first refueling, the plant will be operated during the first cycle using existing instrumentation. This includes two of the three instrumentation systems planned for the final ICC system, as described in Amendment 23 to the FSAR:

- o Subcooled Margin Monitor (SMM)
- o Core Exit Thermocouples (CET's)

The HJTCS will be absent from the interim system. This existing instrumentation will be integrated with:

- o Emergency Operating Instructions
- o Operator Training for ICC Recognition and Mitigation

### Emergency Operating Instructions (EOI)

EOI S023-3-2.30 (Determination of Adequate Core Cooling) delineates instruction for the detection and recovery from ICC. This EOI is cross-referenced into and by the EOI's for the Loss of Coolant Accident (S023-3-5.6), Steam Line Rupture (S023-3-5.9), Loss of Feedwater (S023-3-5.30), Steam Generator Tube Rupture (S023-3-5.29), and Emergency Plant Shutdown (S023-3-5.1). This EOI has been written such that loss of a single instrument will not result in inability of an operator to identify criteria to confirm the approach to ICC. After incorporation of earlier NRC comments, Revision 2 of S023-3-2.30 (dated 2/4/81) was again reviewed by the NRC and there were seven additional comments (provided by NRC on March 6, 1981). A meeting with the NRC RSB and PTRB on April 10, 1981 was successful in resolving these NRC concerns.

The operating instructions require a Shift Technical Advisor (STA) or Control Room Operator to perform an ICC evaluation whenever it is required by the EOI's. The following example illustrates the typical use of the existing EOI's in detecting an approach to ICC.

A Reactor Coolant System (RCS) event, such as a LOCA, leads to an alarm annuniciation in the control room and a reactor trip. The particular alarm (or alarm sequence) requires the use of one of the emergency procedures listed above, and this, in turn, requires that the procedure for determination of ICC be executed. Diverse data is collected on RCS subcooled margin, pressurizer pressure, steam generator $\Delta$P, RCP motor amps, RCS temperatures (including readings from the SMM and CETs) and HPSI flow. Three readings are taken; one to start and each 10 minutes over a 20 minute period. Criteria as specified in the EOI are applied to the data to determine the existence of, or the approach to, ICC. If ICC is indicated, the Watch Engineer is notified to take corrective action in accordance with the EOI's to recover from ICC and data is taken until the event is concluded.

This example illustrates several important features of the EOI's:

- o There is a requirement for collecting diverse specific data to evaluate approach to or existence of ICC.
- o There is a requirement for trending data.
- o There are specific criteria for identification of ICC.
- o There are actions specified for recovery from ICC.

Training

All operators and STA's receive a training program consisting of a three-week classroom session conducted by CE on core cooling dynamics and recognition of degraded core conditions. In addition, SCE will complete operator training (including simulator training) prior to fuel load on use of the existing control room instrumentation related to ICC as utilized in the approved EOIs.

Based on the existing instrumentation, training and procedures for ICC recognition, SCE is confident that SONGS 2 can be safely operated prior to implementation of the final ICC instrumentation during the first refueling outage.

REFERENCES

1. NUREG-0737, "Clarification of TMI Action Plan Requirements," U. S. Nuclear Regulatory Commission, November, 1980.

2. CEN-117, "Inadequate Core Cooling - A Response to NRC I E Bulletin 79-06C, Item 5 for Combustion Engineering Nuclear Steam Supply Systems," Combustion Engineering, October, 1979.

3. CEN-125, "Input for Response to NRC Lessons Learned Requirements for Combustion Engineering Nuclear Steam Supply Systems," Combustion Engineering, December, 1979.

4. Anderson, R. L., Banda, L. A., Cain, D. G., "Incore Thermocouple Performance Under Simulated Accident Conditions", IEEE Nuclear Science Symposium, Vol. 28, No. 1 page 773, Figure 81.

5. Letter C-E Owners Group to NRC, "C-E Generic Emergency Procedure Guidelines," December 10, 1980.

## APPENDIX A

## SUBCOOLED MARGIN MONITOR

A two-channel sub-cooled margin monitor system (SMMS) is being incorporated into the San Onofre Units 2 & 3 design to provide on-line control room indication of reactor coolant saturation conditions. The SMMS is designed for use as post-accident monitoring instrumentation and is designed to safety grade Seismic Class I, and Quality Class II standards. The SMMS described below will be operational for SONGS-2 prior to fuel load.

### A. SYSTEM DESCRIPTION

The SMMS is a two-channel on-line microprocessor based system which uses reactor coolant process signals to provide a continuous indication of the margin from saturation conditions. As shown in figure II.F.2-1, a combination of primary coolant cold leg and hot leg RTD temperature sensors provides wide range primary coolant temperature input to the SMM. Temperature is monitored in a cross-core arrangement (i.e., $T_H$ Loop 1, $T_c$ Loop 2A, and $T_c$ Loop 1A into one monitor) to minimize the impact of a single failure. Primary pressure inputs to the SMMS are provided by two wide range safety grade redundant pressurizer pressure channels. The SMMS microprocessor contains steam tables and interpolation routines for calculating saturation temperatures and pressures. The microprocessor compares the calculated saturation values to the temperature and pressure values from the process inputs and calculates a margin to saturation. Either the temperature or pressure margin can be displayed on the main control board mounted digital display meters which are part of the SMM system. Additionally, the system provides a low margin alarm function with a pre-programmed alarm setpoint for San Onofre Units 2 & 3. The alarm function of the system inputs the plant annunciation system to provide a low margin alarm to the control room operators.

### B. DESIGN SPECIFICATIONS

The following specifications are applicable to the subcooled margin monitoring system.

1. Power Requirements: The two channels of microprocessors, indicators, and process equipment are powered from two different safety grade 120V instrument buses which receive their power from the vital bus power supplies.

2. Process Inputs: (See figure II.F.2-1)

| | |
|---|---|
| Pressurizer Pressure | 0 to 3000 $lb/in^2a$ |
| RCS Cold Leg Temperature | 0 to 710F |
| RCS Hot Leg Temperature | 0 to 710F |

3. Low Margin Alarm Setpoint:

   30F Subcooled

4. Microprocessor Range:

   0 to 200F Subcooled

Response to NRC Action Plan NUREG 0660
San Onofre 2 & 3

APPENDIX B

HEATED JUNCTION THERMOCOUPLE SYSTEM

## A. SYSTEM DESCRIPTION

The Heated Junction Thermocouple System (HJTC) that is planned to be installed in San Onofre Units 2 & 3 consists of two separete channels of instrumentation which meet the design requirements for a post-accident monitoring system. The sensors are internal to the reactor vessel and the system performs indication, recording, and alarm functions. Each channel consists of a sensing probe, signal processing equipment, and control room display and alarm equipment. This system is described in detail in Section 3 of the Status Report.

## B. TECHNICAL DESCRIPTION OF THE REACTOR VESSEL INTERNALS CHANGE

The changes concern hardware modifications internal to the reactor vessel which will serve as a holder and guide path for level detector assemblies. The design of the holders will facilitate future use of the level detectors.

Basically, three major components are affected by the modification. These include the upper guide structure assembly, the instrument support plate assembly, and the in-core instrumentation nozzle. The upper guide structure changes include two instrument guide tubes, support brackets and lead-in funnels as shown on figure II.F.2-2. The instrument support plate is being modified to accommodate the thimble cluster assembly as shown in figure II.F.2-3. An additional penetration is being added in each of two ICI nozzle flanges.

When the above changes are complete, San Onofre Unit 2 will have provisions for two level detector assemblies located as shown in Figure (3-4). An identical arrangement will be added to Unit 3.

## C. IMPLEMENTATION SCHEDULE

The future HJTC probe assembly to be installed in the holders is shown in Figure 3-3 and described in Section 3.1.2 of the accompanying report. The HJTC probe/holder locations are depicted in Figure 3-4. The probe and associated HJTC process instrumentation (described in Section 3.2) will be installed in Unit 2 during the first refueling and in Unit 3 prior to fuel load. The limitations which necessitate SCE implementing the probe assemblies, process equipment and displays on this schedule are detailed in Section 8 of the Status Report.

## APPENDIX - C

### Core Exit Thermocouple System

## APPENDIX C

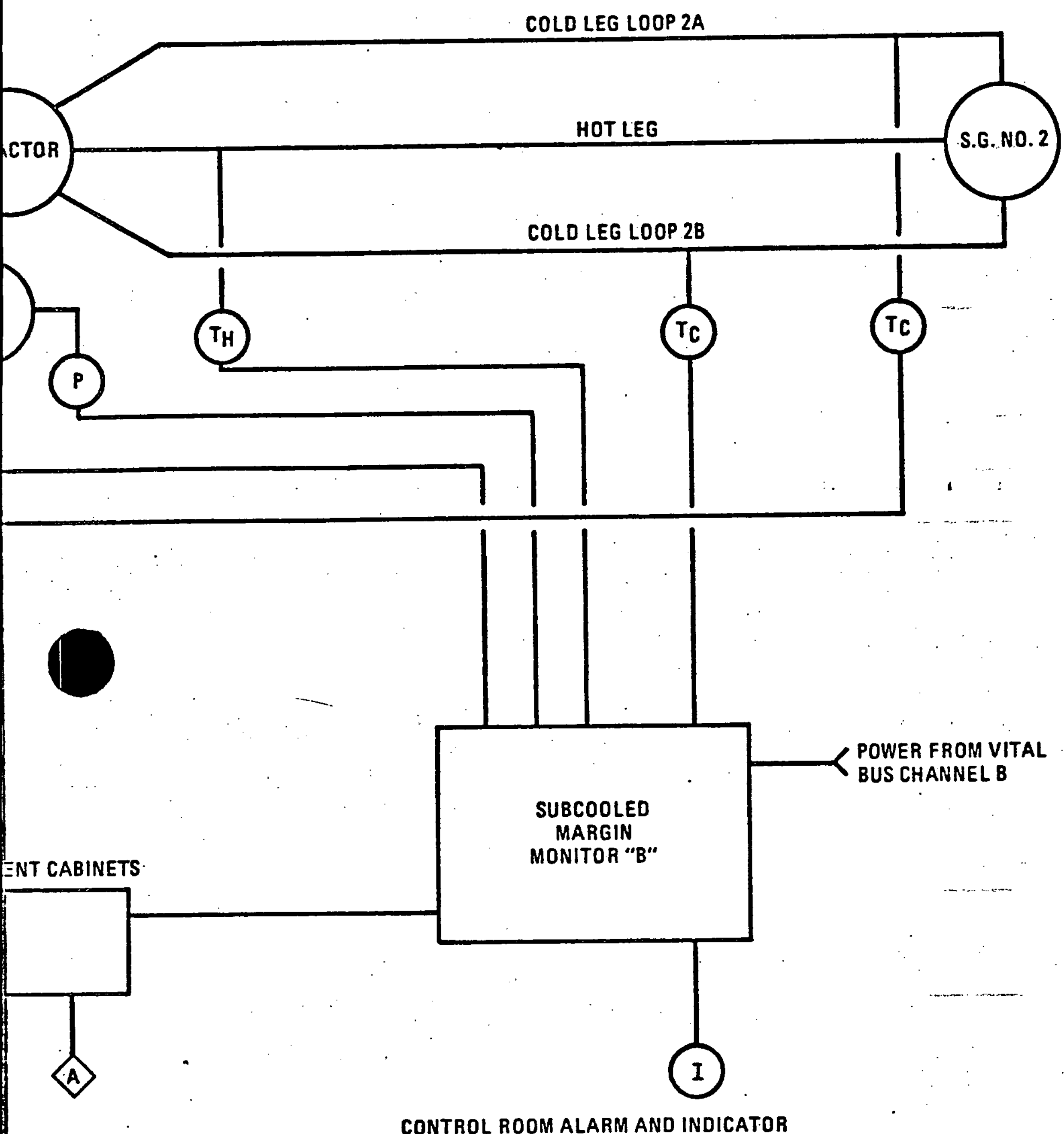
## CORE EXIT THERMOCOUPLE SYSTEM

The basic design of the San Onofre 2 & 3 Core Exit Thermocouples (CET) is described in Section 3.1.3 of the accompanying report. The CETs are included in the 56 In-Core Instrument (ICI) Detector Assemblies as shown in Figure 3-4A; the locations of which are shown in Figure 3-4B. For the first cycle of San Onofre Unit 2, the ICI Detector Assemblies will not meet all of the qualification criteria of Section 5.0, but the detectors and associated CET cabling will be upgraded for environmental qualification during the first Unit 2 refueling outage.

The following describes the CET processing and display to be used during first cycle operation of Unit 2, until the integrated ICC Detection Instrumentation is fully implemented:

The primary means of monitoring CET temperature is via the plant computer. The computer analog subsystem, as prt of its plant analog signal acquisition, processes the signals. All CETs are scanned and processed every two minutes and all the temperatures are printed every hour as part of the Hourly In-Core Detector Log. The log may also be printed or displayed upon demand from the operator console. In addition, any CET temperature value may be displayed on CRT, line printer, or trend recorders from the computer operator console.

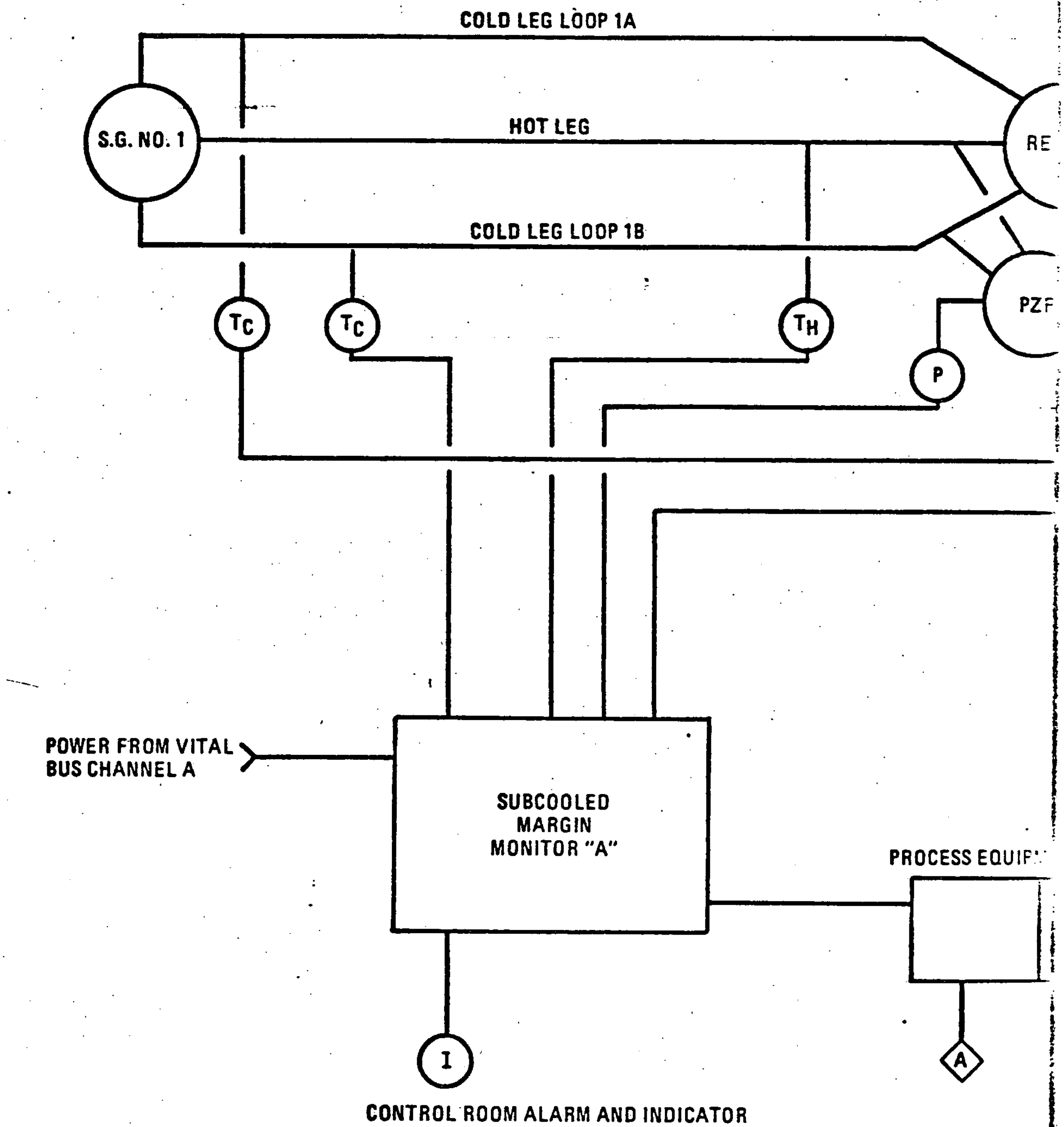
A backup means of determining CET temperatures is by reading the output voltage of each individual thermocouple directly at the terminal strip in the computer termination cabinet using a digital voltmeter. The voltage measurements are then converted to temperature values. A complete set of readings using this backup method would take from twenty minutes to one hour to perform. SCE is evaluating an alternate means of providing a more readily available backup display of the CET information for San Onofre Unit 2 - Cycle 1. SCE intends to submit this alternate method to NRC in May, 1981.

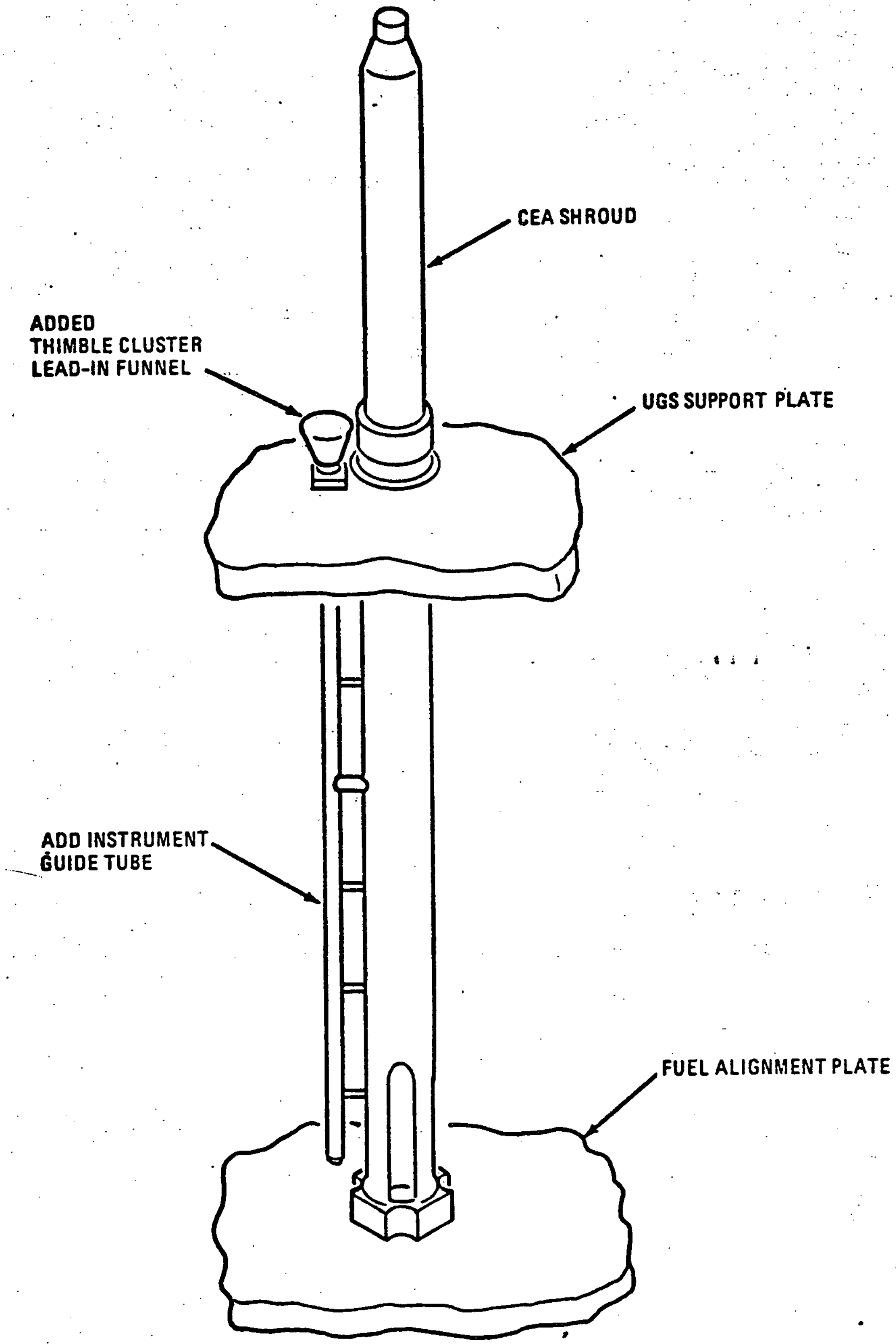



SAN ONOFRE
NUCLEAR GENERATING STATION
Units 2 & 3

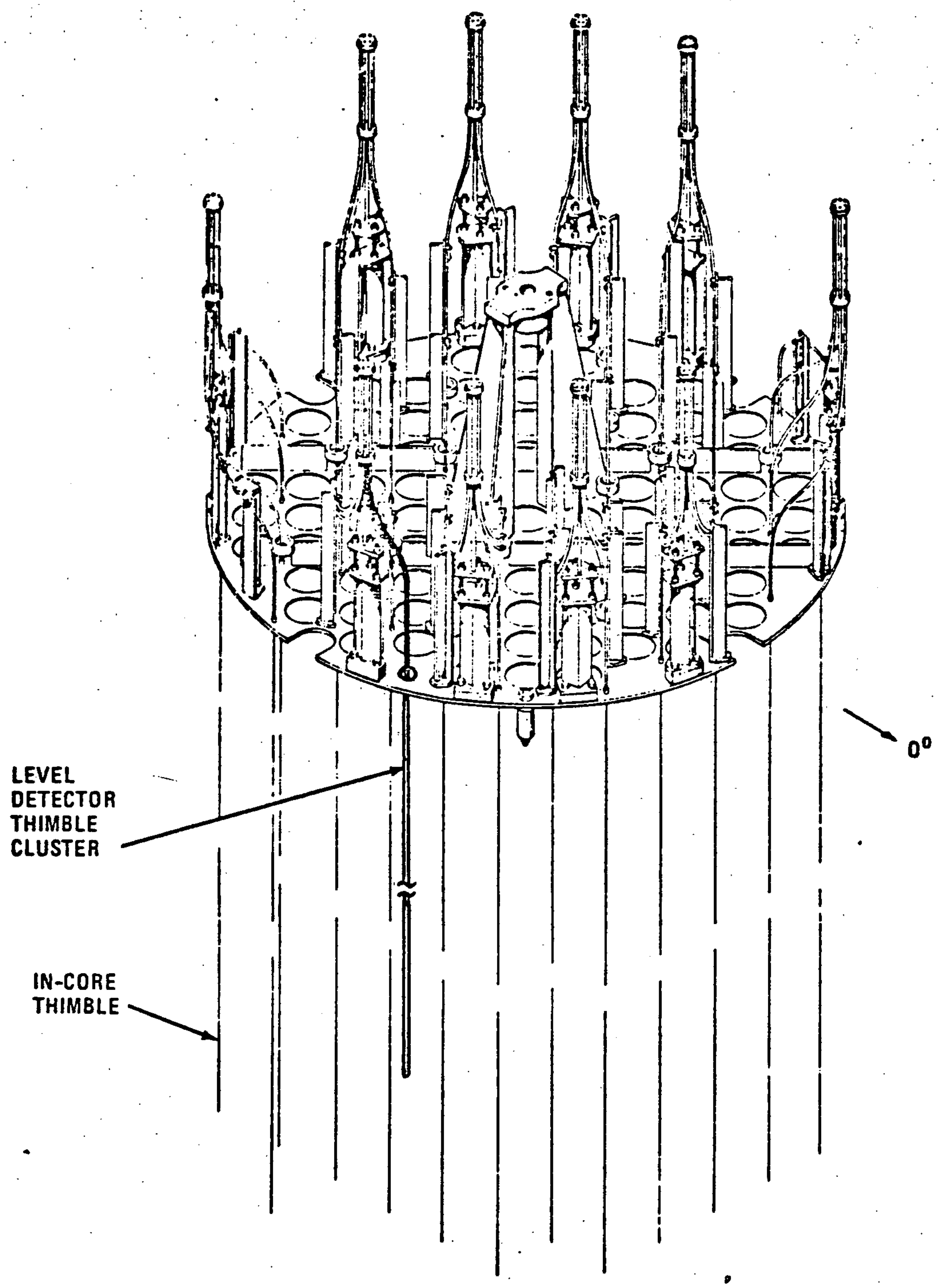
SMM SYSTEM LOGIC DIAGRAM

Figure II.F.2-1


COLD LEG LOOP 1A
S.G. NO. 1
HOT LEG
RE
COLD LEG LOOP 1B
PZF
$T_C$
$T_C$
$T_H$
P
POWER FROM VITAL
BUS CHANNEL A
SUBCOOLED
MARGIN
MONITOR "A"
PROCESS EQUIF
I
A
CONTROL ROOM ALARM AND INDICATOR




| SAN ONOFRE NUCLEAR GENERATING STATION Units 2 & 3 |
|---|
| REACTOR VESSEL LEVEL MONITORING SYSTEM INSTRUMENT GUIDE TUBE |
| Figure II.F.2-2 |

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INSTRUMENT SUPPORT PLATE

Figure II.F.2-3