BWR OWNERS' GROUP

CONTROL ROOM DESIGN REVIEW COMMITTEE

HUMAN FACTORS ENGINEERING

CONTROL ROOM SURVEY

SUPPLEMENT

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CONTROL ROOM SURVEY SUPPLEMENT

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INTRODUCTION

This supplement is intended to augment Revision 1 of the BWR Owners Group Control Room Survey (CRS) Program dated 1/1/81. It is to be included as part of the Control Room Review Checklists (Section III of the CRS Program) to further document proposed control room enhancements. The additional items listed in the supplement have been drawn from human engineering guidelines recommended in NUREG-0700 and verified through considerable experience of Owners Group Survey teams.

Major sections of the supplement checklists are identified by letters corresponding to section designations used in the original checklists. In order to differentiate between the two numbering systems, an "S" prefix has been assigned to each supplement item.

The CRS Supplement is to be implemented in accordance with the methodology discussed on page 15 of the CRS package. As before, Sections SA, SB, and SC are to be completed for each panel containing controls and displays normally operated by control room operators. The remaining sections apply to the entire control room and therefore need to be completed only once. Sections A, B, and C should also be completed for the remote shutdown panel.

In addition to the attached checklist supplement, several other modifications have been adopted in the CRS Program. These are listed in Table I. All other aspects of the program remain unchanged.

TABLE I

CRS PROGRAM MODIFICATIONS

The following modifications have been implemented in the BWR Owners Group Control Room Survey Program:

- Sections A, B, and C of the Control Room Review Checklists are to be performed for the remote shutdown panel in addition to those panels previously recommended.

- A supplement (attached) has been added to the Control Room Review Checklists.

- Task analyses and walkthroughs are performed based upon symptom oriented emergency procedures developed from the BWR Owners Group Emergency Procedure Guidelines. If plant-specific procedures are not yet available, the guidelines themselves should be utilized in the analysis. In this case, existing procedures for a scram, relief valve failure, and loss of coolant accident should also be evaluated.

Panel_____

SA PANEL LAYOUT AND DESIGN

SA1 Anthropometrics

SA1.1	Is seating area adjacent to desks and sit-down consoles sufficient to allow the operator to get into and out of a chair easily and to turn in the chair to view the equipment behind (30" lateral space, 36" between desk and opposing panel or surface)?	4 3 2 1 0	x 1	= ____
SA1.2	Is sufficient space allowed between the panel and opposing surfaces such that the operator may perform required tasks without hindrance?	4 3 2 1 0	x 2	= ____
SA1.3	If the operator is required to see over a stand-up console, does the console height not exceed 58 inches?	4 3 2 1 0	x 2	= ____

SA2 Control Room Layout

SA2.1	Does the location of the shift supervisor's office permit prompt access to the control room under all conditions?	4 3 2 1 0	x 2	= ____

Panel_____

SA2.2	Are operator's desks and chairs comfortable and in good repair?	4 3 2 1 0	x 1	= ____
SA2.3	For a multi-unit plant, are senior operators who supervise or assist in the operations of more than one unit stationed such that they may communicate effectively with all operators and view each control board?	4 3 2 1 0	x 2	= ____
SA2.4	Are operators provided with sufficient desk and working space for performance of required tasks?	4 3 2 1 0	x 1	= ____

SA3 Control/Display Grouping

Is the association of feedback indication to related controls made readily apparent through labeling, mimics, demarcation lines or position?	4 3 2 1 0	x 3	= ____

Panel_____

SA4 Labels

SA4.1	Where abstract symbols are used, are they of standard configuration, distinguishable from other symbols, and consistent in use within and across panels?	4 3 2 1 0	x 2 =	____
SA4.2	Are labels located such that they do not cover or detract from other necessary information?	4 3 2 1 0	x 3 =	____
SA4.3	Is extraneous information not included (e.g., manufacturer's trademark, patent notice, etc.)?	4 3 2 1 0	x 1 =	____

SA5 Unit Integration

SA5.1	For a multi-unit plant, are alarms for shared plant systems duplicated in all control rooms?	4 3 2 1 0	x 3 =	____
SA5.2	For multi-unit plants, if equipment is shared between control rooms, is there administrative control over use of the equipment?	4 3 2 1 0	x 2 =	____

Panel_____

SA5.3 Is the status of shared equipment displayed in each control room?

4	3	2	1	0	x	3	=	___

Panel_____

SB INSTRUMENTATION AND HARDWARE

SB1 Indicators

SB1.1	Are indicator scales easily read when stationed at the panel?	4 3 2 1 0	x	3	= ____
SB1.2	Is the use of multiscale and logarithmic scale indicators minimized?	4 3 2 1 0	x	2	= ____
SB1.3	Are displays which reflect only a demand signal labeled accordingly?	4 3 2 1 0	x	3	= ____
SB1.4	Are process units and multipliers specified?	4 3 2 1 0	x	3	= ____
SB1.5	Are drum-type counters readable from the normal viewing position?	4 3 2 1 0	x	3	= ____

Panel_____

SB1.6	Are digital displays readable from the normal viewing position?	4 3 2 1 0	x 3 =	____

SB2 Recorders

SB2.1	Is all recorder information visible through recorder windows (i.e. open-door operation not required)?	4 3 2 1 0	x 2 =	____
SB2.2	Do multi-channel recorders clearly display the channel being plotted?	4 3 2 1 0	x 2 =	____

SB3 Indicating Lights

	Have procedural or design provisions been implemented to prevent interchanging indicating light lenses?	4 3 2 1 0	x 2 =	____

Panel_____

SB4 Switches

SB4.1	Where contiguous legend pushbuttons are used, are barriers provided to prevent inadvertent actuation of adjacent pushbuttons?	4 3 2 1 0	x 3	= ____
SB4.2	Are key-operated switches used only where appropriate (i.e., to prevent unauthorized control actuation)?	4 3 2 1 0	x 2	= ____

Panel_____

SC ANNUNCIATORS

SC1 Window Design

Is the density of annunciator matrices such that the operator may quickly ascertain a window position?	4	3	2	1	0	x	3	= ____

SC2 Acknowledgement

Are annunciator response controls coded for ease of recognition (color, shape, demarcation, etc.)?	4	3	2	1	0	x	2	= ____

SD COMPUTERS

SD1 Console

SD1.1	Do typewriter keyboards conform to the standard "QWERTY" arrangement?	4 3 2 1 0	x	1	= ____
SD1.2	Do numeric keyboards conform to either the "telephone" style or the "calculator" style arrangement?	4 3 2 1 0	x	1	= ____
SD1.3	Do function keyboards contain only those keys which are used by the operators (i.e. no irrelevant keys such as used by programmers)?	4 3 2 1 0	x	1	= ____
SD1.4	Are function controls segregated from alpha-numeric keys?	4 3 2 1 0	x	1	= ____
SD1.5	Are function controls clearly labeled to indicate their function?	4 3 2 1 0	x	2	= ____

SD2 Capability

SD2.1	Is computer use and software access administratively controlled?	4 3 2 1 0	x 2	= ____
SD2.2	Is the system designed such that data is not lost during printer down periods?	4 3 2 1 0	x 2	= ____

SD3 CRTs

SD3.1	Are CRTs free from glare and easily readable from normal viewing positions?	4 3 2 1 0	x 2	= ____
SD3.2	Are messages which require immediate operator response highlighted to attract the operator's attention?	4 3 2 1 0	x 3	= ____
SD3.3	Are prompts and error messages used to guide the operator in proper system operation?	4 3 2 1 0	x 2	= ____
SD3.4	Are abbreviations, acronyms, and synonyms used consistent with those used elsewhere in the control room?	4 3 2 1 0	x 2	= ____

SD4 Printers

SD4.1	Are printers located in a readily accesible area in the control room?	4 3 2 1 0	x 1	= ____
SD4.2	Do printers have the capability to record alarm, trend, and plant status data?	4 3 2 1 0	x 1	= ____
SD4.3	Is the system capable of providing a hard copy of any page appearing on the CRT?	4 3 2 1 0	x 1	= ____

SE PROCEDURES

SE1	Are procedures, reference materials and other documents readable (i.e. not dirty, torn, dog-eared or otherwise difficult to read)?	4 3 2 1 0	x 3	= ____
SE2	Is a set of computer operating procedures available in the control room describing the computer system, procedures necessary to accomplish operator-computer interface functions and contingency actions in the event of a computer failure?	4 3 2 1 0	x 2	= ____

SF CONTROL ROOM ENVIRONMENT

SF1 Communications

SF1.1	Are periodic maintenance tests performed on all communications sytems?	4 3 2 1 0	x	2	= ____
SF1.2	Is sufficient communications equipment (cords, jacks, etc.) provided in well marked locations?	4 3 2 1 0	x	2	= ____
SF1.3	Is an intercom system provided connecting the control room with the shift supervisor's office?	4 3 2 1 0	x	2	= ____
SF1.4	Are instructions provided for the use of all communications systems?	4 3 2 1 0	x	2	= ____
SF1.5	Are operators trained in the use of all communications systems?	4 3 2 1 0	x	3	= ____

SF2 Lighting

SF2.1	Are local illumination levels at operator desks (e.g., desk lamps) adequate for the tasks being performed (50 footcandles minimum, 100 footcandles maximum, 75 footcandles recommended)?	4 3 2 1 0	x	3	= ___
SF2.2	Is illumination uniform over a given work station and from one station to another?	4 3 2 1 0	x	2	= ___
SF2.3	Is shadowing avoided on panels and other operator work areas?	4 3 2 1 0	x	2	= ___
SF2.4	Have direct sources of glare been avoided (e.g., light emitted from displays and indicators)?	4 3 2 1 0	x	2	= ___

SF3 Emergency Response Equipment

SF3.1	Is operator protective equipment periodically checked?	4 3 2 1 0	x	2	= ____
SF3.2	Is a sufficient quantity of protective equipment and expendables provided?	4 3 2 1 0	x	2	= ____
SF3.3	Are instructions provided for the use of protective equipment and expendables?	4 3 2 1 0	x	2	= ____
SF3.4	Are operators trained in the proper use of protective equipment and expendables?	4 3 2 1 0	x	3	= ____
SF3.5	Are fire and rescue equipment periodically checked?	4 3 2 1 0	x	2	= ____
SF3.6	Are instructions provided for the use of fire and rescue equipment?	4 3 2 1 0	x	2	= ____

SF3.7	Are operators trained in the proper use of fire and rescue equipment?	4	3	2	1	0	x 3 =	____
SF3.8	Is radiation monitoring equipment periodically checked?	4	3	2	1	0	x 2 =	____
SF3.9	Are instructions provided for the use of radiation monitoring equipment?	4	3	2	1	0	x 2 =	____
SF3.10	Are operators trained in the proper use of radiation monitoring equipment?	4	3	2	1	0	x 3 =	____

SG MAINTENANCE AND SURVEILLANCE

SG1 Tags

Are maintenance tags securely affixed to panel components?	4 3 2 1 0	x	2	= ____

SG2 Spare Parts

Are inventories kept for operational spare parts and expendables?	4 3 2 1 0	x	1	= ____

APPENDIX

B

BWR OWNERS' GROUP

CONTROL ROOM IMPROVEMENTS COMMITTEE

HUMAN FACTORS ENGINEERING

CONTROL ROOM SURVEY

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Chairman, Control Room Improvements Committee
BWR Owners' Group

BWR OWNERS GROUP

CONTROL ROOM SURVEY

PLANT/UNIT: _____

DATE PERFORMED: PHASE I _____ II _____

III _____ IV _____

SURVEY TEAM MEMBERS: _____ Team Leader

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

OTHER PARTICIPANTS (HFE CONSULTANT, GE A-E, etc.): _____

_____

_____

_____

_____

_____

NOTE: CHECKLIST ITEMS FOR WHICH ADVANCE RESEARCH IS NECESSARY HAVE BEEN IDENTIFIED WITH AN ASTERISK IN FRONT OF THE ITEM NUMBER.

Revision 1
01/01/81

CONTROL ROOM SURVEY

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I OPERATOR INTERVIEW

DISCUSSION

The purpose of the Operator Interview is to obtain direct operator input to aid in identifying potential or actual deficiencies in the control room layout or design or in operating procedures that result in confusion (mental activities), difficulty (manual activities) or distraction (the environment).

Using the attached questionaire, operators are asked to respond in writing based on their operational experience and knowledge of control rooms. Copies of the written responses will be sent to the survey team for a preliminary review prior to team arrival at the site. Interviewees will retain their copies and review them with a survey team member during a later oral interview. If additional space is needed, the attached Comment Form is to be used.

For the interview a representative group of one-third or more of the operators is selected covering a range of experience, education, ability and physical size. If available, at least two should have a current SRO license and two a current RO license.

The interviews should be conducted by utility personnel and survey team members with background or experience in operations and engineering or design with a position conducive to a free flow of information. It is expected that the oral interview will take one to two hours for each operator with the entire interview taking about one day.

Following the interviews, the survey team will consolidate the information obtained and analyze it to help identify specific areas of concern for detailed analysis during the control room review.

I OPERATOR INTERVIEW

INTRODUCTION TO QUESTIONAIRE

Job Position _____

Years Experience _____ Commercial Nuclear _____ Fossil

_____ Navy Nuclear

Date of first License _____ RO _____ SRO

Education/Degrees _____

Age _____ Sex _____ Height _____ Weight _____

In response to a post-TMI NRC requirement, your utility, along with other BWR owners, is conducting a control room review to identify and correct design deficiencies in the operator-control room interface to minimize the potential for human error. This review is performed by a survey team composed of representatives of several utilities using checklists prepared by the Control Room Improvements Subgroup of the BWR Owners Group.

You are asked to complete the attached questionaire basing your responses on your operational experience and knowledge of your control room and interfacing systems. You may complete this questionaire in the control room if you desire but please do so without discussing your detailed responses with other operators completing this survey. If additional space is needed, the attached Comment Form is to be used.

Following completion, a survey team representative will review your responses with you. Upon completion of all interviews, the survey team will consolidate the information obtained and apply it in their evaluation of your control room for compliance with human factor engineering principles.

The biographical information requested above will be used in compiling statistics on operating personnel physical characteristics. Current recommendations for panel design are based largely on data obtained from measurements of military personnel; there are few statistics presently available on, for example, the average height and weight of operators.

This survey provides you with a valuable opportunity for applying your knowledge and experience toward improving operating conditions in both your control room and future control room designs. Your honest and forthright opinions are not only welcomed, but needed.

I OPERATOR INTERVIEW

QUESTIONAIRE

A Would you recommend any changes in the following areas:

A1 shift coverage

A2 shift turnover

A3 training

A4 color coding

A5 control room access

A6 control panel layout or access

A7 communication systems

A8 heating or ventilation

A9 lighting or noise levels

A10 special test equipment

A11 maintenance or surveillance testing

A12 data recording and log entries

A13 information flow

A14 furniture, equipment or workspace

A15 computers

A16 other?

I OPERATOR INTERVIEW

QUESTIONAIRE

B Are any controls difficult to operate?

C Are any controls designed, positioned or labeled in a manner that causes risk of inadvertent operation?

D Are any recorders or indicators difficult or confusing to read?

E Are any important indicators located such that they are difficult to see during normal or emergency operation?

F Do you feel any control room displays are unnecessary, provide unimportant information or needlessly clutter the control panels?

G Based on your operational experience, does your control room lack any controls or displays needed in your response to normal or emergency situations?

I OPERATOR INTERVIEW

QUESTIONAIRE

H Do you consider the annunciator system to be effective in conveying important information to you?

I Do you have any problems locating or using procedures or operational instructions?

J Are individual responsibilities and chain-of-command clearly understood during all operating conditions?

K Is there an adequate number of operators available in the control room (or immediately available) to effectively operate the plant during all conditions?

L Are you required to perform any duties that you consider unreasonable or distracting in your responsibility as an SRO or RO?

M Based on your operational experience, have any errors or incidents occured which could have been averted through improved control room design?

I OPERATOR INTERVIEW

QUESTIONAIRE

N Have you experienced any problems using or understanding your procedures?

P Is there a particular panel which you consider more difficult or confusing to operate than the others?

Q General Comments:

I OPERATOR INTERVIEW

COMMENT FORM

This form is for use by the operator or interviewer for expanded responses to the Operator Interview questions. When used, each response will be identified by item number on this form and also so noted in the space following the applicable question to assure proper cross-referencing.

Item	Response

I OPERATOR INTERVIEW

SUMMARY FORM

This form is used by the Interviewer to summarize the information obtained during the Operator Interview. Each entry is to be cross-referenced to the specific checklist item for further evaluation during the Control Room Review.

Item or Area of Concern	Checklist Item(s)

II LICENSEE EVENT REPORT ANALYSIS

DISCUSSION

The purpose of the Licensee Event Report (LER) Analysis is to identify plant specific design deficiencies known to have previously contributed to operator errors and to document the need for further evaluation during the Control Room Review.

Prior to the arrival of the survey team, the host utility will review their plant LERs and scram reports from the past two years. Any occurence for which operator error was identified as a contributing factor will be listed on the attached LER form indicating the LER number and a description of the operator error.

The survey team will then analyze each event to identify possible deficiencies in the human engineering design of the control room by cross referencing the corresponding criteria from the Control Room Review checklists. These items will be included in the detailed evaluation during the Control Room Review.

II LICENSEE EVENT REPORT ANALYSIS

LICENSEE EVENT REPORTS (LERs)

*LER NUMBER	*OPERATOR ERROR	CHECKLIST ITEM

III CONTROL ROOM REVIEW

DISCUSSION

The purpose of the Control Room Review is to review and assess the adequacy of the arrangement and identification of important controls and displays, the usefullness of audio and visual alarm systems, plant status information provided, procedures and training with respect to limitations of existing instrumentation, information recording and recall capability, the control room layout and environment, and other areas of human factor engineering that potentially impact operator effectiveness. The ultimate objective is to identify potential modifications of the operator-control room interface which will reduce the potential for human error.

Each Control Room Review is conducted by the survey team using the attached checklists which are titled, in order, (A) Panel Layout and Design, (B) Instrumentation and Hardware, (C) Annunciators, (D) Computers, (E) Procedures, (F) Control Room Environment, (G) Maintenance and Surveillance, and (H) Training and Manning. Checklist (A), (B), and (C) will be completed for each panel in the control room, including back panels, auxiliary panels and peripheral equipment that contain controls and displays normally operated by the control room operator. The remaining checklists will be completed only once for each control room since they are applicable to the entire control room.

In completing the checklists, particular attention must be given to items identified as a potential problem area in the Operator Interview or the LER Analysis to ensure complete coverage. These items will have been cross-referenced to the checklist items where applicable.

Supplemental information is provided in the workshop to give additional guidance in completing the checklists.

It is anticipated that performance of the Control Room Review will take approximately one week. Due to the functional approach of the survey, in many cases input from on-shift operations personnel will be necessary in evaluation compliance for a given checklist item. In other cases, additional technical information will be required. Checklist items for which advance research is necessary have been identified with an asterisk in front of the item number. It is expected the host utility will compile this information prior to the arrival of the survey team and also provide operations personnel support.

Each checklist item is presented in the form of a question for consideration by a survey team member. Following that question is a series of numbers in which the specific item being reviewed is evaluated. The first set of numbers (4 3 2 1 0) indicates the degree of compliance wherein 4 indications <u>no</u> compliance, 3 indicates <u>somewhat</u> compliance, 2 indicates <u>mostly</u> compliance, 1 indicates <u>full</u> compliance and 0 indicates the specific question being considered is <u>not applicable</u> or cannot be considered at this time since the plant being evaluated is not operational. As each specific question is evaluated, the team member(s) actually doing the evaluation of that question indicates the relative degree of compliance by circling the applicable number.

DISCUSSION (Continued)

Following the number indicating the degree of compliance for each item being evaluated is a predetermined number ranging from one to three which indicates the relative importance of that item with respect to the potential for causing or contributing to operator error. A 3 indicates high potential for operator error, 2 indicates moderate potential and 1 indicates low potential. In the final evaluation of each item considered, it is the product of the degree of compliance times the potential for operator error that determines if the consideration of corrective action is justified. Since some items will not be applicable for consideration in all control rooms, it should be noted that a general comparison of several control rooms by comparison of "scores" is not valid.

Following each checklist item is space for the person performing the evaluation to enter comments. For each specific checklist item, these comments will identify items or components of non-compliance, the scope of review, or any qualifying statement judged to be appropriate to the evaluation. If, for example, a large number of components are reviewed and only a few are in non-compliance, these would be specifically noted in the comment space and the general rating would be "mostly compliance". To provide additional documentation, still photographs will be taken of major items or components of non-compliance such as mimic layouts, control/display groupings, labeling systems or equipment locations. These photographs are cross referenced to the specific checklist item by a notation in the comment space. Due to the importance of comments in the evaluation, additional Comment Forms will be attached for more detail when necessary.

As an example, a review item would possibly be as follows:

		No	Somewhat	Mostly	Full	Not Applicable		Potential for error		Product
		Compliance								
E1	Does the control room operator have available:	4	3	(2)	1	0	x	3	=	6
	E1.1 a full set of up-to-date plant procedures	Surveillance procedures are incomplete and not all are latest revision; others are OK								

Since all procedures except surveillance procedures are available to the control room operator and are up-to-date, 2 is circled indicating "mostly" compliance and multiplying that by 3, the potential for error, gives a product of 6.

III CONTROL ROOM REVIEW

COMMENT FORM

This form is to be used during the performance of the Control Room Review to identify, for each specific checklist item as necessary, the scope of review, items or components of non-compliance, or any qualifying statements appropriate to the evaluation of that checklist item. When this form is used, the checklist item number is to be entered here, and a note is to be made in the space following the checklist item to identify the use of this comment form, assuring proper cross-referencing. This form is to be placed in the survey package directly following the page on which the checklist item appears.

Item	Comment

III CONTROL ROOM REVIEW

Panel _____

A PANEL LAYOUT and DESIGN

A1 For control panels:

A1.1	does the design generally meet measurement standards per the attached anthropometric diagrams (complete and attach)	4 3 2 1 0	x 2 = ____
A1.2	are they of the same layout and design on multi-unit plants (not mirror image)	4 3 2 1 0	x 2 = ____
A1.3	when panel components are permanently removed, are spaces covered to prevent debris or dust from entering panel internals and repainted to avoid visual distinctiveness	4 3 2 1 0	x 2 = ____
A1.4	have sharp corners and edges been eliminated?	4 3 2 1 0	x 1 = ____

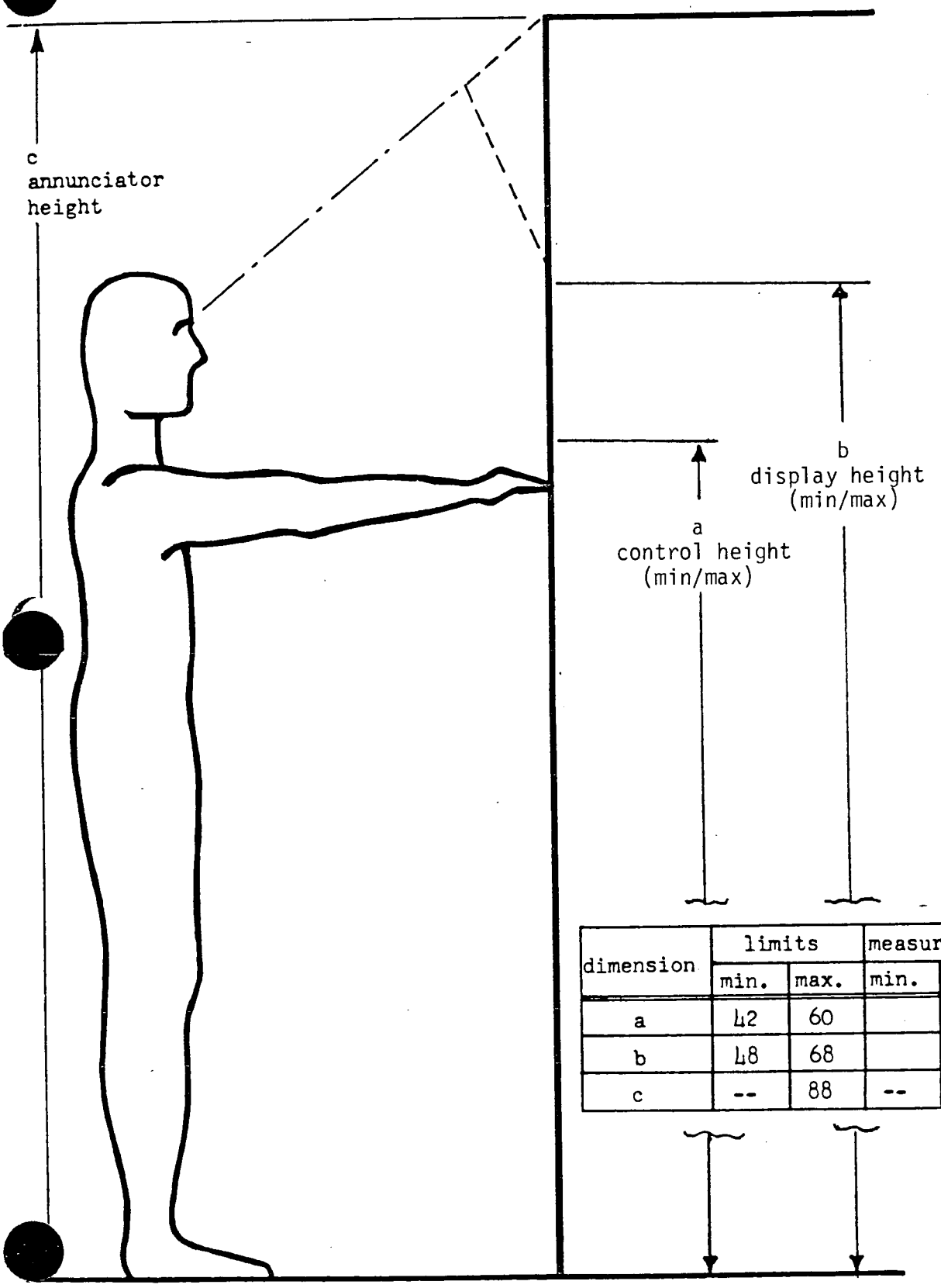
A2 Are lines of demarcation, mimics or other graphic displays:

A2.1	used to distinguish between commonly shared systems or components in control rooms	4 3 2 1 0	x 2 = ____
A2.2	used to enclose related displays	4 3 2 1 0	x 3 = ____

A PANEL LAYOUT and DESIGN (Continued)

(A1.1) Anthropometric Diagram

VERTICAL PANEL MEASUREMENT
PANEL _____

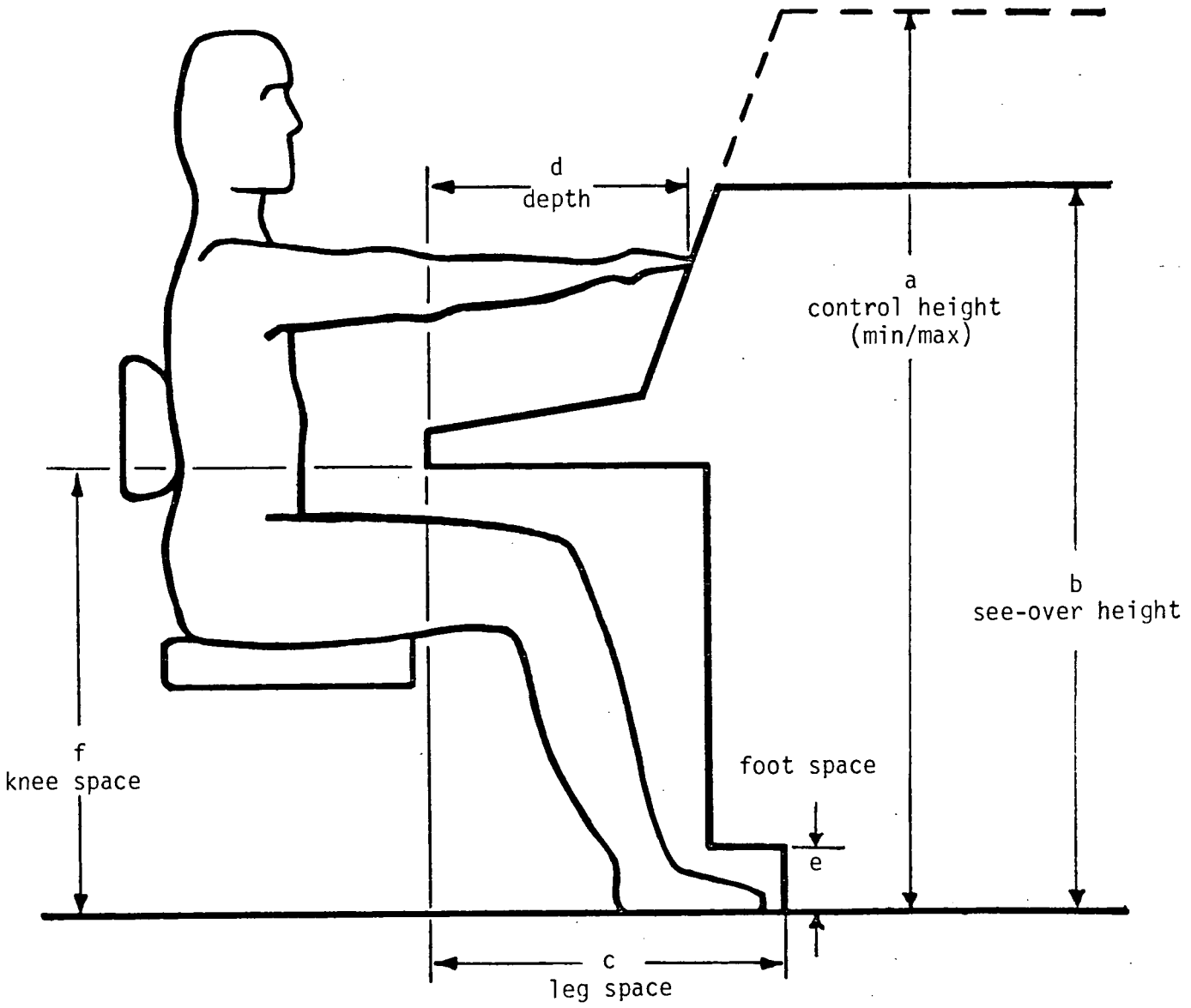


dimension	limits		measurement		comments
	min.	max.	min.	max.	
a	42	60			
b	48	68			
c	--	88	--		

A PANEL LAYOUT and DESIGN (Continued)

(A1.1) Anthropometric Diagram

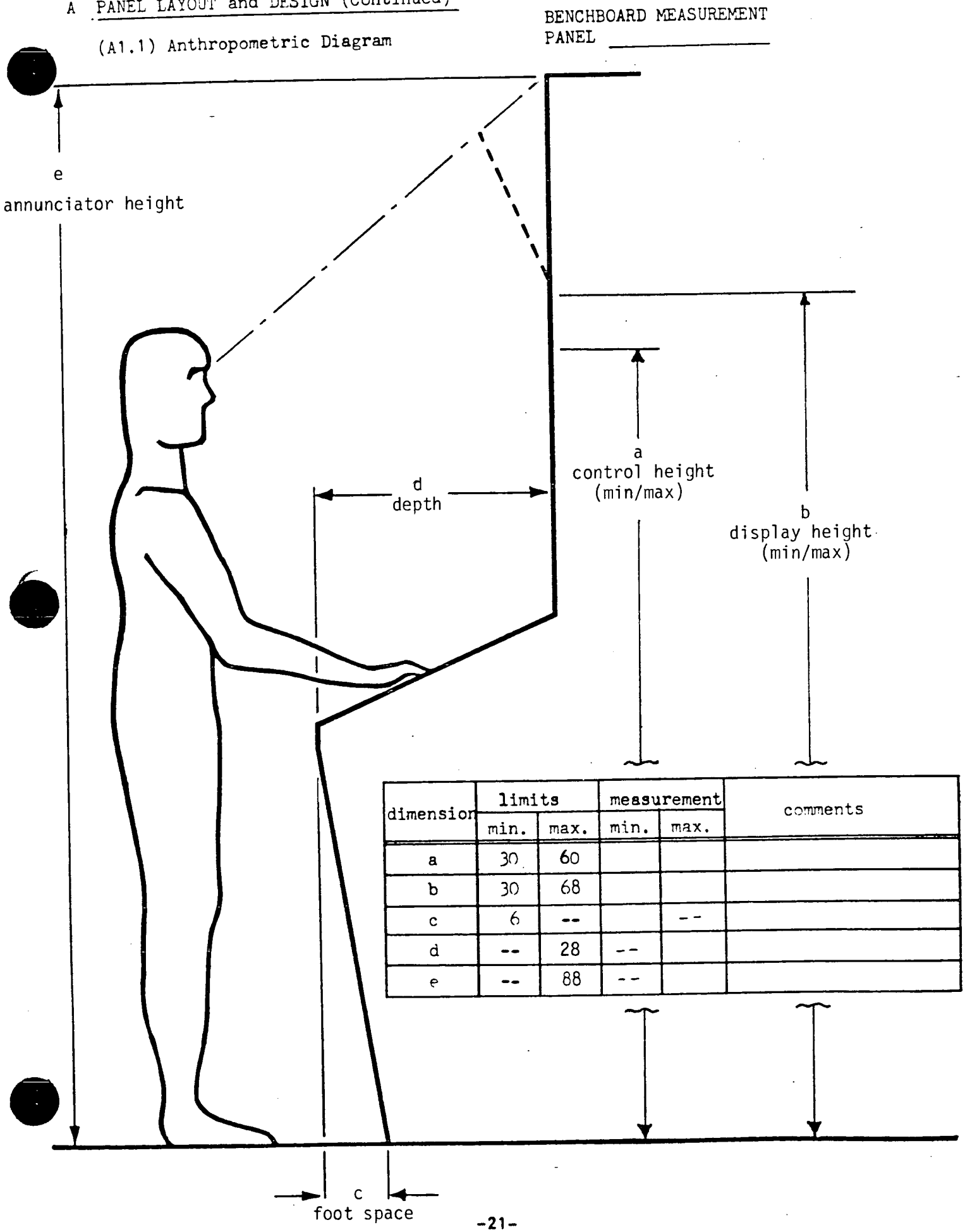
CONSOLE/DESK MEASUREMENT
PANEL _____



dimension	limits		measurement		comments
	min.	max.	min.	max.	
a	25	54			
b	--	42	--		
c	24	--		--	
d	--	25	--		
e	4	--		--	
f	25	--		--	

A PANEL LAYOUT and DESIGN (Continued)

(A1.1) Anthropometric Diagram



dimension	limits		measurement		comments
	min.	max.	min.	max.	
a	30	60			
b	30	68			
c	6	--		--	
d	--	28	--		
e	--	88	--		

PANEL LAYOUT and DESIGN (Continued)

Panel _____

A2.3	used to separate similar functions within system or component groupings	4 3 2 1 0 x 2 =	
A2.4	used for divisional identification	4 3 2 1 0 x 2 =	
A2.5	used to distinguish between primary and secondary flow paths	4 3 2 1 0 x 2 =	
A2.6	visually distinctive between each other and panel/background	4 3 2 1 0 x 2 =	
A2.7	permanent and maintained	4 3 2 1 0 x 2 =	
A2.8	laid-out so that flow paths and arrangements are orderly and easily recognized	4 3 2 1 0 x 3 =	

Panel _____

PANEL LAYOUT and DESIGN (Continued)

A2.9	identical in lay-out for repetitive groupings of components	4 3 2 1 0 x 3 =	
A2.10	clearly marked with arrows to show direction of "flow"	4 3 2 1 0 x 2 =	
A2.11	identified with starting and end points	4 3 2 1 0 x 2 =	
A2.12	used to integrate switches, pumps, manual and remotely-operated valves, isolation paths, etc.	4 3 2 1 0 x 2 =	
A2.13	consistent in the application of symbols for pumps, valves and other process elements (describe on Comment Form and attach)?	4 3 2 1 0 x 2 =	

A3 For controls and displays:

A3.1	are they generally grouped by system (with identical lay-out for repetitive groups)	4 3 2 1 0 x 3 =	

Panel _____

PANEL LAYOUT and DESIGN (Continued)

A3.2	is grouping for components of similar function consistently from left-to-right or top-to-bottom	4 3 2 1 0	x ~~2~~ 3 =
A3.3	arranged in functional or sequential relationships	4 3 2 1 0	x ~~2~~ 3 =
A3.4	when strings (6 or more) or matrices (greater than 4x4) of components of similar or common function are installed, are they visually distinguishable by lines-of-demarcation, hierarchical labeling, color contrast, spacing, shape, etc.	4 3 2 1 0	x ~~2~~ 3 =
A3.5	are coding methods consistently applied (list on Comment Form and attach)	4 3 2 1 0	x 3 =
A3.6	are they generally located in zone "a" or "b" on the anthropometric diagram (see A1.1)	4 3 2 1 0	x 3 =
A3.7	are control components located within an arms reach of feedback indications?	4 3 2 1 0	x 3 =

Panel _____

PANEL LAYOUT and DESIGN (Continued)

A4 For color use:

*A4.1	is there a plant standard (complete attached list)	4 3 2 1 0 x 3 =	
A4.2	is selected use of colors consistently applied for alarm prioritization, indicating lights, labels, lines-of-demarcation, legend plates, graphic displays, indicating devices, tags, etc.	4 3 2 1 0 x 3 =	
A4.3	when there is a possible dual meaning for colors, is there an additional indication for visual distinction?	4 3 2 1 0 x 3 =	

A5 Are labels, legend plates and escutcheons:

A5.1	used to identify component function	4 3 2 1 0 x 3 =	
*A5.2	used to identify operational limits or warnings	4 3 2 1 0 x 3 =	

A PANEL LAYOUT and DESIGN (Continued)

(A4.1) To evaluate the consistency of the application of color standards in the control room, complete the following for each meaning:

Color	Meaning
_____	Valve Open
_____	Valve Closed
_____	Breaker Open
_____	Breaker Closed
_____	Mid or Transitional Position
_____	On or Operating
_____	Off or Not Operating
_____	Start
_____	Stop
_____	Danger or Warning
_____	Caution, Trouble or Pre-Trip
_____	Trip or Failure
_____	Automatic Operation or Control
_____	Manual Operation or Control
_____	Limit Condition
_____	General Status
_____	Hot
_____	Cold
_____	Other (specify)_____ _____
	CRTs
_____	Alpha-Numeric Identification
_____	Process Variable (in limits)
_____	Process Variable (out of limits)
_____	Process Diagram lines and Symbols
_____	Reference or Scale Markings
_____	Other (specify) _____ _____

Panel _____

PANEL LAYOUT and DESIGN (Continued)

A5.3	used to identify system and component designation	4 3 2 1 0 x 2 =	
A5.4	used to identify panel by number and function	4 3 2 1 0 x 2 =	
A5.5	consistent in nomenclature, use of acronyms, abbreviations, etc. (list on Comment Form and attach)	4 3 2 1 0 x 2 =	
A5.6	consistent in type style and the application of type size (ie, larger letters in headings, all letters same height, etc.)	4 3 2 1 0 x 2 =	
A5.7	size coded in a hierarchical system for components, components and displays	4 3 2 1 0 x 2 =	
A5.8	visually distinctive (light letters on dark background or dark letters on light background)	4 3 2 1 0 x 2 =	

Panel _____

PANEL LAYOUT and DESIGN (Continued)

A5.9	easily read when stationed at the panel (see A1.1)	4 3 2 1 0	x 3	=
*A5.10	succinctly worded and accurate with respect to function or input signal	4 3 2 1 0	x 3	=
A5.11	consistently positioned above or below devices and readily associated with corresponding controls and displays	4 3 2 1 0	x 3	=
A5.12	permanent but replaceable	4 3 2 1 0	x 2	=
A5.13	conspicuous and visually distinctive from the panel background	4 3 2 1 0	x 3	=
A5.14	oriented to read from left-to-right?	4 3 2 1 0	x 2	=

Panel _____

PANEL LAYOUT and DESIGN (Continued)

A6 When temporary changes or modifications are made, are they:

A6.1	minimized	4 3 2 1 0	x 2	= ____
*A6.2	controlled in application (for information or status, corrective or cautionary purpose only)	4 3 2 1 0	x 2	= ____
*A6.3	consistent and controlled in nomenclature, font and color	4 3 2 1 0	x 2	= ____
*A6.4	accurate with respect to use or design intent	4 3 2 1 0	x 3	= ____
*A6.5	incorporated into procedures (if informative, cautionary or corrective)	4 3 2 1 0	x 3	= ____
A6.6	applied to not obscure adjacent or background information or colors	4 3 2 1 0	x 2	= ____

Panel _____

PANEL LAYOUT and DESIGN (Continued)

*A6.7 reviewed periodically and made permanent or removed? 4 3 2 1 0 x 2 = ____

A7 From the operator's primary control area:

A7.1 is the path to the control panel unobstructed 4 3 2 1 0 x 3 = ____

A7.2 are control surfaces visible 4 3 2 1 0 x 3 = ____

A7.3 are communication systems accessible 4 3 2 1 0 x 3 = ____

A7.4 are annunciator windows visible and identifiable

II CONTROL ROOM REVIEW

Panel _____

A INSTRUMENTATION and HARDWARE

B1 Are controllers that require manual operation:

B1.1	easily reached (see A3.6)	4 3 2 1 0 x 3 =	
*B1.2	designed to facilitate precise control where fine adjustments are required	4 3 2 1 0 x 2 =	
B1.3	marked to clearly show manual or automatic mode	4 3 2 1 0 x 2 =	
*B1.4	provided with mechanical stops at the beginning and end of travel	4 3 2 1 0 x 1 =	
B1.5	provided with space for hand support?	4 3 2 1 0 x 1 =	

B2 Are indicating devices:

B2.1	marked to show normal or abnormal, safe or unsafe, or expected or unexpected range of operation where applicable	4 3 2 1 0 x 3 =	

Panel _____

INSTRUMENTATION and HARDWARE (Continued)

B2.2	free from glare and parallax when stationed at the panel (see A1.1)	4 3 2 1 0	x 3	= ____
*B2.3	scaled in process units that relate to system operation	4 3 2 1 0	x 3	= ____
B2.4	provided with visual contrast or distinctiveness between scale graduations, process units, numerals, background and pointer	4 3 2 1 0	x 2	= ____
B2.5	designed so that pointers do not obscure graduation marks, numerals or process units	4 3 2 1 0	x 2	= ____
B2.6	designed so that pointers move from bottom-to-top, left-to-right or clockwise, depending on the display design and orientation	4 3 2 1 0	x 2	= ____
*B2.7	designed so that indicator direction follows control movement	4 3 2 1 0	x 2	= ____

Panel _____

B INSTRUMENTATION and HARDWARE (Continued)

*B2.8	easily correlated with backup indications, especially those instruments with elevated zeros	4 3 2 1 0	x 2 = ____
B2.9	aligned between pointer or moveable indicator and scale without need for visual extrapolation	4 3 2 1 0	x 2 = ____
B2.10	visually aligned and provided with identical scales to facilitate comparative reading in groups of similar displays	4 3 2 1 0	x 2 = ____
*B2.11	marked with subdivisions that are consistent with the accuracy needed by the operator	4 3 2 1 0	x 2 = ____
B2.12	scaled with a maximum of nine intermediate graduations between numbered markings	4 3 2 1 0	x 2 = ____
B2.13	scaled with subdivisions in decimal multiples of 1, 2 or 5	4 3 2 1 0	x 1 = ____

Panel _____

B INSTRUMENTATION and HARDWARE (Continued)

B2.14 marked or color coded to provide visual distinctiveness between the case, panel or similiar components	4	3	2	1	0	x	1	=	____
B2.15 marked with numerals oriented in an upright position	4	3	2	1	0	x	1	=	____
*B2.16 maintained, calibrated and surveillance tested on a regular basis	4	3	2	1	0	x	3	=	____
*B2.1 designed so that a failure mode is evident and in a safe direction	4	3	2	1	0	x	3	=	____
B2.18 marked or color coded to differentiate between scales on multiple range meters?	4	3	2	1	0	x	2	=	____

B3 For recorder charts:

B3.1 are printed values easily read and distinguishable	4	3	2	1	0	x	3	=	____

Panel _____

INSTRUMENTATION and HARDWARE (Continued)

B3.2	are printing devices properly aligned such that printed value corresponds to scale value	4 3 2 1 0	x 3	=
B3.3	is alarm point identified and does it correspond to scale value	4 3 2 1 0	x 3	=
B3.4	is there adequate distinction for markings on multi-pen recorders	4 3 2 1 0	x 3	=
*B3.5	where fast tracking rates or trends are periodically required, is there Hi/Lo speed capability and do administrative procedures require chart notation	4 3 2 1 0	x 2	=
B3.6	is point select capability available on multi-point recorders	4 3 2 1 0	x 2	=
B3.7	is recorder clearly marked indicating proper type and size of chart paper	4 3 2 1 0	x 1	=

Panel _____

B INSTRUMENTATION and HARDWARE (Continued)

*B3.8	is paper replaceable without physically disconnecting wiring or linkage	4 3 2 1 0 x 1 =	
*B3.9	can the ink supply be maintained without disconnecting wiring or linkage	4 3 2 1 0 x 1 =	
B3.10	are pen colors consistent from one recorder to another and/or is the color association unambiguous and clearly displayed	4 3 2 1 0 x 2 =	
*B3.11	does chart paper not bind, eliminating frequent manual corrections	4 3 2 1 0 x 2 =	
*B3.12	are charts marked periodically (at least once per shift) with date, time and initials to aid in data recovery	4 3 2 1 0 x 2 =	
*B3.13	has administrative procedure been established for chart marking and used chart/record retention	4 3 2 1 0 x 2 =	

Panel _____

B INSTRUMENTATION and HARDWARE (Continued)

B3.14 are they free from glare and parallax when stationed at the panel (see A1.1) — 4 3 2 1 0 x 3 = ____

B3.15 marked to show normal or abnormal, safe or unsafe, or expected or unexpected or unexpected range of operation? — 4 3 2 1 0 x 3 = ____

B4 For indicating lights:

B4.1 does intensity provide adequate visual distinction between lit and extinguished lights — 4 3 2 1 0 x 3 = ____

*B4.2 does the use of lit indicating lights consistently indicate a positive state or positive response (an unlighted condition only indicates "power off") — 4 3 2 1 0 x 3 = ____

B4.3 is the size and intensity of alarm lights adequate to command attention — 4 3 2 1 0 x 3 = ____

*B4.4 is there a positive means of diagnosing failed indicating lights — 4 3 2 1 0 x 2 = ____

Panel _____

INSTRUMENTATION and HARDWARE (Continued)

*B4.5	is bulb replacement easily and safely performed	4 3 2 1 0	x 2	= ____
B4.6	are sets of lights in alignment to facilitate comparison between related system elements	4 3 2 1 0	x 2	= ____
*B4.7	is direct indication used in preference to implied indication that a function has been performed	4 3 2 1 0	x 3	= ____
*B4.8	when direct indication is not practical, is there backup instrumentation to indicate that a function has occurred?	4 3 2 1 0	x 3	= ____

B5 For switches:

B5.1	do handles move consistently in the same direction in accordance with expectations (i.e., right for on or start; left for off or stop; center for tripped, standby, or normal; pull-to-lock, etc)	4 3 2 1 0	x 3	= ____
B5.2	is each position clearly marked	4 3 2 1 0	x 3	= ____

Panel _____

B INSTRUMENTATION and HARDWARE (Continued)

B5.3	is each reachable at a normal operating distance	4 3 2 1 0	x 3	= ____
B5.4	are handles that are located near the edge of the control panels protected with a guard to prevent inadvertent operation	4 3 2 1 0	x 3	= ____
*B5.5	do handles require normal hand pressure to operate (i.e. no thumb-busters)	4 3 2 1 0	x 3	= ____
B5.6	are handles durable and of adequate size	4 3 2 1 0	x 2	= ____
*B5.7	is switching action responsive and precise	4 3 2 1 0	x 2	= ____
B5.8	when operated, are displays, indicator lights and flags that are functionally associated free from visual obstruction by hand or arm	4 3 2 1 0	x 2	= ____

Panel _____

INSTRUMENTATION and HARDWARE (Continued)

B5.9 is there adequate hand space between them 4 3 2 1 0 x 2 = ____

B5.10 are they physically or functionally distinguishable between pumps, valves, indicating lights, divisional separation, power source, etc. 4 3 2 1 0 x 2 = ____

B5.11 are handles or knobs shaped so as to clearly indicate position without obstruction of legends or confusion of direction? 4 3 2 1 0 x 2 = ____

Are switches for emergency or abnormal use (such as turbine trip, scram, emergency trip, etc.):

B6.1 clearly marked 4 3 2 1 0 x 3 = ____

B6.2 protected from inadvertent operation 4 3 2 1 0 x 3 = ____

B6.3 readily accessible 4 3 2 1 0 x 3 = ____

Panel _____

B INSTRUMENTATION and HARDWARE (Continued)

*B6.4	controlled by specific procedural instructions?	4 3 2 1 0	x 3	=
B7	Where key-lock switches are used:			
*B7.1	does normal operation or immediate action not require use of keys in key-lock switches	4 3 2 1 0	x 3	=
B7.2	are keys conveniently located and immediately available	4 3 2 1 0	x 3	=
B7.3	are keys clearly identified for specific use	4 3 2 1 0	x 3	=
*B7.4	is key use administratively controlled	4 3 2 1 0	x 3	=
*B7.5	do procedures provide specific instructions for use	4 3 2 1 0	x 3	=
*B7.6	is switch action smooth and positive without use of excessive force?	4 3 2 1 0	x 3	=

III CONTROL ROOM REVIEW

Panel _____

ANNUNCIATORS

C1 Are annunciators grouped:

C1.1	within annunciator box by specific systems	4 3 2 1 0 x 2 =	
C1.2	above related controls and displays	4 3 2 1 0 x 2 =	
C1.3	such that warning and diagnostic alarms are segregated from informational and advisory displays?	4 3 2 1 0 x 2 =	

Does alarm window:

C2.1	meet checklist criteria for labels, legend plates and escutcheons (see A5)	4 3 2 1 0 x 2 =	
C2.2	meet checklist criteria for changes or modifications as established for labels, legend plates and escutcheons (see A6)	4 3 2 1 0 x 2 =	
C2.3	accurately describe intent of input signal per design	4 3 2 1 0 x 3 =	

III CONTROL ROOM REVIEW

Panel _____

ANNUNCIATORS

C2.4	Provide setpoints for parameters with multiple trip levels (water level, vacuum, containment pressure etc.)	4 3 2 1 0 x 2 =	
C2.5	not use multiple choice indication (high/low level/pressure)	4 3 2 1 0 x 3 =	
C2.6	prioritize alarm for required response level by legend plate color (preferred) or bulb color in accordance with color use standards (see A4.1)	4 3 2 1 0 x 3 =	
C2.7	have an alpha-numeric code in addition to legends for positive and prompt response procedure identification	4 3 2 1 0 x 2 =	
C2.8	meet checklist criteria for indicating lights (see B4)?	4 3 2 1 0 x 3 =	
C3	Does the audible feature meet checklist criteria for audible displays (see F2)?	4 3 2 1 0 x 2 =	

Panel _____

ANNUNCIATORS (Continued)

C4 For alarm response, are the following provided:

C4.1 audible-silence button 4 3 2 1 0 x 3 = ____

C4.2 visual acknowledge button 4 3 2 1 0 x 3 = ____

C4.3 visual reset button 4 3 2 1 0 x 2 = ____

C4.4 visual and audible test feature 4 3 2 1 0 x 3 = ____

C4.5 silence and reset buttons of consistent size, shape, color, sequence and location between panels 4 3 2 1 0 x 2 = ____

C4.6 a "first-out" feature or dual reset for information retrieval for high priority alarms? 4 3 2 1 0 x 2 = ____

Panel _____

ANNUNCIATORS (Continued)

C5 For visual annunciation, will each window:

C5.1 flash for initial alarm input — 4 3 2 1 0 x 3 = ____

C5.2 remain in alarm state (solid light) when acknowledged but alarm input has not cleared — 4 3 2 1 0 x 3 = ____

C5.3 reflash for second alarm input — 4 3 2 1 0 x 3 = ____

C5.4 automatically blink (at slower rate) when alarm input clears — 4 3 2 1 0 x 2 = ____

C5.5 clear only on operator action? — 4 3 2 1 0 x 2 = ____

*C6 Do annunciator response procedures meet procedure checklist criteria for:

C6.1 format (see E3) — 4 3 2 1 0 x 3 = ____

Panel _____

ANNUNCIATORS (Continued)

C6.2 content (see E4) 4 3 2 1 0 x 3 = ____

C6.3 reference material (see E5)? 4 3 2 1 0 x 3 = ____

*C7 For annunciator maintenance:

C7.1 if bulb replacement requires legend plate removal, is there a method to assure plate replacement in correct location 4 3 2 1 0 x 3 = ____

C7.2 has an administrative procedure been implemented to allow prompt recognition of an out-of-service annunciator 4 3 2 1 0 x 3 = ____

C7.3 are annunciators periodically tested? 4 3 2 1 0 x 3 = ____

C8 Are only meaningful alarms present during a given operating state (list on Comment Form)? 4 3 2 1 0 x 3 = ____

COMPUTERS

D1 Are the computer console and output devices:

D1.1 conveniently located and readily available for operator use — 4 3 2 1 0 x 2 = ____

D1.2 generally laid-out per standards of the anthropometric diagrams (see A1.1) — 4 3 2 1 0 x 2 = ____

D1.3 arranged for visual distinction and use of dials, buttons and switches? — 4 3 2 1 0 x 2 = ____

*D2 Is the computer:

D2.1 capable of displaying selected input information — 4 3 2 1 0 x 2 = ____

D2.2 equipped with display change capability — 4 3 2 1 0 x 2 = ____

D2.3 available for on-demand use by the control room operator — 4 3 2 1 0 x 2 = ____

COMPUTERS (Continued)

D2.4	capable of receiving all inputs and performing programmed functions without becoming overloaded	4 3 2 1 0	x 2	=
D2.5	available after power transients or accident conditions	4 3 2 1 0	x 2	=
D2.6	capable of use in post-transient evaluation	4 3 2 1 0	x 1	=
D2.7	capable of automatic or manual switchover for processor failure ("failover")?	4 3 2 1 0	x 1	=

D3 Are CRT displays:

D3.1	accessible and easily visible when stationed at the controls	4 3 2 1 0	x 2	=
D3.2	comprehensible with a minimum of visual search	4 3 2 1 0	x 2	=

COMPUTERS (Continued)

D3.3	of adequate brightness for lighting conditions or equipped with conviently located focus, brightness, and/or contrast controls	4 3 2 1 0	x 2 =	____
D3.4	consistent with color standards (see A4.1)	4 3 2 1 0	x 2 =	____
*D3.5	color coded so that loss of a primary color gun does not result in loss of a numerical value or scale	4 3 2 1 0	x 2 =	____
D3.6	consistent with checklist standards for procedural format (see E3)	4 3 2 1 0	x 2 =	____
D3.7	identified by system or program	4 3 2 1 0	x 2 =	____
D3.8	provided with an access mode for display selection (either display menu or sectoring mode)	4 3 2 1 0	x 2 =	____

COMPUTERS (Continued)

D3.9	provided with verification that the computer is operational and that data is being updated on a periodic basis?	4 3 2 1 0 x 2 =	

D4 For the typer/printer:

*D4.1	is output prioritized	4 3 2 1 0 x 2 =	
*D4.2	is output periodically reviewed and updated so that only useful information is printed	4 3 2 1 0 x 2 =	
*D4.3	is capacity sufficient (output not overloaded)	4 3 2 1 0 x 2 =	
D4.4	is the output identified by time, date, component and system	4 3 2 1 0 x 2 =	
*D4.5	is a backup available	4 3 2 1 0 x 2 =	

D COMPUTERS (Continued)

D4.6	is it silenced to not be a noise distraction	4 3 2 1 0	x 1	=
*D4.7	are paper and ribbon easily replaced	4 3 2 1 0	x 1	=
D4.8	are printout easily readable (spacing, headings, formats, print, etc.)?	4 3 2 1 0	x 2	=

E PROCEDURES

E1 Does the control room operator have available:

E1.1	a full set of up-to-date plant procedures	4 3 2 1 0 x 3 =	
E1.2	a full set of up-to-date emergency, abnormal and normal procedures for each unit on multi-unit plants with a common control room	4 3 2 1 0 x 3 =	
E1.3	a complete set of up-to-date, as-built flow diagrams and schematics	4 3 2 1 0 x 3 =	
E1.4	a set of up-to-date Technical Specifications	4 3 2 1 0 x 3 =	
E1.5	storage space for procedures and reference materials	4 3 2 1 0 x 3 =	
*E1.6	procedural instructions for the operation of both manual and automatic controllers	4 3 2 1 0 x 3 =	

E PROCEDURES (Continued)

E1.7 lay down space for use of procedures and reference materials? 4 3 2 1 0 x 2 = ____

E2 For immediate access and recognition:

E2.1 are procedures readily available and centrally located 4 3 2 1 0 x 3 = ____

E2.2 is each procedure binder or folder clearly marked 4 3 2 1 0 x 2 = ____

E2.3 does each procedure binder or folder have an index or table of contents 4 3 2 1 0 x 3 = ____

E2.4 are emergency procedures in a separate binder or folder 4 3 2 1 0 x 3 = ____

E2.5 are annunciator response procedures in a separate binder or folder 4 3 2 1 0 x 2 = ____

E PROCEDURES (Continued)

E2.6 are individual procedures readily located (i.e., through use of index tabs or alpha-numeric code)? 4 3 2 1 0 x 3 = ____

*E3 Has an administrative procedure been implemented to assure standardization of procedure format for:

E3.1 type size and style 4 3 2 1 0 x 2 = ____

E3.2 use of nomenclature, grammar, terminology, synonyms, acronyms, and abbreviations 4 3 2 1 0 x 2 = ____

E3.3 use of as-labeled designations for components, systems and process units 4 3 2 1 0 x 2 = ____

E3.4 numbering of procedures, paragraphs, steps and sub-steps for increased levels of detail 4 3 2 1 0 x 1 = ____

E3.5 step or paragraph spacing and page layout and identity 4 3 2 1 0 x 1 = ____

E PROCEDURES (Continued)

E3.6	identity of purpose or scope	4	3	2	1	0	x	1	=	____
E3.7	entry and exit conditions	4	3	2	1	0	x	2	=	____
E3.8	cross-referencing	4	3	2	1	0	x	1	=	____
E3.9	rapid identification and recognition of revisions or changes?	4	3	2	1	0	x	2	=	____

E4 Do procedures that require operator action:

E4.1	have succinct action verbs	4	3	2	1	0	x	2	=	____
E4.2	have succinct action statements	4	3	2	1	0	x	2	=	____

PROCEDURES (Continued)

E4.3	separate steps from each other and from cautions, notes, reference material, etc.	4 3 2 1 0	x 2	= ____
*E4.4	provide cautionary statements (that are positioned to relate to the consequences or results of that action)	4 3 2 1 0	x 3	= ____
E4.5	minimize the need for memorization of actions	4 3 2 1 0	x 2	= ____
E4.6	distinguish between required (shall) and optional (should) actions	4 3 2 1 0	x 3	= ____
E4.7	distinguish between automatic and manual actions	4 3 2 1 0	x 3	= ____
E4.8	provide symptomatic or diagnostic analysis or entry event guidance to assure correct procedure is in use	4 3 2 1 0	x 3	= ____

PROCEDURES (Continued)

*E4.9	give required operational sequencing of actions and identify actions which should be performed in parallel	4 3 2 1 0	x 3	= ____
*E4.10	identify critical steps where errors of omission, commission or sequence cannot be tolerated	4 3 2 1 0	x 3	= ____
E4.11	integrate charts, diagrams, and graphs into body of procedure as needed to directly supplement steps	4 3 2 1 0	x 2	= ____
E4.12	provide physical panel locations of referenced instrumentation and hardware, especially those that are infrequently used	4 3 2 1 0	x 3	= ____
E4.13	give normally expected results (such as valve positions, flow rates, currents, alarms indicating lights, etc.) where appropriate	4 3 2 1 0	x 2	= ____
E4.14	give setpoints and sensor identity for annunciator response	4 3 2 1 0	x 3	= ____

PROCEDURES (Continued)

*E4.15	give equipment and administrative limits for operation	4 3 2 1 0	x 2	=
E4.16	give contingency actions or conditional instructions if expected results or actions are not achieved	4 3 2 1 0	x 3	=
E4.17	emphasize the use of multiple or independent indications to provide feedback that an action has occurred in response to a control command	4 3 2 1 0	x 2	=
*E4.18	limit actions to those that are essential and effective	4 3 2 1 0	x 2	=
*E4.19	explicitly contain all essential actions and not require use of reference material for those actions	4 3 2 1 0	x 3	=
E4.20	identify how or when emergency systems or automatic controls may be manually controlled or overridden after automatic initiation	4 3 2 1 0	x 3	=

E PROCEDURES (Continued)

E4.21	identify conditions under which instrumentation may be inaccurate and stress the use of multiple indications	4 3 2 1 0	x 2	=
*E4.22	provide direction for placing and maintaining the plant in cold shutdown	4 3 2 1 0	x 3	=

E5 When reference material is identified in a procedure:

E5.1	is it readily available	4 3 2 1 0	x 3	=
E5.2	is the latest available revision identified	4 3 2 1 0	x 2	=
E5.3	are steps or actions compatible with the procedure from which it is entered	4 3 2 1 0	x 2	=
E5.4	is it standardized or condensed for ease of use?	4 3 2 1 0	x 2	=

PROCEDURES (Continued)

*E6 For revision or corrections to procedures, is there a controlled method:

E6.1	to assure operator review and walkthru to verify correctness, understanding and ability to use	4 3 2 1 0	x 3	=
E6.2	for operator feedback and to clarify intent of changes recommended by operators	4 3 2 1 0	x 2	=
E6.3	for feedback to the operator as to resolution of recommended change	4 3 2 1 0	x 2	=
E6.4	to permit temporary or interim revision by shift personnel to allow deviation from approved procedures	4 3 2 1 0	x 3	=
E6.5	to assure prompt revision (both interim and permanent) to incorporate design changes or operational deviations	4 3 2 1 0	x 3	=
E6.6	to assure prompt review and approval by personnel experienced in operations and engineering or design	4 3 2 1 0	x 2	=

PROCEDURES (Continued)

E6.7	for prompt distribution and updating of controlled sets (especially control room)	4 3 2 1 0 x 3 =	
E6.8	for destruction of superseded controlled copies	4 3 2 1 0 x 3 =	
E6.9	for updating of Index or Table of Contents to show latest available revisions of all procedures	4 3 2 1 0 x 3 =	
E6.10	to evaluate and incorporate changes made by operators on control panels such as scales or process units, cautionary or informative notes, power sources, charts and graphs, etc.?	4 3 2 1 0 x 2 =	

*E7 Has an administrative procedure been established to require:

E7.1	recording of time, date and signature (or initials) on all log book entries	4 3 2 1 0 x 2 =	
E7.2	marking of charts and graphs on a regular basis	4 3 2 1 0 x 2 =	

E PROCEDURES (Continued)

E7.3	recording of both permanent and temporary plant and equipment status change, including maintenance and testing activities	4 3 2 1 0	x 2	=
E7.4	recording of verbal instructions and feedback on execution	4 3 2 1 0	x 2	=
E7.5	recording of cyclic operations or transients	4 3 2 1 0	x 2	=
E7.6	recording of other information useful to other operators or supervisors	4 3 2 1 0	x 2	=
E7.7	reading and initialing of log books by supervisory personnel on a regular basis	4 3 2 1 0	x 2	=
E7.8	retention of log books and recorder charts in permanent plant files for required periods of time?	4 3 2 1 0	x 1	=

F CONTROL ROOM ENVIRONMENT

F1 Are communication systems:

F1.1	redundant, diverse or varied (such as hand-held, sound powered, dedicated to specific panels, radio, bell)	4 3 2 1 0	x 3 = ____
*F1.2	available for emergency or abnormal use (such as a loss of normal power)	4 3 2 1 0	x 3 = ____
F1.3	accessible, unobstructive, and organized	4 3 2 1 0	x 3 = ____
*F1.4	available to the control room operator on a priority basis	4 3 2 1 0	x 3 = ____
*F1.5	capable of accessing all in-plant areas	4 3 2 1 0	x 3 = ____
F1.6	designed to permit hand free operation	4 3 2 1 0	x 2 = ____

CONTROL ROOM ENVIRONMENT (Continued)

F1.7 equipped with channel select 4 3 2 1 0 x 2 = ____

F1.8 physically adjustable for individual users 4 3 2 1 0 x 2 = ____

F1.9 provided for dedicated links to the TSC, EOF and OSC 4 3 2 1 0 x 2 = ____

F1.10 distinctive/color coded 4 3 2 1 0 x 1 = ____

F1.11 clearly understood, intelligible and free from reverberation? 4 3 2 1 0 x 1 = ____

F2 Are audible signals (such as bells, klaxons and sirens):

F2.1 distinguishable for alarm location 4 3 2 1 0 x 2 = ____

F CONTROL ROOM ENVIRONMENT (Continued)

F2.2	prioritized	4 3 2 1 0	x 2	=
*F2.3	tested on a periodic basis	4 3 2 1 0	x 2	=
F2.4	audible in all parts of the control room	4 3 2 1 0	x 2	=
F2.5	not irritating or excessively loud (90 db maximum)	4 3 2 1 0	x 2	=
F2.6	loud enough to be heard during noisy periods (at least 20 db over background)?	4 3 2 1 0	x 3	=

F3 Is lighting:

F3.1	adequate at panel surfaces (30 footcandles minimum, 50 footcandles recommended. Measure at each operating area and record on Control Room Arrangement Diagram)	4 3 2 1 0	x 3	=

CONTROL ROOM ENVIRONMENT (Continued)

F3.2 diffuse or indirect to eliminate glare? 4 3 2 1 0 x 2 = ____

F4 Is control room heating and ventillation:

F4.1 adequate for both operator comfort and equipment performance (normally between 65-75°F and 25-45% relative humidity) 4 3 2 1 0 x 2 = ____

F4.2 diffuse to eliminate areas of stagnation or direct blowing? 4 3 2 1 0 x 1 = ____

F5 In case of fire:

F5.1 is fire-fighting equipment immediately accessible 4 3 2 1 0 x 3 = ____

*F5.2 is there an automatic warning system? 4 3 2 1 0 x 2 = ____

F6 During emergency situations:

*F6.1 is access to the control room procedurally controlled 4 3 2 1 0 x 3 = ____

CONTROL ROOM ENVIRONMENT (Continued)

F6.2	is protective clothing accessible	4 3 2 1 0	x 3	=
F6.3	is breathing apparatus accessible	4 3 2 1 0	x 3	=
F6.4	is portable radiation monitoring equipment accessible	4 3 2 1 0	x 3	=
*F6.5	is special clothing or breathing equipment compatible with required operator functions for visibility, reach, tactile sensitivity, communication, hearing and weight	4 3 2 1 0	x 3	=
F6.6	are sanitary facilities and drinking water accessible	4 3 2 1 0	x 1	=
*F6.7	have provisions been made for handling of telephone communications when operator is occupied	4 3 2 1 0	x 2	=

F CONTROL ROOM ENVIRONMENT (Continued)

*F6.8	are emergency lighting levels adequate (20 footcandles minimum at panel surfaces. Measure at each operating area and document on Control Room Arrangement Diagram.)	4 3 2 1 0	x 3	=

F7 In general:

F7.1	is the noise level routinely below an interference level for normal conversation (65 db maximum. Measure at each operating area and document on Control Room Arrangement Diagram)	4 3 2 1 0	x 3	=
F7.2	have noise distractions from both inside and outside the control room been reduced	4 3 2 1 0	x 2	=
F7.3	is there adequate, organized storage space for protective gear, personal belongings, spare parts, tools, etc.	4 3 2 1 0	x 2	=
*F7.4	are smoking and eating areas controlled	4 3 2 1 0	x 1	=
F7.5	is the control room clean and free of unnecessary loose paper, books and other materials	4 3 2 1 0	x 1	=

CONTROL ROOM ENVIRONMENT (Continued)

F7.6	is the control room free of safety hazards such as loose floor mats, long phone leads, defective furniture, etc.	4 3 2 1 0	x 1 = ____
F7.7	is seating provided at consoles for control room operators adjustible from 15 to 18 inches?	4 3 2 1 0	x 1 = ____

G MAINTENANCE AND SURVEILLANCE

*G1 Are operator maintenance functions and surveillance responsibilities:

G1.1 clearly established 4 3 2 1 0 x 3 = ____

G1.2 adminstratively controlled? 4 3 2 1 0 x 2 = ____

*G2 Are jumpers and lifted leads:

G2.1 procedurally controlled 4 3 2 1 0 x 3 = ____

G2.2 approved and periodically reviewed 4 3 2 1 0 x 3 = ____

G2.3 distinctive or color coded 4 3 2 1 0 x 3 = ____

G2.4 tagged and logged for traceability? 4 3 2 1 0 x 3 = ____

G MAINTENANCE AND SURVEILLANCE

*G3 Are permanent modifications:

G3.1 recorded on as-built drawings to show specific changes — 4 3 2 1 0 x 2 = ____

G5.2 incorporated into operational procedures? — 4 3 2 1 0 x 3 = ____

*G4 Are tags:

G4.1 procedurally controlled — 4 3 2 1 0 x 3 = ____

G4.2 readily available — 4 3 2 1 0 x 2 = ____

G4.3 installed to not obscure components to which they are attached or adjacent components — 4 3 2 1 0 x 3 = ____

G4.4 distinctive for each functional use — 4 3 2 1 0 x 2 = ____

MAINTENANCE AND SURVEILLANCE (Continued)

G4.5	readable	4 3 2 1 0	x 3	=
G4.6	temporary	4 3 2 1 0	x 2	=
G4.7	logged for traceability	4 3 2 1 0	x 2	=
G4.8	periodically reviewed?	4 3 2 1 0	x 2	=

G5 For operational spare parts:

G5.1	is there an adequate supply of fuses, indicating lights, ink and inking pens, recorder charts, computer paper, etc.	4 3 2 1 0	x 2	=
G5.2	are they readily accessible	4 3 2 1 0	x 1	=

MAINTENANCE AND SURVEILLANCE (Continued)

*G5.3	are necessary or special replacement tools available	4 3 2 1 0	x 2	=
G5.4	is adequate storage space available	4 3 2 1 0	x 2	=
G5.5	where different types, sizes, or styles are required, are they clearly and distinctively marked to avoid misapplication	4 3 2 1 0	x 2	=
G5.6	can they be installed without disconnecting linkage or removing component internals?	4 3 2 1 0	x 2	=

*G6 Do maintenance and surveillance procedures require:

G6.1	operability verification when returning any system or component to service	4 3 2 1 0	x 3	=
G6.2	notification of operations personnel both prior to and upon completion of all activities?	4 3 2 1 0	x 3	=

MAINTENANCE AND SURVEILLANCE (Continued)

G6.3	out-of-service components and equipment to be clearly marked at the control station to preclude inadvertent operation and to provide distinction of that condition	4 3 2 1 0	x 3	=
G6.4	use of checklists or status boards to identify out-of-service equipment	4 3 2 1 0	x 3	=
G6.5	use of checklists or status boards for routine activities	4 3 2 1 0	x 2	=
G6.6	prioritization of control room maintenance?	4 3 2 1 0	x 3	=

III CONTROL ROOM REVIEW

H TRAINING AND MANNING

*H1 Does the training/requalification program:

H1.1	use new or revised procedures as they are implemented	4 3 2 1 0	x 3	=
H1.2	identify known limitations of instrumentation displays in the control room	4 3 2 1 0	x 3	=
H1.3	provide for perodic review and walkthru of emergency procedures by operators	4 3 2 1 0	x 3	=
H1.4	include training in the use of the computer and CRT displays?	4 3 2 1 0	x 3	=

*H2 For control room manning, are administrative guidelines established:

H2.1	to limit the number of hours an operator may work in any given period of time	4 3 2 1 0	x 3	=
H2.2	to evaluate the physical and mental condition of on-coming shift operators on a daily basis	4 3 2 1 0	x 3	=

III CONTROL ROOM REVIEW

TRAINING AND MANNING

H2.3	to define specific duties, responsibilities, work locations and authority for all shift members, especially during emergency situations?	4 3 2 1 0	x 3	=

*H3 During shift change:

H3.1	are congestion and potentially disruptive situations averted	4 3 2 1 0	x 2	=
H3.2	are administrative procedures established to require reading of log entries and review of status boards by on-coming shift personnel from time of previous shift coverage	4 3 2 1 0	x 3	=
H3.3	are written instructions and checklists used?	4 3 2 1 0	x 2	=

IV EMERGENCY PROCEDURE WALKTHROUGH

DISCUSSION

The purpose of the Emergency Walkthrough is to evaluate the operational aspects of control room design in terms of control/display relationships, display grouping, control feedback, visual and communication links, manning levels and traffic patterns.

As a minimum, walkthroughs will be conducted for emergency procedures for a small break inside the containment, a stuck open relief valve and a loss of feedwater. Additional procedures for normal or transient conditions may be selected at the discretion of the survey team.

The walkthrough is conducted in the following sequence:

1) Evaluate the selected procedure for conformance to procedure criteria as given in part III E of the Control Room Review checklists. Record the results of this evaluation in part IV A.

2) Develop a scenario for each selected procedure. Include the entry conditions, symptoms, transient trends, equipment failures and end points that the operators must take into consideration when performing the procedure. An experienced SRO should validate the developed scenario.

3) Develop a task analysis for each transient using the selected procedure and scenario. The task analysis should identify the task sequence, critical controls and displays, annunciators and required operator actions to be evaluated during the walkthrough. This task analysis is to be validated by an experienced SRO.

4) Perform a walkthrough of the transient using the procedure and task analysis. This is accomplished by first giving the control room operator the preselected symptoms (entry conditions). The operator must select the correct emergency procedure and complete a step-by-step simulation of that procedure, pointing out each control/display used or referenced and communication links or tasks where assistance is required. As the walkthrough progresses, additional information (contingencies, equipment failures, etc.) is presented to the operators as necessary to reach the predetermined end point. Additional operators may assist the control room operator only if they would normally be expected to be available.

   Traffic patterns, equipment locations and operating areas are recorded on the Control Room Arrangement drawing that most closely depicts the control room being evaluated. Solid, dashed or dotted lines may be used to identify operators by primary responsibility or function. Indicate the locations of desks, chairs, procedures, panels, cabinets, consoles or other pieces of equipment or furniture as near to scale as possible.

DISCUSSION (Continued)

As each task is addressed, determine if adequate information is provided, if sufficient personnel are available to complete the task and whether each critical control and display meets checklist criteria given in part III of the Control Room Survey. Note discrepancies in Column 5 of the Task Analysis as the walkthrough progresses. Notation should also be made of omissions or errors in the procedure or task analysis if identified by the operator during the walkthrough.

5) Summarize deficiencies noted in review of the arrangement drawings and column 5 of the task analysis. List these deficiencies by general category in part IV B of the Control Room Survey, cross referencing to checklist criteria where applicable.

IV EMERGENCY PROCEDURE WALKTHROUGH

TRANSIENT SCENARIO

Procedure Selected _____ SRO Review _____

Include entry conditions, symptoms, transient trends, equipment failures and end points.

IV EMERGENCY PROCEDURE WALKTHROUGH

TASK ANALYSIS INSTRUCTIONS

(1) TASK

The task sequence is developed from the procedure being evaluated and the predetermined scenario. Each required operator action is listed as a separate task with diagnosis considered the first task for emergency procedures. Subtasks are listed in the same column, identified by indentation.

(2) DEVICE/LOCATION

For each task or subtask considered in Column (1), the primary control or display utilized by the operator in accomplishing this task is identified and located.

(3) ASSOCIATED DEVICES/LOCATION

Listed is this column are any devices associated with the primary control or display listed in Column (2). This may include backup instrumentation, indicating lights, alarms, etc.

(4) ASSISTANCE/COMMUNICATIONS

Notation is made in this column if assistance is required by the operator to complete the task or if a communication must be made.

(5) NOTES

Any item found discrepant in the walkthrough will be listed in this column. For each task, columns (1) through (4) are analyzed in terms of the following considerations:

- Is the sequence valid and complete?
- Is sufficient information immediately available to the operator to complete the task?
- Does each critical control and display identified in columns (2) and (3) conform to checklist evaluation criteria?
- Do control/display relationships meet checklist criteria?
- Are shift manning levels adequate to perform the task?
- Are traffic patterns unobstructive?
- Is direct feedback used to verify control functions?

IV EMERGENCY P[illegible]RE WALKTHROUGH

TASK ANALYSIS

PROCEDURE SELECTED_____ SRO REVIEW _____ SHEET _____OF_____

Task (1)	Device/Location (2)	Associated Devices/Location (3)	Assistance/ Communications (4)	Notes (5)

IV EMERGENCY PROCEDURE WALKTHRU

CHECKLIST

Procedure Selected: _____

A Does the emergency procedure selected meet checklist standards for procedure:

A1	standardization and format (see III.E3)	4 3 2 1 0	x 2	= ____
A2	operator action (see III.E4)	4 3 2 1 0	x 3	= ____
A3	use of reference material (see III.E5)?	4 3 2 1 0	x 2	= ____

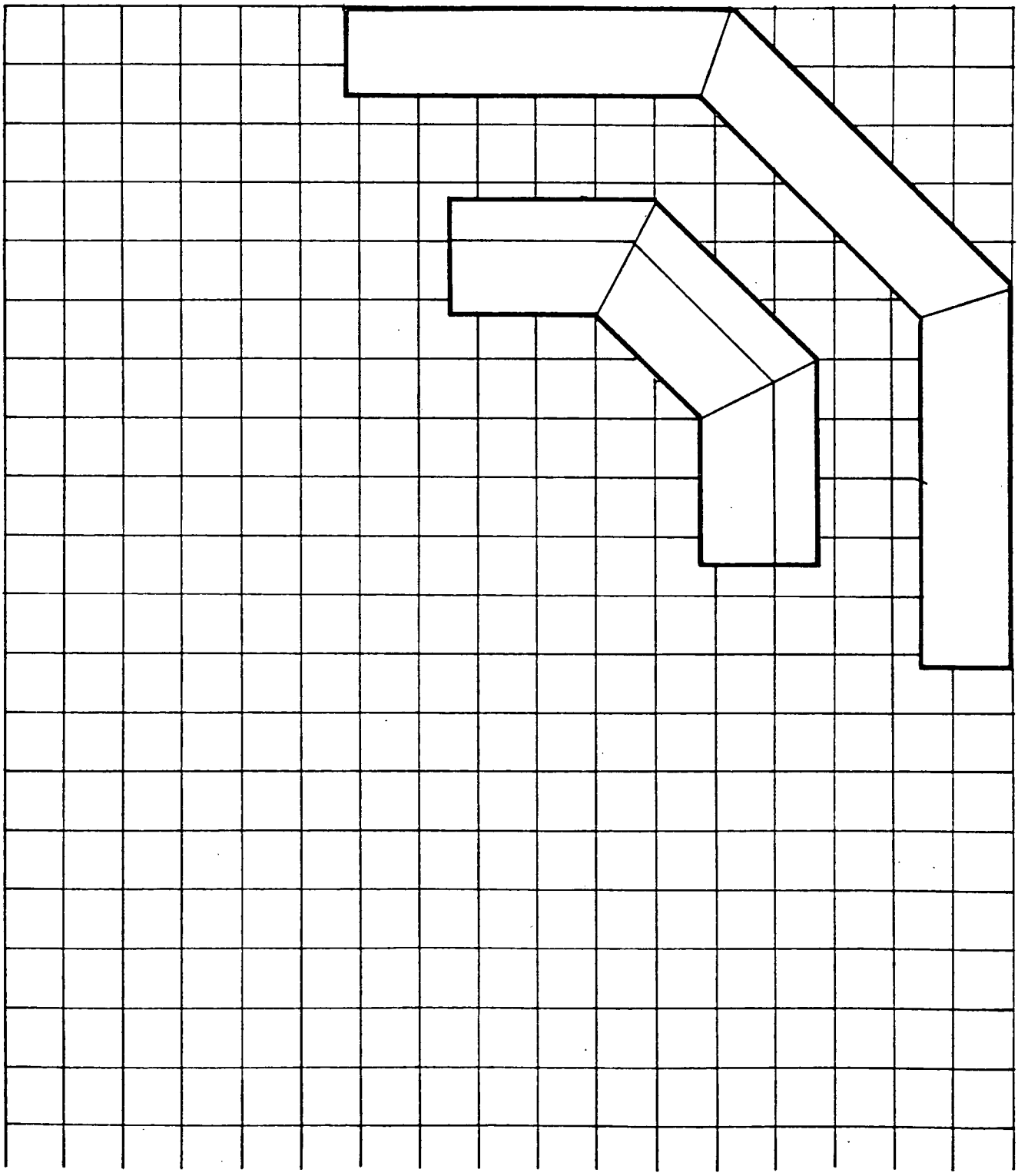
B. Summary:

Area of Concern	Checklist Item(s)

CONTROL ROOM ARRANGEMENT

PLANT/UNIT _____ PROCEDURE _____

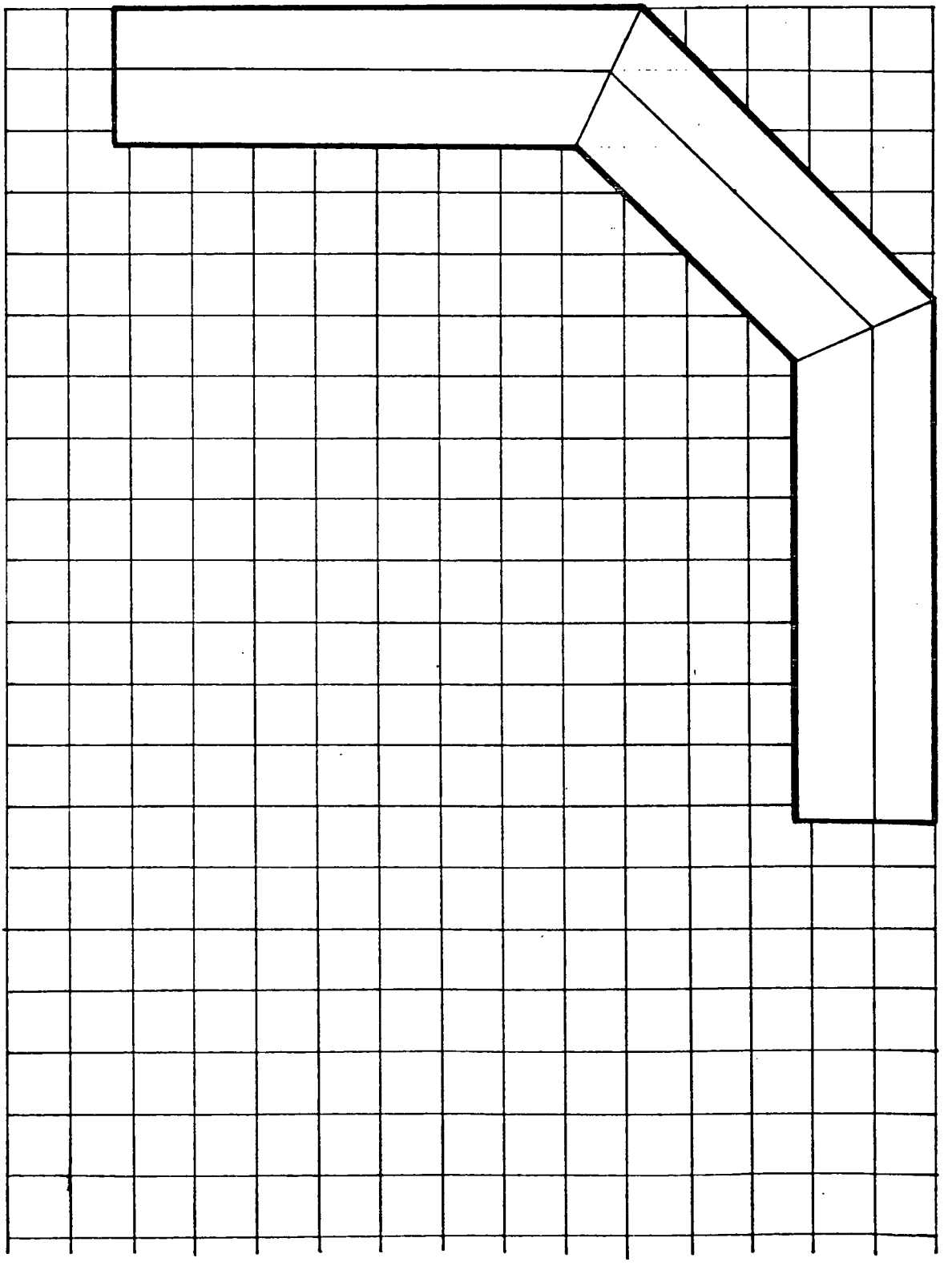
DATE _____ COMMENTS _____



CONTROL ROOM ARRANGEMENT

PLANT/UNIT _____ PROCEDURE _____

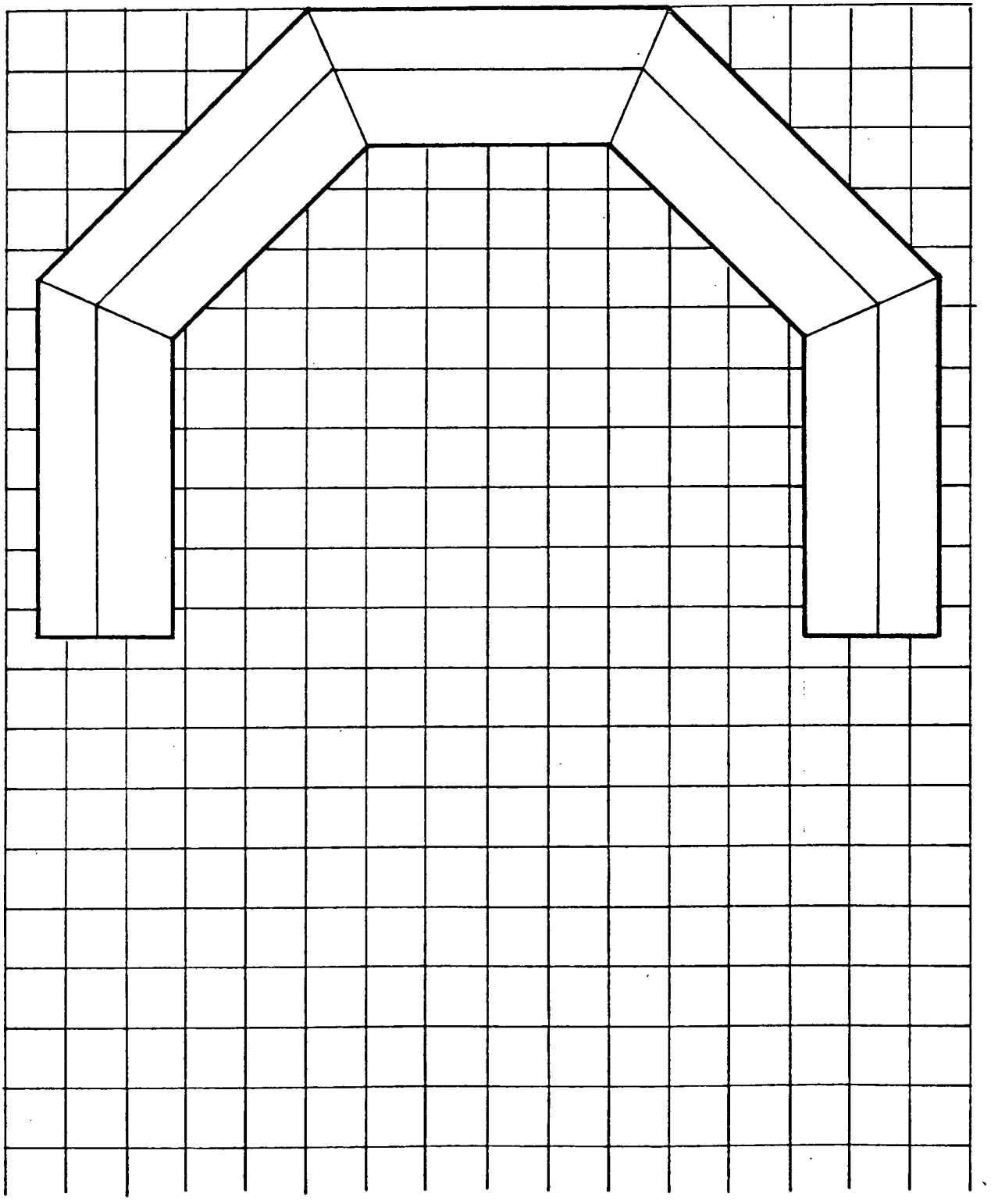
DATE _____ COMMENTS _____



CONTROL ROOM ARRANGEMENT

PLANT/UNIT _____ PROCEDURE _____

DATE _____ COMMENTS _____



CONTROL ROOM SURVEY

PHOTO LOG

Plant/Unit _____

Photo Number	Panel Number	Checklist Item	Notes

APPENDIX

C

Resume of

John H. Gebert

PERSONAL INFORMATION

Born: September 27, 1929
Boone, Iowa

EDUCATION

Associate of Science Degree
Electricial Engineering

Boone Junior College
International Correspondent School

EMPLOYMENT HISTORY

3/49 - 1/57	Estimator and Construction Superintendent, Lippert Brothers Construction Company
1/57 - 8/63	Power Plant Employee, Iowa Electric Light and Power Company
8/63 - 5/69	Production and Substation Superintendent, Iowa Electric and Power Company
5/69 - 5/71	Engineering Department Iowa Electric Light and Power Company
5/71 - 3/74	Electrical and Mechanical Maintenance Supervisor DAEC
3/74 - 9/80	Maintenance Superintendent DAEC
9/80 - Present	Senior Electrical Engineer Iowa Electric Light and Power Company

CONTROL ROOM DESIGN REVIEW

* BWR Owners Group Control Room Survey Workshop, Morris, IL
* Team Leader for BWR Owners Group Control Room Survey at the Duane Arnold Energy Center Nuclear Plant
* Team Leader for BWR Owners Group Control Room Survey at the FERMI-2 Nuclear Power Plant

CONTROL ROOM DESIGN REVIEW (cont.)

* Team Leader for BWR Owners Group Control Room Survey at the Cooper Nuclear Power Plant

* Team Member for BWR Owners Group Control Room Survey at the Hatch Nuclear Power Plant

* Team Member for BWR Owners Group Control Room Survey at the Moticello Nuclear Power Plant

* Committee Member of INPO NUTAC Control Room Design Review Committee

May 31, 1984

RESUME

Name: Kenneth T. Cackoski

Position: Electrical Engineer

Company: Iowa Electric Light and Power Company

Education: BSEE, University of North Dakota, May 11, 1980

Training:

1. Passed Engineer In Training Examination, July 1, 1980.
2. Attended BWR Owner's Group - Control Room Survey Workshop, Tulsa, OK., October 1983.

Work Experience: Four years engineering experience with Iowa Electric. Projects included specifying panel mounted instruments and developing control panel layouts for Iowa Electric's 6th Street Power Station (Fossil Units). Nuclear experience includes detail design work on modifications to safety-related control systems of Iowa Electric's Duane Arnold Energy Center.

DAEC CONTROL ROOM DESIGN REVIEW

PAUL BROWER - Senior Electrical Engineer

Based primarily on pre-WWII experience in amateur radio, Paul Brower was employed in 1942 by the Federal Bureau of Investigation, first as a CW (code) radio operator and later as a Radio Engineer, in the FBI Technical Laboratory in Washington, D.C. He returned to college in 1946 and was graduated from Oregon State University with BSEE in 1948. He spent 18 months on Allis-Chalmers' Graduate Training Program in Milwaukee after which he was assigned to the Transformer Department in the Betatron Engineering Group. From 1950 to 1956 he was employed as a staff member at the Los Alamos National Laboratory, Los Alamos, NM, where he worked on atomic and hydrogen boosted weapons design and associated research apporatus. In 1956 he moved to Cedar Rapids to employment by the Collins Radio Company, first in communications equipment design and later as a group head for automatic test equipment development for avionics devices. In 1972 he was instrumental in founding Spectra Associates, Inc., a Cedar Rapids consulting firm which deals primarily with radio and telephone communications system design. In 1977 he joined Iowa Electric Light and Power Company as a Communications Engineer in the Electrical Engineering Deparment. He was transferred to the Nuclear Generation Division as a design engineer in January 1984.

Over the years each of the above positions have involved, to various degrees, the design, construction, installation or supervision of work related to control room type operations:

1) Layout, and equipment selection and assembly for a radio communications room with 4 operator receive/transmit positions. (FBI)

2) A radiologists operating console for a 22 MV betation (x-ray machine). (Allis-Chalmers)

3) Detailed design and equipment selection for the building, control room and equipment rooms for a high-pressure (30,000 psi) trituim gashandling system and associated cryogenic (liquid nitrogen)/vacuum purification system. The control consoles and instrument panels were all custom made and included a isotope ratio mass spectrometer for hydrogen isotope analysis. (Los Alamos)

4) Various designs of electronic test equipment consoles, packaging of radio communications control consoles for shipboard installation and assembly supervision of a 5-bay, computer operated test station for avionics equipment. (Collins Radio)

5) Layout of microwave repeater stations and selections of buildings, towers and real estate for their installation. (Iowa Electric)

GEORGE THULLEN

OPERATIONS SHIFT SUPERVISOR

June 6, 1984

RECEIVED
JUN 7 1984
I.E.L.P.
Mech/Nuclear
Engineering

EDUCATION:

US Navy Nuclear Power Training
Reactor Operator License Training
Senior Reactor Operator License Training

EXPERIENCE:

1976 to Present

Duane Arnold Energy Center
Three years as a plant operator
Five years as a control room operator

1975 to 1976

Calvert Cliffs (twin 850 mw PWRs)
Auxiliary operator on unit one and start-up
Testing on unit two

1968 to 1975

US Navy
Nuclear trained operator and mechanic
Two years as an instructor on S5G prototype
One and a half years as leading machinery division petty officer on USS Trepang SSN 674

HUMAN FACTORS EXPERIENCE:

DAEC Control room coordinator for paint, tape and label modifications and human factors design changes

Iowa Electric representitive at the detailed control room design review seminar held by Torrey Pines Technology and Boston Edison

RICHARD CRINIGAN

Electrical Engineer

Education:	BA Mathematics - University of Northern Iowa, 1955 BS, Electrical Engineering - Iowa State University, 1960 Registered Professional Engineer (Iowa)
Experience:	Field Engineering - military products Maintainability Engineering - military products Facilities Engineering - food processing and equipment manufacturing plants Design Engineering - products for a crane manufacturer
Iowa Electric Experience:	Development of design guides for the following: Human Factors Considerations for the Control Room, Switch Handle Standards, and Color Code Standards. Also involved in the replacement of turbine supervisory recorders for temperature and vibration.

THOMAS B. SHERIDAN

CONSULTANT - HUMAN FACTORS ENGINEERING

EDUCATION

Massachusetts Institute of Technology - Sc. D. in Systems Engineering and Psychology

University of California - M.S.
Purdue University - B.S.

PROFESSIONAL AFFILIATIONS

Institute of Electrical and Electronics Engineers (IEEE) - Fellow; Former Editor of IEEE; Transactions on Man-Machine Systems; Systems Man and Cybernetics Society - Former President; Committee on Technology Forecasting and Assessment - Former Chairman
Human Factors Society - Fellow

HONORS AND AWARDS

Human Factors Society - Paul M. Fitts Award
Listed in American Men and Women of Science
Listed in Who's Who in the East

EXPERIENCE SUMMARY

For most of his career, Dr. Sheridan has remained at the Massachusetts Institute of Technology where, until recently, he was Professor of Mechanical Engineering and is now Professor of Engineering and Applied Psychology. He heads the Man-Machine Systems Laboratory and has taught a graduate course for many years in man-machine systems, and has taught various control and design courses. He assisted in the development of a new interdepartmental graduate degree program in Technology and Policy and presently is responsible for the core Seminars in Technology and Policy for that program.

Dr. Sheridan has served as visiting faculty member at the University of California, Berkeley; Stanford University; and Technical University of Delft, Netherlands. His research has been on mathematical models of human operatory and socioeconomic systems, on man-computer interaction in supervising robotic systems, and on technology for group decisionmaking.

Dr. Sheridan has served on the Accident Prevention and Injury Control Study Sections of the National Institute of Health, the NASA Life Sciences Advisory Committee, the NSF Automation Research Council, the NASA Study Group on Robotics; the OTA Task Force on Appropriate Technology, and the NSF Advisory Committee on Applied Physical, Mathematical, and Biological Sciences.

His industrial consulting activities have included associations with Stone & Webster Engineering Corporation, as well as the General Motors Corporation (auto safety); General Electric Company (telemanipulators); C.S. Draper Laboratory (design of astronaut interface for Apollo Guidance system, industrial robots); Biodynamics, Incorporated (biomedical and human factors); Public Broadcast Service (TV audience feedback); National Bureau of Standards (industrial robots); Group Dialog Systems, Incorporated (group meeting and decision technology); The Babcock & Wilcox Company (industrial instrumentation); Lockhead and General Physics Corporation and Electric Power Research Institute (man-machine aspects of nuclear reactor safety); and General Public Utilities (human factors in control room design).

PUBLICATIONS

"Understanding Human Error and Aiding Human Diagnostic Behavior in Nuclear Power Plants" in Human Detection and Diagonosis of System Failures, (J. Rasmussen and W.B. Rouse), Proceedings of NATO Symposium, Aug. 4-8, 1980, Plenum Press, 1980.

"Metal Workload, What Is It, Why Bother With It?" Human Factors Society Bulletin, 1980.

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"Human Error in Nuclear Power Plants," Technology Review, pp. 22-23, 1980.

"Selection Measures of Plant Information with Application to Nuclear Reactors," (coauthor T. Kiguchi), IEEE Trans. Systems Man and Cybernetics, 1979.

"Human/Computer Control of Undersea Teleoperators," (coauthors W.L. Verplank and T.L. Brooks), Proceedings of the International Conference on Cybernetics and Society, IEEE 78-CH-1306-o-SMC, pp. 969-978, Tokyo, Japan, 1978.

"A Model for Dynamic Allocation of Human Attention Among Multiple Tasks," (coauthor M.K. Tulga), Proceedings of the International Conference on Cybernetics and Society, pp. 1112-1117, IEEE 78-CH-1306-0-SMC, pp. 1112-1117, Tokyo, Japan, 1978.

"The Changing Role of the Pilot from Manual Controller to Computer Supervisor," Proc. Symp. on Man-System Interface: Advances in Workload Study, Air Line Pilots Assn., pp. 132-143, 1978.

"Design of Control Devices for People with Severe Motor Impairment," (coauthor) R.W. Mann), Human Factors, Vol. 20(3), pp. 321-338, 1978.

"Integrating Technology Assessment Techniques," (coauthor T.E. Burke, et al.), Eighth Annual Pittsburgh Conf. on Modeling and Simulation, 1977.

"Nutrition Slide Show with Audience Participation," (coauthor A. Palgi), Journal of Nutrition Education, Vol. 9, No. 3, pp. 123-126, 1977.

"Supervision of Dynamic Decision Making in Multi-Task Monitoring and Control," (coauthor M.K. Tulga), 13th Annual Conference on Manual Control, M.I.T., 1977.

"Estimation of a Group's Multi-Attribute Utility Function in Real Time by Anonymous Voting," (coauthor A. Sicherman), IEEE Transactions Systems, Man and Cybernetics, Vol. SMC 7, No. 5, 1977.

"Selecting Measures of Plant Information: Some Criteria Based on Information and Decision Theory," (coauthor T. Kiguchi), Proceedings of the International Symposium on Systems, Man and Cybernetics, IEEE/SMC, Washington, D.C., 1976.

"Monitoring Behavior and Supervisory Control," (coeditor G. Johannsen), Plenum Press, 1976.

"Production Control Task Allocation to Man vs. Computer," Proc. Joint Automatic Control Conference, Purdue University, 1976.

"On the Human Supervision of Industrial Robots," Paper A4 in Third Conference on Industrial Robot Technology and 6th International Symposium on Industrial Robots, Univeristy of Nottingham, United Kingdom, 1976.

"On Interfacing Models and Decision Makers," IEEE Proceedings of the International Conference on Cybernetics and Society, San Francisco, 1975.

"Several Roles of Man as a Supervisor of Robots," Proceedings of the 6th Congress International Federation of Automatic Control, M.I.T., Cambridge, Massachusetts, 1975.

"Computer-Aided Group Decision-Making: Theory and Practice," (coauthor W.B. Rouse), Proceedings of the 1974 International Conference on Systems, Man and Cybernetics, IEEE 74-CHO-908-4-SMC, 1974. Also published in Technology Forecasting and Social Change, Vol. 7, pp. 113-126, 1975.

"Technology for Citizen Participation in Planning," NRC Transportation Research Record, 1975.

"Community Dialog Technology," Proceedings of the IEE: Special Issue on Social Systems, Vol. 63, No. 3, pp. 463-474, 1975.

"The Several Roles of Man as a Supervisor of Robots," in Proceedings of the International Conference on Systems, Man and Cybernetics, IEEE 74-CHO-908-4-SMC, pp. 453-457, 1974.

"Man-Machine Systems: Information, Control and Decision Models of Human Performance," (coauthor W.R. Ferrell), M.I.T. Press, 1974.

Man-Machine Systems: Information, Control and Decision Models of Human Performance, (coauthor W.R. Ferrell), M.I.T. Press, Cambridge, Massachusetts, 1974.

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"Vibration Analysis of the Cane," (coauthor T.L. DeFazio), American Foundation for the Blind Research Bulletin, No. 3, New York, 1963.

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"The Human Response Equation," M.I.T. Technology Review, 1962.

"The Human Operator in Control Instrumentation," Chapter in Progress in Control Engineering, (R.E. MacMillan, ed.), Heywood and Co., Ltd., London, 1962.

"Dynamics of Human Operator Control Systems Using Tactile Feedback," (coauthor S. Weissenberger), Journal of Basic Engineering, 1962.

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"Human Operator's Time-Varying Transfer in the Study of Perception and Fatigue," Proceedings of the Symposium on Recent Mechanical Engineers, Institute of Mach. Engrs., London, 1960.

"Experimental Analysis of Time-Variation of the Human Operator's Transfer Function," Proceedings of the First International Congress of the International Federation of Automatic Control (Moscow), Butterworths, London, 1960.

ANTHONY MORSE, JR. I&C CONSULTANT

EDUCATION

Yale University - B. E. in Mechanical Engineering
U.S. Naval Academy - Graduate Courses in Marine and Electrical Engineering

LICENSES AND REGISTRATIONS

Professional Engineer - Massachusetts and Wisconsin

PROFESSIONAL AFFILIATIONS

Human Factors Society - Member
AIF Subcommittee on Control Room and Emergency Response Facilities
American Society of Naval Engineers - Member
Society of Naval Architects & Marine Engineers - Associate Member

EXPERIENCE SUMMARY

Mr. Morse has more than 35 years of experience in the engineering and application of a wide range of power generation equipment and systems.

He has recently completed an assignment as Project Engineer for the Detailed Control Room Design Revew - Planning Phase of Wisconsin Public Service Corporation's Kewaunee Nuclear Power Plant. As the Control Systems Division Licensing Representative, he is also responsible for resolving licensing issues related to instrumentation and control systems.

Since joining Stone & Webster Engineering Corporation (SWEC), he has been in charge of the engineering, design, and application of instruments and control systems associated with SWEC's Reference Nuclear Power Plant Designs and interim spent fuel storage facilities.

Prior to joining SWEC, Mr. Morse had extensive experience in the design and application of fluid and electrical systems at General Dynamics, Quincy Shipbuilding Division, and General Electric Company.

PUBLICATIONS

"Nuclear Power Plant Standardization - Reference Plant Design" with W.J.L. Kennedy and B.G. Schultz, ANS 1976 Annual Meeting.

"Major Considerations in the Development of a Reference Nuclear Power Plant Design" with W.J.L. Kennedy, Nuclear Engineering International, October 1976.

OUTSIDE PARTICIPATION IN HFE ACTIVITIES AND FUNCTIONS

EPRI Nuclear Control Room Enhancements Workshop, Minneapolis, MN

Control Room Design Review Seminar, Technology for Energy Corporation, Knoxville, TN

Periodic Meetings of the AIF Subcommittee on Control Room and Emergency Response Facilities, Bethesda, MD

STONE & WEBSTER ENGINEERING CORPORATION, Boston, Massachusetts

Control Systems Division

Senior Control Engineer, assigned as lead of the human factors engineering group, responsible for all human factors engineering activities, including consulting and support services required by the operation centers. Also assigned as division licensing representative, responsible for establishing company positions on appropriate regulatory guides and generic issues established by the NRC.

Virginia Electric and Power Company North Anna Power Station Unit 3

Participated in the development of a human factors engineering program plan for the design of the North Anna 3 control complex.

Wisconsin Public Service Corporation Kawaunee Nuclear Power Plant

Assigned as project engineer for the preparation of a DCRDR program plan in accordance with NRC guidance given in NUREG-0700 and NUREG-0801.

Wisconsin Electric Power Company Point Basch Nuclear Power Plant Units 1 and 2

Assigned as Assistant Project Engineer on a project to design and install equipment required to comply with various post-TMI NRC requirements.

Stone & Webster PWR Reference Nuclear Power Plant

Assigned as Lead Control Engineer, was responsible for the Engineering and design of instrumentation and controls and control complex for the Stone & Webster Reference Nuclear Power Plant design utilizing four PWR designs; the preparation of the instrumentation and controls section of the Preliminary Safety Analysis Report; and I&C presentations to the NRC and SCRS, leading to preliminary design approvals. Was assigned similar responsibilities associated with the design of an Interim Spent Fuel Storage Facility, and the preparation of a topical report which was approved by the NRC.

Also was assigned as Coordinator for spent fuel disposal studies and for the performance of study contracts performed by the Reference Nuclear Power Plant Project for TVA and UNC - Nuclear Industries, Richland, Washington.

New York State Electric & Gas Corporation
New Haven Units No. 1 & 2 (1,300 MW, PWR)

Assigned as Lead Control Engineer. responsible for the application of the instrumentation and controls portion of the Stone & Webster Reference Nuclear Power Plant design (utilizing Combustion Engineering PWR) to the BYSE&G plant requirements and for the preparation of the appropriate sections of the Preliminary Safety Analysis Report. This assignment was in addition to activities associated with the Stone & Webster Reference Nuclear Power Plant.

Long Island Lighting Company
Jamesport Units 1 & 2 (1,150 MW, PWR)

Assigned as Principal Instrumentation Application and Systems Engineer. In the absence of a Lead Control Engineer, was responsible for engineering, design, preparation of specifications, bid evaluation, and selection of instrumentation and controls.

GENERAL DYNAMICS, QUINCY SHIPBUILDING DIVISION
Needham, Massachussetts

Served as Chief, Marine Control and Instrumentation. Responsible for sale, engineering, manufacturing, and profit and loss of shipboard automated engine room control systems.

GENERAL ELECTRIC COMPANY
Boston, Massachusetts

Assigned as Field Sales and Application Engineer resoponsible for the application and sales of all the company's industrial products to the marine industry and government in New England.

ANTHONY MORSE, JR.

GENERAL ELECTRIC COMPANY
Schenectady, New York

Served as Test Engineer, responsible for the production testing of electrical equipment.

U.S. NAVY

Served as Engineering Officer at sea.

MICHAEL E. WIKLUND HUMAN FACTORS ENGINEER

EDUCATION

Tufts University - M.S. in Engineering Design (ABT)
Tufts University - B.S. in Civil Engineering
Massachusetts Institute of Technology - Graduate Studies in Transportation Engineering
Seminar on Instrumentation and Control Technology - Foxboro Company
Seminars on Project Management and Technical Writing - Transportation System Center

TRAINING

Issues Relating to Speech Input - Output for Computers - Massachusetts Institute of Technology

Human Factors Design Guidelines for Nuclear Power Plants - Electric Power Research Institute

LICENSES AND REGISTRATIONS

Engineer-in-Training - Massachusetts

PROFESSIONAL AFFILIATIONS

Human Factors Society - Associate Member

EXPERIENCE SUMMARY

Mr. Wiklund is a Human Factors Engineer in the Control Systems Division. He has recently completed an assignment as Lead Human Factors Engineer for the Detailed Control Room Design Review (DCRDR) of the Kewaunee Nuclear Power Plant - Planning Phase. The project resulted in a Program Plan for the Review, Assessment and Implementation, and Reporting Phase of the DCRDR.

He is responsible for the application of human factors engineering on diverse projects within SWEC. As a basis for this work, he developed the SWEC engineering standard for human factors engineering.

On the Beaver Valley Power Station Unit 2 project, Mr. Wiklund performed a human factors engineering review of the alternate shutdown facility. The review included identifying human engineering deficiencies in the facility workspace and control panel layouts, and developing necessary design corrections prior to facility construction.

EXPERIENCE SUMMARY (Continued)

Prior to that, he participated in the development of a human factors engineering program for the design of the North Anna Power Station Unit 3 control complex.

While attending graduate school, Mr. Wiklund taught "Introduction to Engineering Design" at Tufts University. For Oak Ridge Associated Universities, Mr. Wiklund developed a human factored conceptual design for an advanced servomanipulator control room used to perform, by remote control, maintenance in nuclear fuel reprocessing plants. With Applied Ergonomics Corporation, Mr. Wiklund participated in consumer product design projects and product liability studies.

Prior to attending graduate school, Mr. Wiklund worked for two years as a civil engineer with the U.S. Department of Transportation. His duties included construction economics studies, hardware assessments, and computer simulations related to rapid transit systems technology development.

DETAILED EXPERIENCE

STONE & WEBSTER ENGINEERING CORPORATION
Boston, Massachusetts

Control Systems Division

Assigned to human factors engineering group responsible for the application of human factors engineering on diverse projects within SWEC. As a basis for this work, he developed the SWEC engineering standard for human factors engineering.

Florida Power Corporation
Cystal River Unit 3

Provided consulting servicxes to Cherry Hill Operations Center for the human factors analysis for the design and installation of inadequate core cooling instrumentation.

Duquesne Light Company
Beaver Valley Power Station Unit 2

Performed a human factors engineering review of the alternate shutdown facility. The review included identifying human engineering deficiencies in the facility workspace and control panel layouts, and development of necessary design corrections prior to facility construction.

Virginia Electric Power Company
North Anna Power Station Unit 3

As Lead Human Factors Engineer, responsible for the development of a program to integrate human factors engineering in the design of an advanced control complex for the North Anna Unit 3 Nuclear Power Plant. Also participated as SWEC's human factors engineering representative on the VEPCO Steering Committee for the design of the plant's control complex.

Wisconsin Public Service Corporation
Kewaunee Nuclear Power Station

As Lead Human Factors Engineer, participated in the development of the technical approach and procedures for the Detailed Control Room Design Review of the Kewaunee Nuclear Power Plant.

Oak Ridge Associated Universities

Participated in the development of a human factored control room used to perform, by remote servo-manipulator control, maintenance of nuclear fuel reprocessing plants. Also, designed test apparatus used for psychophysical scaling of moment of inertia perception by servo-manipulator operators.

APPLIED ERGONOMICS
Medford, Massachusetts

Participated in human factors analyses of children's toys and furniture safety to support product liability law suit. Also participated in the development of a human factored catheter system for improved patient care and reduced costs.

TUFTS UNIVERSITY - COLLEGE OF ENGINEERING
Medford, Massachusetts

Taught "Introduction to Engineering Design," a project-based course primarily covering engineering drawing and the design process.

TRANSPORTATION SYSTEMS CENTER
Cambridge, Massachusetts

Engineer, responsible for construction economics studies, hardware design and assessments, and computer simulations related to rapid transit systems technology development.

PHILIP E. KNOBEL HUMAN FACTORS ENGINEER

EDUCATION

Rensselaer Polytechnic Institute - B.S. in Electrical Engineering

PROFESSIONAL AFFILIATIONS

Human Factors Society - Associate Member
Institute of Electrical and Electronic Engineers - Member

EXPERIENCE SUMMARY

Mr. Knobel is an Engineer in the Electrical Control Group of the Control Systems Division. He recently completed an assignment as Lead Control System Engineer for the Detailed Control Room Design Review - Planning Phase of Wisconsin Public Service Corporation's Kewaunee Nuclear Power Plant.

He was previously assigned to the 888 MWe Beaver Valley Power Station Unit 2 where he was responsible for preparation of the technical and scheduling portions of the response to NRC Generic Letter 82-33. In addition, he was resposible for conducting a plant-wide survey of post-accident monitoring instrumentation, engineering of upgrades identified to meet the requirements of Regulatory Guide 1.97, and preparation of the associated licensing documents. Other duties included desgn of control boards, support of a human factors engineering design review, and activities concerned with TMI Action Plan Items.

Prior to joining SWEC, Mr. Knobel served as an officer in the U.S. Marine Corps. His duties included a field assignment as Maintenance Officer and two years as a Senior Instructor at the U.S. Army Field Artillery School. His responsibilities included designing and implementing several programs of instruction based on task analysis results.

DETAILED EXPERIENCE

STONE & WEBSTER ENGINEERING CORPORATION
Boston, Massachusetts

Control Systems Division - Human Factors Group

As Lead Control Engineer in the Human Factors Engineering Group, responsible for providing HFE consulting services, including program planning and scheduling, conduct of control room surveys, correction design, and project documentation management.

Virginia Electric and Power Company
North Anna Power Station Unit 3

As Lead Control Engineer in the Human Factors Engineering Group, responsible for planning HFE program for North Anna Unit 3. This program included the development of a conceptual control room design, documentation of operator experience, and refinement of the CRT-based control complex using HFE criteria.

Wisconsin Public Service Corporation
Kewaunee Nuclear Power Plant

As Lead Control Engineer for the detailed control room design review (planning phase), responsible for review of control systems design of the control room and main control board and development of survey, document management, assessment, and correction techniques.

Duquesne Light Company
Beaver Valley Power Station - Unit No. 2

As an Engineer in the Electrical Control Group, was responsible for the preparation of elementary diagrams, control board design, and project engineering and scheduling responses to Supplement 1 to NUREG-0737. In addition, was responsible for plant wide study of post-accident monitoring instrumentation, including inadequate core coding instrumentation upgrade of the main control board to meet post-Three Mile Island requirements, and on-project support of human factors engineering design reviews of emergency shutdown and alternate shutdown panels in accordance with NUREG-0700 criteria.