

EVALUATION OF EMERGENCY PROCEDURES
FOR
ARKANSAS NUCLEAR ONE

PRELIMINARY REPORT

29 December 1980

Prepared for
Nuclear Regulatory Commission
7920 Norfolk Avenue
Bethesda, Maryland 20014

Prepared by

Xyzyx

INFORMATION CORPORATION
21116 Vancouver Street
Canoga Park, Calif. 91302
(818) 883-8200

810 115 0592

TABLE OF CONTENTS

SECTION	PAGE
1 BASIS FOR EVALUATION OF EMERGENCY PROCEDURES . . .	1
Sets of Evaluation Criteria	1
Rationale for Presumption of Need for Procedural Detail	2
2 SPECIFIC CRITERIA	4
3 EVALUATION OF SPECIFIC EMERGENCY PROCEDURES . . .	11
Overview	12
Checklist	13
Discussion of Negative Comments	19
4 LIMITATIONS, CONCLUSIONS, AND RECOMMENDATIONS . .	21
Limitations	21
Conclusions	21
Recommendations	22

SECTION 1

BASIS FOR EVALUATION OF EMERGENCY PROCEDURES

SETS OF EVALUATION CRITERIA

There are four basic sets of properties that determine the adequacy of an emergency procedure. They are: completeness and accuracy, presentation style, level of detail, and administrative control.

Completeness and accuracy are technical properties. They refer to the extent to which required actions are covered without errors of omission, sequence, or detail fact. Evaluation of these properties is outside the scope of the present effort. Completeness and accuracy must be checked by personnel familiar with the specific characteristics of the object system.

Presentation style is a human factors property that can be evaluated without knowledge of the object system. Presentation style involves factors that affect the operator's comprehension of the message being delivered. Those factors are based on established principles of information transfer that apply to all procedures of any kind. Presentation style is covered in this evaluation.

Level of detail refers to the degree of guidance provided beyond the identification of essential actions. Such detail normally is expressed in terms of "how-to" steps and point locations. The need for "how-to" and point location data is absolute. There is no way the operator can function without them. However, that need is sometimes satisfied by the fact that the operator already holds the data in his memory. Where he does, detailed procedures are of limited use (except in training). Where he does not, detailed procedures are essential. In this evaluation, the latter condition is presumed to exist. The rationale for that presumption is summarized later in the discussion.

Administrative control refers to other properties of importance to the procedure user. It includes provisions for: access, denotation of identity and revision status, and verification of completed work by the user. Those aspects of administrative control are covered by this evaluation. In some plants, administrative control is also used to govern the procedure development process. That aspect is not covered here. The procedure development process is extremely important but its evaluation lies beyond the scope of the present study.

RATIONALE FOR PRESUMPTION OF NEED FOR PROCEDURAL DETAIL

A presumption has been stated that nuclear power plant operators confronted with an emergency involving loss of coolant need procedures that tell them not only what to do but how to do it. Further, the procedure must indicate the location of each required control and indicator. The rationale for that presumption is based on the personal experience of the author and ample evidence provided by Swain and Guttman in a recent report for the NRC. That report is the Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications (NUREG/CR-1278). The rationale is summarized below.

1. The LOCA task is relatively long in terms of the number of actions required. Some actions lie in arbitrary sequences. Others are of a diagnostic nature, requiring operator judgement.
2. Proper execution of the task is not self-evident in the physical structure of the hardware. That is, the completion of one action typically furnishes no clue regarding the action next required.
3. The task is accompanied by a level of stress high enough to disrupt human behavior. Such disruption tends to increase the likelihood of operator errors.
4. Some operator errors are recoverable; others are not. Recoverable errors carry in-process time penalties. Non-recoverable errors involve much graver consequences affecting plant integrity.
5. Each operator comes to the job with enough training to assure that he understands the object system. Moreover, during that training, the operator receives enough practice to assure that he can correctly perform this particular task. However, in the months and years following basic training, operator skills relative to this task can be expected to decay, if further practice is not received on a periodic basis. That is, the operator will gradually forget what to do and how to do it. Sufficient practice typically has not been provided in the past.
6. The ability of the operator to carry out this task effectively will be further impeded if the control panels are not marked to help him locate key instruments quickly and accurately. Adequate panel markings have not been provided for in the past.

7. In view of these circumstances, the most defensible position to take with regard to LOCA procedures is to require that they be designed for use under worst-case conditions. That is, operators will feel the stress, will be out of practice, and will have to work at poorly marked control panels. Therefore, they must have procedures able to supply all the information they need. That means what to do, how to do it, and where to do it.

SECTION 2

SPECIFIC CRITERIA

Specific criteria for evaluating a given set of LOCA procedures are presented here in four parts. All are in the form of checklists. The first three checklists correspond to the three properties discussed earlier: presentation style, level of detail, and administrative control. The fourth checklist provides for a walk-through of the procedures.

All four checklists are designed to obtain "yes" answers for acceptable conditions and "no" answers for conditions that are not acceptable. In actual use, each checklist is accompanied by an explanation and/or illustration of every "no" answer.

Most questions can be answered by reference to the procedures themselves. These questions are marked DOCUMENT. Some require direct contact with the plant. These questions are marked SITE.

Most of the questions are straightforward in nature and require no explanation, except for Questions 6 and 7 on Checklist II. Questions 6 and 7 provide an opportunity to verify by inspection the condition of the control panels and the practice schedule. The answers to these questions can be used to help determine the urgency of the need for step-level instructions and control/indicator location data in the LOCA procedures.

Checklist IV provides one final opportunity to gauge the adequacy of the LOCA procedures within the context of the existing operator skill levels and control panel design. In applying Checklist IV, it is important to observe all the stated precautions. Otherwise, an erroneous conclusion might be drawn regarding procedure quality.

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

I. PRESENTATION STYLE

INFO SOURCE	ITEM	COMMENT
DOCUMENT	1. Are approximately 90% or more of the instructions written in short, concise, identifiable steps (as opposed to paragraphs)?	
DOCUMENT	2. Evaluate the complexity of the action instructions by determining the average number of actions (verbs) called out per step. Base estimate on a sample of 20% of the steps or, if the sample size is less than 10, use all steps. Is the average number of actions per step 1.5 or less?	
DOCUMENT	3. Where a decision must be made based on more than two variables, is the information organized to support the decision?	
DOCUMENT	4. If precautions apply to the performance of specific steps or series of steps, are they always placed immediately ahead of the step(s) to which they apply?	
DOCUMENT	5. Are command statements kept out of precautions and explanations?	
DOCUMENT	6. If equipment is operating outside the range specified by the procedure, is the operator told what action to take?	
DOCUMENT	7. Are graphs, charts, and tables adequate for readability and interpolation or extraction of values?	

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

I. PRESENTATION STYLE (continued)

INFO SOURCE	ITEM	COMMENT
DOCUMENT	8. If worksheets are needed to facilitate some actions, are spaces provided for recording all data and processing them (performing additions, multiplications, etc.)?	
DOCUMENT	9. If more than one person is required to perform the procedure, is the procedure written to one "primary" user; that is, is it clear from the way that instructions are written that one person is responsible for coordinating the activity?	
SITE	10. Are references to external procedures limited to situations where it would be inconvenient for the operator to have the entire (referenced) instruction reiterated within this procedure?	
DOCUMENT	11. Are externally referenced procedures listed at the beginning of the procedure?	

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

II. LEVEL OF DETAIL

INFO SOURCE	ITEM	COMMENT
DOCUMENT	1.	Are actions expressed at the step level? That is, are they driven by verbs (e.g., open, close, adjust) against <u>specific</u> controls and indicators?
DOCUMENT	2.	Where actions require the use of controls, are specific positions given?
DOCUMENT	3.	Where actions require the use of indicators, are specific values given?
DOCUMENT	4.	Are control/indicator panel locations given?
SITE	5.	Is the nomenclature used in the procedure identical to that displayed on the panels, controls, and indicators?
SITE	6.	Are indicator values called out in the procedure expressed in the same units as are shown on the indicators?
SITE	7.	Are all control panels properly marked to support this procedure?
SITE	8.	Is every operator required to practice this procedure under simulated emergency conditions at least once per month?

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

III. ADMINISTRATIVE CONTROLS

INFO SOURCE	ITEM	COMMENT
SITE	1. Is an emergency procedure manual located in the control room and accessible by all operators?	
DOCUMENT	2. Is the title of the primary LOCA procedure referenced to an observable emergency condition?	
SITE	3. Are the LOCA procedures easily located within the manual?	
DOCUMENT	4. Does each page provide the following identification information? 4.1 Procedure number and/or title 4.2 Date of issue 4.3 Revision number 4.4 Page number	
DOCUMENT	5. Is the last page of the procedure clearly identifiable by marking; e.g., Page _____ of _____ ; Final Page?	
SITE	6. Does the procedure have a unique and permanently assigned number? That is, if the procedure becomes deleted, will the number be retired rather than reassigned?	
SITE	7. If this is a temporary procedure, is it clearly marked with the expiration date?	
SITE	8. Are personnel prevented from taking the LOCA procedures out of the control room?	
SITE	9. Are documents referenced by the LOCA procedures easily located in an emergency?	

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

III. ADMINISTRATIVE CONTROLS (continued)

INFO SOURCE	ITEM	COMMENT
DOCUMENT	10. Does the procedure provide for verification and signoff of actions?	
DOCUMENT	11. If yes, is <u>every</u> step signed off or initialed?	
SITE	12. If yes, are the verifications predominantly performed by persons other than those performing the action?	

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

IV. OPERATIONAL TEST OF LOCA PROCEDURES (SITE)

Plan a walk-through of the LOCA procedures under simulated conditions of use. Observe the following precautions:

- a. Employ a Reactor Operator selected from a group having the least experience at the plant involved.
- b. Employ a Senior Reactor Operator selected from a group having the least experience in that capacity.
- c. Postulate a plant situation known to represent LOCA conditions, but do not tell the RO or SRO in advance what it is.
- d. Plan for the operator to verbalize each step.

Conduct the walk-through under close observation, while collecting answers to the questions listed below.

COMMENT

1. Can the procedure be performed in the sequence it is written?
2. Can the operator locate and identify all controls and indicators referred to in the instructions?
3. Where general rather than specific instructions are provided, can the operator explain in detail how to perform each general instruction?
4. Can the operator perform the procedure without obtaining additional information or assistance from persons or documents not specified by the procedure?

SECTION 3

EVALUATION OF SPECIFIC EMERGENCY PROCEDURES

Emergency procedure guidelines from Arkansas have been partially evaluated, using the criteria presented in Section 2. The guidelines evaluated were produced by Babcock and Wilcox.

The guidelines were issued in July of 1980.

The complete evaluation calls for examination of the procedures themselves and for observation of various factors at the plant site. Thus far, only the guidelines have been reviewed. A visit to the plant site and a review of the actual procedures is tentatively scheduled for January 1981.

Part 1, Procedural Guidelines, of Abnormal Transient Operating Guidelines (ATOG) was used for this evaluation. The results of the review are expressed in terms of an annotated checklist and a brief discussion of negative comments. A summary page appears at the beginning of the review.

EMERGENCY PROCEDURES HUMAN FACTORS CHECKLIST

Plant Arkansas (1) Procedure No. (See p.11) Title (p.11)
 Revision (p.11) Review Date 12/20/80 Reviewer J. Engelschall

OVERVIEW

	TOTAL	YES	NO	
		QUANTITY	QUANTITY	ITEMS
I. PRESENTATION STYLE				
Document Items	10	Four	Six	3, 4, 5, 7, 9, 11
Site Items	1			
Total Items	11			
II. LEVEL OF DETAIL				
Document Items	4	Zero	Four	1, 2, 3, 4
Site Items	4			
Total Items	8			
III. ADMINISTRATIVE CONTROLS				
Document Items	8	Two	Six	2, 4.1-4.3, 5, 11
Site Items	7			
Total Items	15			
IV. OPERATIONAL TEST				
Document Items	0			
Site Items	4			
Total Items	4			

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

I. PRESENTATION STYLE

INFO SOURCE	ITEM	COMMENT
DOCUMENT	1. Are approximately 90% or more of the instructions written in short, concise, identifiable steps (as opposed to paragraphs)?	yes
DOCUMENT	2. Evaluate the complexity of the action instructions by determining the average number of actions (verbs) called out per step. Base estimate on a sample of 20% of the steps or, if the sample size is less than 10, use all steps. Is the average number of actions per step 1.5 or less?	yes
DOCUMENT	3. Where a decision must be made based on more than two variables, is the information organized to support the decision?	no
DOCUMENT	4. If precautions apply to the performance of specific steps or series of steps, are they always placed immediately ahead of the step(s) to which they apply?	no
DOCUMENT	5. Are command statements kept out of precautions and explanations?	no
DOCUMENT	6. If equipment is operating outside the range specified by the procedure, is the operator told what action to take?	yes
DOCUMENT	7. Are graphs, charts, and tables adequate for readability and interpolation or extraction of values?	no

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

I. PRESENTATION STYLE (continued)

INFO SOURCE	ITEM	COMMENT
DOCUMENT	8. If worksheets are needed to facilitate some actions, are spaces provided for recording all data and processing them (performing additions, multiplications, etc.)?	yes
DOCUMENT	9. If more than one person is required to perform the procedure, is the procedure written to one "primary" user; that is, is it clear from the way that instructions are written that one person is responsible for coordinating the activity?	no
SITE	10. Are references to external procedures limited to situations where it would be inconvenient for the operator to have the entire (referenced) instruction reiterated within this procedure?	
DOCUMENT	11. Are externally referenced procedures listed at the beginning of the procedure?	no

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

II. LEVEL OF DETAIL.

INFO SOURCE	ITEM	COMMENT
DOCUMENT	1. Are actions expressed at the step level? That is, are they driven by verbs (e.g., open, close, adjust) against <u>specific</u> controls and indicators?	no
DOCUMENT	2. Where actions require the use of controls, are specific positions given?	no
DOCUMENT	3. Where actions require the use of indicators, are specific values given?	no
DOCUMENT	4. Are control/indicator panel locations given?	no
SITE	5. Is the nomenclature used in the procedure identical to that displayed on the panels, controls, and indicators?	
SITE	6. Are indicator values called out in the procedure expressed in the same units as are shown on the indicators?	
SITE	7. Are all control panels properly marked to support this procedure?	
SITE	8. Is every operator required to practice this procedure under simulated emergency conditions at least once per month?	

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

III. ADMINISTRATIVE CONTROLS

INFO SOURCE	ITEM	COMMENT
SITE	1. Is an emergency procedure manual located in the control room and accessible by all operators?	
DOCUMENT	2. Is the title of the primary LOCA procedure referenced to an observable emergency condition?	no
SITE	3. Are the LOCA procedures easily located within the manual?	
DOCUMENT	4. Does each page provide the following identification information?	
	4.1 Procedure number and/or title	no
	4.2 Date of issue	no
	4.3 Revision number	no
	4.4 Page number	yes
DOCUMENT	5. Is the last page of the procedure clearly identifiable by marking; e.g., Page _____ of _____ ; Final Page?	no
SITE	6. Does the procedure have a unique and permanently assigned number? That is, if the procedure becomes deleted, will the number be retired rather than reassigned?	
SITE	7. If this is a temporary procedure, is it clearly marked with the expiration date?	
SITE	8. Are personnel prevented from taking the LOCA procedures out of the control room?	
SITE	9. Are documents referenced by the LOCA procedures easily located in an emergency?	

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

III. ADMINISTRATIVE CONTROLS (continued)

INFO SOURCE	ITEM	COMMENT
DOCUMENT	10. Does the procedure provide for verification and signoff of actions?	yes
DOCUMENT	11. If yes, is <u>every</u> step signed off or initialed?	no
SITE	12. If yes, are the verifications predominantly performed by persons other than those performing the action?	

EMERGENCY PROCEDURE HUMAN FACTORS CHECKLIST

IV. OPERATIONAL TEST OF LOCA PROCEDURES (SITE)

Plan a walk-through of the LOCA procedures under simulated conditions of use. Observe the following precautions:

- a. Employ a Reactor Operator selected from a group having the least experience at the plant involved.
- b. Employ a Senior Reactor Operator selected from a group having the least experience in that capacity.
- c. Postulate a plant situation known to represent LOCA conditions, but do not tell the RO or SRO in advance what it is.
- d. Plan for the operator to verbalize each step.

Conduct the walk-through under close observation, while collecting answers to the questions listed below.

COMMENT

1. Can the procedure be performed in the sequence it is written?
2. Can the operator locate and identify all controls and indicators referred to in the instructions?
3. Where general rather than specific instructions are provided, can the operator explain in detail how to perform each general instruction?
4. Can the operator perform the procedure without obtaining additional information or assistance from persons or documents not specified by the procedure?

DISCUSSION OF NEGATIVE COMMENTS
ON ARKANSAS PROCEDURAL GUIDELINES

I. PRESENTATION STYLE

Item 3: Where a decision must be made based on more than two variables, the information is not always organized to support such a decision. In some cases, decision criteria are scattered and difficult to locate. An example is the separation of decision information in Section II, Step 7.0, Pages 3, 4, and 5.

Item 4: Cautions and notes should be placed immediately ahead of the actions to which they apply. Any other location incurs the risk of their being read too early or too late for most effective use. An example of a misplaced note is shown below from Section II, Step 7.0, Page 4. This note follows the applicable actions.

NOTE: All bypass and feedwater valves are functional from the control room hand-auto stations. Feed the "A" OTSG only enough feedwater to maintain its pressure equal to "B" OTSG. Maintain the plant stable until NNI power is restored.

Item 5: Cautions and notes should NEVER be used to deliver command data. Any intended action or decision must be presented as a separate numbered statement to attract the operator's attention. An example of command data in a note is found in the example cited above in Item 4.

Item 7: Procedures often include graphs, diagrams, and charts to aid the operator. Unfortunately, print may be so small and quality of reproduction so poor that the illustration is practically illegible. Shading used to highlight procedures often obliterates headings which presumably have been included for context. An example of an inadequate diagram is found in Section III B, Steps 3.13 to 3.15, Page 15.

Item 9: Some steps appear to require that several actions be performed concurrently. Such steps are not oriented to a primary user and do not indicate responsibility for coordination of activities.

Item 11: Externally referenced procedures are not listed at the beginning of each section.

II. LEVEL OF DETAIL

Item 1: Although some of the actions are expressed as direct commands against specific controls and indicators, this is rarely the case. An example is given below from Section III C, Step 6.5, Page 24.

6.5 A problem in the feed water control system is indicated (overfeeding). Station management needs to decide whether or not a cool-down is required. If there are other abnormal symptoms, treat them per the applicable section of this procedure. If there are not abnormal symptoms, this procedure is complete.

Item 2: As indicated in Item 1, above, specific controls are rarely given. Where controls are mentioned, exact positions for the controls are generally not indicated. The verb "select" is often used where its meaning is unclear.

Item 3: Specific values for indicators are rarely provided.

Item 4: Control/indicator panel locations are not given.

III. ADMINISTRATIVE CONTROLS

Item 2: The procedure titles do not refer to observable emergency conditions.

Item 4.1: Titles are provided only at the beginnings of sections. Procedure numbers are provided only on tabulated dividers.

4.2: The date of issue is indicated only by the dated signatures on the first page of the guidelines.

4.3: Revision numbers are nowhere indicated in the guidelines.

Item 5: Pages are marked for the purpose of assuring the reader that he has (or does not have) the complete set. The final pages of the procedures evaluated are not clearly marked.

Item 11: While some steps provide for verification and signoff of actions, such provisions are not made for all steps.

SECTION 4

LIMITATIONS, CONCLUSIONS, AND RECOMMENDATIONS

LIMITATIONS

This evaluation is subject to the following limitations:

1. This evaluation does NOT address procedural completeness or accuracy. Evaluation of those properties requires knowledge of the object system.
2. This evaluation provides for but has not yet addressed SITE items. There are 16 questions that cannot be answered without observation of conditions at the plant itself. This will be accomplished at a site visit tentatively scheduled for January 1981.
3. This evaluation addresses DOCUMENT items only. It poses 22 questions regarding procedural presentation style, level of detail, and administrative controls.
4. In identifying kinds of deficiencies, no effort was made to specify individual instances within kind.
5. All deficiencies noted are considered to be correctable prior to active use of the procedures.
6. This document evaluation is based on the procedural guidelines provided by Babcock and Wilson. A complete evaluation requires a review of the actual procedures from the plant.

CONCLUSIONS

The evaluation resulted in the following conclusions:

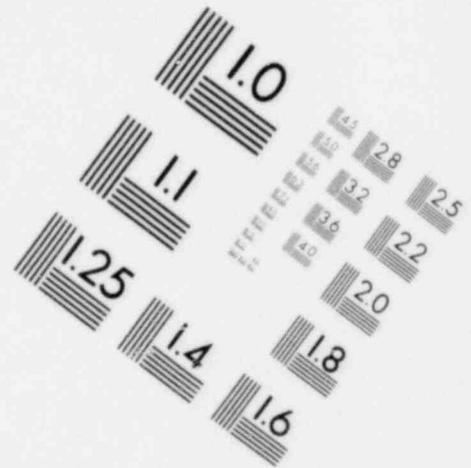
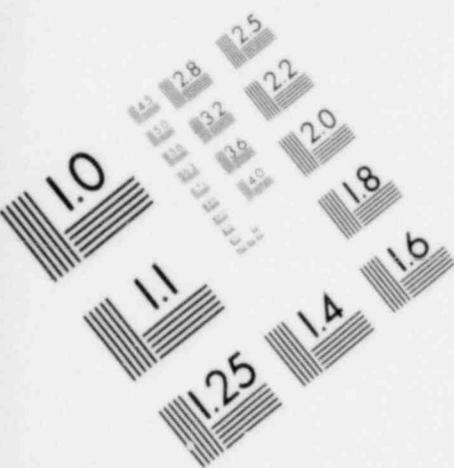
1. The guidelines were found to be acceptable on six of the 22 document characteristics examined.
2. The guidelines were found to be deficient on 16 of the 22 document characteristics examined.
3. The deficiencies fall into three categories, as follows:
 - Presentation Style 6 kinds
 - Level of Detail 4 kinds
 - Administrative Controls 6 kinds

4. Presentation style deficiencies concern multiple-variable decisions; placement and content of cautions and notes; legibility of graphs and charts; indication of a primary user; and listing of referenced procedures.
5. Level of detail deficiencies concern specificity of actions, control positions, and indicator values; and control/indicator panel location data.
6. Administrative control deficiencies concern titles of procedures, page identification data, and provisions for verification.

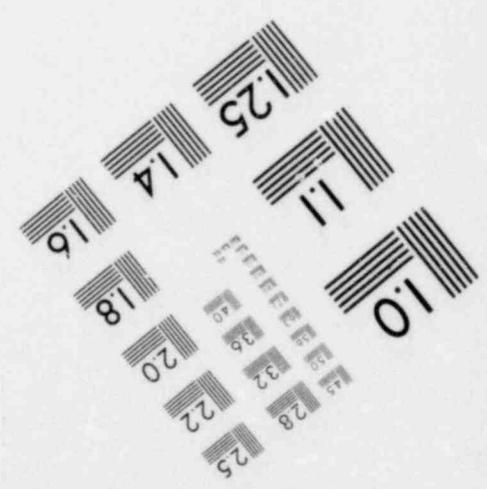
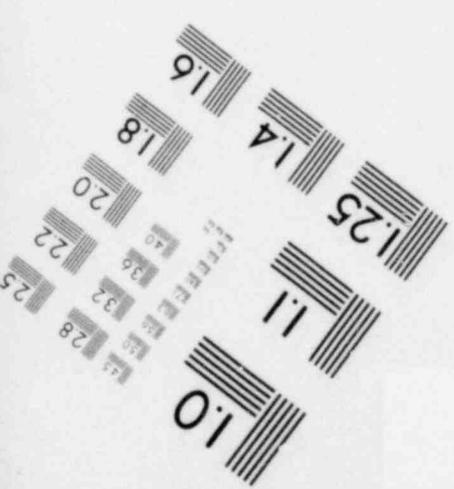
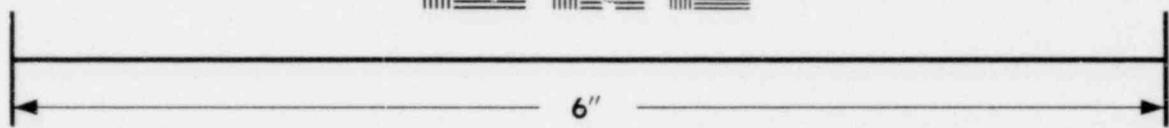
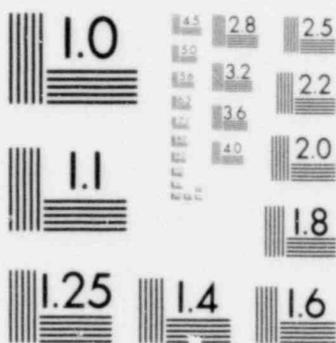
RECOMMENDATIONS

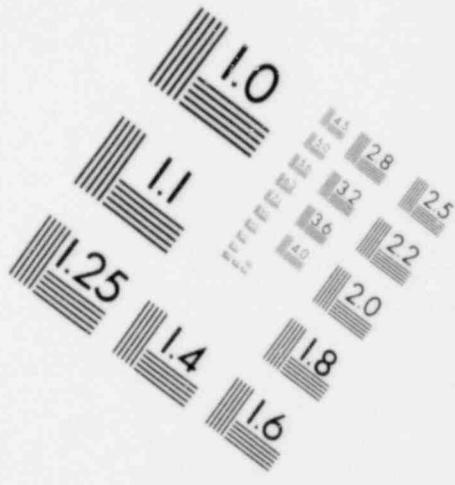
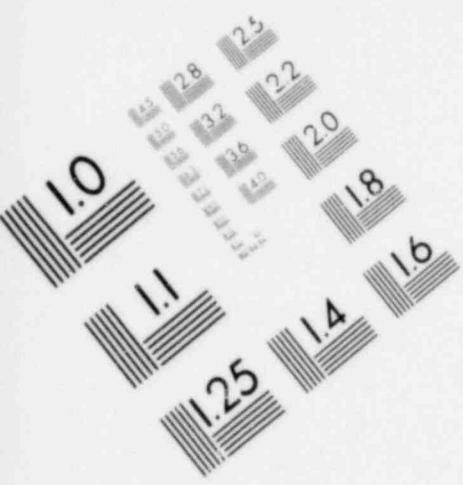
The following recommendations are presented in pursuit of effective emergency procedures at Arkansas Nuclear One.

- (I-3) On actions where decisions must be made based on more than two variables, reorganize the copy so as to make it clearer. Use a tabular format, linking desired actions or step references to specific indications or groups of indications. Number sub-steps clearly.
- (I-4) Place all caution and note messages immediately ahead of the steps to which they apply.
- (I-5) Remove all command statements from caution and note messages. Where operator actions are required, provide command steps.
- (I-7) Provide clear, legible graphs and charts to aid the operator.
- (I-9) Where necessary, indicate the need for more than one operator and provide directions for partitioning the work among them.
- (I-11) Whenever a procedure requires the use of other procedures, provide a list of these other procedures up front.
- (II-1) Express all actions at the step level, i.e., as direct command verbs against specific controls and indicators.
- (II-2) Always provide specific control positions.
- (II-3) Always provide specific indicator values.

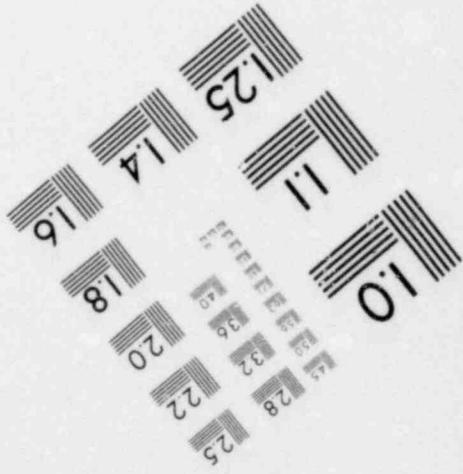
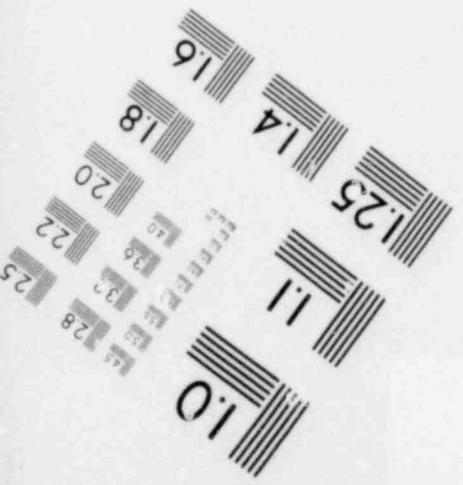
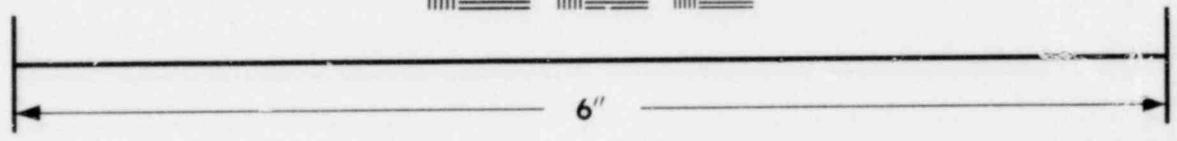
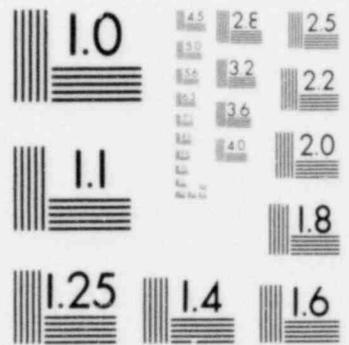


**IMAGE EVALUATION
TEST TARGET (MT-3)**





**IMAGE EVALUATION
TEST TARGET (MT-3)**



- (II-4) Show the panel location of controls and indicators referred to in the procedure.
- (III-2) Provide procedure titles that clearly reference an observable emergency condition.
- (III-4) Provide the following information on every page:
- procedure number and/or title
 - date of issue
 - revision number
- (III-5) Provide a method of clearly identifying the final page of each procedure. Consider marking each page as Page ___ of ___.
- (III-11) Provide a method of verifying all operator actions.
2. Extend the evaluation to cover procedural characteristics observable only at the plant site.
 3. Revise the procedures as indicated by the results of the plant site review.