DLH247.WP-1

NUPLEX 80+ HUMAN FACTORS DESIGN PROCESS SUMMARY

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TABLE OF CONTENTS

PURPOSE

The purpose of this document is to define the human factors engineering (HFE) components of the Nuplex 80+ design process, to date, in relation to the contents of the Draft Human Factors Review Criteria elements (Reference 1). Since ABB-CE agrees with the NRC Staff (herein referred to as "the Staff") on the overall goals of a process to incorporate human factors into the design product, the intent here is to identify the differences (i.e., "deltas") between the ABB-CE approach and that embodied in Reference 1. This is being done to facilitate Staff review of the System 80+ design features that are the products of the ABB-CE process.

BACKGROUND

ABB-CE submitted CESSAR-DC Chapter 18 for staff review in December 1988. Chapter 18 contained mostly information relating to the design of the Nuplex 80+ control room and man-machine interface features (the product), along with a lesser amount of information on the design process. However, up to this point, the Staff review (as reflected in the RAIs) has focused primarily on the design process, with little emphasis on the design product. In an April 9, 1992 meeting, ABB-CE requested that the Staff also review the MMI design features (as defined in a subsequent letter to the NRC.) Staff reviewers have indicated that they cannot complete their review of the design features from a Human Factors Engineering (HFE) standpoint because they cannot determine that the design process to this point has been acceptable.

The NRC Staff's current basis for an acceptable design process for an advanced nuclear power plant is embodied in the Draft Human Factors Review Criteria Report (Reference 1). Reference 1 identifies eight elements of an HFE program (see Figure 1), and defines Design Acceptance Criteria (DAC) in terms of various criteria on the program (rather than on the resulting design itself).

Reference 1 was provided to ABB-CE in April 1992; but the Nuplex 80+ Design was begun in 1987. ABB-CE and the Staff are in agreement that it is impractical to repeat or reorganize the previous five years of design activity, *ex post facto*, to correspond to a subsequent approach. However, ABB-CE believes that its own design process has thus far achieved the necessary and verifiable goals of an adequate HFE program, including the performance of many activities that typify the Reference 1 Elements (e.g., task analysis). More importantly, ABB-CE believes that its own design process has produced an adequate design product in Nuplex 80+. Finally, ABB-CE believes that some portions of the Reference 1 approach are inappropriate for evolutionary design.

and would lead to a less conservative product, in a less cost-effective manner, than the approach employed by ABB-CE for Nuplex 80+.

This last point is of key importance, since the Staff and ABB-CE agree that most of the problematic deltas between the Reference 1 process requirements and the ABB-CE process to date reflect different views of the evolutionary/revolutionary status of the Nuplex 80+ design. ABB-CE believes that both the System 80+ plant and Nuplex 80+ control room are evolutionary upgrades of successful designs; the modest changes from the existing designs have been made to solve specific, existing problems, and reflect lessons learned from operating experience (not hypothesized from analysis). The Staff concurs that System 80+ is an evolutionary design from the System 80 plants. However, the Staff views the Nuplex 80+ control room as a completely new design which warrants extensive design studies and analyses before an adequate MMI can be developed. Appendix A identifies the basis for ABB-CE's position that Nuplex 80+ is an incremental and modest step from previous generation control room designs.

The purpose of the present document is to summarize the HFE activities within the ABB-CE design process up to the present time with respect to each of the Reference 1 Elements (resolution of the future process will be conducted as part of the human factors ITAAC/DAC for ABB-CE.) This process has produced the present Nuplex 80+ features (MCR Configuration, Integrated Process Status Overview, standard MMI features, and the Reactor Coolant System (RCS) panel) for which ABB-CE is requesting Staff review. This report also identifies significant differences between the Reference 1 and the ABB-CE processes, to facilitate their resolution, so that Staff review of the design product may proceed. In this regard, it is ABB-CE's position that deficiencies in the past process are moot points if they do not result in irremediable deficiencies in the design product itself, or in our future ability to verify and validate it.

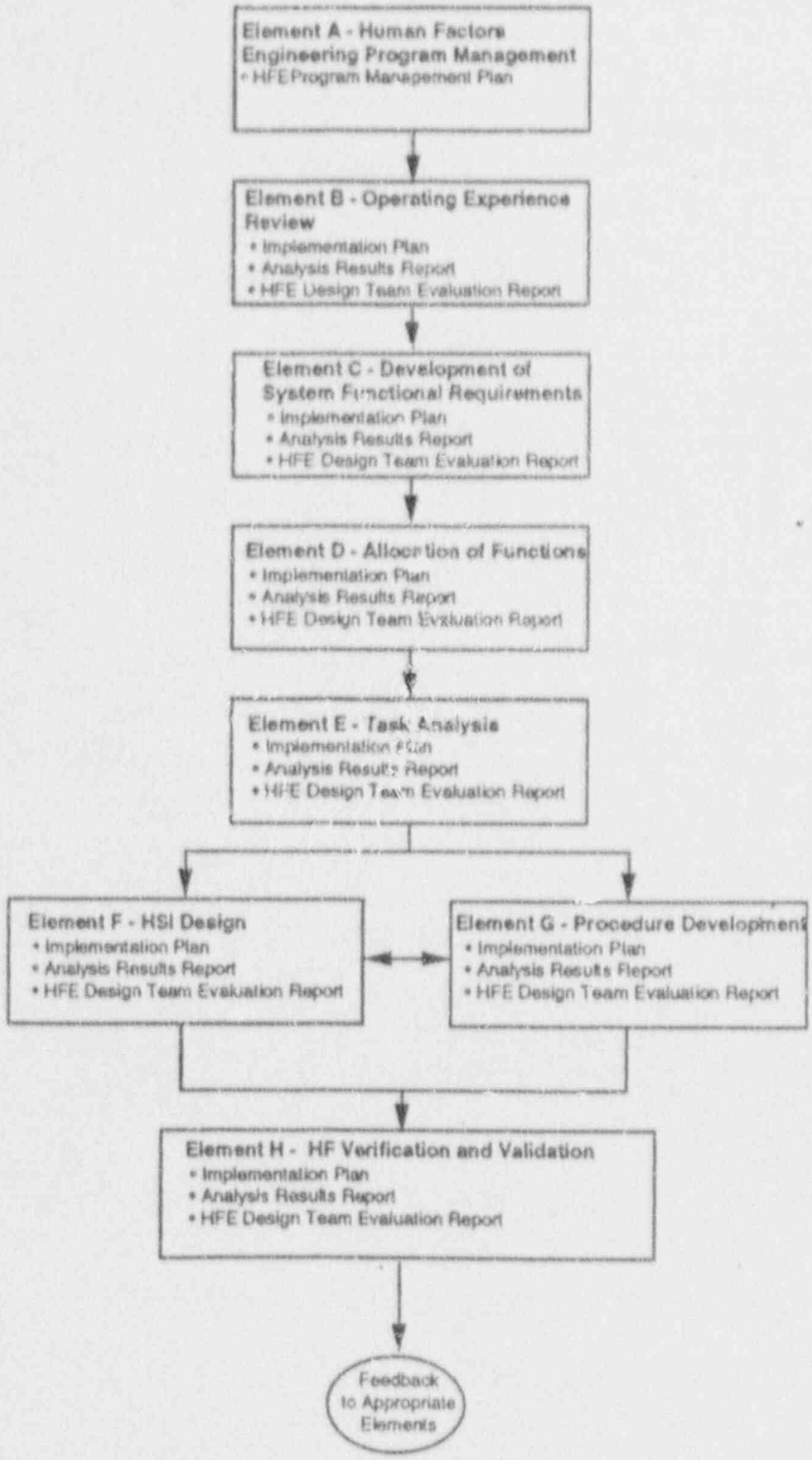


Figure 1. HFE Elements

(Draft 4/17/92)

REFERENCES

(1) "Interim Human Factors Review Criteria for the Design Process of an Advanced Nuclear Power Reactor," Brookhaven National Laboratory, April 21, 1992.

(2) "Description of the Human Factors Program Plan for the System 80+ Standard Plant Design," P. M. Simon, February 1992.

(3) EPRI Advanced Light Water Reactor (ALWR) Utility Requirements Document (URD), 1989.

NUPLEX 80+ DESIGN PROCESS REVIEW

ELEMENT A - HFE PROGRAM MANAGEMENT

Description

The human factors engineering (HFE) efforts performed during the Nuplex 80+ design process have been an integrated part of the overall advanced control complex design process. Human factors specialists were part of the design team, and also served as independent reviewers, but were not organized as a separate human factors entity. This was consistent with the presence and organization of other disciplines in design team activities, and permitted HFE to interact effectively with other design team members. The multi-disciplinary design team assembled for Nuplex 80+ consisted of members having the expertise identified in Element A of Reference 1.

The overall Nuplex 80+ man-machine interface (MMI) design process, with integral HFE elements, was defined in CESSAR-DC. In response to RAI 620.1, a dedicated human factors program plan description was written describing the HFE activities performed to date and defining future HFE activities with their schedule relative to the overall System 80+ schedule (Reference 2). In response to RAI 620.3, a dedicated method for tracking HFE issues is being implemented based on a project-wide open issues tracking system. These issues thus have received a commitment for resolution.

Design Process/Criteria Differences

The referenced RAIs are taken to represent Element A deltas whose resolution is in progress.

Unresolved deltas include criteria requiring the design team to afford special or superordinate status to the HFE discipline in terms of 1) dominance of the design team focus (Criterion 6), 2) "freedom from cost and schedule considerations," (Criterion 5), and 3) specialized stop-work mechanisms without clear connection to program safety or quality requirements (Criterion 4).

ABB-CE views HFE as a discipline on a par with other design team disciplines. Thus, HFE is subject to similar cost, schedule, and tradeoff constraints, and has available to it the same stop-work mechanisms as other project disciplines (through Nuclear Systems Quality Assurance) to protect the health and safety of the public.

Remaining deltas are limited to relatively minor issues related to the contents of program plan description (Reference 2).

ELEMENT B - OPERATING EXPERIENCE REVIEW

Description

Operating experience from existing nuclear plants, including System 80 control rooms, has been factored into the Nuplex 80+ design. This has been accomplished primarily by using existing nuclear industry reports and studies to define the design bases for the advanced control complex which, in turn, have been used to direct the design. The design bases clearly define the past industry problems for which Nuplex 80+ is expected to provide an acceptable MMI design.

A major vehicle used to incorporate operating experience into Nuplex 80+ has been the EPRI ALWR URD (Reference 3) which contains requirements developed by the nuclear industry specifically to solve MMI concerns with existing plants. Other sources of operating plant problems included reviews of LERs, DCRDR reports, and INPO's Significant Operating Event Reports. Industry studies performed by NRC (NUREGs), EPRI (nuclear power reports) and the OECD Halden Reactor Project were also used to identify concerns based on operating experience. In selected areas, such as alarm and annunciation problems, separate reports were generated for Nuplex 80+ to consolidate the information from industry-wide sources. Problems identified in other areas (e.g., via the Corrective Actions Program) were factored directly into the design bases for Nuplex 80+.

As one evolutionary aspect of the Nuplex 80+ design, operating experience is implicitly incorporated through the use of mature MMI designs that have been through iterations of implementation and upgrade in existing plants. For example, the Critical Function Monitoring Systems (CFMS) is in use at four existing ABB-CE plants, and has received few changes for its application in Nuplex 80+.

Another important source of operating experience is the use of licensed operators on both the design and design review teams, both at ABB-CE and at Duke Engineering Services, a subcontractor. Finally, the Executive Advisory Board brings industry operating concerns to the attention of the project.

Design Process/Criteria Differences

ABB-CE believes that sufficient operating experience information has been incorporated into the Nuplex 80+ design using existing industry sources, mature design concepts, and experienced designers, operators, and reviewers. A single stand-alone effort performing and documenting the review of operating experience has not been performed, nor is it deemed necessary. However, ABB-CE has clearly documented the design bases for Nuplex 80+ in general and for each MMI element of the design to track resolution of identified concerns.

The most significant difference with Reference 1 is the lack of formality of ABB-CE efforts. However, ABB-CE has documented its "boiler room" meetings in which past problems were identified, and Nuplex 80+ solutions were developed. This process was similar to that utilized in development of Reference 3, and is an accepted method of integrating expert knowledge and decision-making.

ELEMENT C - SYSTEM FUNCTIONAL REQUIREMENTS ANALYSIS

Descr' 'on

System 80+ is a design evolved from the System 80 standard plant design with few changes to the system requirements and system functions. Existing plant operating functions are sufficiently developed and well understood. Refinement to, rather than complete reassessment of operating functions was appropriate and resulted in few identified impacts. The System 80+ function and task analysis was used to organize functions without extensive system functional requirements analysis as would be expected for a new plant design.

Similarly, the Nuplex 30+ control room is an evolutionary step from the previous generation System 80 plant control rooms (the Nuplex 80 control room was not a baseline, but only a hypothetical point of departure for considering solutions to problems identified with the baseline conventional control room.) Each Nuplex 80+ MMI meets the same or similar system and functional requirements as their predecessor MMI implementations in conventional plants (baseline functional MMI requirements are indication and control Availability data based on Palo Verde instrument lists and the SONGS 2 & 3 Instrument and Controls Characteristics Review.) For example, the Nuplex 80+ alarms perform the same operating functions of alerting, guiding, informing and confirming as conventional annunciators. Operator functions interacting with process and component controls is likewise similar to conventional plant implementations. This is true for each of the Nuplex 80+ MMI features (see Appendix A).

What has changed is the detailed interface design and the underlying I&C technology used to implement these functional MMI requirements. However, even at this underlying level (which is not the issue here, under Element C), only proven technology that has previously been used in nuclear control rooms has been utilized.

Of significant importance to safety, the existing critical function and success path approach for safety monitoring in CE plants has been implemented in Nuplex 80+ as an integrated part of the interface. The Nuplex 80+ functions will be validated as part of the human factors Verification and Validation activities describe in the Human Factors Program Plan (Reference 2).

Design Process/Criteria Differences

ABB-CE and NRC staff agree that the System 80+ plant is an evolutionary design from System 80 and, therefore, the need for extensive functional analysis does not exist for plant functions. ABB-CE considers the Nuplex 80+ control room design to be similarly evolutionary in nature and, thus, also does not require extensive functional reassessment. However, the Staff reviewers perceive Nuplex 80+ to be a completely new design which warrants extensive functional re-analysis according to the criteria of Element C in Reference 1, before an adequate MMI can be developed.

DLH247.WP-13

ELEMENT D - ALLOCATION OF FUNCTION

Description

As described in the description of Element C, the functions for the System 80+ plant and Nuplex 80+ control room have not changed extensively from previous generation plants. As operating experience has dictated in existing plants, the assignment of functions to personnel, machines or a combination of the two has been changed to address specific problems (e.g., low power feedwater control has been automated). A similar function allocation philosophy has been applied to this evolutionary design. Changes from the previous generation (System 80) were made only to address identified problems.

After review of operating experience from a function allocation perspective, only two functions have been automated. These are automatic load dispatching and automatic margin preservation. The resulting function allocation (prima[illegible]changed from existing plants) will be validated as part of the verification and validation activities.

This approach to allocating functions is conservative and appropriate for an evolutionary design. It has resulted in no substantial change to the control room operators role or function between baseline System 80 plants and System 80+. Substantial changes to the existing allocation based on a theoretical analysis would plausibly have led to more problems than they solved (particularly since few problems resembling allocation issues have been identified) and would certainly have required extensive validation. To minimize such risk, and to maintain an acceptable function allocation in System 80+, the ABB-CE approach was to change only problem areas. This is explicitly an evolutionary approach. Note that there are virtually no changes in RCS indication and control functions, reflecting the maturity of the baseline design.

Also, in the wake of these design decisions, there have been no specific problems surfaced in review of these allocation decisions. ABB-CE feels that this reflects the soundness and adequacy of these allocations.

Design Process/Criteria Difference

ABB-CE has maintained the existing function allocation of the System 80 plant and its conventional control room with changes only to address identified problem areas, as appropriate for an evolutionary design that reflects nearly 100 reactor operating years of experience. It is unclear that making formal analyses the basis for allocation would have added significant value to this approach, (and one should probably question any analysis whose results contradicted such an experience base) but it would have added some costs and liabilities to an otherwise evolutionary design process. Nonetheless, the DAC in Element D of Reference 1 requires a formal function allocation analysis with accompanying documentation.

ELEMENT E - TASK ANALYSIS

Description

A top-down preliminary task analysis has been performed for RCS related functions and tasks as part of the RCS panel design process. This analysis was based on an accepted function and task analysis methodology used for DCRDRs in existing CE plants. It identified task (i.e., information and controls) requirements for the RCS and evaluated the acceptability of operator task loading based on time response requirements for limiting events, with minimum staffing. This was sufficient to support panel design activities, and will be repeated for subsequent panels. Because of the evolutionary nature of the System 80+ plant, the analysis relied heavily on existing task analysis results for function and controls requirements. The task analysis analyzed event sequences for accidents (e.g., LOCA, SGTR), normal operations (e.g., steady-state power, start-up) and abnormal operations.

The results of the task analysis were used to develop the RCS panel MMI and layout and in an availability verification to ensure the accessibility of necessary indications and controls.

"Critical" task analysis is defined by and limited to analysis of human tasks by HRA methods that have been identified by PRA to have a significant effect on plant safety. However, no such critical tasks have yet been identified.

Further analysis and confirmation of tasks will be performed as part of the Validation process using a control room prototype, when the design is at or near completion. This will allow more appropriate analyses of interactive tasks associated with communication and workplace factors than could be performed through formal paper analyses. Performance with limiting staff sizes (both minimum and maximum) will be validated at this time. Also at this time, detailed task analysis shall be performed as a documenting mechanism, resulting in Availability data in the form of Instrumentation and Controls Characteristics Review (ICCR) data.

Design Process/Criteria Difference

ABB-CE considers the preliminary task analysis methodology to be appropriate for the purpose to which it has been applied, including support for the design of features which the Staff has been requested to review. The same analysis will be performed for subsequent panels. Element E of Reference 1 requires formal identification of critical tasks; this will be performed in the context of PRA (and then fed to the design, as analysis deems issues significant) rather than control room design, *per se*.

The NRC staff has questioned why separate task analyses were not performed for various crew sizes. This is felt to be an issue of methods, not goals; however, it is noted that task analysis of maximum staffing would have afforded no useful information in the context of the present analysis. Also, there are likely some staff concerns related to the depth of the analysis for identified tasks and assumptions made in limiting the scope of the analysis.

ELEMENT F - HUMAN SYSTEM INTERFACE DESIGN

Description

The Nuplex 80+ man-machine interface has been developed incorporating accepted principles and guidelines from the HFE literature. High level design bases were developed for the control room as a whole, and certain generic man-machine interface features. Low level or elemental human factors criteria were obtained from standard human factors reference sources. These elemental criteria have since been consolidated into an HFE Standards and Guidelines document which defines specific criteria selections for Nuplex 80+.

Preliminary designs for these features were then developed by the design team; this included significant involvement of human factors specialists, as well as the incorporation (by the full design team) of the HFE Standards and Guidelines. The preliminary design activity included an exhaustive effort to resolve misfit allocations to interface devices which existed in previous generation designs. For example, operator aids and status information were removed from alarm tiles and provided through a CRT interface. The resulting designs were then reviewed by a multi-disciplinary team which included human factors specialists and licensed operators.

A design document was generated specifying the preliminary standard design for each MMI feature. Once matured these standard interfaces are used to design all Nuplex 80+ panels. Each preliminary design feature was prototyped using the RCS panel information and controls as a demonstration application. Each prototype was made sufficiently dynamic so that interactive operations could be performed with the prototype. The prototypes were evaluated via a suitability verification using human factors and operations expertise. This evaluation determined the interface acceptability for supporting intended user tasks. Significant feedback to the designs was provided, resulting in mature designs to be used as design standards for all panels within Nuplex 80+. These designs were documented in project documentation and CESSAR-DC, and are the features that ABB-CE is requesting the NRC staff to review.

Design Process/Criteria Differences

The ABB-CE process for the design of the man-machine interfaces meets most of the criteria in the draft review criteria report for Element F. The HFE Standards and Guidelines Document has only appeared in draft form but will be available for formal Staff review, along with its basis document.

Staff concerns exist regarding the formality of documentation early in the design process; a desire has at times been expressed to review ABB-CE's unselected design alternatives. ABB-CE does not consider this necessary for reviewing the adequacy of the design submittal.

There is concern that not all documentation is up-to-date; ABB-CE is committed to providing this where needed.

The possible Staff concern for a lack of specification of human task performance requirements is felt by ABB-CE to be an issue of methodological approach and detail, but should not result in any inadequacy in the design features being reviewed.

ELEMENT G - PLANT AND EMERGENCY OPERATING PROCEDURE DEVELOPMENT

Element G is being addressed by Building Block 7 of the NPOC Strategic Plan. It has not been addressed by the Nuplex 80+ design process, to date.

ELEMENT H - HUMAN FACTORS VERIFICATION AND VALIDATION

Description

To date, the HF Verification and Validation activities have focused on verification of the RCS panel interfaces and IPSO. An Availability Analysis was performed to determine if all necessary information and controls identified in the task analysis were available. The Availability Analysis also mapped the resultant RCS panel information and controls to functional groups identified in the task analysis to assure that no unnecessary information or controls were present.

A Suitability Analysis was performed on dynamic prototypes of all MMI features to verify their capability to support the performance of specific tasks intended for the feature. It evaluated both the adequacy and appropriateness of the features design selections. A formal Verification Analysis report documented the Availability and Suitability results, recommendations and design team resolutions.

No Validation activities have been performed, to date, because Validation is appropriate for the entire control room ensemble. Validation of the entire Nuplex 80+ control room is planned using an integration test facility consisting of fully dynamic MMI features driven by simulation models. Plans for continued verification activities and eventual validation activities are developed and documented.

Design Process/Criteria Differences

ABB-CE believes that there are no significant differences between the draft review criteria and the implementation of the Verification (and Validation) activities, to date.

CONCLUSION

This document has described the design process used, to date, to develop the Nuplex 80+ MMI features for which ABB-CE is requesting NRC Staff review. It has also identified the major differences between this process and the Draft Human Factors Review Criteria by which the design process, and by extension, the design, is being evaluated. The major source of these differences is ABB-CE's perception that Nuplex 80+ is a modest evolutionary step in control room implementation that is properly grounded in operating experience, versus the NRC Staff's perception that Nuplex 80+ is a completely new control room design that should be grounded in more extensive theoretical analyses.

Even in light of these differences, it is ABB-CE's belief that review of the design features and their development process can proceed. Nonetheless, there must be some consideration given by such a review process for the use of alternate approaches to the design process which, though not strictly matching the criteria specified in Reference 1, are technically justifiable, and more importantly, can produce a viable product.

APPENDIX A
THE EVOLUTIONARY BASIS OF NUPLEX 80+

A fundamental principle of the Nuplex 80+ advanced control complex is its evolutionary nature with respect to previous generations of control room technology. A decision was made early in the design process to make changes to existing man-machine interface (MMI) features and their integration only where problems existed. The result of this premise was a relatively small step in design advancement primarily to use advances in technology to solve the existing problems. The fact that Nuplex 80+ was purposely evolved from an existing, proven generation of control room and MMI designs having extensive operating experience has had a significant impact on the design process used to develop the control room and its man-machine interfaces. The design approach has relied heavily on operating experience input and design review to make improvements to similar existing designs. An emphasis has then been placed on verification and validation to demonstrate acceptability of the resulting design.

This Appendix identifies the basis for ABB-CE's position that the Nuplex 80+ control room and the MMI features embodied therein are, in fact, modest and incremental steps from previous generation designs.

The Nuplex 80+ control room represents an advancement in instrumentation and control implementation of the existing MMI functions that are presently used in System 80 plants. This includes only minimal changes to the plant operating philosophy due to the close correlation of System 80+ to its predecessor plant design System 80 and the conservative application of functional changes. The control room operator's role has not changed in that the changes to operational functions and tasks are minimal and operational support information (e.g., procedures, technical specifications) is essentially the same as that employed in previous generation plants. In addition, the inventory and availability of plant indicating and control functions has changed little as is evidenced by comparing the Nuplex 80+ RCS panel prototype to the System 80 RCS panel interfaces.

The remainder of this Appendix compares the Nuplex 80+ main control room (MCR) configuration and MMI features to their corresponding previous generation designs to demonstrate their evolutionary nature.

Main Control Room Configuration

Control room panels in previous generation nuclear plants are typically dedicated to plant systems with one or two systems per panel arranged in appropriate functional groups. The Nuplex 80+ design makes use of this same approach, assigning system related indications and controls to designated panels. The footprint for previous generation control rooms typically separates frequently used system panels (e.g., CVCS) from those that are infrequently used (e.g., ESF panels). Nuplex 80+ has evolved this concept into separate consoles for normal operations, safety operations and auxiliary operations. Panel profiles used for Nuplex 80+ are similar to those of many previous generation control rooms with minor changes to accommodate the specific interface hardware, viewing requirements and the anthropometric assumptions made (e.g, Nuplex 80+ is designed for the 5th percentile female). The location and design of the control room supervisor's console is similar to that used in existing control rooms.

The Nuplex 80+ controlling workspace is designed to accommodate operating staff complements equivalent to those in currently operating plants per requirements in the EPRI ALWR URD. Also equal to current plants, the division of work among operators is by plant systems with function coordination by the control room supervisor. In Nuplex 80+ the addition of all plant information available at every panel minimizes unnecessary movement and miscommunication among personnel.

The addition of control room offices in Nuplex 80+ is an improvement to accommodate the interaction of control room staff with non-operating personnel without impacting operations at the panels. This has only an incremental but beneficial impact on plant operations in the controlling workspace.

Integrated Process Status Overview

The Nuplex 80+ IPSO directly addresses the EPRI ALWR URD requirements relating to provision of an integrating display and mimic. The purpose of this display is to provide a spatially dedicated, continuously viewable presentation of aggregate plant function status information. This is similar to and an extension of the spatially dedicated information presented in conventional control rooms for bypassed and inoperable status (RG 1.47) and critical safety functions (NUREG-0696). For IPSO, as in these conventional applications, raw data is processed into useful overview information.

The Nuplex 80+ IPSO concept evolved from the critical function and success path methodology used as a basis for existing Emergency Operating Procedures (EOPs), based on CEN-152, and Safety Parameter Display Systems (SPDS). This methodology is evidenced in the SONGS 2 and 3 EOP and Critical Function Monitoring System (CFMS). The critical function and success path approach has long been accepted in the nuclear industry and extensively applied in ABB-CE plants.

The IPSO display has evolved from top level SPDS displays which consolidate the derived status of critical functions and success paths for integrated presentation to the operator. The large panel implementation of IPSO in Nuplex 80+ has evolved from a similar design in use at the Borsselle plant in the Netherlands. In addition to the operating experience acquired from Borsselle, IPSO received positive evaluation results from the OECD Halden Reactor Project for its effectiveness in supporting operations. The primary difference between previous generation IPSOs and that in Nuplex 80+ are implementation details specific to the System 80+ plant and hardware implementation using rear screen projection technology. This remains consistent with the evolutionary nature of the design.

Alarm Tiles

The Nuplex 80+ alarm tiles are an evolutionary step from previous generation control room alarm tile designs. The Nuplex 80+ alarms tiles provide the same basic operational functions (to alert, inform, guide and confirm feedback) as do existing alarm tiles. The Nuplex 80+ tiles are functionally grouped in a matrix arrangement located at the top of control room panels in a similar manner to current designs. These alarm tile matrices have attributes which mimic conventional alarm tiles through a flat panel display implementation.

The changes incorporated into the Nuplex 80+ alarm tiles have been made to resolve identified problems with existing systems. These changes have been implemented without radically altering the presentation of alarms or the operator's interaction with them. The potential overload of alarm information during high alarm activity conditions has been addressed by using alarm tiles only for alarms relating to significant operator action conditions (i.e., no status alarms), combining functionally similar alarms into single tile presentations and signal validation. Validating data before alarm presentation ensures that alarms now will reliably indicate important process deviations not equipment failures. Upon acknowledgement, tiles representing grouped alarms automatically display messages identifying the specific alarm condition. This is an evolutionary improvement from conventional plants where specific messages for grouped alarms were displayed through a separate plant computer display. Alarm tiles are individually acknowledged in Nuplex 80+ by touching the tile touch target on the flat panel display implementation. This change from a global acknowledgement button in previous generation designs was made to assure that pertinent information was not lost by common acknowledgement of many alarms. Use of touch for interaction with video display units has previously been used acceptably in other MMI applications for nuclear plants (e.g., I&C system operator modules).

To allow the desired operational changes to be made the alarm tiles have been implemented through software based flat panel display technology rather than a light box matrix. The advancement in alarm display media technology has little effect on the MMI other than to facilitate the evolutionary functional changes previously discussed. A key benefit of flat panel technology implementations is the flexibility and ease of making future changes in the software enviornment rather than with previous generation hardware environments. Flat panel displays have been used extensively in the nuclear industry as operator modules, SPDS interfaces and local control and monitoring stations. It is likely that every currently operating nuclear control room makes use of similar flat panel displays. The Nuplex 80+ design also uses these for implementing discrete indicators and process controllers.

Discrete Indicators

Discrete indicators are an improved method of displaying spatially dedicated parameter information in Nuplex 80+ without overloading the operator with all plant data available. Discrete indicators are designed to meet the same information and controls requirements as previous generation control room meters, trend recorders and digital indicators. The interface is designed to retain a critically useful aspect of previous generation hardwired displays (i.e., spatial dedication) using flat panel display technology (discussed in the alarm section). The benefit of spatial dedication could be lost by blanket implementation of CRTs.

Extraneous spatially d dicated information has been eliminated by using data reduction techniques to generate synthesized process representation values. Similar techniques have been used in generating representative Core Exit Thermocouple temperatures in Inadequate Core Cooling Monitoring Systems (ICCMS) and synthesized neutron flux distributions in the Core Operating Limit Supervisory System. This methodology has only received wider use in Nuplex 80+.

Discrete indicators are also used to provide selectable access to a limited set of plant parameters not requiring spatially dedication but required to be displayed on diverse technology from CRTs to meet common mode failure criteria. Similar touch selectable applications of multiple parameter flat panel displays have been used in the ICCMS and in system operator modules in previous generation plants.

CRT Displays

Nuplex 80+ CRTs provide essentially the same operational functions as previous generation plant computer and SPDS CRT interfaces. The primary change is enhanced integration of this interface into the MMI ensemble by having a single CRT to serve both purposes at each MCR panel. Previous generation control rooms typically have stand-alone locations for both SPDS and plant computer CRTs.

The CRT displays provided in Nuplex 80+ are directly evolved from previous generation plant computer display sets and SPDS (i.e., the Critical Function Monitoring System) displays. Previous generation plant computers have all Nuplex 80+ display types implemented in a similar hierarchy and in like fashion. This includes graphic mimic displays, alarm lists, historical data storage and retrieval displays and hierarchy directories. The critical function hierarchy display set in Nuplex 80+ is identical to the previous generation CFMS hierarchy with changes only to accommodate plant differences and extension of the concept to power production functions.

The Nuplex 80+ navigation method is based on touch, but similar in nature to cursor oriented techniques which use trackballs or keyboards. CRT touch screens have been used extensively and effectively in the fossil power industry.

The coding conventions used in CRT displays and throughout the control room interfaces are similar to those used in existing plant computer and SPDS applications. All of the coding methods (e.g., reverse video, flashing, color, etc.) have been used in previous ABB-CE computer generated display applications. Though some unique coding meanings have been generated for Nuplex 80+, most are consistent with previous applications. CRT symbology has also been derived from previous computer generated display implementation.

Controls

The implementation of controls on Nuplex 80+ panels is nearly unchanged from previous generation control rooms. A combination of process control and spatially dedicated component control is afforded the same function allocation as exists for System 80. In addition, the availability requirements for controls in Nuplex 80+ are the same as for previous generation System 80 control rooms. Control panel switches use the same momentary switch technology employed in System 80 control rooms and on other units. The Nuplex 80+ switch design is the same as the previous generation. Process control is provided through flat panel displays which mimic previous generation manual/auto stations. This interface allows selection of mode and inputs, setpoint selection and output control. This meets control requirements defined by the task analysis for a given function. The advantage of the flat panel implementation is that it allows master and subloop controls to be integrated on one functionally dedicated device (e.g., pressurizer pressure control integrated with spray and heater controls) instead of requiring multiple devices.

Combination of Spatially Dedicated and Selectable MMI

Nuplex 80+ uses a combination of selectable MMI devices (e.g., CRTs) and spatially dedicated MMI devices (e.g. alarm tiles). This approach is similar to that used in previous generation control rooms. In these control rooms the greatest portion of MMI are spatially dedicated devices, though this is changing as selectable backfit interfaces are being implemented. Nuplex 80+ likewise uses a mix of selectable and spatially dedicated MMI, but has evolved to make greater use of selectable displays. This allows operational needs to be met with less panel real estate and greater operational flexibility. Selectively maintaining the advantages of spatially dedicated displays and controls allows important controls and information to be accessed without the burden of searching through less important devices. Nuplex 80+ uses the MMI mix in a cohesive, integrated manner which is not as readily achieved for backfit applications.

Conclusion

The Nuplex 80+ control room is a System 80+ implementation of nearly the same functional requirements as previous generation plants using advances in technology to resolve identified problems. The plant operating philosophy, indication and control functions and operator's role have minimal changes from previous generation control rooms. The control room configuration and the design of each MMI feature are relatively small steps from previous designs, typically employing advances in I&C technology to provide solutions to problem areas without radical change to the overall MMI functions.

Based on the evolutionary nature of the entire control room and the MMI features described herein, it is ABB-CE's position that Nuplex 80+ is an evolutionary step from previous generation control rooms. It is therefore prudent to develop and use a design process which makes most effective use of previous generation designs with an emphasis on verification and validation of the design result, not analysis of the design inputs.

ATTACHMENT 4

ABB-CE has reviewed human factors-related submittals pertaining to the System 80+ Standard Design in order to determine which referenced documents should be docketed in whole or in part. A list summarizing the resolution of the documents identified in Reference 2 of this letter is provided below. The documents which should be docketed are enclosed with this attachment. The two bases used to select documents for docketing were:

1) relevance to the RCS/IPSO/Nuplex 80+ configuration and
2) support of an RAI response. The RAI responses have been modified (Attachment 1 of this letter) to clearly reference the docketed documents and to delete references to documents not placed on the docket.

In addition to the above, thirty-two revised CESSAR-DC figures are enclosed. These figures will be included in the next amendment of Chapter 18.

DOCUMENTS REFERENCED IN RAIs

Documents	Note on Resolution	Topic
ALWR-87-109	1	Letters Regarding Advanced I&C Program Schedule & Plan
ALWR-88-014	1	"
ALWR-89-028	1	"
DP-791-01	2	Cond/FW Panel Layout
SD-791-01	4	System Description for Control Complex Info. Systems (RAI 620.5)
TE-790-01	3	Verification Report (RAI 620.1)
SD640	2	CCS System Description
CEN-307	5	CE Owners Group Task Analysis

DP790.02	3	FTA Report (RAI 620.13, 620.5, 620.1, et al.)
RR-791-01	2	RCS Panel Description
SC-710-01	2	DPS System Description
NPX-IC-RR-791-01	6	(Same as DP-791-01)
NPX80-1000-2706-00	6	(Same as DP-791-002)
STD-100-2706-00	6	(Same as HF Standards and Guidelines)
Human Factors Standards and Guidelines for System 80+	8	(RAI 620.5, 620.1, 620.31, et al.)
Critical Functions Monitoring	4	
Information Systems Descriptions	6	(Same as SD-791-01)
Alarm Processing Description	2	
Halden Critical Functions Monitoring Study	9	HWR 213/222 (RAI 620.1, 620.11)
Halden Success Path Monitoring Study	9	HWR 223/224 (RAI 620.1, 620.11)
Halden IPSO Study	9	HWR 158/184 (RAI 620.1, 620.11)
Department of Energy Human Factors Design Guidelines for Maintainability DE 85-016790	7	
System 80+ Quality Assurance Plan 18386-Q0-001	2	

NOTES

1. This reference will be deleted as it has been superseded by the modified response to RAI 620.1.

2. Reference to this item has been deleted. Pertinent data are already docketed.

3. This item is being docketed in its entirety.

4. Applicable portions of this document contain proprietary information which is being docketed in a separate transmittal (letter LD-92-066).

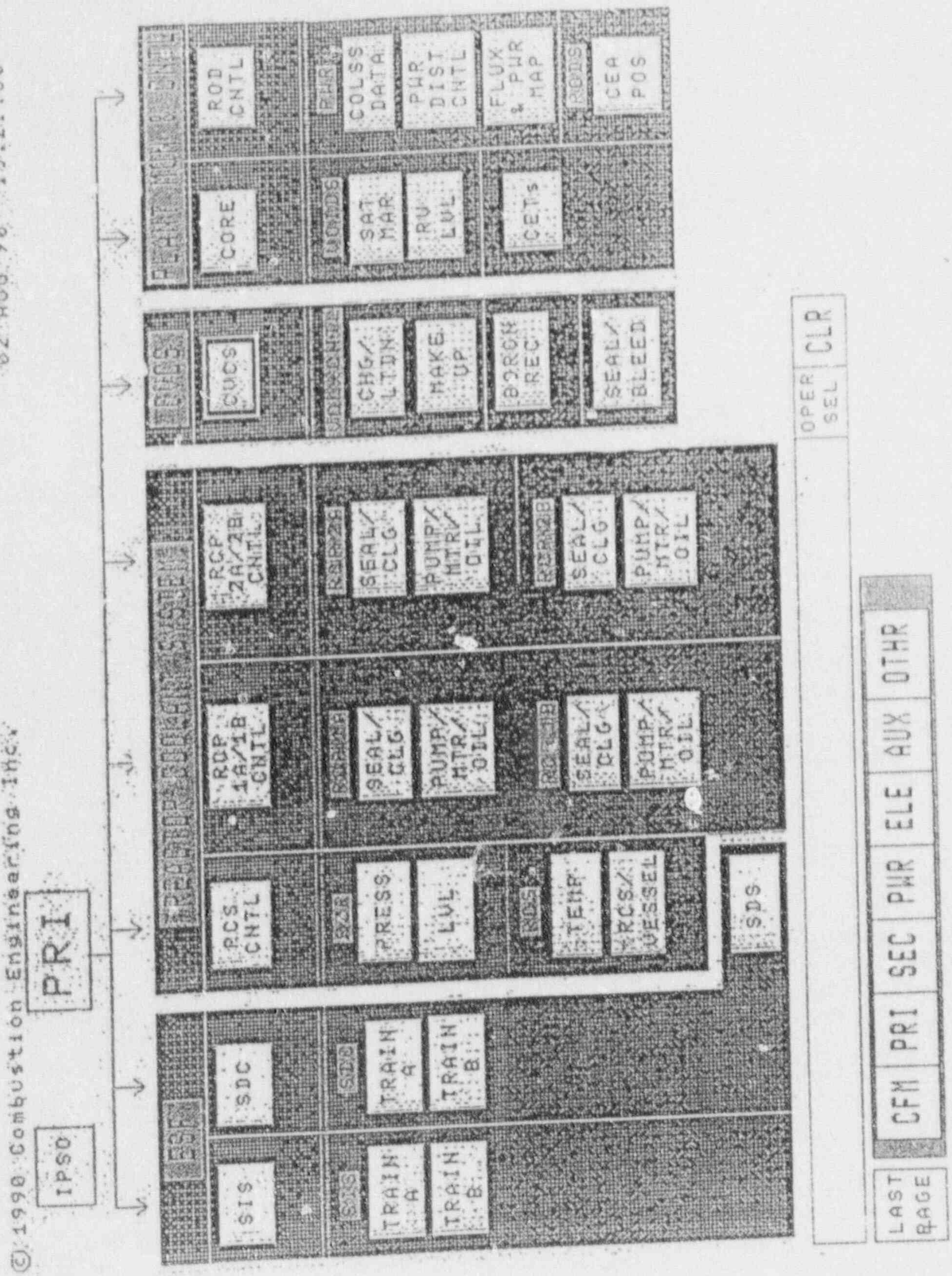
5. This document is proprietary to the CE Owners Group. It was referenced for historical purposes only. The reference will be deleted.

6. This item is the same as an item listed earlier.

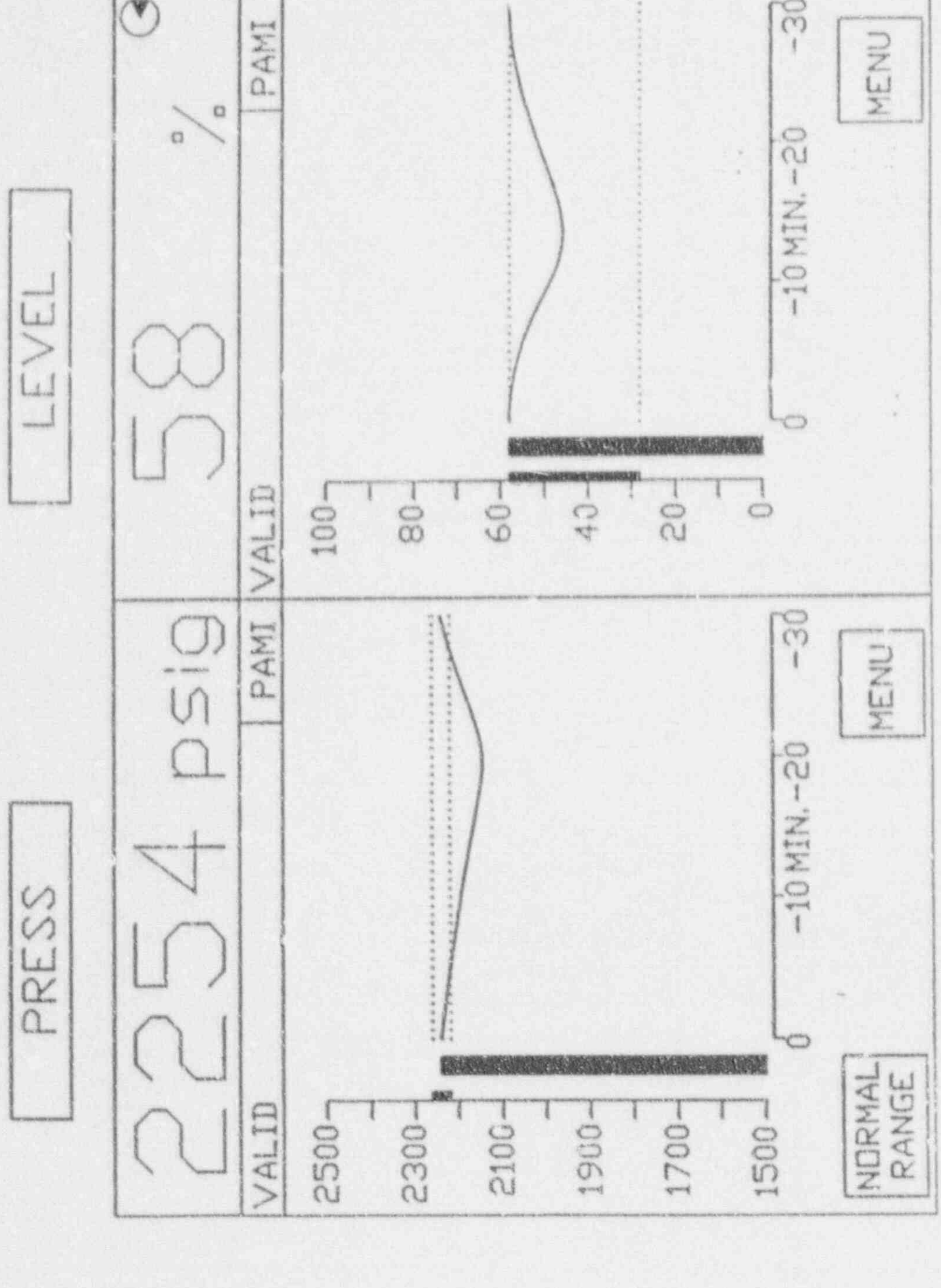
7. This item is in the public domain (not a CE document).

8. This item will be docketed as soon as finalized.

9. Abstracts of these studies are being docketed to show a summary of findings and provide the applicable study numbers and titles to the NRC.



SYSTEM 80+™	PRIMARY DISPLAY PAGE DIRECTORY	Figure 18.7.1.5



SYSTEM 80+™	DISCRETE INDICATOR WITH TREND FORMAT	Figure 18.7.1-7

© 1991 Combustion Engineering Inc. 10 JUL 91 14:08:58

Unack. Alarms

TILE	DESCRIPTION	SET POINT	VALUE	TIME
PRI : RCS PANEL : RCS Control (level 2)				
RCS TEMP HIGH	1 RCS Thot Hi	XXXXX	/XXXXX	15:14:26
	1 RCS Tcold Hi	XXXXX	/XXXXX	15:14:26
PZR LEVEL/RELIEF	2 Pzr Level Error Low	XXXXX	/XXXXX	15:14:26
	2 Pzr Safety to RDT Temp Hi	XXXXX	/XXXXX	15:14:26
PRI : CVCS PANEL: CHG/LETDOWN (Level 2)				
LTDN HDR	2 Ltdn Hx Inlet Temp Hi	XXXXX	/XXXXX	15:14:26
	2 High Letdown Pressure	XXXXX	/XXXXX	15:14:26
VCT PRESS/TEMP	2 VCT Pressure High	XXXXX	/XXXXX	15:14:26
	2 VCT Temp High	XXXXX	/XXXXX	15:14:26

ACKNOWLEDGE PAGE

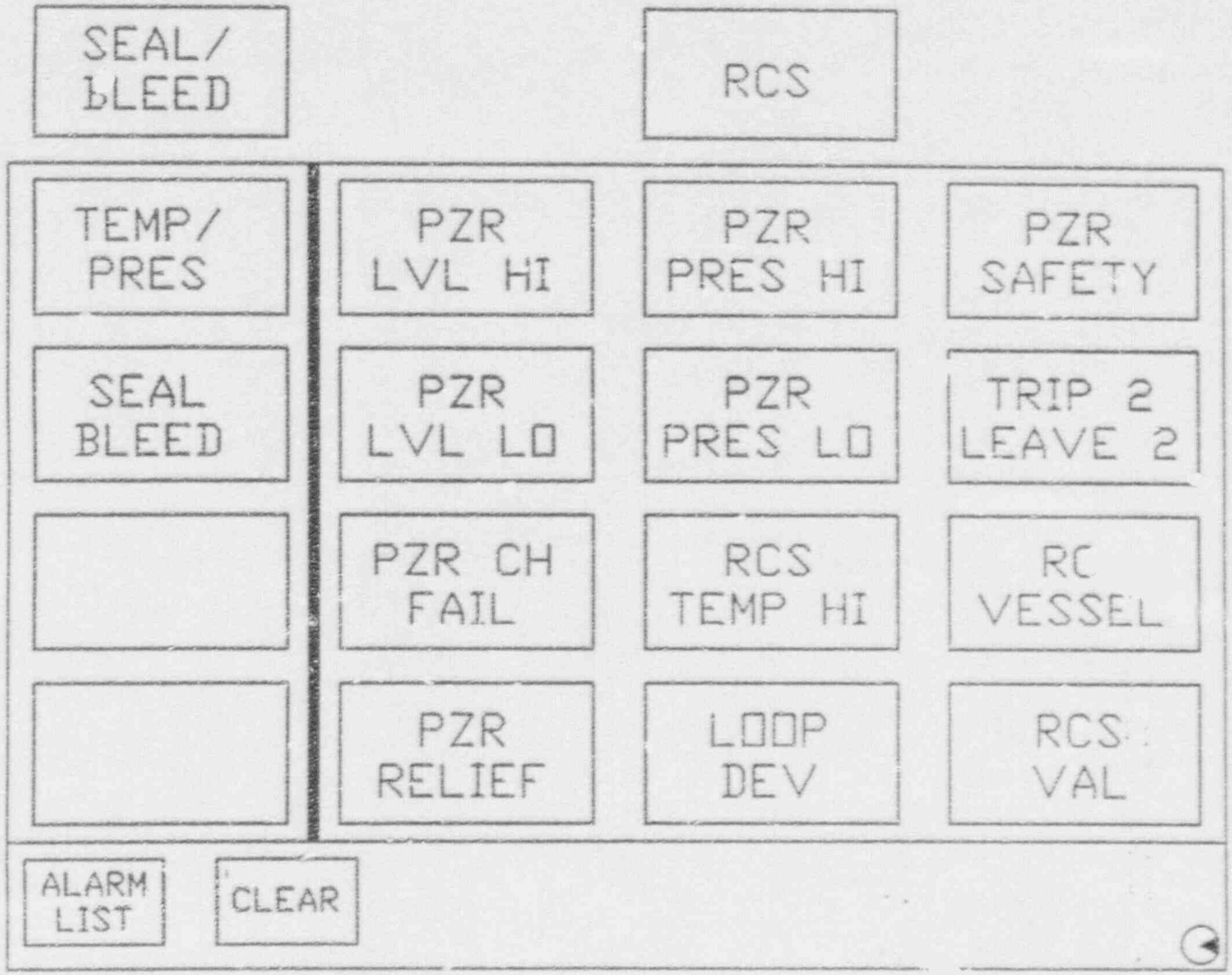
OPER SEL | CLR

LAST PAGE | CFM | PRI | SEC | PWR | ELE | AUX | OTHR

SYSTEM 80+

Unacknowledged ALARM PAGE

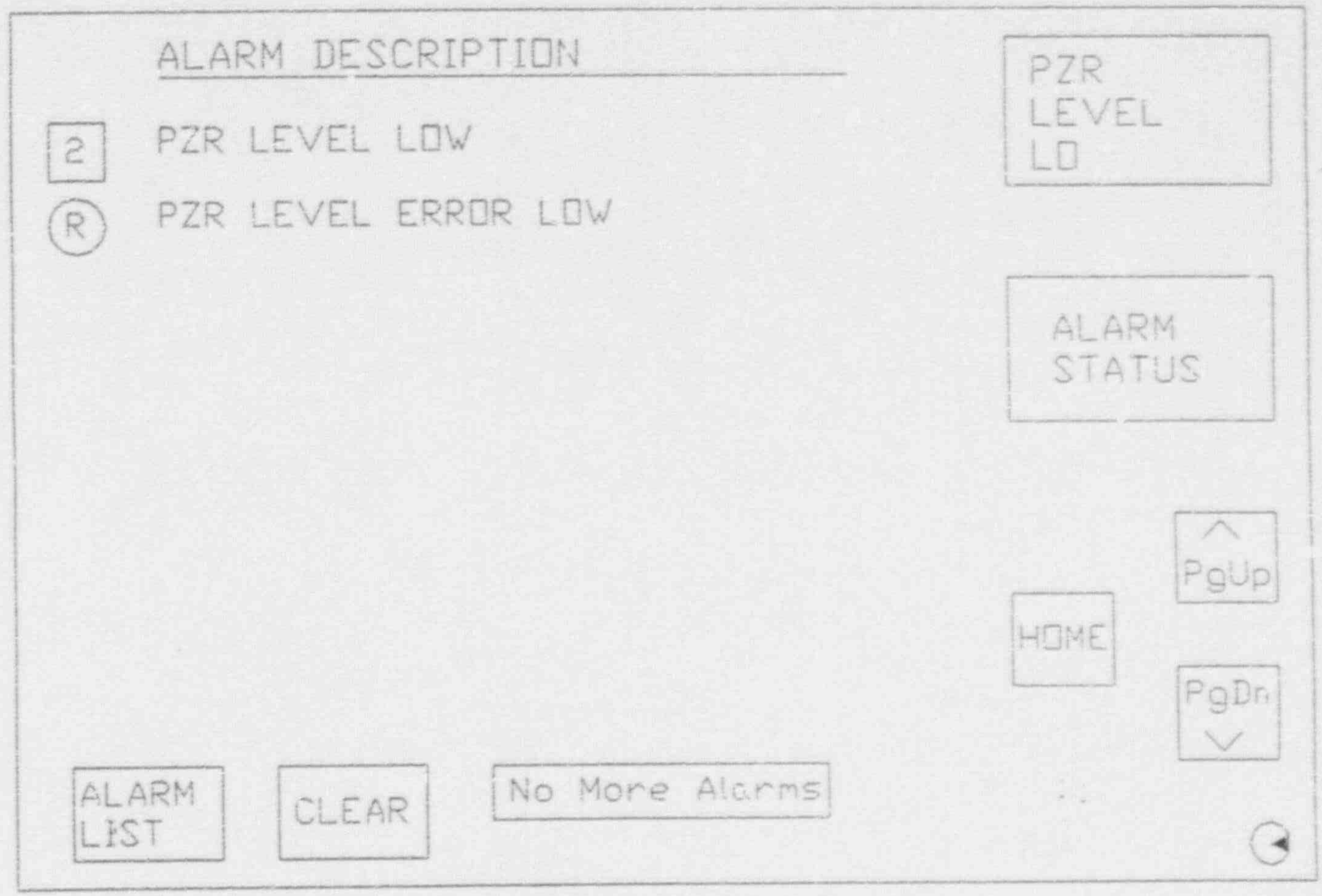
Figure 18.7.1-9



SYSTEM 80+™

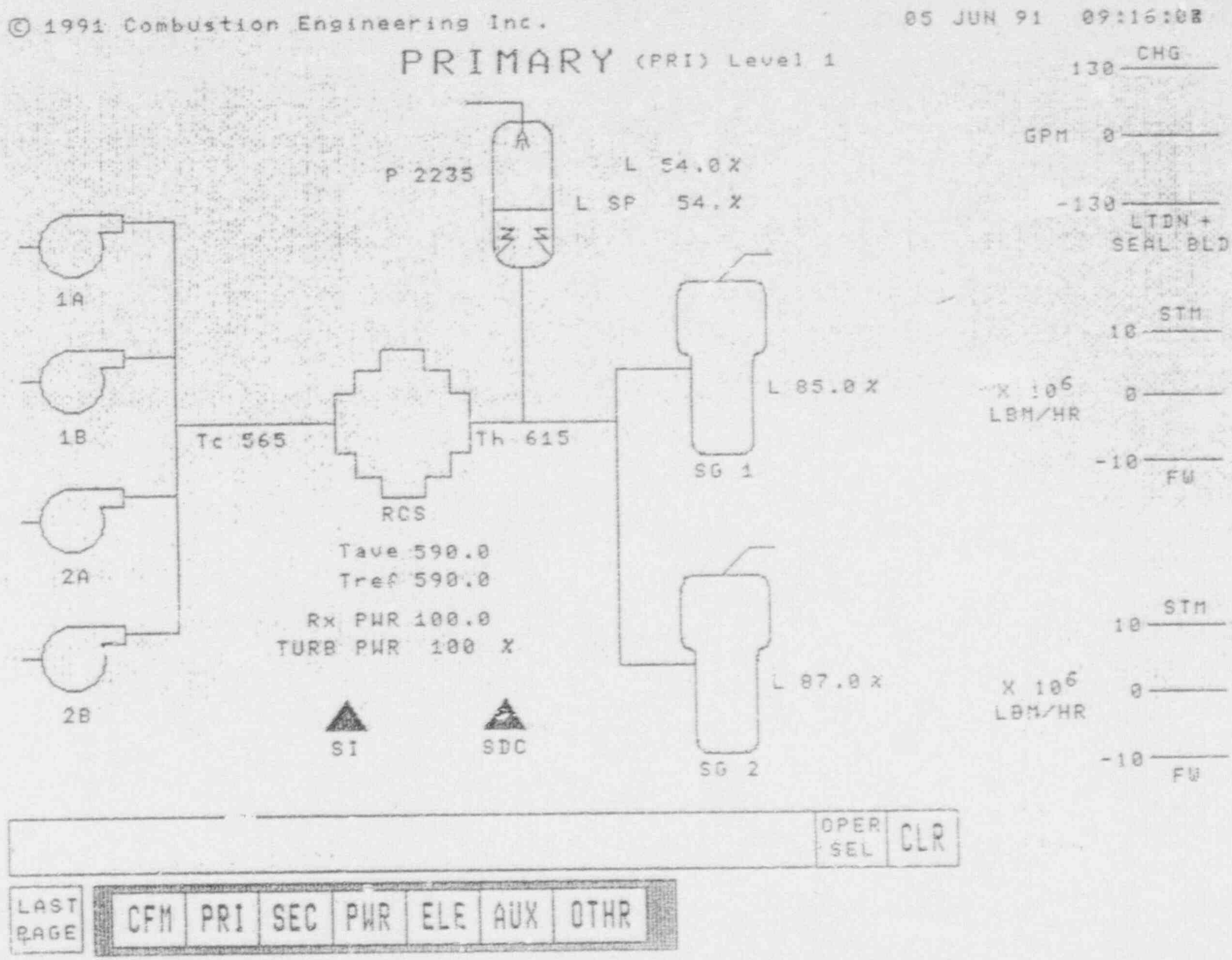
SEAL/BLEED RCS AND OTHER ALARM TILES

Figure 18.7.1-10



SYSTEM 80+™

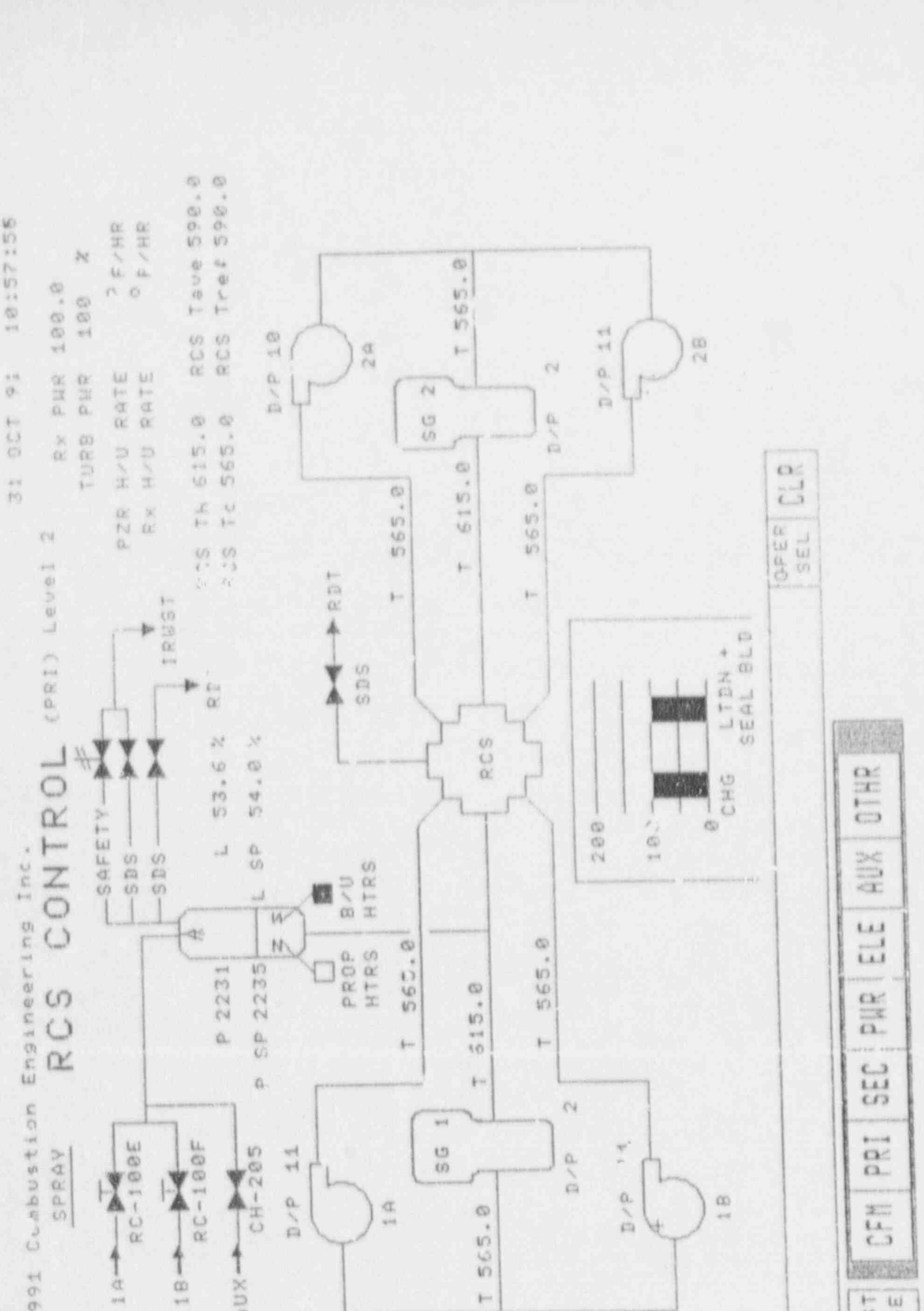
Figure 18.7.1-11



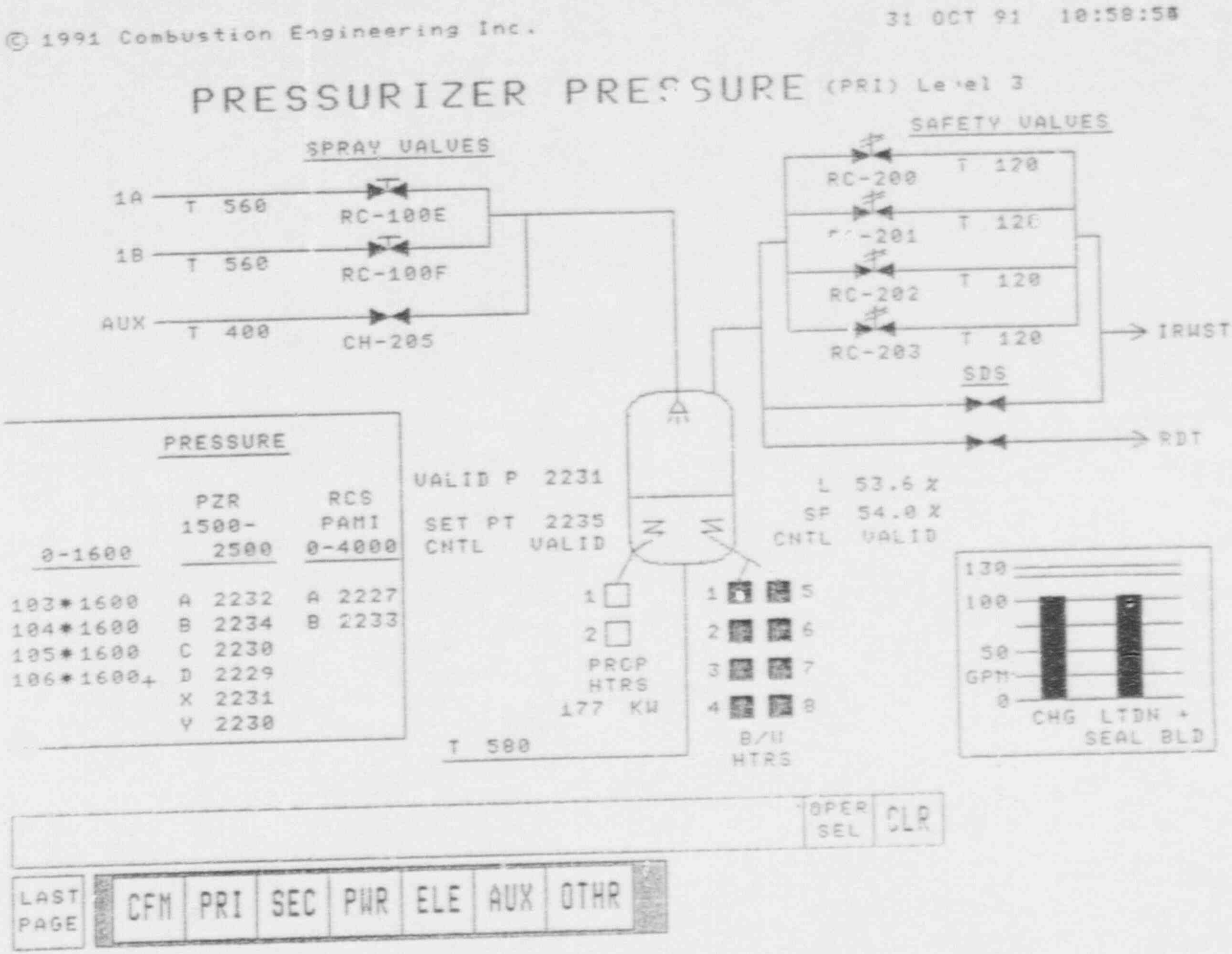
System 80+™

PRIMARY SYSTEMS PAGE (LEVEL 1)

Figure 18.7.3-1



SYSTEM 80+™	RCS CONTROL PAGE (LEVEL 2)	Figure 18.7.3-2

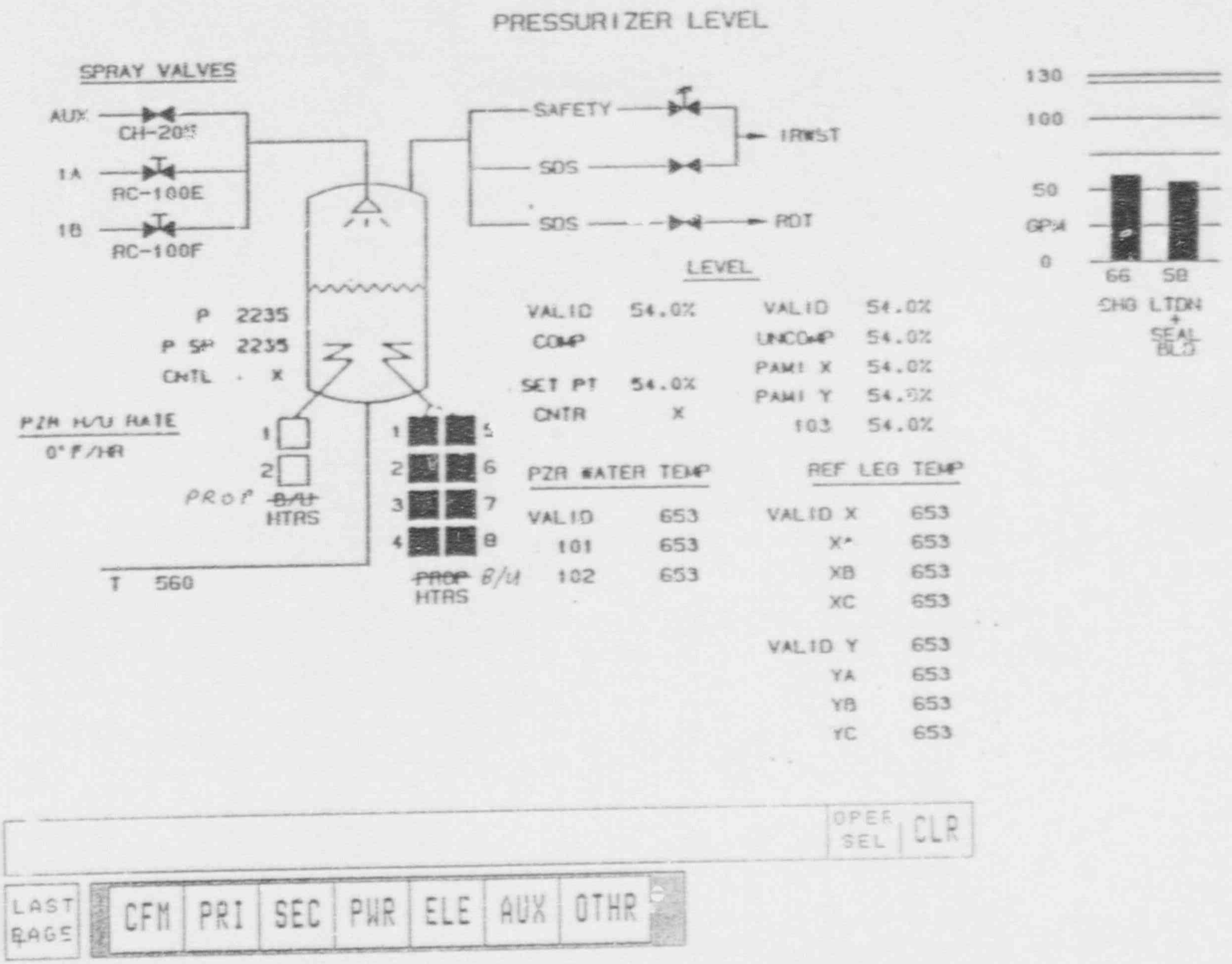


SYSTEM 80+

PRESSURIZER PRESSURE DIAGNOSTIC PAGE (LEVEL 3)

Figure 18.7.3-3

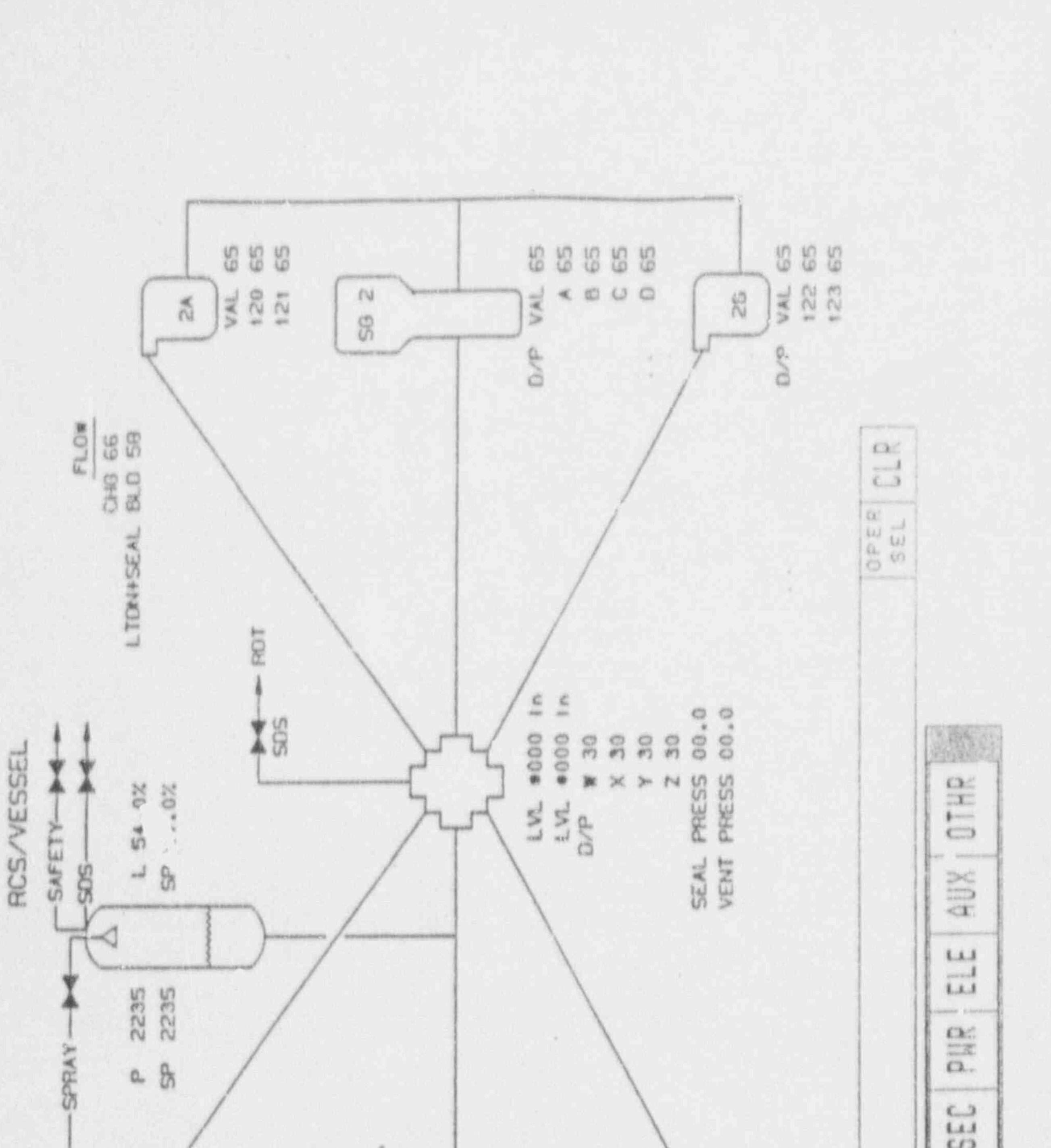
Page 153



SYSTEM 80+™

PRESSURIZER LEVEL DIAGNOSTIC PAGE (LEVEL 3)

Figure 18.[illegible].3-4



SYSTEM 80+™

RCS/VESSEL DIAGNOSTIC PAGE (LEVEL 3)

Figure 18.7.3-5

RCS TEMP

RCS Tave
VALID 590.0

RCS Tcold
VAL 565.0

RANGE	LEG 1A	LEG 1B	LEG 2A	LEG 2B
	COLD LEG 1 VAL 565.0		COLD LEG 2 VAL 565.0	
CALC	VAL 565.0	VAL 565.0	VAL 565.0	VAL 565.0
465-615	A 565.0	B 565.0	A 565.0	B 565.0
	C 565.0	D 565.0	C 565.0	D 565.0
PAMI				
50-750	A 565.0	B 565.0	A 565.0	B 565.0

RCS Thot
VAL 615.0

RANGE	LOOP 1	LOOP 2
CALC	VAL 615.0	VAL 615.0
525-675	A 615.0	A 615.0
	B 615.0	B 615.0
	C 615.0	C 615.0
	D 615.0	D 615.0
PAMI		
50-750	A 615.0	A 615.0
	B 615.0	B 615.0

OPER SEL | CLR

LAST PAGE | CFM | PRI | SEC | PWR | ELE | AUX | OTHR

SYSTEM 80+™

RCS TEMPERATURE DIAGNOSTIC PAGE (LEVEL 3)

Figure 18.7.3-6

SYSTEM 80+™

RCP 1A/1B CONTROL PAGE (LEVEL 2)

RCP 1A, 1B CONTROL

1A

CURRENT	400
D/P	65
SEAL INJ FLOW	7.0
SEAL BLEED FLOW	2.0
SEAL INLET PRESS (1)	2235
(2)	1305
(3)	505
MTR UPR OIL RSVR L	1.5 IN
MTR LWR OIL RSVR L	1.0 IN
PP BRG OIL RSVR L	5.0 IN
OIL LIFT TK LEVEL	+0.2 IN

OIL PUMP   SPACE HEATERS

ESSENTIAL COOLING WATER FLOW	501
LOOSE PARTS MONITORING SYSTEM	ON

1B

CURRENT	400
D/P	65
SEAL INJ FLOW	7.0
SEAL BLEED FLOW	2.0
SEAL INLET PRESS (1)	2235
(2)	1305
(3)	505
MTR UPR OIL RSVR L	1.5 IN
MTR LWR OIL RSVR L	1.0 IN
PP BRG OIL RSVR L	5.0 IN
OIL LIFT TK LEVEL	+0.2 IN

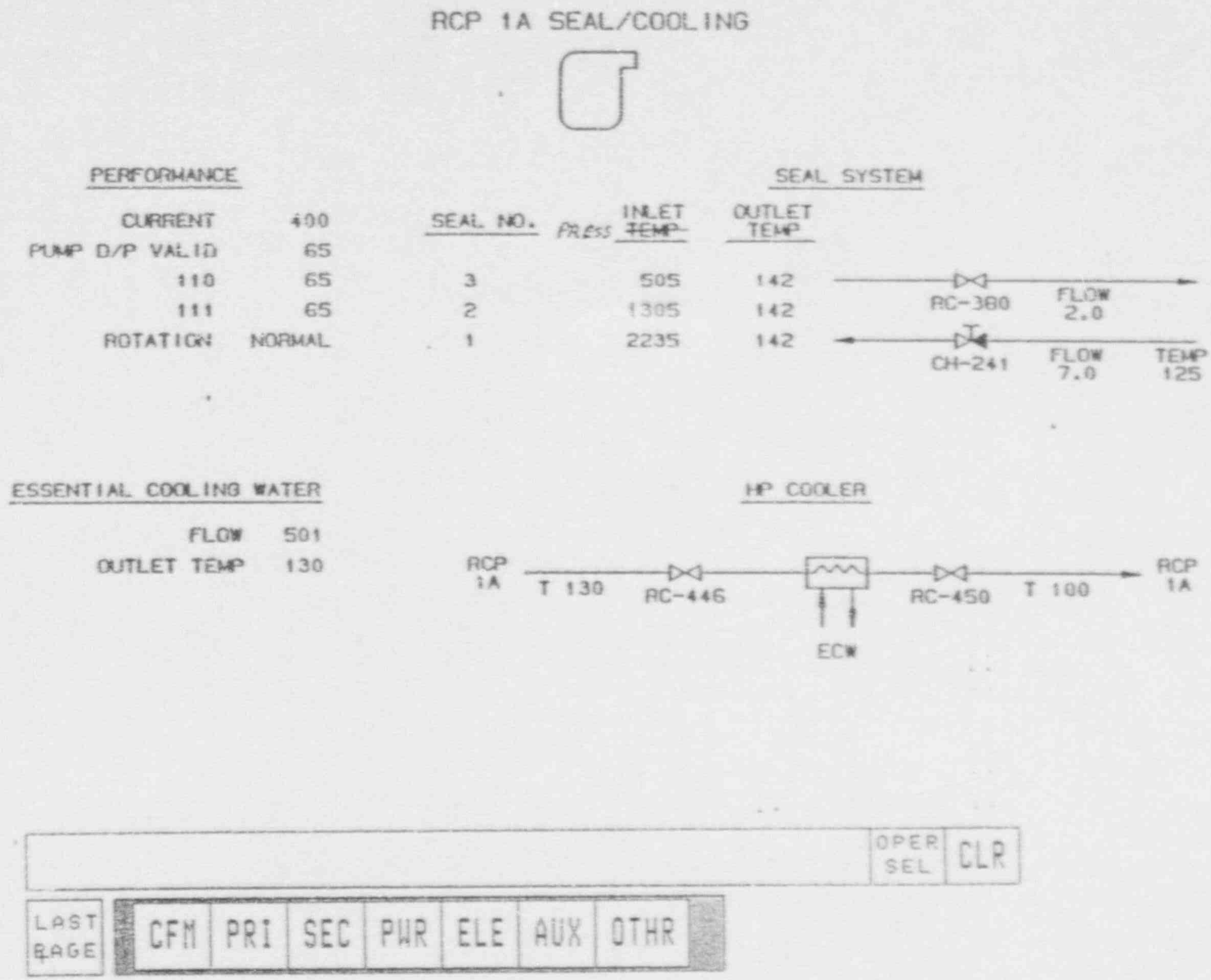
OIL PUMP   SPACE HEATERS

ESSENTIAL COOLING WATER FLOW	501
LOOSE PARTS MONITORING SYSTEM	ON

OPER SEL | CLR

LAST PAGE | CFM | PRI | SEC | PWR | ELE | AUX | OTHR

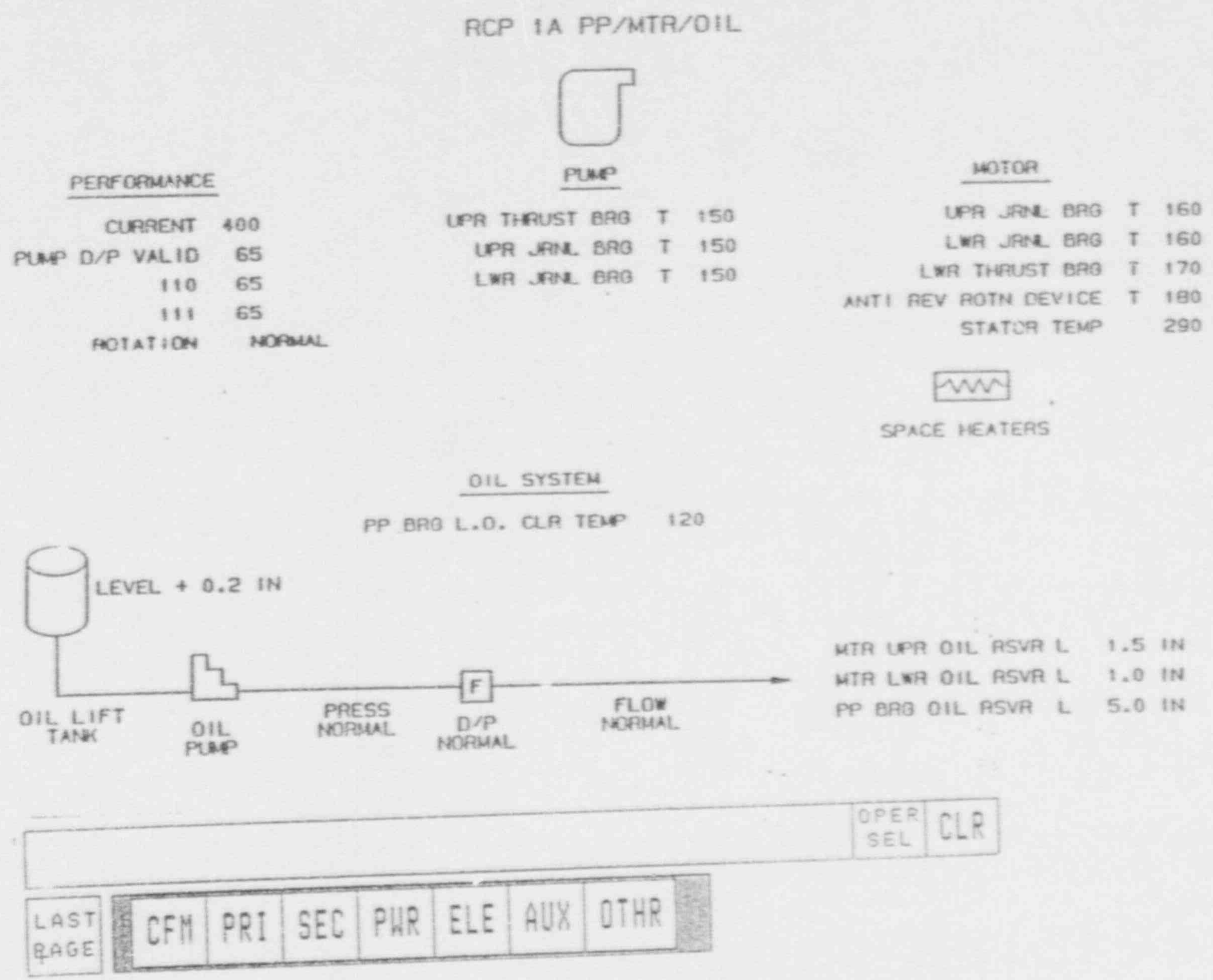
Figure 18.7.3-7



SYSTEM 80+™

RCP 1A SEAL/COOLING DIAGNOSTIC PAGE (LEVEL 3)

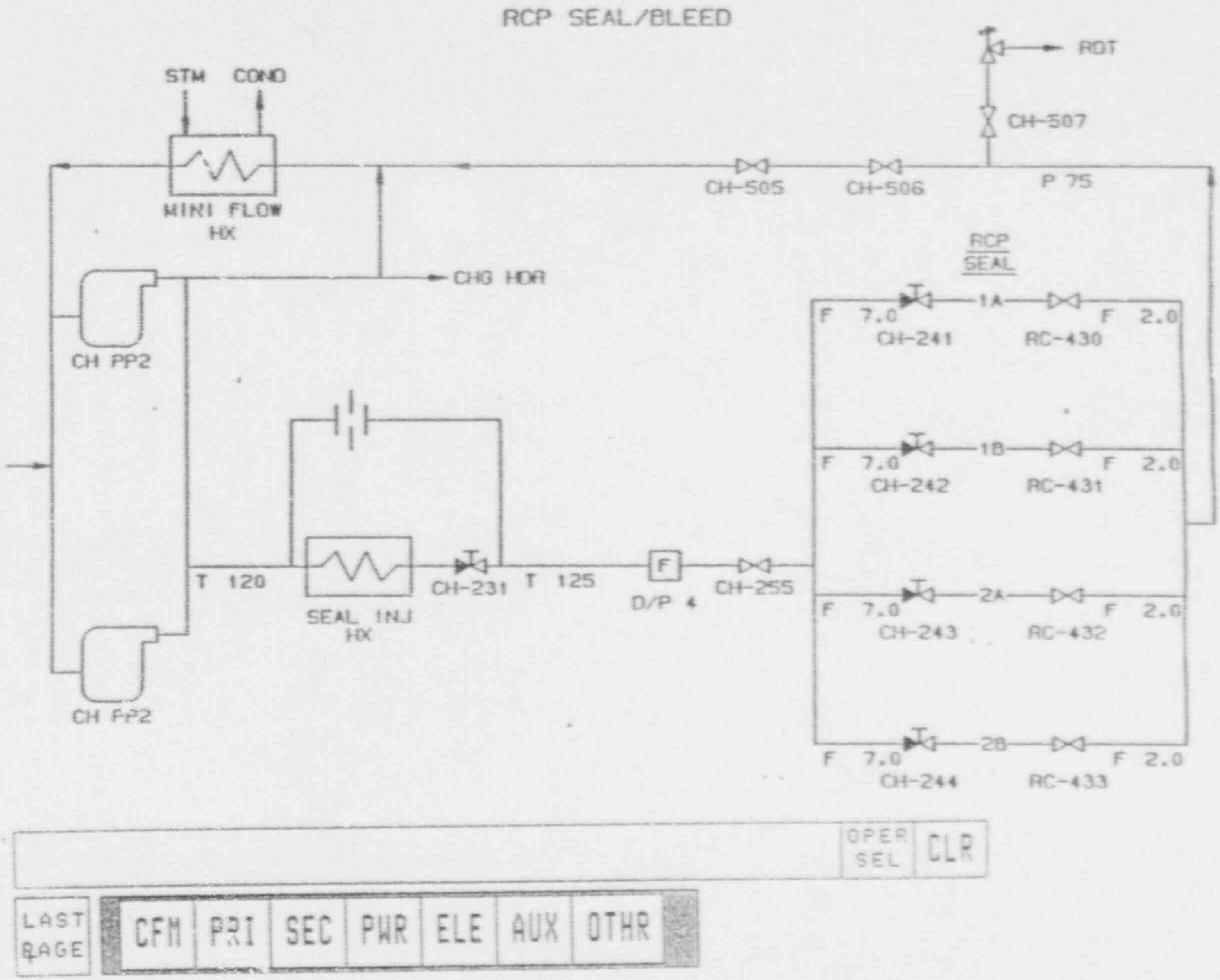
Figure 18.7.3-8



SYSTEM 80+™

RCP 1A PUMP, MOTOR AND OIL SYSTEM DIAGNOSTIC PAGE (LEVEL 3)

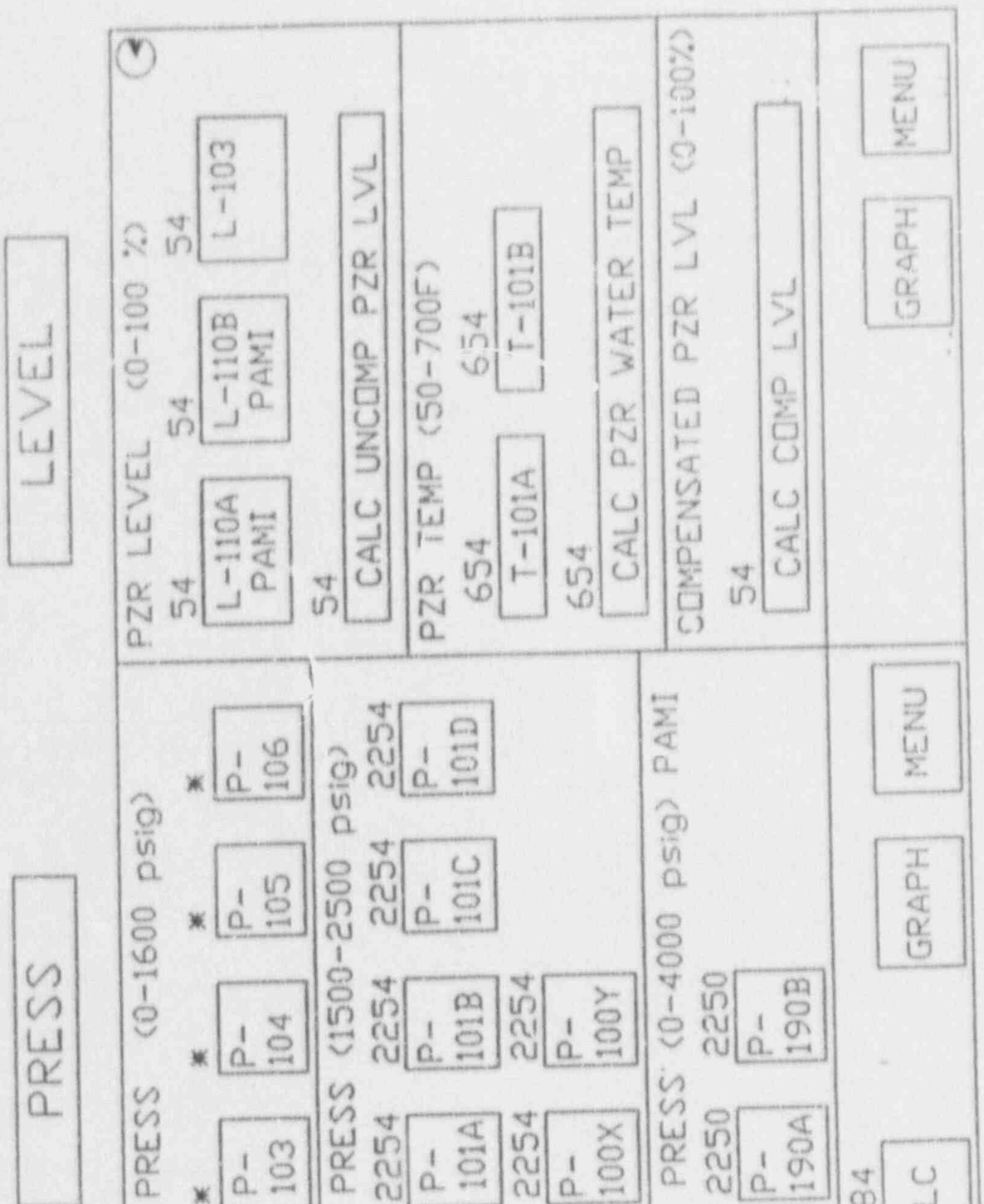
Figure 18.7.3-9



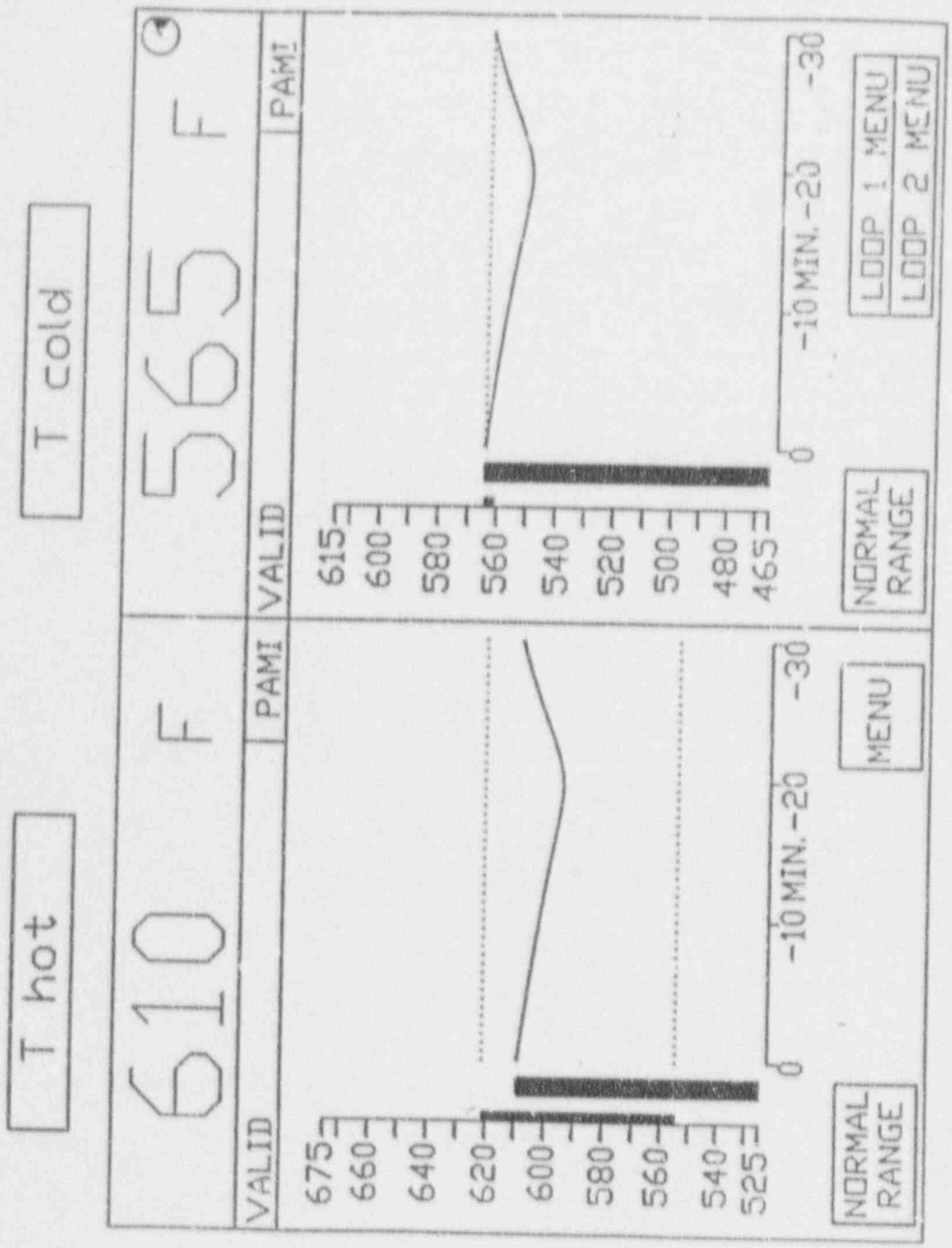
SYSTEM 80+™

RCP SEAL/BLEED SUBSYSTEM
DIAGNOSTIC PAGE (LEVEL 3)

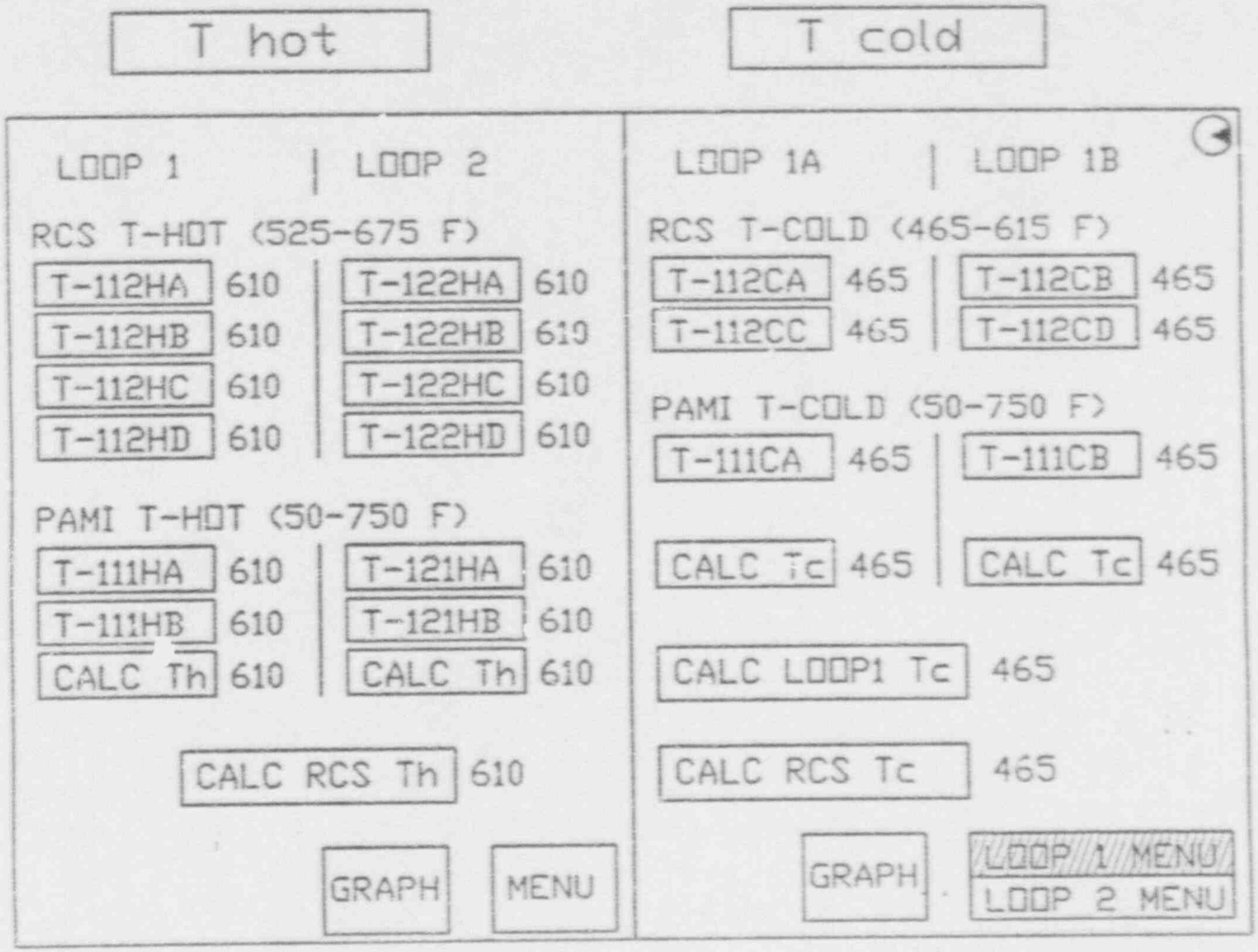
Figure 18.7.3-10



SYSTEM 80+™	PRESSURIZER PRESSURE AND LEVEL MENU PAGES FOR DIAS	Figure 18.7.3-11



SYSTEM 80+™	T_{HOT} AND T_{COLD} TREND PAGES FOR DIAS	Figure 18.7.2-17

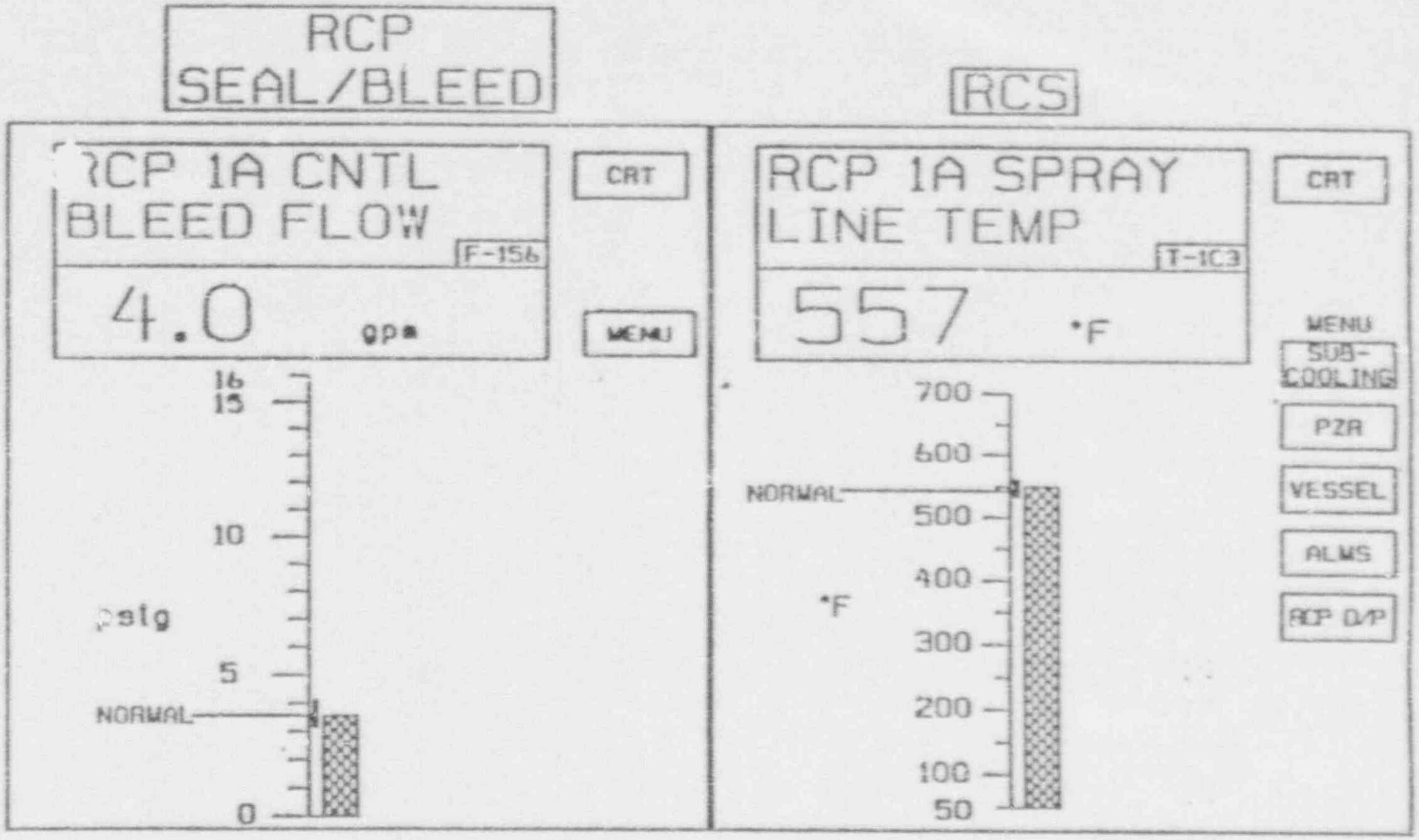


SYSTEM 80+™

THOT AND TCOLD MENU PAGES FOR DIAS

Figure 18.7.3-13

Actual Implementation will be similar to Figures 28-32



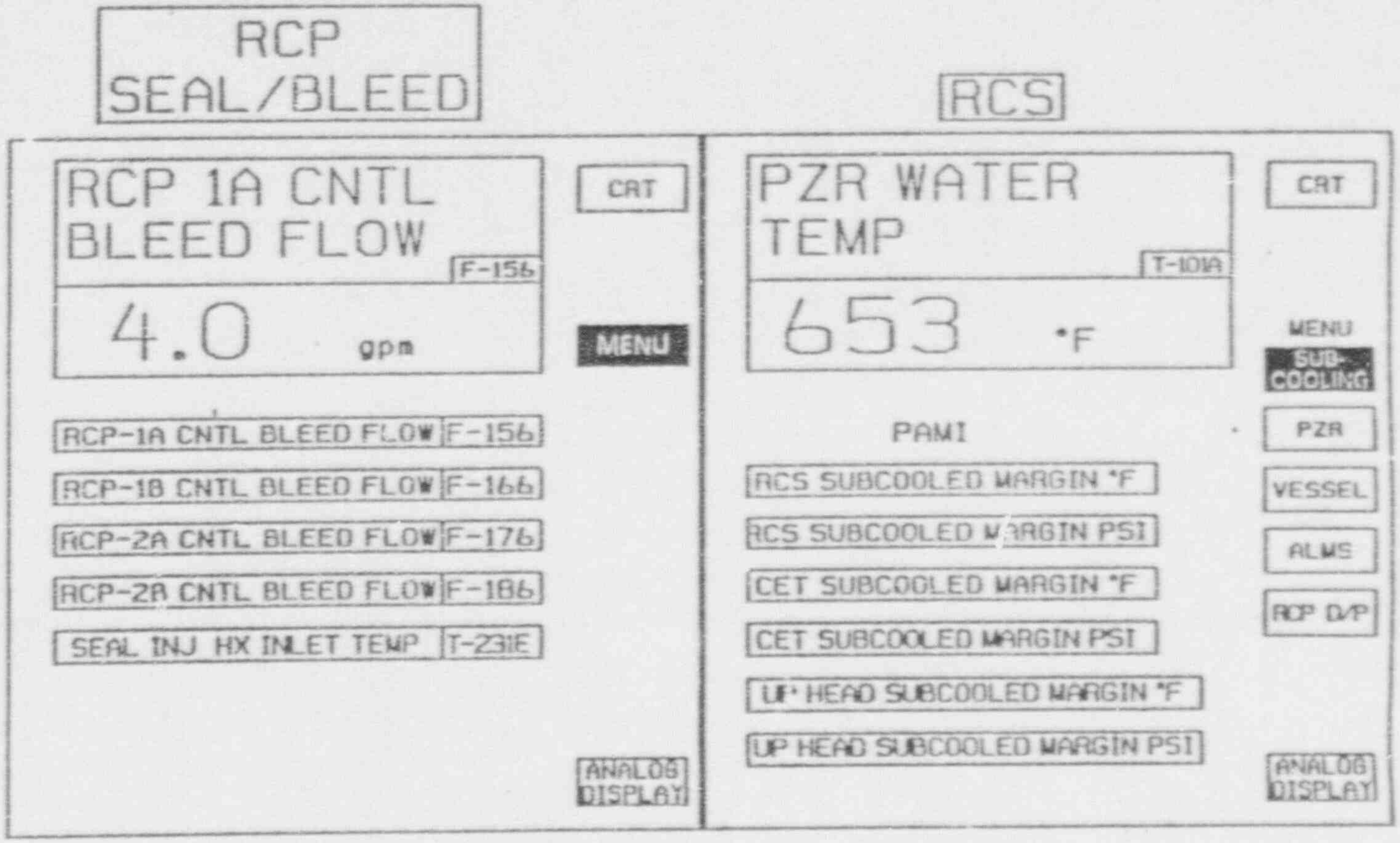
NPS-PANELFRONTS (SHT5)

SYSTEM 80+™

RCP SEAL/BLEED AND RCS DIAS DISPLAYS

Figure 18.7.3-14

Actual Implementation will be similar to Figures 28-32



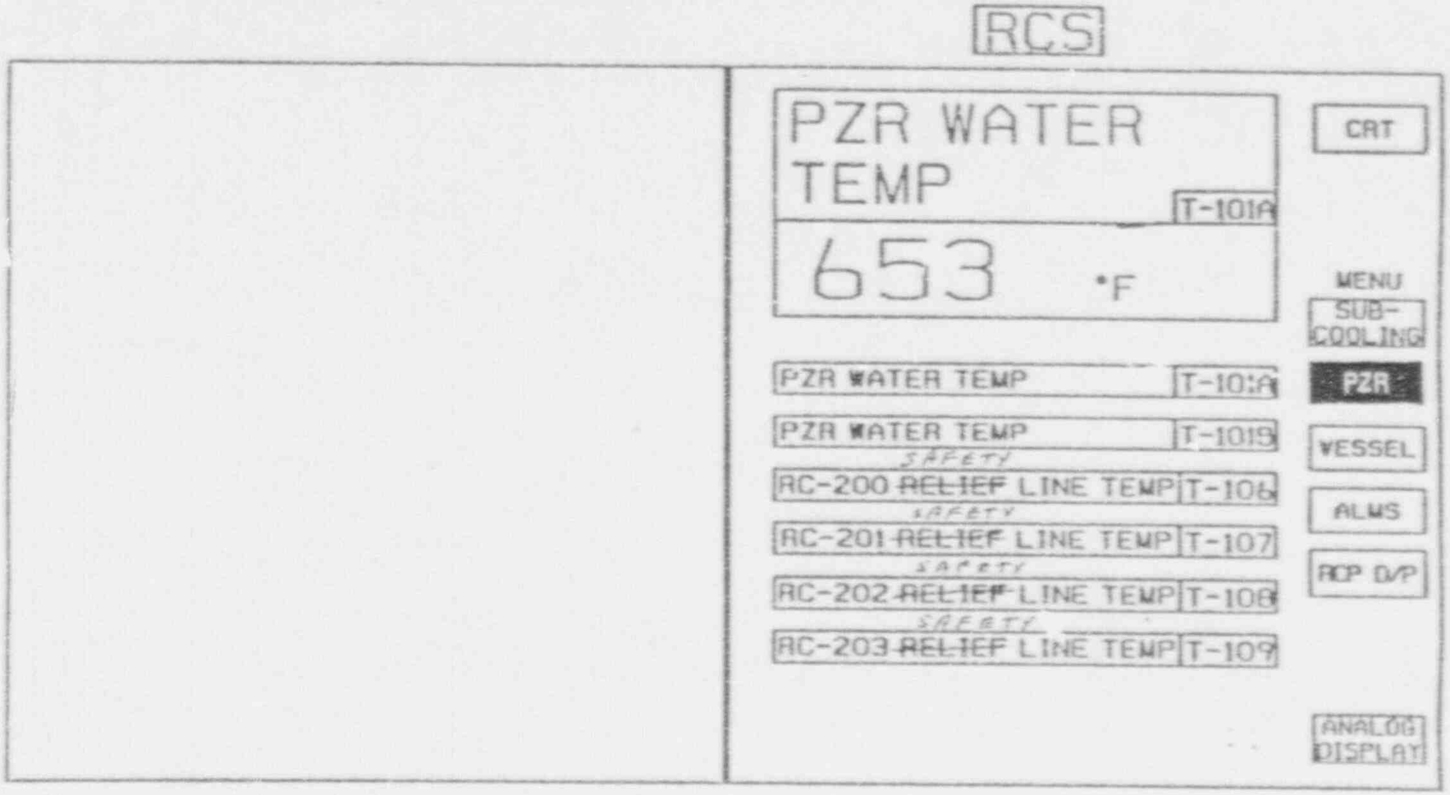
NPS-PANELFRONTS (SI .3)

SYSTEM 80+

RCP SEAL/BLEED AND RCS SUBCOOLING MENU PAGES

Figure 18.7.3-15

Actual Implementation will be similar to Figures 28-32



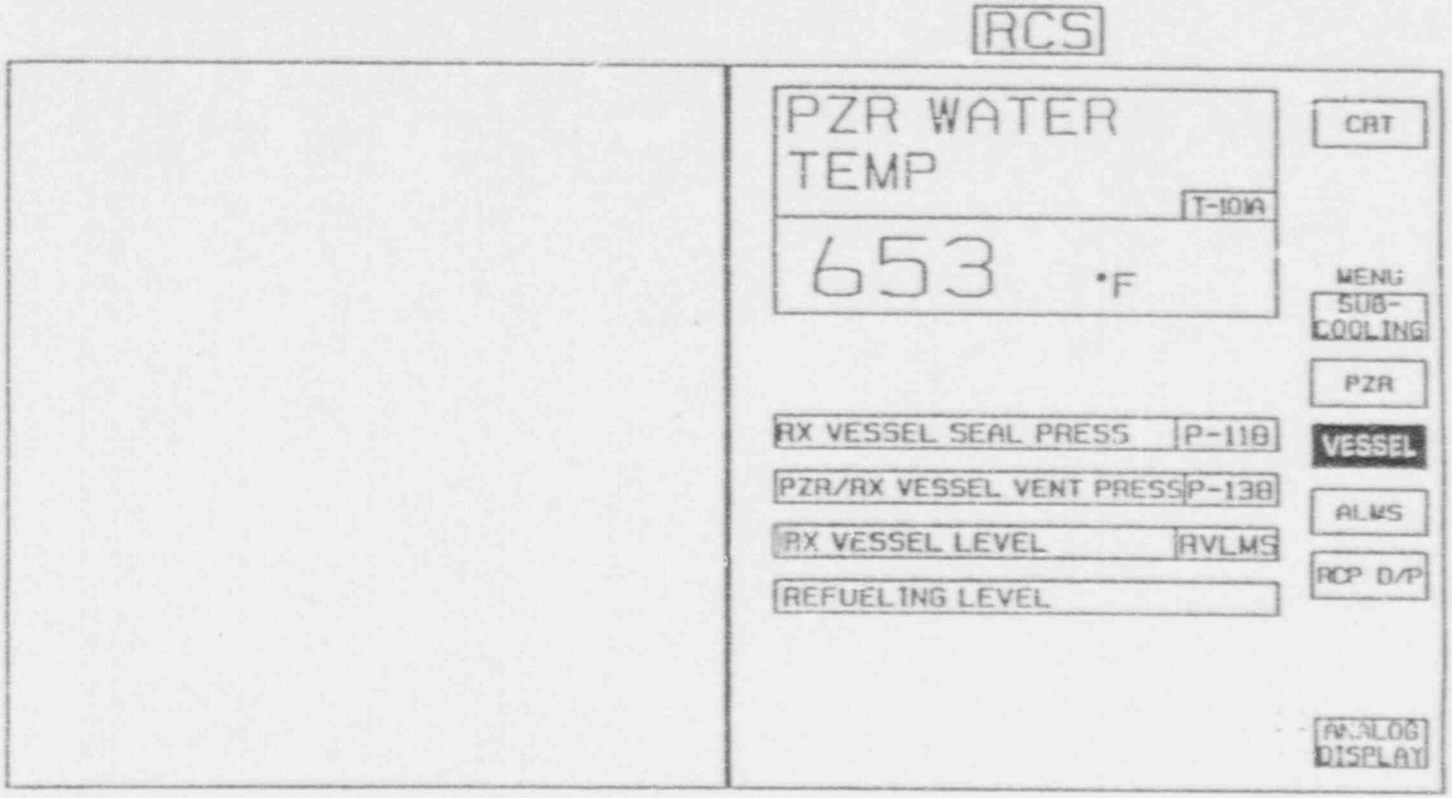
NPS-PANELFRONTS (SHT14)

SYSTEM 80+™

RCS PRESSURIZER MENU PAGE

Figure 18.7.3-16

Actual Implementation will be similar to Figures 28-32



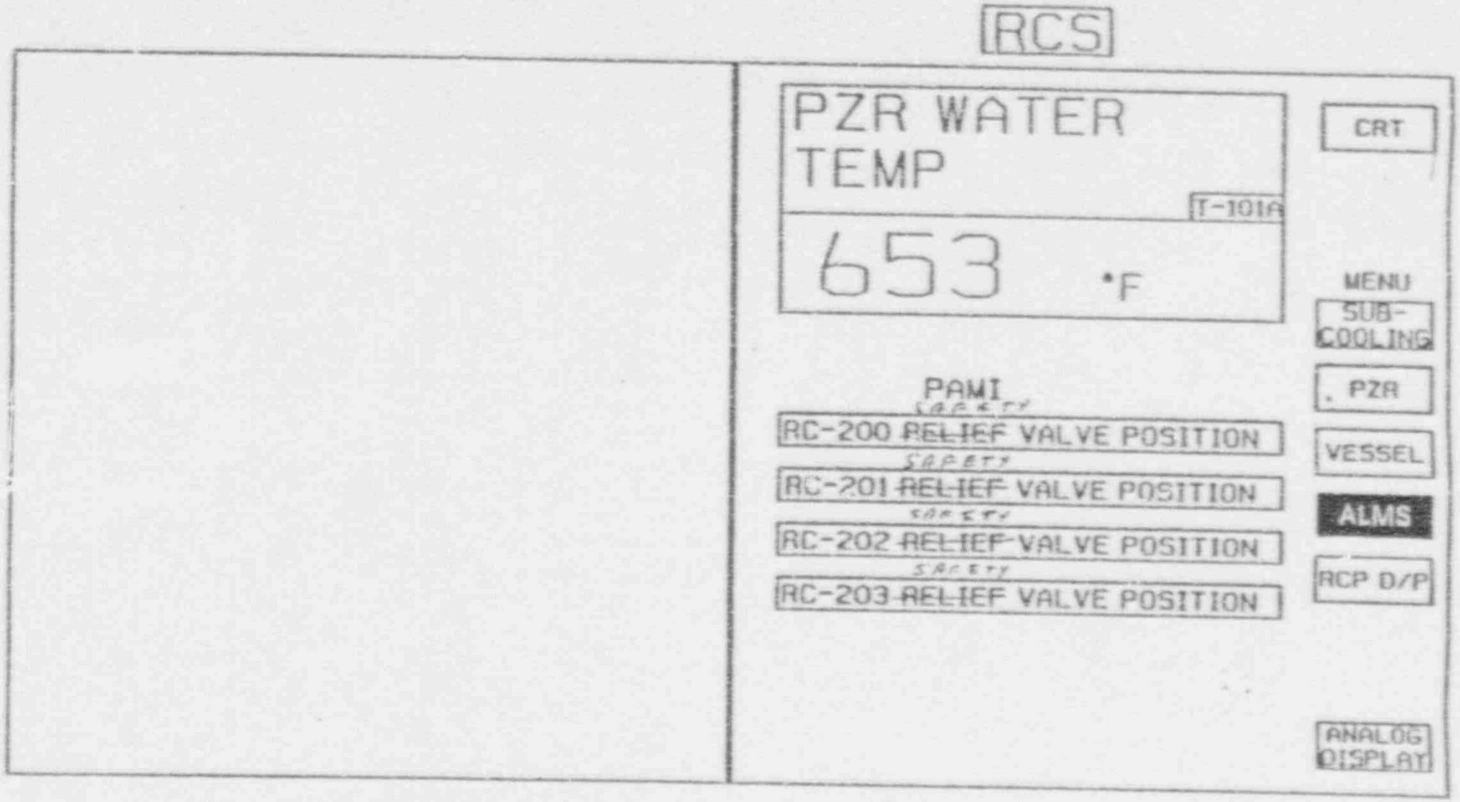
NPS-PANELFRONTS (SHT15)

SYSTEM 80+™

RCS VESSEL MENU PAGE

Figure 18.7.3-17

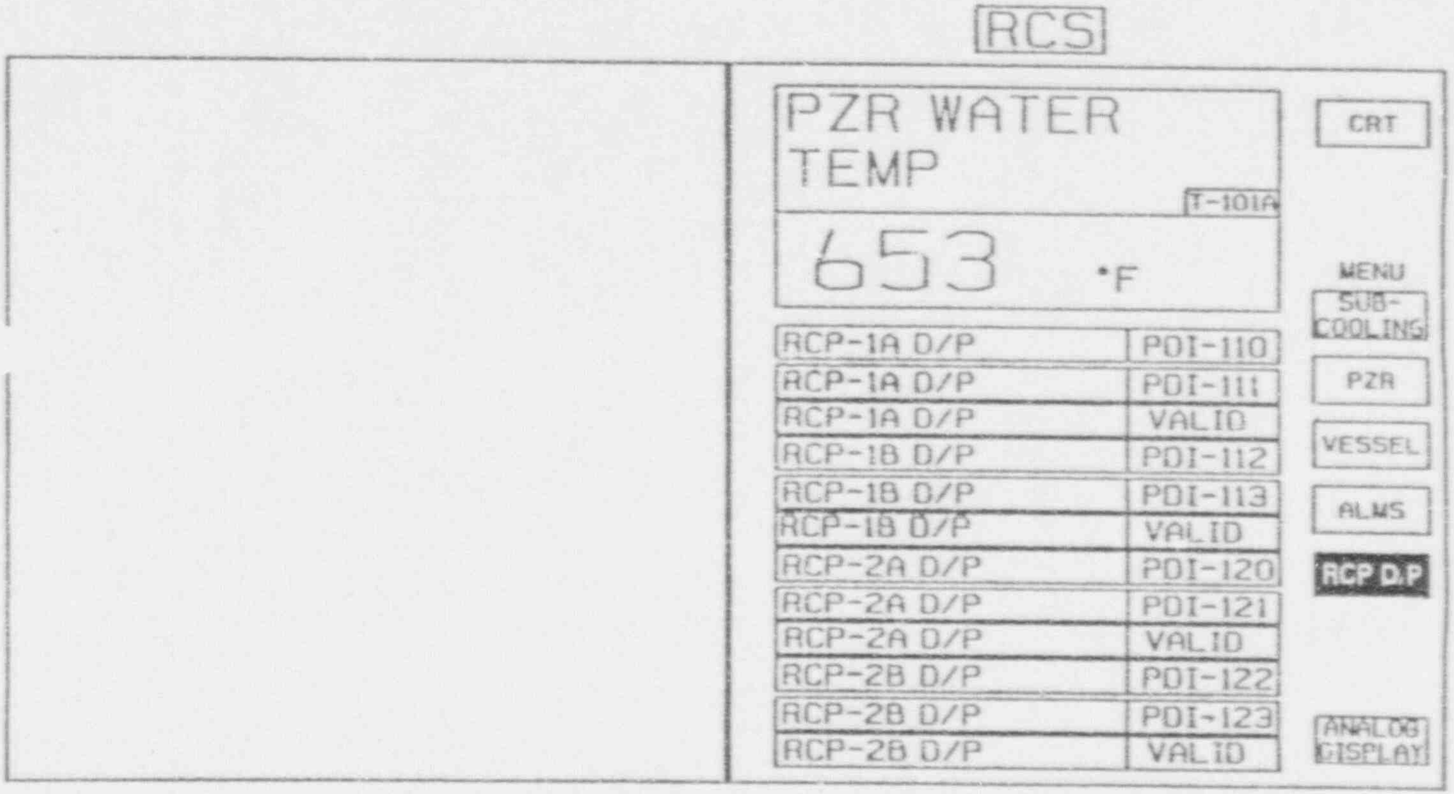
Actual Implementation will be similar to Figures 28-32



NPS-PANELFRONTS (SHT16)

SYSTEM 80+™ | RCS ACOUSTIC LEAK MONITORING SYSTEM MENU PAGE | Figure 18.7.3-18

Actual Implementation will be similar to Figures 28-32.

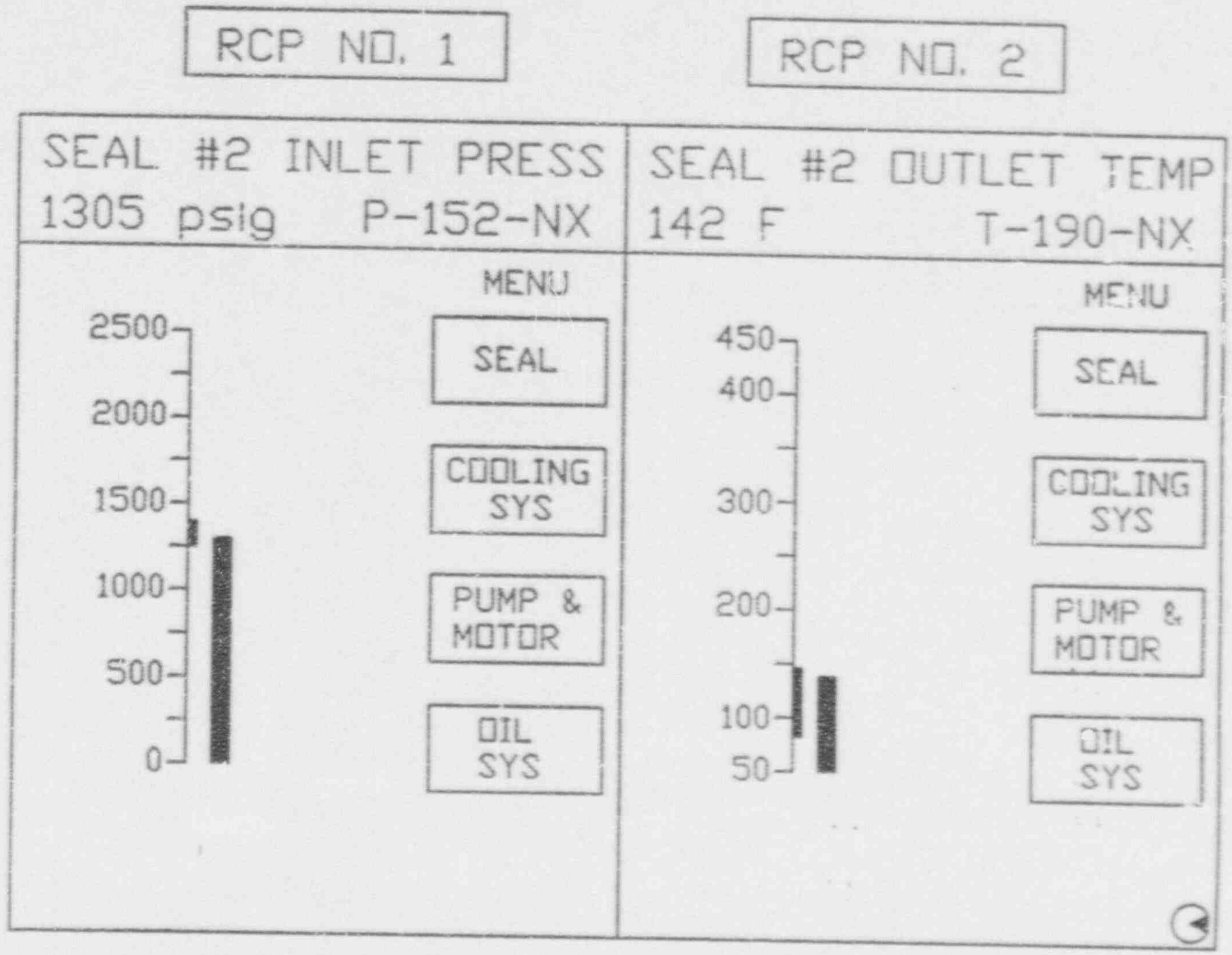


NPS-PANELFRONTS (SHT17)

SYSTEM 80+™

RCS RCP D/P MENU PAGE

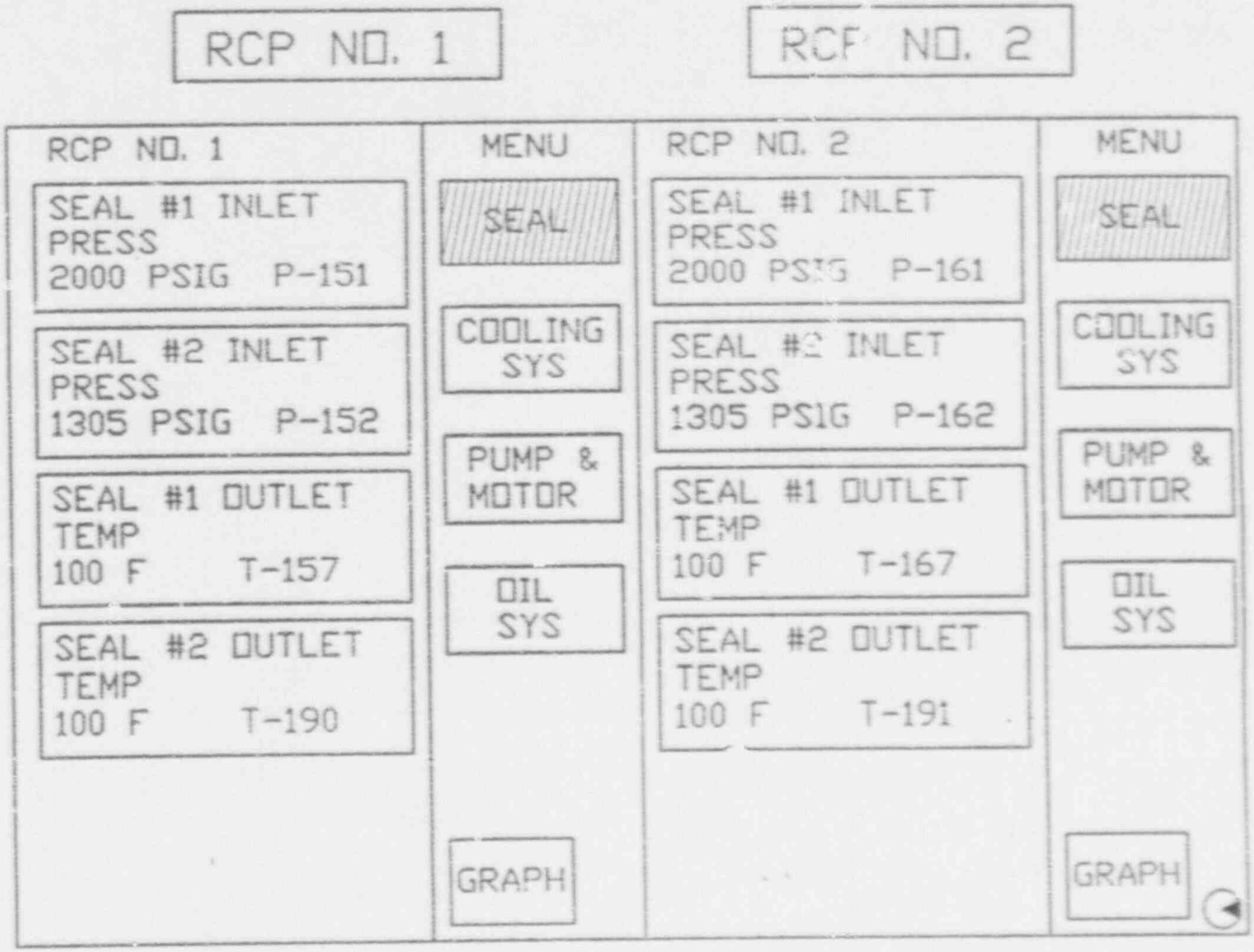
Figure 18.7.3-14



SYSTEM 80+™

RCPS 1A AND 1B TYPICAL ANALOG DISPLAY

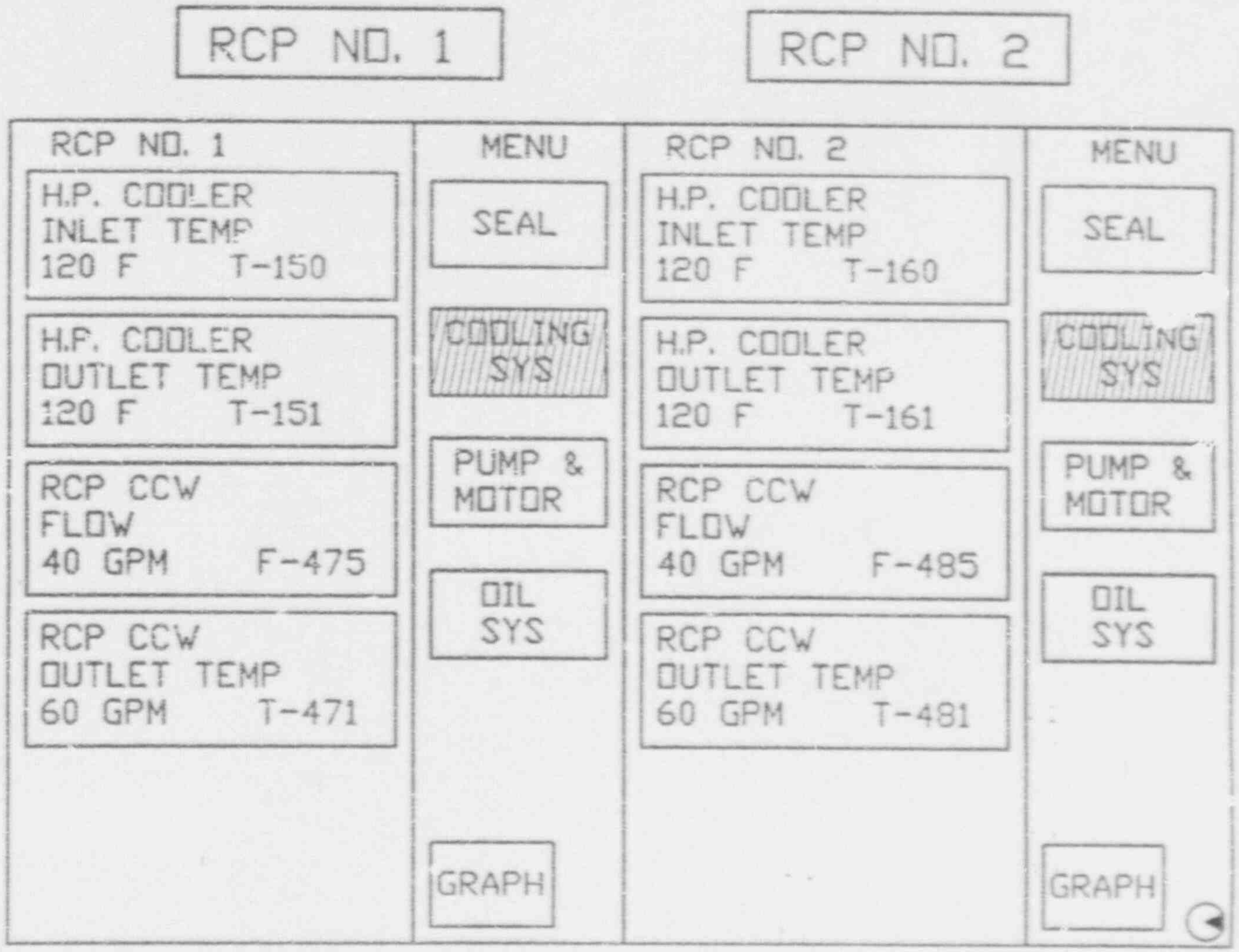
Figure 18.7.3-2L



SYSTEM 80+™

RCP 1A SEAL SYSTEM MENU PAGE

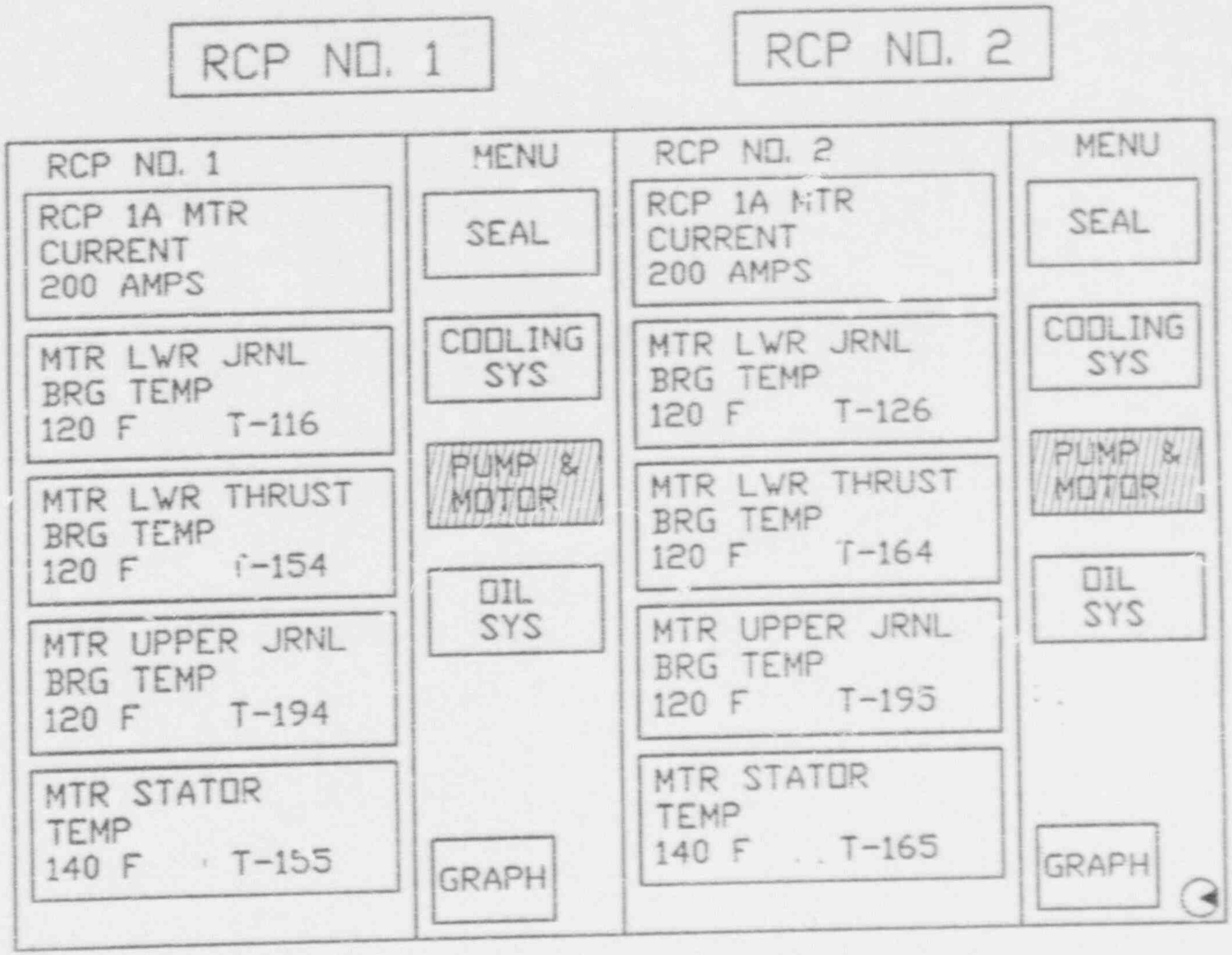
Figure 18.7.3-21



SYSTEM 80+™

RCP 1A COOLING SYSTEM MENU PAGE

Figure 18.7.3-22



SYSTEM 80+

RCP 1A PUMP/MOTOR MENU PAGE

Figure 18.7.3-23

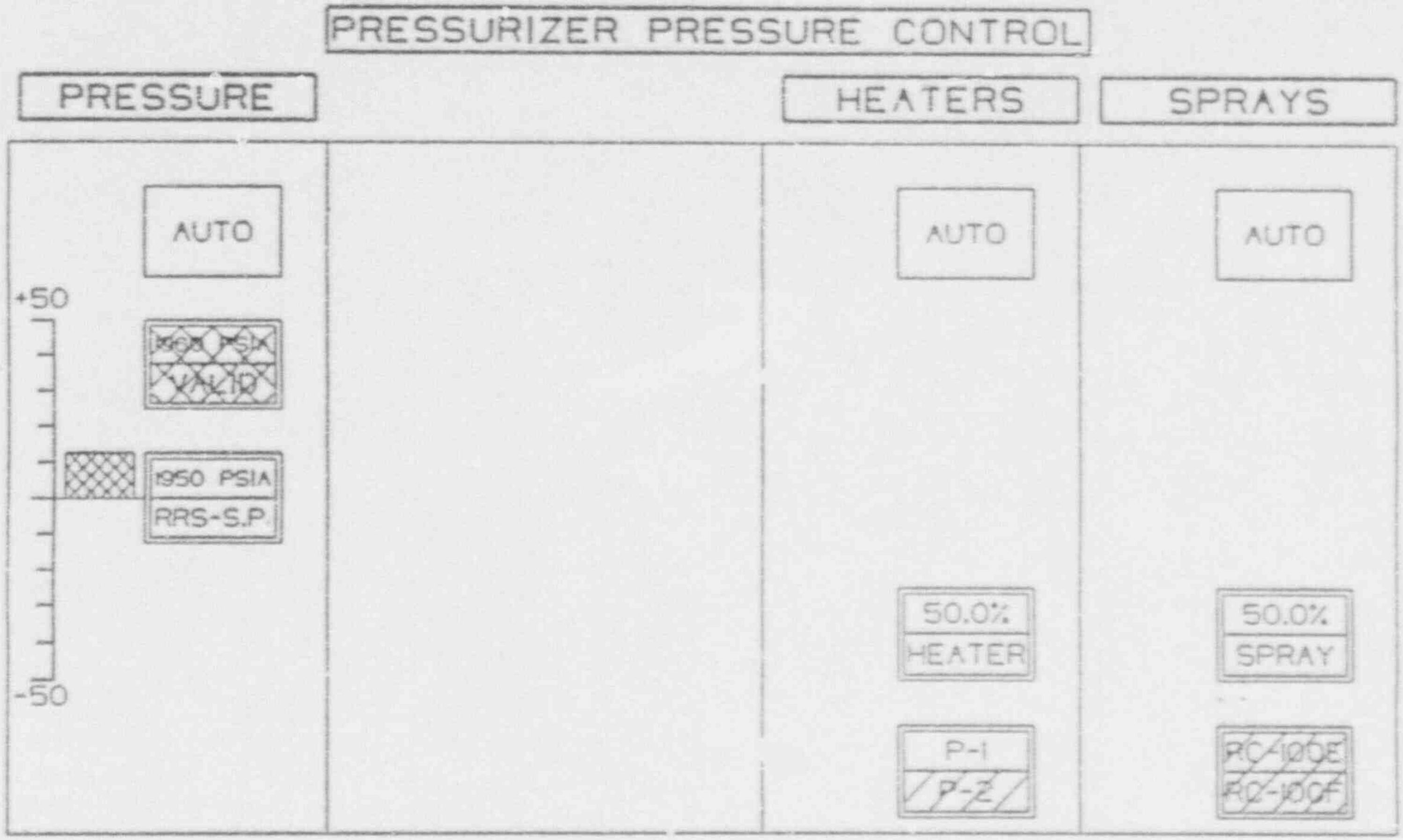


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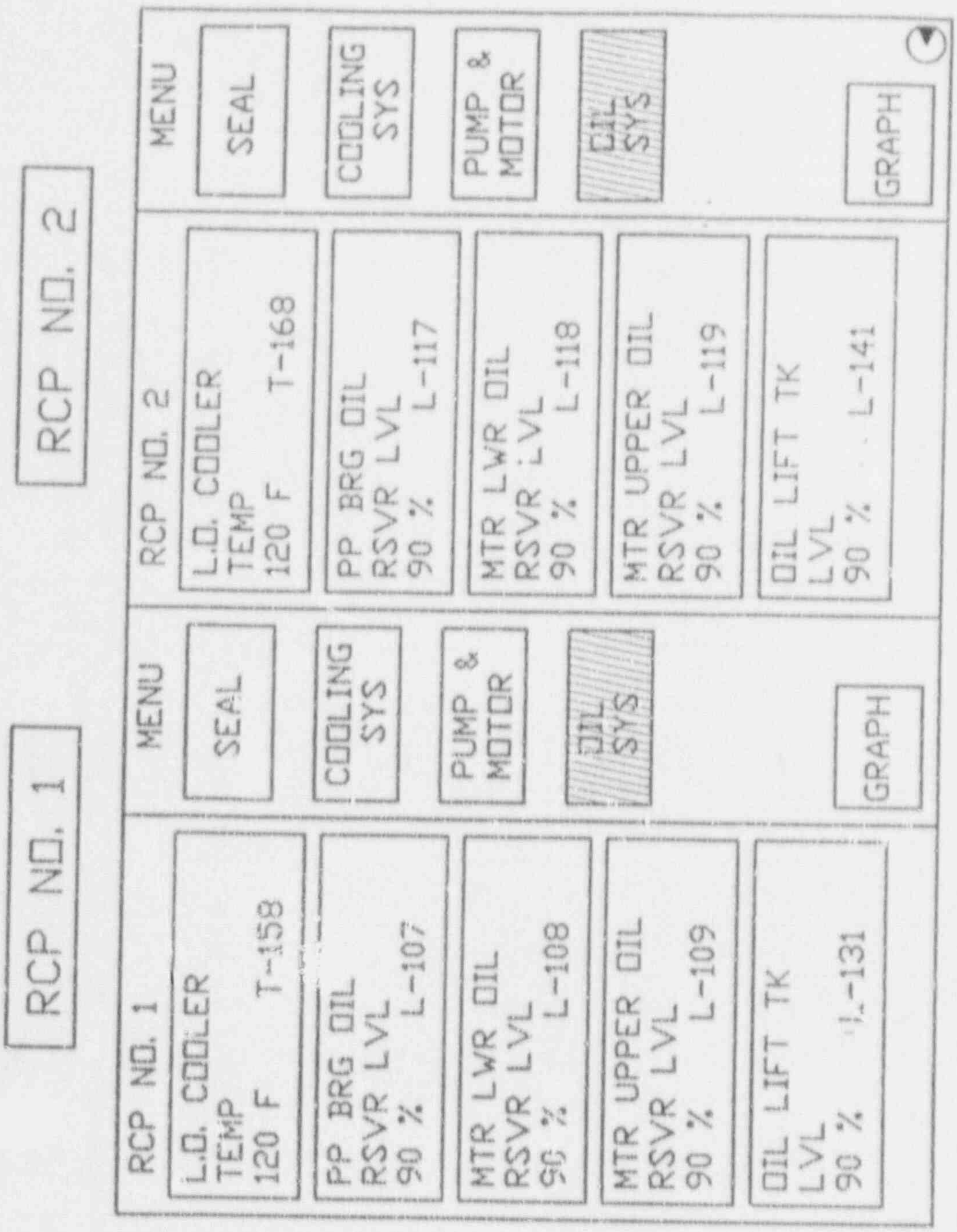
Figure

PRESSURIZER PRESSURE CONTROLLER



SYSTEM 80+™	RCP 1A OIL SYSTEM MENU PAGE	Figure 18.7.3-24

SYSTEM 80+

CCP ALARM TILES

Figure 18.7.3-5

RCP

RCP 1A SEAL	RCP 1B SEAL	RCP 2A SEAL	RCP 2B SEAL	
RCP 1A COOLING SYS	RCP 1B COOLING SYS	RCP 2A COOLING SYS	RCP 2B COOLING SYS	
RCP 1A PUMP/ MOTOR	RCP 1B PUMP/ MOTOR	RCP 2A PUMP/ MOTOR	RCP 2B PUMP/ MOTOR	
RCP 1A SEAL/OIL SYS	RCP 1B SEAL/OIL SYS	RCP 2A SEAL/OIL SYS	RCP 2B SEAL/OIL SYS	

Actual Implementation same as Figure 4. (18.7.1-10)
No revised picture available.

Actual Implementation Format Same as Figure 8.

TIME SEQUENTIAL ALARM LIST

DATE: 9 NOV 88
TIME: 08:00:08

DESCRIPTION	PRIO	VALUE / SET POINT	POINT ID	TIME
PRESSURIZER LEVEL HI	2	58% / 57	VALID	08:00:07
PRESSURIZER RELIEF (RC-202) TO RDT TEMP HI	2	160°F / 150	TI-107	08:00:06
PRESSURIZER RELIEF (RC-201) TO RDT TEMP HI	2	168°F / 150	TI-106	08:00:05
PRESSURIZER PRESSURE HI	1	2500 PSIG / 2360	ALMS	08:00:04
PRESSURIZER SAFETY	1	OPEN / N/A	VALID	08:00:03
PRESSURIZER PROPORTIONAL HEATER NO. 2	3	FAIL / N/A	GP2	08:00:02
PRESSURIZER PROPORTIONAL HEATER NO. 1	3	FAIL / N/A	GP1	08:00:01

END OF ALARMS

OPER SEL | CLR

LAST PAGE | CFM | PRI | SEC | PWR | ELE | AUX | OTHR

SYSTEM 80+™

TIME SEQUENTIAL ALARM PAGE

Figure 18.7.3-38

PMS019.WP-1

ABSTRACTS OR SUMMARIES

HALDEN REACTOR REPORTS

HWR-158	Integrated Process Status Overview (IPSO): Status Report
HWR-184	Further Evaluation Exercises with the IPSO
HWR-213	Success Path Monitoring System (PMS)
HWR-222	SPM System Description and Implementation Base
HWR-223	SPMS Design and Methodology
HWR-224	SPMS Results and Concerns

HWR-158

INTEGRATED PROCESS STATUS OVERVIEW (IPSO): STATUS REPORT

ABSTRACT

This report summarizes findings to date with the IPSO, a large plant status overview currently under development at the OECD Halden Reactor Project. As part of a joint Halden and Combustion Engineering project, the overview is being tested in part to determine whether the large screen overview concept being entertained for use in the nuclear power plant(NPP) industry will facilitate operator performance. To this end an interactive simulation technique was used to establish a proof-of-principle test for the IPSO. Process control, operations, and human factors experts at Halden participated in the test and evaluation. Five subjects well versed in the NORS PWR simulator made use of the NORS display formats in conjunction with the IPSO overview. Results show that even with limited training, a properly designed large format overview supports positive operator performance. Accurate detection and diagnoses were noted for all conditions tested and subjects were able to make good use of the detailed process formats. Analysis of post-test questionnaire responses suggests that IPSO highlighted plant systems, pointing the subjects toward lower level formats, and providing them with an adequate update rate for plant process data. Data presented herein also provide information regarding strengths and weaknesses of the current IPSO design. Additional, in depth testing of the IPSO system will be conducted later in 1986.

HWR-184
FURTHER EVALUATION EXERCISES WITH THE IPSO

Abstract

The recent trend towards the presentation of process information on relatively small CRT screens which must be addressed sequentially, has stimulated interest in the potential benefits of providing operators with a computer-generated overview of plant and process status. One approach to this question has been pursued at the Halden Project with the development, in cooperation with Combustion Engineering, of the large screen Integrated Process Status Overview (IPSO). The preliminary "proof of principle" study reported in HWR-158 indicated that the IPSO could help operators in the detection and diagnosis of plant disturbances, and subject operators responded favourably to the concept of a large screen overview display.

This report describes two further evaluation exercises with the IPSO. The first experiment reported here investigates five individual subjects' use of the IPSO during three phases of operation - transient handling, plant manipulation and monitoring - as they perform a realistic control room task involving running up both NORS turbines. The task lasted for more than two hours, during which two transients were inserted into the process. The results show that the IPSO was used most frequently during monitoring, and subjects felt the display was more suited to normal than abnormal operations. Although subjects regarded the size of the display as an advantage they were critical of certain aspects of its design and content.

The second experiment investigates use of the IPSO by a team of three operators, as it has been suggested that a potential benefit of the IPSO is that it might act as a focal point for crew decision- making. The team was exposed to nine static snapshots of the NORS process presented in three display conditions; IPSO, IPSO plus text alarm list and NORS formats plus text alarm list. The snapshots showed the plant in different stages of normal operation or affected by transients, and the team was required to ascertain the plant state. Although few systematic differences between performance in the three display conditions were observed, the IPSO facilitated a rapid impression of plant state, and promoted lively discussion between crew members.

The findings of the two experiments reinforce the support for a large screen plant overview in the control room. However, a number of qualifications were raised regarding the content of the IPSO. Subjects expressed a desire for more process and alarm information on the display. A future possibility is the large screen presentation of the HALO alarm overview, the content of which has been more favourably received than the IPSO.

HWR-213

SUCCESS PATH MONITORING SYSTEM (SPMS)

ABSTRACT

The Success Path Monitoring System is an advanced computer-based operator aid which is intended to enhance the operator's ability to handle plant disturbances effectively. It achieves this by providing an on-line assessment of both the status of critical safety functions and the status of appropriate success paths for correcting any threat to the critical functions. In order to obtain a systematic evaluation of the system, a prototype version has been implemented on the Halden Project's PWR simulator. This report describes the development of the system and its implementation at Halden, it also provides an outline of the proposed full-scale evaluation experiment which is to be carried out later in 1987.

SPM SYSTEM DESCRIPTION AND IMPLEMENTATION BASE

1. INTRODUCTION

One goal of the "NORS-HAMMLAB Success Path Monitoring System project" was to develop a working prototype of a plant monitoring system based on the Critical Safety Function - Success Path concept and to integrate this system with the existing NORS/HAMMLAB computerised control room systems. The other major goal was to evaluate the performance of operators utilising this SPMS prototype version by way of simulator experiments in the Halden Man Machine Laboratory.

To accomplish these goals, a prototype version of the SPMS was implemented in the NORS/HAMMLAB control room incorporating critical safety function and success path algorithms. These algorithms perform the analyses which determine the status of 4 critical safety functions and 11 different success paths. To construct the success path algorithms, a plant expert defined the structure of the algorithms in terms of the availability and performance of the various systems and components which, when utilised, constitute a success path.

The objective of this report is first to give a description of the NORS-SPMS system components, the algorithms, the displays and interaction methods and how the system was integrated with the existing control room systems. Next, the implementers' experience with this task are discussed from a system and process engineering point of view.

Note. The implementers' experience must be judged from the fact that they were working with an unfinished system - a prototype system. Their hope is that the comments are found useful by the designers of the SPMS system when they finalise it.

Finally, the report concludes with a discussion of issues which will be critical when putting the success path monitoring system into a real nuclear power plant control room.

The experimental methodology and the results from the evaluation experiment are given in (Baker88a) and (Baker88b).

2. SPMS BASIC CONCEPTS

A critical safety function is a plant function which must be accomplished in order to keep the plant in a safe and stable condition.

The methods which can be employed by the plant operator to accomplish these safety functions are defined as Success Paths.

For example, establishing natural circulation in the primary coolant system is considered to be a success path to accomplish the core heat removal critical safety function. The Success Path Monitoring System (SPMS) is envisioned as a real time operator aid which would provide the information necessary to monitor the status of the critical safety functions and to utilise the appropriate success paths.

The NORS Critical Safety Function and Success Path Algorithms are based on the Loviisa plant design. The critical safety function algorithms continuously monitor plant status to determine if the critical

HWR-223
SPMS DESIGN AND METHODOLOGY

ABSTRACT

The Success Path Monitoring System is an advanced computer-based operator support system which aims to provide an on-line assessment of both the status of critical safety functions and the status of success paths for correcting the threat to the critical functions. In order to obtain a systematic evaluation of the system, a prototype version has been installed on the Halden Project's PWR simulator. This report describes in detail the methodology and experimental procedure adopted for carrying out the evaluation, and provides an account of the training programme used to prepare subjects for participation in the study.

HWR-224
SPMS RESULTS AND CONCLUSIONS

ABSTRACT

The Success Path Monitoring System is an advanced computer-based operator support system which aims to provide an on-line assessment of both the status of critical safety functions and the status of success paths for correcting the threat to the critical functions. In order to obtain a systematic evaluation of the system, a prototype version has been installed on the Halden Project's PWR simulator. This report describes the results and conclusions from the study.

Three groups of experienced operators were carefully observed coping with a series of transients embedded in a realistic scenario in the simulator control room. Critical process parameters were recorded and the status of these was related to use of the information display systems available in the three conditions. Operator performance was evaluated on the basis of video recording and the simulator event log. Assessment was made in terms of the ideal response to the transient scenario, operator actions and time taken to complete actions. Operators were encouraged to comment on the system after the experiment and this provided valuable though more subjective, data about the system.

The experiment generated a great deal of valuable data but there has been limited time available for detailed analysis. Even so, it was felt that the results obtained so far have fulfilled the principal aims of the evaluation. Overall the results clearly illustrated quite distinct advantages of the Success Path Monitoring System, as currently implemented. Speed and accuracy of operator performance in taking appropriate corrective action was clearly superior with the SPMS and well up to prior expectations. Subsequently operators returned to take part in retention trials and static tests with revised SPMS formats. Results from these tests are also included.

TABLE 1 - DOCKETED DOCUMENTS

Document Number	Proprietary	Title	Submittal Status
NPX80-IC-DP-790-02	No	Nuplex 80+ Function and Task Analysis Report	A
NPX80-IC-SD-791-01	Yes	Nuplex 80+ Control Complex Information Systems Description	P
NPX80-IC-TE-790-01	No	Nuplex 80+ Verification, Analysis Report	A
Draft (LATER)	N/A	[ALWR] HF Standards and Guidelines and Bases (Sample Pages)	P
NPX80-IC-SD790-02	Yes	Nuplex 80+ Critical Functions Monitoring System Description	P

A = All
P = Partial