

CONTROL DISCREPANCY

A. Discrepancy

- 2.1h. Cannot readily distinguish between controls for valves, pumps, fans, etc. (Category 3)

B. Research

1. Interviewed operations personnel.
2. Consulted SCE&G shift technical advisor.
3. Reviewed logic prints.
4. Reviewed flow diagrams.

C. Backfit (PA-4)

The replacement CMC switch inserts provide a symbol in the lower right hand corner to distinguish between controls for valves, pumps, fans, etc. (see page 12A). The GE type SB switches are clearly labeled as to type of equipment they operate. The summary/component group labeling to be incorporated along with the demarcation scheme will increase control recognition. Refer to LABELING, DEMARCATION, AND MIMIC SPECIFICATION.

CONTROL DISCREPANCY

A. Discrepancy

- 2.1i. Legend labels on the controls are inconsistent (automatic sometimes means closed). (Category 1)
- 2.1j. Component number (or other information) that is engraved on the red and green lenses are difficult to read, particularly when the green lenses are not illuminated. (Category 2)

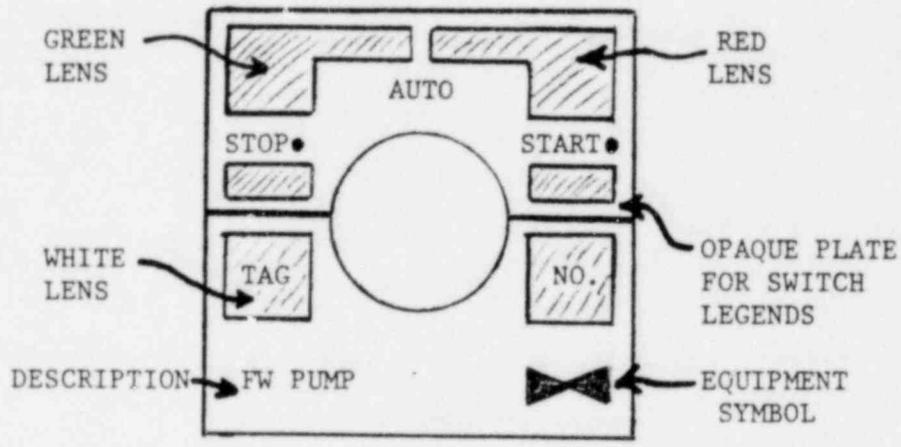
B. Research

- 1. Interviewed operations personnel.
- 2. Consulted SCE&G shift technical advisor.
- 3. Consulted G/CC engineers.
- 4. Reviewed electrical elementaries.
- 5. Reviewed logic prints.

C. Backfit (CON-8A)

Switch select position legends will be effectively disassociated from the indicator lights that display equipment status information. In addition, low contrast information remaining on colored lenses will be top engraved with white lacquer filled to attain the legibility required. The specification for implementing this backfit will be developed. See page 12A for typical example.

CMC SWITCH INSERT



DISPLAY DISCREPANCY

A. Discrepancy

- 3.f. There are no normal operating ranges or setpoints indicated on meters. (Category 1)

B. Research

1. Interviewed operations personnel.
2. Consulted SCE&G shift technical advisor.
3. Reviewed PLS.
4. Performed vertical indicator task analysis.
5. Consulted I and C technicians.

C. Backfit (VD-5)

Where appropriate vertical indicators will have normal range, high and low setpoints highlighted by color coding as specified by APPENDIX B, VERTICAL INDICATOR SPECIFICATION.

DISPLAY DISCREPANCY

A. Discrepancy (Essex Report)

- 3.h. Information which is not displayed in the control room includes:
1. EHC Temperature/closed cycle temperature. (Category 4)
 2. Reactor building dewpoint. (Category 4)
 3. Circ. water valve positions. (Category 4)

B. Research

1. Interviewed operations personnel.
2. Consulted SCE&G shift technical advisor.

C. Backfit (VD-52)

EHC oil temperature and closed cycle temperature can be monitored on the plant computer CRT. The Reactor building dewpoint is not required because condensate flow from RB cooling units can be used to monitor RB humidity. There are CW valve position indicators (CMC switch) plus there will be the addition of a 30% OPEN indicator for the CW Pump discharge valves.

MODUFLASH DISPLAY SYSTEM DISCREPANCY

A. Discrepancy

- 3.1b. The system cannot be easily related to specific annunciators on the main control board (e.g., no indication on annunciator tiles as to whether that parameter is monitored by the Moduflash system). (Category 2)

B. Research

1. Interviewed operations personnel.
2. Consulted SCE&G shift technical advisor.
3. Reviewed electrical elementaries.
4. Performed annunciator moduflash task analysis.
5. Consulted I and C technicians.

C. Backfit (PA-5)

The annunciators will be coded with M1, M2, M3, or M4 to indicate which MODUFLASH unit the alarmed parameter is indicated on. Nomenclature on annunciators and moduflash parameters will be matched. The coded annunciator along with the corresponding alarm light on the moduflash unit in conjunction with the consistent nomenclature should provide the operator with sufficient correlation between displays.

HVAC PANEL DISCREPANCY

A. Discrepancy

- 4.2a. Mimic is color coded but the coding is not carried out over the controls and the panels. (Category 2)

B. Research

Reviewed the color coding on the HVAC mimic applicable to the controls and the panel.

C. Backfit (PA-6)

The controls on the HVAC Panel will be color coded, demarcated and labeled so they can be readily identified with the corresponding system on the mimic. Refer to Appendix A, Labeling, Demarcation, and Mimic Specification.

REACTIVITY CONTROL SYSTEM PANEL DISCREPANCY

A. Discrepancy

- 4.3b. NIS RECORDER PEN SELECTORS control position is difficult and awkward to determine because alphanumeric labels are sideways. (Category 2).
- bl. Selector control must be turned through SOURCE range to go from INTERMEDIATE to POWER. (Category 3)

B. Research

- 1. Examined actual control design and labeling.
- 2. Consulted SCE&G shift technical advisor.
- 3. Reviewed vendor technical manual.
- 4. Consulted SCE&G electrical technicians.

C. Backfit (CON-12A)

Control position labels will be oriented horizontally to be read from left to right. New switches were installed to correct the sequence of operation problem noted in 4.3bl. In addition, the pointer end of the knob will not overlap any of the control position labels.

REACTIVITY CONTROL SYSTEM PANEL DISCREPANCY

A. Discrepancy

4.3c. Part Length Rod control is not used. (Category 2)

B. Research

N/A

C. Backfit (CON-4)

The unused control will be removed from the board. |

FIRST-OUT PANEL DISCREPANCY

A. Discrepancy

- 4.6 There is no identification of the first out alarm panel on the control board. (Category 1)

B. Research

1. Interviewed operations personnel.
2. Examined alarm panel configuration.

C. Backfits (PA-10)

The alarm windows in the first out annunciator alarm panel will be red and the bezel will be labeled to make it readily distinguishable from the other annunciator panels.

RAD MONITOR SYSTEM DETECTOR DISCREPANCY

A. Discrepancy

- 4.9 Detectors are not associated with their related annunciators, such as, detectors RMA-11 is located in Section No. 4 of the panel while the corresponding annunciator is located in Section No. 5, RMA-6 is located in Section No. 5 of the panel while the corresponding annunciator is located in Section No. 6. (Category 2)

B. Research

1. Reviewed actual system configurations.
2. Checked technical specifications.
3. Reviewed electrical elementaries.
4. Assessed space availability on board.
5. Consulted SCE&G operations personnel.
6. Performed task analysis of annunciators.
7. Consulted SCE&G shift technical advisor.

C. Backfits (VD-36)

Where wiring and separation criteria permit, annunciators will be rearranged so that they are collocated in the same panel sections as the related controls and displays.

STEAM GENERATOR PANEL DISCREPANCY

A. Discrepancy

- 4.10c. There are three sets of meters which are used for comparison checking and which have similar but different scales. These are "Main Steam HDR Press" (0-1300 PSIG); "FW Pump DISCH HEAD" (0-1500 PSIG); "FW Pumps A,B,C" (0-1800 PSIG). (Category 1)

B. Research

1. Reviewed meter configuration.
2. Interviewed operations personnel.
3. Reviewed electrical elementaries.
4. Consulted SCE&G shift technical advisor.
5. Conducted measurements to assess space requirements relative to space availability.
6. Conducted task analysis.
7. Consulted I and C technicians.

C. Backfit (VD-31)

The vertical indicator scales for FW Pumps A,B,C and FW Pump Discharge Head will be changed to allow comparison checking. The Main Steam HDR indicator has no direct relation to the FW Pumps discharge pressures. Refer to APPENDIX B, VERTICAL INDICATOR SPECIFICATION.

The Main Steam Header Press, FW Pump Header Press and FW Pump Discharge Press Indicators can not be changed to reflect the same ranges. The FW Pump Discharge Press should remain at 0 to 1800 psig. There are times when the discharge pressure will exceed 1500 psig. At present the discharge high press trip for the pumps are for pump A (1660 psig), pump B (1690 psig) and pump C (1720 psig). The individual discharge pressures are measured at the discharge of each pump where as the FW Header pressure is measured at the FW Header common to all three loops. The range of the FW Header Press can not be changed because this loop is scaled to control FW Pump Speed. The indicator should reflect the same range as that used to scale the control channel. The indicator scales were modified to be the same type and to have the same units in accordance with Appendix B, Vertical Indicator Specification.

LABELING DISCREPANCY

A. Discrepancy

- 5.0e. Labeling techniques are not consistent (e.g., black on white and white on black labels, etc.). (Category 1)

B. Research

1. Performed labeling study for consistency in nomenclature, abbreviations, and acronyms.
2. Consulted SCE&G shift technical advisor.

C. Backfit (PA-17)

All individual component labels will have black print on white background. All Post Accident Monitoring Indicator Labels will have black print on yellow background. System summary and component group labeling will be black lettering applied (painted) directly onto control panel or engraved into a label plate that is the same color as control board. Refer to APPENDIX A, LABELING, DEMARCATION AND MIMIC SPECIFICATION.

NOTE: General Electric SBM switch escutcheons are standard equipment and will not be included in this backfit.

LABELING DISCREPANCY

A. Discrepancy (Essex Report)

- 5.n. Labels can be associated with wrong controls.

B. Research

1. Interviewed operations personnel.
2. Consulted SCE&G shift technical advisor.
3. Performed labeling study for consistency in nomenclature, abbreviations, and acronyms.

C. Backfit(PA-23)

Labels will be revised and standardized for improved readability. Also labels are being consistently positioned above controls and displays where physically possible which will alleviate most of the problems in associating labels with the appropriate control/display. Refer to APPENDIX A, LABELING, DEMARCATION, AND MIMIC SPECIFICATION.

COMMUNICATION DISCREPANCY

A. Discrepancy

- 6.2d. No procedures for communication control during an emergency. (Category 1)

B. Research

1. Consulted SCE&G shift technical advisor.
2. Reviewed emergency procedures and applicable regulations.

C. Backfit (Comm-5)

SCE&G has generated procedures for communication during an emergency. EPP-002 is the communication and notification procedure.

ANNUNCIATOR DISCREPANCY

A. Discrepancy

- 7.e. Fire and Security alarm systems could not be reviewed. This system was not turned over to operations at the time of our audit. (Category 1)

B. Research

1. Consult SCE&G shift technical advisor.
2. Reviewed Fire and Security alarm system technical manual and layout prints.

C. Backfit(VD-50)

The Fire and Security Panel and Alarm System have been reviewed and required backfits have been implemented. For details see letter from T. C. Nichols, Jr. to Harold R. Denton, dated February 23, 1982; Docket No. 50/395.

PROCESS COMPUTER DISCREPANCY

A. Discrepancy (Essex Report)

- 8.k. Nomenclature is inconsistent (e.g., "CONDENSATE PUMP" and also written as "COND PUMP", etc.). (Category 2)

B. Research

1. Interviewed operations personnel.
2. Performed labeling study for consistency in nomenclature, abbreviations, and acronyms.
3. Consulted SCE&G shift technical advisor.

C. Backfit

At present there are approximately 1700 computer points (digital and analog). The process computer is not required for operation of the plant. The computer is an operator aid used for data logging and information only and is not used for plant manipulations or accident analysis. The time and expense required to make the software modification cannot be justified for a nomenclature requirement only. We have provided a data point cross-index as specified in discrepancy 8.g which aids the operator in addressing the computer and also provides him with nomenclature of that particular point.

We feel the existing nomenclature does not create the potential for operator errors that could affect plant safety.

OTHER DISCREPANCY

A. Discrepancy

- 9.b There is operator confusion concerning the manual initiation of Safety Injection (SI). (Category 1)

B. Research

1. Interviewed operations personnel.
2. Reviewed emergency operating procedures.
3. Consulted SCE&G shift technical advisor.
4. Consulted G/CC engineers.
5. Analyzed control movement in terms of location usefulness and clearance measurement.

C. Backfit(CON-20)

One of the SI actuation controls will be moved from panel 6 to panel 13. This will allow operator two convenient locations for manual SI being as only one control actuation is required for manual SI initiation. If cable lengths allow, the remaining SI control on panel 6 will be moved to a higher location to provide required clearance between control handle and knob switch control on bench board.

OTHER DISCREPANCY

A. Discrepancy

- 9.d RB cooling units are cooled by industrial coolers. Controls for cooler pumps are on XCP 606 (sloping panel) while the industrial cooler temperature alarm windows are on CP 610 (7-8 feet away). (Category 2)

B. Research

1. Interviewed operations personnel.
2. Reviewed electrical elementaries.
3. Annunciator task analysis.
4. Consulted SCE&G shift technical advisor.

C. Backfit(VD-36)

Research is to be continued for feasibility of rearrangements which would allow the integration of BOP and train parameters to be collocated. If feasible, the RB cooling unit's annunciators will be relocated at XCP 606 and XCP 607.

NOTE: Implementation may extend beyond fuel load date.

Due to electrical separation criteria, the alarm points for the Industrial coolers cannot be moved to XCP-606 or XCP-607. XCP-606 and XCP-607 are train related annunciators. The present location for these alarms in XCP-610 is the nearest location which will not violate the electrical separation criteria. Also see Annunciator Discrepancy 7.C.

OTHER DISCREPANCY

A. Discrepancy

- 9.e Emergency procedures require operators to rely on pattern recognition to identify Train A and Train B initiation on 6 ESF status monitor light panels. Patterns are confusing and difficult to recognize on display panels. Patterns are shown and described in Attachment 1 to EOP-1, and these patterns were even difficult to interpret in the EOP. (Category 1)

B. Research

1. Interviewed operations personnel.
2. Reviewed emergency operating procedures.
3. Reviewed ESF logic prints.
4. Consulted SCE&G shift technical advisor.

C. Backfit(VD-33)

Monitor lights were regrouped and located in the same area of the board. The revised grouping allows the operator to quickly identify functional status by groups of monitor lights depicting the bright-is-right convention.

OTHER DISCREPANCY

A. Discrepancy

- 9.f There is construction in the area of the Remote Shutdown Panel; therefore, we did not complete our review of the panels, lighting, and communication system. (Category 1 until reviewed)

B. Research

1. Performed preliminary evaluation on Remote Shutdown Panel in relation to panel layout, controls, displays, annunciators, labels, communications, and environment.
2. Identified discrepancies.
3. Consulted SCE&G shift technical advisor.
4. Consulted G/CC engineer.

C. Backfit(WAR-8)

Modifications to the Remote Shutdown Panels have been completed and Essex has done the Human Factors Review. The required backfits have been implemented. For details see letter from T. C. Nichols, Jr. to Harold R. Denton, dated February 23, 1982; Docket No. 50/395.

OTHER DISCREPANCY

A. Discrepancy

- 9.j Emergency AC lighting levels were not measured or evaluated. Actuation of this system was not accomplished. The applicant should provide us a copy of its survey results for our review and evaluation prior to January 15, 1981. (Category 1)

B. Research

1. Consulted SCE&G shift technical advisor.
2. Performed illumination level evaluation.

C. Backfit(CRE-3)

After making modifications to the Control Room Lighting System, a detailed lighting survey was performed which documented the acceptability of the system. For details see letter from T. C. Nichols, Jr. to Harold R. Denton, dated November 25, 1981; Docket No. 50/395.

AMENDMENT TO HUMAN ENGINEERING REQUIREMENTS SPECIFICATION

(APPENDIX A - LABELING, DEMARCATION, AND MIMIC SPECIFICATION)

PLANT: V. C. Summer Nuclear Station

DATE: 9/30/81

TITLE: Amendment to the Labeling Specification with Design Criteria for Summary Labels to Be Placed over Modules

CONTACTS:	<u>Name</u>	<u>Phone</u>
UTILITY:	Steve Cunningham	(803) 748-3272
A&E:	Gilbert/Commonwealth Co.	(215) 775-2600
Essex:	T. J. Voss	(803) 345-5209

SPECIFICATION:

A. Background — The requirements contained herein supersede portions of the Labeling, Demarcation, and Mimic Specification prepared for the V. C. Summer Nuclear Station and dated 1/15/81. The superseded portions include (1) the recommended font (contained in Specification Section 5.0 C. 501 and illustrated in Figure 2); (2) the size of alphanumerics for system, subsystem, and component labeling (contained as part of Specification Section 5.0 D 2c & d); and (3) the design of summary labels to be placed over control modules with bezels (previously Specification Section 5.0 D 2d and illustrated in Figure 3). Adherence to all other portions of the specification is recommended. The present document should be used as supplemental to the intact portions of the specification.

B. Recommended Font — The font recommended is Futura Medium (regular width) for system and subsystem labels, and Futura Medium condensed for component labels.

1. For system and subsystem labeling, press-to-apply lettering, such as that made by Chartpak, should be used. The width of the letters is predetermined by the manufacturer, but is within the character height-to-width ratio limits of 1:1 and 5:3. The character height-to-stroke width is also predetermined at an acceptable 7:1. To ensure permanence, the labeling should be sandwiched within two layers of clear mylar tape and then applied to the control board.
2. For component labeling, the Engravograph Futura condensed lettering has an acceptable character height-to-width ratio of approximately 5:3. The stroke width is adjustable to some extent and should achieve an acceptable character height-to-stroke width ratio of between 6:1 and 8:1.

C. Size of Alphanumerics — The sizes listed below represent recommendations which should be adhered to except in instances where space constraints exist. Where space is limited, somewhat smaller lettering is allowable, but in all instances lettering at a given level should be at least 25% larger than lettering at the next lower level.

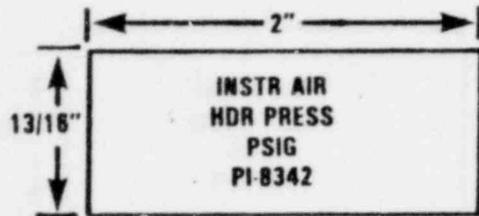
1. System Labeling (press-to-apply)
Character height = 72-pt. Futura Medium
2. Large Subsystem
Character height = 48-pt. Futura Medium

3. Small Subsystem
Character height = 36-pt. Futura Medium
 4. Component Labeling (Engravograph)
Character height = 1/4" Futura Medium Condensed
Stroke width \cong .03"
 5. Vertical Indicator Labeling (see Attachment 1)
Character height = 1/8" Futura Medium Condensed
Stroke width \cong .02"
Label size*
 - a. width = 2"
 - b. height = 13/16"
 6. Reminder relative to spacing:
 - a. Character spacing — The minimum space between characters should be one stroke width.
 - b. Word spacing — The minimum space between words should be the width of one character.
 - c. Line spacing — The minimum space between lines should be one-half character height.
- D. Design of Summary Labels (System or Subsystem) to Be Placed over Control Modules with Bezels — See Attachment 2.

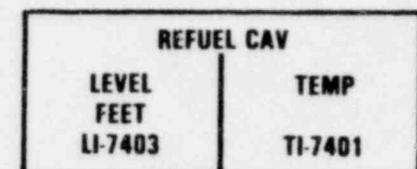
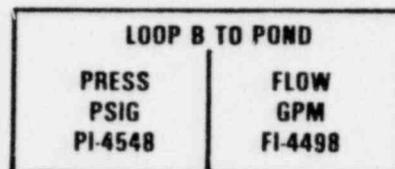
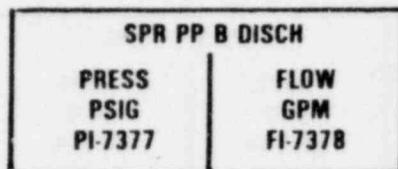
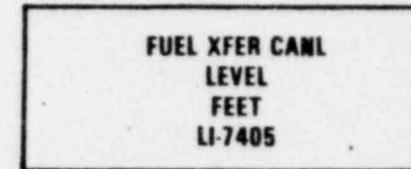
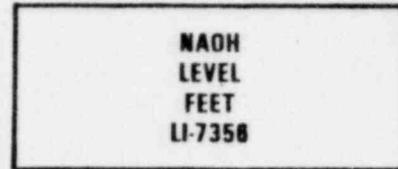
<u>Concern Addressed</u>	<u>Specification</u>
1. Inadvertent removal of label from control board	1. Attach label with screws or similar hardware.
2. Interference with removal of control modules	2. See "1" above. Labels removable, but not too easily.
3. Snagging on clothing or other items with consequent injury to personnel	3. a. Round slightly, and smooth edges and corners of labels. b. Fill area beneath labels.
4. Collection of debris under labels	4. See "3b" above.
5. Shadowing of nearby controls or other labels	5. Keep labels as close to the board surface as possible.
6. Limitations in the amount of available board space	6. See dimensions on attachment (height \cong 1"; length varies with message, but at least 4 1/2").
7. Lack of uniformity in spacing between modules (MCB \cong 1/2", HVAC = 2")	7. Custom fitting may be required for each label.
8. Location of labels	8. Center labels at or near the top of groups, within demarcation lines.

*Except as noted in Attachment 1.

**ATTACHMENT 1
EXAMPLES OF LABELS TO BE MOUNTED ABOVE
VERTICAL INDICATORS**



LETTER SIZE = 1/8"



NOTE: DUE TO SPACE CONSTRAINTS ON THE CONTROL BOARD, IN A FEW INSTANCES LABEL HEIGHT WILL HAVE TO BE REDUCED TO 3/4" WITH 7/64" LETTERING. ALSO, IN A FEW INSTANCES LABEL WIDTH WILL HAVE TO BE REDUCED TO 1 3/4" (SIZE OF THE LETTERING WILL REMAIN THE SAME).

ATTACHMENT 2
SUMMARY LABELS TO BE PLACED
OVER CONTROL MODULES

SUMMARY LABEL

7/8"

1/4"

4 3/8"

SCALE = 1:1

NOTE:
SOME LABELS MAY HAVE
TO BE MOUNTED AS SHOWN
IN FIGURE 3 OF THE 1/15/81
LABELING SPECIFICATION

APPENDIX B

VERTICAL INDICATOR SPECIFICATION

HUMAN ENGINEERING REQUIREMENT
SPECIFICATION

1.0 PLANT: V.C. Summer Nuclear Power Plant

3.0 SPEC. NO

SPEC. DATE 1/15/81

REV. NO. 1

REV. DATE 3/25/82

2.0 TITLE: VERTICAL INDICATORS

4.0 CONTACTS:

	<u>Name</u>	<u>Phone</u>
• UTILITY:	Steve Cunningham	(803) 748-3000
• A&E:	Gilbert/Commonwealth Co.	(215) 775-2600
• ESSEX:	T.J. Voss	(803) 345-5209
• OTHER:		

5.0 SPECIFICATIONS

The requirements contained in the present document apply to single and dual vertical indicators on the Control Board and HVAC panel in the V.C. Summer Nuclear Power Plant. The aim is to provide specific guidance and criteria for the labeling of vertical indicator scale faces. Adherence to these criteria will provide a uniform, standardized scheme for labeling vertical indicators which will enhance visual search while reducing control and display errors.

5.1 INFORMATION

- A. Content — The information displayed to an operator shall be limited to that which is necessary to perform specific actions or to make decisions.
- B. Format — Information shall be presented to the operator in a directly usable form (requirements for transposing, computing, interpolating, or mental translation into other units shall be avoided whenever possible).
- C. Precision — Information shall be displayed only to the degree of specificity and precision required for a specific operator action or decision.
- D. Redundancy — Redundancy in the display of information to a single operator shall be avoided unless it is required to achieve specified reliability.

- E. Display Failure Clarity — Displays shall be so designed that failure of the display or display circuit will be immediately apparent to the operator.
- F. Unrelated Markings — Trademarks and company names or other similar markings not related to the panel function shall not be displayed on the panel face.

5.2 ARRANGEMENT

- A. Accuracy — Displays shall be located and designed so that they may be read to the degree of accuracy required by personnel in the normal operating or servicing positions.
- B. Consistency — The arrangement of displays shall be consistent in principle from application to application.

5.3 DESIGN REQUIREMENTS

- A. Linearity — Except where system requirements clearly dictate nonlinearity to satisfy operator information requirements, linear scales shall be used in preference to nonlinear scales.
- B. Scale Markings
 - 1. Gradations - Wherever possible, scale gradations shall progress by one, two, or five units or decimal multiples thereof.
 - 2. Intermediate marks - The number of minor or intermediate marks between numbered scale graduations shall not exceed nine.
 - 3. Similar scales - When two or more similar scales appear on the same panel, they should have compatible numerical progression and scale organization.
 - 4. Spacing - Minor graduation marks should be spaced no closer than .04 inch. If possible, major graduation marks should be spaced no closer than .50 inch. All major graduation marks shall be numbered.
 - 5. Length and Stroke Width
 - Single indicators — see Attachment A and Page 10.
 - Dual indicators — see Attachment B and Page 10.
- C. Alphanumerics
 - 1. Style - Labeling should be in all capital letters without flourishes, embellishments, or serifs. Diagonal parts of letters and numbers should be

as close to 45° as possible; characteristic features such as breaks or openings should be readily apparent, and critical details should be simple but prominent. An example of a recommended and acceptable font is MIL-M-18012B, also referred to as NAMEL or AMEL (see Attachment C).

2. Character size - The width of the character shall be determined by the height of the character, and is usually expressed in terms of width-to-height ratio. For numerals, the width-to-height ratio should be about 3:5 except for four, which should be one strokewidth wider, and one, which should be one strokewidth wide. Stroke width-to-height ratio is about 1:7. In the case of letters, a width-to-height ratio of 3:5 is recommended, except for letters M and W, which should be one strokewidth wider, and the letter I, which should be one strokewidth wide. For specific recommendations concerning the size of alphanumerics to be used on single and dual indicators, see Attachments A and B respectively.
3. Spacing - The minimum acceptable space between characters is one strokewidth; between words, one character width, and between lines, one half of the character height (see Attachments A and B).
4. Numbering of Scale Gradation - Except for measurements that are normally expressed as decimals, whole numbers shall be used for every major gradation mark. Display scales shall start at zero, except where this would be inappropriate for the function involved. The end points of the scales should be numbered.

D. Scale Bands

1. Single indicator bands - Single indicators have two scale bands, one wider than the other (see Attachment A for specific dimensions). The wider band shall retain both the scale markings and numerals. The narrow band should retain the units description (e.g., GPM, PSIG, FEET).
2. Dual indicator bands - Dual indicators are comprised of three scale bands, two of equal width and one narrower band located between the wider bands. The narrower band is to contain both sets of scale markings as it does at present. The wider bands which presently contain both numerals and unit description are to retain only the numerals. The units description (GPM, PSIG, FEET, etc.) will be included in the labeling above the indicator. See Attachment B for the specific dimensions of the scale

bands. The change will allow more digits to be displayed on the scale band, permitting simplification of the units' designation and less mental translation by the operator.

E. Other Markings

1. Minus signs - Minus signs shall precede any negative value, and shall be dimensioned as any other character. See Attachments A and B for specific character sizes.
2. Plus signs - Plus signs should not be used.
3. Size graduation - Subscripts and superscripts (e.g., "6" in 10^6) should be avoided on scales, but when necessary should be about 25 percent smaller than other numerals (see Attachments A and B for normal size recommendations).

F. Color — Vertical indicator scale faces should be white with black characters.

G. Coding — Both single and dual indicators should be color coded for normal operating range and set points (see Attachments D and E).

H. Pointers

1. Length - The display shall be designed so that the control or display pointer will extend to, but not obscure, the shortest scale graduations.
 2. Width - The width of the pointer, where it intercepts the graduation marks, shall not exceed the width of the intermediate marks.
 3. Mounting - The pointer shall be mounted as close as possible to the face of the dial to minimize parallax.
 4. Calibration information - Provisions shall be made for placing calibration stickers on instruments without interfering with dial legibility.
- I. Specific Scales - Attachments F and G list all single and dual scale indicators, respectively, with recommendations for each specific scale and set points, if appropriate. The normal operating range of each indicator is not, at this point, available but should be added later. Comments have been written to point out any unusual cases or specific problems.

6.0 CONSEQUENCES OF VIOLATION

Incorrect display reading and interpretation.

ATTACHMENT A

Single Meter Scales

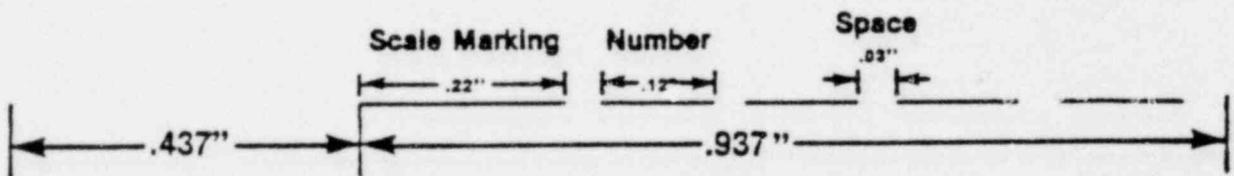
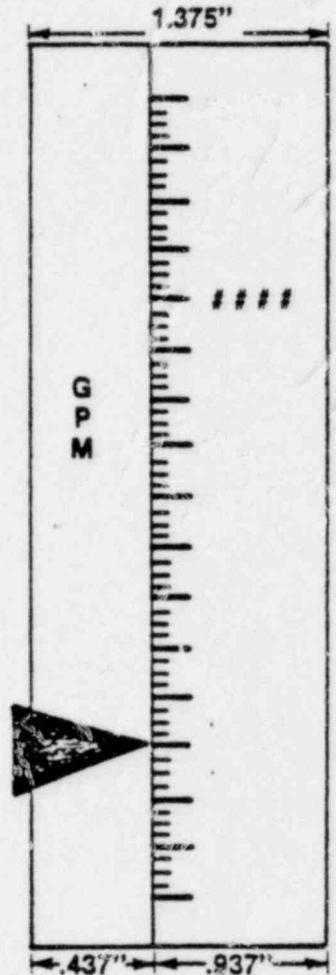
Scale Marking & Alphanumeric Size

A. DISPLAY AREA

1. Height - 4.50"
2. Width (Total) - 1.375"
 - (a) Band With Markings & Numerals - .937"
 - (b) Band With Units Description - .437"

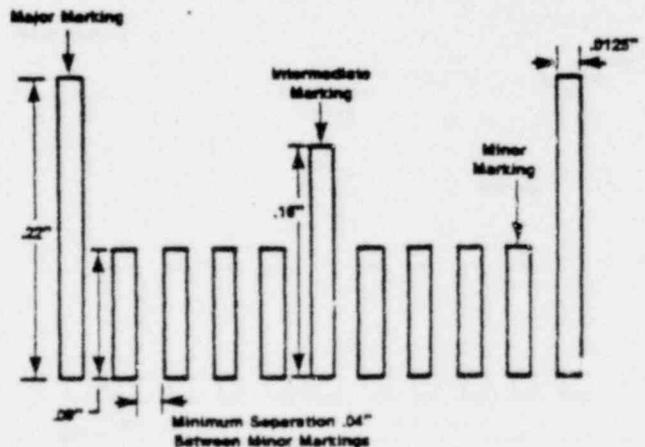
B. RECOMMENDED CHARACTER SIZE *

1. Height - .20"
2. Width - .12"
3. Stroke Width - .03"
4. Spacing Between Characters - .03"
5. Spacing Between Words - .12"
6. Spacing Between Lines - .10"



C. RECOMMENDED SCALE MARKING SIZE

	<u>Length</u>	<u>Stroke Width</u>
Major -	.22"	.0125"
Intermediate -	.16"	.0125"
Minor -	.09"	.0125"



* Letraset brand press to apply characters were used in a point size to approximate the recommended size. See Page 10 for specifics.

ATTACHMENT B

Dual Meter Scales

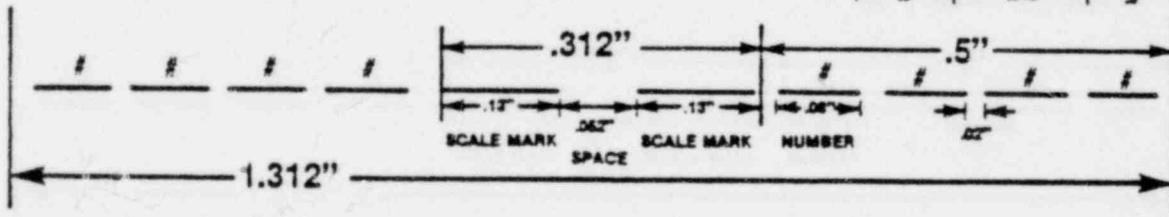
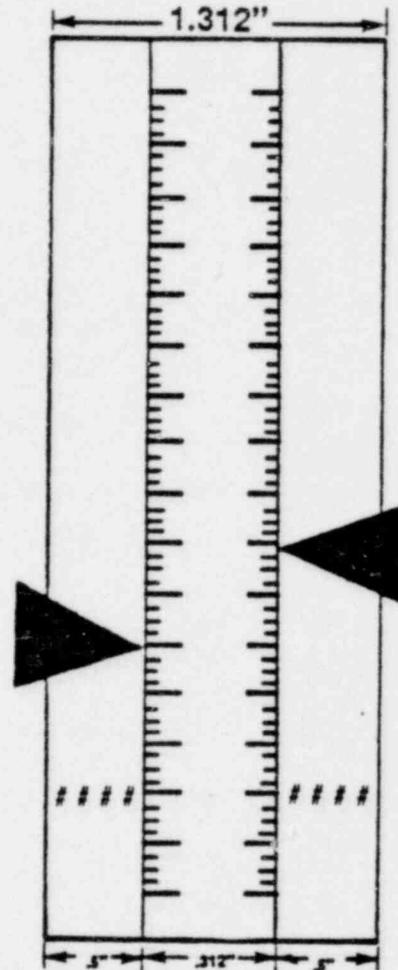
Scale Marking & Alphanumeric Size

A. DISPLAY AREA

1. Height - 4.50 "
2. Width (Total) - 1.312"
 - (a) Band With Scale Markings - .312"
 - (b) Each Band With Numbers - .500"

B. RECOMMENDED CHARACTER SIZE *

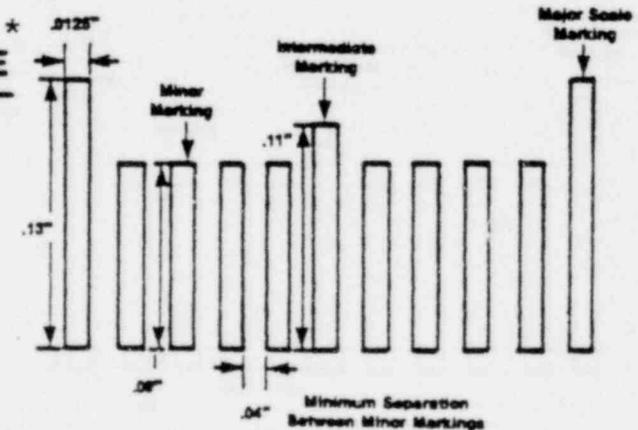
1. Height - .15"
2. Width - .08"
3. Stroke Width - .02"
4. Spacing Between Characters - .02"



C. RECOMMENDED SCALE MARKING SIZE

	<u>Length</u>	<u>Stroke Width</u>
Major -	.13	.0125
Intermediate -	.11	.0125
Minor -	.09	.0125

* See Page 10 for (1) press to apply lettering sizes used to approximate recommendations and (2) modifications to recommended scale marking size.



ATTACHMENT C

Suggested Alphanumeric Style



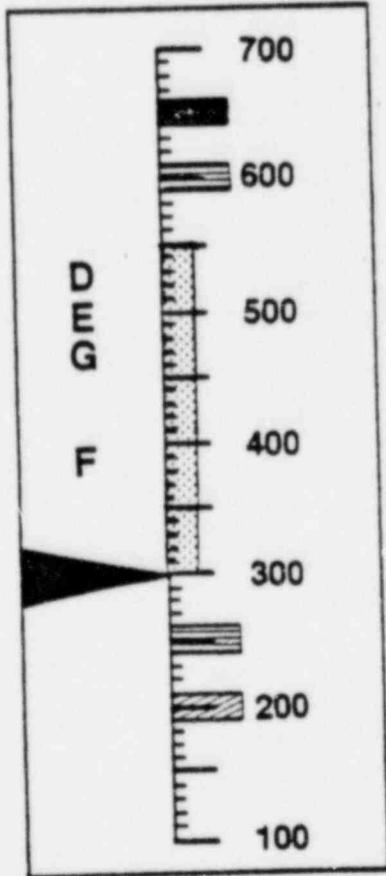
Letter and numerical font of United States Military Specification No. MIL-M-18012B (July 20, 1964); also referred to as NAMEL (Navy Aeronautical Medical Equipment Laboratory) or as AMEL.

Font of Alphanumeric Characters — Most conventional fonts of alphanumeric characters (and many of the nonconventional styles) can be read with reasonable accuracy under normal conditions where size, contrast, illumination, and time permit. There are, however, significant differences in the legibility and readability of different type fonts when viewing conditions are adverse, where time is important, or where accuracy is important. In this connection, the font of capital letters and numerals shown in the Figure (United States Military Specification No. MIL-M-18012B) has been rather widely tested and found to be generally satisfactory.

ATTACHMENT D

Recommendations

Set Points on Single Scale Indicators

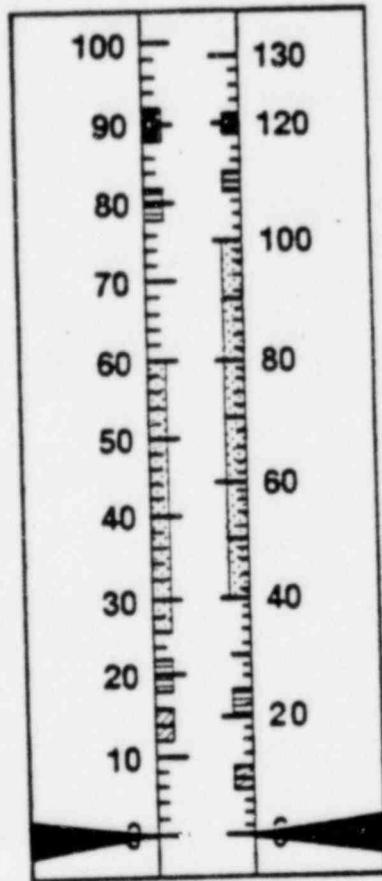


- GREEN —  — Normal Range
- YELLOW —  — Hi-Lo Alarms
- RED —  — INTERLOCK
- BLUE —  — TECH, SPEC.

ATTACHMENT E

Recommendations:

Set Points on Dual Scale Indicators



- GREEN —  — Normal Range
- YELLOW —  — Hi-Lo Alarms
- RED —  — INTERLOCK
- BLUE —  — TECH. SPEC.

CHARACTER SIZE EMPLOYED AND MODIFIED
DUAL SCALE MARKINGS

- A. To facilitate the manufacture of scales Futura Medium press to apply alphanumerics (Lacraset brand) were used in the font sizes listed below. The sizes listed are a close approximation to the sizes recommended in Attachments A and B, or, in one instance (see below 2b.), an improvement from a human factors perspective.

1. Single Meter Scales

- a. Numbers: 18 point Futura Medium
- b. Letters: For 1-15 letters use 18 point Futura Medium
For 16-30 letters use 14 point Futura Medium

2. Dual Meter Scales - only numbers appear on dual scales:

- a. With 4 numbers across scale use 14 point Futura Medium
- b. With 3 or fewer numbers use 18 point Futura Medium

NOTE: In no instance should number sizes be mixed on a given scale.

- B. Recommended scale marking sizes for dual scale meters were modified to increase discriminability. Revised scale markings are as follows:

	<u>LENGTH</u>	<u>STROKE WIDTH</u>
MAJOR	.13"	.03"
INTERMEDIATE	.10"	.02"
MINOR	.07"	.0125"

APPENDIX C

ANNUNCIATOR SPECIFICATION

HUMAN ENGINEERING REQUIREMENT
SPECIFICATION

1.0 PLANT: Virgil C. Summer Nuclear Station

3.0 SPEC. NO

SPEC. DATE 1/15/81

REV. NO. 1

REV. DATE 3/25/82

2.0 TITLE: ANNUNCIATOR SYSTEMS

4.0 CONTACTS:

Name

Phone

- | | | |
|------------|--------------------------|----------------|
| o UTILITY: | Steve Cunningham | (803) 748-3000 |
| o A&E: | Gilbert/Commonwealth Co. | (215) 775-2600 |
| o ESSEX: | T.J. Voss | (803) 345-5209 |
| o OTHER: | | |

5.0 SPECIFICATIONS

5.1 INTRODUCTION

A major source of information in nuclear power plant control rooms is provided by the annunciator system. Plant annunciators are used to do the following: a) alert operators to impending out-of-tolerance conditions; b) inform operators of malfunctioning or out-of-tolerance systems; c) bring attention to out-of-tolerance alarms which have returned-to-normal process conditions; and d) diagnose plant accidents and transients.

This document provides human engineering specifications for the design and operation of the annunciator system in the Virgil C. Summer Nuclear Station control room. Adherence to these criteria will provide a uniform, standardized scheme for the following: a) general annunciator alarm indication; b) first-out annunciator alarm indication; c) localization of annunciator controls and alarm signals; d) prioritization of annunciator alarms; and e) labeling annunciator messages, all of which will reduce human error related to the annunciator system.

5.2 GENERAL SPECIFICATIONS

- A. Annunciators are provided with redundant lamps.

- B. Annunciator luminance must be at least 10% greater than surrounding luminance.
- C. Annunciator windows do not hang open.
- D. Annunciator flash rates are between 1 to 7 flashes/second.
- E. When flash rates must be discriminated, rates differ by at least 50%.
- F. No more than three flash rates are used.
- G. Nuisance alarms are avoided.
- H. Annunciators are designed so that legend plates cannot be interchanged during maintenance.

5.3 DETAILED SPECIFICATIONS

- A. General Annunciator Alarm Indication — Annunciators are used to call the operator's attention to abnormal and returned-to-normal process conditions by means of audible signals and diacritical flash rates.
 1. Annunciators flash at a SLOW-FLASH to indicate abnormal process conditions; the flash changes to STEADY when alarms are acknowledged.
 2. Annunciators have reflash capability (FAST-FLASH) to denote when annunciator alarms have cleared and should be reset, and to allow for subsequent multiple input alarms to be identified and acknowledged.
 3. General annunciator alarm conditions as well as the appropriate operator control action and its associated annunciator alarm response are illustrated in the matrix below.

<u>ALARM CONDITION</u>	<u>CONTROL ACTION</u>	<u>ANNUNCIATOR ALARM RESPONSE</u>
NORMAL	—	OFF
ABNORMAL	—	SLOW-FLASH
ABNORMAL	ACKNOWLEDGE	STEADY
NORMAL	—	FAST-FLASH
NORMAL	RESET	OFF

B. First-Out Annunciator Indication — First-out annunciator indication allows for faster fault analysis by informing the operator of the annunciator trip alarm which initiated subsequent annunciator alarms. By knowing the initial cause of a trip the operator can more efficiently and quickly diagnose the problem and reduce temporal, interpretative and diagnostic errors.

1. The first-out annunciator panel is set apart from other annunciator panels by a red border.
2. Annunciator information is not redundant and therefore the term "reactor trip" is deleted from the message.
3. For discriminable indication, the "first-out annunciator" flashes at an INTERMITTENT FAST-FLASH to indicate an abnormal process condition which has caused a reactor trip; the flash changes to FAST-FLASH when alarm is acknowledged.
4. First-out and subsequent annunciator alarm conditions as well as the appropriate operator control action and its associated annunciator alarm response are illustrated in the matrix below.

<u>ALARM CONDITION</u>	<u>CONTROL ACTION</u>	<u>ANNUNCIATOR ALARM RESPONSE</u>	
		<u>FIRST-OUT</u>	<u>SUBSEQUENT</u>
NORMAL	—	OFF	OFF
ABNORMAL	—	INTERMITTENT	SLOW-FLASH
ABNORMAL	ACKNOWLEDGE	FAST-FLASH	STEADY
ABNORMAL	RESET	STEADY	STEADY
NORMAL	—	FAST-FLASH	FAST-FLASH
NORMAL	RESET	OFF	OFF

C. Localization of Annunciator Controls and Audible Alarm Signals — Annunciator controls and audible alarm signals minimize the possibility of error by reducing the confusion factor involved in trying to locate which annunciator panel is in alarm, and thereby also minimizing the control/display response time.

1. Annunciator Controls

- a. Six annunciator control stations exist:

- 1) Five stations are specific to all general alarms on the main control board
 - 2) One station exists solely for those alarms on the first-out panel.
 - b. Annunciator control stations are localized to that panel which is in the alarming state.
 - c. Annunciator control stations are distinct from nearby unassociated controls and displays.
 - d. Annunciator control stations are placed such that:
 - 1) All annunciators controlled are clearly readable from the point of operation of the controls
 - 2) Association between annunciators and controls is clear
 - 3) All controls necessary for annunciator operation are collocated.
 - e. Each general alarm annunciator control station consists of the following controllable features:
 - 1) ACKNOWLEDGE — used to "inform" the system that annunciators have been acknowledged by operators
 - 2) RESET — used to clear annunciator when system/component problem has been corrected
 - 3) SILENCE — used to silence any incoming audible signal on the main control board
 - 4) TEST — used to test operability of annunciator flash unit, bulbs, and audibles.
 - f. The first-out annunciator control station consists of ACKNOWLEDGE, RESET, and TEST functions.
 - g. When testing, annunciators flash simultaneously so that inoperative annunciator window(s) is (are) clearly and quickly identified.
2. Annunciator Audible Alarm Signals
- a. Audible alarm signals are localized to that panel which is in alarm state.
 - b. Sound sources located at or above head level.
 - c. Annunciators have ring-back capability to denote when alarms have cleared and should be reset. Ring-back and reflash occur simultaneously.

- d. Auditory signals do not compete for operator's attention.
- e. Concurrent annunciators require independent acknowledgements (two or more alarms with same or different audibles require a separate acknowledgement for each).
- f. Signal frequencies do not resemble ambient control room noises or other alarms and signals.
- g. Intensity level is 20dB above ambient, but not above 80dB.
- h. Equispaced frequencies of between 200 and 3000 Hz are used.
- i. No more than 7 (preferably 4) coded frequencies are used for each particular audible signal (e.g., horn, bell, siren).

D. Prioritization of Annunciator Alarms — Annunciator prioritization enhances the operator's ability to diagnose problems quickly and reduces erroneous assumptions made about the importance of annunciator alarms. Annunciators are prioritized by location and/or color.

1. Location

- a. Annunciators that represent a system/component failure and/or those requiring immediate action are located at the top of the annunciator block.
- b. Individual annunciators are then arranged in descending order of priority.
- c. Annunciators are arranged within relation to their associated controls and displays.
- d. Train colocation is maintained.
- e. Where the system/components are the same and the parameter monitored differs, the annunciators are vertically positioned.
- f. Where the system/components differ and the parameter monitored is the same, the annunciators are horizontally positioned.

2. Color Coding

- a. Red denotes emergency conditions which require immediate operator action to prevent a hazard to plant or public safety.
- b. Amber denotes alarms that require an immediate response to prevent the station from going off-line due to a reactor or turbine trip or potential loss of safety features.
- c. White denotes alarms that signify a trouble or pretrip condition.
- d. Blue denotes control interlocks.

E. Labeling Annunciator Messages — Annunciator labels must communicate information rapidly, efficiently and clearly, with minimal likelihood of delays or errors in reading and interpretation. To prevent ambiguity in messages, the use of whole words is desired. However, labeling space is constrained by annunciator size, and as such whole word messages cannot often be used. Abbreviations and acronyms are used to increase the amount of information presented within the compact space of an annunciator. In order to relay information most effectively, this nomenclature must be consistent and clear. Variable or ambiguous nomenclature increases the time required for an operator to understand an alarm and increases the possibility of misreading or misinterpretation, followed by erroneous responses. In order to minimize the possibility of error: nomenclature was revised and standardized; a standard format for the layout of annunciator legends was established; and annunciator character size was determined based on NUREG 1580 specifics.

1. Annunciator General Labeling Requirements

- a. Font is consistent throughout the entire control room.
- b. Labeling is in capital letters, without flourishes, embellishments, or serifs (e.g., block lettering).
- c. Diagonal parts of letters and numerals are as close to 45° as possible.
- d. Characteristic features such as breaks or openings are readily apparent (e.g., SG A, not SGA).
- e. Figure-ground contrast is at least 50%.
- f. Annunciator labeling is readable without back-lighting.
- g. Symbols are vertically oriented.
- h. Messages are printed left to right, not top to bottom.

2. Revised and Standardized Nomenclature — Consistent use of abbreviations and acronyms reduces message length and permits wider margins and larger font engraving. Readability is improved because key terms are not buried in a margin-to-margin legend but are noticeable in the open annunciator field.

- a. Standard terminology is derived from labeling specifications.
- b. Conventions used specify that where there is room, the entire word should be spelled out; however, there are exceptions: the term HIGH is always referenced as HI, LOW as LO, and TEMPERATURE as TEMP.

c. Abbreviations for system/components such as STEAM GENERATOR and FEEDWATER are always standardized as SG and FW, respectively, whether spacing for a longer abbreviation is available or not (e.g., STM GEN; FD WTR).

3. Format for Layout of Annunciator Legends — Labeling density is reduced and readability improved by the use of three-line tier-of-information format that provides the operator with information in a regular pattern

- a. First line: system or component.
- b. Second line: subcomponent or parameter monitored.
- c. Third line: alarm status.
- d. When message length requires a violation of format, a slight deviation is allowed (FLO LO on third line):

RB SPR
PP A DISCH
FLO LO
(panel 608)

e. In such instances where annunciator message requires multiple alarm parameters and/or statuses, the format is maintained where possible:

VCT
TEMP/PRESS
HI
(panel 613)

CC SRG TK
LVL
HI/LO/LO-LO
(panel 601)

However, some may require deviations from the format:

PRT PRESS/
TEMP/LVL HI
LVL LO
(panel 616)

INSTR AIR
PRESS LO
FLO HI
(panel 607)

- f. Major deviations are allowed only when there is no alternative.
- g. For those annunciator messages requiring component number information the number of lines of legend is extended from three to four with the fourth line containing the component number.
- h. Component number character size is half that of message character size. This information is used under "Annunciator Character Size and Related Information".

4. Annunciator Character Size and Related Information

- a. At least 1/8" of space between nomenclature and top and bottom borders of annunciator tile.
- b. Viewing angle from normal operator position to warning and primary displays is between 30° and 45° (normal operator position is seated at the control room foreman's console).
- c. For capital letters, the width-to-height ratio is 3:5 except for the letters M and W, whose width-to-height ratio does not dip below 4:5, and the letter I, which is one strokewidth wide.
- d. Strokewidth-to-height ratio is 1:6.
- e. Minimum space between characters is one strokewidth.
- f. Minimum space between words is the width of one character.
- g. Minimum space between lines is one-half the character height.

The above criteria are used to determine character size and related specifics which are listed below. Refer to Figure 1 for example of annunciator legends with specifications corresponding to those listed below:

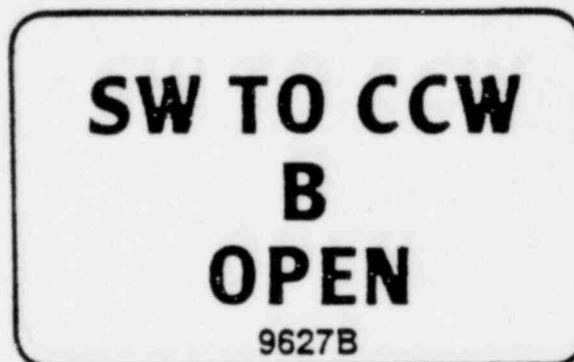
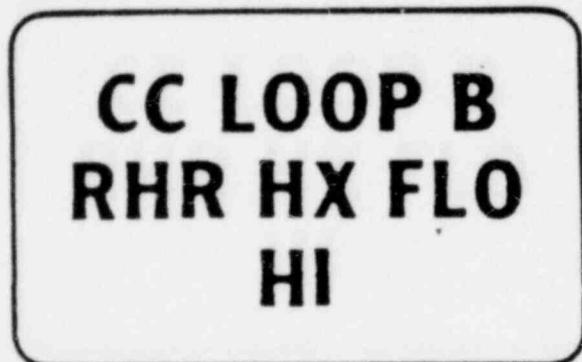
- a. Total annunciator tile width is 2.75".
- b. Total annunciator tile height is 1.75".
- c. Visible ** annunciator tile width is 2.318"
- d. Visible annunciator tile height is 1.12".
- e. Viewing angle from normal operator position and annunciator panels 601 and 638 is 35° and 45°, respectively (see Figure 2).
- f. Left and right margins are .216".
- g. Top and bottom margins are .315".
- * h. Height of character is .22".
- * i. Width of character is .13".
- * j. Strokewidth is .03".
- * k. Character separation is .03".
- * l. Word separation is .13".
- * m. Line separation is .11".

* Figures represent as built modifications to the character size stipulated in the specification as originally issued in January, 1981. The modified size, although somewhat smaller than originally specified, does meet human factors criteria for readability (1/82).

** Visibility is based on recommended border heights and viewing angles where legend is no longer visible due to protrusion of annunciator frame (see Figures 3a and 3b).

- n. Available character spacing is 11 character spaces except where the message becomes meaningless when using 11 characters. In such an instance 12 character spaces are permissible where narrow strokewidth characters (e.g., I) are used.
- o. The use of 12 spaces should, however, be avoided.
- p. Available line spacing is 3 lines of legend, except where component number information is required.
- q. Height of component number is .14".
- r. Width of component number is .084".
- s. Strokewidth is .023".
- t. Component number character separation is .023".
- u. Separation between component number is .084".

FIGURE 1
ANNUNCIATOR CHARACTER SIZE SPECIFICATIONS



TOTAL ANNUNCIATOR TILE WIDTH IS 2.75"
TOTAL ANNUNCIATOR TILE HEIGHT IS 1.75"
VISIBLE ANNUNCIATOR TILE WIDTH IS 2.318"
VISIBLE ANNUNCIATOR TILE HEIGHT IS 1.12"

LEFT AND RIGHT MARGINS ARE .216"
TOP AND BOTTOM MARGINS ARE .315"

- * HEIGHT OF CHARACTER IS .22".
- * WIDTH OF CHARACTER IS .13".
- * STROKEWIDTH IS .03".

- * CHARACTER SEPARATION IS .03".
- * WORD SEPARATION IS .13".
- * LINE SEPARATION IS .11".

* Figures represent as built modifications to the character size stipulated in the specification as originally issued in January, 1981. The modified size, although somewhat smaller than originally specified, does meet human factors criteria for readability. Tiles were engraved with a New Hermes Engravograph using Futura Condensed type (1/82).

FIGURE 3a
ANNUNCIATOR FRAME AND TILE MEASUREMENTS

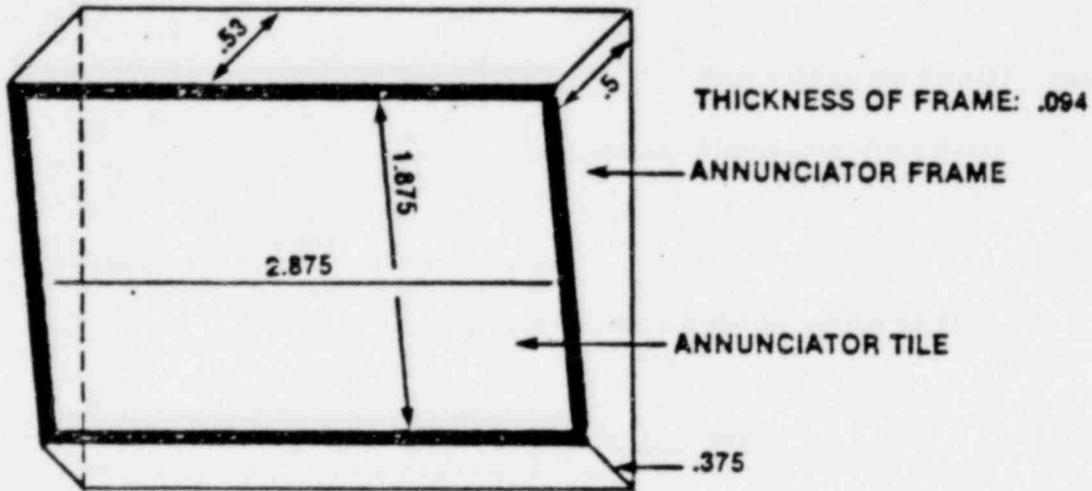


FIGURE 3b
ANNUNCIATOR FRAME OBSTRUCTS VIEW OF TILE

