Attachment 1

Safety Parameter Display System
Safety Analysis Report

Consolidated Edison Company of New York, Inc.
Indian Point Unit No. 2
Docket No. 50-247

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CONSOLIDATED EDISON SAFETY ASSESSMENT SYSTEM

SAFETY PARAMETER DISPLAY SYSTEM

SAFETY ANALYSIS REPORT

FOR

INDIAN POINT

NUCLEAR GENERATING UNIT NO. 2

Prepared for:

CONSOLIDATED EDISON COMPANY

New York, New York

Safety Analysis Report (SAR)

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1 INTRODUCTION

1.1 Purpose And Scope

This report has been prepared in fulfillment of a commitment contained in our January 24, 1986 submittal (reference 1) and presents the safety analysis of the Indian Point 2 (IP2) Safety Assessment System (SAS)/Safety Parameter Display System (SPDS). Our SAS/SPDS implementation plan and schedule is also contained in our January 24, 1986 submittal.

One of the principal bases for determining the adequacy of the IP2 SAS/SPDS parameters is compatibility with the IP2 Emergency Operating Procedures (EOPs) (reference 2). SAS/SPDS capability to monitor a wide range of plant responses to transients and accidents was further evaluated based on the Updated Final Safety Analysis Report (UFSAR) (reference 3) and the IP2 Technical Specifications (reference 4).

Further discussion of SAS/SPDS and EOP compatibility and definitions of SAS/SPDS terminology used in this report are given in sections 1.2 and 1.3. An overview of the IP2 SAS/SPDS design and installation, including the definition of the primary SAS/SPDS displays is presented in section 2. Selection and evaluation of parameters is presented in section 3. A safety assessment of the IP2 SAS/SPDS implementation is presented in section 4. The summary and conclusions are presented in section 5, and references are listed in section 6.

1.2 Terminology

This section defines key SAS/SPDS terminology used in this report.

1.2.1 Critical Safety Functions

Critical safety functions (CSFs) are those safety functions that are essential to prevent a direct and immediate threat to the health and safety of the public. The CSFs to be monitored by the IP2 SAS/SPDS status trees, as stated in our January 24, 1986 NRC submittal are:

- o Reactivity control (F-0.1),
- o Reactor core cooling (F-0.2),
- o RCS heat sink (F-0.3),
- o Reactor coolant system integrity (F-0.4),
- o Containment conditions (F-0.5) and,
- o RCS inventory control (F-0.6).

1.2.2 Parameters

Parameters are those measures of plant status or performance which are obtained directly or are calculated from plant signals. Plant signals are obtained from monitoring and control sensors installed in the plant systems. Each parameter is measured by one or more sensors, each of which produces a signal corresponding to the value of the parameter being measured.

1.2.3 Plant Signals

Plant signals are the electronic or electrical outputs of the monitoring and control sensing devices installed in the plant systems. These devices are calibrated so that the signals produced correspond to actual values of the parameters being measured.

1.3 Relationship Of Critical Safety Functions And Barrier Concept

The definitions of critical safety functions are based on the activities required to assess the integrity of, and the potential for breach of, the radioactive material barriers. The status of the reactor core cooling and reactivity control safety functions provides information required to assess the potential for breach of fuel cladding integrity. The status of the coolant system integrity function provides information required to assess the integrity of the nuclear system process barrier. The status of containment conditions provides information required to assess the integrity of, and the potential for breach of, the primary containment barrier. The status of the radiation control function provides the information required to assess radioactive releases to the environment resulting from breaches of one or more of the radioactive material barriers. Therefore, as long as the critical safety functions are adequately monitored and maintained, the radioactive barriers will remain intact.

1.4 Compatibility Of EOPs And SAS/SPDS

The IP2 emergency operating procedures (EOPs) provide control room operators specific directions to diagnose and mitigate the consequences of accidents, normal and abnormal transients, and other symptoms of critical safety function degradation. Since the purpose of a SAS/SPDS is to continuously display overall plant safety status in terms of how well the CSFs are being maintained, the SAS/SPDS parameter set is selected so as to be compatible with the EOPs. Also, by definition, a SAS/SPDS parameter set which is compatible with the EOPs will cover a wide range of events.

The IP2 SAS/SPDS has been designed with the following specific considerations for EOP compatibility. The CSF terminology used in the IP2 SAS/SPDS is the same as that used in the IP2 EOPs. The IP2 SAS/SPDS includes dynamic displays for each of the CSF status tree diagrams in the EOPs. The CSFs used in the IP2 SAS/SPDS correlate directly to the safety functions suggested in Supplement 1 to NUREG-0737 (reference 5) as shown in the following table.

NUREG-0737 Supplement 1, CSFs	Corresponding IP2 EOP CSF Status Trees
Reactivity Control	Subcriticality (F-0.1)
Reactor Core Cooling and Heat Removal from the Primary System	Core Cooling (F-0.2), Inventory (F-0.6), and Heat Sink (F-0.4)
Reactor Coolant System Integrity	Integrity (F-0.4)
Containment Conditions	Containment (F-0.5)

Radioactivity Control	Radioactivity control safety function parameters are included on the top level and trend displays for monitoring the radioactivity control function

The entire IP2 SAS/SPDS parameter set was also evaluated against the parameters used in the EOPs with the goal of ensuring that the IP2 SAS/SPDS would include all EOP parameters that are primary indicators of CSF status or are indicators of the status or result of actions to restore CSFs within safe limits.

2 SAS/SPDS DESIGN AND OPERATION

The IP2 SAS/SPDS is a part of the IP2 Emergency Response capability implementation program as required by Supplement 1 to NUREG-0737. Since this report presents the safety analysis of the SAS/SPDS parameters, the other Supplement 1 features will be discussed only as needed for comprehension of the SAS/SPDS function, design and operation.

2.1 Hardware Description

The basic IP2 SAS/SPDS hardware (see figure 2-1) consists of three major subsystems:

- o A data acquisition system (DAS) supplied by Computer Products, Inc. (CPI)
- o Redundant DEC VAX 11/780 computer systems with associated peripherals
- o Chromatics display CRTs for the man-machine interface.

The basic configuration provides a redundant system for critical components of the SAS/SPDS computer system.

Data collected by the DAS is input to the redundant VAX computer systems. A primary computer performs data acquisition and processing, and drives the display CRTs. The backup computer performs data acquisition in parallel with the primary computer and periodically performs data processing and calculation functions for intracomputer verification purposes. It does not, however, drive any CRTs. The loss of any critical component on the primary system triggers a failover to the backup system, which then provides all primary system functions. The SAS/SPDS database is maintained on the primary system's disk and simultaneously on a disk shared by the primary and backup system. Failover to the backup system causes the shared disk to

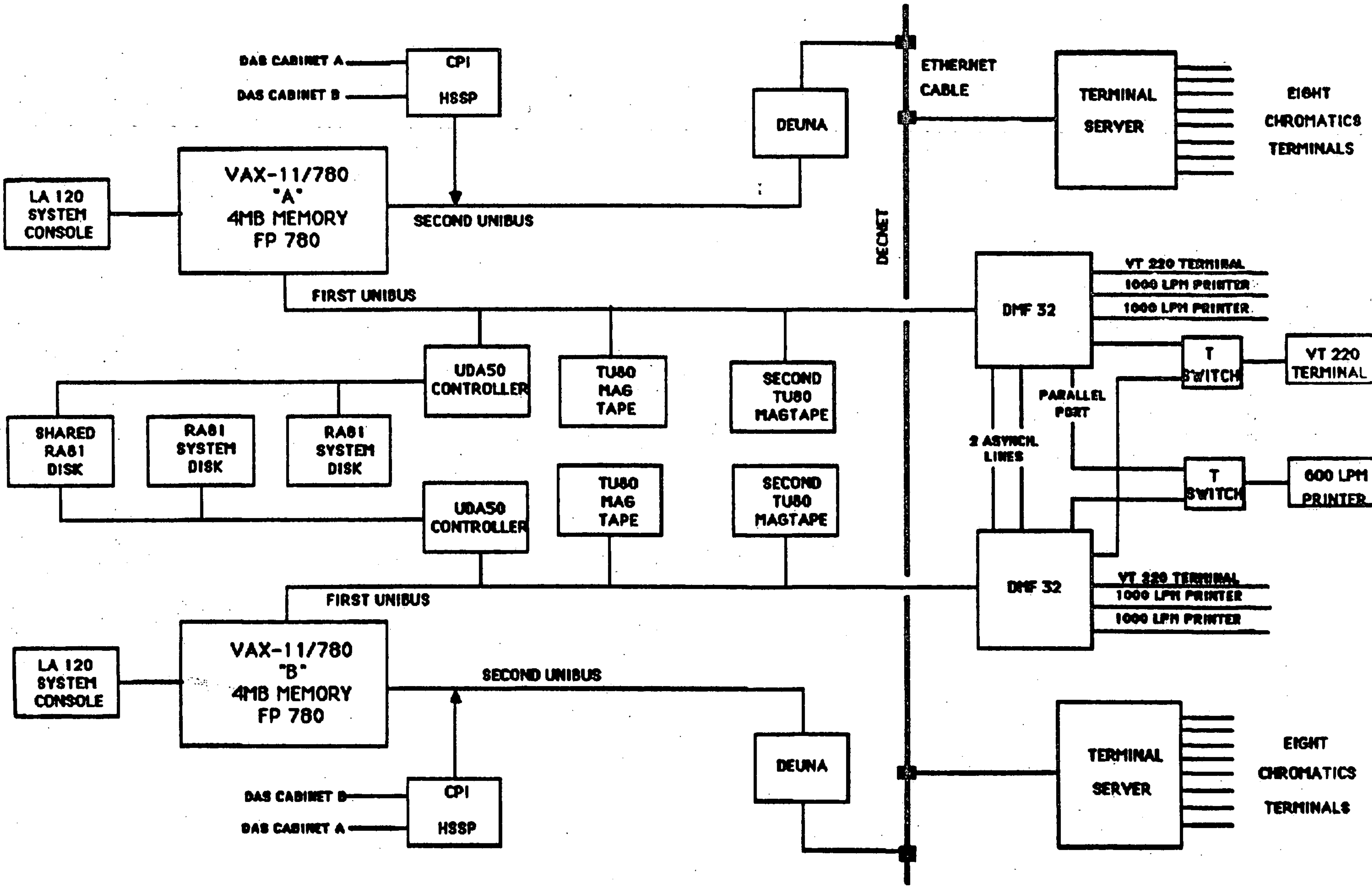


Figure 2-1. SAS/SPDS Computer System Hardware

be attached to the backup (now primary) system and data transferred to disk is not lost. Data is viewable on Chromatics color-graphic display CRTs in the central control room (CCR), Technical Support Center (TSC), recovery center (RC), the emergency control center (ECC), and the alternative emergency control center (AECC).

2.1.1 Data Acquisition System

The data acquisition system (DAS) samples each input channel data 10 times every second for processing by the host computer. The DAS, manufactured by Computer Products, Inc., is housed in two identical cabinets (figure 2-2). Each cabinet is capable of accepting 154 analog inputs and 160 digital inputs.

All analog and digital input signals are wired to barrier terminal strip cable assemblies (BTSCAs). Each analog BTSCA is able to terminate eight signals and is connected to a dedicated analog input gate card. Each gate card has a low-pass filter, a programmable-gain amplifier, and a multiplexer to select one of the eight input signals. An analog-to-digital converter (ADC) that digitizes selected analog signals for input to the computer system is housed with the gate cards in a chassis. A digital and analog calibration (DALCAL) card is provided for each ADC to allow automatic calibration of the ADC. The DALCAL also provides signals necessary to manually calibrate the programmable-gain amplifiers. Zero offset compensation is automatically performed by the hardware on the ADC card prior to each digitizing cycle.

Each digital BTSCA is able to terminate 16 signals and is connected to a dedicated digital input card. The digital input cards accept contact closure inputs and provide optical isolation for each channel.

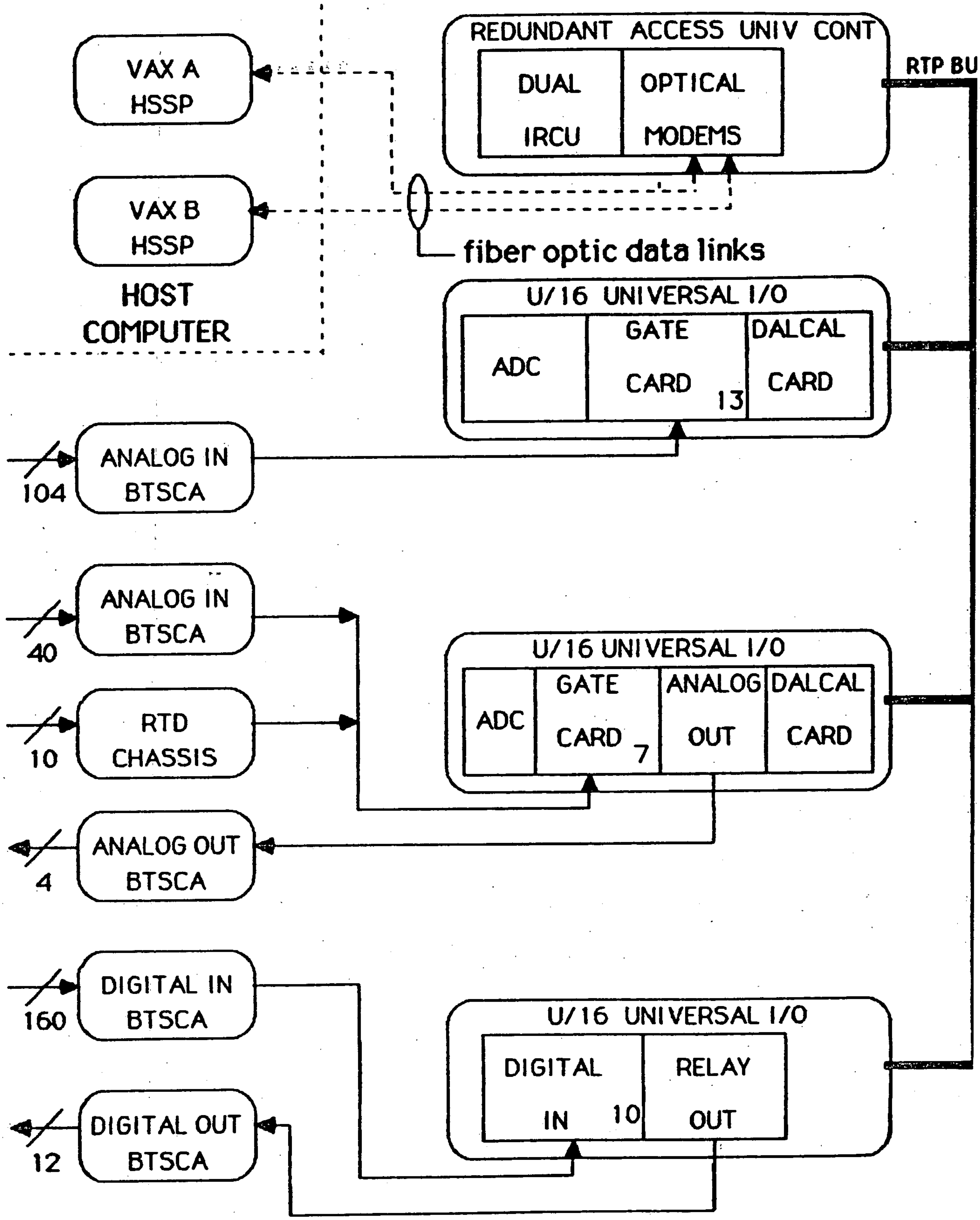


Figure 2-2 Data Acquisition System Arrangement

Analog and digital input cards are housed in separate chassis to minimize noise induced in the analog data.

Each DAS cabinet contains a dual redundant intelligent remote control unit (IRCU). The IRCU's control the transfer of commands, data, and status information. It is microprocessor-based and consists in part of a CPU card which uses a Motorola 68000 microprocessor. The IRCU acquires the digitized analog data and stores it as 16-bit words. Each 16-bit data word contains the digital value and pertinent status. Digital inputs are also acquired by the IRCU as 16-bit data words, each of which represent the 16 discrete inputs to the digital input BTSCAs.

The data which has been acquired by the IRCU is transmitted to the host processor by means of a fiber-optic link to a high-speed serial port (HSSP) mounted in the VAX expansion chassis. The use of redundant IRCUs provides independent communications paths to each VAX of the redundant host processor system. The fiber-optic link allows the DAS to transmit and receive data and also to receive commands.

The HSSP provides a high speed serial interface between the VAX and the IRCU with a transfer rate of 1 megabit per second. It is a 68000 microprocessor based intelligent I/O controller and performs interface functions, data link management, and general message handling operations. The HSSP also contains a sequence of events (SOE) timer, to identify the time of the occurrence of certain events, and a watchdog timer. This device is set to a period of approximately 100 milliseconds.

2.1.2 Computer Systems

Raw data acquired by the DAS is transferred to the host processor where it is analyzed, output to display as requested by the operators, and archived. The host processor is a dual DEC VAX 11/780 computer system configured to provide redundancy for operationally critical components.

The central processing unit (CPU) of the VAX system is a high performance, 32-bit processor. It features a virtual memory operating system designed for a concurrent-process, multiprogramming environment. Each process is assigned a priority commensurate with the importance of, and the level of service required by the process. Each processor in the dual computer configuration has:

- o 8K byte cache memory (also an address translation buffer and an instruction buffer)
- o Processor clocks (a programmable realtime clock and a time-of-year clock)
- o 4 MB of 600-nanosecond metal-oxide-semiconductor (MOS) memory
- o Single-bit error correction and double-bit error detection on MOS memory
- o Hardware memory protection
- o High-speed hardware floating point accelerator
- o Microprocessor-based controller,
- o Capacity for up to eight RS-232 asynchronous connections (DMF 32),
- o ETHERNET (a coaxial cable network that supports 10-megabit-per-second transmission).

Each computer has a dedicated 456 MB hard disk for the non-volatile storage of programs and data. A third dual-ported hard disk is shared between the computers to store data needed by the backup computer in the event it becomes the primary computer. Each disk subsystem has the following characteristics:

- 456 MB capacity
- A transfer rate of 2.2 MB per second
- 28 millisecond average seek time
- 8.3 millisecond average rotational latency.

Each computer has two magnetic tape systems, providing a means for installing software on the VAX, backing up existing software and data files, and archiving historical data.

General purpose peripherals are connected to the VAX through the UNIBUS. The VAX architecture treats peripheral devices as memory mapped I/O, so the UNIBUS occupies a portion of virtual memory. Two DEC peripherals which are attached to the UNIBUS and are used to communicate with terminals and printers are the DMF 32 Communications Controller and the Digital Equipment unibus network adapter (DEUNA). The DMF 32 is used for connecting line printers and programmer's terminals to the VAX. The DEUNA is the UNIBUS device that communicates with Chromatics terminals over the ETHERNET link. Devices attached to UNIBUS are assigned priority levels when installed.

ETHERNET is the local area network that provides a communication facility for high speed data exchange among computers and other devices. The ETHERNET local area network is interfaced to the VAX by means of the DEUNA.

Redundant terminal servers are used to relieve the VAX processors of the overhead associated with communicating to the Chromatics CRTs. The terminal servers are minicomputer-based concentrators which enable the connection of multiple terminals to a host processor using the ETHERNET network. The DEUNA communicates with the terminal server over the high speed synchronous ETHERNET data link. The terminal server formats this data and establishes the slower asynchronous communications with each of the Chromatics terminals over 19.2K baud RS-232 communication links.

Each computer is provided with a system console (LA120 DECwriter). The system console is used with the VMS operating system to boot the system, for diagnostics, and as a general purpose terminal. It allows the system manager to interactively communicate with the CPU using a special console command language.

2.1.3 Display System

The SAS/SPDS display subsystem is comprised of eight Chromatics CGC 7900 color graphic CRTs. Each terminal has a 19-inch display and is driven by a 16-bit microprocessor. Three CRTs are to be located in the central control room (CCR), two CRTs in the TSC, and one CRT each in the recovery center, emergency control center, and alternate emergency control center. Each Chromatics CRT has the following characteristics (except for the Senior Reactor Operator's CRT, which has a function keyboard):

- o 19-inch, high-resolution CRT using long-persistance phosphor
- o Motorola 68000, 16-bit CPU,
- o 1,128K bytes RAM
- o 151-key keyboard with 24 programmable function keys
- o Eight bezel keys located below the CRT
- o Hardware vector generator
- o interfacing with a Seiko color copier to provide hard copies of user-selected displays.

2.1.4 Availability

The overall system availability goal for the IP2 SAS/SPDS is 99% minimum. A 2200-hour availability test will be performed subsequent to system installation at IP2 to quantify and document actual availability. Availability is defined as the ratio of test time less downtime divided by test time. The IP2 SAS/SPDS shall be considered available when all on-line functions are executing without degradation and a specified minimum complement of system hardware components is operational. Detailed logs and records shall be maintained in accordance with written procedures during the entire test period.

2.2 Software Description

2.2.1 Functions

The basic software configuration supports the totally redundant design for critical components of the SAS/SPDS. The two VAX 11/780s are configured as a primary/backup system. The primary system is capable of performing all functions necessary to support SAS/SPDS operation, including data acquisition, calculations and processing, data storage, providing information to display devices, and monitoring the status of the computer system. The backup computer is capable of performing all primary computer functions, but normally performs only a subset of functions necessary to support automatic failover. Either VAX 11/780 may be designated as the primary or the backup computer.

The following software functions are supported by the primary computer:

- o Data acquisition for remote multiplexers at specified frequencies
- o Data processing and storage functions (data is stored on primary system disk and shared disk simultaneously)
- o Functions necessary to gather and format data for each selected display and to transmit data to appropriate CRT
- o Functions necessary to aid user in calibrating remote multiplexer inputs
- o Functions necessary to create and maintain the ERFCS database
- o Functions necessary to determine its own status and transfer control to the backup computer upon the detection of a failure.

The following software functions are supported by the backup computer:

- o Data acquisition from remote multiplexers at specified frequencies
- o The data processing function (but not data storage) periodically to verify intercomputer data
- o Functions necessary to support the listing and displaying of historical data
- o Functions necessary to create and maintain the SAS/SPDS database
- o Functions necessary to determine its own status and to take control of primary system functions upon the detection of a primary computer failure
- o Functions necessary to verify the integrity of software
- o Software development.

2.2.2 Processing And Response Times

Key processing and response times of the IP2 SAS/SPDS are as follows:

- o The data acquisition function receives data from the DAS every second
- o SAS/SPDS parameter determination and validation is performed every second
- o The six CSF status trees (section 2.3.1.3) are evaluated every second
- o The date and time of day are transmitted from VAX to each active CRT every second
- o Displays that provide current, updated data are refreshed at intervals no longer than two seconds.
- o Except for the cold shutdown top-level display (section 2.3.1), requests for a primary display shall be completed within four seconds of function key or bezel key activation (section 2.3.2.3); a request for the cold shutdown display will be completed within fifteen seconds.
- o Requests for secondary displays (section 2.3.1.4) will be completed within seven seconds of bezel key activation.

2.2.3 Historical Data

The SAS/SPDS computer system has the ability to process and output information from a previous period in time. This information is retained in historical files, and the utilization of these historical files is implemented in two parts, archiving and retrieval/display. The primary method for storing historical data is the daily historical file (DHF). Each day's DHF is maintained on both the primary system's disk and the shared disk. The current value of every input is included in the DHF once each hour. The current value of each input will also be included in the DHF whenever the change in value of the input since the last filing reaches its user defined threshold. At midnight, each day's DHF is closed and a new day's file is opened. Additionally, a circular file with a two-hour duration is maintained on the primary system disk. This circular file contains the values of every input in the SAS/SPDS system taken at one-second intervals. This historical information from the DHF and circular files is stored on magnetic tape by the system operator at regular intervals in accordance with established procedures.

The user can recall the historical data as information about point IDs which is spooled to a user-selected printer, or as the playback of a historical file in real-time on a selected CRT. The data about a point ID which is spooled off on a printer includes time, point, identification, converted-to-engineering unit values for analog inputs, and SET/RESET for digital inputs. The user can select the start time, stop time, and time resolution for the output. For real-time playback, the data is transmitted in the same fashion as with current real-time data, with all normal display functions available to the user.

2.2.4 Maintenance And Diagnostics

Software is provided for system maintenance and diagnostics. The maintenance software allows the user to calibrate the CPI analog circuits after reviewing the calibration data. In addition to calibrating the analog inputs, the following service functions can be performed on input points:

- o Delete a user-specified point from scan
- o Return a deleted point to scan
- o Return a user-specified multiplexer to service (following maintenance or power supply failure)
- o Produce a list of all comparison errors found in the 10-minute periodic data integrity check.

The diagnostic software provides thorough diagnostic programs for each major hardware component, including CPU, memory, peripherals, man-machine interface hardware, communications interface hardware, and multiplexer equipment. The diagnostic programs are divided into four levels of diagnostics, depending upon the computer functions checked by that program. In addition to the diagnostic software to verify the correct operation of hardware, a software simulator is included that verifies the integrity of all software downstream of the data acquisition programs.

The user can also activate a display of the results of the latest status check performed by the system. This display informs the user of the status of:

- o Data acquisition systems
- o DECnet for both computers
- o Computer disk drives
- o Computer assignments for both computers
- o Computer room line printer availability
- o Errors on the last comparison for the requested unit
- o Chromatics status.

2.2.5 Failover And Backup Provisions

Failover is the action of the backup computer taking control of the primary computer's functions. Failure is detected by the status monitoring program, which initiates the failover process automatically. The time interval for the complete failover process to be complete is less than 60 seconds.

The SAS/SPDS is configured to perform normally with one computer acting as primary and one computer acting as the backup. In the event of failure of the primary computer, leading to failover to the backup computer, acquisition of DAS data is activated and operational on the backup (now primary) computer within 10 seconds of failover, since the backup computer is normally scanning the DAS in parallel with the primary computer.

Failures on the backup computer cause the computers' status to change from "computers with failover capability" to "computers without failover capability." If the primary computer fails and failover capability does not exist, a special state is created in which either computer that has an operational VAX/CPI interface, a main data processing program, and sufficient disk space on which to store historical data continues data processing and storage as long as possible.

A function is provided by which the status of each computer can be changed from primary-to-backup or backup-to-primary in an orderly fashion without the reinitialization of either computer system.

2.2.6 System Security

The security of the SAS/SPDS software shall be provided by multiple levels of password protection. Each authorized user must enter a password to gain entry to the system. Passwords will not appear on any screens or in any files accessible by general users. Password authorization shall be accomplished through a system administration file defining the users' privileges and read/write access to SAS/SPDS files. Password authorization shall be controlled and documented by a designated system administrator in accordance with written procedures.

2.3 Man-Machine Interface

The man-machine interface of the IP2 SAS/SPDS consists of 34 dynamic, colorgraphic displays and function keyboard. Twenty-four are considered primary displays which are available to the operators at the central control board CRT (see table 2-1, SAS/SPDS Primary Displays). The other ten displays are considered secondary displays and are available to supervisory and management personnel on other SAS/SPDS CRTs. The first twenty-two primary displays satisfy the SAS/SPDS requirements of Supplement 1 to NUREG-0737.

2.3.1 SAS/SPDS Displays

Three types of displays are included in the SAS/SPDS. These are the Plant Mode, 30-minute Trend, and Critical Safety Function Status Tree displays. The Plant Mode (except for Cold Shutdown) and the 30-minute Trend displays include the following common display features: a Critical Safety Function (CSF) Monitor summary area and a message area, as illustrated in figure A.1 for a typical Plant Mode display. (Appendix A contains the 24 primary displays.)

The CSF summary area lists the current status of the six critical safety functions monitored via the IP2 EOPs. The CSFs are listed in the same order of priority as in the EOPs. The CSF status area includes dynamic color and number coded targets which indicate the status of each CSF. Each CSF target is driven by the same logic as specified on the corresponding status tree for the CSF in the EOPs. Each CSF status tree is also included as a dynamic display in the IP2 SAS/SPDS.

The common message area includes the following information:

a. Current Conditions. At the top of the message area, the current values of reactor power, average reactor coolant temperature, and startup rate are listed. Reactor power is displayed in units of counts per second, detector amperage, or percent of full power, as appropriate for the power level.

b. Occurrence of Key Events and Plant Responses. Selected key event and plant response information is displayed below the current conditions. This information includes reactor trip, reactor trip demand, safety injection demand, feedwater isolation demand and main steam isolation demand, along with the date and time of occurrence. The number of the event will appear on the appropriate trend graphs at the time of occurrence.

c. Computer System Diagnostics. This information includes three computer system malfunction messages that will appear as appropriate.

d. Current Date/Time. The current date and time will be displayed in the lower left-hand corner of all displays (except Plant Mode Cold Shutdown where the date/time appears in the upper right hand corner).

e. Channel Malfunction Information. Information regarding channel malfunction is available on a secondary display.

Table 2-1.

SAS/SPDS Primary Displays

Appendix A Figure No.	Display Description	Display Type
A.1	normal operation	plant mode
A.2	heatup/cooldown	plant mode
A.3	cold shutdown	plant mode
A.4	F-0.1 subcriticality	CSFM
A.5	F-0.2 core cooling	CSFM
A.6	F-0.3 heat sink	CSFM
A.7	F-0.4 integrity	CSFM
A.8	F-0.4-1 integrity	CSFM
A.9	F-0.4-2 integrity	CSFM
A.10	F-0.5 containment	CSFM
A.11	F-0.6 inventory	CSFM
A.12	F-0.1 subcriticality	trend
A.13	F-0.2 core cooling	trend
A.14	F-0.3 heat sink (1)	trend
A.15	F-0.3 heat sink (2)	trend
A.16	F-0.4-1 integrity (1)	trend
A.17	F-0.4-2 pressure/temperature curve	trend
A.18	F-0.5 containment	trend
A.19	F-0.6 inventory	trend
A.20	RCS temperature	trend
A.21	steam flow-feed flow	trend
A.22	containment and radiation monitors	trend
A.23	tank levels	trend
A.24	loss of electrical power (LOEP)	EOP parameter (EOPP)

*RCS: reactor coolant system

2.3.1.1 Plant Mode Displays

The IP2 SAS/SPDS includes three Plant Mode displays: one for Normal Operation, one for Heatup/Cooldown and one for Cold Shutdown.

The Normal Operation and Heatup/Cooldown displays are nearly identical and include color-coded bar charts with displayed values, color-coded targets and individual displayed values in addition to the common display features discussed above (see figure A.1). The arrangement of the displayed parameters is similar to the way they appear on the Flight Panel in the Central Control Room. Two color-coded targets are included. One is for secondary radiation which is driven by the auctioneered high value of steam generator blowdown radiation, steam jet air ejector radiation, and steamline radiation. The other target is for containment atmosphere which is driven by the auctioneered high value of containment temperature, pressure, sump level, and dew-point. These displays provide the operators with a concise overview of SAS/SPDS parameters. All of the parameters monitored through these displays are also included on Trend Graph displays, which are grouped for access according to the CSF which they monitor. Thus, the Plant Mode displays will alert the operators to imminent adverse developments in any of the parameters, and the operators may then further investigate the conditions by accessing the Trend Graphs.

The Cold Shutdown display monitors the parameters important during cold shutdown. This display is similar in format to the 30-minute Trend Graph displays. This display includes bar chart indications of current conditions on the left and trend graphs of these conditions during the past two hours on the right.

2.3.1.2 Trend Graph Displays

Each SAS/SPDS Trend Graph display provides the operators with a 30-minute history of parameters associated with monitoring a particular CSF. Bar charts indicating the current value of each parameter are included on the left, with the trend graph showing the values of the parameters over the past 30 minutes on the right (see figures A.12 through A.16 and A.18 through A23). One dynamic plot of RCS pressure vs. temperature is also included in conjunction with the Integrity Trend Graph display to monitor operational pressure/temperature limits (see figure A.17).

2.3.1.3 CSF Status Tree Displays

These are dynamic displays of the CSF Status Trees, as defined in the IP2 EOPs (see figures A.4 through A.11). These displays (along with the common CSFM summary area targets on the Top-Level and Trend Graph displays) shall be automatically activated when either a reactor trip or safety injection (SI) actuation signal occurs. These displays and the common summary areas will normally be inactive when neither a reactor trip nor SI actuation signal is present. Although a function button may be used to manually activate these displays at any time, it will not be possible to deactivate these displays if either the reactor trip or SI actuation signal is present.

The operator target values for the subcooling and steam generator parameters, used to determine which branch of the F-0.2 Core Cooling and F-0.3 Heat Sink trees to follow, will change automatically, in response to a change in containment conditions from normal to adverse, as defined in the IP2 EOPs. Other displayed values are either not subjected to adverse containment or only the adverse value is used in the IP-2 EOPs.

Two dynamic plots of RCS pressure vs. temperature are also included in conjunction with the Integrity CSF Status Tree display to monitor current conditions in relation to the cold overpressure limits as defined in the EOPs.

2.3.1.4 Other SAS Displays

The remaining displays are discussed for the purpose of providing a complete SAS/SPDS description only. These displays are not required to satisfy NUREG-0737 Supplement 1 requirements for an SPDS.

The last two primary displays, Tank Levels and Loss of All AC Power (see table 2-1) provide supplemental information to the operators regarding the status of the emergency coolant inventories and the availability of emergency power to safely shutdown the plant in the event of a total AC power loss.

The remaining ten displays (table 2-2, SAS/SPDS Secondary Displays) are accessed using bezel keys (bezel keys are located under the CRT screen) from all locations except the senior reactor operator's CRT. These displays are dynamic and fully interactive where input parameters are available. When plant input parameters are not available, the data is entered manually via the keyboard. Manually entered data is readily distinguishable from dynamically input data.

Table 2-2.
Secondary Displays

	Display Description	Type
25.	loss-of-coolant accident (LOCA)	EOPP
26.	steam generator tube rupture (SGTR)	EOPP
27.	loss of secondary cooling (LOSC)	EOPP
28.	SSRM overall system status	SSRM
29.	SSRM high-pressure injection system status	SSRM
30.	SSRM prediction	SSRM
31.	SSPM	SSPM
32.	channel malfunction monitor	CMM
33.	P&ID high-pressure injection system	P&ID
34.	AIDS	AIDS

The Emergency Operating Procedure Parameter (EOPP) displays group the selected parameters, display parameter values, and indicate whether the values are increasing or decreasing. Safety System Readiness Monitor displays present the status of selected safety systems (at this time only the high pressure injection system is implemented). The Safety System Performance Monitor display verifies that the proper sequence of safety system actuation occurs. It will also verify the proper system response following a reactor trip, main steam line isolation, or feedwater isolation. A Piping and Instrumentation Diagram display provides the user with an indication of the current status of the high pressure injection system. The Accident Identification Display System (AIDS) displays the calculated relative probability for each of the four major PWR accidents; Loss of Coolant (LOCA), Steam Generator Tube Rupture (SGTR), Loss of Secondary Cooling (LOSC), and Inadequate Core Cooling (ICC). Finally, the user can define and display numeric or graphic trends and logs.

2.3.2 Human Factors Design Considerations

An interdisciplinary team of operations and engineering personnel were involved in conceptualizing, designing, and reviewing the display placement and formats to provide a set of displays consistent with the requirements of NUREG-0737, Supplement 1. As expected, the inclusion of IP2 operations personnel on the design team yielded valuable technical input in the design and evaluation process; in addition, it is felt that their participation during this stage of the IP2 SAS/SPDS development was essential to help ensure operator acceptance of the SAS/SPDS after installation.

2.3.2.1 General Features

The display formats are designed to have low information densities but to include that information required to support the activities of the user. Simple display formats reinforce user recognition of plant status. Demarcation lines are employed to separate classes of data or parameters. On top level displays, vertical bar indicators are used for level parameters, while horizontal bar indicators are used for pressure and temperature parameters. On all predefined trend displays, vertical bar indicators are used exclusively. Operating limits are highlighted by prominent beige lines on the bar graphs.

As numerous alarms currently exist in the central control room, the use of alarms on the SAS/SPDS display system is kept to a minimum. Once an alarm has been set, the alarm is then placed in a dead band to eliminate alarm chatter should the parameter causing the alarm oscillate around the alarm setpoint.

A predetermined set of trend graphs are provided for the CSF displays to present historical data over the previous 30-minute period. These magnitude-versus-time trend graphs allow for comparison of historic data about functionally related sets of parameters. Up to four parameters are presented on each graph.

Arrangement consistency is maintained on the SAS/SPDS displays to the maximum extent practicable. Types of data common to more than one display (display titles, data/time, critical safety function monitor, system alert messages) appear in the same area on related displays. This is done to promote user identification of data appearing on multiple displays. Generally, the information is ordered in a top-to-bottom ranking, with the most important data at the top of the display.

Graphic symbology is extensively used on the displays. Standard symbols are used to the maximum practical extent. Clarity is achieved for symbols, color and lines by using a high resolution (1024 X 768 dots) colorgraphic CRT. With the high-resolution display and sharpness provided, high levels of object/background and object/object discrimination is obtained. Visual coding techniques of color and pattern recognition are consistently used from display to display.

Finally, the user remains continuously appraised of the validity of the data being displayed. If the value of a parameter is GOOD, the digital value is displayed in white. If a parameter value is SUSPECT, the digital value is displayed in white, but surrounded by a one-pixel yellow box. If the parameter value is FAILED (not valid), a series of yellow asterisks (*) appears in place of the digital value. In no case is the display void; an indication is always presented to inform the user of the quality of displayed data. Validation logic is discussed in section 3.6.

2.3.2.2 Graphic Coding

2.3.2.2.1 Normal And Heatup/Cooldown Plant Mode Displays

Bar charts were selected as the means of presenting primary status indications, putting the data into a form easily comprehended by the user. Vertical bar graph indicators are used for level parameters, while horizontal indicators are used for temperature and pressure indicators. Alarm limits are designated by beige lines which cross the bar indicator at their respective alarm set point value. The bar graphs are displayed in green if the parameter values are within alarm limits and they are displayed in red if the values are outside the bounds of low or high limits.

Those parameters which are only indicated by a target are displayed as a green square if all parameters used for target evaluation are normal. If any parameter used for target evaluation is in alarm, the target is displayed as a red square. If any of the parameters used to evaluate the target is SUSPECT or FAILED, the green or red box is displayed, as appropriate, surrounded by a one-pixel yellow box. If all the parameters are FAILED, the target is replaced by a yellow asterisk (*) surrounded by a one-pixel beige box.

For containment radiation, RVLIS, and core exit TC temperatures, the parameter values are displayed in white if GOOD and within alarm boundaries. If values exceed the high or low alarm limit setpoints, the value is displayed in white, surrounded by a four-pixel red box. For subcooling, the display conventions as just described are used. Additionally, the word SUBCOOL is displayed in white if the parameter value is less than the user-defined setpoint and the word SATURATE (in replacement of SUBCOOL) is displayed in orange if the parameter value is between the user-defined setpoints. Similarly, the word SUPERHEAT is displayed in red if the value is greater than the user-defined setpoint.

The six Critical Safety Function Monitor targets are displayed on all primary displays except Cold Shutdown. The CSF status is indicated by a number inside a color-coded circle. The color coding represents the results of the individual CSF tree evaluations. A red circle with a "1" inside indicates "prompt action required." An orange circle with a "2" inside indicates "prompt action may be required." A yellow circle with a "3" inside indicates "action required"; and a green circle with a "4" inside indicates "no action required." A beige circle with a yellow asterisk (*) means that the tree is not evaluated because of FAILED input data, while a target outlined by a one-pixel yellow box means that SUSPECT data was used to evaluate the tree.

The message area of the primary displays (except for Cold Shutdown) has indication for individual parameters (POWER, RCS AVG TEMP, and STARTUP RATE), event markers (RX TRIP, RX TRIP DEMAND, FW ISOLATION, SI ACTUATION, and MS ISOLATION), and computer system trouble messages (COMPUTER TROUBLE, EXCESSIVE CABINET TEMP, and CHANNEL MALFUNCTION).

The POWER parameter can be displayed in percent of full power, amps, or counts per second, depending upon the condition of the reactor (tripped/not tripped) and the source range detector high voltage (on/off). The RCS AVG TEMP parameter is displayed as narrow-range average TAVE or cold leg wide-range TEMP, depending on the value of the average TAVE signal.

The event markers display the name of the event and the time and date the event occurred. Information (name, time, and date) is displayed in white if both sensors indicated an event occurred. If only one sensor so indicates, all information is presented in white, but the name of the event is surrounded by a one-pixel yellow box. If neither sensor indicates an event has occurred, the field remains blank. If the computer is unable to indicate what time an event occurred, the event name is displayed in white, the time and date are replaced by yellow asterisks (*). An event marker number corresponding to the time of the event is placed on each trend graph (excluding the COLD SHUTDOWN graphs).

The computer system trouble message fields remain blank unless a problem is encountered. At that time the appropriate message is displayed in white.

2.3.2.2.2 CSF Status Tree Displays

The status of each individual CSF decision tree is depicted by a color-coded line along the path evaluated, followed by a numbered, color-coded circle with the appropriate IP2 procedure number or message displayed next to the circle (see Figures A.4 through A.7, and A.10 and A.11). The number and color-coding is the same as discussed above for the CSF Monitor. If the evaluation is based on SUSPECT data, a one-pixel yellow box outlines the words YES or NO at a decision point. If the evaluation is based in part on FAILED data, a broken magenta line extends as far as the path can be evaluated with GOOD data, and a magenta box outlines the decision point that cannot be evaluated.

2.3.2.2.3 Cold Shutdown And All Other Trend Displays

Up to four parameters can be displayed on the predefined trend graph displays. All bar graphs are vertical, and all have a trend color key above the bar to indicate the color with which the bar graph is drawn and the corresponding color and line width of the respective trend graph trace.

2.3.2.3 Display Access

The SAS/SPDS displays are available on two types of display terminals, a primary CRT and secondary CRTs. The primary CRT is normally used by the senior reactor operator, and is provided with a keypad in which each function key is designated for a specific primary display (figure 2-3). This allows rapid and error-free display requests.

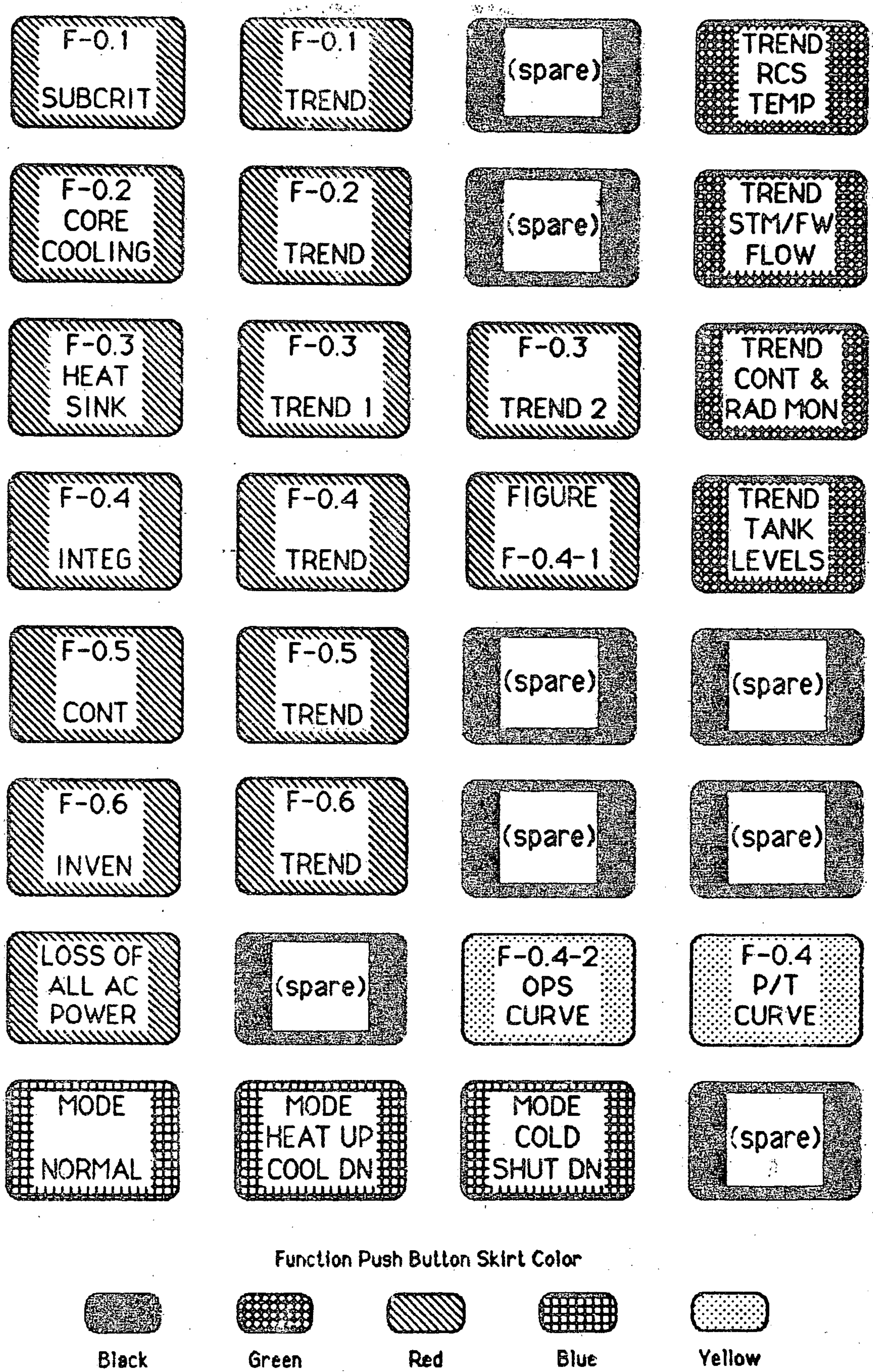


Figure 2-3. Senior Reactor Operator's Function Keypad

On all other CRTs, displays are accessed through a hierarchial menu system via bezel key activation. The menu is displayed on the bottom of the CRT screen as a template above the bezel keys. To select a display, the user presses the bezel key directly below the menu selection for that display. The menu selections are outlined in blue and the selectable display names on any given template are in white. The bezel key on the extreme left always is available for returning the user to the primary menu.

2.3.2.4 Control Room Location

Three CRTs will be located in the central control room and will be readily accessible and visible to control room personnel at their normal and emergency work stations. The primary CRT will be suspended from the ceiling between the Flight Panel and the Accident Assessment Control Panel (figure 2-4). The primary CRT will not interfere with the normal movements of the control room operations crew, and will not interfere with visual access to other control room indicators due to its suspended, ceiling mounting, independent of other control panels. The keypad for the primary CRT will be located on the senior reactor operator's console. The two secondary CRTs (#2 & #3) will be located as shown on Figure 2-4.

2.4 Verification And Validation Program

The verification and validation program for the IP2 SAS/SPDS is in accordance with the guidance of NSAC-39, Verification and Validation for Safety Parameter Display Systems. The V&V activities are performed by individuals who are independent of the design effort and who have sufficient

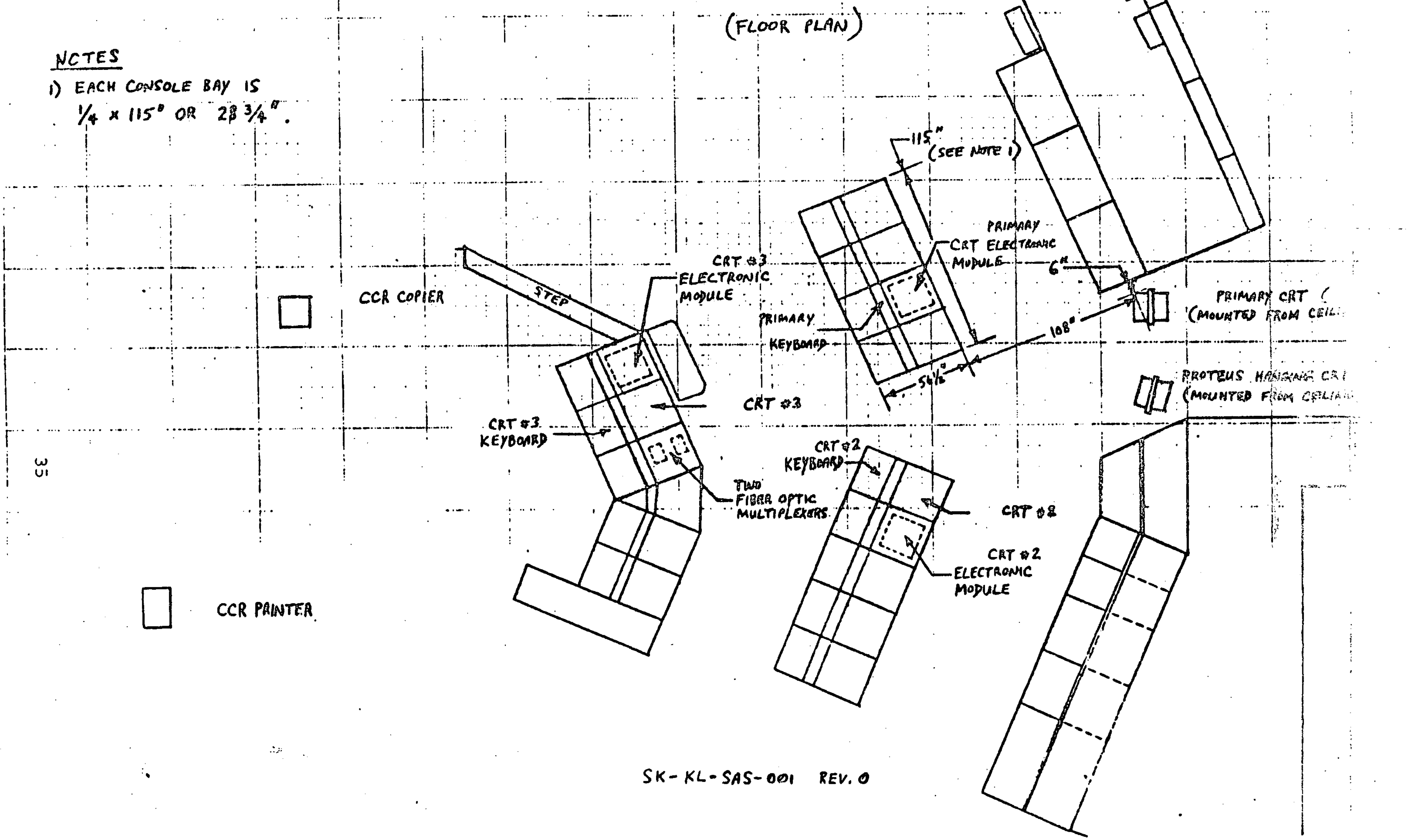


Figure 2-4. CRT Locations in Control Room

experience and expertise to properly evaluate the various activities which affect the final design and installation of the SAS/SPDS. Activities covered in the V&V Plan include the design and installation phases.

2.4.1 Verification

The verification phase of the V&V demonstrates the consistency, completeness, and correctness of each stage of development of the SAS/SPDS on the basis of fulfillment of requirements imposed on the design by various documents. These requirements provide the bases for the design, construction, integration, acceptance, and operation of the system. Therefore, pertinent documents are reviewed at the start of the project and appropriate requirements identified. These requirements are listed in a matrix which is used throughout the project for tracking.

The design specifications are then verified to ensure design conformance with regulatory requirements and requirements contained in the Conformed Specification. These specifications include functional, hardware, software, and hardware purchase specifications. Verification procedures and checklists are used by the verifiers to ensure completeness and uniformity. Upon completion of these design specification verifications, the V&V team prepares a report summarizing the findings, deficiencies, open items, and comments identified by the verifiers. The report also contains the resolutions for deficiencies and open items.

2.4.2 Validation

Validation is the demonstration of the correctness of the final system as determined by testing against overall functional, performance, and interface requirements. Validation tests the proper operation of each hardware component and software module, as well as the operation of the integrated system. The actual validation testing is performed using procedures and checklist in conformance with the Factory Acceptance Test (FAT) plan and the Site Acceptance Test (SAT) plan. The FAT is performed at Quadrex facilities in Campbell, California, while the SAT is performed after installation at the Indian Point 2 plant. The system configuration is established prior to the start of each test, and any changes to the system are documented in a controlled manner through anomaly reports.

At the conclusion of each test, a test report is generated by the V&V team. Each test report contains descriptions of the tests performed, documentation of test results, analysis of the results, and identification of any nonconformances to the test acceptance criteria. The test reports also contain the resolutions to any anomalies and open items. Upon conclusion of the V&V effort, a final Verification and Validation Report will be prepared by the V&V team to summarize the activities performed, the findings and corrective actions which occurred in all V&V activities, and the resolution of discrepancies uncovered in the V&V effort.

2.5 System Documentation

2.5.1 Hardware Documentation

Hardware documentation includes manuals and instruction books for the hardware describing the circuitry, its generation, trouble-shooting and maintenance procedures, configuration block diagrams, and a master component list.

2.5.2 Software Documentation

Software documentation includes a system overview, inventory of the programs, data variable dictionary, data file layouts, inventory of system constants and validation tables, functional and logic descriptions of algorithms, programs, program interfaces, and program/data file interfaces.

2.5.3 System Operations Manual

The operations manual includes an integrated operational description of the system hardware, software, and CRT displays, and procedures explaining the step-by-step actions required to operate the system, adjust parameters, and to interpret and recover from error messages.

2.5.4 Documentation Maintenance And Control

SAS/SPDS documentation will be controlled in accordance with station administrative orders.

2.6 Training And Integration With Emergency Operations

Training includes a combination of classroom and hands-on instruction in accordance with written lesson plans utilizing the system operations manual to the maximum practical extent.

Use of the IP2 SAS/SPDS will be integrated with the existing emergency operations such that emergency response will be enhanced when the SAS/SPDS is available, but will not be hindered if the SAS/SPDS becomes unavailable.

The planned training program will include a trouble report/feedback system such that user suggestions will be recorded, evaluated and resolved. The suggestions which may require changes to the software or hardware will be incorporated into the SAS/SPDS following proper V&V. Large scope changes will be done following system site acceptance.

3 SELECTION AND EVALUATION OF SAS/SPDS INPUT PARAMETERS

3.1 Selection And Evaluation Process

The objective of the selection and evaluation process was to ensure that the type, number, and ranges of SAS/SPDS parameters are sufficient to determine the maintenance or accomplishment status of each critical safety function for a wide variety of events, including severe accidents, and during various modes of reactor operation.

Starting with an enhanced set of generic SAS displays/parameters, the IP2 SAS/SPDS design team prepared an IP2-specific set of displays and parameters which included detailed design input from IP2 supervisory operations, engineering, and human factors personnel.

The IP2 parameters were then evaluated for compatibility with the IP2 emergency operating procedures as discussed in section 1.4. EOP parameters that are considered primary indicators of CSF status, or are indicators of actions to restore CSFs within safe limits are either included directly on the IP2 SAS/SPDS displays, can be inferred from other SAS/SPDS parameters, or are already prominently displayed in the central control room.

The specific type and number of IP2 parameters selected for monitoring each CSF is discussed in section 3.2. A listing of these parameters is provided in Appendix B.

The IP2 parameter ranges were evaluated for consistency with design basis, performance requirements, and transient and accident responses in the IP2 updated final safety analysis report, the IP2 Emergency Operating Procedures Background Documents (reference 7), and with the setpoints, alarm limits, and bases in the IP2 Technical Specifications, as applicable. Adequacy of the parameter ranges displayed on the IP2 SAS/SPDS is discussed in section 3.3.

3.2 Type And Number Of Parameters Required To Assess Each CSF

3.2.1 Reactivity Control

Reactor power provides the primary and the most direct measure of core reactivity. Therefore, in order to adequately assess the reactivity control function, the operators must be cognizant of reactor power level and the status of the manual and automatic signals and equipment utilized to reduce reactor power level when required.

The neutron monitoring system is used to monitor reactivity control. For normal plant operation, the primary indication of core reactivity is neutron flux, which is monitored and displayed on the SAS/SPDS. Neutron flux information is provided on the Plant Mode displays. The SAS/SPDS receives this information via the source range monitors (SRMs), intermediate range monitors (IRMs) and power range monitors (PRMs), which monitor the entire power range as identified in Appendix C. This range includes the source range, measured in counts per second, intermediate range, measured in amps, and power range, measured in percent of full power; intermediate or source range startup rate in decades per minutes are also displayed, as appropriate. The SRMs, IRMs, and PRMs are also available in trend graph format along with source range high voltage which indicates the on/off status of the SRMs.

Two Plant Mode displays (normal operation and heatup/cooldown) also present information on reactor trip demand and the reactor trip breakers. Safety injection demand signal is also monitored and displayed.

For off-normal or accident conditions, the primary means of maintaining reactivity control is reactor subcriticality. The Subcriticality Critical Safety Function Status Tree provides general surveillance of the maintenance of subcriticality and directs the operator to the appropriate function restoration guide, if required, to maintain or restore adequate subcriticality.

The type and number of parameters monitored by the SAS/SPDS for reactivity control enable the operators to monitor reactivity level, the success of manual or automatic actions to reduce the reactivity level, and to monitor the status of emergency actions to reduce reactivity level, and, therefore, provide for adequate assessment of the reactivity control function.

3.2.2 Reactor Core Cooling And Heat Removal From The Primary System

Adequate core cooling and heat removal from the primary system ensure that fuel cladding temperatures remain below failure limits. In order to assess adequate core cooling, coolant inventory, coolant temperatures, level of subcooling, and primary system heat sinks are monitored.

Inadequate coolant inventory is a consideration in core cooling. To ensure a proper coolant inventory exists in the primary system, the operator must be cognizant of reactor vessel and pressurizer water levels. Adequate vessel level ensures that the core is covered and a correct pressurizer level ensures that a total coolant inventory is maintained. Both of these levels are monitored and displayed by the SAS/SPDS. Reactor vessel level is monitored and displayed on Plant Mode displays and also in trend graph format. Reactor vessel level is also used as an input to the Core Cooling and Inventory CSF status tree displays. Pressurizer level is monitored for display on the Normal Operation and Heatup/Cooldown Plant Mode displays and as an input to the Inventory CSF status tree.

Primary indicators of core cooling include coolant temperature and level of subcooling. Cold leg, core exit, reactor coolant system average temperature, and level of subcooling are monitored and displayed on one or more Plant Mode displays. For off-normal and accident conditions, core exit temperature, level of subcooling, reactor vessel water level, and reactor coolant pump status are monitored and used in a decision-making process of the Core Cooling CSF status tree. These variables and decision tree branches provide indication of the core thermodynamic state and the degree to which core cooling is accomplished. Additionally, core exit temperature, cold leg temperature, hot leg temperature, loop average temperature, and level of subcooling are available in trend graph format.

The principal heat sink for the primary system consists of four steam generators. If the steam generators are receiving adequate feedwater flow, and have sufficient inventory, then an adequate heat sink exists. Steam generator level and pressure and main steam and feedwater isolation initiation are monitored and displayed on the Normal Operation and Heatup/Cooldown Plant Mode displays. For off-normal or accident conditions, steam generator level and pressure, and total auxiliary feedwater flow are monitored on the Heat Sink CSF status tree. Steam generator level and pressure, and auxiliary feedwater flow are also available in trend graph format. Additionally, steam flow and feedwater flow are monitored and displayed as trend graphs to provide indication of a steam/feedwater flow mismatch.

For cold shutdown, decay heat is removed using the manually initiated residual heat removal (RHR) system. RHR system flow and heat exchanger inlet and outlet temperatures which indicate the performance of this heat sink are monitored, displayed and trends are graphed on the Cold Shutdown Plant Mode display.

The parameters monitored by the SAS/SPDS for reactor core cooling enable the operators to monitor reactor pressure vessel level and temperature and to monitor the status of manual and automatic actions to remove heat from the core and the primary system. These parameters, therefore, provide for adequate assessment of the core cooling function.

3.2.3 Reactor Coolant System Integrity

In order to assess the reactor coolant system (RCS) integrity function, the operator must be cognizant of the potential for breach of integrity by pressurized thermal shock and indication that a breach may have occurred, and status of actions taken to mitigate the potential for breach of integrity.

Parameters for monitoring the potential for breach of the reactor coolant system integrity by pressurized thermal shock include reactor coolant system pressure, reactor coolant system average temperature, and cold leg temperature. Parameters for monitoring the actual breach of the reactor coolant system due to loss of coolant accidents include reactor coolant system pressure, reactor vessel and pressurizer levels, containment pressure and radiation, and containment sump level. These parameters are available on Plant Mode displays as well as in trend graph format.

Because of the potential for breach of reactor coolant system integrity due to adverse reactor coolant system pressure and temperature combinations, RCS cold leg temperature and RCS pressure parameters are monitored on the Integrity CSF status tree. Additionally, a dynamic plot of RCS pressure vs. cold leg temperature is available to indicate the status of current conditions relative to the cold overpressure limit.

Detection that a breach has occurred will be indicated by various parameters, depending upon the location and magnitude of the breach. Decreasing reactor coolant system pressure, reactor vessel level, and pressurizer level will indicate a breach (or a loss of coolant accident). Increasing containment pressure, radiation, and containment sump level will indicate that a breach has occurred, and provide an indication of the magnitude of the breach (or a loss of coolant accident). These parameters are monitored and displayed on Plant Mode displays except for sump level which is available on CSF F-0.5 (Figure A.10) and its associated trend graph (Figure A.18).

The parameters monitored by the SAS/SPDS for reactor coolant system integrity enable the operators to monitor the potential for, and magnitude of, a breach of integrity and, therefore, provide for adequate assessment of RCS integrity.

3.2.4 Containment Conditions

In order to assess the status of containment integrity, the operators must be cognizant of the potential for breach of containment integrity and the status of actions taken to mitigate the potential for breach of integrity.

Containment conditions monitored which indicate a possible threat to integrity include containment pressure, radiation, and sump level. The primary threat to containment is from overpressurization, or failure of penetration valves to close, which could potentially cause a breach of containment. Radiation, which does not pose a threat to containment integrity directly, is monitored to assess the magnitude of potential consequences of a breach and the need to ensure proper isolation of containment. Containment sump level is monitored to indicate the potential for flooding. Additionally, the containment hydrogen level, temperature, relative humidity, and dew-point are monitored to provide an indication of the status of the containment atmosphere. Hydrogen concentration indication is of particular importance, since hydrogen build-up to a combustible level, if ignited, could cause breach of containment integrity. Containment radiation is monitored and displayed on the normal mode, heatup/cooldown and trend displays. Containment atmospheric conditions are monitored (temperature, sump level, pressure and dew-point) and represented by a "target" on the Normal Mode and Heatup/Cooldown Plant Mode displays. Additionally, all of the above parameters are displayed in trend graph formats.

The parameters monitored by the SAS/SPDS for containment conditions enable the operators to monitor the potential for breach of containment integrity, and the results of actions to mitigate the potential for breach of integrity. These parameters, therefore, provide for adequate assessment of the containment function.

3.2.5 Radioactivity Control

In order to assess the status of the radioactivity control function, the operators must be cognizant of the major identified release points.

The principal radioactive release point during normal, off-normal, and accident conditions is the main stack. The SAS/SPDS monitors Auxiliary Building exhaust (stack) gaseous radiation. Containment radiation level, both normal and high range, is also monitored by the SAS/SPDS, to enable the operators to assess the potential magnitude of release resulting from accidents. The above parameters are displayed in a trend graph format. Additionally, steam generator blowdown radiation, steam jet air ejector radiation, and steam line radiation are monitored by the SAS/SPDS and represented by a secondary radiation target on the Normal Mode and Heatup/Cooldown Plant Mode displays.

The parameters monitored by the SAS/SPDS for radioactivity control enable the operators to monitor major identified release points and to monitor the potential for releases as a result of accidents. These parameters, therefore, provide an adequate assessment of the status of the radioactivity control function.

3.3 Parameter Ranges

The parameter ranges are presented in Appendix C. Analog signals which provide input to the SAS/SPDS are identified with their corresponding ranges and applicable reference documents which identify the basis for the range. In general, ranges monitored by the SAS/SPDS are identical to those in the control room and envelope system design criteria, EOP entry conditions, and plant responses to design basis accidents and transients.

3.4 Selection Of Alarm Setpoints

Alarm setpoints for the SAS/SPDS parameters are consistent with the existing IP2 setpoints for these parameters as defined in the IP2 Alarm Response Procedures.

3.5 Operability During Reactor Modes

The SAS/SPDS is intended to be operational during all reactor operating modes. The CSFM is turned on automatically when either a reactor trip (one of two breakers open or the trip demand signal is initiated) or when the Safety Injection (SI) signal is activated.

3.6 Provisions For Validation Of Displayed Data

The following paragraphs describe the logic used in the IP2 SAS/SPDS to validate inputs and parameters. The displayed value of each parameter is determined by processing one or more input signals. The quality of a displayed parameter value depends on the quality and number of inputs used to calculate the parameter value. Display conventions for valid and invalid data are discussed in section 2.3.2.

3.6.1 Criteria For Failed Input Values

The quality of an individual input value shall be considered FAILED if one or more of the following conditions exist. Otherwise, the input value shall be considered GOOD. Manually entered data shall be treated as SUSPECT.

- o The sensor is out of sensor range.
- o Input has been deleted from scan (including for calibration).
- o The CPI/VAX interface is inoperable.
- o A software error is detected.

3.6.2 Single-Input Parameters

- If the input quality is GOOD, the parameter value shall be the input value, and the parameter quality shall be GOOD.
- If the input quality is FAILED, the parameter value shall be unknown, and the quality shall be FAILED.

3.6.3 Two-Input Parameters

- If the input quality of both inputs is GOOD and the two values are within the divergence limit of each other, the parameter value shall be a function of the two input values, and the quality shall be GOOD. A function can be high, low or average, depending on the algorithm.
- If the quality of both inputs is GOOD, and the two values are not within the divergence limit of each other, the parameter value shall be a function of the two inputs, and the quality shall be SUSPECT.
- If the input quality of only one input is GOOD, and the other input is FAILED, the value of the parameter shall be the value of the GOOD input, and the parameter value shall be SUSPECT.
- If the input quality of both inputs is FAILED, the parameter value shall be unknown, and the quality shall be FAILED.

3.6.4 Three-Input Parameters

- If only two inputs are GOOD, the two-input logic shall be used for the two GOOD inputs, and the other input shall be ignored.
- If only one input is GOOD, the GOOD input shall be used as the parameter value, and the quality shall be SUSPECT.
- If all inputs are BAD, the parameter value shall be unknown and the quality shall be FAILED.
- If all inputs are GOOD, the values shall be arranged in ascending order and evaluated as follows:

  V(1)

  V(2)

  V(3)

  If V(3)-V(1) is $<$ the divergence limit, all three values shall be used to calculate the parameter value, and the quality shall be GOOD.

  If V(3)-V(1) is $\geq$ the divergence limit, then the values shall be arranged into two sets:

  V(1) and V(2)

  V(2)   V(3)

  If V(2)-V(1) and V(3)-V(2) are both $<$ or are both $\geq$ the divergence limit, all three values shall be used to calculate the parameter, and the quality shall be SUSPECT.

  If either V(2)-V(1) or V(3)-V(2) is $<$ the divergence limit, the two values which satisfy the test shall be used to calculate the parameter value, and the quality shall be GOOD.

3.6.5 Parameters Calculated From Four Inputs

- If only three inputs are GOOD, the three-input logic shall be used.
- If only two inputs are GOOD, the two-input logic shall be used.
- If only one input is GOOD, the GOOD input value shall be used as the parameter value, and the quality shall be SUSPECT.
- If all inputs are BAD, the parameter value shall be unknown, and the quality shall be FAILED.
- If all inputs are GOOD, the values shall be arranged in ascending order and evaluated as follows:

  V(1)
  V(2)
  V(3)
  V(4)

  If V(4)-V(1) is < the divergence limit, all four values shall be used to calculate the parameter value, and the quality shall be GOOD.

  If V(4)-V(1) is ≥ the divergence limit, then two sets shall be formed:

V(1)		V(2)
V(2)	and	V(3)
V(3)		V(4)

  If V(3)-V(1) and V(4)-V(2) are both < the divergence limit, all four values shall be to calculate the parameter value, and the quality shall be SUSPECT.

  If either V(3)-V(1) or V(4)-V(2) is < the divergence limit, the three values which satisfy the test shall be used to calculate the parameter value, and the quality shall be GOOD.

If V(3)-V(1) and V(4)-V(2) are both ≥ the divergence limit then three sets shall be formed:

V(1) and	V(2) and	V(3)
V(2)	V(3)	V(4)

If V(2)-V(1) and V(3)-V(2) and V(4)-V(3) are either all < or all ≥ the divergence limit, all four values shall be used to calculate the parameter, and the quality shall be SUSPECT.

If only two sets individually satisfy the divergence criteria, then the values that are included in those two sets shall be used. Since the difference between minimum and maximum of the inputs does not satisfy the divergence criteria, the quality shall be SUSPECT.

If only one set satisfies the divergence criteria, the two inputs in the set which satisfy the test shall be used to calculate the parameter value. The quality shall be GOOD since the two inputs outside the divergence limit are considered FAILED, which reduces to the two-input logic case.

3.6.6 Multiple-Parameter Parameters

- One of the above three methods shall be used to determine individual parameters, depending on the number of inputs.
- If all parameter values are GOOD, the resultant parameter value shall be GOOD.
- If any parameter value is SUSPECT, the resultant parameter shall be determined; and the resultant parameter shall be SUSPECT.
- If any parameter value is FAILED, the resultant parameter shall be FAILED.

3.6.7 CSF Status Tree Branch Node Parameters

Validation of branch node parameters depends on the quality and number of inputs and the results of the branching algorithm for each input at the node. The displayed quality and branch directions for all possible combinations of input qualities and branch algorithm results are consistent with the EOP Background Documents for the CSF status tree.

3.6.8 Display/Data-Link Failure

Failure of the data-link between the SAS/SPDS computers and a display will be annunciated by a full screen message on the affected display.

4 SAFETY ASSESSMENT

4.1 Function And Design Of SAS/SPDS

The SAS/SPDS will provide a concise display of critical plant parameters to the control room personnel to aid them in rapidly and reliably determining the safety status of the plant. The SAS/SPDS is intended to be available during normal operations, as well as during abnormal conditions and will continuously display real-time information in the control room from which the plant safety status can be readily and reliably assessed by control room personnel.

The SAS/SPDS is not a safety-grade system and it will perform no safety function. The existing control room instrumentation provides the operators with the information necessary for reactor operation under normal, transient, and accident conditions. The SAS/SPDS will be used in addition to the existing instrumentation and will serve to aid and augment it.

4.2 SAS/SPDS Installation

The SAS/SPDS installation process does not affect the safe operation of IP2 for the following reasons:

- o Portions of the installation requiring the Plant to be off-line will be accomplished during scheduled outages.
- o Work interfacing with existing safety-related equipment will be performed and documented in accordance with modification procedures.
- o SAS/SPDS calibration and thru-channel checks will be designed such that they cannot degrade Class 1E systems.

- Prior to SAS/SPDS startup, the operators will be trained on the system, existing system documentation will be updated, and post-installation/modification testing will be performed to ensure that the system does not affect any safety-related functions.

4.3 SAS/SPDS Operation

The seismic and electrical effects on existing safety systems, effects on operator performance and functional requirements verification and validation testing were assessed.

Although the SAS/SPDS need not be seismically qualified, the data acquisition system (DAS) hardware will be housed in two seismic, fire-resistant, prefabricated cabinets. The chassis and power supplies will be seismically qualified so that no part of the DAS presents a missile hazard during a seismic event.

SAS/SPDS display and reprographic equipment located in the control room will be mounted so that they will not affect any safety system. The SAS/SPDS supporting computers are located in a separate, fire-protected room adjacent to the control room, and will not affect any safety system.

The operation of the SAS/SPDS will require plant signals to be input from existing instrumentation and control circuitry; therefore, the SAS/SPDS is required to be suitably isolated from electrical or electronic interference with equipment and sensors that are in use for safety systems. The DAS hardware arrangement was designed so that its operation will not have an adverse impact upon the normal operation of the existing plant equipment with which it interfaces. The DAS is electrically isolated from Class 1E signals by the standard Indian Point isolation systems. In no case is a 1E signal applied to the DAS. As a further precaution, analog input cards are transformer coupled and digital input cards are optically isolated to insure that sufficient electrical isolation is provided. The analog input amplifiers have high input impedance with power on and power off. Input terminations are designed with appropriate surge protection. The DAS provides analog to digital conversion and prepares all data for transmission to the SAS/SPDS host processor over the fiber optic link. The fiber optic links are constructed of silica glass fiber surrounded by a Kevlar buffer tube and jacketed with Tefzel. These materials also provide complete electrical isolation between the SAS/SPDS and the DAS since they cannot propagate voltage or current.

In response to the NRC letter of April 3, 1986 (reference 6), the following is provided:

The SAS/SPDS implementation is subject to a verification and validation (V&V) program which follows the guidance of NSAC 39. The verification portion of the V&V program will provide an independent review to verify that:

- o Interfaces with existing safety-related and non-safety related equipment have been properly identified.
- o The proper design standards have been invoked.
- o The applicable design requirements have been properly implemented in the design, functional, and procurement specifications.
- o The training is proper and adequate.

The validation testing and field verification portions of the V&V program provide for comprehensive testing and documentation of test results to ensure the proper functioning of the SAS/SPDS in accordance with the design, functional and procurement specifications.

Human factors considerations and thorough training ensure that operation of the SAS/SPDS cannot degrade operators' performance. The graphic design of the display and the location of the SAS/SPDS terminals in the control room are human-factor engineered. Validation provisions are designed into the SAS/SPDS software for each input signal. The human factors and signal validation provision in the SAS/SPDS design ensure that the monitoring and presentation of plant safety status information will not be misleading to the operators. Display conventions such as ranges, units, and format for individual parameters are consistent with existing control room instrumentation. Also, clear, unambiguous indication of unvalidated or invalid data, or manually entered data, will be provided.

The operators will be trained in procedures which describe the timely and correct safety status assessment when the SAS/SPDS is and is not available.

4.4 Conclusion

In summary:

- o The SAS/SPDS will perform no safety function, and the installation, operation, or failure of the SPDS will not degrade the performance of safety systems.

- o The potential for operator error will not be increased because the presentation of SAS/SPDS data will be consistent with control room indication, and thorough training will be provided with and without the SAS/SPDS available.

5 SUMMARY AND CONCLUSIONS

This report was prepared in fulfillment of a commitment contained in our January 24, 1986 submittal (reference 1). This SAR describes the methodology and basis on which the plant parameters selected for monitoring on the IP2 SAS/SPDS have been determined to be sufficient to assess the overall safety status of the plant in terms of the following five critical safety functions of Supplement 1 to NUREG-0737:

- o Reactivity control
- o Reactor core cooling and heat removal from the primary system
- o Reactor coolant system integrity
- o Containment conditions
- o Radioactivity control

The IP2 SAS/SPDS parameter set was evaluated against the IP2 emergency operating procedures (EOPs), UFSAR, and Technical Specifications, for sufficiency in terms of the type and number of parameters monitored to assess each safety function, and the range of plant conditions covered by the parameters. On the basis of this review and evaluation process, the IP2 parameters are considered to be compatible with the IP2 EOPs and sufficient to assess plant safety over a wide range of conditions, including the symptoms of severe accidents and all modes of reactor operation. The function, design, installation, and operation of the IP2 SAS/SPDS were also assessed, and it was concluded that no unreviewed safety question is involved with the SAS/SPDS implementation at IP2.

APPENDIX A

Indian Point #2 SAS/SPDS
Primary Displays

Appendix A

SAS/SPDS Primary Displays**

Appendix A Figure No.	Display Description	Display Type
A.1	normal operation	plant mode
A.2	heatup/cooldown	plant mode
A.3	cold shutdown	plant mode
A.4	F-0.1 subcriticality	CSFM
A.5	F-0.2 core cooling	CSFM
A.6	F-0.3 heat sink	CSFM
A.7	F-0.4 integrity	CSFM
A.8	F-0.4-1 integrity	CSFM
A.9	F-0.4-2 integrity	CSFM
A.10	F-0.5 containment	CSFM
A.11	F-0.6 inventory	CSFM
A.12	F-0.1 subcriticality	trend
A.13	F-0.2 core cooling	trend
A.14	F-0.3 heat sink (1)	trend
A.15	F-0.3 heat sink (2)	trend
A.16	F-0.4-1 integrity (1)	trend
A.17	F-0.4-2 pressure/temperature curve	trend
A.18	F-0.5 containment	trend
A.19	F-0.6 inventory	trend
A.20	RCS* temperature	trend
A.21	steam flow-feed flow	trend
A.22	containment and radiation monitors	trend
A.23	tank levels	trend
A.24	loss of electrical power (LOEP)	EOP parameter (EOPP)

*RCS: reactor coolant system

**NOTE: The color primary displays presented are the latest available, however, there are additions (e.g. time scales) and minor changes which will be incorporated in the final delivered version.

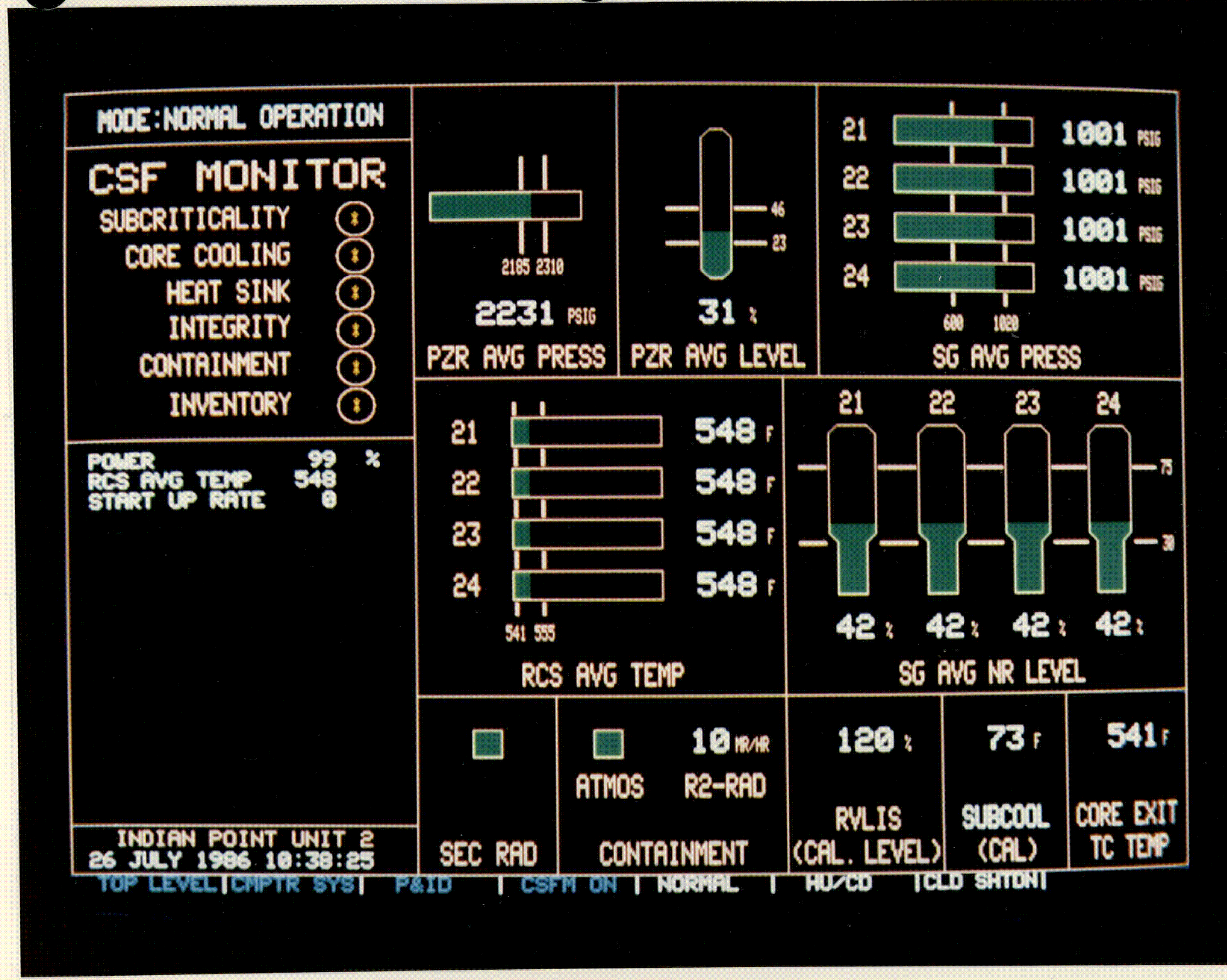

MODE:NORMAL OPERATION
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 99 %
RCS AVG TEMP 548
START UP RATE 0
2185 2310
2231 PSIG
PZR AVG PRESS
46
23
31 %
PZR AVG LEVEL
21 1001 PSIG
22 1001 PSIG
23 1001 PSIG
24 1001 PSIG
600 1020
SG AVG PRESS
21 548 F
22 548 F
23 548 F
24 548 F
541 555
RCS AVG TEMP
21 22 23 24
75
30
42 % 42 % 42 % 42 %
SG AVG NR LEVEL
SEC RAD
10 MR/HR
ATMOS R2-RAD
CONTAINMENT
120 %
RVLIS (CAL. LEVEL)
73 F
SUBCOOL (CAL)
541 F
CORE EXIT TC TEMP
INDIAN POINT UNIT 2
26 JULY 1986 10:38:25
TOP LEVEL | CMPTR SYS | P&ID | CSFM ON | NORMAL | HU/CD | CLD SHTDN |

Figure A.1

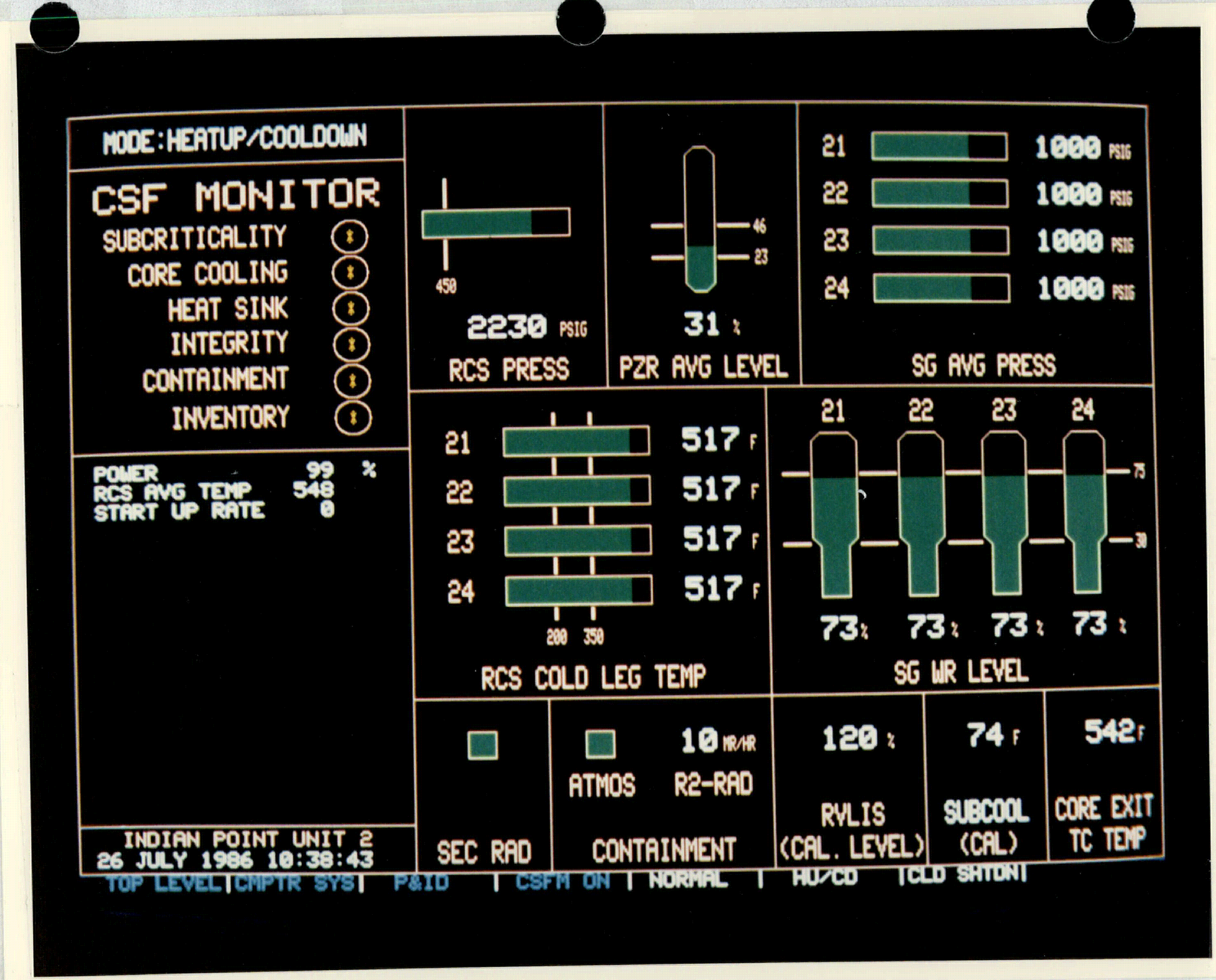

MODE:HEATUP/COOLDOWN
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 99 %
RCS AVG TEMP 548
START UP RATE 0
INDIAN POINT UNIT 2
26 JULY 1986 10:38:43
450
2230 PSIG
RCS PRESS
46
23
31 %
PZR AVG LEVEL
21 1000 PSIG
22 1000 PSIG
23 1000 PSIG
24 1000 PSIG
SG AVG PRESS
21 517 F
22 517 F
23 517 F
24 517 F
200 350
RCS COLD LEG TEMP
21 22 23 24
75
30
73% 73% 73% 73%
SG WR LEVEL
SEC RAD
10 MR/HR
ATMOS R2-RAD
CONTAINMENT
120 %
RVLIS (CAL. LEVEL)
74 F
SUBCOOL (CAL)
542F
CORE EXIT TC TEMP
TOP LEVEL | CMPTR SYS | P&ID | CSFM ON | NORMAL | HU/CD | CLD SHTDN |

Figure A.2

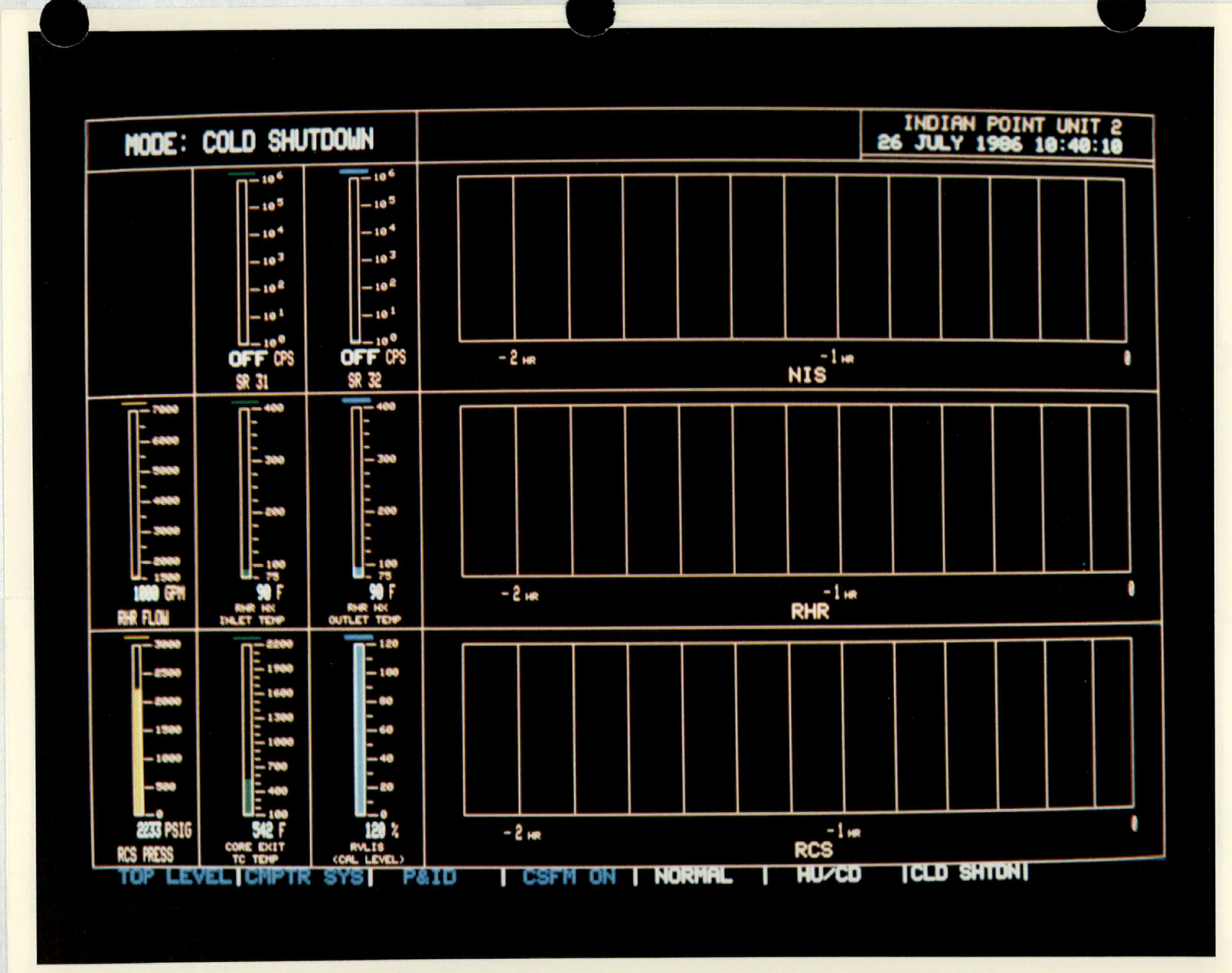
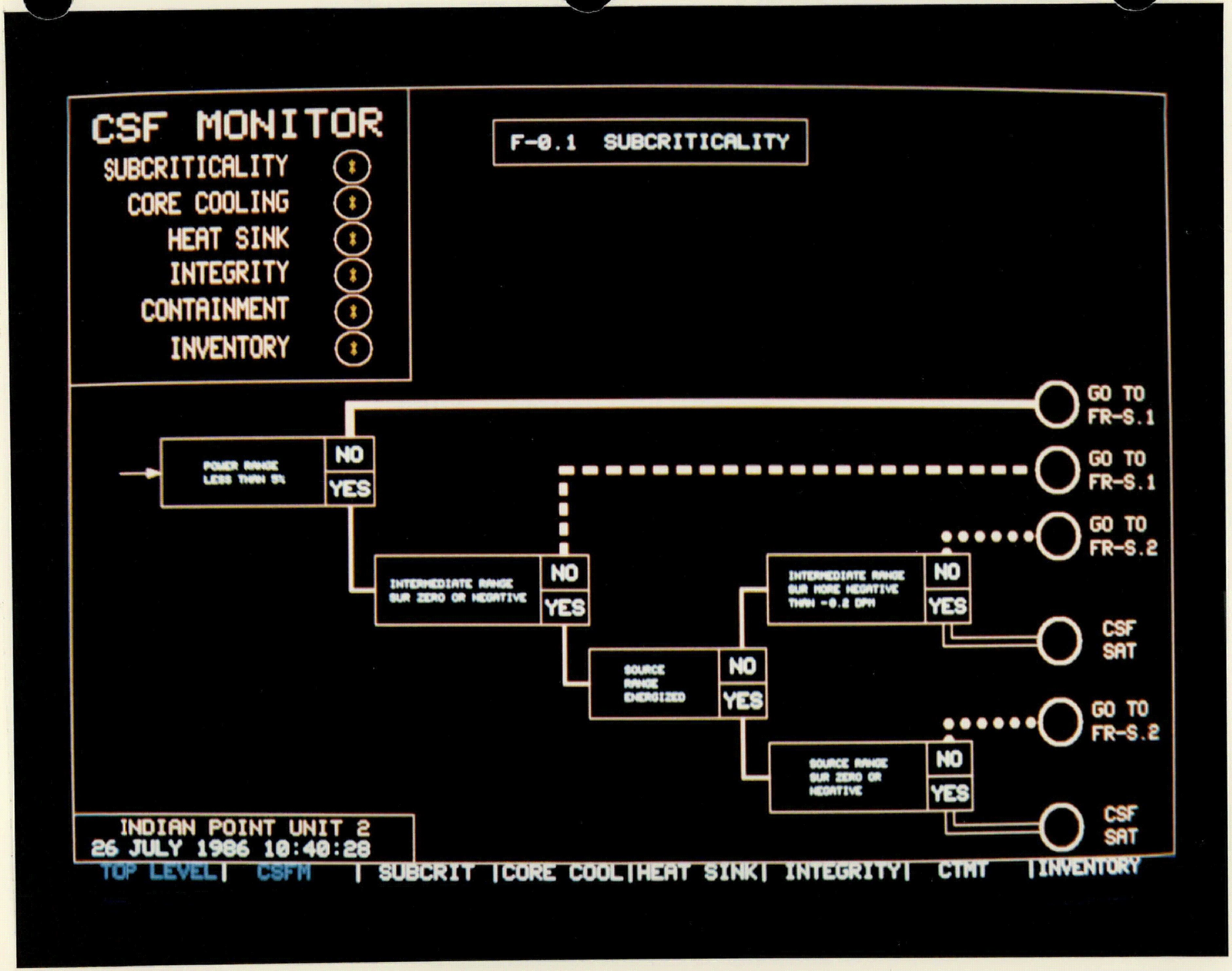

MODE: COLD SHUTDOWN
INDIAN POINT UNIT 2
26 JULY 1986 10:40:10
OFF CPS
SR 31
OFF CPS
SR 32
-2 HR
-1 HR
0
NIS
1000 GPM
RHR FLOW
90 F
RHR HX INLET TEMP
90 F
RHR HX OUTLET TEMP
-2 HR
-1 HR
0
RHR
2233 PSIG
RCS PRESS
542 F
CORE EXIT TC TEMP
120 %
RVLIS (CAL LEVEL)
-2 HR
-1 HR
0
RCS
TOP LEVEL | CMPTR SYS | P&ID | CSFM ON | NORMAL | HU/CD | CLD SHTDN |

Figure A.3



CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
F-0.1 SUBCRITICALITY
POWER RANGE LESS THAN 5%
NO
YES
INTERMEDIATE RANGE SUR ZERO OR NEGATIVE
NO
YES
SOURCE RANGE ENERGIZED
NO
YES
INTERMEDIATE RANGE SUR MORE NEGATIVE THAN -0.2 DPM
NO
YES
SOURCE RANGE SUR ZERO OR NEGATIVE
NO
YES
GO TO FR-S.1
GO TO FR-S.1
GO TO FR-S.2
CSF SAT
GO TO FR-S.2
CSF SAT
INDIAN POINT UNIT 2
26 JULY 1986 10:40:28
TOP LEVEL | CSFM | SUBCRIT | CORE COOL | HEAT SINK | INTEGRITY | CTMT | INVENTORY

Figure A.4

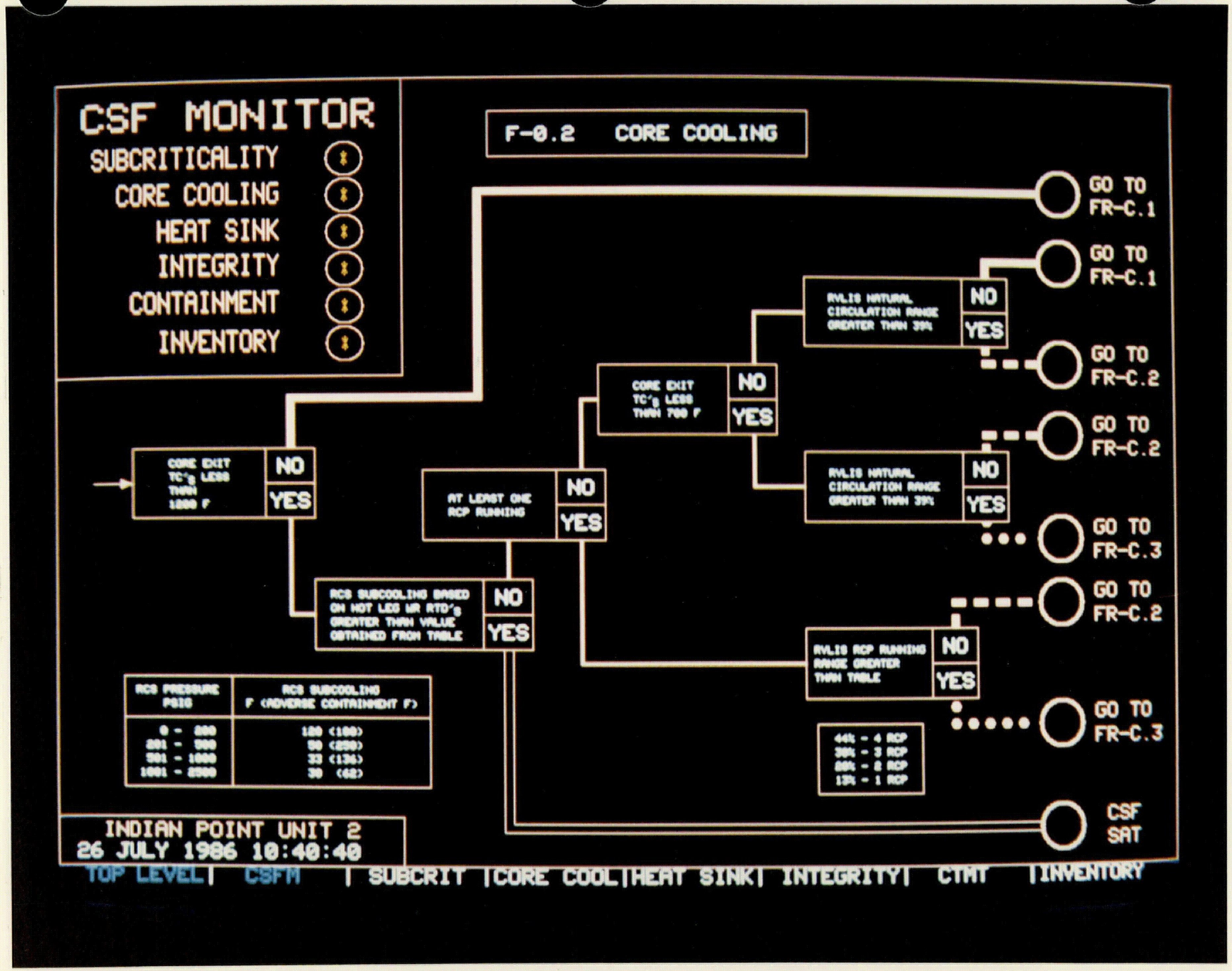
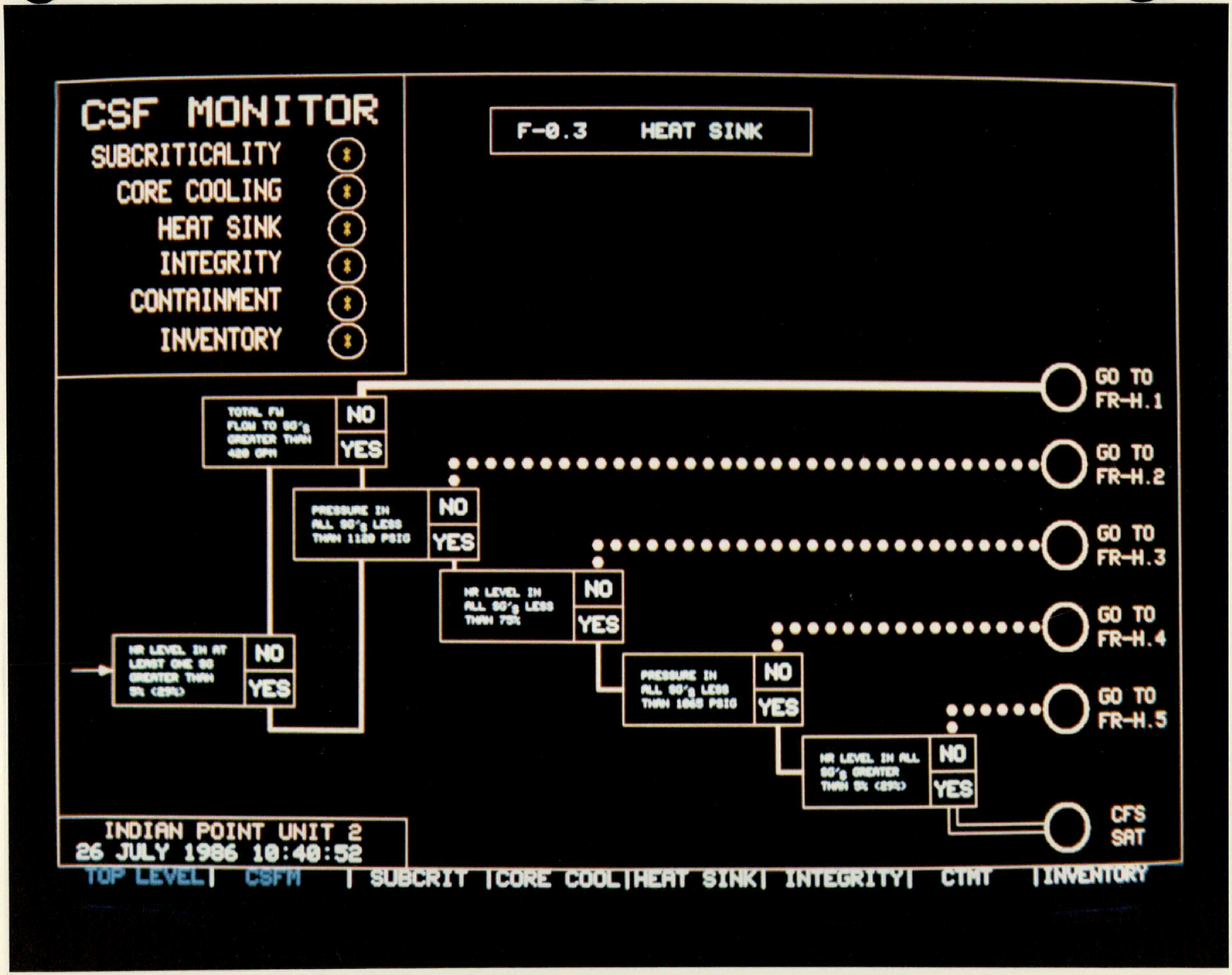
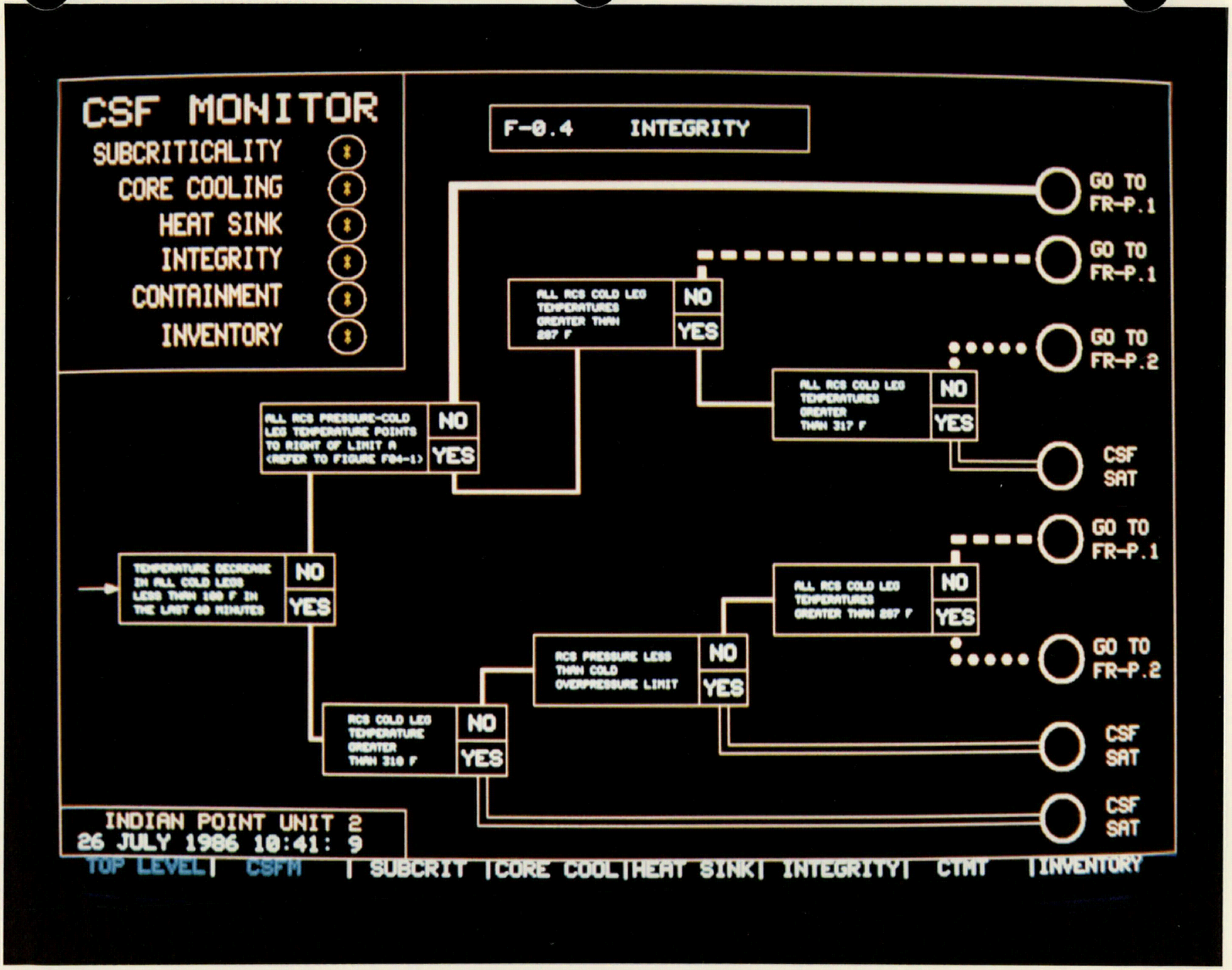

CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
F-0.2 CORE COOLING
CORE EXIT TC's LESS THAN 1200 F
NO
YES
AT LEAST ONE RCP RUNNING
CORE EXIT TC's LESS THAN 700 F
RVLIS NATURAL CIRCULATION RANGE GREATER THAN 39%
RCS SUBCOOLING BASED ON HOT LEG WR RTD's GREATER THAN VALUE OBTAINED FROM TABLE
RVLIS RCP RUNNING RANGE GREATER THAN TABLE
GO TO FR-C.1
GO TO FR-C.2
GO TO FR-C.3
CSF SAT
RCS PRESSURE PSIG
RCS SUBCOOLING F (ADVERSE CONTAINMENT F)
44% - 4 RCP
13% - 1 RCP
INDIAN POINT UNIT 2
26 JULY 1986 10:40:40
TOP LEVEL | CSFM | SUBCRIT | CORE COOL | HEAT SINK | INTEGRITY | CTMT | INVENTORY

Figure A.5



CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
F-0.3 HEAT SINK
TOTAL FW FLOW TO SG's GREATER THAN 420 GPM
PRESSURE IN ALL SG's LESS THAN 1120 PSIG
NR LEVEL IN ALL SG's LESS THAN 75%
NR LEVEL IN AT LEAST ONE SG GREATER THAN 5% (25%)
PRESSURE IN ALL SG's LESS THAN 1065 PSIG
NR LEVEL IN ALL SG's GREATER THAN 5% (25%)
NO
YES
GO TO FR-H.1
GO TO FR-H.2
GO TO FR-H.3
GO TO FR-H.4
GO TO FR-H.5
CFS SAT
INDIAN POINT UNIT 2
26 JULY 1986 10:40:52
TOP LEVEL | CSFM | SUBCRIT | CORE COOL | HEAT SINK | INTEGRITY | CTMT | INVENTORY

Figure A.6



CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
F-0.4 INTEGRITY
TEMPERATURE DECREASE IN ALL COLD LEGS LESS THAN 100 F IN THE LAST 60 MINUTES
NO
YES
ALL RCS PRESSURE-COLD LEG TEMPERATURE POINTS TO RIGHT OF LIMIT A (REFER TO FIGURE F04-1)
NO
YES
ALL RCS COLD LEG TEMPERATURES GREATER THAN 287 F
NO
YES
ALL RCS COLD LEG TEMPERATURES GREATER THAN 317 F
NO
YES
RCS COLD LEG TEMPERATURE GREATER THAN 310 F
NO
YES
RCS PRESSURE LESS THAN COLD OVERPRESSURE LIMIT
NO
YES
ALL RCS COLD LEG TEMPERATURES GREATER THAN 287 F
NO
YES
GO TO FR-P.1
GO TO FR-P.1
GO TO FR-P.2
CSF SAT
GO TO FR-P.1
GO TO FR-P.2
CSF SAT
CSF SAT
INDIAN POINT UNIT 2
26 JULY 1986 10:41: 9
TOP LEVEL | CSFM | SUBCRIT | CORE COOL | HEAT SINK | INTEGRITY | CTMT | INVENTORY

Figure A.7

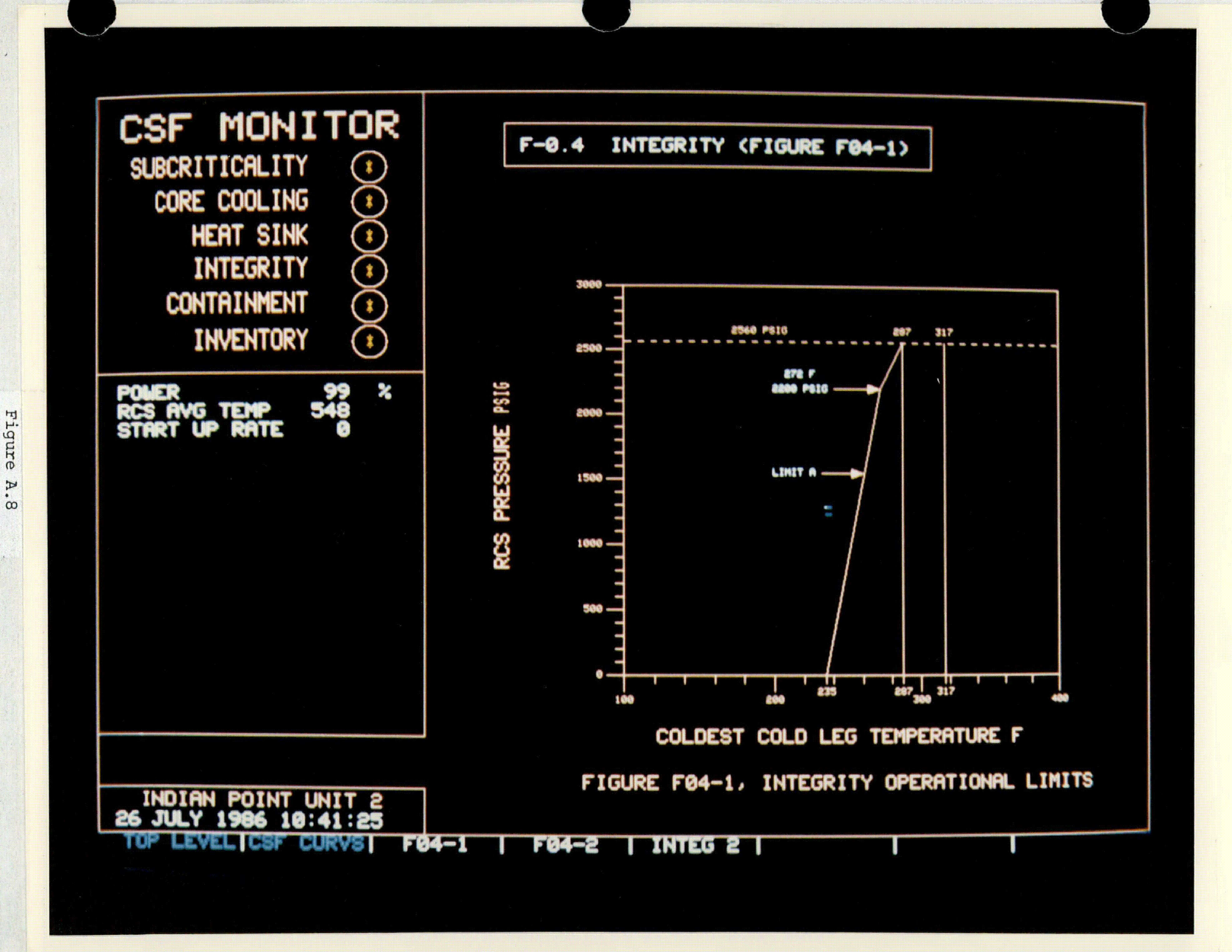

CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 99 %
RCS AVG TEMP 548
START UP RATE 0
INDIAN POINT UNIT 2
26 JULY 1986 10:41:25
TOP LEVEL | CSF CURVS | F04-1 | F04-2 | INTEG 2 |
F-0.4 INTEGRITY (FIGURE F04-1)
RCS PRESSURE PSIG
3000
2500
2000
1500
1000
500
0
2560 PSIG
287
317
272 F
2200 PSIG
LIMIT A
100
200
235
287
300
317
400
COLDEST COLD LEG TEMPERATURE F
FIGURE F04-1, INTEGRITY OPERATIONAL LIMITS

Figure A.8

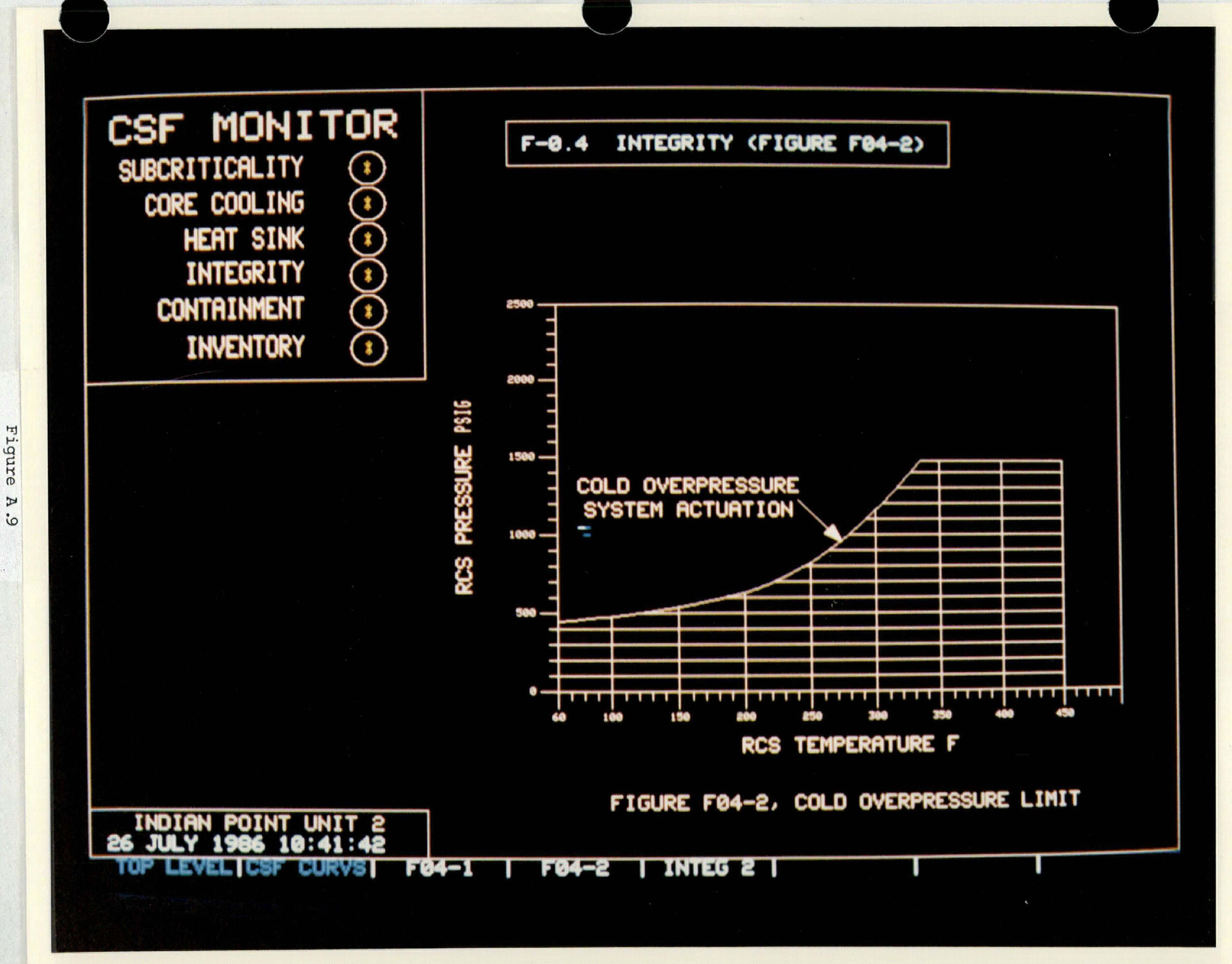
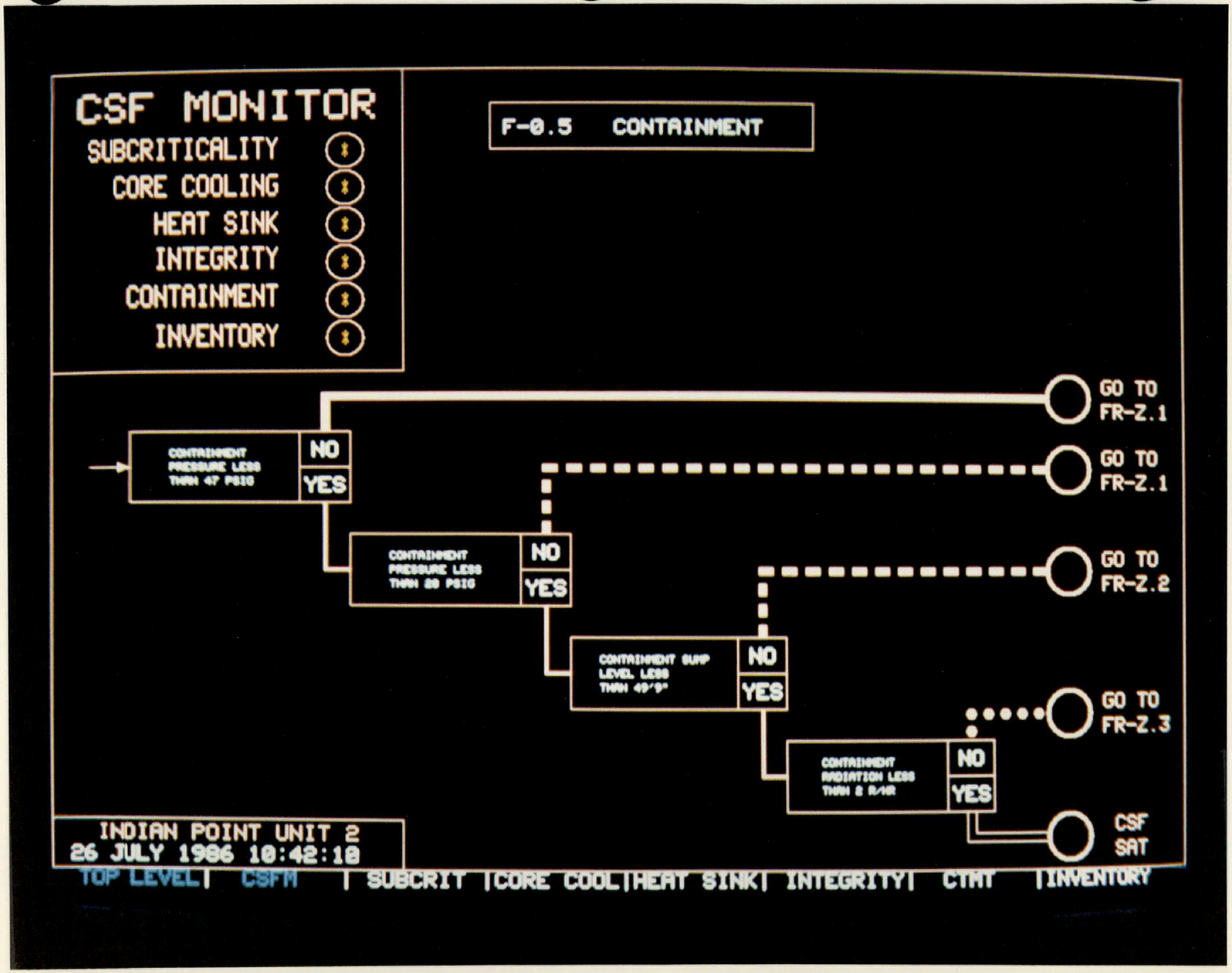

CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
F-0.4 INTEGRITY (FIGURE F04-2)
RCS PRESSURE PSIG
2500
2000
1500
1000
500
0
COLD OVERPRESSURE
SYSTEM ACTUATION
60
100
150
200
250
300
350
400
450
RCS TEMPERATURE F
FIGURE F04-2, COLD OVERPRESSURE LIMIT
INDIAN POINT UNIT 2
26 JULY 1986 10:41:42
TOP LEVEL | CSF CURVS | F04-1 | F04-2 | INTEG 2 |

Figure A.9



CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
F-0.5 CONTAINMENT
CONTAINMENT PRESSURE LESS THAN 47 PSIG
NO
YES
GO TO FR-Z.1
CONTAINMENT PRESSURE LESS THAN 20 PSIG
NO
YES
GO TO FR-Z.1
CONTAINMENT SUMP LEVEL LESS THAN 49'9"
NO
YES
GO TO FR-Z.2
CONTAINMENT RADIATION LESS THAN 2 R/HR
NO
YES
GO TO FR-Z.3
CSF SAT
INDIAN POINT UNIT 2
26 JULY 1986 10:42:10
TOP LEVEL | CSFM | SUBCRIT | CORE COOL | HEAT SINK | INTEGRITY | CTMT | INVENTORY

Figure A.10

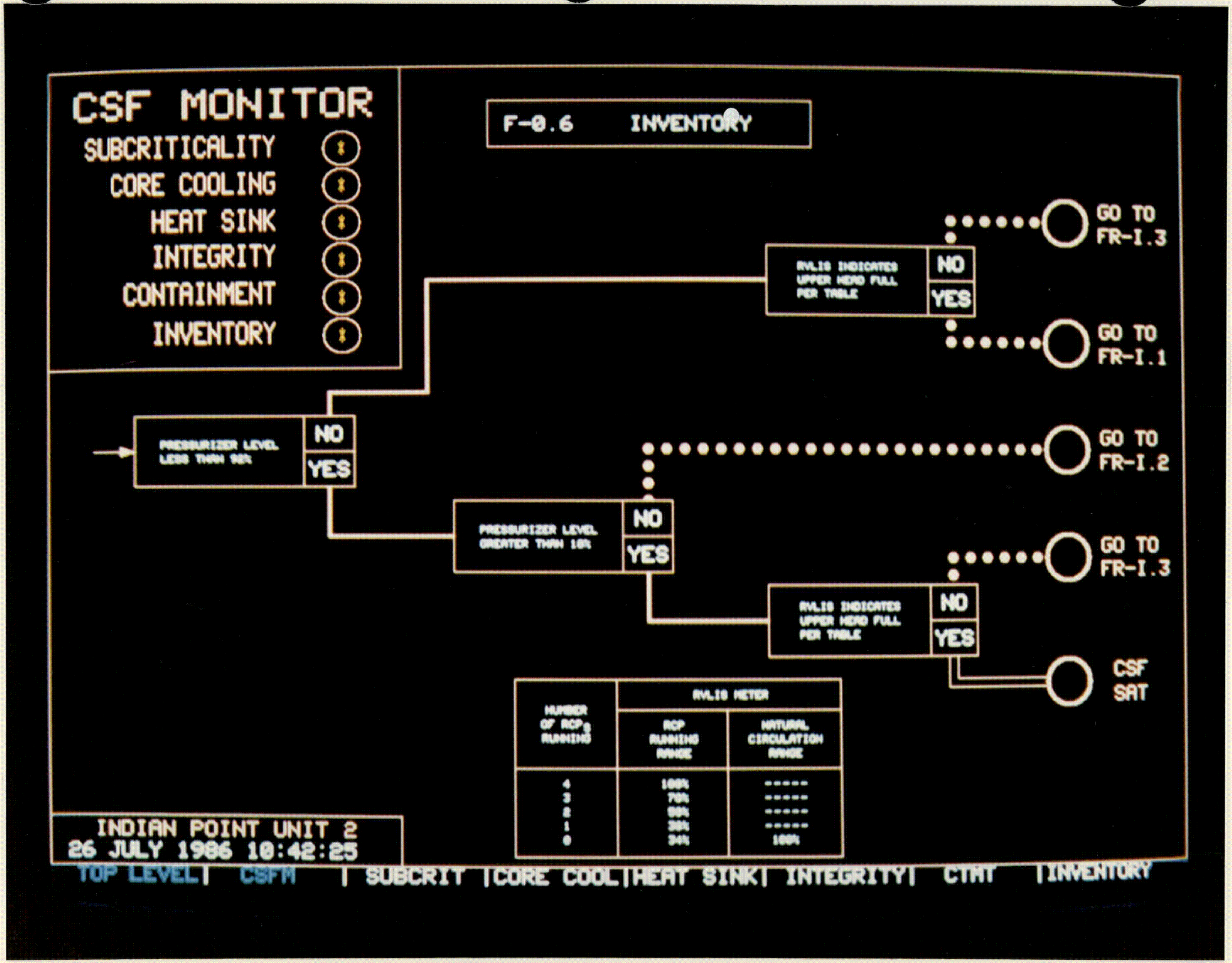

CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
F-0.6 INVENTORY
PRESSURIZER LEVEL LESS THAN 92%
NO
YES
RVLIS INDICATES UPPER HEAD FULL PER TABLE
NO
YES
GO TO FR-I.3
GO TO FR-I.1
PRESSURIZER LEVEL GREATER THAN 10%
NO
YES
GO TO FR-I.2
RVLIS INDICATES UPPER HEAD FULL PER TABLE
NO
YES
GO TO FR-I.3
CSF SAT
NUMBER OF RCPs RUNNING
RVLIS METER
RCP RUNNING RANGE
NATURAL CIRCULATION RANGE
4 100% -----
3 70% -----
2 -----
1 -----
0 34% 100%
INDIAN POINT UNIT 2
26 JULY 1986 10:42:25
TOP LEVEL| CSFM | SUBCRIT |CORE COOL|HEAT SINK| INTEGRITY| CTMT |INVENTORY

Figure A.11

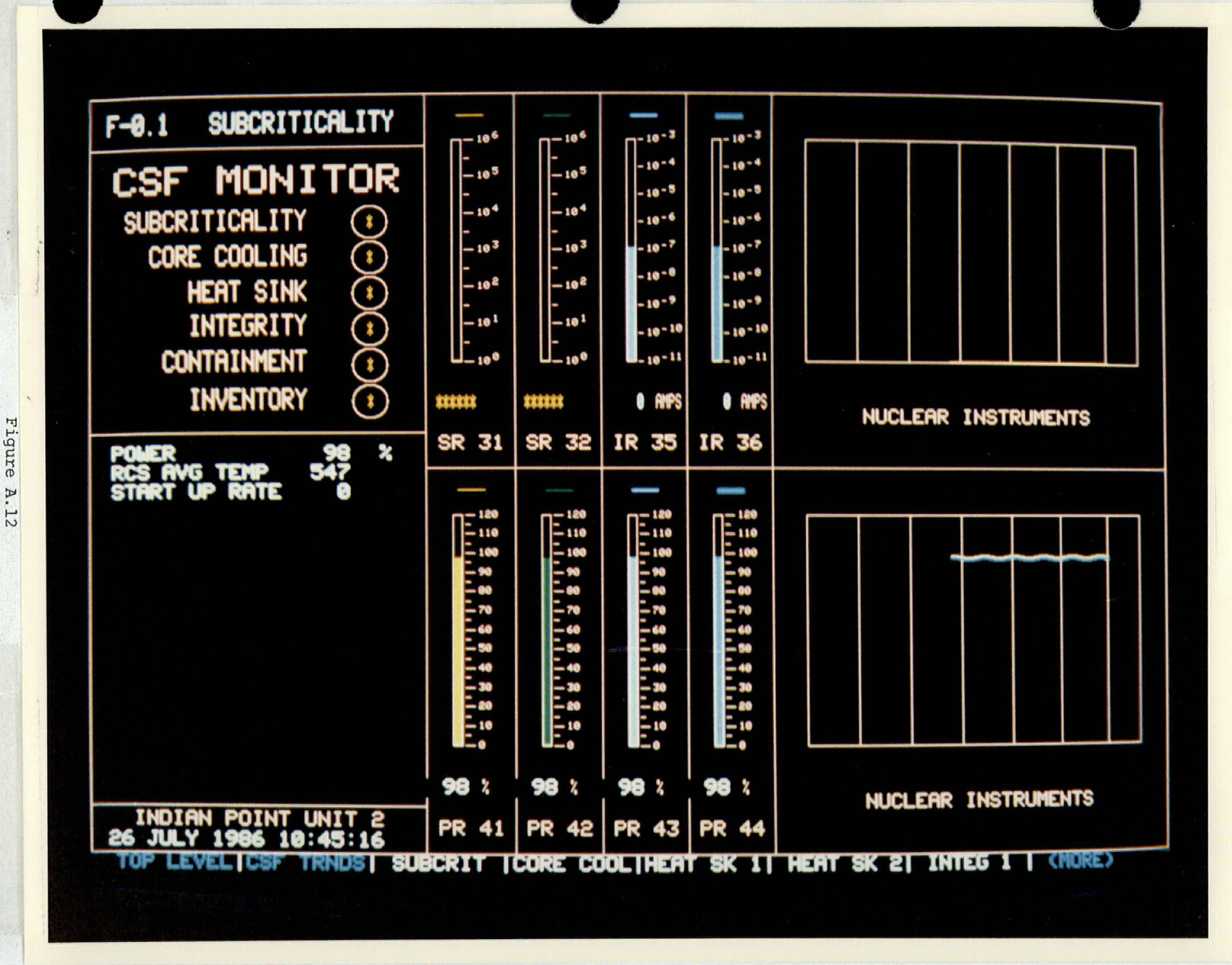
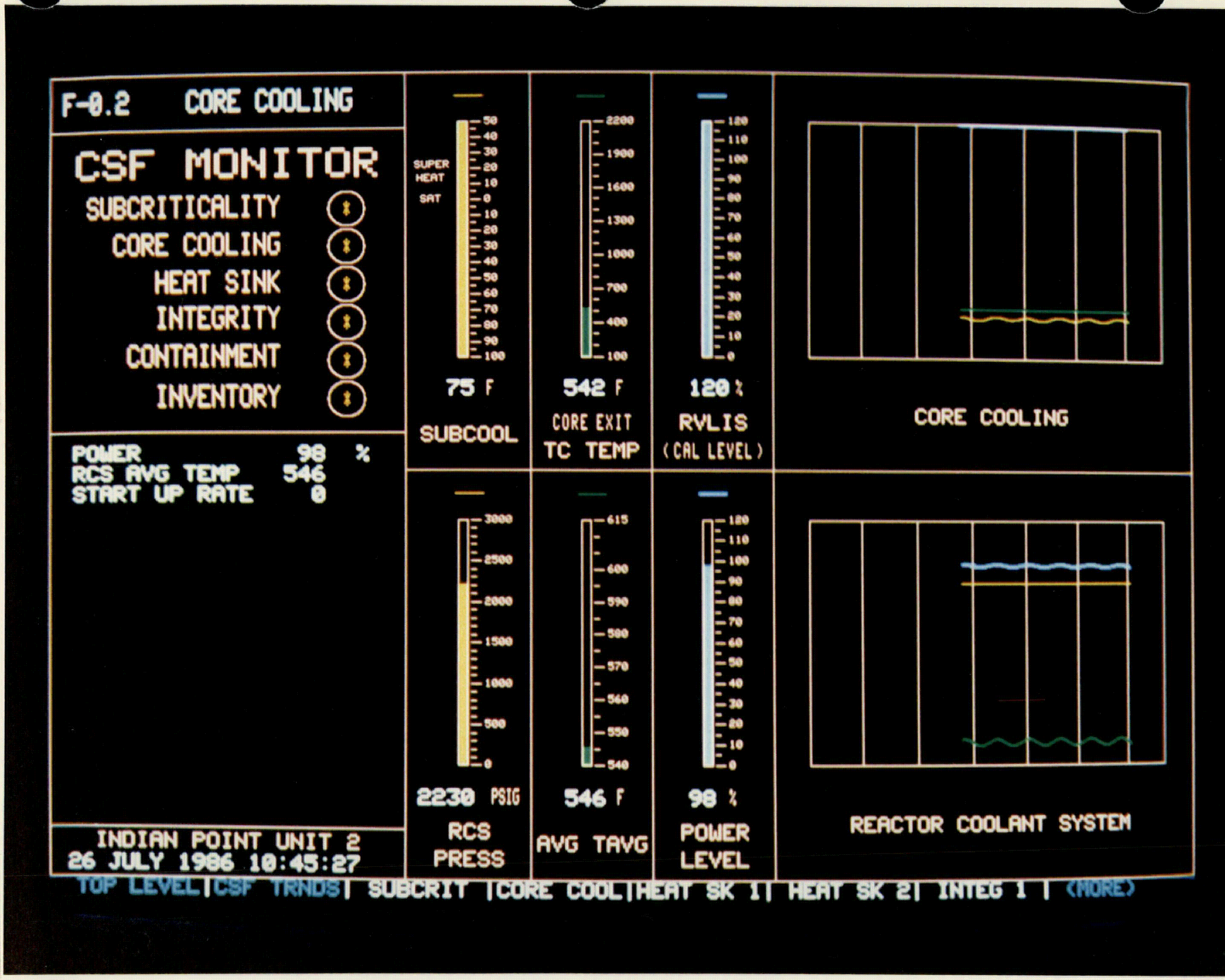

F-0.1 SUBCRITICALITY
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 98 %
RCS AVG TEMP 547
START UP RATE 0
INDIAN POINT UNIT 2
26 JULY 1986 10:45:16
0 AMPS
0 AMPS
SR 31
SR 32
IR 35
IR 36
NUCLEAR INSTRUMENTS
98 %
98 %
98 %
98 %
PR 41
PR 42
PR 43
PR 44
NUCLEAR INSTRUMENTS
TOP LEVEL|CSF TRNDS| SUBCRIT |CORE COOL|HEAT SK 1| HEAT SK 2| INTEG 1 | (MORE)

Figure A.12



F-0.2 CORE COOLING
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 98 %
RCS AVG TEMP 546
START UP RATE 0
INDIAN POINT UNIT 2
26 JULY 1986 10:45:27
SUPER HEAT
SAT
75 F
SUBCOOL
542 F
CORE EXIT TC TEMP
120 %
RVLIS (CAL LEVEL)
CORE COOLING
2230 PSIG
RCS PRESS
546 F
AVG TAVG
98 %
POWER LEVEL
REACTOR COOLANT SYSTEM
TOP LEVEL | CSF TRNDS | SUBCRIT | CORE COOL | HEAT SK 1 | HEAT SK 2 | INTEG 1 | (MORE)

Figure A.13

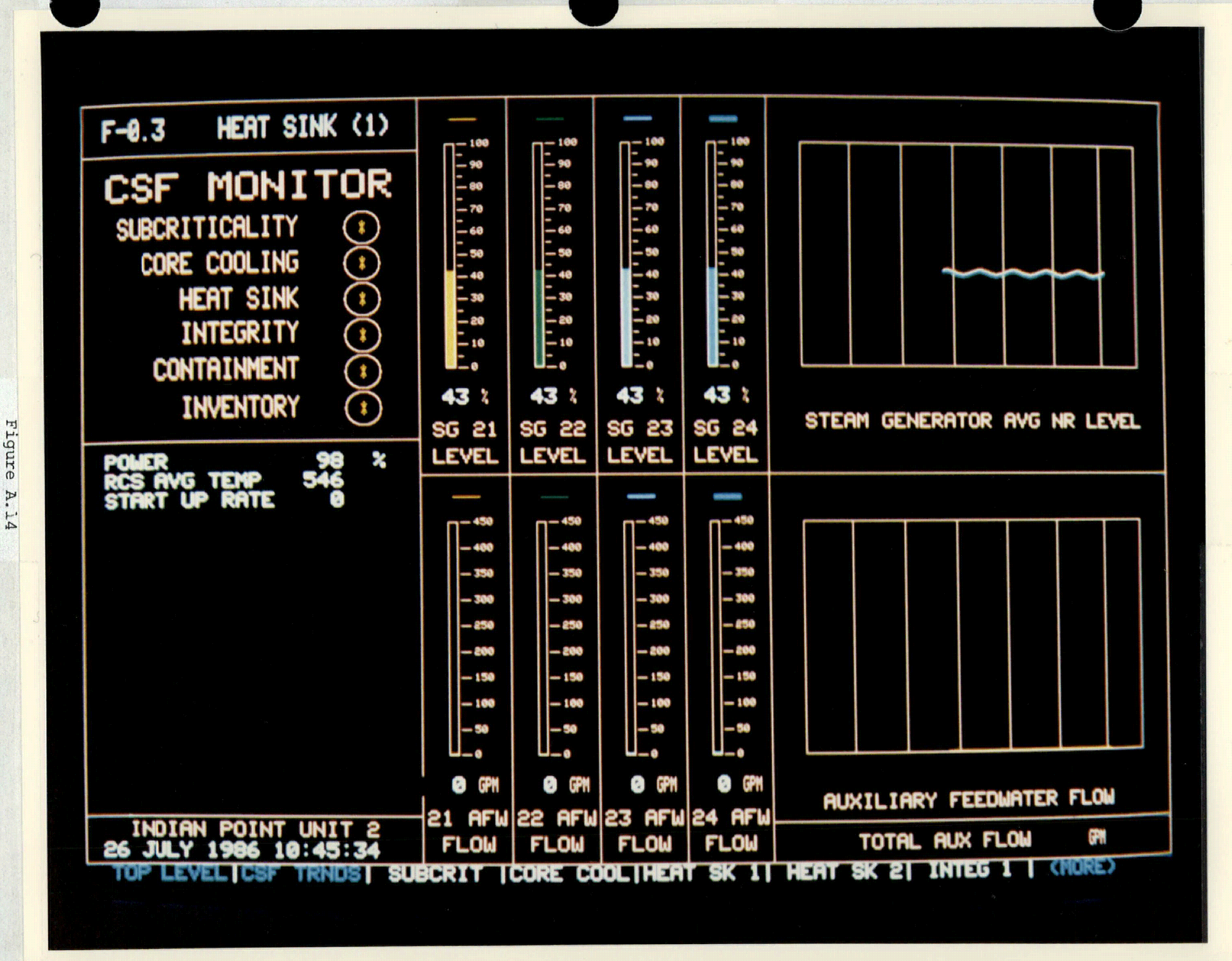

F-0.3 HEAT SINK (1)
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 98 %
RCS AVG TEMP 546
START UP RATE 0
43 % SG 21 LEVEL
43 % SG 22 LEVEL
43 % SG 23 LEVEL
43 % SG 24 LEVEL
STEAM GENERATOR AVG NR LEVEL
0 GPM 21 AFW FLOW
0 GPM 22 AFW FLOW
0 GPM 23 AFW FLOW
0 GPM 24 AFW FLOW
AUXILIARY FEEDWATER FLOW
TOTAL AUX FLOW GPM
INDIAN POINT UNIT 2
26 JULY 1986 10:45:34
TOP LEVEL | CSF TRNDS | SUBCRIT | CORE COOL | HEAT SK 1 | HEAT SK 2 | INTEG 1 | (MORE)

Figure A.14

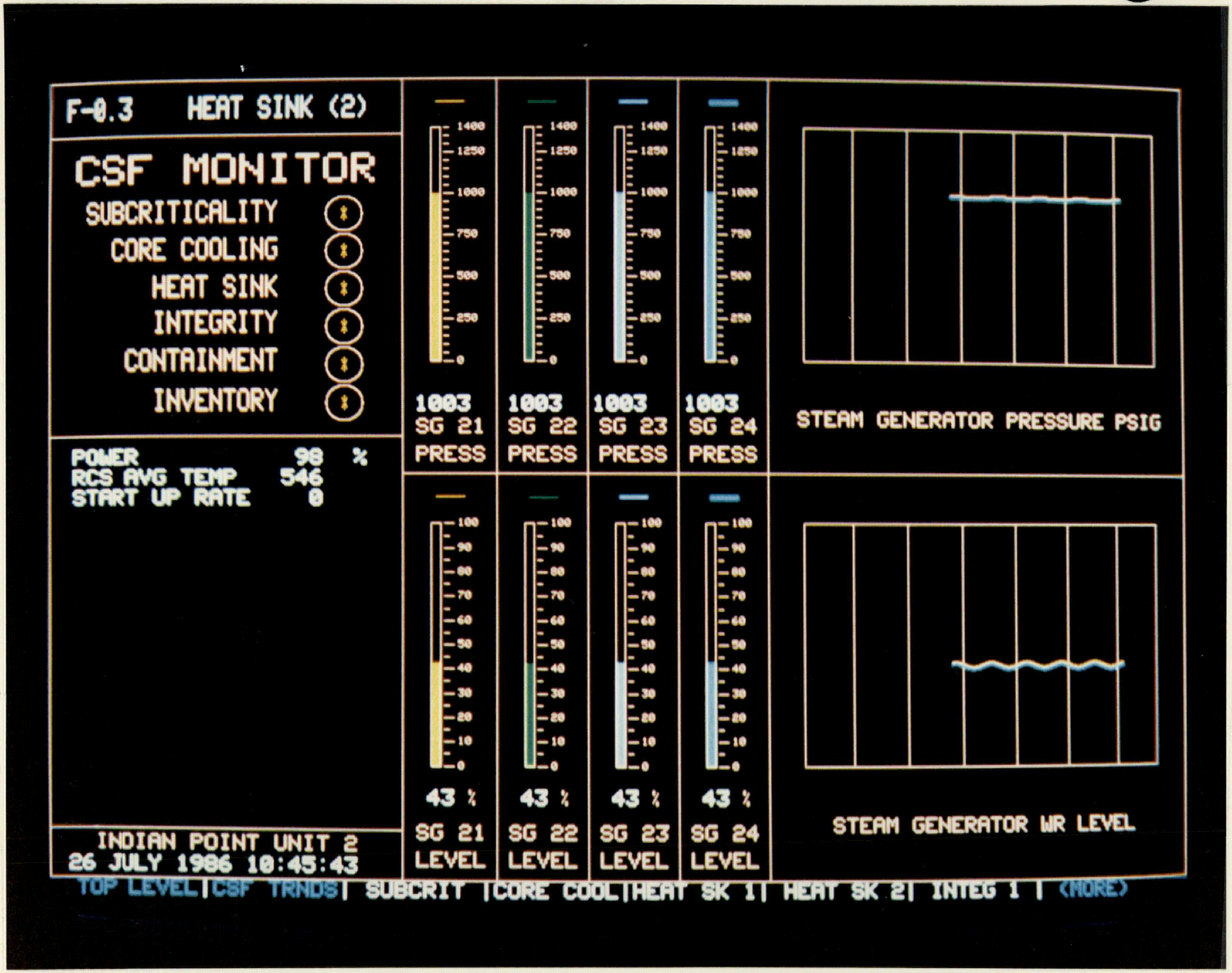

F-0.3 HEAT SINK (2)
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 98 %
RCS AVG TEMP 546
START UP RATE 0
INDIAN POINT UNIT 2
26 JULY 1986 10:45:43
1400
1250
1000
750
500
250
0
1003 SG 21 PRESS
1003 SG 22 PRESS
1003 SG 23 PRESS
1003 SG 24 PRESS
STEAM GENERATOR PRESSURE PSIG
100
90
80
70
60
50
40
30
20
10
0
43 % SG 21 LEVEL
43 % SG 22 LEVEL
43 % SG 23 LEVEL
43 % SG 24 LEVEL
STEAM GENERATOR WR LEVEL
TOP LEVEL|CSF TRNDS| SUBCRIT |CORE COOL|HEAT SK 1| HEAT SK 2| INTEG 1 | (MORE)

Figure A.15

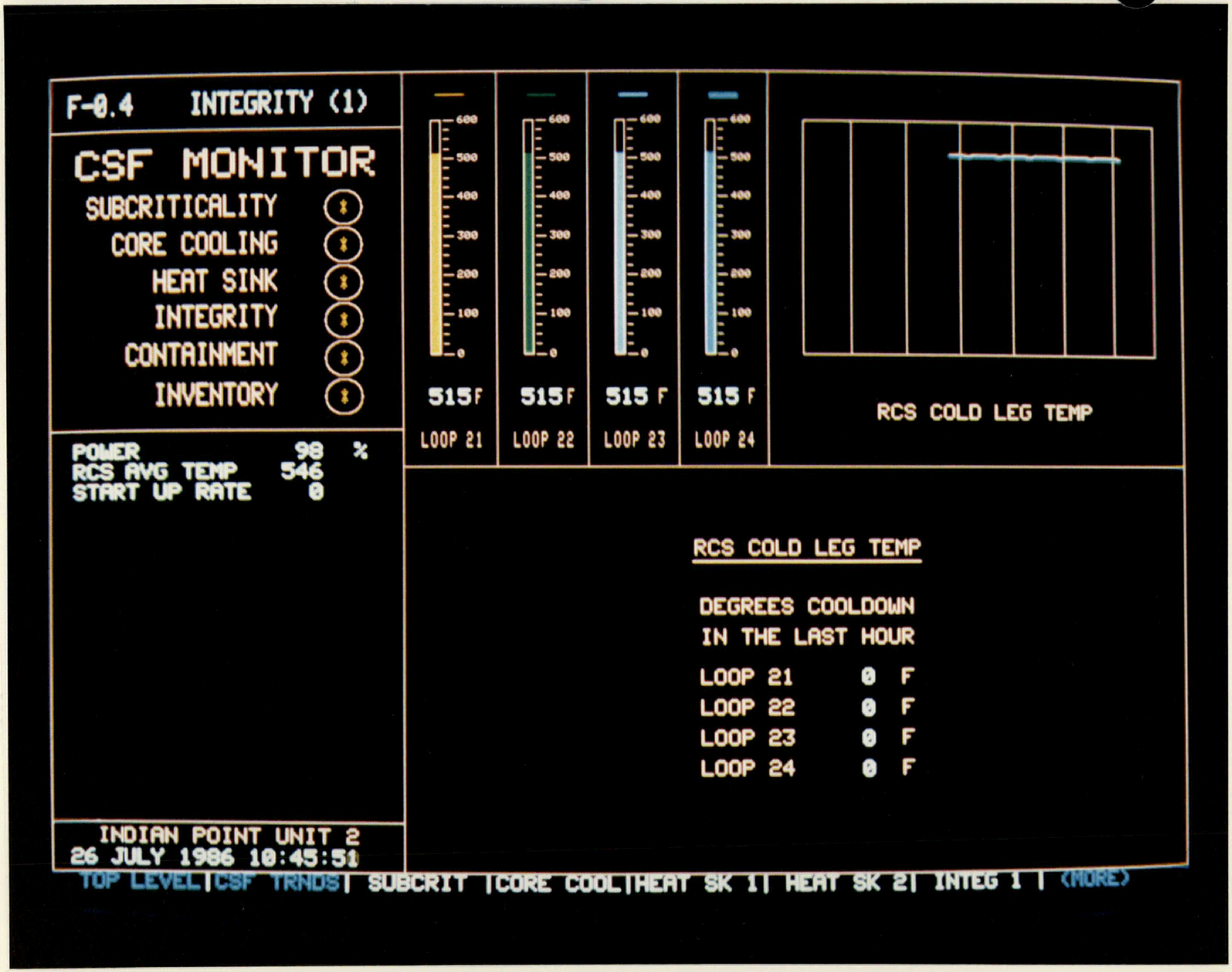

F-0.4 INTEGRITY (1)
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 98 %
RCS AVG TEMP 546
START UP RATE 0
600
500
400
300
200
100
0
515 F
515 F
515 F
515 F
LOOP 21
LOOP 22
LOOP 23
LOOP 24
RCS COLD LEG TEMP
RCS COLD LEG TEMP
DEGREES COOLDOWN
IN THE LAST HOUR
LOOP 21 0 F
LOOP 22 0 F
LOOP 23 0 F
LOOP 24 0 F
INDIAN POINT UNIT 2
26 JULY 1986 10:45:51
TOP LEVEL|CSF TRNDS| SUBCRIT |CORE COOL|HEAT SK 1| HEAT SK 2| INTEG 1 | (MORE)

Figure A.16

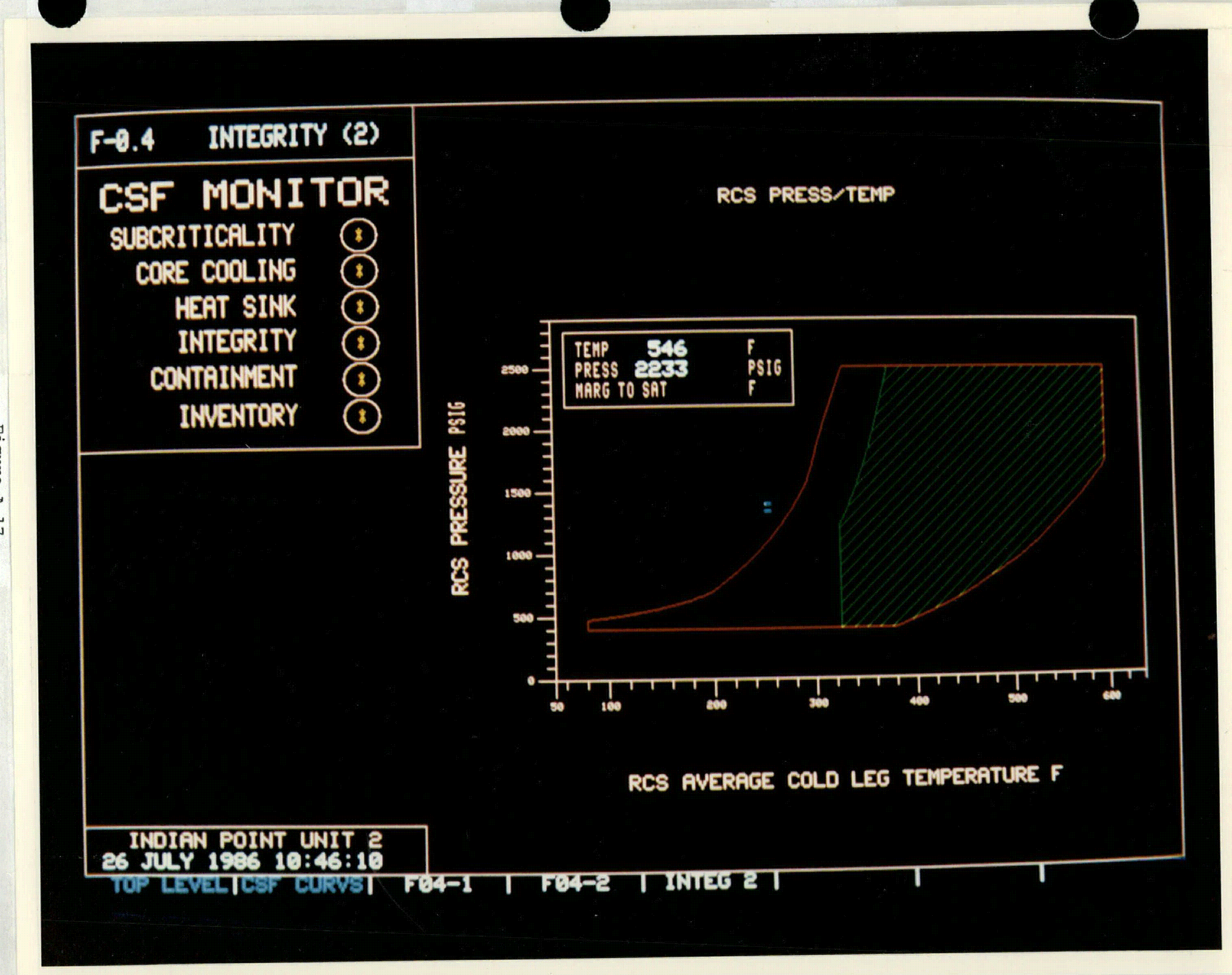

F-0.4 INTEGRITY (2)
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
RCS PRESS/TEMP
TEMP 546 F
PRESS 2233 PSIG
MARG TO SAT F
RCS PRESSURE PSIG
2500
2000
1500
1000
500
0
50
100
200
300
400
500
600
RCS AVERAGE COLD LEG TEMPERATURE F
INDIAN POINT UNIT 2
26 JULY 1986 10:46:10
TOP LEVEL
CSF CURVS
F04-1
F04-2
INTEG 2

Figure A.17

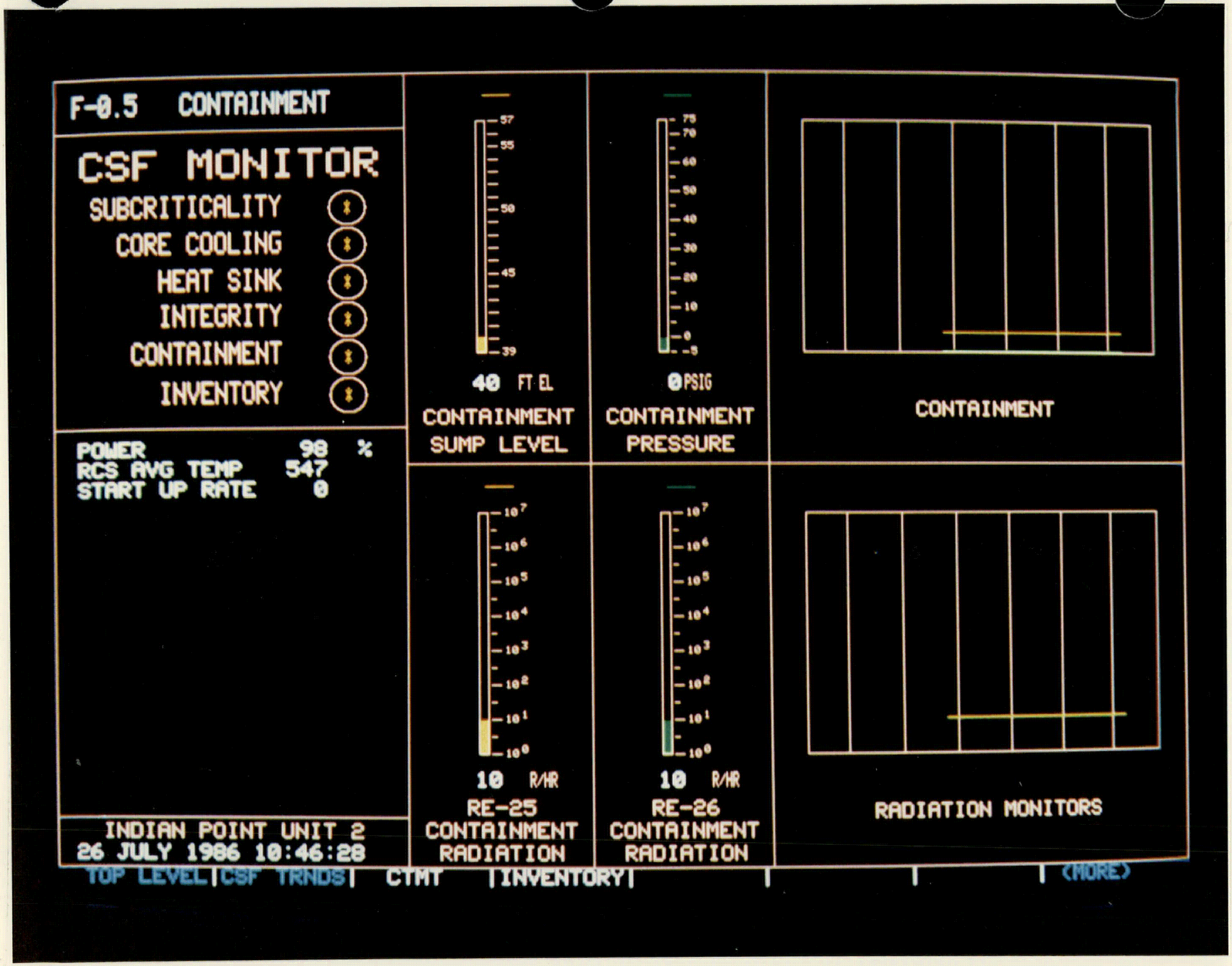
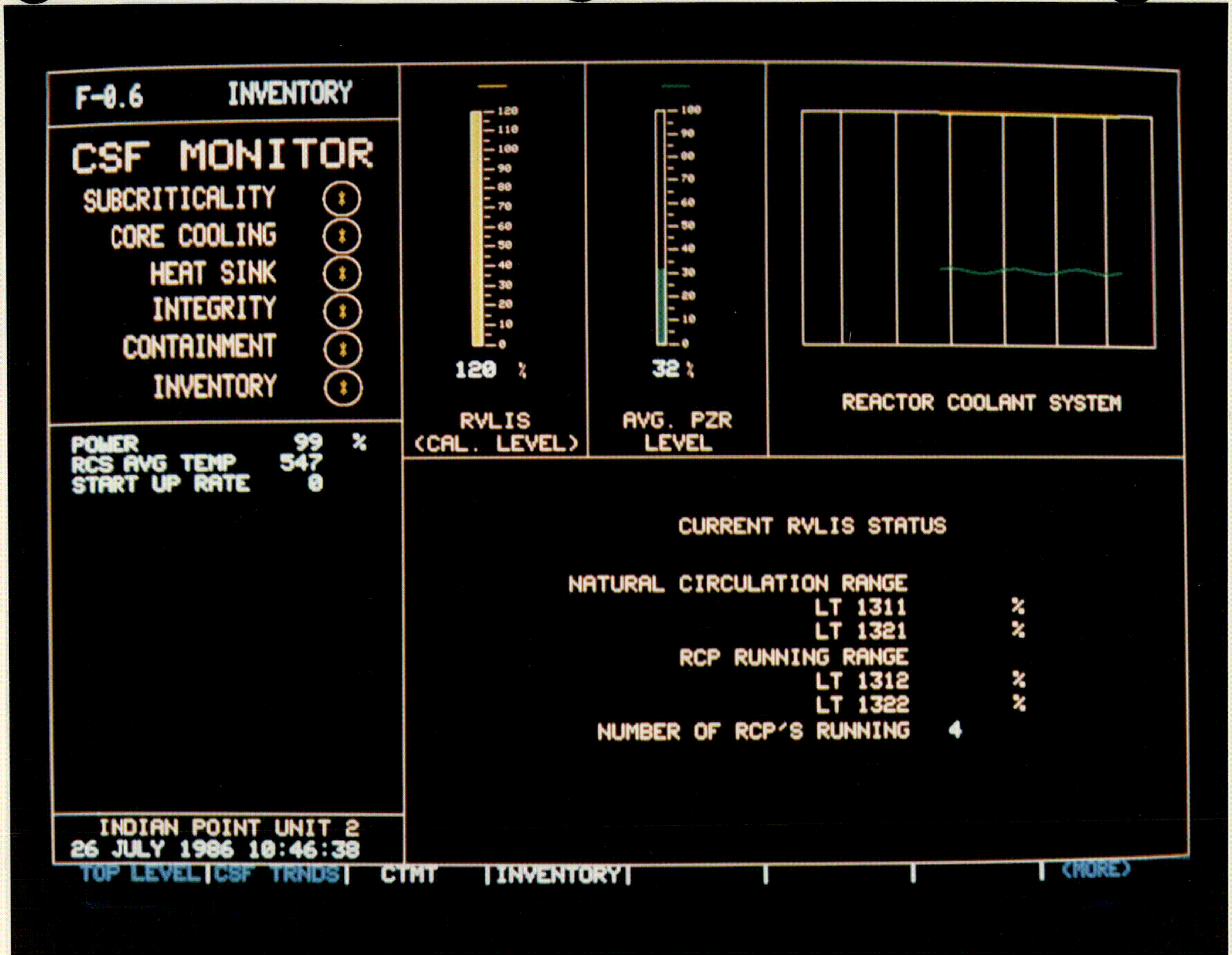

F-0.5 CONTAINMENT
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 98 %
RCS AVG TEMP 547
START UP RATE 0
57
55
50
45
39
40 FT EL
CONTAINMENT SUMP LEVEL
75
70
60
50
40
30
20
10
0
-5
0 PSIG
CONTAINMENT PRESSURE
CONTAINMENT
10 R/HR
RE-25 CONTAINMENT RADIATION
10 R/HR
RE-26 CONTAINMENT RADIATION
RADIATION MONITORS
INDIAN POINT UNIT 2
26 JULY 1986 10:46:28
TOP LEVEL | CSF TRNDS | CTMT | INVENTORY | (MORE)

Figure A.18



F-0.6 INVENTORY
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
120
110
100
90
80
70
60
50
40
30
20
10
0
120 %
RVLIS
(CAL. LEVEL)
100
90
80
70
60
50
40
30
20
10
0
32 %
AVG. PZR
LEVEL
REACTOR COOLANT SYSTEM
POWER 99 %
RCS AVG TEMP 547
START UP RATE 0
CURRENT RVLIS STATUS
NATURAL CIRCULATION RANGE
LT 1311 %
LT 1321 %
RCP RUNNING RANGE
LT 1312 %
LT 1322 %
NUMBER OF RCP'S RUNNING 4
INDIAN POINT UNIT 2
26 JULY 1986 10:46:38
TOP LEVEL
CSF TRNDS
CTMT
INVENTORY
(MORE)

Figure A.19

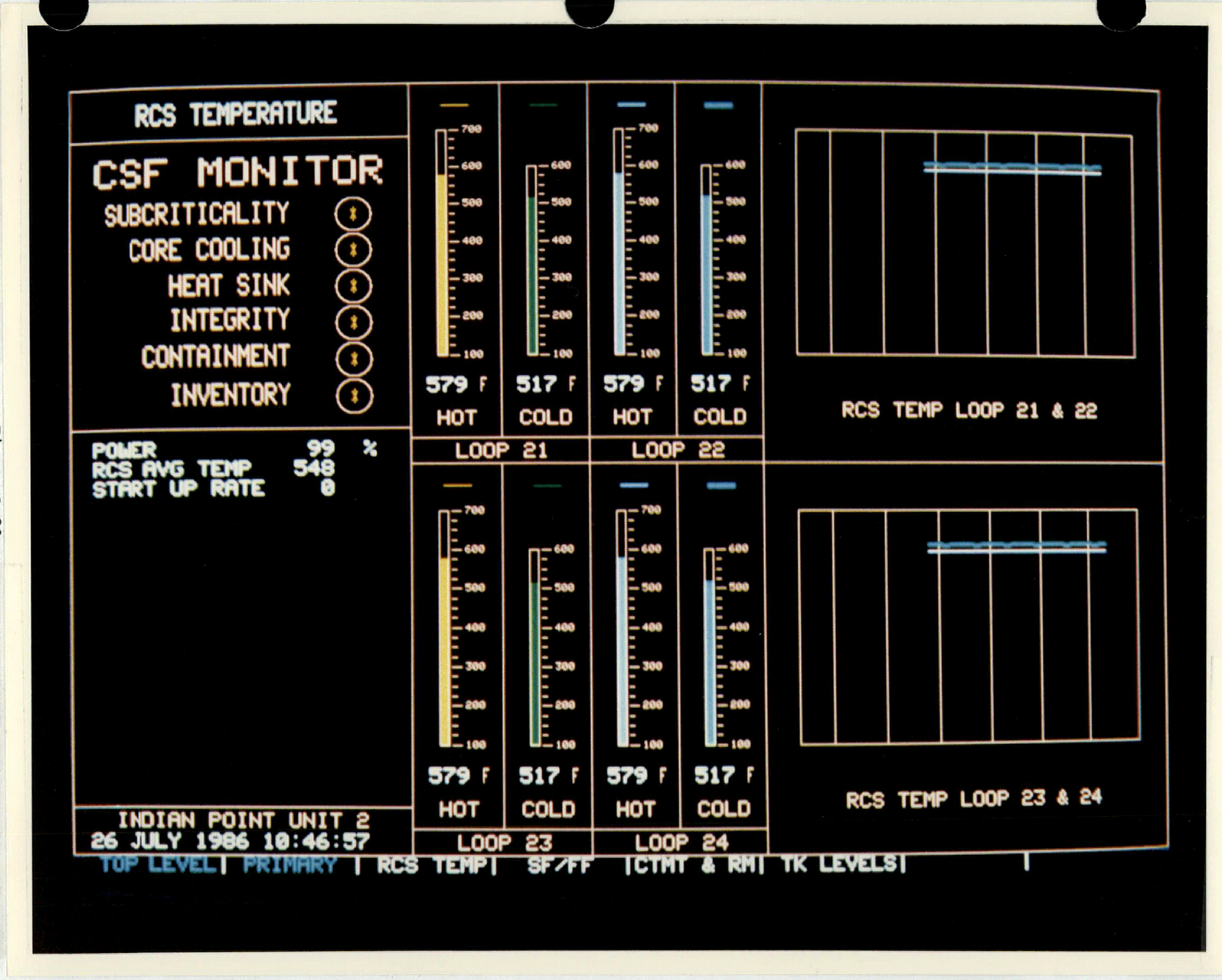

RCS TEMPERATURE
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 99 %
RCS AVG TEMP 548
START UP RATE 0
579 F
HOT
517 F
COLD
579 F
HOT
517 F
COLD
LOOP 21
LOOP 22
RCS TEMP LOOP 21 & 22
579 F
HOT
517 F
COLD
579 F
HOT
517 F
COLD
LOOP 23
LOOP 24
RCS TEMP LOOP 23 & 24
INDIAN POINT UNIT 2
26 JULY 1986 10:46:57
TOP LEVEL | PRIMARY | RCS TEMP | SF/FF | CTMT & RM | TK LEVELS |

Figure A.20

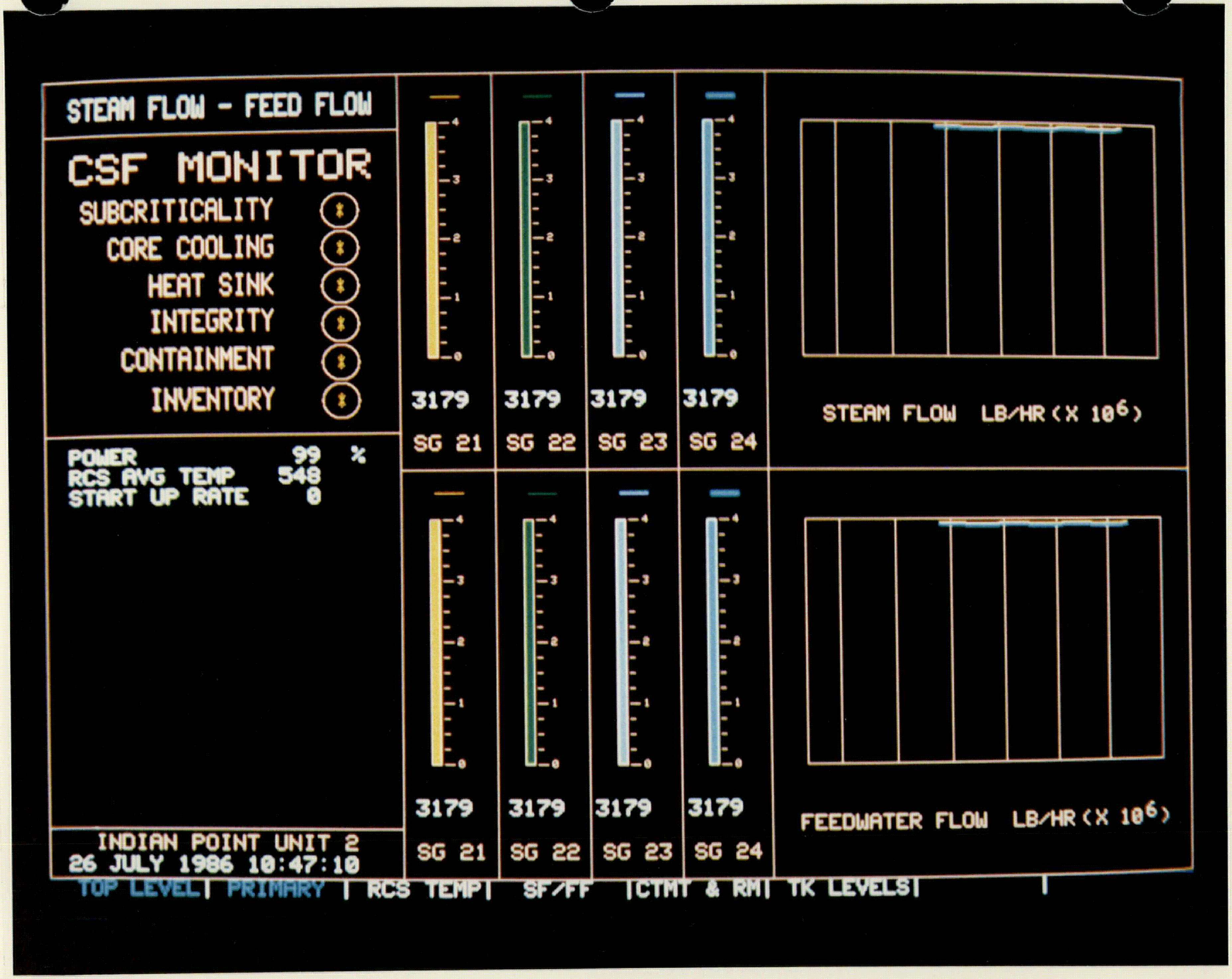

STEAM FLOW - FEED FLOW
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 99 %
RCS AVG TEMP 548
START UP RATE 0
INDIAN POINT UNIT 2
26 JULY 1986 10:47:10
3179 3179 3179 3179
SG 21 SG 22 SG 23 SG 24
STEAM FLOW LB/HR (X 10^6)
3179 3179 3179 3179
SG 21 SG 22 SG 23 SG 24
FEEDWATER FLOW LB/HR (X 10^6)
TOP LEVEL | PRIMARY | RCS TEMP | SF/FF | CTMT & RM | TK LEVELS |

Figure A.21

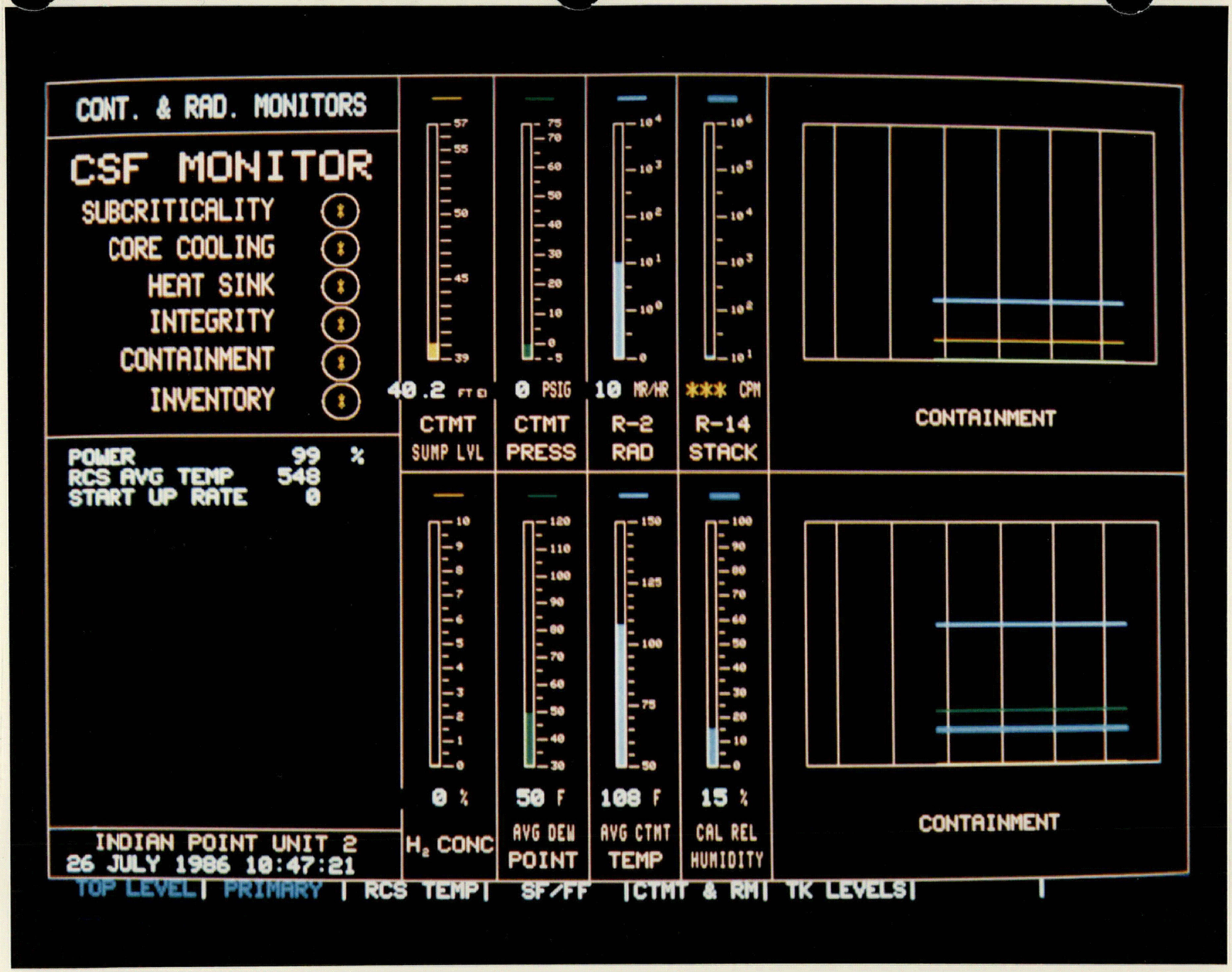

CONT. & RAD. MONITORS
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 99 %
RCS AVG TEMP 548
START UP RATE 0
40.2 FT El
CTMT
SUMP LVL
0 PSIG
CTMT
PRESS
10 MR/HR
R-2
RAD
*** CPM
R-14
STACK
CONTAINMENT
0 %
H_2 CONC
50 F
AVG DEW
POINT
108 F
AVG CTMT
TEMP
15 %
CAL REL
HUMIDITY
CONTAINMENT
INDIAN POINT UNIT 2
26 JULY 1986 10:47:21
TOP LEVEL | PRIMARY | RCS TEMP | SF/FF | CTMT & RM | TK LEVELS |

Figure A.22

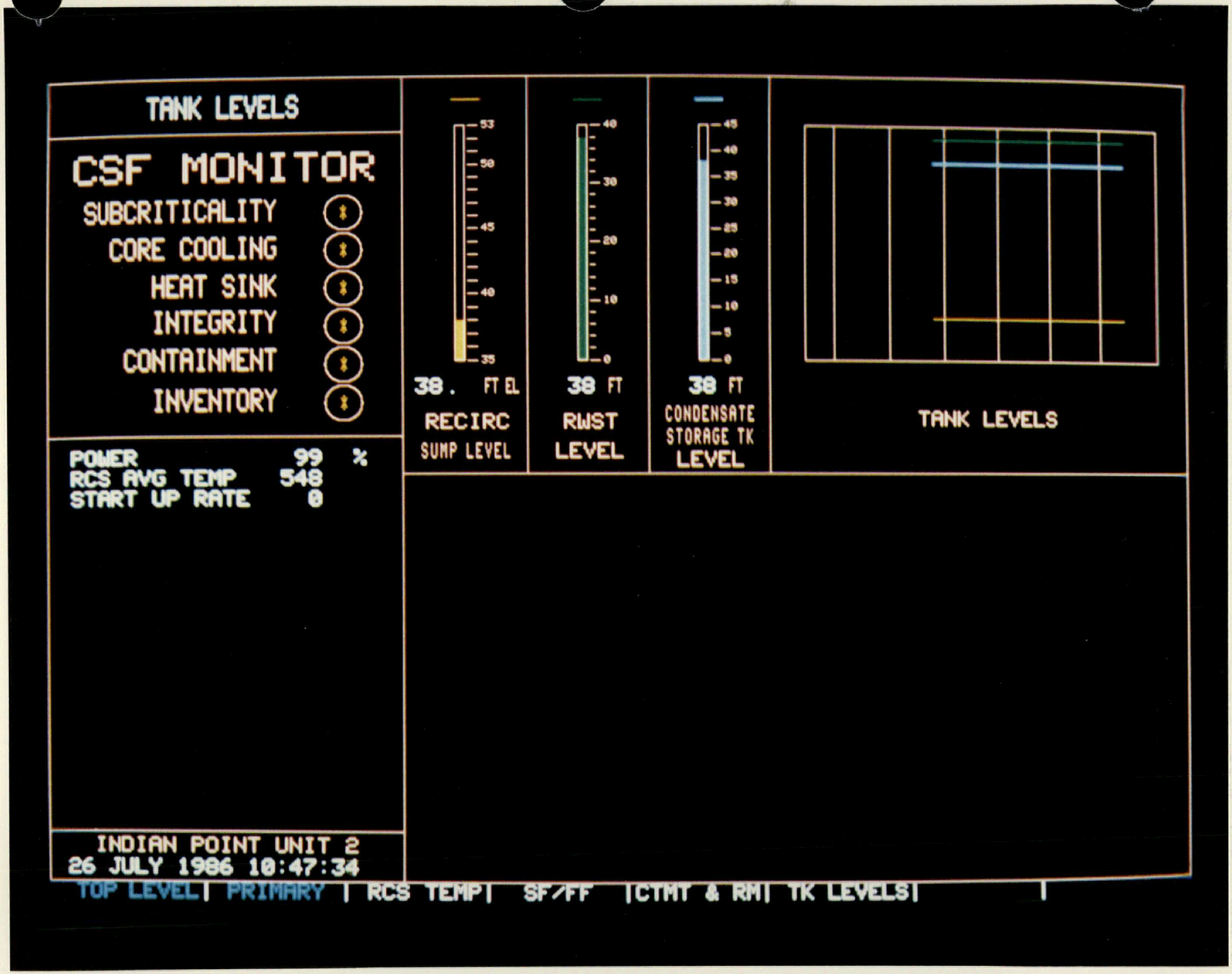

TANK LEVELS
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
POWER 99 %
RCS AVG TEMP 548
START UP RATE 0
INDIAN POINT UNIT 2
26 JULY 1986 10:47:34
53
50
45
40
35
38. FT EL
RECIRC
SUMP LEVEL
40
30
20
10
0
38 FT
RWST
LEVEL
45
40
35
30
25
20
15
10
5
0
38 FT
CONDENSATE
STORAGE TK
LEVEL
TANK LEVELS
TOP LEVEL| PRIMARY | RCS TEMP| SF/FF |CTMT & RM| TK LEVELS|

Figure A.23

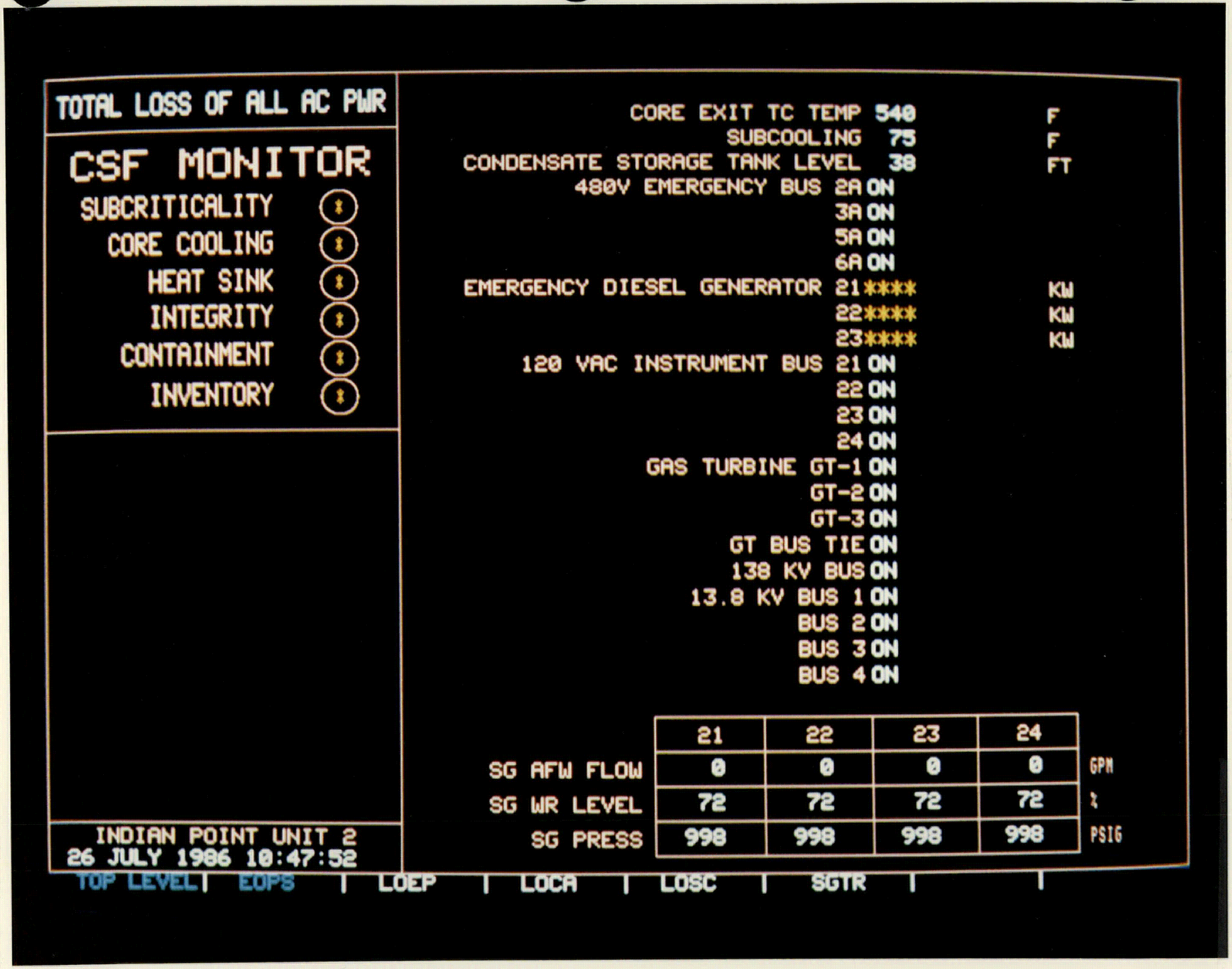

TOTAL LOSS OF ALL AC PWR
CSF MONITOR
SUBCRITICALITY
CORE COOLING
HEAT SINK
INTEGRITY
CONTAINMENT
INVENTORY
INDIAN POINT UNIT 2
26 JULY 1986 10:47:52
CORE EXIT TC TEMP 540 F
SUBCOOLING 75 F
CONDENSATE STORAGE TANK LEVEL 38 FT
480V EMERGENCY BUS 2A ON
3A ON
5A ON
6A ON
EMERGENCY DIESEL GENERATOR 21**** KW
22**** KW
23**** KW
120 VAC INSTRUMENT BUS 21 ON
22 ON
23 ON
24 ON
GAS TURBINE GT-1 ON
GT-2 ON
GT-3 ON
GT BUS TIE ON
138 KV BUS ON
13.8 KV BUS 1 ON
BUS 2 ON
BUS 3 ON
BUS 4 ON
21 22 23 24
SG AFW FLOW 0 0 0 0 GPM
SG WR LEVEL 72 72 72 72 %
SG PRESS 998 998 998 998 PSIG
TOP LEVEL | EOPS | LOEP | LOCA | LOSC | SGTR | |

Figure A.24

APPENDIX B

Indian Point #2 - SAS/SPDS Critical Safety Functions
& Associated Primary Display Parameters

Indian Point 2 - SAS/SPDS Critical Safety Functions
& Associated Primary Display Parameters

Critical Safety Function	Monitored Parameter	Displayed Parameter	Trend Graphed
Reactivity Control	Rx Power-Power Range	Power Range Power	X
	Intermediate	Intermediate Power	X
	Source Range	Source Counts	X
	Intermediate Range SUR	SUR	
	Source Range SUR	SUR	
	Source Range High Voltage	Source Range On/Off	
	Rx Trip Bkr Position	Rx Trip	
	Rx Trip Demand Signal	Rx Trip Demand	
	SI Signal Actuated	SI Actuation	
Reactor Core Cooling and Heat Removal from Primary System	RVLIS (Calc. Level)	RVLIS (Calc. Level)	X
	No. RCPs Running	No. RCPs Running	
	Pressurizer Level	PZR Avg Level	X
	Core Exit Temperature	Core Exit TC	X
	Loop Cold Leg Temp	RCS Cold Leg Temp	X
	Loop Hot Leg Temp	RCS Hot Leg Temp	X
	T-Average	RCS Avg Temp	X
	RCP Bkr Position	At Least One RCP Running/Not Running	
	Saturation Temp Margin	Subcool	X
	SG Avg NR Level	SG NR Level	X
	SG Avg WR Level	SG WR Level	X
	SG Steam Outlet Press	SG Avg Pressure	X
	SG Steam Outlet Flow	SG Steam Flow	X
	MSL Isolation Signal	MS Isolation	
	SG Feedwater Inlet Flow	SG Feedwater Flow	X

Critical Safety Function	Monitored Parameter	Displayed Parameter	Trend Graphed
	Feedwater Isol. Signal	FW Isol	
	Aux Feedwater Flow	AFW Flow	X
	RHR Loop Flow	RHR Flow	X
	RHR HX Inlet Temp	RHR HX Inlet	X
	RHR HX Outlet Temp	RHR HX Outlet	X
Reactor Coolant System Integrity	Rx Coolant Sys Press	RCS Pressure	X
	Loop Cold Leg Temp	RCS Cold Leg Temp	X
	T-Average	RCS Avg Temp	X
	Rx Vessel Level	RVLIS (Calc. Level)	X
	Pressurizer Level	PZR Avg Level	X
	Containment Pressure	Ctmt Pressure	X
	Containment Radiation	R-2 Rad	X
	High Range Cont Rad	R-25 (26) Ctmt Rad	X
	Containment Sump Lvl	Ctmt Sump Level	X
Containment Conditions	Containment Pressure	Ctmt Pressure	X
	Containment Radiation	R-2 Rad	X
	High Range Cont Rad	R-25 (26) Ctmt Rad	X
	Containment Sump Lvl	Ctmt Sump Level	X
	Containment Temp	Avg Ctmt Temp	X
	Containment Temp	Relative Humidity (calc)	X
	Containment Dew-Point	Avg Dew Point	X
	Hydrogen Concentration	H2 Conc	X

Critical Safety Function	Monitored Parameter	Displayed Parameter	Trend Graphed
Radioactivity Control	Containment Radiation	R-2 Rad	X
	High Range Cont Rad	R-25 (26) Ctmt Rad	X
	Aux Bldg Exh Gas Rad	R-14 Stack	X
	S/G Blowdown Rad	Sec Rad	
	SJAE Radiation	Sec Rad	
	Steam Line Radiation	Sec Rad	

APPENDIX C

SAS/SPDS Parameter Ranges

SAS/SPDS Parameter Ranges

Displayed Parameter	Displayed Range	Basis For Range
Average Power	0 - 120%	CSF Status Tree F-0.1, UFSAR Section 14.1.2 and Table 7.4.2 Tech Spec Section 2.3
Intermediate Power	10E-11 - 10E-3 amps	UFSAR Section 14.1, UFSAR Section 7.4.2.1
Source Counts	0 - 10E+6 cps	UFSAR Section 14.1, UFSAR Section 7.4.2.1
SUR (Source Range) SUR (Intermediate Range)	-0.5 - +5.0 dpm	CSF Status Tree F-0.1 UFSAR Section 7.4.2.1.3
RVLIS (Calc. Level)	0 - 120%	(1) & CSF Status Tree F-0.6
RCS Pressure	0 - 3000 psig	CSF Status Tree F-0.4 UFSAR Table 4.1-1 Tech Spec Section 2.2
PZR Avg Level	0 - 100%	CSF Status Tree F-0.6 Tech Spec Section 2.3

(1) Same as existing control room indicators.

Displayed Parameter	Displayed Range	Basis For Range
PZR Avg Pressure	1700 - 2500 psig	UFSAR Section 14.1 UFSAR Table 4.1-1 Tech Spec Section 2.3 and Table 3-1
Core Exit TC	100 - 2200 F	(1) & CSF Status Tree F-0.2
RCS Cold Leg Temp	100 - 600 F	(1) & CSF Status Tree F-0.4
RCS Hot Leg Temp	100 - 700 F	UFSAR Section 14.1
RCS Avg Temp	540 - 615 F	UFSAR Section 14.1 UFSAR Table 3.2-6 Tech Spec Section 2.1
Subcooling	-800 - +800 F	(1) & CSF Status Tree F-0.2
SG Avg Level	0 - 100%	CSF Status Tree F-0.3 UFSAR Section 14.1
SG Avg Pressure	0 - 1400 psig	CSF Status Tree F-0.3 UFSAR Section 14.3
SG Feedwater Flow	0 - 4E+06 lbm/hr	(1) & CSF Status Tree F-0.3

(1) Same as existing control room indicators.

Displayed Parameter	Displayed Range	Basis For Range
AFW Flow	0 - 450 gpm	Tech Spec Section 3.4 UFSAR Fig. 10.2-9 and Table 10.1-1
SG Steam Flow	0 - 4E+06 lbm/hr	UFSAR Table 4.1-4
RHR Flow	1000 - 7000 gpm	UFSAR Table 9.3-3
RHR HX Inlet	75 - 400 F	UFSAR Table 9.3-3
RHR HX Outlet	75 - 400 F	UFSAR Table 9.3-3
Ctmt Pressure	-5 - +75 psig	CSF Status Tree F-0.5 UFSAR Section 14.3 Tech Spec Section 3.6 and Table 3-1
Ctmt Sump Level	39 - 57 ft elevation	CSF Status Tree F-0.5 Tech Spec Section 3.1.F
R-2 Rad	0 - 1E+04 mR/hr	CSF Status Tree F-0.5 UFSAR Section 14.3.6
R-25 & 26 Ctmt Rad	10^0 - 10^7 R/hr	UFSAR Section 4.3.6 and Figures 7.1.3

(1) Same as existing control room indicators.

Displayed Parameter	Displayed Range	Basis For Range
Avg Ctmt Temp	50 - 150 F	UFSAR Section 5.1.1.1.7 Tech Spec Section 3.6
Relative Humidity (Calc.)	0 - 100%	(1)
Avg Dew Point	30 - 120 F	(1)
H@ Conc (Volume)	0 - 10%	UFSAR Section 14.3.5.6 Figure 14.3-120
R-14 Stack	$10 - 10^6$ CPM	UFSAR Section 11.2.3.2.3
S/G Blowdown Rad	$10 - 10^6$ CPM	UFSAR Section 11.2.3.2.9
SJAE Radiation	$10 - 10^6$ CPM	UFSAR Section 11.2.3.2.4
Steam Line Radiation	$10 - 10^6$ CPM	UFSAR Section 11.2.3.2.10

(1) Same as existing control room indicators.

Attachment 2

Responses to NRC Request for Information

Consolidated Edison Company of New York, Inc.
Indian Point Unit No. 2
Docket No. 50-247

July, 1986

The Indian Point plant utilizes a Westinghouse Proteus process computer system. Proteus replaced Prodac, which was Indian Point's original computer when licensed. The inputs to Proteus are taken from non-safety grade sources including isolated loops off the safety grade signal loops.

Where SAS/SPDS signals are required from safety grade signal loops they are taken from the same non-safety grade side of the signal loops as the Proteus. The following transformer type isolation amplifiers are employed to separate safety grade from non-safety grade signals:

1) Current-to-Current, I/I;

   a. Foxboro Model 66BR
   b. Foxboro Model 66C
   c. Moore Industries Model SCT

2) Voltage-to-Current, V/I;

   a. Foxboro Model 66GR-OW

3) Voltage-to-Voltage, V/V;

   a. Westinghouse Model NLP 3

The SAS/SPDS, now under construction, is a Quadrex designed, non-safety grade system. In addition to the isolation described above, for increased protection, each analog input channel in this system includes its own transformer type isolation. Electrically, the data acquisition system's input circuitry is similar to the suppliers, Computer Products Inc., nuclear qualified equipment data acquisition system.

In two cases, for non-safety grade signals, the I/I isolation amplifiers manufactured by Moore Industries of Sepulveda, California are used. They were selected for their compact outline and ease of installation. The transformer catalog specified isolation is 500 volts rms.

Based on the above, the responses to the NRC questions of April 3, 1986 are provided below:

a. The Foxboro I/I isolation amplifiers, used to isolate safety grade signals from the Proteus process computer and SAS/SPDS system are described above and in FSAR section 7.2.2.9.

b. The maximum credible faults are considered to be the algebraic sum of the 115 VAC peak line voltage. The Quadrex SAS/SPDS uses the same line voltage.

c. This was the test voltage used. This is also within Moore Industries isolator's catalog specified isolation of 500 volts rms.

d. Loss of isolation is considered the failure criteria.

e. Isolators between safety grade circuits and the SAS/SPDS will use isolators which comply with the environmental qualifications (10 CFR 50.49) and with the seismic qualifications which were the basis for plant licensing. These are located in the control room which is a mild environment.

f. Shielded cables are run between the plant's isolated analog safety grade systems and the SAS/SPDS. The Quadrex SAS/SPDS uses an EMI filter at the power input and fiber optic links between the data acquisition system's input circuitry, multiplexers, and the computer system.

g. We are currently reviewing the power sources to the isolators between the safety grade circuits and the SAS/SPDS to verify the power source.