P-84487
Attachment 2

PUBLIC SERVICE COMPANY OF COLORADO

FORT ST. VRAIN NUCLEAR GENERATING STATION

SAFETY PARAMETER DISPLAY SYSTEM PROGRAM PLAN

September 30, 1983

Revised November 13, 1984

TABLE OF CONTENTS

ABBREVIATIONS

SPDS	Safety Parameter Display System
NUTAC	Nuclear Utility Task Action Committee
FSV	Fort St. Vrain
HTGR	High Temperature Gas-Cooled Reactor
V&V	Verification and Validation
DD	Design Directive
TSC	Technical Support Center
FCP	Forward Command Post
CRT	Cathode Ray Tube
RO	Reactor Operator
CSF	Critical Safety Functions

DEFINITIONS

Podian Subsystem - Post-Disturbance Analysis software that stores historical "snapshots" of the data base on disk.

Check-point Failover Subsystem - Software that keeps the data current from on-line to standby and causes a "failover" from online to standby.

40-700 - The memory coupling device that allows the on-line computer system to communicate with the standby system.

Man-machine Subsystem - Software that controls the interface between the console keyboards and the computer.

Abnormal Operation - operation under conditions which, if left uncorrected, could allow or have already allowed fission products to escape from the fuel particles or from the PCRV.

Validated Parameters - data that can be validated by redundant sensors and/or a validation algorithm.

Invalid Data - data which is not current (For example: the computer is not able to scan that data point because of hardware failure).

1.0 INTRODUCTION AND PURPOSE

1.1 PROGRAM PLAN

The Safety Parameter Display System (SPDS) is one element of several interrelated efforts designed to improve control rooms, emergency response capabilities and procedures. The regulatory requirements for providing a SPDS is contained in NUREG 0737, Supplement 1 (Generic Letter 82-33).

Guidance for the SPDS and related activities has been derived from various NUREGS (See Section 1.2) and the industry sponsored SPDS Nuclear Utility Task Action Committee (NUTAC) document entitled "Guidelines for an Effective SPDS Implementation Program". Methodology developed within this plan takes into account the unique characteristics of the Fort St. Vrain (FSV) High Temperature Gas-Cooled Reactor (HTGR).

The purpose of this program plan is to describe the manner in which Public Service Company (PSC) intends to proceed to implement the SPDS at the FSV Station.

1.2 SPDS

The purpose of the SPDS is to provide a concise display of critical plant variables to control room operators to aid them in rapidly and reliably determining the safety status of the plant and in assessing whether abnormal conditions warrant corrective action. The SPDS simply concentrates the Critical Safety Functions of the plant (most of which are indicated on the control board) into a single set of dedicated displays.

The design of the primary or principal display format shall be as simple as possible, consistent with the required function, and shall include pattern and coding techniques to assist the operator in memory recall for the detection and recognition of potentially unsafe operating conditions. The SPDS will include some audible notification to alert personnel of an unsafe operating condition. The design of the SPDS will be expandable to accept new functions.

Displayed data shall present a current and accurate status of the plant. Hardware rejects, errors detected by transducer range limit checking, and errors detected during engineering unit conversion will cause the data to be flagged as invalid. Conservative alarm and warning limits will be selected for the SPDS parameters so that the operator will be alerted of approaching abnormal operating conditions prior to reaching PPS setpoints when practical. Quarterly surveillances of the SPDS parameters and hardware checks will be performed. A Verification and Validation program will be followed in accordance with the guidelines in the attached document, "Fort St. Vrain SPDS Verification and Validation Plan".

Selected Emergency Procedures will be reviewed as part of the Control Room Design Review. Any necessary changes with regard to SPDS will be incorporated at that time.

1.3 REFERENCES/APPLICABLE DOCUMENTS

The following documents were considered in the development of Fort St. Vrain's SPDS program:

NUREG-0696 - "Functional Criteria for Emergency Response Facilities".

NUREG-0835 - "Human Factors Review Guidelines for the Safety Parameter Display System"

NUREG-0737 - "Requirements for Emergency Response Capability"

Supplement 1 to NUREG-0737

IEEE 384 - "Criteria for Independence of Class 1E Equipment and Circuits", 1981

Other Public Service Company of Colorado documents utilized:

Design Directive CRT-1 (DD CRT-1)

Design Directive KEY-1 (DD KEY-1)

Design Directive SLS-1 (DD SLS-1)

Control Room Design Review Program Plan

Software Specification (EMO1.AAO.GI020)

Fort St. Vrain SPDS Safety Analysis Report

2.0 REQUIREMENTS

The following subsections provide the description of the requirements essential to the successful development of the Safety Parameter Display System. Using the NUREGs as guidance, these requirements were developed as they apply to an HTGR.

2.1 FUNCTIONAL/OPERATIONAL REQUIREMENTS

2.1.1 Functions/Features

1. A dedicated display with a single primary display format will continuously display the minimum parameter set necessary to assess the safety status of the plant at each mode of plant operation. Modes of plant operation are determined by the Interlock Sequence Switch (Startup, Low Power, Power) and the Reactor Mode Switch (Fuel Loading, Off, Run).

2. The secondary display may be individual plant parameters or may be composed of a number of parameters or derived variables giving an overall system status.

3. The recall of additional data on secondary formats or displays will be available.

4. Display of time derivatives of the parameters in lieu of trends to both optimize operator-process communication and conserve space is acceptable.

5. The secondary display format will contain the magnitude of all variables being displayed and the time derivatives of selected parameters.

6. A rate-of-change algorithm will be used to determine time derivatives of plant parameters for increasing or decreasing plant parameter trends.

7. The SPDS will contain operator interactive devices.

8. The display system will positively acknowledge each request that the design allows the operator to make.

9. A display will be included of calendar date and time of day with some means of indicating the passage of seconds. The display will be updated only when the system is operating properly so that a static time would indicate a system failure. The date and time will be located in a corner of the display so as not to distract the operator.

10. The use of color coding will be used to indicate the approach to unsafe operations and to indicate unsafe operation.

11. The display system will emit a distinct, audible sound, such as the beeper available on computer terminals, upon detecting an abnormal operating condition.

12. The SPDS alarm system will have provisions to silence, acknowledge, and reset.

13. Performance tests of the silence, acknowledge, and reset functions will be performed.

2.1.2 Parameters

1. Data will be displayed to provide sufficient information to plant operators about:

   (a) Reactivity Control

   (b) Primary System Heat Removal

   (c) Secondary System Heat Removal

   (d) Radioactivity Control

   (e) Primary Coolant System Integrity

   The parameters to be displayed, justification for their selection and SPDS response time necessary for each parameter are contained in the Fort St. Vrain SPDS Safety Analysis Report.

2. Conservative alarm and warning limits will be selected for the SPDS parameters so that the operators will be alerted of abnormal operating conditions prior to reaching PPS setpoints when practical. Blinking, non-blinking and color coded numbers will be displayed to indicate the condition of the selected parameters. Invalid data will be flagged.

3. Initial validation of the SPDS parameters will be done by manual calculations verifying the computer's conversion from raw millivolts to engineering units. Calculated SPDS parameters will also be validated by manual calculation. Some parameters may be compared with predetermined limits for different modes of plant operation. The validity of parameters will be checked during quarterly surveillances. Parameters whose validity is in question will be flagged on the SPDS displays.

2.1.3 Equipment

1. The processing and display devices of the SPDS will be of proven high quality and reliability.

2. The SPDS will be suitably isolated from electrical or electronic interference with equipment and sensors that are in use for safety systems.

3. The SPDS will be located in the control room with additional SPDS displays provided in the TSC & FCP.

2.1.4 Human Factors

1. The SPDS shall be designed to incorporate accepted human factors principles so that the displayed information can be readily perceived and comprehended by SPDS users.

2. Each group of parameters will be displayed so that all are visible to the operator within one field of view.

3. The parameters will be sequenced in a logical manner to facilitate operator comparison of parameters in evaluating the safety status of the plant.

4. The primary display format will utilize patterns and display enhancements as discussed in Section 3 of NUREG 0835 as it applies to an HTGR.

5. The SPDS will be readily distinguished from other displays on the control board.

6. The displays design will conform to the appropriate display readability guidelines stated in FSV Design Directive CRT-1 such as viewing distance, viewing angle, and screen location for standing and seated operators at the West End Reactor Operator's Station.

7. The data displayed on the CRT will have acceptably low flicker and noise.

8. Alpha-numeric characters generated with a 7x9 dot matrix or larger are preferable; characters with 5x7 dot matrix are acceptable.

9. The density of the display will be less than 25% when complex symbology are displayed (e.g. mimics).

10. Glare from normal or emergency lighting will not restrict viewing of the SPDS from within the control room. The use of antiglare techniques and devices are acceptable when they are in accord with other criteria stated in FSV Design Directive CRT-1.

11. For ease of detection, acceptable symbol to background contrast ratio will fall within the range specified in Design Directive CRT-1 for all important data.

12. Alpha-numeric keyboards for the SPDS will have the same keyboard layout as the other keyboards in the control room (Design Directive KEY-1).

13. The display system will emit a distinct, audible sound, such as the beeper available on computer terminals, upon detecting an abnormal operating condition.

14. Pattern and coding techniques shall be used to assist operator detection and recognition of the approach to unsafe operating conditions.

15. Physical obstructions will not block a person's field of view of the SPDS when the person is at the normal work station.

16. If the SPDS is not in the operator's direct field of view at the work station, a reorientation of his/her field of view will allow viewing the SPDS from the work station.

17. Members of the control room operating crew have physical access to the SPDS keyboard from their normal work station. A short direct walk to the SPDS keyboard is acceptable.

18. Luminance levels and luminance contrast will not limit viewing from the normal work station.

19. The SPDS shall be of such size as to be compatible with the existing space in the control area.

20. The SPDS shall not interfere with normal movement or with full visual access to other control room operating systems and displays.

21. Operation of the plant with the SPDS out of service is allowed provided that the control board is sufficiently human factored to allow the operations staff to perform the safety status assessment task in a timely manner. The Control Room Design Review currently in progress will insure that this requirement is met.

22. The SPDS will be designed incorporating human factors in accordance with the FSV Design Directives (CRT-1, KEY-1, SLS-1). The overall integration of the SPDS will be evaluated by the Verification and Validation program.

2.1.5 Operations

1. Operator interaction with the SPDS will be designed such that training in computer programming is not required.

2. No additional operating staff other than the normal control room operating staff will be added for operation of the SPDS.

3. Operator requests to the display system from consoles other than the dedicated SPDS CRT will result in display of additional data.

4. Operator acknowledgment of a change in the displayed parameters from the primary SPDS display will be possible in a matter of seconds.

5. The display system will positively acknowledge each request that the design allows the operator to make.

6. There will be operator interaction incorporated in the display designs.

7. After the SPDS has been installed operating procedures will be available that will allow timely and correct safety status assessment when the SPDS is not available.

2.2 PERFORMANCE REQUIREMENTS

1. The sampling rate for each parameter is chosen such that there is no meaningful loss of information in the data presented to the operator.

2. The parameter update frequency and the alarm/warning response times are discussed in the SPDS Safety Analysis Report.

3. Data will be available for retrieval and will not be lost as a result of an electrical power failure.

4. Data stored for retrieval will be stored on a secure medium and will be available upon demand.

5. Response times to operator requests for information on secondary displays will conform to FSV Design Directive SLS-1 guidelines for computer response time to operator queries.

6. The SPDS as used in the control room shall be designed to an annual operational unavailability goal of .01.

7. The startup annual unavailability goal for the SPDS during startup mode for the reactor shall be .2.

2.3 INTERDEPENDENCIES

2.3.1 Training

1. The control room operations staff shall be provided with sufficient information and criteria for performance of an operability evaluation of the SPDS.

2. Operating procedures and operator training in the use of the SPDS shall contain information and provide guidance for the resolution of unsuccessful data validations.

3. After the SPDS has been installed, operating procedures will be available that will allow timely and correct safety status assessment when the SPDS is not available.

4. Operating procedures and operator training in the use of the SPDS shall contain information and provide guidance for the resolution of invalid data.

5. The operator training program will contain instructions on the use of the SPDS.

6. An SPDS user's manual will be available for operator reference in the control room.

2.3.2 Verification and Validation

1. A qualification program will be established to demonstrate SPDS conformance to the functional criteria of this document.

2. A test plan will be available for the SPDS which will define a minimum of one test case for each major functional criterion of the display system.

3. All display formats in the design will be tested, including mode dependent formats.

4. A test report containing the results of the test cases will be compiled. All major functional criteria must be tested successfully.

2.3.3 Safety Analysis

1. Public Service Company will prepare a written safety analysis describing the basis on which the selected parameters are sufficient to assess the safety status of each identified function for a wide range of events, which include symptoms of severe accidents.

2. The selection of specific information that will be provided for FSV will be based on engineering judgement, taking into account the importance of prompt implementation.

3. The minimum set of critical functions will be the ones by which the operator evaluates the safety status of the plant.

3.0 FEATURE OVERVIEW

3.1 FEATURES

The FSV Safety Parameter Display System will be built around the current Fort St. Vrain plant computer system. It will use the existing data base, data acquisition subsystem, the alarming subsystem and man-machine subsystem. Additions and some modifications will be made to the existing software to perform the SPDS functions. The analog scan rate will remain unchanged. The historical data requirements will be met by the Podian Subsystem, the Post Trip Subsystem and the Historical Data Subsystem. Minor modifications will be made to the existing Checkpoint-Failover Subsystem to incorporate a second 40-700 (memory coupling device) into the scheme. This is to increase system reliability.

A single dedicated CRT will be used in the control room for the SPDS displays. The CRT will be mounted in the control board in the I-04 panel and will share the keyboard of the West End Reactor Operator's console. Only SPDS displays will be allowed on the CRT. Any other CRT will have access to these same SPDS displays. The Technical Support Center (TSC) and the Forward Command Post (FCP) will have CRTs which are capable of displaying the SPDS parameters but not dedicated to that function.

The SPDS displays will be distinguished from the other displays by the five boxes (one for each CSF category) on the display which will indicate whether each category has any acknowledged or unacknowledged warnings or alarms (see the detailed feature descriptions in Section 4 and the prototype displays for further explanation of this feature). Accessing the SPDS displays will be as simple as possible. An audible alarm on the CRT will be added for the SPDS parameters which can be silenced from the control board. The alarm limits of the SPDS parameters may be variable depending on the plant status. Alarms generated by the SPDS parameters will be distinguishable from other computer system or control room alarms.

3.2 FUNCTIONAL RELATIONSHIPS

See Figure 1 for functional relationships. This diagram shows the areas in which new code must be added or existing code must be modified.

3.3 INTERFACES

All interfaces to the SPDS system are through the CRT's. There will be very few changes required to the existing Man-Machine subsystem. The definition of the SPDS keyboard will take care of limiting the functional capabilities of the SPDS CRT to those things which are needed to determine the safety status of the plant.

4.0 FEATURE DESCRIPTIONS

The following subsections describe in detail the external features introduced in Section 3.0 (FEATURE OVERVIEW).

4.1 DEDICATED CRT

4.1.1 The SPDS will be a single dedicated CRT in the control room.

4.2 2-ON-1 CONSOLE/3-ON-1 KEYBOARD

4.2.1 Although the SPDS is a physically separate CRT, it will be part of a 2-on-1 console with a 3-on-1 keyboard. The SPDS CRT will be located in the I-04 panel; the other two CRTs are located at the West End Reactor Operator's Station in the control room. There are 3 buttons, numbered 1,2,3 respectively. Numbers 1 and 2 will access the 2 CRTs at the West End Reactor Operator's Station; number 3 will access the SPDS. When the SPDS is accessed, the physical keyboard layout remains the same but the pre-assigned function keys are defined specifically for the SPDS.

4.3 PRIMARY DISPLAY

4.3.1 The primary display format consists of the 5 Critical Safety Function (CSF) categories through which the associated parameters for each category can be accessed. This display serves as the "master menu" to the other SPDS displays.

When the operator recognizes there is an alarm/warning condition in one of the five CSF categories, he pushes button number 3 at the West End Reactor Operator's console. At this time he has the option of going to either:

1. The poke point to the left of the category in alarm at the top of the display, or

2. The poke points across the top of the large boxes at the bottom of the display.

By pressing the "cursor transmit" key, he will then access the secondary display with the associated parameters for that category.

4.4 SECONDARY DISPLAY

4.4.1 The secondary display format consists of:

- the parameter name
- the value
- a rate of change value (where applicable)
- an associated display where the operator can access further information at another CRT

4.5 ACCESS TO DISPLAYS

4.5.1 Access to the various displays will be through the following methods:

- poke points located next to the CSF category name and immediately above the large alarm boxes at the bottom of screen
- "page forward" key will access the displays in the following order:

  SPDS Master Menu
  Reactivity Control
  Primary System Heat Removal
  Secondary System Heat Removal
  Primary Coolant System Integrity
  Radioactivity Control

- "page back" will access the previous category's secondary display
- all other paging keys will return to the "master menu" display

Another method of accessing the SPDS displays quickly and easily will be through pre-assigned function keys. This requires pressing the number 3 button on the West End Reactor Operator's console at which time the keyboard is assigned to SPDS. The SPDS master menu and the secondary displays will then be available through the assigned function keys.

There will be a pushbutton on the control board which will enable the operator to "page forward" through the SPDS displays on the SPDS CRT.

All of the other consoles will have the same pre-defined function keys. However, these keys will bring up displays that will allow the operators to use the "paging" function keys to automatically bring up associated displays. See prototype displays and Figure 4 for further explanation. Also, on any CRT other than the dedicated SPDS CRT an operator can bring up any other display by typing the display number on Line 1 of the CRT and pressing the "display" function key. These features are currently in use and will require only minimal operator training.

4.6 ALARM/WARNING

4.6.1 When any designated plant or SPDS parameter goes into an alarm/warning condition, an alarm/warning message will be posted on the appropriate summary. A small red (alarm) or yellow (warning) box will blink at the top of all plant computer CRT displays until all alarms/warnings are acknowledged. Acknowledgment of SPDS alarms/warnings will be by Reactor Operators only from the West End RO's console when the secondary SPDS display containing the parameter in alarm or warning is up on that console.

4.7 ALARM BOXES

4.7.1 All SPDS displays, both primary and secondary, will contain five large alarm boxes across the bottom of the screen that indicate a warning/alarm/normal condition for all parameters in each of the Critical Safety Function (CSF) categories. See the prototype displays included in Appendix A.

The appearance of the boxes will be (for each CSF category):

blank - normal condition for all parameters

blinking yellow - unacknowledged warning for one or more parameters

solid yellow - acknowledged warning for one or more parameters

blinking red - unacknowledged alarm for one or more parameters

solid red - acknowledged alarm for one or more parameters

4.8 ALARM BOX "REFLASH" CAPABILITY

4.8.1 The large blinking boxes will have "reflash" capability. This implies that within the same CSF category, when a parameter goes into an alarm/warning state and is acknowledged or returns to a normal state, a second parameter going into an alarm/warning state will cause the box to flash again.

4.9 AUDIBLE ALARM

4.9.1 An audible alarm will sound when any of the SPDS parameters go into an alarm or warning condition. The alarm can be silenced by the operator at the control board or at the West End RO's console.

4.10 AUDIBLE ALARM "RESOUND" CAPABILITIES

4.10.1 The audible alarm will have "resound" capabilities. This implies that within the same CSF category, when a parameter goes into an alarm/warning condition and is silenced, a second parameter going into alarm/warning will cause the audible alarm to sound again.

4.11 PARAMETER DISPLAY

4.11.1 Change of condition of a parameter will be indicated by the following codes:

Color
- o red - alarm
- o yellow - warning
- o green - normal
- o magenta - bad telemetry

Next to Value	o inverse video blinking magenta "V" - SPDS data may be invalid o white asterisk - value was manually replaced o cyan "I" - alarm on parameter is inhibited
Appearance	o blinking - unacknowledged alarm/warning o solid - acknowledged alarm/warning or normal

It should be noted that no SPDS parameter can have its value manually replaced or have its alarms inhibited except by an authorized person with the proper written authorization.

4.12 ACKNOWLEDGMENT OF REQUESTS TO THE SYSTEM

4.12.1 When the operator makes a request to the system, it is acknowledged in the usual manner: 1) the cursor goes away and upon return the request is complete or, 2) an appropriate message indicates the request is in progress.

Acknowledgment of SPDS alarms and warnings is recognized by the blinking red or yellow box becoming solid. The method by which these alarms are acknowledged is discussed in Sections 4.6.1 and 4.8.1.

4.13 TIME DERIVATIVES

4.13.1 Time derivatives will be displayed for selected parameters. This will include displaying the rate-of-change value and an arrow next to that value indicating a positive or negative rate.

4.14 ACCURACY OF PARAMETERS

4.14.1 Instrument sensitivity, alarm/warning limits and deadband values will be analyzed for each parameter to insure sufficient accuracy for the operator to evaluate the safety status of the plant.

4.15 PARAMETER SELECTION AND ANALYSIS

4.15.1 The parameters to be displayed, justification for their selection, and the SPDS response times necessary for each parameter is contained in the Fort St. Vrain SPDS Safety Analysis Report.

4.16 HIGH RESOLUTION CRT

4.16.1 A high resolution CRT will be used for the SPDS. Documentation of the acceptance criteria can be found in Design Directive CRT-1.

4.17 LOCATION IN THE CONTROL ROOM

4.17.1 The SPDS will be located in the I-04 panel of the control board for easy access and readability. A section of the I-04 panel will be cut out for the CRT which will be mounted from the ceiling with the appropriate supports. This implies that the SPDS is separate from I-04 and does not affect the seismic qualifications of the panel. The SPDS keyboard will be on the 3-on-1 keyboard at the West End Reactor Operator's work station.

4.18 SYSTEM DATE

4.18.1 The system date will be displayed in the upper left hand corner of all SPDS displays and will automatically "refresh" the passage of seconds. MST is indicated with the semi-colon (;) as a delimiter (i.e. 08:23:20) while MDT is indicated with the colon (:) as a delimiter. Usually, the ability of "walk back" in time is allowed on displays (indicated by inverse video - solid background, black letters) but this feature will not be available on the dedicated SPDS CRT. This insures that the information viewed by the operator is current.

4.19 LOCATIONS

4.19.1 The SPDS will be:

- o A dedicated CRT in the Control Room
- o An optional function of the CS-19 1-on-1 console in the TSC. The 1-on-1 was purchased primarily for the SPDS.
- o An optional function of the CS-19 2-on-1 console in the Forward Command Post (Emergency Operations Facility)
- o An optional function of any other console

4.20 OPERATION MODES

4.20.1 Variable alarm limits will be applied to the SPDS parameters as a function of the Interlock Sequence Switch (Startup, Low Power, Power) and the Reactor Mode Switch (Fuel Loading, Off, Run).

4.21 RESPONSE TIME

4.21.1 Response time for each SPDS parameter is addressed in the Fort St. Vrain SPDS Safety Analysis Report.

4.22 DATA AVAILABILITY

4.22.1 Historical data is stored on disk and dumped to tape periodically. Historical data residing on disk may be accessed from any other CRT than the dedicated SPDS CRT.

4.23 DUAL COMPUTER SYSTEM

4.23.1 The FSV plant computer will be a dual computer system (Figure 2). The existing computer system (Figure 3) will be expanded by the addition of a duplicate system to improve availability. The back-up computer will be kept current through check-pointing software. An automatic fail-over from on-line to stand-by will be used.

All safety-related, Class 1E equipment will be electrically isolated from the FSV computer system. The intention is to provide additional isolation for safety-related analog inputs, only as all safety-related, digital inputs are isolated through the use of auxiliary relay contacts per IEEE 384 (1981).

4.24 COMPUTER SYSTEM RELIABILITY

4.24.1 The computer system reliability goals are based on historical reliability data collected for the Pawnee Plant computer system (see Figures 5 and 6 in Appendix A for further information). The hardware configuration resembles Pawnee's dual system with the exception of the communications link between the two CPUs. Pawnee's system has a single 40-700 memory coupling device. Fort St. Vrain's system will have two 40-700 devices to insure that a secondary communications path is available if the primary path is not (i.e. a hardware failure occurs).

The primary and secondary computer systems will have separate non-interruptible power sources. Loss of power to the on-line system would cause an automatic fail-over to the standby system.

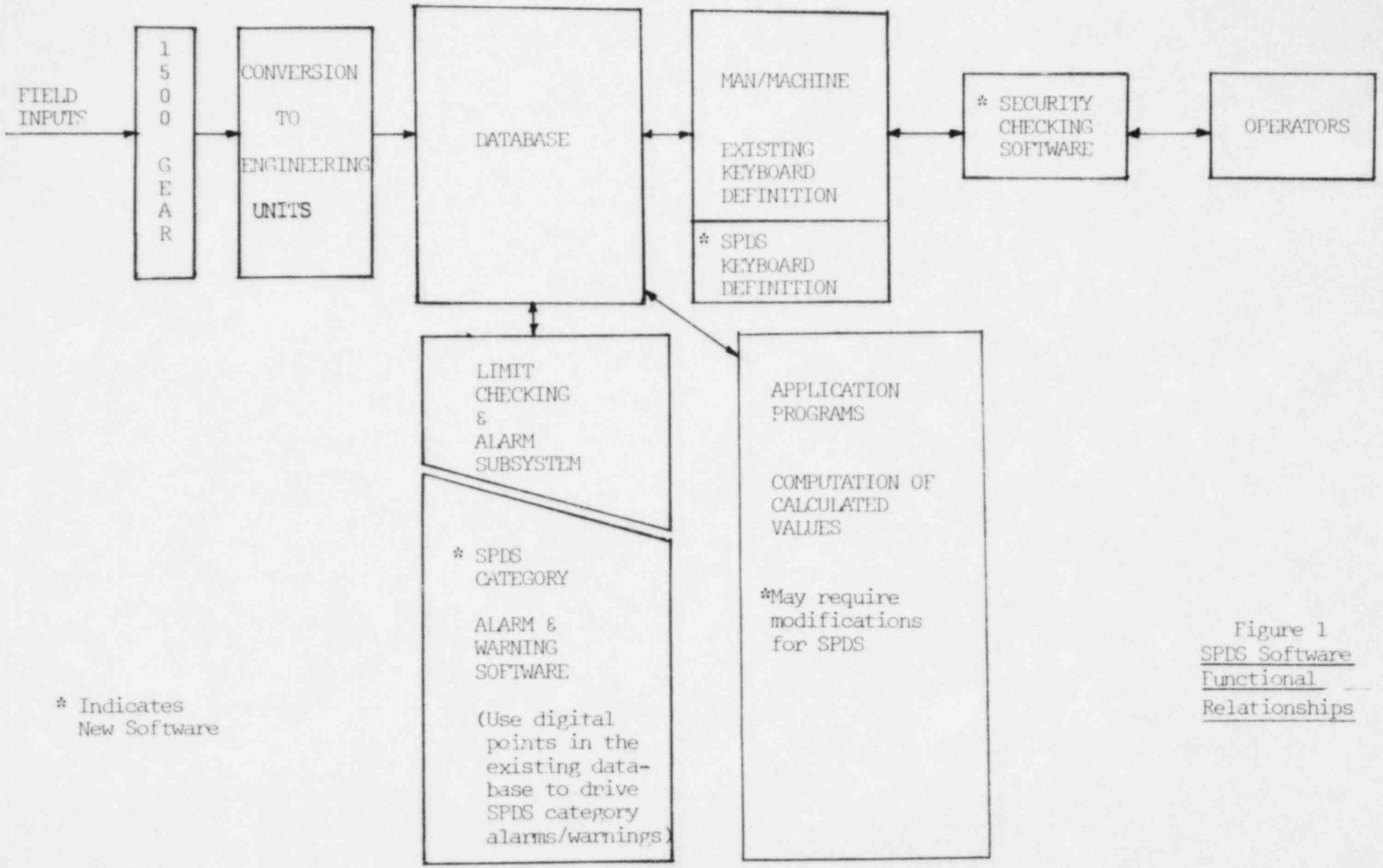
4.25 COMPUTER SYSTEM EXPANDABILITY

4.25.1 The CDC 1700 as it exists today is very near its potential in data acquisition and computing capabilities. However, a team of analysts from the Information Systems Division is currently developing a 1700/CYBER configuration to expand the capabilities of the Energy Management System (gas and electric distribution) CDC 1700 computer system. This is the system on which Pawnee and Fort St. Vrain computer systems were based. If the result of their efforts is a reliable, more powerful system, it is possible that the Fort St. Vrain 1700 system could be upgraded to a similar configuration.

4.26 SAFETY ANALYSIS

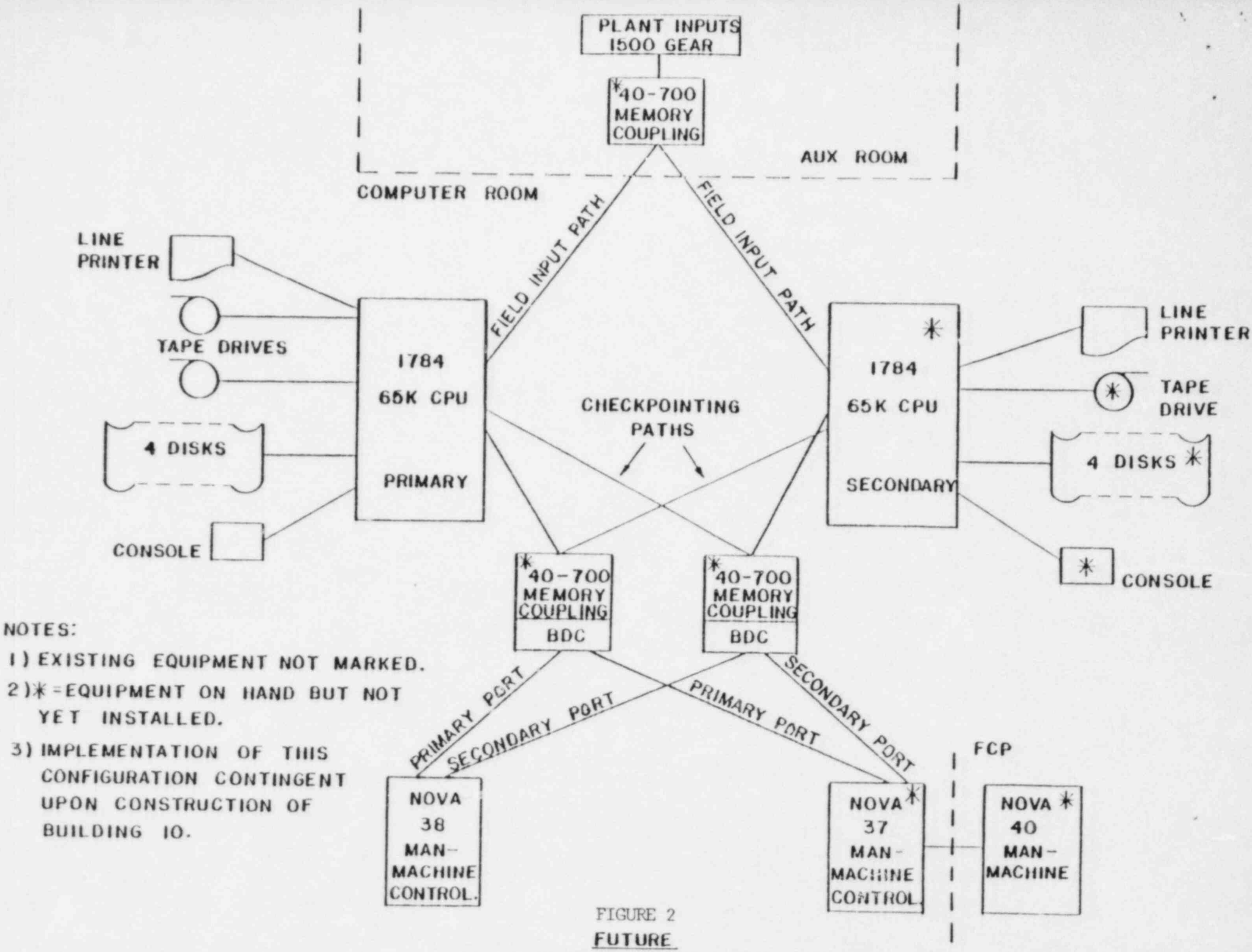
4.26.1 The primary safety analysis for the SPDS is in a document entitled "Fort St. Vrain Safety Parameter Display System Safety Analysis Report". Safety analyses will also be prepared for utilization to implement the SPDS system as is required by existing Fort St. Vrain procedures.

APPENDIX A



* Indicates New Software

Figure 1
SPDS Software
Functional
Relationships



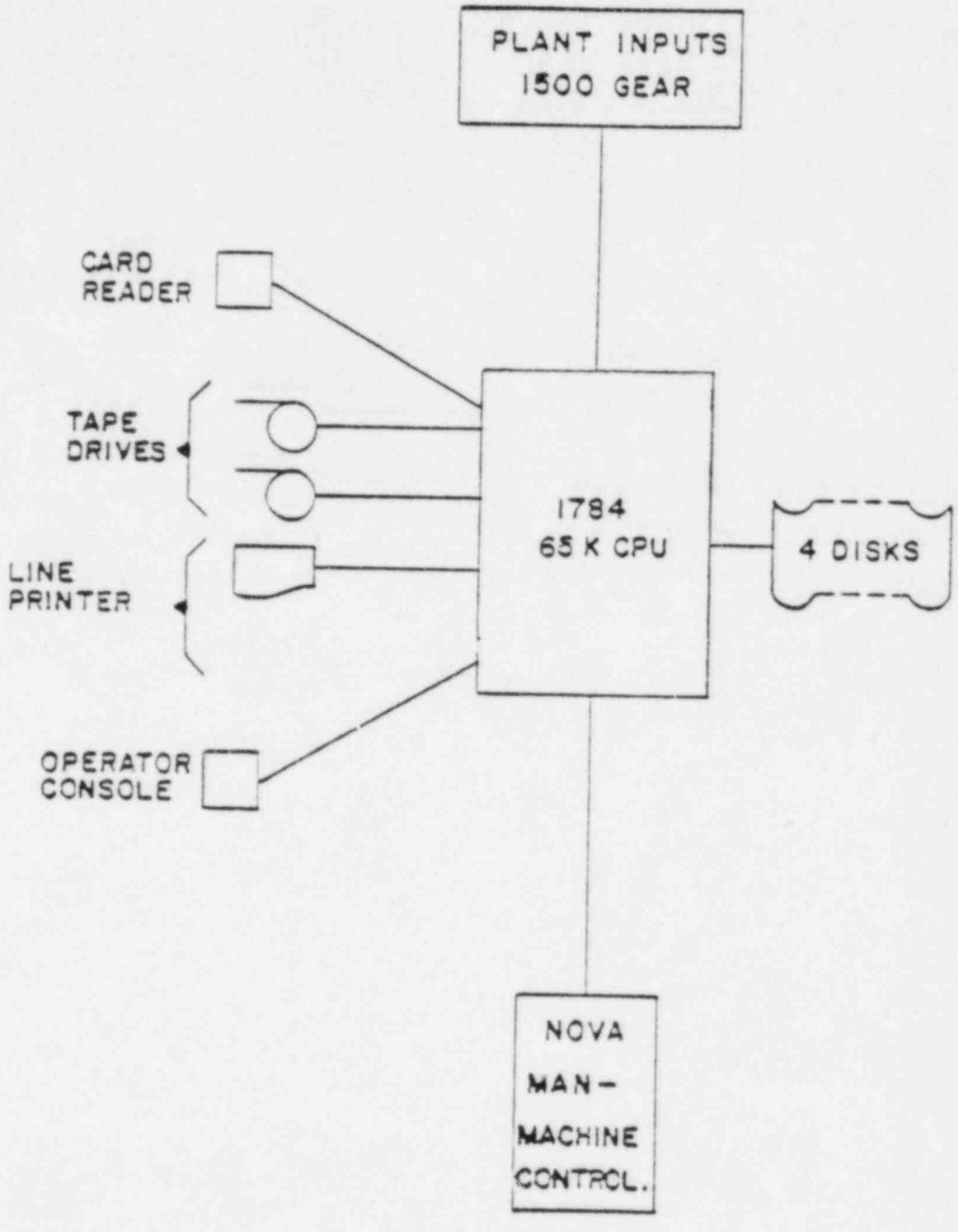
NOTES:

1) EXISTING EQUIPMENT NOT MARKED.
2) * = EQUIPMENT ON HAND BUT NOT YET INSTALLED.
3) IMPLEMENTATION OF THIS CONFIGURATION CONTINGENT UPON CONSTRUCTION OF BUILDING 10.

FIGURE 2

FUTURE

PLANT COMPUTER CONFIGURATION

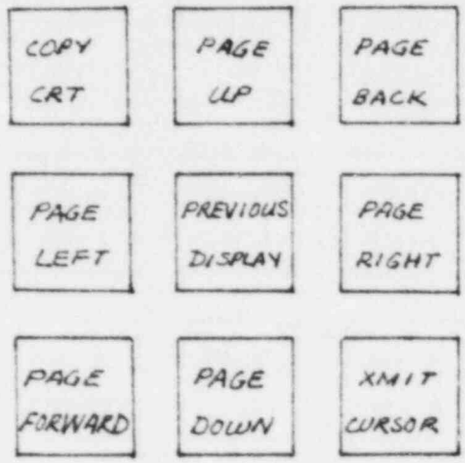


EXISTING PLANT COMPUTER CONFIGURATION

FIGURE 3

Figure 4

FUNCTION KEY LAYOUT



THE POSITION OF THE EDGE LABELS CORRESPOND TO THE FUNCTION KEY TO DEPRESS

09:32:51 10/31/84 P R I M A R Y S Y S T E M 0021

CØRE INLET ØRIFICE VALVES DATA 0317

SPDS REACTIVITY

page left — page up — page back

ASSØCIATED DISPLAYS
317
1171
1173

page right

PRIMARY COOLANT PRESSURE & FLOW - 1/2

REACTØR PØWER 1171

PØWER-TØ-FLØW RATIØ

MEASURED PØWER-TØ-FLØW 0.000

PØWER-TØ-FLØW RECØRDER ALARM NØRMAL

PRIMARY HELIUM FLØW 18.2 KLB/HR

CØRE AVERAGE ØUTLET TEMP 331 DEG F

MAX REGIØN ØUTLET TEMP MISMATCH ACTIØN CØDE

MAXIMUM MISMATCH A - 399 DEG F 00

MAXIMUM MISMATCH B - 380 DEG F 00

ACTIØN CØDE: 100=SHUTDØWN 200=2 HRS 300=24 HRS

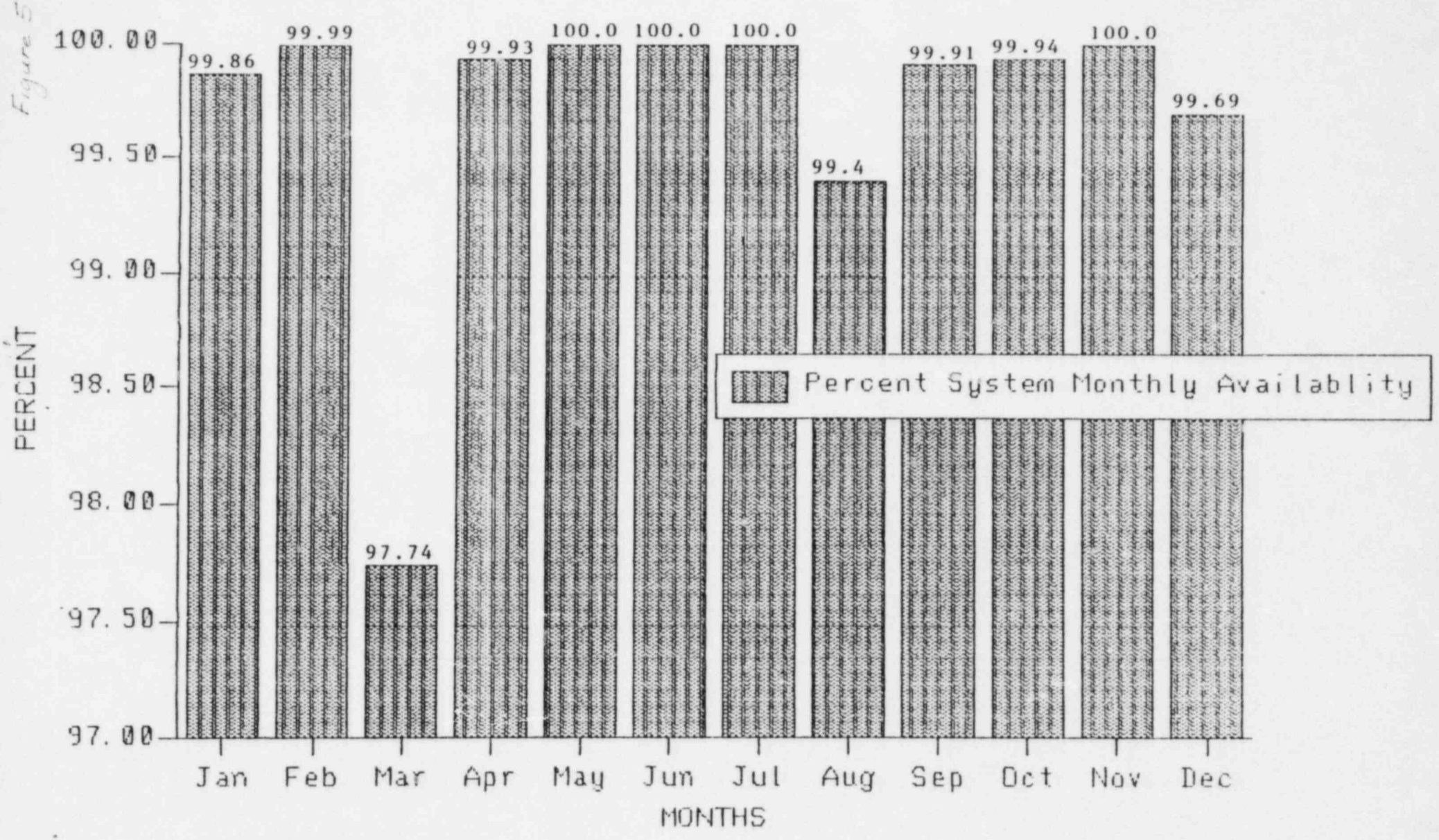
AVERAGE CIRCULATØR INLET TEMP 342 DEG F

REACTIVITY | PRIMARY SYSTEM | SECØNDARY SYSTEM | PRIMARY CØØLANT PRESSURE | RADIØACTIVE RELEASE

SPDS SECØNDARY SYSTEM — page forward

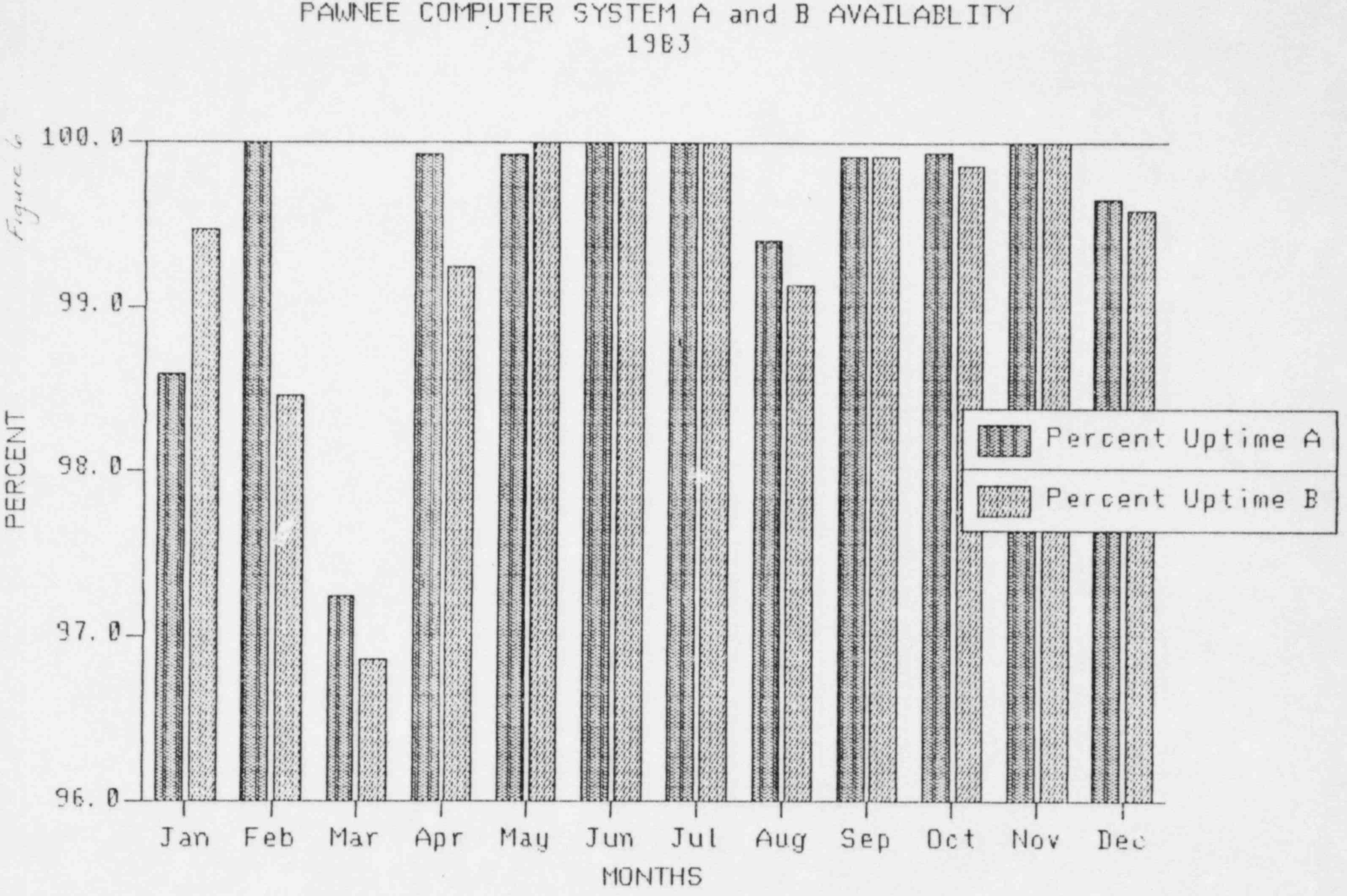
SPDS MASTER MENU — page down

Figure 5



Pawnee Overhaul Feb - April 15, 1983

Figure 6



Pawnee Overhaul Feb - April 15, 1983

TABLE 1

FORT ST. VRAIN SPDS RECOMMENDED PARAMETER LIST

	Parameter	Critical Safety Function(*)	Comments
1.	Average Neutron Power	RC	
2.	Neutron Flux Rate of Change	RC	
3.	Primary Heat Balance Power	RC	
4.	Secondary Heat Balance Power	RC	
5.	Power-To-Flow Ratio	PHR	
6.	Primary Helium Flow	PHR	
7.	Core Average Outlet Temperature	PHR	Tech. Spec. Def. 2.20
8.	Max Region Outlet Temperature Mismatch	PHR	A & B (LCO 4.1.7)
9.	Average Circulator Inlet Temperature	PHR	
10.	Feedwater Flow	SHR	Each Loop
11.	Main Steam Temperature	SHR	Each Loop
12.	Main Steam Pressure	SHR	Each Loop
13.	Hot Reheat Steam Temperature	SHR	Each Loop
14.	Hot Reheat Steam Pressure	SHR	Each Loop
15.	Steam Jet Air Ejector Activity	SHR	
16.	Primary Coolant Pressure	CSI-	
17.	Primary Coolant Moisture	CSI	
18.	Circulator and Steam Generator Penetration Interspace Pressure	CSI	Alarm High Only
19.	Primary Coolant Activity	RAC	
20.	Reactor Plant Exhaust Stack Activity	RAC	

(*) Critical Safety Functions

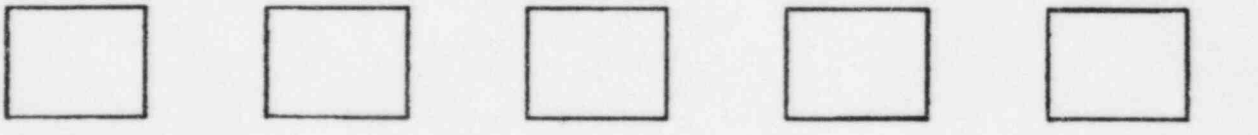
CSI = Reactor Coolant System Integrity
PHR = Primary Heat Removal
RAC = Radioactivity Control
RC = Reactivity Control
SHR = Secondary Heat Removal

PROTOTYPE

09:43:09 10/31/84 S P D S M A S T E R M E N U 0030

- ☐ REACTIVITY
- ☐ PRIMARY SYSTEM
- ☐ SECØNDARY SYSTEM
- ☐ PRIMARY CØØLANT PRESSURE
- ☐ RADIØACTIVE RELEASE

SPDS



REACTIVITY | PRIMARY SYSTEM | SECØNDARY SYSTEM | PRIMARY CØØLANT PRESSURE | RADIØACTIVE RELEASE

PROTOTYPE

09:34:35 10/31/84 R E A C T I V I T Y 0025

SPDS RADIØACTIVE RELEASE

ASSØCIATED DISPLAYS
1171
1175

AVERAGE NEUTRØN PØWER

LINEAR PØWER CHANNEL AVERAGE 0.0 %

NEUTRØN FLUX RATE-ØF-CHANGE

NI-1131-2	.1	DPM
NI-1132-2	.2	DPM
NI-1133-2	.1	DPM

PRIMARY HEAT BALANCE PØWER 0.2 %

SECØNDARY HEAT BALANCE PØWER 0.5 %

REACTIVITY | PRIMARY SYSTEM | SECØNDARY SYSTEM | PRIMARY CØØLANT PRESSURE | RADIØACTIVE RELEASE

SPDS PRIMARY SYSTEM

PROTOTYPE

09:35:52 10/31/84 P R I M A R Y S Y S T E M 0026

SPDS REACTIVITY

ASSØCIATED DISPLAYS
317
1171
1172

PØWER-TØ-FLØW RATIØ			
MEASURED PØWER-TØ-FLØW	0.000		
PØWER-TØ-FLØW RECØRDER ALARM	NØRMAL		
PRIMARY HELIUM FLØW	18.2	KLB/HR	
CØRE AVERAGE ØUTLET TEMP	331	DEG F	
MAX REGIØN ØUTLET TEMP MISMATCH			ACTIØN CØDE
MAXIMUM MISMATCH A	- 399	DEG F	00
MAXIMUM MISMATCH B	- 380	DEG F	00

ACTIØN CØDE: 100=SHUTDØWN 200=2 HRS 300=24 HRS

AVERAGE CIRCULATØR INLET TEMP	342	DEG F	

REACTIVITY | PRIMARY SYSTEM | SECØNDARY SYSTEM | PRIMARY CØØLANT PRESSURE | RADIØACTIVE RELEASE

SPDS SECØNDARY SYSTEM

PROTOTYPE

09:37:17 10/31/84 SECONDARY SYSTEM 0027

SPDS PRIMARY SYSTEM

ASSOCIATED DISPLAYS 1171. 1175

	LOOP 1		LOOP 2	
FEEDWATER FLOW	0.0	KLB/HR -	2.5	KLB/HR
MAIN STEAM TEMPERATURE	115	DEG F	180	DEG F
MAIN STEAM PRESSURE	- 3	PSIG -	18	PSIG
HOT REHEAT STEAM PRESS	8	PSIG	20	PSIG
HOT REHEAT STEAM TEMP				
	SG B-1-1 THRU 6		SG B-2-1 THRU 6	
CALCULATED AVERAGE	0	DEG F	0	DEG F

STEAM JET AIR EJECTOR ACTIVITY

4.778 E+ 2 CPM

REACTIVITY | PRIMARY SYSTEM | SECONDARY SYSTEM | PRIMARY COOLANT PRESSURE | RADIOACTIVE RELEASE

SPDS PRIMARY CLNT PRESSURE

PROTOTYPE

09:38:32 10/31/84 0028

PRIMARY COOLANT PRESSURE

SPDS SECONDARY SYSTEM

ASSOCIATED DISLAYS
1172
1173

PRIMARY COOLANT PRESSURE 20.2 PSIA

PRIMARY COOLANT MOISTURE

			CALC RATE OF CHANGE		
MI-9306	27.3	PPM	▲	0	DEG F/MIN
MI-9307	1.1	PPM	▲	0	DEG F/MIN

CIRCULATOR PENETRATION INTERSPACE PRESSURE

	A	B	C	D
CIRCULATOR PENETRATION PRESSURE ALARM HIGH	NORMAL	NORMAL	NORMAL	NORMAL

STEAM GENERATOR PENETRATION INTERSPACE PRESSURE

	LOOP 1	LOOP 2
STEAM GENERATOR PENETRATION PRESSURE ALARM HIGH	NORMAL	NORMAL

REACTIVITY | PRIMARY SYSTEM | SECONDARY SYSTEM | PRIMARY COOLANT PRESSURE | RADIOACTIVE RELEASE

SPDS RADIOACTIVE RELEASE

PROTOTYPE

09:39:48 10/31/84 R A D I Ø A C T I V E R E L E A S E 0029

SPDS PRIMARY C ØØ LANT PRESS

ASSØCIATED DISPLAYS
7025
7370
8972

PRIMARY C ØØ LANT ACTIVITY

RIS-9301	1.891	E+ 0	CPM

STACK ACTIVITY

STACK NØBLE GAS RIS-7324-1	3.800	E+ 1	CPM
STACK NØBLE GAS RIS-7324-2	1.346	E+ 1	CPM

				CALCULATED RATE ØF CHANGE
STACK IØDINE RIS-73437-1	1.747	E+ 1	CPM	↓ 5 CPM/MIN

REACTIVITY | PRIMARY SYSTEM | SECØNDARY SYSTEM | PRIMARY CØØLANT PRESSURE | RADIØACTIVE RELEASE

SPDS REACTIVITY

FORT ST. VRAIN

SPDS VERIFICATION AND VALIDATION PROGRAM

A. INTRODUCTION

1. This section of the SPDS Program Plan profiles the verification and validation program to be implemented at the FSV plant.

B. GENERAL

1. Design, development, qualification, and installation shall be verified by qualified personnel other than the original designers and developers.

2. These requirements and the acceptance criteria for validation shall be documented and verified with the safety system requirements for programmable digital computer systems in accordance with the following:

   a. Organization - The V&V group shall be organized to be independent of personnel responsible for the system design and development. The technical qualifications of the V&V team shall be comparable to those of the design team.

   b. Review and Audit Procedures - Verification of phase by phase documentation is needed in addition to comprehensive test results (validation) in order to demonstrate that the completed system works as required to perform its intended function. If the translation from one stage of development to another can be understood by knowledgeable persons other than the originator, and it is determined that a faithful and accurate translation has been performed, then the stage-by-stage verification can be considered satisfied.

   c. Software Test and Analysis - Procedures will be developed outlining the tests required for software and any modifications to software.

3. There may be a need for two types of V&V plans and/or procedures for safety and non-safety systems.

4. The V&V program will be a three phase program made up of reviews, testing, and documentation.

5. To assure a logical translation from one stage to another for the SPDS, the Designers and V&V will adopt a sequence of events similar to that denoted in Figure 1.

C. REVIEWS

1. Reviews of three basic areas will occur:

    1. Design
    2. Development
    3. Test

2. V&V will provide assurance that the designers and developers have met the requirements of all associated documents (System Requirements, Design Specification, NUREGs, etc.).

3. V&V shall provide assurance of operational conformance to design specifications.

4. V&V will provide assurance that significant changes to the system are verified and the changes are accompanied by a statement indicating whether or not availability will be affected.

5. V&V will provide assurance that the users are trained both initially and when modifications occur.

6. The results of the control room design review will be applied to verification of the SPDS parameter selection, data displays, and functions.

7. V&V will serve as a second check of computer software for correctness, etc.

8. Discrepancies will be documented that arise during review and will be accompanied by their resolution.

D. TESTING

1. All data displayed shall be validated where practicable on a real time basis as part of the display to the control room personnel.

2. The computational capacity and data throughput of the plant processor must be sufficient to accomodate the combined computational and input-output loads of the ERF system and other functions being performed by the plant processor. V&V will test to verify this.

3. The data acquisition system will be initially tested by V&V to provide assurance of correlation of data with the readings observed by the operators.

4. The integrity of the software and the integrated system will be tested (validation).

5. A formal test plan will be produced.

E. DOCUMENTATION

1. V&V plans to use where possible existing documentation from Lookout Center, Fort St. Vrain, and Engineering. This documentation will be adapted for use with the V&V program.

2. V&V shall provide an auditable trail for QA with regard to the following:

    a. Performance of V&V functions;

    b. Satisfaction of requirements from NUREGs, Reg. Guides, etc. by the designers, developers, and the V&V team;

    c. Satisfaction of Systems Requirements and associated documentation requirements;

    d. Test and evaluation results; and

    e. Discrepancies and their resolutions.

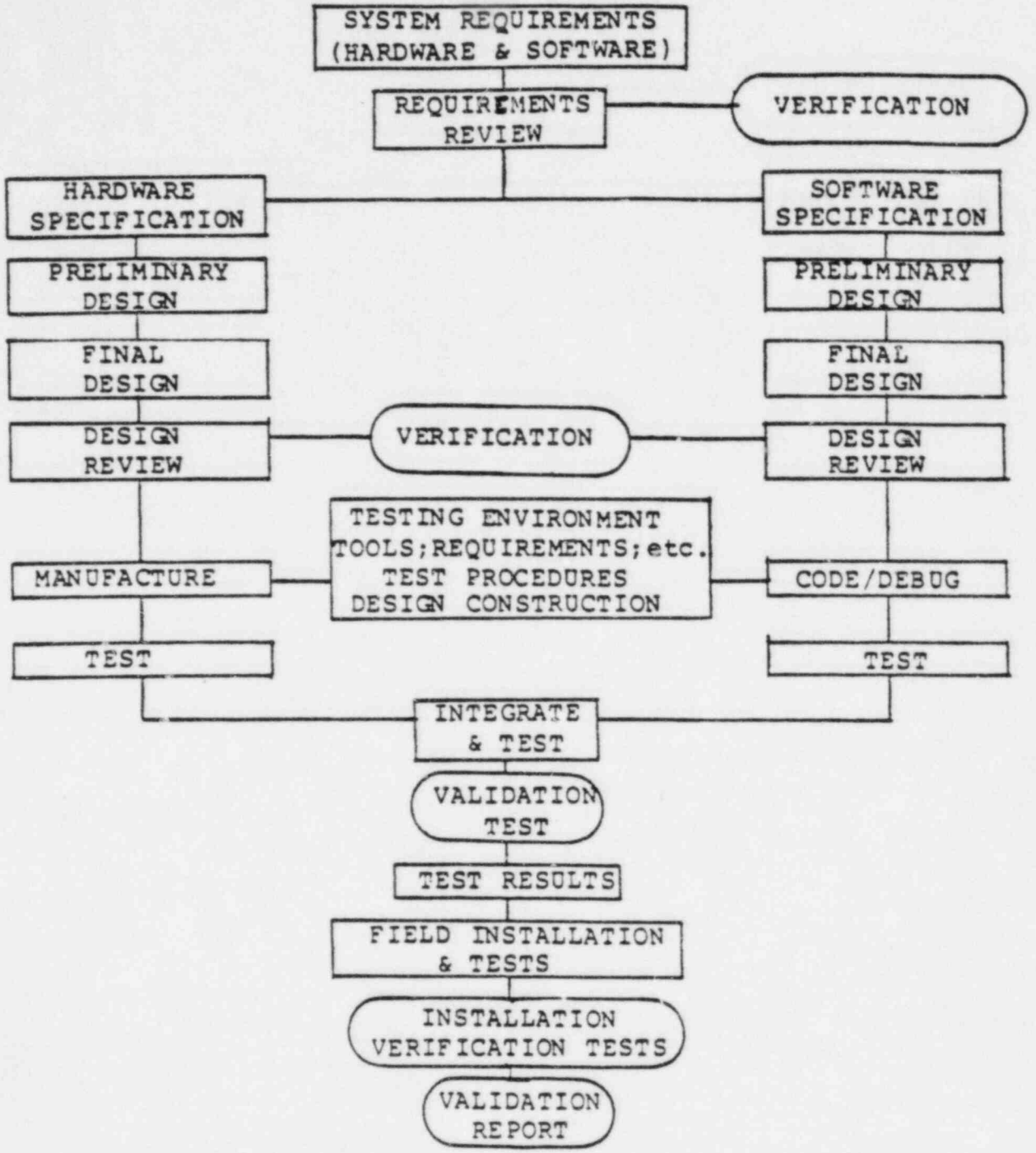
F. SUMMARY

1. In the near term, Verification and Validation will provide adequate documentation and evidence of a comprehensive independent evaluation of the SPDS.

2. In the long term, SPDS Verification and Validation will provide the same for any modification of SPDS software.

FIGURE 1.

SEQUENCE OF EVENTS



Revision 1

Prepared by: D. Shipman

T. McIntire

Approved by: M. E. Niehoff

F. J. Novachek

SPDS INSTALLATION SCHEDULE

1.	SPDS Power System Installed	April 1985
2.	Installation of Second CDC Mainframe	October 1985
3.	SPDS Software Design & Development Completed	March 1986
4.	SPDS Hardware Operational	July 1986
5.	SPDS Verification and Validation Completed	4th Refueling Outage
6.	Control Room SPDS Operational	4th Refueling Outage

REQUIRED SEISMIC RESPONSE SPECTRA CURVES

FOR

FSV ELECTRICAL ISOLATION SYSTEM

Figures 1-4: Response spectra for mounting equipment in existing cabinets.

Figures 5-6: Response spectra for qualification of new cabinets.

ATTACHMENT 4
1 OF 6

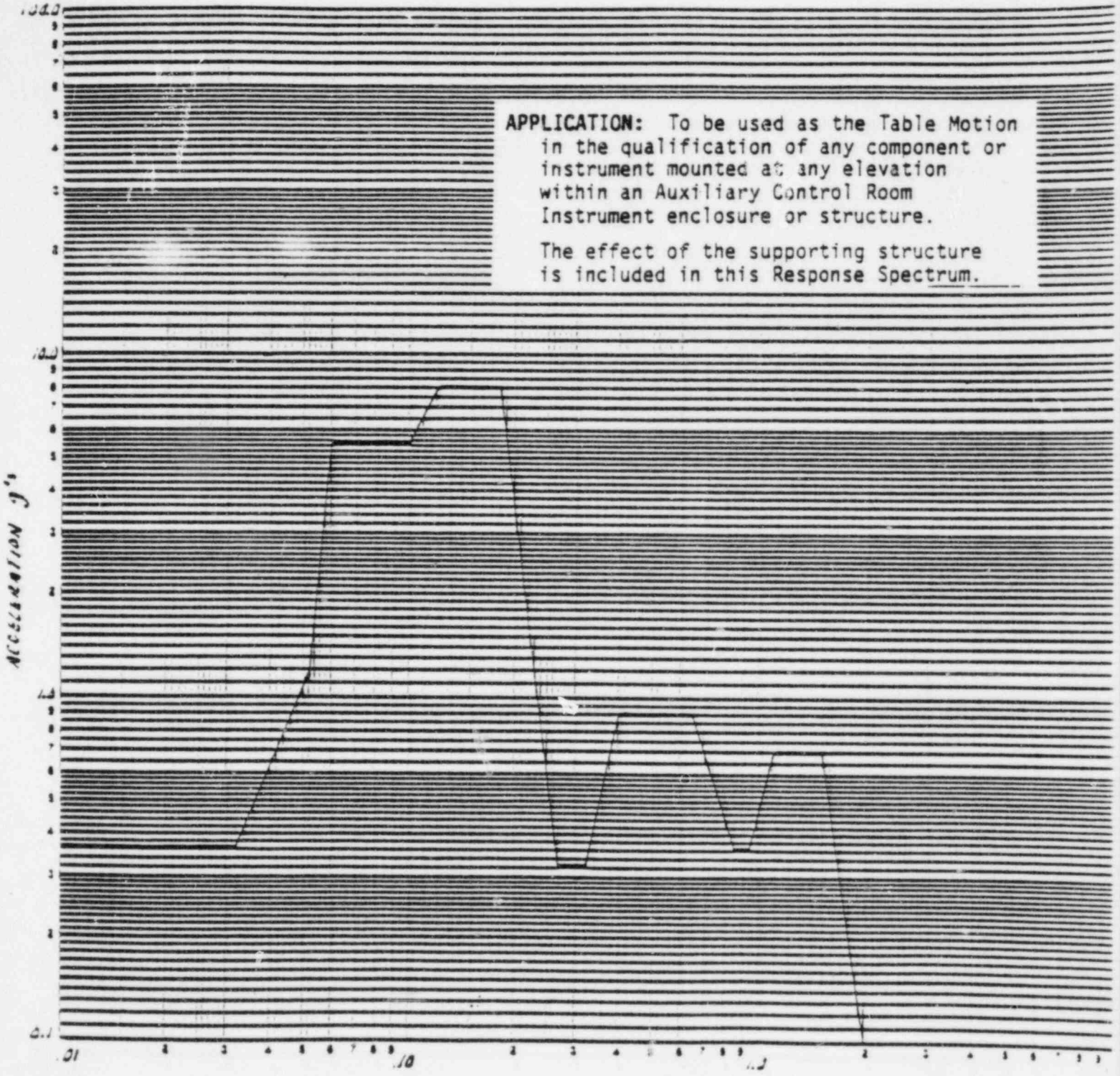
Figure 1

Auxiliary Control Room
Instrument Response Spectra

Combined Instrument Spectra

Maximum Horizontal - 0.10g OBE

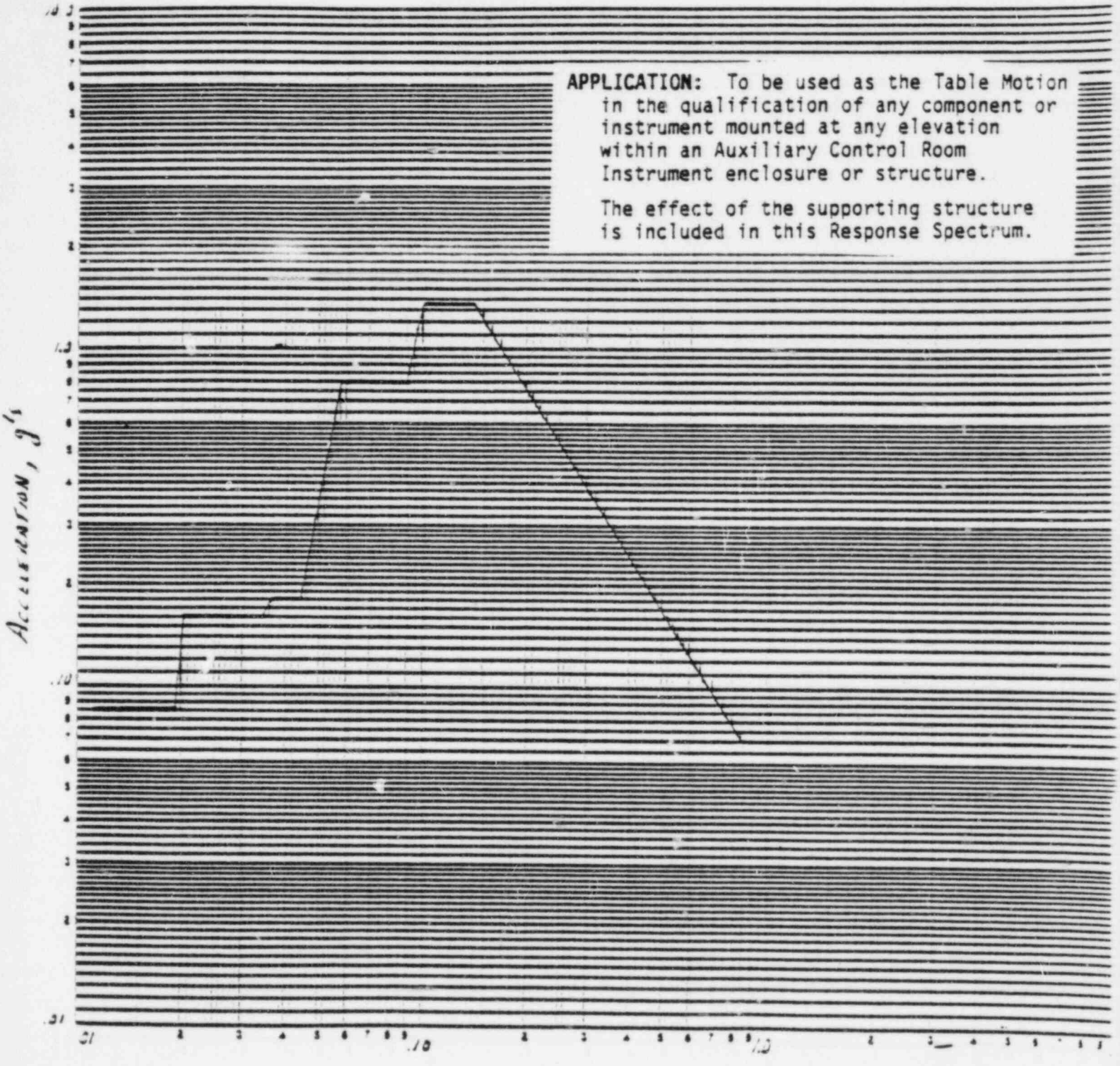
1% Equipment Damping



Full Logarithmic, 3 x 3 Cycles

Figure 2

Auxiliary Control Room
Instrument Response Spectra
Combined Instrument Spectra
Maximum Vertical - 0.10g OBE
1% Equipment Damping



Full Logarithmic, 3 x 3 Cycles

Figure 3

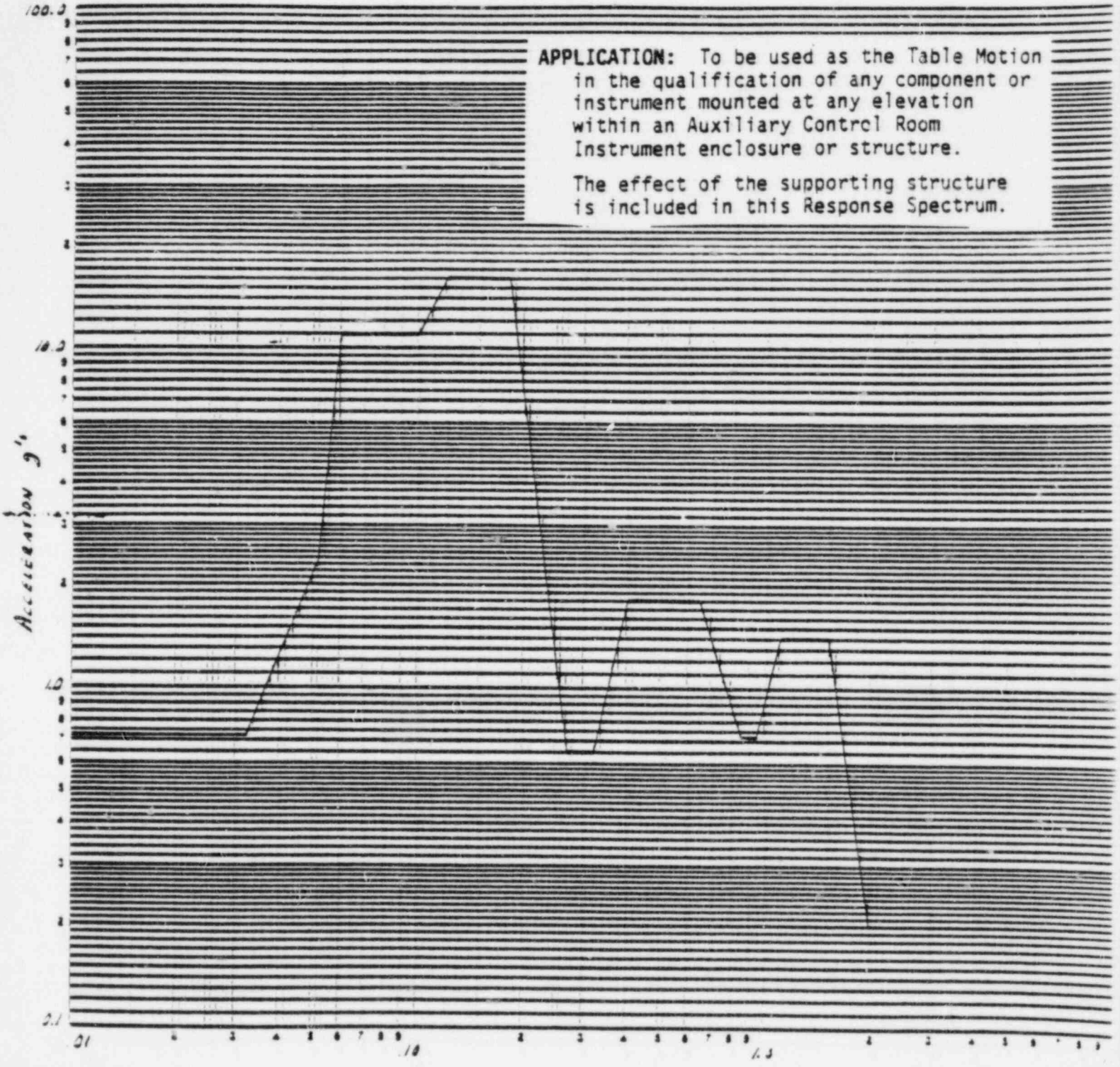
Auxiliary Control Room

Instrument Response Spectra

Combined Instrument Spectra

Maximum Horizontal - 0.10g SSE

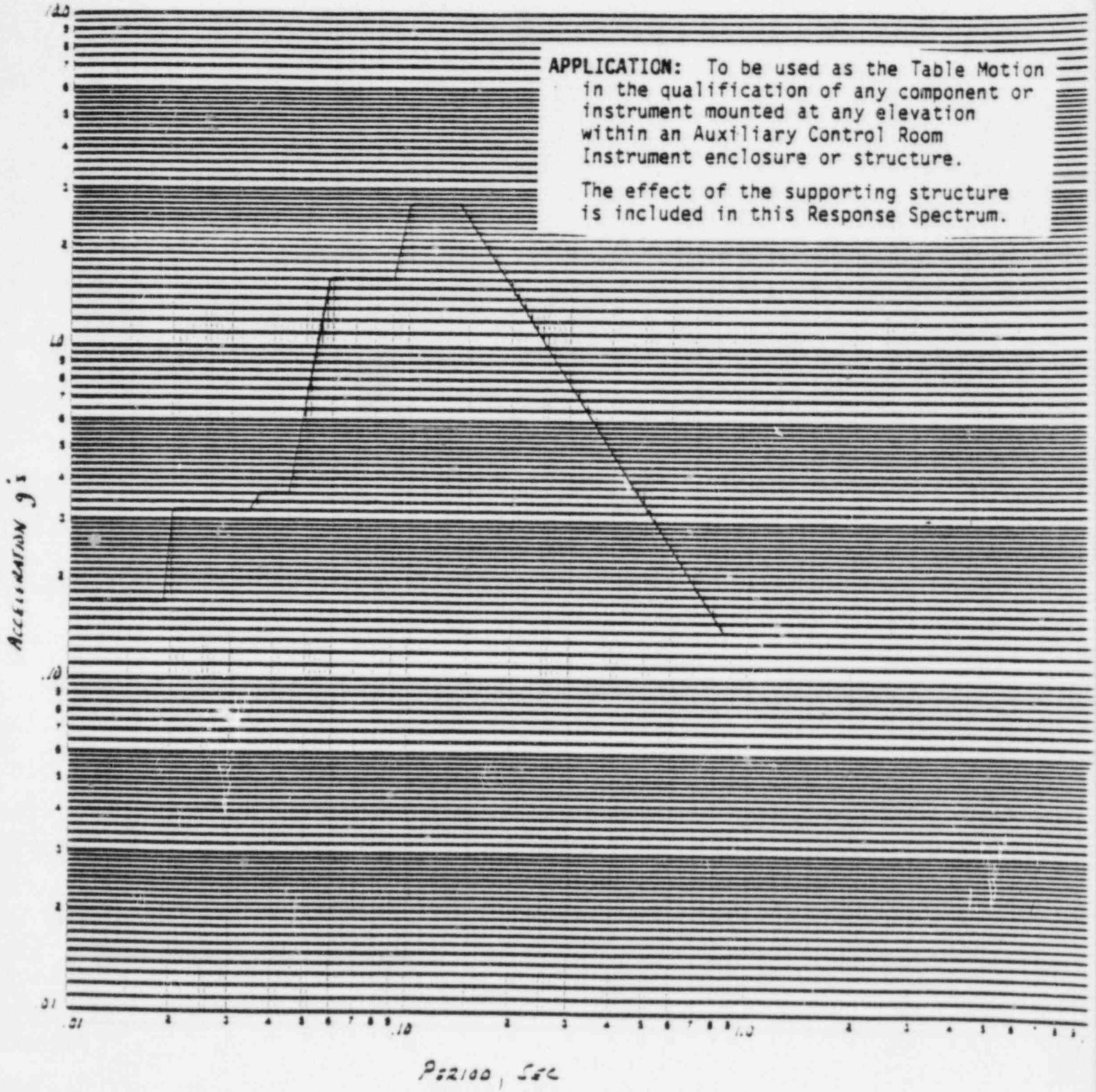
1% Equipment Damping



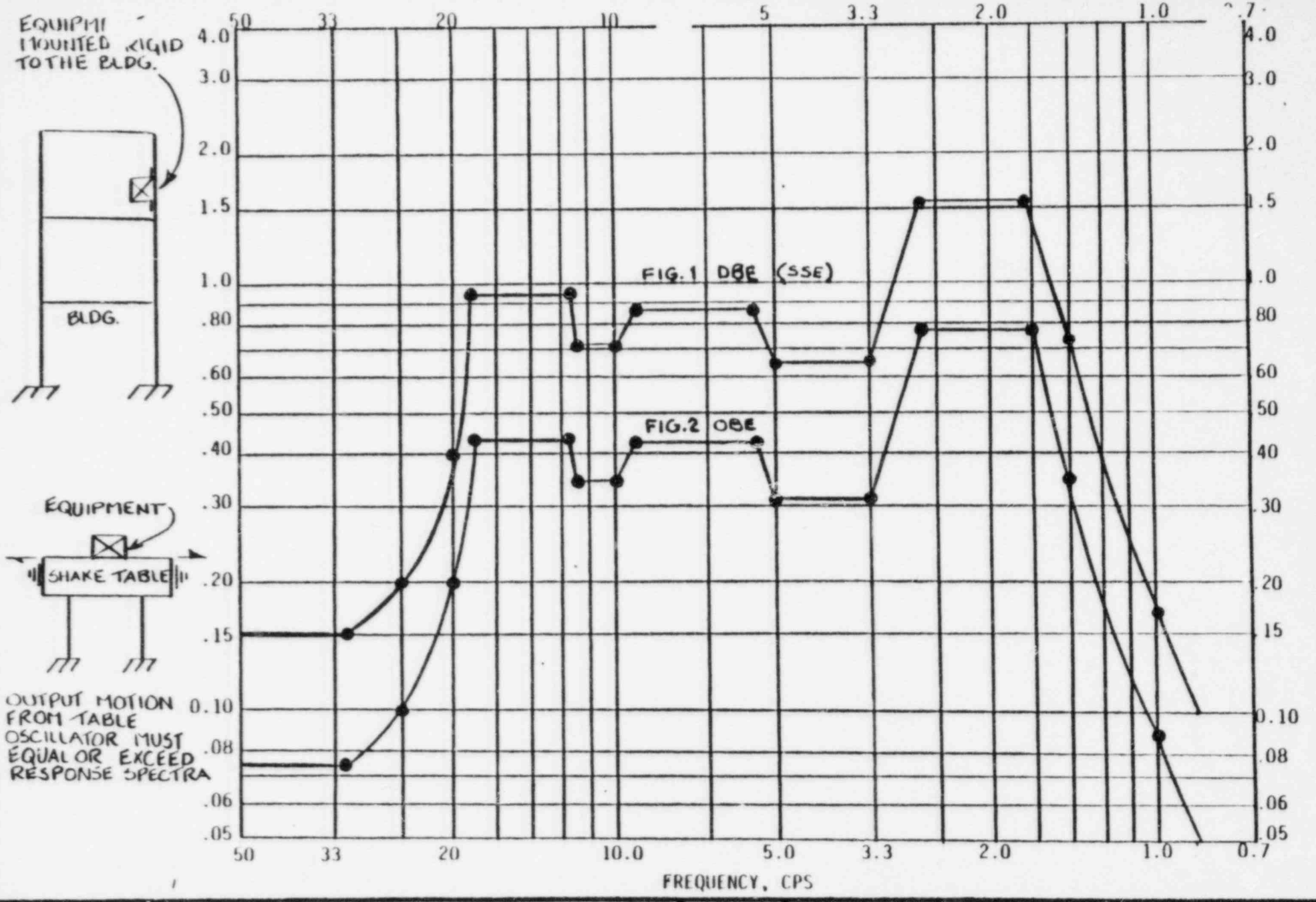
Full Logarithmic, 3 x 3 Cycles

Figure 4

Auxiliary Control Room
Instrument Response Spectra
Combined Instrument Spectra
Maximum Vertical - 0.10g SSE
1% Equipment Damping



Full Logarithmic, 3 x 3 Cycles



SHEET OF

CKD. BY

DATE DATE

Public Service Company of Colorado

ENGINEERING AND PLANNING

EP NO.

FSV HORIZONTAL
FLOOR RESPONSE
SPECTRA 1% DAMPING
@ 488' & BELOW

Approvals

E

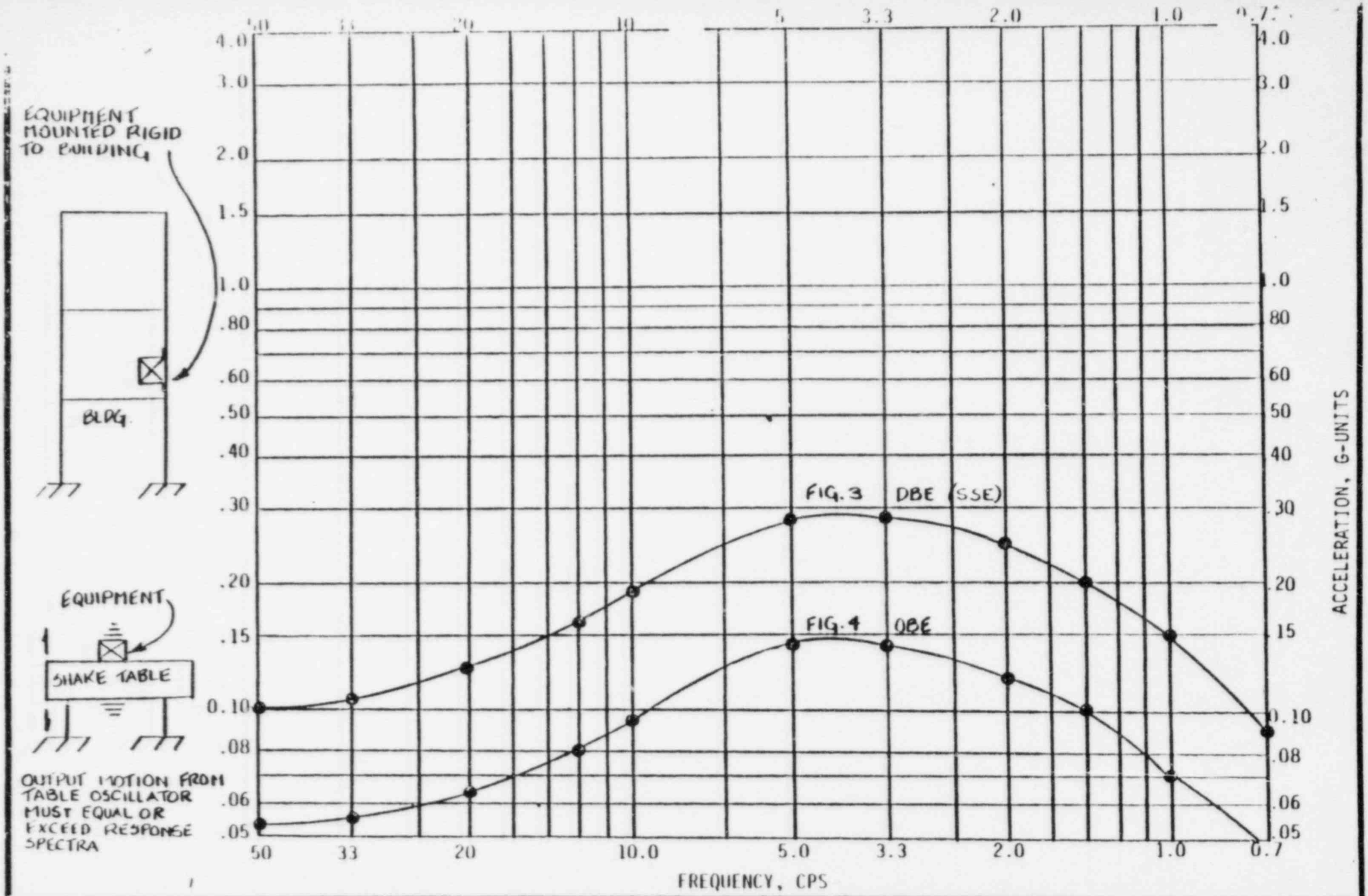
M

A

FIGURE 5

ATTACHMENT 4

5 of 6



Public Service Company of Colorado

FSV VERTICAL
FLOOR RESPONSE
SPECTRA, 1% DAMPING
ALL ELEVATIONS

ENGINEERING AND PLANNING

EP NO.

Approvals
E
M
A

FIGURE 6

ATTACHMENT 4
6 of 6