METHODOLOGY FOR DEVELOPMENT OF EMERGENCY ACTION LEVELS

NUMARC NESP-007

The Nuclear Management
and
Resources Council, Inc.

February 1991

Revision 1

184 pp.

FORWARD

Revision 1 to NUMARC/NESP-007 presents the methodology for development of emergency action levels as an alternative to NRC/FEMA guidelines contained in Appendix 1 of NUREG-0654/FEMA-REP-1, Rev. 1 "Criteria for Preparation and Evaluation of Radiological Emergency Response pLans and Preparedness in Support of Nuclear Power Plants," October 1980 and 10 CFR 50.47 (a)(4). Revision 1 incorporates improvements for clarification and also incorporates errata from the original document. These revisions are highlighted by a vertical bar in the right margin. The Appendices included in the original have been dropped from this revision as being no longer needed.

NRC has indicated its intent to draft a revision of Regulatory Guide 1.101 stating that licensees may utilize the NUMARC EAL methodology (modified by any possible NRC exceptions) as an alternative which may be used in place of the existing NUREG-0654 Appendix 1 classification scheme.

If it is concluded upon completion of the tasks associated with plant shutdown conditions that added guidance will further improve emergency action level classification, a future revision will be provided.

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EXECUTIVE SUMMARY

Nuclear utilities must respond to a formal set of threshold conditions that require plant personnel to take specific actions with regard to notifying state and local governments and the public when certain off-normal indicators or events are recognized. Emergency classes are defined in 10 CFR 50. Levels of response and the conditions leading to those responses are defined in a joint NRC/FEMA guidelines contained in Appendix 1 of NUREG-0654/FEMA-REP-1, Rev. 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," October 1980.

The nuclear utility industry has had over eight years of experience in adapting these NRC guidelines, which have been a good beginning, to specific plant configurations, using them both in exercises and under actual emergency conditions. As a result, a number of improvements have been identified as NUREG-0654, Appendix 1 guidelines have been applied in the development of plant Emergency Action Levels (EALs). The purpose of this study is to re-evaluate EALs in the context of utility operating experience.

The study develops a systematic approach and supporting basis for EAL development. This methodology develops a set of generic EAL guidelines, together with the basis for each, so that they can be used and adapted by each utility on a consistent basis. The review of the industry's experiences with EALs, in conjunction with regulatory considerations, was applied directly to the development of this generic set of EAL guidelines. The generic guidelines are intended to clearly define conditions that represent increasing risk to the public and can give consistent classifications when applied at different sites.

The guidance presented here is not intended to be applied to plants as-is. It is intended to give the user the logic for developing site-specific EALs (i.e., instrument readings, etc.) using site-specific EAL presentation methods (formats). Basis information is provided to aid station personnel in preparation of their own site-specific EALs, to provide necessary information for training, and for explanation to state and local officials. In addition, state and local requirements have not been reflected in the generic guidance and should be considered on a case-by-case basis with appropriate state and local emergency response organizations. It is important that the NUMARC guideline EALs be treated as an integrated package. Selecting only portions of this guidance for use in developing site-specific EALs can lead to inconsistent or incomplete EALs.

Each Task Force utility member provided copies of their plant Initiating Conditions (ICs) and EALs, taken from the Emergency Plan Implementing Procedures (EPIPs) for each of their nuclear power stations. Additional plant ICs and EALs were obtained through NUMARC. The total sample reflected in the study includes 26 plants, representing 16 utilities. The study reviewed at least one PWR and one BWR in each NRC region, and obtained examples of EALs for as many variations of plant and containment designs as possible. All four commercial light water reactor suppliers are represented. Utility EALs reviewed by the Task Force are summarized in Table 1 of this report.

The EAL analysis included results of interviews with nuclear industry professionals who have had experience in the development and use of EALs: nuclear plant operating personnel, emergency response support personnel, and emergency planners. The Task Force developed a detailed questionnaire to be sent in advance to the selected utilities and used as the interview guide. These interviews were completed in September 1988. Utility affiliation of interviewees is noted in Table 1 of this report.
The results of these interviews are summarized in Table 2 of this report.

The Task Force conducted a careful review of the relevant parts of 10 CFR 50, and how the regulations were interpreted in two NUREG documents that have dealt specifically with EALs: NUREG-0654/FEMA-REP-1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants"; and NUREG-0818, "Emergency Action Levels for Light Water Reactors". This review of the pertinent regulatory documents was performed as a basis for developing or reinforcing key definitions. The review led to the conclusion that the current regulatory structure was not an impediment to the development of the appropriate EALs. Rather, the detailed guidance currently in place could be enhanced. In addition, alternate schemes such as a new or parallel emergency classes were examined, as well as the French Severity Scale. These were rejected as duplicating existing regulations, or requiring substantial revisions of existing regulations with minimal added benefit.

Based on the above review of regulations, review of common utility usage of terms, discussions among Task Force members, and existing published information, the following terms were defined by the Task Force:

- Emergency Class
- Initiating Condition (IC)
- Emergency Action Level (EAL)

Under the current implementation of emergency classes, every "Unusual Event" that currently is being reported is considered by many to be a nuclear accident, no matter what explanation is provided. The current implementation of the NUREG-0654 guidelines may not foster public understanding.

The Task Force reviewed the advantages and disadvantages of symptom-based, barrier-based, and event-based ICs and EALs and found that each type had application over the plant technical specification operating modes. This is illustrated by Figure 1 of this report.

Although the basic concerns with barrier integrity and the major safety problems of nuclear power plants are similar across plant types, design differences will have a substantial effect on EALs. The major differences are found between a BWR and a PWR. In these cases, EAL guidelines unique to BWRs and PWRs must be specified. Even among PWRs, however, there are substantial differences in design and in types of containment used. There is enough commonality among plants that many ICs will be the same or very similar. However, others will have to match plant features and safety system designs that are unique to the plant type or even to the specific plant.

The Task Force identified eight characteristics that were to be incorporated into

model EALs. These were:

(1) Consistency (i.e., the EALs would lead to similar decisions under similar circumstances at different plants);

(2) Human engineering and user friendliness;

(3) Potential for classification upgrade only when there is an increasing threat to public health and safety;

(4) Ease of upgrading and downgrading;

(5) Thoroughness in addressing, and disposing of, the issues of completeness and accuracy raised regarding NUREG-0654, Appendix 1;

(6) Technical completeness and appropriateness for each classification level;

(7) A logical progression in classification for combinations of multiple events;

(8) Objective, observable values.

The Task Force concluded that the EAL development procedure is much easier to understand if it can be visualized as a matrix. Figure 2 of this report presents such a matrix, with the column headings as emergency classes and the rows as ICs.

Using the concept of an IC/EAL Matrix and recognizing that there are thresholds between emergency classes, it then becomes important to define the emergency classes so that proper thresholds can be determined. There are three considerations related to emergency classes. These are:

(1) The potential impact on radiological safety, either as now known or as can be reasonably projected;

(2) How far the plant is beyond its predefined design, safety, and operating envelopes; and

(3) Whether or not conditions that threaten health are expected to be confined to within the site boundary.

Thus, higher emergency classification represents higher risk.

The Task Force then reviewed upgrading and downgrading and makes the following recommendations:

UPGRADING - The best approach is basing the emergency class on the highest EAL reached with appropriate consideration for Emergency Director judgement. Properly structured EALs, which include equivalent risk, will appropriately escalate to a higher emergency class.

DOWNGRADING - A combination approach involving going to recovery from General Emergencies and some Site Area Emergencies and termination from Unusual Events, Alerts, and certain Site Area Emergencies causing no long-term plant damage appears to be the best choice. Downgrading to lower emergency classes adds notifications but may have merit under certain circumstances.

The Task Force examined human factors considerations and has the following recommendations:

LEVEL OF INTEGRATION OF EALs WITH PLANT PROCEDURES - Visual cues in the plant procedures that it is appropriate to consult the EALs is a method currently used by several utilities. This method can be effective when it is tied to appropriate training. Notes in the appropriate plant procedures to consult the EALs can also be used. It should be noted that this discussion is not restricted to only the emergency procedures; alarm recognition procedures, abnormal operating procedures, and normal operating procedures that apply to cold shutdown and refueling modes should also be included. In addition, EALs can be based on entry into particular procedures or existence of particular Critical Safety Function conditions.

METHOD OF PRESENTATION - The method of presentation or format of EALs should be one with which the operations and health physics staff are comfortable. As is the case for emergency operating procedures, bases for steps should be in a separate (or separable) document suitable for training and for reference by emergency response personnel and offsite agencies. Each nuclear plant should already have presentation and human factors standards as part of its procedure writing guidance. EALs that are consistent with those procedure writing standards (in particular, emergency operating procedures which most closely correspond to the conditions under which EALs must be used) should be the norm for each utility.

SYMPTOM-BASED, EVENT-BASED, OR BARRIER-BASED EALs - The Task Force recommends use of a combination approach that ranges from primarily event-based for Unusual Events to primarily symptom- or barrier-based for General Emergencies. This is to better assure that timely recognition and notification occurs, that events occurring during refueling and cold shutdown are appropriately covered, and that multiple events can be effectively treated in the EALs.

Based on the information gathered and reviewed, the Task Force has developed generic EAL guidance. Because of the wide variety of presentation methods (formats) used at different utilities, the Task Force believes that specifying guidance as to what each IC and EAL should address, and including sufficient basis information for each EAL will best assure uniformity of approach. The information is presented by Recognition Category:

- A - Abnormal Rad Levels/Radiological Effluent
- F - Fission Product Barrier Degradation
- H - Hazards and Other Conditions Affecting Plant Safety
- S - System Malfunction

Each of the EAL guides in Recognition Categories A, H, and S is structured in the following way:

- Recognition Category - As described above.
- Emergency Class - Unusual Event, Alert, Site Area Emergency or General Emergency.
- Initiating Condition - Symptom- or Event-Based, Generic Identification and Title.

- Operating Mode Applicability - Power Operation, Hot Standby, Hot Shutdown, Cold Shutdown, Refueling, Defueled or All.

- Example Emergency Action Level(s) corresponding to the IC.

- Basis information for plant-specific readings and factors that may relate to changing the generic IC or EAL to a different emergency class, such as for Loss of All AC Power.

For Recognition Category F, basis information is presented in a format consistent with Tables 3 and 4 in Section 5.0. The presentation method shown for Fission Product Barriers was chosen to clearly show the synergism among the EALs and to support more accurate dynamic assessments. Other acceptable methods of achieving these goals which are currently in use include flow charts, block diagrams, and checklist tables.

The EAL Guidance has the primary threshold for Unusual Events as operation outside the safety envelope for the plant as defined by plant technical specifications, including LCOs and Action Statement Times. In addition, certain precursors of more serious events such as loss of offsite AC power and earthquakes are included in Unusual Event EALs. This provides a clear demarcation between the lowest emergency class and "non-emergency" notifications specified by 10 CFR 50.72.

ACRONYMS

AC	Alternating Current
AEOD	NRC Office for Analysis and Evaluation of Operational Data
ATWS	Anticipated Transient Without Scram
B&W	Babcock and Wilcox
BWR	Boiling Water Reactor
CCW	Component Cooling Water
CE	Combustion Engineering
CECO	Commonwealth Edison Company
CFR	Code of Federal Regulations
CSF	Critical Safety Function
CSFST	Critical Safety Function Status Tree
CP&L	Carolina Power & Light Company
DC	Direct Current
DHR	Decay Heat Removal
DOT	Department of Transportation
EAL	Emergency Action Level
ECCS	Emergency Core Cooling System
ECL	Emergency Classification Level
EOP	Emergency Operating Procedure
EPA	Environmental Protection Agency
EPG	Emergency Procedure Guideline
EPIP	Emergency Plan Implementing Procedure
EPRI	Electric Power Research Institute
ERG	Emergency Response Guideline
ESF	Engineered Safeguards Feature
ESW	Emergency Service Water
FEMA	Federal Emergency Management Agency
FSAR	Final Safety Analysis Report
GE	General Electric
GPU	General Public Utilities
HPCI	High Pressure Coolant Injection
HPSI	High Pressure Safety Injection
IC	Initiating Condition

ACRONYMS (Continued)

LCO	Limiting Condition of Operation
LER	Licensee Event Report
LILCO	Long Island Lighting Company
LOCA	Loss of Coolant Accident
LPSI	Low Pressure Safety Injection
MPC	Maximum Permissible Concentration
MSIV	Main Steam Isolation Valve
mR	milliRem
Mw	Megawatt
NRC	Nuclear Regulatory Commission
NUE	Notification Of Unusual Event
NUMARC	Nuclear Management and Resources Council
OBE	Operating Basis Earthquake
ODCM	Offsite Dose Calculation Manual
PSIG	Pounds per Square Inch Gauge
R	Rem
RCIC	Reactor Core Isolation Cooling
RPS	Reactor Protection System
SBGTS	Stand-By Gas Treatment System
SG	Steam Generator
SPDS	Safety Parameter Display System
SRO	Senior Reactor Operator
SSE	Safe Shutdown Earthquake
TVA	Tennessee Valley Authority
UE	Unusual Event
WE	Westinghouse Electric
WOG	Westinghouse Owners Group
WPPSS	Washington Public Power Supply System

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1.0 METHODOLOGY FOR DEVELOPMENT OF EMERGENCY ACTION LEVELS

1.1 BACKGROUND

Nuclear utilities must respond to a formal set of threshold conditions that require plant personnel to take specific actions with regard to notifying state and local governments and the public when certain off-normal indicators or events are recognized. Emergency classes are defined in 10 CFR 50. Levels of response, and the conditions leading to those responses are defined in joint NRC/FEMA guidelines contained in Appendix 1 of NUREG-0654/FEMA-REP-1, Rev. 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," October 1980.

The nuclear utility industry has had over eight years of experience in adapting these NRC guidelines, which were a good starting point, to specific plant configurations, using them both in exercises and under actual emergency conditions. As a result, a number of improvements have been identified as NUREG-0654 Appendix 1 guidelines have been applied in the development of plant Emergency Action Levels (EALs).

Emergency situations have developed that were not contemplated when the guidelines were written, leaving plant personnel without specific guidance to determine the emergency class. In other cases, inconsistencies among the example initiating conditions (ICs) that define a particular emergency class, and the broad range of potential risks implied by the ICs within those bounds, have forced some utilities to take inappropriate levels of emergency actions. Further, there are broad variations in the way the NUREG-0654 guidelines have been applied by the different utilities. There is a probability that two plants, faced with the same set of conditions, would arrive at different determinations of the level of emergency being faced.

The potential of misclassifying an emergency are real. Additionally, the industry has had over eight years of experience in developing and using EALs. It is for this reason that NUMARC established a Task Force to conduct a "Re-evaluation of Emergency Action Levels."

1.2 TASK FORCE CHARTER

The purpose of this study is to re-evaluate EALs in the context of utility operating experience. The nuclear industry has the hands-on experience with developing and applying the regulations and regulatory guidance. Thus, nuclear utilities are in a good position to evaluate EAL guidance and develop a comprehensive, generic set of EALs.

The study develops a systematic methodology and supporting basis for EAL development. This methodology is used to develop a set of generic EAL guidelines, together with the basis, so that they can be used and adapted by each utility in a consistent manner. A review of the industry's experiences with EALs, in conjunction with regulatory considerations, was applied directly to the development of a generic

set of EAL guidelines.

1.3 STRUCTURE OF THE STUDY

The study was conducted in two phases. Phase I activities included a review of the regulatory basis for the current EAL structure; analysis of existing EALs from a representative sample of nuclear power plant types, designs and locations; determination of the strengths and weaknesses of current EAL approaches; and development of a methodology for future EAL development. Phase II developed generic EAL guidelines that apply to both BWR and PWR plants along with a basis for each EAL guideline.

The EAL analysis included results of interviews with nuclear industry professionals who have had experience in the development and use of EALs: nuclear plant operating personnel, emergency response support personnel, and emergency planners. These interviews were completed in September 1988.

2.0 CURRENT EMERGENCY ACTION LEVEL USAGE

2.1 UTILITY CONCERNS

In order to get the EAL Study moving, the NUMARC Task Force held a two-day kick-off meeting June 8 and 9, 1988, at the NUMARC offices in Washington. The meeting included representatives of the eight task force utilities and the NRC. Each of the utility members provided an overview of the EAL process at their utility, including background, methodology, strengths, weaknesses and planned revisions. General comments and concerns raised by the Task Force members included:

- After eight years of operating experience, the time has come to revisit the NRC guidance on EALs derived from 10 CFR 50 and promulgated in NUREG-0654 and NUREG-0818, "Emergency Action Levels for Light Water Reactors," October 1981. For years, utilities have been upgrading their EALs. The industry therefore has the experience necessary to conduct a thorough review of EALs and to propose improvements to NUREG-0654, thus this study was initiated.

- ICs and EALs are defined differently; terms like symptom, event, and barrier-based ICs need to be defined and applied uniformly; some plants integrate their Emergency Operating Procedures (EOPs) with their EALs, and some do not; some plants have applied technical specification operating mode considerations to their event classifications, some have not.

- NRC EAL guidance can easily be misinterpreted in EAL documents. Many initiating conditions (ICs) have been misclassified, some ICs have not been classified at all and some events should not be classified as emergencies.

- The notification requirements of the "Notification of Unusual Event" and "Alert" emergency classifications leave operations staff with little flexibility. As EALs are presently constituted under these emergency classes, they can detract from plant operations.

- Each NRC Region's inspectors interpret and apply EAL regulations differently. For example, whenever one utility's NRC Hotline is down, this utility must declare an "Unusual Event." However, other utilities in other regions declare such events as a "reportable event."

2.2 SCENARIO APPLICATIONS

Following the utility overviews, several scenarios were presented to the Task Force members to gauge the variability in EAL classification processes among the utilities. The results of that exercise were as expected, with several utilities identifying different emergency classifications from the same scenario data and calling for different levels of emergency response.

2.3 INITIAL DATA COLLECTION

Each Task Force utility member provided copies of their plant ICs and EALs, taken from the Emergency Plan Implementing Procedures (EPIPs) for each of their nuclear power stations. Additional plant ICs and EALs were obtained through NUMARC. Total sample reflected in the study includes 26 plants, representing 16 utilities.

2.3.1 Sample Characteristics

The study reviewed at least one PWR and one BWR in each NRC region, and obtained examples of EALs for as many variations of plant and containment designs as possible. Table 1 gives a summary of the units that have been examined and entered into the study data base. The 26 stations consisting of 38 nuclear units evaluated by the Task Force are located in 14 states, throughout all five NRC regions and in nine of the ten FEMA regions (only FEMA Region VIII is not represented). The sample contains 15 PWR stations (22 units) and 11 BWR stations (16 units). Among the PWRs, there are 2, 3 and 4 loop plants. The sample reflects all major PWR and BWR containment designs. All four commercial light water reactor suppliers are represented: Babcock & Wilcox, Combustion Engineering, General Electric, and Westinghouse.

2.3.2 Data Base Structure

This data base contains over 1750 ICs and EALs. Using dBase III Plus[1] the Task Force was able to load these ICs and EALs and group and sort them according to various plant and IC characteristics. The data base also allowed comparisons among plants and utilities by IC category, operating mode, methodology and other IC characteristics. For example, the Task Force was able to focus on the impacts that plant technical differences have on IC development by indexing IC categories with certain parameters (e.g., BWR and PWR reactors; number of steam generators for PWRs; containment design; etc.). The data base also offers the capability to organize these data easily for presentation. Each IC and its associated EAL(s) make up one record in the data base. Each record contains several fields that help identify and describe the IC and EAL.

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[1] dBase III Plus is a product of Ashton-Tate.

TABLE 1

PLANT EAL INFORMATION EXAMINED IN THIS STUDY

OPERATOR	PLANT	REACTOR TYPE	MFG	NRC REGION	STATE
Arizona Public Service	Palo Verde	PWR (2 loop)	CE	V	AZ
CP&L	Brunswick	BWR	GE	II	NC
CP&L	Robinson	PWR (3 loop)	WE	II	SC
CP&L	Harris	PWR (3 loop)	WE	II	NC
CECO	Braidwood	PWR (4 loop)	WE	III	IL
CECO	LaSalle*	BWR	GE	III	IL
Consolidated Edison	Indian Pt-2	PWR (4 loop)	WE	I	NY
Consumers Power	Big Rock Pt	BWR	GE	III	MI
Consumers Power	Palisades	PWR (2 loop)	CE	III	MI
Duke Power	Oconee	PWR (2 loop)	B&W	II	SC
Duke Power	Catawba	PWR (4 loop)	WE	II	SC
Duke Power	McGuire	PWR (4 loop)	WE	II	NC
GPU	Oyster Creek	BWR	GE	I	NJ
GPU	TMI-1	PWR (2 loop)	B&W	I	PA
Gulf States Utilities	River Bend*	BWR	GE	IV	LA
Illinois Power	Clinton	BWR	GE	III	IL
WCNOC	Wolf Creek*	PWR (4 loop)	WE	IV	KS
LILCO	Shoreham	BWR	GE	I	NY
Northeast Utilities	Millstone-1	BWR	GE	I	CT
Northeast Utilities	Millstone-2	PWR (2 loop)	CE	I	CT
Northeast Utilities	Millstone-3	PWR (4 loop)	WE	I	CT
Northeast Utilities	Conn-Yankee	PWR (4 loop)	WE	I	CT
Pennsylvania Power & Light	Susquehanna*	BWR	GE	I	PA
Public Service of New Hampshire	Seabrook	PWR (4 loop)	WE	I	NH
TVA	Browns Ferry*	BWR	GE	II	AL
WPPSS	WNP-2	BWR	GE	V	WA

* Included in site visit.

2.4 UTILITY EAL STRUCTURES AND OPERATING EXPERIENCE

The following discussion addresses some of the preliminary findings of the Task Force from an initial EAL Task Force workshop meeting held June 8 and 9, 1988, reviews of plant ICs and EALs, and related research. For certain utilities, information has been provided on how EAL structures and definitions have progressed over the past eight years. For others, the discussion will be limited to a structural analysis of the materials collected.

In addition, interviews were conducted at a number of plants, as noted in Table 1. In preparation for these interviews, the Task Force developed a detailed questionnaire to be sent in advance to the selected utilities and used as the interview guide. An overview of interview results is shown in Table 2.

2.4.1 Utility EAL Structures

Utility #1. This utility's initial EALs were taken directly from NUREG-0654. Subsequently, each of the utility's plants designed their own EALs. This led to significant inconsistencies among the plants that made it difficult for corporate staff and others to interpret and apply the EALs. However, the utility, like Utility #8, is moving towards generic EALs. Four of the utility's plants are now using the NRC-approved generic EALs. The utility's EALs are based on alarm setpoints and technical specification requirements, making it easier for operators to interpret and apply the EALs.

Generic EALs have several benefits for this utility. First, personnel from different plants can understand each other's EALs. Second, off-site and corporate personnel need only be familiar with one standard EAL format. And third, the NRC can give blanket approval to a utility's generic EALs, rather than review each plant's EALs.

Two of this utility's PWR stations use the same columnar format and the same ICs. ICs are listed at the top of each page and the corresponding EALs are given. The IC, "Radioactive Effluent Releases to the Environment," is divided into "Gaseous Release" and "Liquid Release" EALs. There are some differences in the ICs and their EALs between PWRs and BWRs. For example, "Secondary System Malfunctions, applies only to PWRs. Utility #1 notes this in its BWR EPIP, by leaving the Secondary System Malfunction page blank, but includes the IC so that the IC numbering can remain generic.

Utility plants include their philosophy documentation immediately after the EALs. Each EAL is cited and the reference number is given for quick reference. The EAL is further detailed and the appropriate NUREG-0654 example is referenced, if applicable.

Utility #2. Each of the three utility PWR stations had their own EALs and each plant viewed EALs differently. These EALs were later revised by utility SRO's. The NRC has generally gone along with their changes, although there were some disapprovals. Now, all three plants have documents that look alike, although their EALs differ somewhat to reflect technology differences.

There have been problems with the utility's EALs. One station's personnel have encountered problems downgrading during drills. There are specific upgrading criteria that can be followed, but downgrading criteria are lacking. There are still some questions whether to go directly into recovery at a certain emergency

level, or downgrade and then go into recovery. Downgrading is a judgement call on the part of emergency personnel. Training does direct them to look at certain plant conditions, but if an emergency director feels a condition warrants a downgrading, the emergency is downgraded.

The utility's EALs are in a tabular format and the plants' Technical Specifications factor heavily in classifying an emergency. The EALs are generally symptom-based, with most EALs consisting of several alternative indicators of an IC within each emergency classification.

Utility #3. At one of the PWR stations, this utility uses the most elaborate and inclusive emergency classification flow chart of any plant in the sample. The "Emergency Action Level Network," as the utility calls its EAL flowchart, can be entered via the Critical Safety Function Status Board, a breached barrier, or an off-normal event. Once the Network has been entered, users are instructed to review certain clarifying definitions on entry to the network. Next, the EAL flowpath is reviewed, containing ICs and EALs. The EAL flowpath can be entered at any time, at the discretion of the Site Emergency Coordinator. There are approximately 170 decision points involved in determining an emergency classification, in addition to the Critical Safety Function Status Tree also used by operators. The utility operators like the flowpath, although corporate and offsite personnel may find them difficult to understand.

Like other utilities in the sample, Utility #3 is concerned about misclassification of events. Of the approximately twenty unusual events declared since its latest PWR station received its license, only two have been safety-related. The utility has redefined its EALs somewhat, in order to reduce the frequency of declaring an Unusual Event, but such classifications do continue.

Utility #4. The utility's BWR station began with NUREG-0654 look-alike EALs. Since then, the utility has made significant changes to its EALs, and has reinterpreted some points. Today, the utility uses event-, symptom- and barrier-based EALs. The symptom-based ICs are "big picture" ICs, such as reactor coolant temperature and suppression pool temperature.

Previously, the station considered a symptom-based approach that tied most events to instrument readings. However, these efforts were ended. The approach was good for operators, but other emergency personnel are not as familiar with instrumentation and do not have immediate access to these indicators. Despite different interpretations and significant changes to their EALs, the utility has had no major problems in changing their EALs.

Utility #4 has not addressed a number of NUREG-0654 example ICs in its EALs. The utility has developed documentation explaining why certain ICs were left out its NRC regional inspectors have agreed to these exclusions.

The station EALs are narrative and are grouped by IC. The IC is listed at the top of the page and the corresponding EALs are grouped by emergency classification. The responsibilities of the shift supervisor, emergency director, recovery manager and others are outlined in the front of the EALs. A checklist is provided so that these personnel can quickly confirm that the proper classification procedures have been followed. Emergency class definitions are also provided.

Utility #5. This utility has two nuclear plants, a BWR station and a PWR station. The utility has not developed generic EALs that can be applied to both stations. Both stations use tabular formats, although there are table layout differences. This format does not work well, but plant operators do not like flow charts either.

Instead of using NUREG-0654 examples, the BWR station EAL designers use a Probabilistic Risk Assessment (PRA) approach. The regional inspectors approved this approach, with some exceptions. The BWR station EALs are 14 pages long, with one or more ICs per page. The first column contains a "key word." This is not an IC, as the Task Force has defined it. The second column, labeled "Emergency Action Level," does correspond to the Task Force definition of an IC. The third column is labeled "event" and corresponds to our EAL definition. The last column indicates the emergency classification.

The PWR station used the NUREG-0654 examples, with some changes, to develop its EALs. The PWR station EALs are 33 pages long, with one IC per page. The first column is the emergency classification. Column two is the "Emergency Action Level," essentially the NUREG-0654 ICs, with some adaptations, functioning as EALs. Column three is labeled "Method of Detection" and indicates how the emergency personnel are supposed to know an EAL has been met. The last column, labeled "Actions" indicates what onsite and offsite notification actions must be taken. PWR may revise its EALs to be similar to the BWR station EALs.

Utility #6. This utility's BWR station used NUREG-0654 guidance verbatim and adding an Alert required by the state.

The EAL document is divided into two sections. The first section is in a columnar format. The first column lists the NUREG-0654 ICs, the second column, the plant specific EALs. Section 1 is used by state and local officials. Like NUREG-0654, these EALs are grouped only by emergency classification. Should an event occur that is not classified, the Site Emergency Director is instructed to "use his professional judgement in classifying any events not listed into the proper category."

The second section of the EAL document is also in a columnar format. The EALs are grouped by category and subcategory, but not by ICs as defined in this report. This section is used by plant operators. It is an abbreviated and categorized version of Section 1.

The utility has also started a "low-threshold event" classification for certain events, so that a Notification of Unusual Event does not have to be declared. This event is communicated to state and local officials by fax machine, up to one day after the incident.

Utility #7. At this utility's BWR station, the first EALs were in a two-column format. The left column listed the NUREG-0654 EALs and the right column indicated specific plant parameters (similar to Utility #6's BWR station). This utility has revised its EALs significantly at its BWR station since then. The utility found that the lower classifications are very difficult to interpret and apply. In particular, the station's "emergency director's judgement" IC has led to some over-classifying of events, particularly at the Unusual Event level.

The station now uses a matrix approach. The BWR station EALs are grouped, by what the utility calls "Categories." These are not ICs, as the Task Force has

defined ICs, but are concise, general classifications for the EALs. For the NRC's benefit, an appendix to the EAL document provides justification for the ICs and EALs and cites the corresponding NUREG-0654 examples. This station has incorporated their EALs somewhat into their EOPs. In addition, the BWR station uses specific EOP wording in their EALs. The EOPs instruct operations personnel on what actions to take in response to an event and indicate what EAL event classification they should reference. Although these references do not point to specific EALs within the classification level, they do point operations personnel back to the EALs.

The utility's PWR station's EALs are similar. Like the BWR station, the PWR station uses concise, general category descriptions. In addition, the PWR station subcategorizes the EALs. These categories are useful to emergency personnel trying to identify appropriate EALs, but they offer little assistance in trying to identify the plant condition. The EALs alone fulfill this function.

Utility #8. This utility's first set of ICs was taken verbatim from NUREG-0654. However, the utility made a number of modifications over the years and is currently using its fourth generation of Emergency Plan Implementing Procedures (EPIPs). The EAL structure the utility has developed is essentially generic, and is applied to all four nuclear plants. Although there are some differences in ICs and EALs necessitated by the different reactor types (e.g., BWR, PWR) and reactor suppliers, the format is the same and changes to the EALs for all four plants can be made simultaneously.

The EALs are grouped under the four major 10 CFR 50 classifications with two subdivisions to accommodate its State Posture Code requirements: General Emergency Alpha (applicable only to the offsite dose EAL), General Emergency Bravo, Site Area Emergency, Alert, Unusual Event Delta-Two (applicable only to the Rad Release EAL), and Unusual Event Delta-One.

A major effort has been made to keep the complexity of the utility's EALs to a minimum. The EALs are reviewed by individuals from a variety of disciplines and now reflect human factor considerations. As a result, these EALs can be easily used by SROs, state officials, and corporate management. The utility is working to provide "flags" related to the EALs in each unit's EOPs, while still maintaining a generic approach that can be used by plants with a variety of reactor and plant system designs.

The utility expressed concern that NRC guidelines are not keeping pace with changes in the industry. The utility revised its NUREG-based EALs to remedy perceived shortcomings in NUREG-0654. The methodology is a combination of event-symptom and symptom-barrier approaches.

Utility #9. Operating mode considerations form an integral part of the utility's BWR station EALs. The EAL document is quite voluminous. To help operators classify an off-normal event, the utility has developed an "Event Classification Sheet." Emergency personnel place a check mark beside every applicable event. An "Emergency Classification Guide Flowchart" is used for quick reference. Using this flowchart, the operator checks the appropriate event categories on the Event Classification Sheet.

For each event category checked, emergency personnel turn to supporting documentation, totaling almost 170 pages. The ICs are grouped by event category

and the EALs for each IC are discussed. The applicable operating modes are also indicated. After reviewing this documentation, emergency personnel are to place check marks next to the corresponding classification and number(s) on the Event Classification Sheet. The appropriate EAL(s) are also recorded. The appropriate emergency classification is then declared.

Utility #10. This utility combines ICs and EALs into what they term "Initiating Conditions" for its BWR station. These ICs are not categorized but are grouped by emergency classification, and within these emergency classifications, "Symptomatic Initiating Conditions" and "Situation Based Initiating Conditions" are used. Some ICs are actually divided into ICs and EALs, as the Task Force defines them, but most are not.

A one page summary of all the ICs (in an EAL format) and their emergency classifications is also included. Following these guidelines are situation basis documentation and engineering basis documentation that can be referenced if needed.

Utility #11. This utility's PWR station EALs are based on three main considerations:

- The extent of fission product barrier challenge or failure;
- The projected/actual offsite dose rate associated with radioactive releases; and
- Potential or actual reductions in the level of plant safety.

Emergency personnel classify fission product barrier challenges or failures using a one page summary checklist.

This checklist was developed over a period of time, with intensive participation of plant operating personnel. The intent is to simplify and speed decisions in an emergency. The IC is "Barrier Challenge/Failure Classification Criteria." The EALs are the check points. The shift supervisor/emergency coordinator is required to check the appropriate box. If 1 check is made, then 1 barrier is lost or challenged and an "Alert" is to be declared, if 2 checks are made, then 2 barriers are lost or challenged, and a "Site Area Emergency" is declared; and if 3 checks are made, then 3 barriers are lost or challenged and a "General Emergency" is declared.

Offsite dose projection emergency classifications are determined by symptom-based EALs under the "Offsite Dose Projection Classification Criteria." The EALs are the various monitor readings.

Non-reactor trip events (defined as potential or actual reductions in the level of plant safety) are grouped by ICs and use a combination of symptom- and event-based EALs.

Utility #12. This utility's PWR station uses a fission-product barrier approach as a basis for determining the emergency classification. An "Alert" is "the confirmed loss of 1 barrier," a "Site Area Emergency" is "the confirmed loss of any 2 barriers" and a "General Emergency" is "the confirmed: a) loss of all 3 barriers, or b) greater than 20% of core inventory released to containment." However, if there are no barrier threats, there is an "Unusual Event" table,

with the following ICs:

- Technical specification limit exceeded (EALs are grouped by operational and radiological specifications);
- Personnel;
- Power Loss;
- Fire, Security, Hazards;
- Natural Phenomena; and
- Operational.

2.4.2 Operating Experience as Derived from Plant Interviews

Interviews with utility personnel, including operations, training, emergency planning, health physics, and corporate emergency response support personnel were conducted during August and September 1988. The following stations were visited:

- Region I
  - Beaver Valley
  - Susquehanna
- Region II
  - Duke Power - Oconee, McGuire, Catawba (Pilot Interview)
  - Browns Ferry
- Region III
  - LaSalle
  - Zion
- Region IV
  - Wolf Creek
  - River Bend
- Region V
  - WNP-2
  - Palo Verde

Sites for interviews were selected based on covering the following factors:

- Number of units on site (1, 2, or 3)
- Single station and multiple station nuclear utilities
- All reactor vendors
- All containment types
- All NRC Regions
- Multiple approaches to EALs

An overview of interview results is presented in Table 2.

TABLE 2

RESULTS OF PLANT INTERVIEWS

Overview Of Results

- Emergency Classification procedures developed by each utility differ.
- Varied opinions about the use and purpose of the Notification of Unusual Event (NUE) Category. This category has had a negative impact on operations staff personnel during an emergency.
    - The required notification process distracts operations personnel at just the time when their actions to mitigate the off-normal event are most needed.
    - The NUE declaration does little good for the offsite emergency response organizations. Notification to offsite officials during a NUE is generally for information purposes only.
- Events with no safety impact or alternative non-emergency classification should be deleted.
- EALs having ambiguous wording have made interpretation difficult.
- EALs should be written in a format that licensed operators are comfortable with, because they are first to see an emergency. Procedures should ease the burden placed on operations personnel when initially classifying and reporting an event.
- Use and interpretation of EALs, especially for offsite emergency response support personnel, is not always understood.
- NRC Regions have not been uniform in required adherence to NUREG-0654 Appendix 1.

3.0 DEVELOPMENT OF BASIS FOR GENERIC APPROACH

An essential early step in the overall "Re-evaluation of Emergency Action Levels" was a literature review. The search for existing information was greatly expedited by assistance from the NUMARC/NESP Task Force. Information gained by review of published materials was augmented by the input of utility personnel who responded to either direct interview or a prepared questionnaire (see previous section for more information).

The review of plant-specific materials indicated that the concepts of Emergency Action Level (EAL) and Initiating Condition (IC) have many different interpretations to the nuclear utilities. In some plant Emergency Plan Implementing Procedures (EPIPs), EAL and IC are used interchangeably. In others, the category that effectively is used as an IC is given another name, such as event, module, condition, abnormal condition, etc. Further, most plants have some way of grouping ICs into functional categories; and some plants have two levels of hierarchical IC groupings.

Much of this confusion stems from the lack of terminology definition. Therefore, as a first step toward establishing generic EAL approaches, it became necessary to capture an accurate understanding of both the term "Emergency Action Level" and key terms related to it (e.g., initiating condition, emergency class, etc.) within the context of relevant regulatory requirements.

3.1 REGULATORY CONTEXT

The Task Force conducted a careful review of the relevant parts of 10 CFR 50, and how the regulations were interpreted in two NUREG documents that have dealt specifically with EALs: NUREG-0654/FEMA-REP-1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," October 1980; and NUREG-0818, "Emergency Action Levels for Light Water Reactors," October 1981. This review of the pertinent regulatory documents was performed as a basis for developing or reinforcing key definitions. The review led to the conclusion that the current regulatory structure was not an impediment to the development of the appropriate EALs. Rather, the detailed guidance currently in place could be enhanced. A brief synopsis of the regulatory framework is presented below.

Nuclear power reactor licensees are required to have NRC-approved "emergency response plans" for dealing with "radiological emergencies." The requirements call for both onsite and offsite emergency response plans, with the offsite plans being those approved by FEMA and used by the State and local authorities. *This document deals with the utilities' approved onsite plans and procedures* for response to radiological emergencies at nuclear power plants, and the links they provide to the offsite plans.

Section 50.47 of Title 10 of the Code of Federal Regulations (10 CFR 50.47), entitled "Emergency plans," states the requirement for such plans. Part (a)(1) of this regulation states that "no operating license will be issued unless a finding is

made by NRC that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency."

The major portion of 10 CFR 50.47 lists "standards" that emergency response plans must meet. The "standards" constitute a detailed list of items to be addressed in the plans. Of particular importance to this project is the fourth standard, which addresses "emergency classification" and "action levels." These terms, however, are not defined in the regulation.

10 CFR 50.54, "Conditions of licenses," emphasizes that power reactor licensees must "follow, and maintain in effect, emergency plans which meet the standards in Part 50.47(b) and the requirements in Appendix E to this part." The remainder of this part deals primarily with required implementation dates.

10 CFR 50.54(q) allows licensees to make changes to emergency plans without prior Commission approval only if: (a) the changes do not decrease the effectiveness of the plans and (b) the plans, as changed, continue to meet 10 CFR 50.47(b) standards and 10 CFR 50 Appendix E requirements. The licensee must keep a record of any such changes. Proposed changes that decrease the effectiveness of the approved emergency plans may not be implemented without application to and approval by the Commission.

10 CFR 50.72 deals with "Immediate notification requirements for operating nuclear power reactors." The "immediate" notification section actually includes three types of reports: (1) immediately after notification of State or local agencies (for emergency classification events); (2) one-hour reports; and, (3) four-hour reports.

Although 10 CFR 50.72 contains significant detail, it does not define either "Emergency Class" or "Emergency Action Level." But one-hour and four-hour reports are listed as "non-emergency events," namely, those which are "not reported as a declaration of an Emergency Class." Certain 10 CFR 50.72 events can also meet the Notification of Unusual Event emergency classification if they are precursors of more serious events. These situations also warrant anticipatory notification of state and local officials. (See Section 3.7, "Emergency Class Descriptions".)

By footnote, the reader is directed from 10 CFR 50.72 to 10 CFR 50 Appendix E, for information concerning "Emergency Classes."

10 CFR 50.73 describes the "Licensee event report system," which requires submittal of follow-up written reports within thirty days of required notification of NRC.

10 CFR 50 Appendix E, Section B, "Assessment Actions," mandates that emergency plans must contain "emergency action levels." EALs are to be described for: (1) determining the need for notification and participation of various agencies, and (2) determining when and what type of protective measures should be considered. Appendix E continues by stating that the EALs are to be based on:

(1) In-plant conditions;
(2) In-plant instrumentation;
(3) Onsite monitoring; and
(4) Offsite monitoring.

10 CFR 50 Appendix E, Section C, "Activation of Emergency Organization," also addresses "emergency classes" and "emergency action levels." This section states that EALs are to be based on:

(1) Onsite radiation monitoring information;
(2) Offsite radiation monitoring information; and,
(3) Readings from a number of plant sensors that indicate a potential emergency, such as containment pressure and the response of the Emergency Core Cooling System.

This section also states that "emergency classes" shall include:

(1) Notification of Unusual Events,
(2) Alert,
(3) Site Area Emergency, and
(4) General Emergency.

This section then cites NUREG-0654 for a further discussion of the emergency classes.

Although definitions of "emergency class" and "emergency action level" are not given explicitly, the regulations do offer sufficient information to imply intent.

Without the use of definitions, NUREG-0818 captures (in a single paragraph) what the Task Force believes to be the proper intended use of the three terms, defined below.

> The Nuclear Regulatory Commission (NRC) has established four classes of emergencies. They are, in order of increasing seriousness: notification of unusual event, alert, site area emergency, and general emergency. Appendix 1 of an NRC document, NUREG-0654 Rev. 1, provides example initiating conditions for each of the four emergency classes. These initiating conditions form the basis for the establishment by each licensee of specific plant instrument readings which, if exceeded, would indicate that a given initiating condition had been met and that the appropriate class of emergency must be declared. The plant-specific instrument readings are called emergency action levels (EALs). Their purpose is to provide a clear basis for the rapid identification of a possible problem and for the notification of offsite authorities that an emergency exists."

Although it is believed that the above paragraph offers the clearest available explanation of terms, the following is noted:

(1) "Emergencies" includes both non-radiological and radiological emergencies without distinction;

(2) "Emergency action levels" are restricted to only plant-specific instrument readings (symptom-based EALs).

In addition, some states have regulations for licensee notification to notify them that encompass and, in some cases, go beyond 10 CFR 50.72. Some states have prescribed their own emergency notification schemes.

One of the options considered by the Task Force was creation of a non-emergency Class "X." The purpose of "Class X" would be to remove non-emergency events from the radiological reporting structure, clarifying both the type and level of emergency, if any, that the facility has declared. However, the one-hour and four-hour "non-emergency" reports in 10 CFR 50.72 already cover this category. Therefore, items not belonging in the Emergency Class Structure can be covered under 10 CFR 50.72 "non-emergency" notifications.

In addition to "Class X," another option for non-radiological emergencies that was considered by the Task Force is a non-nuclear emergency notification structure that is parallel to the emergency class structure noted above. This structure would be clearly identified as a system for handling industrial emergencies where there is no existing radiological component and no potential for one to develop. However, there are already reporting requirements (EPA, OSHA) that exist under which utilities already operate. Thus, this option was rejected as unnecessary and outside the scope of this study.

In addition, the French severity scale with six escalating levels based on the criteria of (1) external radioactive releases, (2) internal radioactive leaks, (3) radioactive contamination of plant personnel, and (4) reduction of safety level of the plant was also reviewed by the Task Force. The method used by the French does not appear to offer any advantages over the NUMARC-sponsored EAL development method, which is based on existing US NRC regulations.

3.2 DEFINITIONS NEEDED TO DEVELOP EAL METHODOLOGY

Based on the above review of regulations, review of common utility usage of terms, discussions among Task Force members, and existing published information, the following definitions apply to the generic EAL methodology:

> **EMERGENCY CLASS:** One of a minimum set of names or titles, established by the Nuclear Regulatory Commission (NRC), for grouping off-normal nuclear power plant conditions according to (1) their relative radiological seriousness, and (2) the time-sensitive onsite and off-site radiological emergency preparedness actions necessary to respond to such conditions. The existing radiological emergency classes, in ascending order of seriousness, are called:
>
> - Notification of Unusual Event
> - Alert
> - Site Area Emergency
> - General Emergency

Discussion:

As previously noted, the regulations refer the reader to NUREG-0654 for a discussion of emergency classes. However, NUREG-0654 does not explicitly define either "emergency class" or "emergency action level." The document calls for an "emergency classification scheme" and an "emergency action level scheme" as set forth in NUREG-0654 Appendix 1. Appendix 1 then begins with the very confusing phrase: "Four classes of Emergency Action Levels."

The Task Force believes, in accord with the position taken in NUREG-0818, that the beginning sentence of NUREG-0654 Appendix 1 may be a simple structural error. The sentence reads:

Four classes of Emergency Action Levels are established which replace the classes in Regulatory Guide 1.101, each with associated examples of initiating conditions.

The intention was the establishment of four classes of emergencies (not classes of EALs) with increasing levels of seriousness. As used in this document, Emergency Action Levels (EALs) are synonymous with Emergency Classification Levels (ECLs).

INITIATING CONDITION (IC): One of a predetermined subset of nuclear power plant conditions where either the potential exists for a radiological emergency, or such an emergency has occurred.

Discussion:

In NUREG-0654, the NRC introduced the term "initiating condition." Although several example initiating conditions are contained in NUREG-0654 Appendix 1, the document does not provide a definition of the term.

Since the term is commonly used in nuclear power plant emergency planning, the above definition has been developed and combines both regulatory intent and the greatest degree of common usage among utilities.

Defined in this manner, an IC is an emergency condition, which sets it apart from the broad class of conditions that may or may not have the potential to escalate into a radiological emergency. It can be a continuous, measurable function that is outside technical specifications, such as elevated RCS temperature or falling reactor coolant level (a symptom). It also encompasses occurrences such as fire (an event) or reactor coolant pipe failure (an event or a barrier breach).

EMERGENCY ACTION LEVEL (EAL): A pre-determined, site-specific, observable threshold for a plant Initiating Condition that places the plant in a given emergency class. An EAL can be: an instrument reading; an equipment status indicator; a measurable parameter (onsite or offsite); a discrete, observable event; results of analyses; entry into specific emergency operating procedures; or another phenomenon which, if it occurs, indicates entry into a particular emergency class.

Discussion:

The term "emergency action level" has been defined by example in the regulations, as noted above discussion concerning regulatory background. The term had not, however, been defined operationally in a manner to address all contingencies.

There are times when an EAL will be a threshold point on a measurable continuous function, such as a primary system coolant leak that has exceeded technical specifications for a specific plant.

At other times, the EAL and the IC will coincide, both identified by a discrete event that places the plant in a particular emergency class. For example, "Train Derailment Onsite" is an example of an "Unusual Event" IC in NUREG-0654 that also can be an event-based EAL.

3.3 DIFFERENCES IN PERSPECTIVE

The purpose of this effort is to define a methodology for EAL development that will better assure a consistent emergency classification commensurate with the level of risk. The approach must be easily understood and applied by the individuals responsible for onsite and offsite emergency preparedness and response. In order to achieve consistent application, this recommended methodology must be accepted at all levels of application (e.g., licensed operators, health physics personnel, facility managers, offsite emergency agencies, NRC and FEMA response organizations, etc).

Commercial nuclear facilities are faced with a range of public service and public acceptance pressures. It is of utmost importance that emergency regulations be based on as accurate an assessment of the risk as possible. There are evident risks to health and safety in understating the potential hazard from an event. However, there are both risks and costs to alerting the public to an emergency that exceeds the true threat. This is true at all levels, but particularly if evacuation is recommended.

3.4 RECOGNITION CATEGORIES

One such grouping is familiar to all plant operators and emergency planners. This is the symptom-, event- and barrier-based grouping of ICs and EALs. Figure 1 illustrates when each of these categories is most effective. This figure arrays typical plant technical specification operating modes against a set of internal and external parameters where ICs can be identified.

The symptom-based category for ICs and EALs refers to those indicators that are measurable over some continuous spectrum, such as core temperature, coolant levels, containment pressure, etc. When one or more of these indicators begin to show off-normal readings, reactor operators are trained to identify the probable causes and potential consequences of these "symptoms" and take corrective action. The level of seriousness indicated by these symptoms depends on the degree to which they have exceeded technical specifications, the other symptoms or events that are occurring contemporaneously, and the capability of the licensed operators to gain control and bring the indicator back to safe levels.

Event-based EALs and ICs refer to occurrences with potential safety significance, such as the failure of a high-pressure safety injection pump, a safety valve failure, or a loss of electric power to some part of the plant. The range of seriousness of these "events" is dependent on the location, number of contemporaneous events, remaining plant safety margin, etc.

Barrier-based EALs and ICs refer to the level of challenge to principal barriers used to assure containment of radioactive materials contained within a nuclear power plant. For radioactive materials that are contained within the reactor core, these barriers are: fuel cladding, reactor coolant system pressure boundary, and containment. The level of challenge to these barriers encompasses the extent of damage (loss or potential loss) and the number of barriers concurrently under challenge. In reality, barrier-based EALs are a subset of symptom-based EALs that deal with symptoms indicating fission product barrier challenges. These barrier-based EALs are primarily derived from Emergency Operating Procedure (EOP) Critical Safety Function (CSF) Status Tree Monitoring (or their equivalent). Challenge to one or more barriers generally is initially identified through instrument readings and periodic sampling. Under present barrier-based EALs,

deterioration of the reactor coolant system pressure boundary or the fuel clad barrier usually indicates an "Alert" condition, two barriers under challenge a Site Area Emergency, and loss of two barriers or three barriers under challenge is a General Emergency. Usually, the containment barrier is weighted less than the reactor coolant system pressure boundary and the fuel clad barriers. Loss or potential loss of the containment barrier alone can be treated as an Unusual Event.

Symptom-based ICs and EALs are most easily identified when the plant is in a normal startup, operating or hot shutdown mode of operation, with all of the barriers in place and the plant's instrumentation and emergency safeguards features fully operational as required by technical specifications. It is under these circumstances that the operations staff has the most direct information of the plant's systems, displayed in the main control room. As the plant moves through the decay heat removal process toward cold shutdown and refueling, barriers to fission products are reduced (i.e., reactor coolant system pressure boundary may be open) and fewer of the safety systems required for power operation are required to be fully operational. Under these plant operating modes, the identification of an IC in the plant's operating and safety systems becomes more event-based, as the instrumentation to detect symptoms of a developing problem may not be fully effective; and engineered safeguards systems, such as the Emergency Core Cooling System (ECCS), are partially disabled as permitted by the plant's Technical Specifications.

Barrier-based ICs and EALs also are heavily dependent on being able to monitor instruments that indicate the condition of plant operating and safety systems. Fuel cladding integrity and reactor coolant levels can be monitored through several indicators when the plant is in a normal operating mode, but this capability is much more limited when the plant is in a refueling mode, when many of these indicators are disconnected or off-scale. The need for this instrumentation is lessened, however, and alternate instrumentation is placed in service when the plant is shut down.

It is important to note that in some operating modes there may not be definitive and unambiguous indicators of containment integrity available to control room personnel. For this reason, barrier-based EALs should not place undue reliance on assessments of containment integrity in all operating modes. Technical Specifications generally do not require maintaining containment integrity in modes 5 and 6 in order to provide flexibility in performance of specific tasks during shutdown conditions. Containment pressure and temperature indications may not increase if there is a pre-existing breach of containment integrity. At most plants, a large portion of the containment's exterior cannot be monitored for leakage by radiation monitors.

Several categories of emergencies have no instrumentation to indicate a developing problem, or the event may be identified before any other indications are recognized. A reactor coolant pipe could break; fire alarms could sound; radioactive materials could be released; and any number of other events can occur that would place the plant in an emergency condition with little warning. For emergencies related to the reactor system and safety systems, the ICs shift to an event basis as the plant mode moves toward cold shutdown and refueling modes. For non-radiological events, such as fire, external floods, wind loads, etc., as described in NUREG-0654 Appendix 1, event-based ICs are the norm.

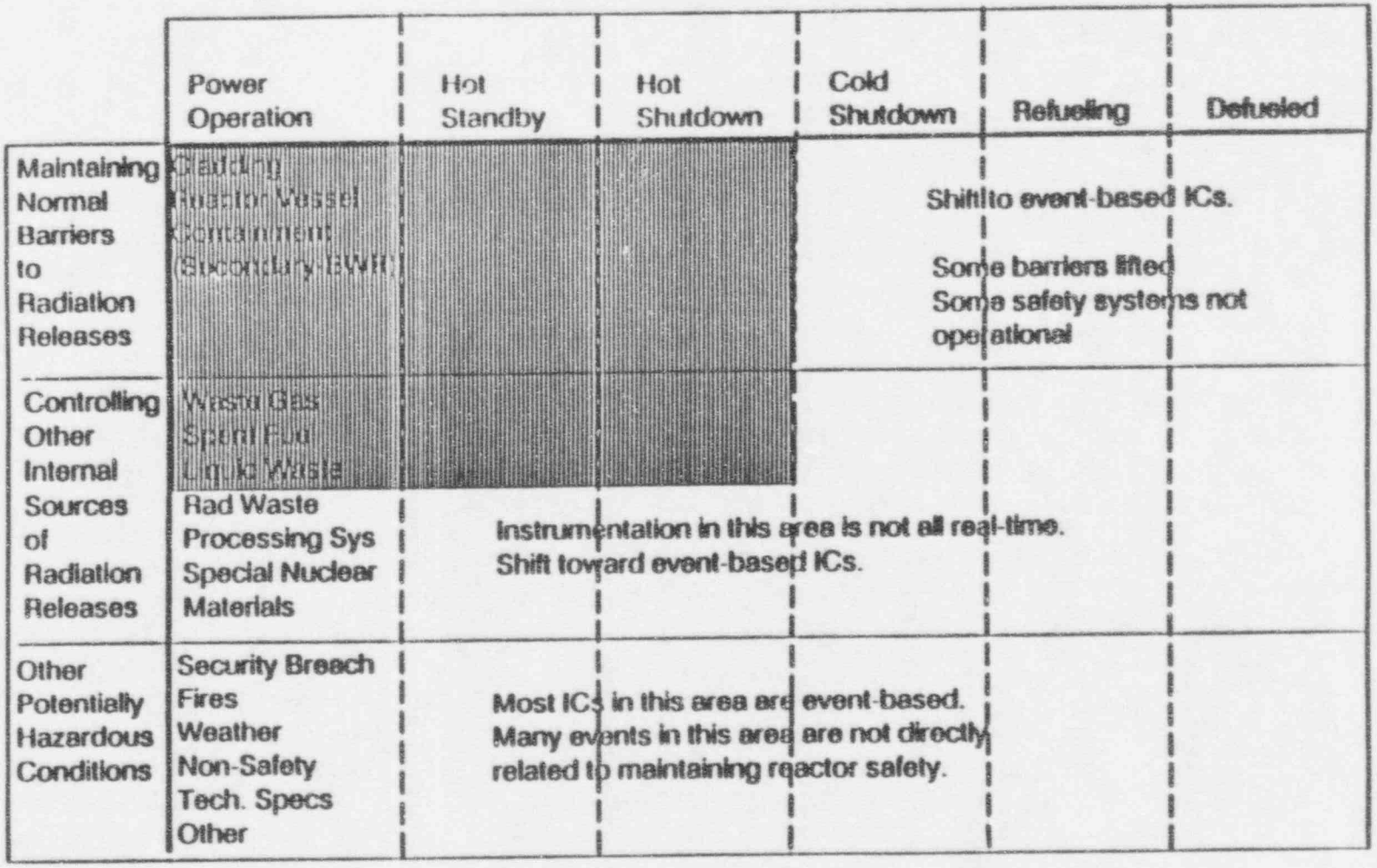
In many cases, a combination of symptom-, event- and barrier-based ICs will be present as an emergency develops. In a loss of coolant accident (LOCA), for example:

- Coolant level is dropping; (symptom)
- There is a leak of some magnitude in the system (pipe break, safety valve stuck open) that exceeds plant capabilities to make up the loss; (barrier breach or event)
- Core (coolant) temperature is rising; (symptom) and
- At some level, fuel failure begins with indicators such as high off-gas, high coolant activity samples, etc. (barrier breach or symptom)

FIGURE 1

BASIS FOR INITIATING CONDITIONS

TYPICAL NUCLEAR PLANT OPERATING MODES



KEY

Lined area indicates availability of maximum real-time instrumentation. Symptom and barrier-based procedures are most effective in this range.

3.5 DESIGN DIFFERENCES

Although the same basic concerns with barrier integrity and the major safety problems of nuclear power plants are similar across plant types, design differences will have a substantial effect on EALs. The major differences are found between a BWR and a PWR. In these cases, EAL guidelines unique to BWRs and PWRs must be specified. Even among PWRs, however, there are substantial differences in design and in types of containment used.

There is enough commonality among plants that many ICs will be the same or very similar. However, others will have to match plant features and safety system designs that are unique to the plant type or even to the specific plant. The basis for each EAL guideline should supply sufficient information as to what is required for a site-specific EAL.

3.6 REQUIRED CHARACTERISTICS

The Task Force identified eight characteristics that were to be incorporated into model EALs. These were:

(1) Consistency (i.e., the EALs would lead to similar decisions under similar circumstances at different plants);

(2) Human engineering and user friendliness;

(3) Potential for classification upgrade only when there is an increasing threat to public health and safety;

(4) Ease of upgrading and downgrading;

(5) Thoroughness in addressing, and disposing of, the issues of completeness and accuracy raised regarding NUREG-0654 Appendix 1;

(6) Technical completeness for each classification level;

(7) A logical progression in classification for multiple events; and

(8) Objective, observable values.

The EAL development procedure pays careful attention to these eight characteristics to assure that all are addressed in the proposed EAL methodology. The most pervasive and complex of the eight is the first--"consistency." The common denominator that is most appropriate for measuring consistency among ICs and EALs is relative risk. The Task Force approach toward definition of an EAL development methodology is based on risk assessment to set the boundaries of the emergency classes and assure that all EALs that trigger that emergency class are in the same range of relative risk. Precursor conditions of more serious emergencies also represent a potential risk to the public and must be appropriately classified.

3.7 EMERGENCY CLASS DESCRIPTIONS

The EAL development procedure is much easier to understand if it can be visualized as a matrix. Figure 2 presents such a matrix, with the column headings as emergency classes and the rows as ICs. An additional dimension on the matrix is a continuum of risk, increasing from left to right in each row. This implies that each cell in the matrix is defined by a lower level of risk on the left boundary and the highest level of risk on the right boundary. There is no equivalent function from top to bottom of the matrix.

Having established the concept of an EAL Matrix and that there are thresholds between emergency classes, it then becomes important to define the emergency classes so that proper thresholds can be determined. As a starting point, the descriptions of the four emergency classes, contained in NUREG-0654 Appendix 1, were examined by the Task Force members. These descriptions were found to be acceptable. Additional discussion is provided on threshold determinations to eliminate ambiguities and to assist in formulation of appropriate IC and EAL guidelines.

There are three considerations related to emergency classes. These are:

(1) The potential impact on radiological safety, either as now known or as can be reasonably projected;

(2) How far the plant is beyond its predefined design, safety, and operating envelopes; and

(3) Whether or not conditions that threaten health are expected to be confined to within the site boundary.

The Task Force ICs deal explicitly with radiological safety impact by escalating from levels corresponding to releases within regulatory limits to releases beyond EPA Protective Action Guideline (PAG) plume exposure levels. In addition, the "Discussion" sections below include offsite dose consequence considerations which were not included in NUREG-0654 Appendix 1.

NOTIFICATION OF UNUSUAL EVENT: Unusual events are in process or have occurred which indicate a potential degradation of the level of safety of the plant. No releases of radioactive material requiring offsite response or monitoring are expected unless further degradation of safety systems occurs.

Discussion:

Potential degradation of the level of safety of the plant is indicated primarily by exceeding plant technical specification Limiting Condition of Operation (LCO) allowable action statement time for achieving required mode change. Precursors of more serious events should also be included because precursors do represent a potential degradation in the level of safety of the plant. Minor releases of radioactive materials are included. In this emergency class, however, releases do not require monitoring or offsite response (e.g., dose consequences of less than 10 millirem).

ALERT: Events are in process or have occurred which involve an actual or potential substantial degradation of the level of safety of the plant. Any releases are expected to be limited to small fractions of the EPA Protective Action Guideline exposure levels.

Discussion:

Rather than discussing the distinguishing features of "potential degradation" and "potential substantial degradation," a comparative approach would be to determine whether increased monitoring of plant functions is warranted at the Alert level as a result of safety system degradation. This addresses the operations staff's need for help, independent of whether an actual decrease in plant safety is determined. This increased monitoring can then be used to better determine the actual plant safety state, whether escalation to a higher emergency class is warranted, or whether de-escalation or termination of the emergency class declaration is warranted. Dose consequences from these events are small fractions of the EPA PAG plume exposure levels, i.e., about 10 millirem to 100 millirem.

SITE AREA EMERGENCY: Events are in process or have occurred which involve actual or likely major failures of plant functions needed for protection of the public. Any releases are not expected to result in exposure levels which exceed EPA Protective Action Guideline exposure levels except near the site boundary.

Discussion:

The discriminator (threshold) between Site Area Emergency and General Emergency is whether or not the EPA PAG plume exposure levels are expected to be exceeded outside the site boundary. This threshold, in addition to dynamic dose assessment considerations discussed in the EAL guidelines, clearly addresses NRC and offsite emergency response agency concerns as to timely declaration of a General Emergency.

GENERAL EMERGENCY: Events are in process or have occurred which involve actual or imminent substantial core degradation or melting with potential for loss of containment integrity. Releases can be reasonably expected to exceed EPA Protective Action Guideline exposure levels offsite for more than the immediate site area.

Discussion:

The bottom line for the General Emergency is whether evacuation or sheltering of the general public is indicated based on EPA PAGs, and therefore should be interpreted to include radionuclide release regardless of cause. In addition, it should address concerns as to uncertainties in systems or structures (e.g. containment) response, and also events such as waste gas tank releases and severe spent fuel pool events postulated to occur at high population density sites. To better assure timely notification, EALs in this category must primarily be expressed in terms of plant function status, with secondary reliance on dose projection. In terms of fission product barriers, loss of two barriers with potential loss of the third barrier constitutes a General Emergency.

3.8 EMERGENCY CLASS THRESHOLDS

Once the EAL matrix structure is defined as shown in Figure 2, the next step is to define the thresholds for each emergency class. The most common bases for establishing these boundaries are the technical specifications and setpoints for each plant that have been developed in the design basis calculations and the Final Safety Analysis Report (FSAR).

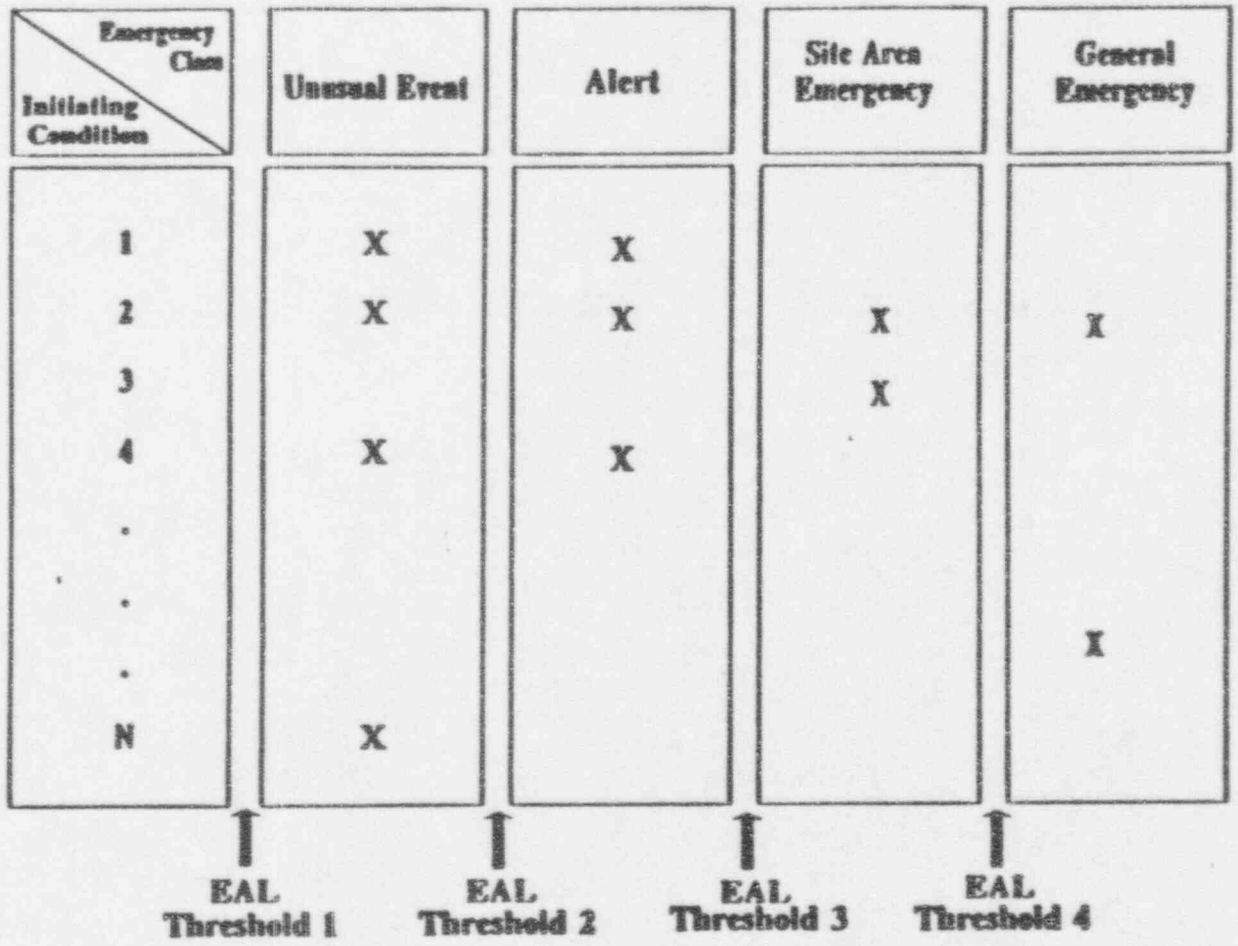
For those conditions that are easily measurable and instrumented, the boundary is likely to be the EAL (observable by plant staff, instrument reading, alarm setpoint, etc.) that indicates entry into a particular emergency class. For example, the main steam line radiation monitor may detect high radiation that triggers an alarm. That radiation level also may be the setpoint that closes the main steam isolation valve (MSIV) and initiates the reactor scram. This same radiation level threshold, depending on plant-specific parameters, also may be the appropriate EAL for a direct entry into an emergency class.

In addition to the continuously measurable indicators, such as coolant temperature, coolant levels, leak rates, containment pressure, etc., the FSAR provides indications of the consequences associated with design basis events. Examples would include steam pipe breaks, MSIV malfunctions, and other anticipated events that, upon occurrence, place the plant immediately into an emergency class.

Another approach for defining these boundaries is the use of a plant-specific probabilistic risk assessment (PRA). PRAs have been completed for several individual plants, but this is by no means comprehensive. There are, however, PRAs that have been completed for representative plant types such as is done in NUREG-1150, "Severe Accident Risks: An Assessment for Five Nuclear Power Plants," as well as several other utility-sponsored PRAs. Existing PRAs can be used as a good first approximation of the relevant ICs and risk associated with emergency conditions for existing plants. Generic insights from PRAs and related severe accident assessments which apply to EALs and emergency class determinations are:

1. Core damage frequency at many BWRs is dominated by sequences involving prolonged loss of all AC power. In addition, prolonged loss of all AC power events are extremely important at PWRs. This would indicate that should this occur, and AC power is not restored within 15 minutes, entry into the emergency class at no lower than a Site Area Emergency when the plant was initially at power would be appropriate. This also implies that precursors to loss of all AC power events should also be appropriately included in the EAL structure.

FIGURE 2
EAL MATRIX



INCREASING RISK ⟶

2. For severe core damage events, uncertainties exist in phenomena important to accident progressions leading to containment failure. Because of these uncertainties, predicting containment integrity may be difficult in these conditions. This is why maintaining containment integrity alone following sequences leading to severe core damage may be an insufficient basis for not escalating to a General Emergency.

3. A review of four full-scope PRAs (3 PWR, 1 BWR) shows that leading contributors to latent fatalities were containment bypass, large LOCA with early containment failure, station blackout greater than 6 hours (e.g., LOCA consequences of Station Blackout), and reactor coolant pump seal failure. This indicates that generic EAL methodology must be sufficiently rigorous to cover these sequences in a timely fashion.

Another critical element of the analysis to arrive at these threshold (boundary) conditions is the time that the plant might stay in that condition before moving to a higher emergency class. In particular, station blackout coping analyses performed in response to 10 CFR 50.63 and Regulatory Guide 1.155, "Station Blackout," may be used to determine whether a specific plant enters a Site Area Emergency or a General Emergency directly, and when escalation to General Emergency is indicated. The time dimension is critical to the EAL since the purpose of the emergency class for state and local officials is to notify them of the level of mobilization that may be necessary to handle the emergency. This is particularly true when a "Site Area Emergency" or "General Emergency" is imminent. Establishing EALs for such conditions must take estimated evacuation time into consideration to minimize the potential for the plume to pass while evacuation is underway.

Regardless of whether or not containment integrity is challenged, it is possible for significant radioactive inventory within containment to result in EPA PAG plume exposure levels being exceeded even assuming containment is within technical specification allowable leakage rates. With or without containment challenge, however, a major release of radioactivity requiring offsite protection actions from core damage is not possible unless a major failure of fuel cladding allows radioactive material to be released from the core into the reactor coolant. NUREG-1228, "Source Estimations During Incident Response to Severe Nuclear Power Plant Accidents," indicates that such conditions do not exist when the amount of clad damage is less than 20%.

3.9 EMERGENCY ACTION LEVELS

With the emergency classes defined, the thresholds that must be met for each EAL that is to be placed under the emergency class can be determined. There are two basic approaches to determining these EALs. EALs and emergency class boundaries coincide for those continuously measurable, instrumented ICs, such as radioactivity, core temperature, coolant levels, etc. For these ICs, the EAL will be the threshold reading that most closely corresponds to the emergency class description using the best available information.

For discrete (discontinuous) events, the approach will have to be somewhat different. Typically, in this category are internal and external hazards such as fire or earthquake. The purpose for including hazards in EALs is to assure that station personnel and offsite emergency response organizations are prepared to deal with consequential damage these hazards may cause. If, indeed, hazards have caused damage to safety functions or fission product barriers, this should be confirmed by

symptoms or by observation of such failures. Therefore, the Task Force believes it appropriate to enter an Alert status for events approaching or exceeding design basis limits such as Operating Basis Earthquake, design basis wind loads, fire within vital areas, etc. This would give the operating staff additional support and improved ability to determine the extent of plant damage unless damage to barriers or challenges to Critical Safety Functions (CSFs) have occurred or are identified, then the additional support can be used to escalate or terminate. The Emergency Class could be escalated or terminated based on what is then found. Of course, security events must reflect potential for increasing security threat levels.

Plant emergency operating procedures (EOPs) are designed to maintain and/or restore a set of CSFs which are listed in the order of priority for restoration efforts during accident conditions. While the actual nomenclature of the CSFs may vary among plants, generally the PWR CSF set includes:

- Subcriticality
- Core cooling
- Heat sink
- Pressure-temperature-stress (RCS integrity)
- Containment
- RCS inventory

There are diverse and redundant plant systems to support each CSF. By monitoring the CSFs instead of the individual system component status, the impact of multiple events is inherently addressed, e.g., the number of *operable* components available to maintain the *function*.

The EOPs contain detailed instructions regarding the monitoring of these functions and provides a scheme for classifying the significance of the challenge to the functions. In providing EALs based on these schemes, the emergency classification can flow from the EOP assessment rather than being based on a separate EAL assessment. This is desirable as it reduces ambiguity and reduces the time necessary to classify the event.

As an example, consider that the Westinghouse Owner's Group (WOG) Emergency Response Guidelines (ERGs) classify challenges as YELLOW, ORANGE, and RED paths. If the core exit thermocouples exceed 1200 degrees F or 700 degrees F with low reactor vessel water level, a RED path condition exists. The ERG considers a RED path as "... an extreme challenge to a plant function necessary for the protection of the public ..." This is almost identical to the present NRC NUREG-0654 description of a site area emergency "... actual or likely failures of plant functions needed for the protection of the public ..." It reasonably follows that if any CSF enters a RED path, a site area emergency exists. A general emergency could be considered to exist if core cooling CSF is in a RED path and the EOP function restoration procedures have not been successful in restoring core cooling.

3.10 TREATMENT OF MULTIPLE EVENTS AND EMERGENCY CLASS UPGRADING

The above discussion deals primarily with simpler emergencies and events that may not escalate rapidly. However, usable EAL guidance must also consider rapidly evolving and complex events. Hence, emergency class upgrading and consideration of multiple events must be addressed.

The Task Force review of existing EALs shows there are three approaches presently in use for covering multiple events and emergency class upgrading. These approaches

are:

(U1) Multiple contemporaneous events are counted and are the basis for escalating to a higher emergency class. For example, two or more contemporaneous Alerts escalate to a Site Area Emergency.

(U2) The emergency class is based on the highest EAL reached. For example, two Alerts remain in the Alert category. Or, an Alert and a Site Area Emergency is a Site Area Emergency.

(U3) Emergency Director judgement. Although all emergency classifications require judgement, some utilities rely on Emergency Director judgement with little or no additional explicit guidance.

An additional approach for plants with PRAs is to make use of event tree analysis to define combinations of events which lead to equivalent risks. Such event sequences should have an equal emergency classification assigned. However, the chief drawback to this approach as well as (U1) above, is that multiple events may be masked when they actually occur. Further, for plants using symptom-based (and barrier-based) emergency procedures, direct perception of multiple events is unnecessary.

Emergency class upgrading for multi-unit stations with shared safety-related systems and functions must also consider the effects of a loss of a common system on more than one unit (e.g. potential for radioactive release from more than one core at the same site). For example, many two-unit stations have their control panels for both units in close proximity within the same room. Thus, control room evacuation most likely would affect both units. There are a number of other systems and functions which may be shared at a given multi-unit station. This must be considered in the emergency class declaration and in the development of appropriate site-specific ICs and EALs based on the generic EAL guidance.

Although the majority of the EALs provide very specific thresholds, the Emergency Director must remain alert to events or conditions that lead to the conclusion that exceeding the EAL threshold is imminent. If, in the judgement of the Emergency Director, an imminent situation is at hand, the classification should be made as if the thresholds has been exceeded. While this is particularly prudent at the higher emergency classes (as the early classification may provide for more effective implementation of protective measures), it is nonetheless applicable to all emergency classes.

TASK FORCE RECOMMENDATION:

The best approach is (U2) above with appropriate consideration for Emergency Director judgement EALs. Properly structured EALs on a fission product barrier basis and which include equivalent risk, will appropriately escalate multiple events to a higher emergency class. For example, common cause failures such as loss of ultimate heat sink or loss of all AC power, will result in multiple contemporaneous symptoms indicating safety system functional failures and increasing challenge to fission product barriers. It is the existence of these symptoms (barrier challenges) that escalate the emergency class, whether there are one or multiple causes.

3.11 EMERGENCY CLASS DOWNGRADING

Another important aspect of usable EAL guidance is the consideration of what to do when the risk posed by an emergency is clearly decreasing. The Task Force review of existing EALs shows there are several approaches presently in use for emergency class downgrading. These approaches are:

(D1) Terminate the emergency class declaration.

(D2) Recovery from emergency class. Plants in one NRC Region report that this region doesn't want them to downgrade. From the lower emergency classes (Unusual Event, Alert), this closely resembles (D1) above.

(D3) Combination of downgrading approaches. Many utilities reviewed include the option to downgrade to a lower emergency class. This is consistent with actions called for in NUREG-0654 Appendix 1. However, these utilities state that their experience more closely resembles (D1) and (D2) above as practical choices.

Another approach possible with risk-based EALs is a relatively simple approach for upgrading to a higher emergency class when the risk increases and downgrading when risk decreases. The boundaries for emergency categories are defined in terms of risk in this approach, and discrete events fall into these categories based on risk. This means that within each emergency class, there is uniformity to the relative levels of risk to human health and safety from radiological accidents. However, this option may not be practical when applied to actual emergencies, especially those involving General Emergencies.

TASK FORCE RECOMMENDATION:

A combination approach involving recovery from General Emergencies and some Site Area Emergencies and termination from Unusual Events, Alerts, and certain Site Area Emergencies causing no long-term plant damage appears to be the best choice. Downgrading to lower emergency classes adds notifications but may have merit under certain circumstances.

4.0 HUMAN FACTORS CONSIDERATIONS

Some factors that must be considered in determining the method of presentation of EALs:

- Who is the audience (user) for this information? A senior utility executive would likely want information presented differently than a licensed operator. Offsite agencies and the NRC would have entirely different information needs.

- The conditions under which the information must be read, understood, and acted upon. Since the subject matter here is *emergency* actions, it is highly likely that the user of the EALs will be under high stress during the conditions where they are required to be used, particularly under conditions corresponding to Site Area Emergency and General Emergency.

- What is the user's perception as to the importance of the EALs compared to other actions and decisions that may be needed at the same time? To allow a licensed operator to discharge his responsibilities for dealing with the situation and also provide prompt notification to outside agencies, the emergency classification and notification process must be rapid and concise.

- Is the EAL consistent with the user's knowledge of what constitutes an *emergency* situation?

- How much help does the user receive in deciding which EAL and emergency class is involved? An offsite Emergency Director has many more resources immediately at his disposal than the licensed operator (typically, the Shift Supervisor) who has to make the initial decisions and take first actions.

Based on review of a number of plants' EALs and associated information, interviews with utility personnel, and a cursory review of drill results, several recommendations can be made.

4.1 LEVEL OF INTEGRATION OF EALs WITH PLANT PROCEDURES

A rigorous integration of EALs and emergency class determinations into the plant procedure set, although having some benefits, is probably unnecessary. Such a rigorous integration could well make it more difficult to keep documentation up-to-date. However, keeping EALs totally separated from plant procedures and relying on licensed operator or other utility Emergency Director memory during infrequent, high stress periods is insufficient.

TASK FORCE RECOMMENDATION:

Visual cues in the plant procedures that it is appropriate to consult the EALs is a method currently used by several utilities. This method can be effective when it is tied to appropriate training. Notes in the appropriate plant procedures to consult the EALs can also be used. It should be noted that this discussion is not restricted to only the emergency procedures; alarm recognition procedures, abnormal operating procedures, and normal operating procedures that apply to cold shutdown and refueling modes should also be included. In addition, EALs can be based on entry into particular procedures or existence of particular Critical Safety Function conditions.

4.2 METHOD OF PRESENTATION

A variety of presentation methods is presently in use. Methods range from directly copying NUREG-0654 Appendix 1 language, adding plant-specific indications to clarify NUREG-0654, use of procedure language including specific tag numbers for instrument readings and alarms, deliberate omission of instrument tag numbers, flow charts, critical safety function status trees, checklists, and combinations of the above.

What is clear, however, is that the licensed operator (typically the Shift Supervisor) is the first user of this information, has the least amount of help in interpreting the EALs, and also has other significant responsibilities to fulfill while dealing with the EALs. Offsite agencies and emergency directors outside the control room to whom responsibilities are turned over have other resources and advisors available to them that a licensed operator does not when he is first faced with an emergency situation. In addition, as an emergency situation evolves, the operating staff and the health physics staff are the personnel who must first deal with information that is germane to changing the emergency classification (up, down, or out of the emergency class).

TASK FORCE RECOMMENDATION:

The method of presentation should be one with which the operations and health physics staff are comfortable. As is the case for emergency procedures, bases for steps should be in a separate (or separable) document suitable for training and for reference by emergency response personnel and offsite agencies. Each nuclear plant should already have presentation and human factors standards as part of its procedure writing guidance. EALs that are consistent with those procedure writing standards (in particular, emergency operating procedures which most closely correspond to the conditions under which EALs must be used) should be the norm for each utility.

4.3 SYMPTOM-BASED, EVENT-BASED, OR BARRIER-BASED EALs

A review of the emergency class descriptions provided elsewhere in this document shows that Unusual Events and Alerts deal primarily with sequences that are precursors to more serious emergencies or that may have taken a plant outside of its intended operating envelope, but currently pose no danger to the public. Observable indications in these classes can be events (e.g. natural phenomena), symptoms (e.g., high temperature, low water level), or barrier-related (e.g., challenge to fission product barrier). As one escalates to Site Area Emergency and General Emergency, potential radiological impact to people (both onsite and offsite) increases.

However, at this point whatever the root cause event(s) leading to the emergency class escalation matter far less than the increased (potential for) radiological releases. Thus, EALs for these emergency classes should be primarily symptom- and barrier-based. It should be noted again, as stated in Section 3.4, that barrier monitoring is a subset of symptom monitoring, i.e., what readings (symptoms) indicate a challenge to a fission product barrier.

TASK FORCE RECOMMENDATION:

The Task Force recommends use of a combination approach that ranges from primarily event-based for Unusual Events to primarily symptom- or barrier-based for General Emergencies. This is to better assure that timely recognition and notification occurs, that events occurring during refueling and cold shutdown are appropriately covered, and that multiple events can be effectively treated in the EALs.

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5.0 GENERIC EAL GUIDANCE

Based on the information gathered and reviewed, the Task Force has developed generic EAL guidance. Because of the wide variety of presentation methods used at different utilities, the Task Force believes that specifying guidance as to what each IC and EAL should address, and including sufficient basis information for each EAL will best assure uniformity of approach. This approach is analogous to reactor vendors' owners groups developing generic emergency procedure guidelines which are converted by each utility into plant-specific emergency operating procedures. Each utility is reminded, however, to review the "Human Factors Considerations" section of this document as part of implementation of the attached Generic EAL Guidance.

The information is presented by Recognition Categories:

- A - Abnormal Rad Levels/Radiological Effluent
- F - Fission Product Barrier Degradation
- H - Hazards and Other Conditions Affecting Plant Safety
- S - System Malfunction

The Initiating Conditions for each of the above Recognition Categories A, H, and S are in the order of Unusual Event, Alert, Site Area Emergency, and General Emergency. For Recognition Category F, the barrier-based EALs are presented in Tables 3 and 4 for BWRs and PWRs respectively. For all Recognition Categories, an Initiating Condition matrix versus Emergency Class is first shown. Separate BWR and PWR Initiating Condition matrices are not required. The purpose of the IC matrices is to provide the reader with an overview of how the ICs are logically related under each Emergency Class.

Each of the EAL guides in Recognition Categories A, H, and S is structured in the following way:

- Recognition Category - As described above.
- Emergency Class - Unusual Event, Alert, Site Area Emergency or General Emergency.
- Initiating Condition - Symptom- or Event-Based, Generic Identification and Title.
- Operating Mode Applicability - Power Operation, Hot Standby (Startup in BWRs), Hot Shutdown, Cold Shutdown, Refueling, Defueled or All.
- Example Emergency Action Level(s) corresponding to the IC.

- Basis information for plant-specific readings and factors that may relate to changing the generic IC or EAL to a different emergency class, such as for Loss of All AC Power. Basis information also includes information related to escalation of the emergency class as appropriate.

For Recognition Category F, basis information is presented in a format consistent with Tables 3 and 4. The presentation method shown for Fission Product Barriers was chosen to clearly show the synergism among the EALs and to support more accurate dynamic assessments. Other acceptable methods of achieving these goals which are currently in use include flow charts, block diagrams, and checklist tables.

The EAL Guidance has the primary threshold for Unusual Events as operation outside the safety envelope for the plant as defined by plant technical specifications, including LCOs and Action Statement Times. In addition, certain precursors of more serious events such as loss of offsite AC power and earthquakes are included in Unusual Event EALs. This provides a clear demarcation between the lowest emergency class and "non-emergency" notifications specified by 10 CFR 50.72.

For a number of Alerts, EALs are chosen based on hazards which may cause damage to plant safety functions (i.e., tornados, hurricanes, fire in plant vital areas) or require additional help directly (control room evacuation) and thus increased monitoring of the plant is warranted. The symptom-based and barrier-based EALs are sufficiently anticipatory to address the results of multiple failures, regardless of whether there is a common cause or not. Declaration of the Alert will already result in the manning of the TSC for assistance and additional monitoring. Thus, direct escalation to the Site Area Emergency is unnecessary. Consequential damage from such hazards, if observed, would be the basis for escalation to Site Area Emergency or General Emergency. Other Alerts that have been specified correspond to conditions which are consistent with the emergency class description.

The basis for Site Area Emergencies and General Emergencies is primarily the extent and severity of fission product barrier challenges, based on plant conditions as presently known or as can be reasonably projected.

The guidance presented here is not intended to be applied to plants as-is. The EAL guidance is intended to give the logic for developing site-specific EALs using site-specific EAL presentation methods. Basis information is provided to aid station personnel in preparation of their own EALs, to provide necessary information for training, and for explanation to state and local officials. In addition, state and local requirements have not been reflected in the generic guidance and should be considered on a case-by-case basis with appropriate state and local emergency response organizations.

RECOGNITION CATEGORY A

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

INITIATING CONDITION MATRIX

UNUSUAL EVENT		ALERT		SITE AREA EMERGENCY		GENERAL EMERGENCY	
AU1	Any Unplanned Release of Gaseous or Liquid Radioactivity to the Environment that Exceeds Two Times the Radiological Technical Specifications for 60 Minutes or Longer. Op. Modes: All	AA1	Any Unplanned Release or Gaseous or Liquid Radioactivity to the Environment that Exceeds 200 Times Radiological Technical Specifications for 15 Minutes or Longer. Op. Modes: All	AS1	Site Boundary Dose Resulting from an Actual or Imminent Release of Gaseous Radioactivity Exceeds 100 mR Whole Body or 500 mR Child Thyroid for the Actual or Projected Duration of the Release. Op. Modes: All	AG1	Site boundary Dose Resulting from an Actual or Imminent Release or Gaseous Radioactivity that Exceeds 1000 mR Whole Body or 5000 mR Child Thyroid for the Actual or Projected Duration of the Release Using Actual Meterology. Op. Modes: All
AU2	Unexpected Increase in Plant Radiation Levels or Airborne Concentration. Op. Modes: All	AA2	Major Damage to Irradiated Fuel or Loss of Water Level that Has or Will Result in the Uncovering of Irradiated Fuel Outside the Reactor Vessel. Op. Modes: All				
		AA3	Release of Radioactive Material or Increases in Radiation Levels Within the Facility that Impedes Operation of Systems Required to Maintain Safe Operations or to Establish or Maintain Cold Shutdown. Op. Modes: All				

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

UNUSUAL EVENT

AU1 Any Unplanned Release of Gaseous or Liquid Radioactivity to the Environment that Exceeds Two Times the Radiological Technical Specifications for 60 Minutes or Longer.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4)

1. A valid reading on one or more of the following monitors that exceeds the value shown indicates that the release may have exceeded the above criterion and indicates the need to assess the release with (site-specific procedure):

   (site-specific list)

   Note: If the monitor reading(s) is sustained for longer than 60 minutes and the required assessments cannot be completed within this period, then the declaration must be made based on the valid reading.

2. Confirmed sample analyses for gaseous or liquid releases indicates concentrations or release rates with a release duration of 60 minutes or longer in excess of two times (site-specific technical specifications).

3. Valid reading on perimeter radiation monitoring system greater than 0.10 mR/hr above normal background for 60 minutes [for sites having telemetered perimeter monitors].

4. Valid indication on automatic real-time dose assessment capability greater than (site-specific value) for 60 minutes or longer [for sites having such capability].

BASIS:

The term "Unplanned", as used in this context, includes any release for which a radioactive discharge permit was not prepared, or a release that exceeds the conditions (e.g., minimum dilution flow, maximum discharge flow, alarm setpoints, etc.) on the applicable permit.

Valid means that a radiation monitor reading has been confirmed by the operztors to be correct.

Unplanned releases in excess of two times the site technical specifications that continue for 60 minutes or longer represent an uncontrolled situation and hence, a potential degradation in the level of safety. The final integrated dose (which is very low in the Unusual Event emergency class) is not the primary concern here; it is the degradation in plant control implied by the fact that the release was not isolated within 60 minutes. Therefore, it is not intended that the release be averaged over 60 minutes. For example, a release of 4 times T/S for 30 minutes does not exceed this initiating condition. Further, the Emergency Director should not wait until 60 minutes has elapsed, but should declare the event as soon as it is determined that the release duration has or will likely exceed 60 minutes.

For sites that have eliminated effluent technical specifications as provided in NRC Generic Letter 89-01, the corresponding maximum limit from the site's Offsite Dose Calculation Manual should be used as the numeric basis of EAL.

10 CFR 50.72 requires a non-emergency four hour report for release that exceeds 2 times maximum permissible concentration (MPC) in unrestricted areas averaged over a period of one hour. There is generally more than one applicable technical specification (e.g., air dose rate, organ dose rate, organ doses, release rate, etc.). Often, effluent monitor alarms are based on instantaneous release rates. Depending on the source term, other technical specifications may be more limiting. For this reason, the EALs should trigger an assessment of all applicable specifications.

Monitor indications should be calculated on the basis of the methodology of the site Offsite Dose Calculation Manual (ODCM), or other site procedures that are used to demonstrate compliance with 10 CFR 20 and/or 10 CFR 50 Appendix I requirements. Annual average meteorology should be used where allowed.

In EAL 3, the 0.10 mR/hr value is based on a proration of two times the 500 mR/yr basis of the 10 CFR 20 non-occupational MPC limits, rounded down to 0.10 mR/hr. If other site-specific values are applicable, these should be used.

Some sites may find it advantageous to address gaseous and liquid releases with separate initiating conditions and EALs.

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

UNUSUAL EVENT

AU2 Unexpected Increase in Plant Radiation or Airborne Concentration.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4 or 5)

1. (Site-specific) indication of uncontrolled water level decrease in the reactor refueling cavity with all irradiated fuel assemblies remaining covered by water.

2. Uncontrolled water level decrease in the spent fuel pool and fuel transfer canal with all irradiated fuel assemblies remaining covered by water.

3. (Site-specific) radiation reading for irradiated spent fuel in dry storage.

4. Valid Direct Area Radiation Monitor readings increases by a factor of 1000 over normal* levels.

   *Normal levels can be considered as the highest reading in the past twenty-four hours excluding the current peak value.

BASIS:

Valid means that a radiation monitor reading has been confirmed by the operators to be correct.

All of the above events tend to have long lead times relative to potential for radiological release outside the site boundary, thus impact to public health and safety is very low.

In light of Reactor Cavity Seal failure incidents at two different PWRs and loss of water in the Spent Fuel Pit/Fuel Transfer Canal at a BWR all occurring since 1984, explicit coverage of these types of events via EALs 1 and 2 is appropriate given their potential for increased doses to plant staff. Classification as an Unusual Event is warranted as a precursor to a more serious event.

EAL 3 applies to plants with licensed dry storage of older irradiated spent fuel to address degradation of this spent fuel. One utility uses values of 2 R/hr at the face of any dry storage module or 1 R/hr one foot away from a damaged module.

EAL 4 addresses unplanned increases in in-plant radiation levels that represent a degradation in the control of radioactive material, and represent a potential degradation in the level of safety of the plant. This EAL escalates to an Alert per IC AA3, if the increases impair safe operation.

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

ALERT

AA1 Any Unplanned Release of Gaseous or Liquid Radioactivity to the Environment that Exceeds 200 Times Radiological Technical Specifications for 15 Minutes or Longer.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4)

1. A valid reading on one or more of the following monitors that exceeds the value shown indicates that the release may have exceeded the above criterion and indicates the need to assess the release with (site-specific procedure):

   (site-specific list)

   Note: If the monitor reading(s) is sustained for longer than 15 minutes and the required assessments cannot be completed within this period, then the declaration must be made based on the valid reading.

2. Confirmed sample analyses for gaseous or liquid releases indicates concentrations or release rates in excess of (200 x site-specific technical specifications) for 15 minutes or longer.

3. A valid reading on perimeter radiation monitoring system greater than 10.0 mR/hr sustained for 15 minutes or longer. [for sites having telemetered perimeter monitors]

4. Valid indication on automatic real-time dose assessment capability greater than (200 x site-specific Technical Specifications value) for 15 minutes or longer. [for sites having such capability]

BASIS:

Valid means that a radiation monitor reading has been confirmed by the operators to be correct.

This event escalates from the Unusual Event by escalating the magnitude of the release by a factor of 100. Prorating the 500 mR/yr criterion for both time (8766 hr/yr and the 200 multiplier, the associated site boundary dose rate would be 10 mR/hr. The required release duration was reduced to 15 minutes in recognition of the increased severity.

For sites that have eliminated effluent technical specifications as provided in NRC Generic Letter 89-01, the corresponding maximum limit from the site's Offsite Dose Calculation Manual, multiplied by 200, should be used as the numeric basis of this EAL.

Monitor indications should be calculated on the basis of the methodology of the site Offsite Dose Calculation Manual (ODCM), or other site procedures that are used to demonstrate compliance with 10 CFR 20 and/or 10 CFR 50 Appendix I requirements -- adjusted upwards by a factor of 200. Annual average

meteorology should be used where allowed.

In EAL 3, the 10 mR/hr value is based on a proration of 200 times the 500 mR/yr basis of the 10 CFR 20 non-occupational MPC limits, rounded down to 10 mR/hr. If other site-specific values are applicable, these should be used.

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

ALERT

AA2 Major Damage to Irradiated Fuel or Loss of Water Level that Has or Will Result in the Uncovering of Irradiated Fuel Outside the Reactor Vessel.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4)

1. A (site-specific set point) alarm on one or more of the following radiation monitors: (site-specific monitors)

   Refuel Floor Area Radiation Monitor
   Fuel Handling Building Ventilation Monitor
   Fuel Bridge Area Radiation Monitor

2. Report of Visual observation of irradiated fuel uncovered.

3. Water Level less than (site-specific) feet for the Reactor Refueling Cavity that will result in Irradiated Fuel Uncovering.

4. Water Level less than (site-specific) feet for the Spent Fuel Pool and Fuel Transfer Canal that will result in Irradiated Fuel uncovering.

BASIS:

This IC applies to spent fuel requiring water coverage and is not intended to address spent fuel which is licensed for dry storage, which is discussed in NUMARC IC AU2, "Unexpected Increase in Plant Radiation or Airborne Concentration."

NUREG-0818, "Emergency Action Levels for Light Water Reactors," forms the basis for these EALs. Each site should also define its EALs by the specific area where Irradiated fuel is located such as Reactor Cavity, Reactor Vessel, or Spent Fuel Pool.

There is time available to take corrective actions, and there is little potential for substantial fuel damage. In addition, NUREG/CR-4982, "Severe Accident in Spent Fuel Pools in Support of Generic Safety Issue 82," July 1987, indicates that even if corrective actions are not taken, no prompt fatalities are predicted, and that risk of injury is low. In addition, NRC Information Notice No. 90-08, "KR-85 Hazards from Decayed Fuel" presents the following in its discussion:

> In the event of a serious accident involving decayed spent fuel, protective actions would be needed for personnel on site, while offsite doses (assuming an exclusion area radius of one mile from the plant site) would be well below the Environmental Protection Agency's Protective Action Guides. Accordingly, it is important to be able to properly survey and monitor for Kr-85 in the event of an accident with decayed spent fuel.

Licensees may wish to reevaluate whether Emergency Action Levels specified in the emergency plan and procedures governing decayed fuel-handling activities appropriately focus on concern for onsite workers and Kr-85 releases in areas where decayed spent fuel accidents could occur, for example, the spent fuel pool working floor. Furthermore, licensees may wish to determine if emergency plans and corresponding implementing procedures address the means for limiting radiological exposures of onsite personnel who are in other areas of the plant. Among other things, moving onsite personnel away from the plume and shutting off building air intakes downwind from the source may be appropriate.

Thus, an Alert Classification for this event is appropriate. Escalation, if appropriate, would occur via Abnormal Rad Level/Radiological Effluent or Emergency Director Judgement.

ALERT

AA3 Release of Radioactive Material or Increases in Radiation Levels Within the Facility That Impedes Operation of Systems Required to Maintain Safe Operations or to Establish or Maintain Cold Shutdown

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. Valid (site-specific) radiation monitor readings GREATER THAN 15 mR/hr in areas requiring continuous occupancy to maintain plant safety functions:

- (Site-specific) list

2. Valid (site-specific) radiation monitor readings GREATER THAN <site specific> values in areas requiring infrequent access to maintain plant safety functions.

- (Site-specific) list

NOTE: The Emergency Director should determine the cause of the increase in radiation levels and review other ICs for applicability.

BASIS:

Valid means that a radiation monitor reading has been confirmed by the operators to be correct.

This IC addresses increased radiation levels that impede necessary access to operating stations, or other areas containing equipment that must be operated manually, in order to maintain safe operation or perform a safe shutdown. It is this impaired ability to operate the plant that results in the actual or potential substantial degradation of the level of safety of the plant. The cause and/or magnitude of the increase in radiation levels is not a concern of this IC. The Emergency Director must consider the source or cause of the increased radiation levels and determine if any other IC may be involved. For example, a dose rate of 15 mR/hr in the control room may be a problem in itself. However, the increase may also be indicative of high dose rates in the containment due to a LOCA. In this latter case, an SAE or GE may be indicated by the fission product barrier matrix ICs.

At multiple-unit sites, the example EALs could result in declaration of an Alert at one unit due to a radioactivity release or radiation shine resulting from a major accident at the other unit. This is appropriate if the increase impairs operations at the operating unit.

This IC is not meant to apply to increases in the containment dome radiation monitors as these are events are addressed in the fission product barrier matrix ICs. Nor is it intended to apply to anticipated temporary increases due to planned events (e.g., incore detector movement, radwaste container

movement, depleted resin transfers, etc.)
Emergency planners developing the (site-specific) lists may refer to the site's abnormal operating procedures, emergency operating procedures, the 10 CFR 50 Appendix R analysis, and/or, the analyses performed in response to Section 2.1.6b of NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short-term Recommendations", when identifying areas containing safe shutdown equipment. With regard to the NUREG-0578 analyses, do not use the dose rates postulated therein as a basis for the radiation monitor readings for this IC, as the NUREG-0573 analyses address general emergency conditions.

Areas requiring continuous occupancy includes the control room and, as appropriate to the site, any other control stations that are manned continuously, such as a radwaste control room or a central security alarm station. The value of 15mR/hr is derived from the GDC 19 value of 5 rem in 30 days with adjustment for expected occupancy times. Although Section III.D.3 of NUREG-0737, "Clarification of TMI Action Plan Requirements", provides that the 15 mR/hr value can be averaged over the 30 days, the value is used here without averaging, as a 30 day duration implies an event potentially more significant than an Alert.

For areas requiring infrequent access, the (site-specific) value(s) should be based on radiation levels which result in exposure control measures intended to maintain doses within normal occupational exposure guidelines and limits (i.e., 10 CFR 20), and in doing so, will impede necessary access. For many areas, it may be possible to establish a single generic EAL that represents a multiple of the normal radiation levels (e.g., 1000 times normal). However, areas that have normally high dose rates may require a lower multiple (e.g., 10 times normal).

SITE AREA EMERGENCY

AS1 Boundary Dose Resulting from an Actual or Imminent Release of Gaseous Radioactivity Exceeds 100 mR Whole Body or 500 mR Child Thyroid for the Actual or Projected Duration of the Release.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4)

1. A valid reading on one or more of the following monitors that exceeds or is expected to exceed the value shown indicates that the release may have exceeded the above criterion and indicates the need to assess the release with (site-specific procedure):

(site-specific list)

Note: If the monitor reading(s) is sustained for longer than 15 minutes and the required assessments cannot be completed within this period, then the declaration must be made based on the valid reading.

2. A valid reading sustained for 15 minutes or longer on perimeter radiation monitoring system greater than 100 mR/hr. [for sites having telemetered perimeter monitors]

3. Valid dose assessment capability indicates dose consequences greater than 100 mR whole body or 500 mR child thyroid.

4. Field survey results indicate site boundary dose rates exceeding 100 mR/hr expected to continue for more than one hour; or analyses of field survey samples indicate child thyroid dose commitment of 500 mR for one hour of inhalation.

BASIS:

Valid means that a radiation monitor reading has been confirmed by the operators to be correct.

The 100 mR integrated dose in this initiating condition is based on the proposed 10 CFR 20 annual average population exposure. This value also provides a desirable gradient (one order of magnitude) between the Alert, Site Area Emergency, and General Emergency classes. It is deemed that exposures less than this limit are not consistent with the Site Area Emergency class description. The 500 mR integrated child thyroid dose was established in consideration of the 1:5 ratio of the EPA Protective Action Guidelines for whole body and thyroid.

Integrated doses are generally not monitored in real-time. In establishing the emergency action levels, it is suggested that a duration of one hour be assumed, and that the EALs be based on a site boundary dose of 100 mR/hour whole body or 500 mR/hour child thyroid, whichever is more limiting (depends

on source term assumptions). If individual site analyses indicate a longer or shorter duration for the period in which the substantial portion of the activity is released, these dose rates should be adjusted.

The FSAR source terms applicable to each monitored pathway should be used in conjunction with annual average meteorology in determining indications for the monitors on that pathway.

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

GENERAL EMERGENCY

AG1 Boundary Dose Resulting from an Actual or Imminent Release of Gaseous Radioactivity that Exceeds 1000 mR Whole Body or 5000 mR Child Thyroid for the Actual or Projected Duration of the Release Using Actual Meteorology.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4)

1. A valid reading on one or more of the following monitors that exceeds or is expected to exceed the value shown indicates that the release may have exceeded the above criterion and indicates the need to assess the release with (site-specific procedure):

   (site-specific list)

   Note: If the monitor reading(s) is sustained for longer than 15 minutes and the required assessments cannot be completed within this period, then the declaration must be made based on the valid reading.

2. A valid reading sustained for 15 minutes or longer on perimeter radiation monitoring system greater than 1000 mR/hr. [for sites having telemetered perimeter monitors]

3. Valid dose assessment capability indicates dose consequences greater than 1000 mR whole body or 5000 mR child thyroid.

4. Field survey results indicate site boundary dose rates exceeding 1000 mR/hr expected to continue for more than one hour; or analyses of field survey samples indicate child thyroid dose commitment of 5000 mR for one hour of inhalation.

BASIS:

Valid means that a radiation monitor reading has been confirmed by the operators to be correct.

The 1000 mR whole body and the 5000 mR child thyroid integrated dose are based on the EPA protective action guidance which indicates that public protective actions are indicated if the dose exceeds 1 rem whole body or 5 rem child thyroid. This is consistent with the emergency class description for a General Emergency. This level constitutes the upper level of the desirable gradient for the Site Area Emergency. Actual meteorology is specifically identified in the initiating condition since it gives the most accurate dose assessment. Actual meteorology (including forecasts) should be used whenever possible.

Integrated doses are generally not monitored in real-time. In establishing the emergency action levels, it is suggested that a duration of one hour be assumed, and that the EALs be based on site boundary doses for either whole

body or child thyroid, whichever is more limiting (depends on source term assumptions). If individual site analyses indicate a longer or shorter duration for the period in which the substantial portion of the activity is released, these dose rates should be adjusted.

The FSAR source terms applicable to each monitored pathway should be used in conjunction with annual average meteorology in determining indications for the monitors on that pathway.

RECOGNITION CATEGORY F

FISSION PRODUCT BARRIER DEGRADATION

INITIATING CONDITION MATRIX

See Table 3 for BWR Example EALs
See Table 4 for PWR Example EALs

UNUSUAL EVENT		ALERT		SITE AREA EMERGENCY		GENERAL EMERGENCY	
FU1	ANY Loss or ANY Potential Loss of Containment. Op Modes: Power Operation Hot Standby/Startup (BWR) Hot Shutdown	FA1	ANY Loss or ANY Potential Loss of EITHER Fuel Clad OR RCS. Op. Modes: Power Operation Hot Standby/Startup (BWR) Hot Shutdown	FS1	Loss of BOTH Fuel Clad AND RCS OR Potential Loss of BOTH Fuel Clad AND RCS OR Potential Loss of EITHER Fuel Clad OR RCS, and Loss of ANY Additional Barrier. Op Modes: Power Operation Hot Standby/Startup (BWR) Hot Shutdown	FG1	Loss of ANY Two Barriers AND Potential Loss of Third Barrier. Op. Modes: Power Operation Hot Standby/Startup (BWR) Hot Shutdown

NOTES:

1. Although the logic used for these initiating conditions appears overly complex, it is necessary to reflect the following considerations:

   - The Fuel Clad barrier and the RCS barrier are weighted more heavily than the Containment barrier (see Sections 3.4 and 3.8 for more information on this point). Unusual Event ICs associated with RCS and Fuel Clad barriers are addressed under System Malfunction ICs.

   - At the Site Area Emergency level, there must be some ability to dynamically assess how far present conditions are from General Emergency. For example, if Fuel Clad barrier and RCS barrier "Loss" EALs existed, this would indicate to the Emergency Director that, in additional to offsite dose assessments, continual assessments of radioactive inventory and containment integrity must be focused on. If, on the other hand, both Fuel Clad barrier and RCS barrier "Potential Loss" EALs existed, the Emergency Director would have more assurance that there was no immediate need to escalate to a General Emergency.

   - The ability to escalate to higher emergency classes as an event gets worse must be maintained. For example, RCS leakage steadily increasing would represent an increasing risk to public health and safety.

2. Fission Product Barrier ICs must be capable of addressing event dynamics. Thus, the EAL Reference Tables 3 and 4 state that IMMINENT (i.e., within 1 to 2 hours) loss or Potential Loss should result in a classification as if the affected threshold(s) are already exceeded, particularly for the higher emergency classes.

BWR EMERGENCY ACTION LEVEL
FISSION PRODUCT BARRIER REFERENCE TABLE
THRESHOLDS FOR LOSS OR POTENTIAL LOSS OF BARRIERS[a]

[a] Determine which combination of the three barriers are lost or have a potential loss and use the following key to classify the event. Also an event (or multiple events could occur which result in the conclusion that exceeding the Loss or Potential Loss thresholds is IMMINENT (i.e., within 1 to 3 hours). In this IMMINENT LOSS situation use judgement and classify as if the thresholds are exceeded.

UNUSUAL EVENT	ALERT	SITE AREA EMERGENCY	GENERAL EMERGENCY
ANY Loss or ANY Potential Loss of Containment	ANY Loss or ANY Potential Loss of EITHER Fuel Clad OR RCS	Loss of BOTH Fuel Clad AND RCS OR Potential Loss of BOTH Fuel Clad AND RCS OR Potential Loss of EITHER Fuel Clad OR RCS, and Loss of ANY Additional Barrier	Loss of ANY Two Barriers AND Potential Loss of Third Barrier

FUEL CLAD BARRIER EXAMPLE EALS

LOSS	POTENTIAL LOSS
1. Primary Coolant Activity Level	
Coolant activity GREATER THAN (site-specific) value	Not Applicable
OR	
2. Reactor Vessel Water Level	
Level LESS THAN (site-specific) Value	Level LESS Than (site-specific value
OR	
3. Drywell Radiation Monitoring	
Drywell Rad Monitor Reading GREATER THAN (site-specific) R/hr	Not applicable
OR	
4. Other (site-specific) Indications	
(Site-specific) as applicable	(site-specific) as applicable
OR	

RCS BARRIER EXAMPLE EALS

LOSS	POTENTIAL LOSS
1. RCS Leak Rate	
(site-specific) Indication of Main Steamline Break	RCS leakage GREATER THAN 50 GPM inside the drywell
	OR
	unisolable primary sys leakage outside drywell as indicated by area temp or area rad alarm
OR	
2. Drywell Pressure	
Pressure GREATER THAN (site-specific) psig	Not applicable
OR	
3. Drywell Radiation Monitoring	
Drywell Rad Monitor Reading GREATER THAN (site-specific) R/hr	Not applicable
OR	
4. Reactor Vessel Water Level	
Level LESS THAN (site-specific) value	Not applicable
OR	

PRIMARY CONTAINMENT BARRIER EXAMPLE EALS

LOSS	POTENTIAL LOSS
1. Drywell Pressure	
Rapid unexplained decrease following initial increase	(site-specific) PSIG and increasing
OR	OR
Drywell pressure response not consistent with LOCA conditions	explosive mixture exists
OR	
2. Containment Isolation Valve After Containment Isolation	
Failure of both valves in any one line to close AND downstream pathway to the environment exists	Not applicable
OR	
Intentional venting per EOPs	Not applicable
OR	
Unisolable primary sys leakage outside dry well as indicated by area temp or area rad alarm	Not applicable
OR	
3. Significant Radioactive Inventory in Containment	
Not applicable	Containment rad monitor reading GREATER THAN (site-specific) R/hr
OR	
4. Reactor Vessel Water Level	
Not applicable	Reactor vessel water level LESS THAN (site-specific) value and the maximum core uncovery time limit is in the UNSAFE region
OR	

BWR EMERGENCY ACTION LEVEL
FISSION PRODUCT BARRIER REFERENCE TABLE
THRESHOLDS FOR LOSS OR POTENTIAL LOSS OF BARRIERS*

* Determine which combination of the three barriers are lost or have a potential loss and use the following key to classify the event. Also an event (or multiple events could occur which result in the conclusion that exceeding the Loss or Potential Loss thresholds is IMMINENT (i.e., within 1 to 3 hours). In this IMMINENT LOSS situation use judgement and classify as if the thresholds are exceeded.

UNUSUAL EVENT	ALERT	SITE AREA EMERGENCY	GENERAL EMERGENCY
ANY Loss or ANY Potential Loss of Containment	ANY Loss or ANY Potential Loss of EITHER Fuel Clad OR RCS	Loss of BOTH Fuel Clad AND RCS OR Potential Loss of BOTH Fuel Clad AND RCS OR Potential Loss of EITHER Fuel Clad OR RCS, and Loss of ANY Additional Barrier	Loss of ANY Two Barriers AND Potential Loss of Third Barrier

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5. Emergency Director Judgement

Any condition in the judgement of the Emergency Director that indicates Loss or Potential Loss of the FUEL CLAD barrier

5. Other (Site-specific) Indications

(Site-specific) as applicable

(site-specific) as applicable

OR

6. Emergency Director Judgement

Any condition in the judgement of the Emergency Director that indicate Loss or Potential Loss of the RCS barrier

5. Other (site-specific) Indications

(site-specific) as applicable

(site-specific) as applicable

OR

6. Emergency Director Judgement

Any condition in the opinion of the Emergency Director that indicates Loss or Potential Loss of the CONTAINMENT barrier

BASIS INFORMATION FOR TABLE 3
BWR EMERGENCY ACTION LEVEL
FISSION PRODUCT BARRIER REFERENCE TABLE

FUEL CLAD BARRIER EXAMPLE EALs: (1 or 2 or 3 or 4 or 5)

The Fuel Clad barrier is the zircalloy or stainless steel tubes that contain the fuel pellets.

1. Primary Coolant Activity Level

   This (site-specific) value corresponds to 300 μCi/gm I_{131} equivalent. Assessment by the NUMARC EAL Task Force indicates that this amount of coolant activity is well above that expected for iodine spikes and corresponds to about 5% to 10% fuel clad damage. This amount of clad damage indicates significant clad heating and thus the Fuel Clad Barrier is considered lost.

   There is no equivalent "Potential Loss" EAL for this item.

2. Reactor Vessel Water Level

   The "Loss" EAL (site-specific) value corresponds to 2/3 coverage of the active fuel. This is the minimum value to assure core cooling without further degradation of the clad. The "Potential Loss" EAL is the same as the RCS barrier "Loss" EAL 4 below and corresponds to the (site-specific) water level at the top of the active fuel. Thus, this EAL indicates a "Loss" of RCS barrier and a "Potential Loss" of the Fuel Clad Barrier. This EAL appropriately escalates the emergency class to a Site Area Emergency.

3. Drywell Radiation Monitoring

   The (site-specific) reading is a value which indicates the release of reactor coolant, with elevated activity indicative of fuel damage, into the drywell. The reading should be calculated assuming the instantaneous release and dispersal of the reactor coolant noble gas and iodine inventory associated with a concentration of 300 μCi/gm dose equivalent I-131 into the drywell atmosphere. Reactor coolant concentrations of this magnitude are several times larger than the maximum concentrations (including iodine spiking) allowed within technical specifications and are therefore indicative of fuel damage (approximately 2 - 5% clad failure depending on core inventory and RCS volume). This value is higher than that specified for RCS barrier Loss EAL #3. Thus, this EAL indicates a loss of both Fuel Clad barrier and RCS barrier.

   Caution: it is important to recognize that in the event the radiation monitor is sensitive to shine from the reactor vessel or piping spurious readings will be present and another indicator of fuel clad damage is necessary.

   There is no "Potential Loss" EAL associated with this item.

4. Other (Site-Specific) Indications

This EAL is to cover other (site-specific) indications that may indicate loss or potential loss of the Fuel Clad barrier, including indications from containment air monitors or any other (site-specific) instrumentation.

5. Emergency Director Judgement

This EAL addresses any other factors that are to be used by the Emergency Director in determining whether the Fuel Clad barrier is lost or potentially lost. In addition, the inability to monitor the barrier should also be incorporated in this EAL as a factor in Emergency Director judgement that the barrier may be considered lost or potentially lost. (See also IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power", for additional information.)

RCS BARRIER EXAMPLE EALs: (1 or 2 or 3 or 4 or 5 or 6)

The RCS Barrier is the reactor coolant system pressure boundary and includes the reactor vessel and all reactor coolant system piping up to the isolation valves.

1. RCS Leak Rate

The "Loss" EAL is based on design basis accident analyses which show that even if MSIV closure occurs within design limits, dose consequences offsite from a "puff" release would be in excess of 10 millirem. Thus, this EAL is included for consistency with the Alert emergency classification. Potential loss of RCS is determined from site-specific alarms in the areas of the main steam line tunnel, main turbine generator, RCIC, HPCI, etc., which indicate a direct path from the RCS to areas outside primary containment.

2. Drywell Pressure

The (site-specific) drywell pressure is based on the drywell high pressure alarm setpoint and indicates a LOCA.

There is no "Potential Loss" EAL corresponding to this item.

3. Drywell Radiation Monitoring

The (site-specific) reading is a value which indicates the release of reactor coolant to the drywell. The reading should be calculated assuming the instantaneous release and dispersal of the reactor coolant noble gas and iodine inventory associated with normal operating concentrations (i.e., within T/S) into the drywell atmosphere. This reading will be less than that specified for Fuel Clad Barrier EAL #3. Thus, this EAL would be indicative of a RCS leak only. If the radiation monitor reading increased to that value specified by Fuel Clad Barrier EAL #3, fuel damage would also be indicated.

However, if the site specific physical location of the drywell radiation monitor is such that radiation from a cloud of released RCS gases could not be distinguished from radiation from adjacent piping and components

containing elevated reactor coolant activity, this EAL should be omitted and other site specific indications of RCS leakage substituted.

There is no "Potential Loss" EAL associated with this item.

4. Reactor Vessel Water Level

This "Loss" EAL is the same as "Potential Loss" Fuel Clad Barrier EAL 2. The (site-specific) water level corresponds to the top of the active fuel. This EAL appropriately escalates the emergency class to a Site Area Emergency. Thus, this EAL indicates a loss of the RCS barrier and a Potential Loss of the Fuel Clad Barrier.

5. Other (Site-Specific) Indications

This EAL is to cover other (site-specific) indications that may indicate loss or potential loss of the RCS barrier.

6. Emergency Director Judgement

This EAL addresses any other factors that are to be used by the Emergency Director in determining whether the RCS barrier is lost or potentially lost. In addition, the inability to monitor the barrier should also be incorporated in this EAL as a factor in Emergency Director judgement that the barrier may be considered lost or potentially lost. (See also IC SG1, "Prolonged Loss of Offsite Power and Prolonged Loss of All Onsite AC Power", for additional information.)

PRIMARY CONTAINMENT BARRIER EXAMPLE EALs: (1 or 2 or 3 or 4 or 5 or 6)

The Primary Containment Barrier includes the drywell, the wetwell, their respective interconnecting paths, and other connections up to and including the outermost containment isolation valves.

1. Drywell Pressure

Rapid unexplained loss of pressure (i.e., not attributable to drywell spray or condensation effects) following an initial pressure increase indicates a loss of containment integrity. Drywell pressure should increase as a result of mass and energy release into containment from a LOCA. Thus, drywell pressure not increasing under these conditions indicates a loss of containment integrity. The (site-specific) PSIG for potential loss of containment is based on the containment drywell design pressure. Existence of an explosive mixture means a hydrogen and oxygen concentration of at least the lower deflagration limit curve exists. This applies to BWRs with Mark III containments, as well as Mark I and II containment designs when they are de-inerted.

2. Containment Isolation Valve Status After Containment Isolation Signal

This EAL is intended to cover containment isolation failures allowing a direct flow path to the environment such as failure of both MSIVs to close with open valves downstream to the turbine or to the condenser. In addition, the presence of area radiation or temperature alarms indicating unisolable primary system leakage outside the drywell are covered. Also, an intentional venting of primary containment per EOPs to the secondary

containment and/or the environment to considered a loss of containment.

There is no "Potential Loss" EAL associated with this item.

3. Significant Radioactive Inventory in Containment

The (site-specific) reading is a value which indicates significant fuel damage well in excess of that required for loss of RCS and Fuel Clad. As stated in Section 3.8, a major release of radioactivity requiring offsite protective actions from core damage is not possible unless a major failure of fuel cladding allows radioactive material to be released from the core into the reactor coolant. Regardless of whether containment is challenged, this amount of activity in containment, if released, could have such severe consequences that it is prudent to treat this as a potential loss of containment, such that a General Emergency declaration is warranted. NUREG-1228, "Source Estimations During Incident Response to Severe Nuclear Power Plant Accidents," indicates that such conditions do not exist when the amount of clad damage is less than 20%. Unless there is a (site-specific) analysis justifying a higher value, it is recommended that a radiation monitor reading corresponding to 20% fuel clad damage be specified here.

There is no "Loss" EAL associated with this item.

4. Reactor Vessel Water Level

In this EAL, the (site-specific) water level corresponds to 2/3 coverage of the active fuel. This is the minimum value to assure core cooling without further degradation of the clad.

The conditions in this potential loss EAL represent imminent melt sequences which, if not corrected, could lead to vessel failure and increased potential for containment failure. In conjunction with the level EALs in the Fuel and RCS barrier columns, this EAL will result in the declaration of a General Emergency -- loss of two barriers and the potential loss of a third. If the emergency operating procedures have been ineffective in restoring reactor vessel level within the maximum core uncovery time limit, there is not a "success" path.

Severe accident analysis (e.g., NUREG-1150) have concluded that function restoration procedures can arrest core degradation with the reactor vessel in a significant fraction of the core damage scenarios, and the likelihood of containment failure is very small in these events. Given this, it is appropriate to provide a reasonable period to allow emergency operating procedures to arrest the core melt sequence. Whether or not the procedures will be effective should be apparent within the time provided. The Emergency Director should make the declaration as soon as it is determined that the procedures have been, or will be, ineffective. There is no "loss" EAL associated with this item.

5. Other (Site-Specific) Indications

This EAL is to cover other (site-specific) indications that may indicate loss or potential loss of the containment barrier.

6. Emergency Director Judgement

This EAL addresses any other factors that are to be used by the Emergency Director in determining whether the Containment barrier is lost or potentially lost. In addition, the inability to monitor the barrier should also be incorporated in this EAL as a factor in Emergency Director judgement that the barrier may be considered lost or potentially lost. (See also IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power", for additional information.)

TABLE 4
PWR EMERGENCY ACTION LEVEL
FISSION PRODUCT BARRIER REFERENCE TABLE
THRESHOLDS FOR LOSS OR POTENTIAL LOSS OF BARRIERS*

* Determine which combination of the three barriers are lost or have a potential loss and use the following key to classify the event. Also an event (or multiple events) could occur which result in the conclusion that exceeding the Loss or Potential Loss thresholds is IMMINENT (i.e., within 1 to 2 hours). In this IMMINENT LOSS situation use judgement and classify as if the thresholds are exceeded.

UNUSUAL EVENT	ALERT	SITE AREA EMERGENCY	GENERAL EMERGENCY
ANY Loss or ANY Potential Loss of Containment	ANY Loss or ANY Potential Loss of EITHER Fuel Clad OR RCB	Loss of BOTH Fuel Clad AND RCB OR Potential Loss of BOTH Fuel Clad AND RCB OR Potential Loss of EITHER Fuel Clad OR RCB, and Loss of ANY Additional Barrier	Loss of ANY Two Barriers AND Potential Loss of Third Barrier

FUEL CLAD BARRIER EXAMPLE EALS		RCB BARRIER EXAMPLE EALS		CONTAINMENT BARRIER EXAMPLE EALS	
LOSS	POTENTIAL LOSS	LOSS	POTENTIAL LOSS	LOSS	POTENTIAL LOSS
1. Critical Safety Function Status		1. Critical Safety Function Status		1. Critical Safety Function Status	
Core Cooling-Red	Core Cooling-Orange OR Heat Sink-Red	Not applicable	RCB Integrity-Red OR Heat Sink-Red	Not applicable	Containment-Red
OR		OR		OR	
2. Primary Coolant Activity Level		2. RCB Leak Rate		2. Containment Pressure	
Coolant Activity GREATER THAN (site-specific) value	Not applicable	GREATER THAN available makeup capacity as indicated by a loss of RCB subcooling	Unisolable leak exceeding the capacity of one charging pump in the normal charging mode	Rapid unexplained decrease following initial increase OR containment pressure or sump level response not consistent with LOCA conditions.	(Site-specific) PSIG and Increasing OR Explosive mixture exists. OR Containment pressure greater than containment depressurization system setpoint with less than one full train of depressurization equipment operating.
OR		OR		OR	
3. Core Exit Thermocouple Readings		3. SG Tube Rupture		3. Containment Isolation Valves Status After Containment Isolation	
GREATER THAN (site-specific) degree F	GREATER THAN (site-specific) degree F	(Site-specific) indication that a SG is Ruptured and Has a Non-Isolable secondary line break OR (Site-specific) indication that a SG is ruptured and a prolonged release of contaminated secondary coolant is occurring from the affected SG to the environment	Site-specific indication that a SG is ruptured and the Primary-to-Secondary leak rate exceeds the capacity of one charging pump in the normal charging mode	Valve(s) not closed AND downstream pathway to the environment exists	Not applicable
OR		OR		OR	

TABLE 4

PWR EMERGENCY ACTION LEVEL

FISSION PRODUCT BARRIER REFERENCE TABLE

THRESHOLDS FOR LOSS OR POTENTIAL LOSS OF BARRIERS

* Determine which combination of the three barriers are lost or have a potential loss and use the following key to classify the event. Also an event (or multiple events) could occur which result in the conclusion that exceeding the Loss or Potential Loss thresholds is IMMINENT (i.e., within 1 to 2 hours). In this IMMINENT LOSS situation use judgement and classify as if the thresholds are exceeded.

UNUSUAL EVENT	ALERT	SITE AREA EMERGENCY	GENERAL EMERGENCY
ANY Loss or ANY Potential Loss of Containment	ANY Loss or ANY Potential Loss of EITHER Fuel Clad OR RCS	Loss of BOTH Fuel Clad AND RCS OR Potential Loss of BOTH Fuel Clad AND RCS OR Potential Loss of EITHER Fuel Clad OR RCS, and Loss of ANY Additional Barrier	Loss of ANY Two Barriers AND Potential Loss of Third Barrier

FUEL CLAD BARRIER EXAMPLE EALS		RCS BARRIER EXAMPLE EALS		CONTAINMENT BARRIER EXAMPLE EALS	
LOSS	POTENTIAL LOSS	LOSS	POTENTIAL LOSS	LOSS	POTENTIAL LOSS
4. Reactor Vessel Water Level		4. Containment Radiation Monitoring		4. SG Secondary Side Release With Primary-to-Secondary Leakage	
Not applicable	Level LESS than (site-specific) value	Containment rad monitor reading GREATER THAN (site-specific) R/hr	Not applicable	Release of secondary side to atmosphere with primary to secondary leakage GREATER THAN tech spec allowable	Not applicable
OR		OR		OR	
5. Containment Radiation Monitoring		5. Other (Site-Specific) Indications		5. Significant Radioactive Inventory in Containment	
Containment rad monitor reading GREATER THAN (site-specific) R/hr	Not applicable	(Site-Specific) as applicable	(Site-Specific) as applicable	Not applicable	Containment rad monitor reading GREATER THAN (site-specific) R/hr
OR		OR		OR	
6. Other (Site-Specific) Indications		6. Emergency Director Judgement		6. Core Exit Thermocouple Readings	
(Site-Specific) as applicable	(Site-Specific) as applicable	Any condition in the opinion of the Emergency Director that indicate loss or potential loss of the RCS barrier		Not applicable	Core exit thermocouples in excess of 1200° and restoration procedures not effective within 15 minutes; or, core exit thermocouples in excess of 700° with reactor vessel level below top of active fuel and restoration procedures not effective within 15 minutes
OR		OR		OR	

TABLE 4

PWR EMERGENCY ACTION LEVEL

FISSION PRODUCT BARRIER REFERENCE TABLE

THRESHOLDS FOR LOSS OR POTENTIAL LOSS OF BARRIERS*

* Determine which combination of the three barriers are lost or have a potential loss and use the following key to classify the event. Also an event (or multiple events) could occur which result in the conclusion that exceeding the Loss or Potential Loss thresholds is IMMINENT (i.e., within 1 to 2 hours). In this IMMINENT LOSS situation use judgement and classify as if the thresholds are exceeded.

UNUSUAL EVENT	ALERT	SITE AREA EMERGENCY	GENERAL EMERGENCY
ANY Loss or ANY Potential Loss of Containment	ANY Loss or ANY Potential Loss of EITHER Fuel Clad OR RCS	Loss of BOTH Fuel Clad AND RCS OR Potential Loss of BOTH Fuel Clad AND RCS OR Potential Loss of EITHER Fuel Clad OR RCS, and Loss of ANY Additional Barrier	Loss of ANY Two Barriers AND Potential Loss of Third Bar

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7. Emergency Director Judgement

Any condition in the opinion of the Emergency Director that indicates loss or Potential Loss of the FUEL CLAD barrier

7. Other (Site-Specific) Indications

(Site-Specific) as applicable

(Site-Specific) as applicable

OR

8. Emergency Director Judgement

Any condition in the opinion of the Emergency Director t
indicates Loss or Potential Loss of the CONTAINMENT barri

BASIS INFORMATION FOR TABLE 4
PWR EMERGENCY ACTION LEVEL
FISSION PRODUCT BARRIER REFERENCE TABLE

FUEL CLAD BARRIER EXAMPLE EALs: (1 or 2 or 3 or 4 or 5 or 6 or 7)

The Fuel Clad Barrier is the zircalloy or stainless steel tubes that contain the fuel pellets.

1. Critical Safety Function Status

This EAL is for PWRs using Critical Safety Function Status Tree (CSFST) monitoring and functional recovery procedures. For more information, please refer to Section 3.9 of this report. RED path indicates an extreme challenge to the safety function. ORANGE path indicates a severe challenge to the safety function.

Core Cooling - ORANGE indicates subcooling has been lost and that some clad damage may occur. Heat Sink - RED indicates the ultimate heat sink function is under extreme challenge and thus these two items indicate potential loss of the Fuel Clad Barrier.

Core Cooling - RED indicates significant superheating and core uncovery and is considered to indicate loss of the Fuel Clad Barrier.

2. Primary Coolant Activity Level

This (site-specific) value corresponds to 300 μCi/cc I_{131} equivalent. Assessment by the NUMARC EAL Task Force indicates that this amount of coolant activity is well above that expected for iodine spikes and corresponds to about 5% to 10% fuel clad damage. This amount of clad damage indicates significant clad heating and thus the Fuel Clad Barrier is considered lost.

There is no equivalent "Potential Loss" EAL for this item.

3. Core Exit Thermocouple Readings

The "Loss" EAL (site-specific) reading should correspond to significant superheating of the coolant. This value typically corresponds to the temperature reading that indicates core cooling - RED in Fuel Clad Barrier EAL 1 which is usually about 1200 degrees F.

The "Potential Loss" EAL (site-specific) reading should correspond to loss of subcooling. This value typically corresponds to the temperature reading that indicates core cooling - ORANGE in Fuel Clad Barrier EAL 1 which is usually about 700 to 900 degrees F.

4. Reactor Vessel Water Level

There is no "Loss" EAL corresponding to this item because it is better covered by the other Fuel Clad Barrier "Loss" EALs.

The (site-specific) value for the "Potential Loss" EAL corresponds to the top of the active fuel. For sites using CSFSTs, the "Potential Loss" EAL is defined by the Core Cooling - ORANGE path. The (site-specific) value in this EAL should be consistent with the CSFST value.

5. Containment Radiation Monitoring

The (site-specific) reading is a value which indicates the release of reactor coolant, with elevated activity indicative of fuel damage, into the containment. The reading should be calculated assuming the instantaneous release and dispersal of the reactor coolant noble gas and iodine inventory associated with a concentration of 300 μCi/gm dose equivalent I-131 into the containment atmosphere. Reactor coolant concentrations of this magnitude are several time larger than the maximum concentrations (including iodine spiking) allowed within technical specifications and are therefore indicative of fuel damage (approximately 2 - 5% clad failure depending on core inventory and RCS volume). This value is higher than that specified for RCS barrier Loss EAL #4. Thus, this EAL indicates a loss of both the fuel clad barrier and a loss of RCS barrier.

There is no "Potential Loss" EAL associated with this item.

6. Other (Site-Specific) Indications

This EAL is to cover other (site-specific) indications that may indicate loss or potential loss of the Fuel Clad barrier, including indications from containment air monitors or any other (site-specific) instrumentation.

7. Emergency Director Judgement

This EAL addresses any other factors that are to be used by the Emergency Director in determining whether the Fuel Clad barrier is lost or potentially lost. In addition, the inability to monitor the barrier should also be incorporated in this EAL as a factor in Emergency Director judgement that the barrier may be considered lost or potentially lost. (See also IC SG1, "Prolonged Loss or All Offsite Power and Prolonged Loss of All Onsite AC Power", for additional information.)

RCS BARRIER EXAMPLE EALs: (1 or 2 or 3 or 4 or 5 or 6)

The RCS Barrier includes the RCS primary side and its connections up to and including the pressurizer safety and relief valves, and other connections up to and including the primary isolation valves.

1. Critical Safety Function Status

This EAL is for PWRs using Critical Safety Function Status Tree (CSFST) monitoring and functional recovery procedures. For more information, please refer to Section 3.9 of this report. RED path indicates an extreme challenge to the safety function derived from appropriate instrument readings, and these CSFs indicate a potential loss of RCS barrier.

There is no "Loss" EAL associated with this item.

2. RCS Leak Rate

The "Loss" EAL addresses conditions where leakage from the RCS is greater than available makeup capacity, including charging and ECCS. Under these conditions, the makeup systems capacity is less than core heat generation, thus subcooling will be lost as core heat is removed by boiling of the coolant. "Available" encompasses both equipment out-of-service considerations and system pressures higher than pump shutoff head or ECCS accumulator pressure is inadequate to the extent that subcooling is lost.

The "Potential Loss" EAL is based on the inability to maintain normal liquid inventory within the Reactor Coolant System (RCS) by normal operation of the Chemical and Volume Control System which is considered as one centrifugal charging pump discharging to the charging header. In conjunction with the SG Tube Rupture "Potential Loss" EAL this assures that any event that results in significant RCS inventory shrinkage or loss (e.g., events leading to reactor scram and ECCS actuation) will result in no lower than an "Alert" emergency classification.

3. SG Tube Rupture

This EAL is intended to address the full spectrum of Steam Generator (SG) tube rupture events in conjunction with Containment Barrier "Loss" EAL 4 and Fuel Clad Barrier EALs. The "Loss" EAL addresses ruptured SG(s) with an unisolable Secondary Line Break corresponding to the loss of 2 of 3 fission product barriers (RCS Barrier and Containment Barrier - this EAL will always result in Containment Barrier "Loss" EAL 4). This allows the direct release of radioactive fission and activation products to the environment. Resultant offsite dose rates are a function of many variables. Examples include: Coolant Activity, Actual Leak Rate, SG Carry Over, Iodine Partitioning, and Meteorology. Therefore, dose assessment in accordance with IC AG1, "Site Boundary Dose Resulting from an Actual or Imminent Release of Gaseous Radioactivity that Exceeds 1000 mR Whole Body or 5000 mR Child Thyroid for the Actual or Projected Duration of the Release Using Actual Meteorology", is required when there is indication that the fuel matrix/clad is potentially lost.

(Site-specific) indication should be consistent with the diagnostic activities of the Emergency Operating Procedures (EOPs), if available. This should include indication of reduction in primary coolant inventory, increased secondary radiation levels, and an uncontrolled or complete depressurization of the ruptured SG. Secondary radiation increases should be observed via radiation monitoring of Condenser Air Ejector Discharge, SG Blowdown, Main Steam, and/or SG Sampling System. Determination of the "uncontrolled" depressurization of the ruptured SG should be based on indication that the pressure decrease in the ruptured steam generator is not a function of operator action. This should prevent declaration based on a depressurization that results from an EOP induced cooldown of the RCS that does not involve the prolonged release of contaminated secondary coolant from the affected SG to the environment. This EAL should encompass steam breaks, feed breaks, and stuck open safety or relief valves.

The "Potential Loss" EAL is based on the inability to maintain normal liquid inventory within the Reactor Coolant System (RCS) by normal

operation of the Chemical and Volume Control System which is considered as one centrifugal charging pump discharging to the charging header. In conjunction with the RCS Leak Rate "Potential Loss" EAL this assures that any event that results in significant RCS inventory shrinkage or loss (e.g., events leading to reactor scram and ECCS actuation) will result in no lower than an "Alert" emergency classification.

4. Containment Radiation Monitoring

The (site-specific) reading is a value which indicates the release of reactor coolant to the containment. The reading should be calcualted assuming the instantaneous release and dispersal of the reactor coolant noble gas and iodine inventory associated with normal operating concentrations (i.e., within T/S) into the containment atmosphere. This reading will be less than that specified for Fuel Clad Barrier EAL #5. Thus, this EAL would be indicative of a RCS leak only. If the radiation monitor reading increased to that specified by Fuel Clad Barrier EAL #3, fuel damage would also be indicated.

However, if the site specific physical location of the containment radiation monitor is such that radiation from a cloud of released RCS gases could not be distinguished from radiation from nearby piping and components containing elevated reactor coolant activity, this EAL should be omitted and other site specific indications of RCS leakage substituted.

There is no "Potential Loss" EAL associated with this item.

5. Other (Site-Specific) Indications

This EAL is to cover other (site-specific) indications that may indicate loss or potential loss of the RCS barrier, including indications from containment air monitors or any other (site-specific) instrumentation.

6. Emergency Director Judgement

This EAL addresses any other factors that are to be used by the Emergency Director in determining whether the RCS barrier is lost or potentially lost. In addition, the inability to monitor the barrier should also be incorporated in this EAL as a factor in Emergency Director judgement that the barrier may be considered lost or potentially lost. (See also IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power", for additional information.)

CONTAINMENT BARRIER EXAMPLE EALs: (1 or 2 or 3 or 4 or 5 or 6 or 7 or 8)

The Containment Barrier includes the containment building, its connections up to and including the outermost containment isolation valves. This barrier also includes the main steam, feedwater, and blowdown line extensions outside the containment building up to and including the outermost secondary side isolation valve.

1. Critical Safety Function Status

This EAL is for PWRs using Critical Safety Function Status Tree (CSFST) monitoring and functional recovery procedures. For more information, please refer to Section 3.9 of this report. RED path indicates an extreme

challenge to the safety function derived from appropriate instrument readings and/or sampling results, and thus represents a potential loss of containment. Conditions leading to a containment RED path result from RCS barrier and/or Fuel Clad Barrier Loss. Thus, this EAL is primarily a discriminator between Site Area Emergency and General Emergency representing a potential loss of the third barrier.

There is no "Loss" EAL associated with this item.

2. Containment Pressure

Rapid unexplained loss of pressure (i.e., not attributable to containment spray or condensation effects) following an initial pressure increase indicates a loss of containment integrity. Containment pressure and sump levels should increase as a result of the mass and energy release into containment from a LOCA. Thus, sump level or pressure not increasing indicates containment bypass (V-sequence) and a loss of containment integrity. The (site-specific) PSIG for potential loss of containment is based on the containment design pressure. Existence of an explosive mixture means a hydrogen and oxygen concentration of at least the lower deflagration limit curve exists. The indications of potential loss under this EAL corresponds to some of those leading to the RED path in EAL 1 above and may be declared by those sites using CSFSTs. As described above, this EAL is primarily a discriminator between Site Area Emergency and General Emergency representing a potential loss of the third barrier.

The second potential loss EAL represents a potential loss of containment in that the containment heat removal/depressurization system (e.g., containment sprays, ice condenser fans, etc., but not including containment venting strategies) are either lost or performing in a degraded manner, as indicated by containment pressure greater than the setpoint at which the equipment was suppose to have actuated.

3. Containment Isolation Valve Status After Containment Isolation

This EAL is intended to address incomplete containment isolation that allows direct release to the environment. It represents a loss of the containment barrier.

There is no "Potential Loss" EAL associated with this item.

4. SG Secondary Side Release With Primary To Secondary Leakage

This EAL addresses SG tube ruptures. Secondary side releases to atmosphere include those from the condenser air ejector, atmospheric dump valves, and main steam safety valves. For smaller breaks, not exceeding the normal charging capacity threshold in RCS Barrier "Potential Loss" EAL 2 (RCS Leak Rate) or EAL 3 (SG Tube Rupture), this EAL results in an Unusual Event. For larger breaks, RCS barrier "Loss" or "Potential Loss" EAL 2 would result in an Alert. For SG tube ruptures which may involve multiple steam generators or unisolable secondary line breaks, this EAL would exist in conjunction with RCS barrier "Loss" EAL 3 and would result in a Site Area Emergency. Escalation to General Emergency would be based on "Potential Loss" of the Fuel Clad Barrier.

5. Significant Radioactive Inventory in Containment

The (site-specific) reading is a value which indicates significant fuel damage well in excess of the EALs associated with both loss of Fuel Clad and loss of RCS Barriers. As stated in Section 3.8, a major release of radioactivity requiring offsite protective actions from core damage is not possible unless a major failure of fuel cladding allows radioactive material to be released from the core into the reactor coolant. Regardless of whether containment is challenged, this amount of activity in containment, if released, could have such severe consequences that it is prudent to treat this as a potential loss of containment, such that a General Emergency declaration is warranted. NUREG-1228, "Source Estimations During Incident Response to Severe Nuclear Power Plant Accidents," indicates that such conditions do not exist when the amount of clad damage is less than 20%. Unless there is a (site-specific) analysis justifying a higher value, it is recommended that a radiation monitor reading corresponding to 20% fuel clad damage be specified here.

There is no "Loss" EAL associated with this item.

6. Core Exit Thermoscouples

In this EAL, the function restoration procedures are those emergency operating procedures that address the recovery of the core cooling critical safety functions. The procedure is considered effective if the temperature is decreasing or if the vessel water level is increasing.

The conditions in this potential loss EAL represent imminent melt sequence which, if not corrected, could lead to vessel failure and an increased potential for containment failure. In conjunction with the core exit thermocouple EALs in the Fuel and RCS barrier columns, this EAL would result in the declaration of a General Emergency -- loss of two barriers and the potential loss of a third. If the function restoration procedures are ineffective, there is no "success" path.

Severe accident analyses (e.g., NUREG-1150) have concluded that function restoration procedures can arrest core degradation within the reactor vessel in a significant fraction of the core damage scenarios, and that the likelihood of containment failure is very small in these events. Given this, it is appropriate to provide a reasonable period to allow function restoration procedures to arrest the core melt sequence. Whether or not the procedures will be effective should be apparent within 15 minutes. The Emergency Director should make the declaration as soon as it is determined that the procedures have been, or will be ineffective. The reactor vessel level chosen should be consistent with the emergency response guides applicable to the facility.

There is no "Loss" EAL associated with this item.

7. Other (Site-Specific) Indications

This EAL should cover other (site-specific) indications that may unambiguously indicate loss or potential loss of the containment barrier, including indications from area or ventilation monitors in containment annulus or other contiguous buildings. If site emergency operating procedures provide for venting of the containment during an emergency as a

means of preventing catastrophic failure, a Loss EAL should be included for the containment barrier. This EAL should be declared as soon as such venting is imminent. Containment venting as part of recovery actions is classified in accordance with the radiological effluent ICs.

B. Emergency Director Judgement

This EAL addresses any other factors that are to be used by the Emergency Director in determining whether the Containment barrier is lost or potentially lost. In addition, the inability to monitor the barrier should also be incorporated in this EAL as a factor in Emergency Director judgement that the barrier may be considered lost or potentially lost. (See also IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power", for additional information.)

RECOGNITION CATEGORY H

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

INITIATING CONDITION MATRIX

UNUSUAL EVENT

HU1 Natural and Destructive Phenomena Occurring Within the Protected Area. Ops. Modes: All

HU2 Fire Within Protected ARea Boundary Not Extinguished Within 15 Minutes of Detection. Op. Modes: All

HU3 Release of Toxic or Flammable Gases Deemed Detrimental to Safe Operation of the Plant. Op. Modes: All

HU4 Confirmed Security Event Which Indicates a Potential Degradation in the Level of Safety of the Plant. Op. Modes: All

HU5 Other Conditions Existing Which in the Judgement of the Emergency Director Warrant Declaration of an Unusual Event. Op. Modes: All

ALERT

HA1 Natural and Destructive Phenomena Occurring Within Plant Vital Area. Op Modes: All

HA2 Fire or Explosion Affecting the Operability of Plant Safety Systems Required to Establish or Maintain Safe Shutdown Op. Modes: All

HA3 Release of Toxic or Flammable Gases Within a Facility Structure Which Jeopardizes Operation of Systems Required to maintain safe operations or to Establish or Maintain Cold Shutdown. Op. Modes: All

HA4 Security Event in a Plant Protected Area. Op. Modes: All

HA5 Control Room Evacuation Has Been Initiated. Op. Modes: All

HA6 Other Conditions Existing which in the Judgement of the Emergency Director Warrant Declaration of an Alert. Op. Modes: All

SITE AREA EMERGENCY

HS1 Security Event in Plant Vital ARea. Op. Modes: All

HS2 Control Room Evacuation Has Been Initiated and Plant Control Cannot be Established. Op. Modes: All

HS3 Other Conditions Existing Which in the Judgement of the Emergency Director Warrant Declaration of a Site Area Emergency. Op. Modes: All

GENERAL EMERGENCY

HG1 Security Event Resulting in Loss of Ability to Reach and Maintain Cold Shutdown. Op. Modes: All

HG2 Other Conditions Existing Which in the Judgement of the Emergency Director Warrant Declaration of A General Emergency. Op. Modes: All

UNUSUAL EVENT

HU1 Natural and Destructive Phenomena Occurring Within the Protected Area.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4 or 5)

1. (Site-Specific) method indicates felt earthquake.
2. Report by plant personnel of tornado striking within protected area boundary.
3. Assessment by the control room that an event has occurred.
4. Vehicle crash into plant structures or systems within protected area boundary.
5. Report by plant personnel of an unanticipated explosion within protected area boundary resulting in visible damage to permanent structure or equipment."
6. (Site-Specific) Occurrences.

BASIS:

The protected area boundary is typically that part within the security isolation zone and is defined in the site security plan.

EAL 1 should be developed on site-specific basis. Damage may be caused to some portions of the site, but should not affect ability of safety functions to operate. Method of detection can be based on instrumentation, validated by a reliable source, or operator assessment. As defined in the EPRI-sponsored "Guidelines for Nuclear Plant Response to an Earthquake", dated October 1989, a "felt earthquake" is:

> An earthquake of sufficient intensity such that: (a) the vibratory ground motion is felt at the nuclear plant site and recognized as an earthquake based on a consensus of control room operators on duty at the time, and (b) for plants with operable seismic instrumentation, the seismic switches of the plant are activated. For most plants with seismic instrumentation, the seismic switches are set at an acceleration of about 0.01g.

EAL 2 is based on the assumption that a tornado striking (touching down) within the protected boundary may have potentially damaged plant structures containing functions or systems required for safe shutdown of the plant. If such damage is confirmed visually or by other in-plant indications, the event may be escalated to Alert.

EAL 3 allows for the control room to determine that an event has occurred and

take appropriate action based on personal assessment as opposed to verification (i.e., an earthquake is felt but does not register on any plant-specific instrumentation, etc.)

EAL 4 is intended to address such items as plane or helicopter crash, or on some sites, train crash, or barge crash that may potentially damage plant structures containing functions and systems required for safe shutdown of the plant. If the crash is confirmed to affect a plant vital area, the event may be escalated to Alert. With regard to explosions, only those explosions of sufficient force to damage permanent structures or equipment within the protected area should be considered. As used here, an explosion is a rapid, violent, unconfined combustion, or a catastrophic failure of pressurized equipment, that potentially imparts significant energy to near-by structures and materials. No attempt is made in this EAL to assess the actual magnitude of the damage. The occurrence of the explosion with reports of evidence of damage (e.g., deformation, scorching) is sufficient for declaration. The Emergency director also needs to consider any security aspects of the explosion, if applicable.

EAL 6 covers other (site-specific phenomena such as hurricane, flood, or seiche. These EALs can also be precursors of more serious events. In particular, sites subject to severe weather as defined in the NUMARC station blackout initiatives, should include an EAL based on activation of the severe weather mitigation procedures (e.g., precautionary shutdowns, diesel testing, staff call-outs, etc).

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

UNUSUAL EVENT

HU2 Fire Within Protected Area Boundary Not Extinguished Within 15 Minutes of Detection.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. Fire in buildings or areas contiguous to any of the following (site-specific) areas not extinguished within 15 minutes of control room notification or verification of a control room alarm:

   - (Site-specific) list

BASIS:

The purpose of this IC is to address the magnitude and extent of fires that may be potentially significant precursors to damage to safety systems. This excludes such items as fires within administration buildings, waste-basket fires, and other small fires of no safety consequence. This IC applies to buildings and areas contiguous to plant vital areas or other significant buildings or areas. The intent of this IC is not to include buildings (i.e., warehouses) or areas that are not contiguous or immediately adjacent to plant vital areas. Verification of the alarm in this context means those actions taken in the control room to determine that the control room alarm is not spurious.

Escalation to a higher emergency class is by IC HA2, "Fire Affecting the Operability of Plant Safety Systems Required for the Current Operating Mode".

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

UNUSUAL EVENT

HU3 Release of Toxic or Flammable Gases Deemed Detrimental to Safe Operation of the Plant.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. Report or detection of toxic or flammable gases that could enter within the site area boundary in amounts that can affect normal operation of the plant.

2. Report by Local, County or State Officials for potential evacuation of site personnel based on offsite event.

BASIS:

This IC is based on releases in concentrations within the site boundary that will affect the health of plant personnel or affecting the safe operation of the plant with the plant being within the evacuation area of an offsite event (i.e., tanker truck accident releasing toxic gases, etc.) The evacuation area is as determined from the DOT Evacuation Tables for Selected Hazardous Materials, in the DOT Emergency Response Guide for Hazardous Materials.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

UNUSUAL EVENT

HU4 Confirmed Security Event Which Indicates a Potential Degradation in the Level of Safety of the Plant.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. Bomb device discovered within plant Protected Area and outside the plant Vital Area.

2. Other security events as determined from (site-specific) Safeguards Contingency Plan.

BASIS:

This EAL is based on (site-specific) Site Security Plan. Security events which do not represent at least a potential degradation in the level of safety of the plant, are reported under 10 CFR 73.71 or in some cases under 10 CFR 50.72. The plant Protected Area Boundary is typically that part within the security isolation zone and is defined in the (site-specific) security plan. Bomb devices discovered within the plant Vital Area would result in EAL escalation.

UNUSUAL EVENT

HU5 Other Conditions Existing Which in the Judgement of the Emergency Director Warrant Declaration of an Unusual Event.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. Other conditions exist which in the judgement of the Emergency Director indicate a potential degradation of the level of safety of the plant.

BASIS:

This EAL is intended to address unanticipated conditions not addressed explicitly elsewhere but that warrant declaration of an emergency because conditions exist which are believed by the Emergency Director to fall under the Unusual Event emergency class.

From a broad perspective, one area that may warrant Emergency Director judgement is related to likely or actual breakdown of site specific event mitigating actions. Examples to consider include inadequate emergency response procedures, transient response either unexpected or not understood, failure or unavailability of emergency systems during an accident in excess of that assumed in accident analysis, or insufficient availability of equipment and/or support personnel.

Specific example of actual events that may require Emergency Director judgement for Unusual Event declaration are listed here for consideration. However, this list is by no means all inclusive and is not intended to limit the discretion of the site to provide further examples.

- o Aircraft crash on-site.
- o Train derailment on-site.
- o Near-site explosion which may adversely affect normal site activities.
- o Near-site release of toxic or flammable gas which may adversely affect normal site activities.
- o Uncontrolled RCS cooldown due to Secondary Depressurization

It is also intended that the Emergency Directors judgement not be limited by any list of events as defined here or as augmented by the site. This list is provided solely as examples for consideration and it is recognized that actual events may not always follow a pre-conceived description.

ALERT

HA1 Natural and Destructive Phenomena Occurring Within the Plant Vital Area.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4 or 5 or 6)

1. (Site-Specific) method indicates Seismic Event greater than Operating Basis Earthquake (OBE).

2. Tornado or high winds striking plant vital areas: Tornado or high winds greater than (site-specific) mph strike within protected area boundary.

3. Report of any visible structural damage on any of the following plant structures:

   - Reactor Building
   - Intake Building
   - Ultimate Heat Sink
   - Refueling Water Storage Tank
   - Diesel Generator Building
   - Turbine Building
   - Condensate Storage Tank
   - Control Room
   - Other (Site-Specific) Structures

4. (Site-Specific) indications in the control room.

5. Vehicle crash affecting plant vital areas.

6. (Site-Specific) occurrences.

BASIS:

EAL 1 should be based on (site-specific) FSAR design basis. Seismic events of this magnitude can cause damage to safety functions.

EAL 2 should be based on (site-specific) FSAR design basis. Wind loads of this magnitude can cause damage to safety functions.

EAL 3 should specify (site-specific) structures containing systems and functions required for safe shutdown of the plant.

EAL 4 should specify the types of instrumentation or indications including judgement which are to be used to assess occurrence.

EAL 5 is intended to address such items as plane or helicopter crash, or on some sites, train crash, or barge crash into a plant vital area.

EAL 6 covers other (site-specific) phenomena such as flood.

Each of these EALs is intended to address events that may have resulted in a plant vital area being subjected to forces beyond design limits, and thus damage may be assumed to have occurred to plant safety systems. Escalation to a higher emergency class, if appropriate, will be based on System Malfunction, Fission Product Barrier Degradation, Abnormal Rad Releases/Radiological Effluent, or Emergency Director Judgement ICs.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

ALERT

HA2 Fire or Explosion Affecting the Operability of Plant Safety Systems Required to Establish or Maintain Safe Shutdown.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Fire or explosion in any of the following (site-specific) areas:

      • (Site-specific) list

      AND

   b. Affected system parameter indications show degraded performance or plant personnel report visible damage to permanent structures or equipment within the specified area.

BASIS:

(Site-specific) Areas containing functions and systems required for the safe shutdown of the plant should be specified. (Site-Specific) Safe Shutdown Analysis should be consulted for equipment and plant areas required for the applicable mode. This will make it easier to determine if the fire or explosion is potentially affecting one or more redundant trains of safety systems. Escalation to a higher emergency class, if appropriate, will be based on System Malfunction, Fission Product Barrier Degradation, Abnormal Rad Levels/Radiological Effluent, or Emergency Director Judgement ICs.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

With regard to explosions, only those explosions of sufficient force to damage permanent structures or equipment required for safe operation within the identified plant area should be considered. As used here, an explosion is a rapid, violent, unconfined combustion, or a catastrophic failure of pressurized equipment, that potentially imparts significant energy to near-by structures and materials. The inclusion of a "report of visible damage" should not be interpreted as mandating a lengthy damage assessment prior to classification. No attempt is made in this EAL to assess the actual magnitude of the damage. The occurrence of the explosion with reports of evidence of damage (e.g., deformation, scorching) is sufficient for declaration. The declaration of an Alert and the activation of the TSC will provide the Emergency Director with the resources needed to perform these damage assessments. The Emergency Director also needs to consider any security aspects of the explosions, if applicable.

ALERT

HA3 Release of Toxic or Flammable Gases Within a Facility Structure Which Jeopardizes Operation of Systems Required to Maintain Safe Operations or to Establish or Maintain Cold Shutdown.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. Report or detection of toxic gases within a Facility Structure in concentrations that will be life threatening to plant personnel.

2. Report or detection of flammable gases within a Facility Structure in concentrations that will affect the safe operation of the plant.

BASIS:

This IC is based on gases that have entered a plant structure affecting the safe operation of the plant. This IC applies to buildings and areas contiguous to plant Vital Areas or other significant buildings or areas (i.e., Service Water Pumphouse). The intent of this IC is not to include buildings (i.e., warehouses) or other areas that are not contiguous or immediately adjacent to plant Vital Areas. It is appropriate that increased monitoring be done to ascertain whether consequential damage has occurred. Escalation to a higher emergency class, if appropriate, will be based on System Malfunction, Fission Product Barrier Degradation, Abnormal Rad Levels/Radioactive Effluent, or Emergency Director Judgement ICs.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

ALERT

HA5 Control Room Evacuation Has Been Initiated.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. Entry into (site-specific) procedure for control room evacuation.

BASIS:

With the control room evacuated, additional support, monitoring and direction through the Technical Support Center and/or other Emergency Operations Center is necessary. Inability to establish plant control from outside the control room will escalate this event to a Site Area Emergency.

Multi-unit stations with shared control rooms should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

SITE AREA EMERGENCY

HS1 Security Event in a Plant Vital Area.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. Intrusion into plant vital area by a hostile force.

2. Other security events as determined from (site-specific) Safeguards Contingency Plan.

BASIS:

This class of security events represents an escalated threat to plant safety above that contained in the Alert IC in that a hostile force has progressed from the Protected Area to the Vital Area.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

SITE AREA EMERGENCY

HS3 Other Conditions Existing Which in the Judgement of the Emergency Director Warrant Declaration of Site Area Emergency.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. Other conditions exist which in the Judgement of the Emergency Director indicate actual or likely major failures of plant functions needed for protection of the public.

BASIS:

This EAL is intended to address unanticipated conditions not addressed explicitly elsewhere but that warrant declaration of an emergency because conditions exist which are believed by the Emergency Director to fall under the emergency class description for Site Area Emergency.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

GENERAL EMERGENCY

HG2 Other Conditions Existing Which in the Judgement of the Emergency Director Warrant Declaration of General Emergency.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. Other conditions exist which in the Judgement of the Emergency Director indicate: (1) actual or imminent substantial core degradation with potential for loss of containment, or (2) potential for uncontrolled radionuclide releases. These releases can reasonably be expected to exceed EPA PAG plume exposure levels outside the site boundary.

BASIS:

This EAL is intended to address unanticipated conditions not addressed explicitly elsewhere but that warrant declaration of an emergency because conditions exist which are believed by the Emergency Director to fall under the General Emergency class.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in how rapidly a General Emergency is declared.

UNUSUAL EVENT

SU1 Loss of All Offsite Power to Essential Busses for Greater Than 15 Minutes.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Loss of power to (site-specific) transformers for greater than 15 minutes.

   AND

   b. At least (site-specific) emergency generators are supplying power to emergency busses.

BASIS:

Prolonged loss of AC power reduces required redundancy and potentially degrades the level of safety of the plant by rendering the plant more vulnerable to a complete Loss of AC Power (Station Blackout). Fifteen minutes was selected as a threshold to exclude transient or momentary power losses.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

UNUSUAL EVENT

SU3 Unplanned Loss of Most or All Safety System Annunciation or Indication in The Control Room for Greater Than 15 Minutes

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Loss of most or all (site-specific) annunciators associated with safety systems for greater than 15 minutes.

   AND

   b. Compensatory non-alarming indications are available.

   AND

   c. In the opinion of the Shift Supervisor, the loss of the annunciators or indicators requires increased surveillance to safely operate the unit(s).

   AND

   d. Annunciator or Indicator loss does not result from planned action.

BASIS:

This IC and its associated EAL are intended to recognize the difficulty associated with monitoring changing plant conditions without the use of a major portion of the annunciation or indication equipment.

Recognition of the availability of computer based indication equipment is considered (SPDS, plant computer, etc.).

"Unplanned" loss of annunciators or indicator excludes scheduled maintenance and testing activities.

"Compensatory non-alarming indications: in this context includes computer based information such as SPDS. This should include all computer systems available for this use depending on specific plant design and subsequent retrofits.

Quantification of "Most" is arbitrary, however, it is estimated that if approximately 75% of the safety system annunciators or indicators are lost, there is an increased risk that a degraded plant condition could go undetected. It is not intended that plant personnel perform a detailed count of the instrumentation lost but use the value as a judgement threshold for determining the severity of the plant

UNUSUAL EVENT

SU4 Fuel Clad Degradation.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. (Site-Specific) radiation monitor readings indicating fuel clad degradation greater than Technical Specification allowable limits.

2. (Site-Specific) coolant sample activity value indicating fuel clad degradation greater than Technical Specification allowable limits.

BASIS:

This IC is included as an Unusual Event because it is considered to be a potential degradation in the level of safety of the plant and a potential precursor of more serious problems. EAL 1 addresses (site-specific) radiation monitor readings such as BWR air ejector monitors, PWR failed fuel monitors, etc., that provide indication of fuel clad integrity. EAL 2 addresses coolant samples exceeding coolant technical specifications for iodine spike. Escalation of this IC to the Alert level is via the Fission Product Barrier Degradation Monitoring ICs.

UNUSUAL EVENT

SU6 Unplanned Loss of All Onsite or Offsite Communications Capabilities.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. Either of the following conditions exist:

   a. Loss of all (site-specific list) onsite communications capability affecting the ability to perform routine operations.

   OR

   b. Loss of all (site-specific list) offsite communications capability.

BASIS:

The purpose of this IC and its associated EALs is to recognize a loss of communications capability that either defeats the plant operations staff ability to perform routine tasks necessary for plant operations or the ability to communicate problems with offsite authorities. The loss of offsite communications ability is expected to be significantly more comprehensive than the addressed by 10 CFR 50.72.

(Site-specific list) onsite communications loss must encompass the loss of all means of routine communications (i.e., phones, sound powered phone systems, page party system and radios/walkie talkies).

(Site-specific list) offsite communications loss must encompass the loss of all means of communications with offsite authorities. This should include the ENS, Bell lines, FAX transmissions, and dedicated EPP phone systems. This EAL is intended to be used only when extraordinary means are being utilized to make communications possible (relaying of information from radio transmissions, individuals being sent to offsite locations, etc.).

ALERT

SA1 **Loss of All Offsite Power and Loss of All Onsite AC Power During Cold Shutdown Or Refueling Mode.**

OPERATING MODE APPLICABILITY: Cold Shutdown
Refueling
Defueled

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Loss of power to (site-specific) transformers.

   AND

   b. Failure of (site-specific) emergency generators to supply power to emergency busses.

   AND

   c. Failure to restore power to at least one emergency bus within 15 minutes from the time of loss of both offsite and onsite AC power.

BASIS:

Loss of all AC power compromises all plant safety systems requiring electric power including RHR, ECCS, Containment Heat Removal, Spent Fuel Heat Removal and the Ultimate Heat Sink. When in cold shutdown, refueling, or defueled mode the event can be classified as an Alert, because of the significantly reduced decay heat, lower temperature and pressure, increasing the time to restore one of the emergency busses, relative to that specified for the Site Area Emergency EAL. Escalating to Site Area Emergency, if appropriate, is by Abnormal Rad Levels/Radiological Effluent, or Emergency Director Judgement ICs. Fifteen minutes was selected as a threshold to exclude transient or momentary power losses.

ALERT

SA3 Inability to Maintain Plant in Cold Shutdown.

OPERATING MODE APPLICABILITY: Cold Shutdown
Refueling

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Loss of (site-specific) Technical Specification required functions to maintain cold shutdown.

   AND

   b. Temperature increase that either:

      - Exceeds Technical Specification cold shutdown temperature limit

      OR

      - Results in uncontrolled temperature rise approaching cold shutdown technical specification limit.

BASIS:

This EAL addresses complete loss of functions required for core cooling during refueling and cold shutdown modes. Escalation to Site Area Emergency or General Emergency would be via Abnormal Rad Levels/Radiological Effluent or Emergency Director Judgement ICs.

For PWRs, this IC and its associated EAL are based on concerns raised by Generic Letter 88-17, "Loss of Decay Heat Removal." A number of phenomena such as pressurization, vortexing, steam generator U-tube draining, RCS level differences when operating at a mid-loop condition, decay heat removal system design, and level instrumentation problems can lead to conditions where decay heat removal is lost and core uncovery can occur. NRC analyses show that sequences that can cause core uncovery in 15 to 20 minutes and severe core damage within an hour after decay heat removal is lost. Under these conditions, RCS integrity is lost and fuel clad integrity is lost or potentially lost, which is consistent with a Site Area Emergency. (Site-specific) indicators for these EALs are those methods used by the plant in response to Generic Letter 88-17 which include core exit temperature monitoring and RCS water level monitoring. In addition, radiation monitor readings may also be appropriate as an indicator of this condition.

"Uncontrolled" means that system temperature increase is not the result of planned actions by the plant staff.

ALERT

SA4 Unplanned Loss of Most or All Safety System Annunciation or Indication in Control Room With Either (1) a Significant Transient in Progress, or (2) Componsatory Non-Alarming Indicators are Unavailable.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Loss of most or all (site-specific) annunciators associated with safety systems for greater than 15 minutes.

   AND

   b. In the opinion of the Shift Supervisor, the loss of the annunciators or indicators requires increased surveillance to safely operate the unit(s).

   AND

   c. Annunciator or Indicator loss does not result from planned action

   AND

   d. Either of the following:

      1. A significant plant transient is in progress.

      OR

      2. Compensatory non-alarming indications are unavailable.

BASIS:

This IC and its associated EAL are intended to recognize the difficulty associated with monitoring changing plant conditions without the use of a major portion of the annunciation or indication equipment during a transient. Recognition of the availability of computer based indication equipment is considered (SPDS, plant computer, etc.).

"Planned" loss of annunciators or indicators included scheduled maintenance and testing activities.

Quantification of "Most" is arbitrary, however, it is estimated that if approximately 75% of the safety system annunciators or indicators are lost, there is an increased risk that a degraded plant condition could go undetected. It is not intended that plant personnel perform a detailed count

UNUSUAL EVENT

SA5 AC power capability to essential busses reduced to a single power source to greater than 15 minutes such that any additional single failures would result in station backout.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVELS:

1. The following conditions exists: (a and b)

   a. Loss of Power to <site-specific> Transformers for Greater Than 15 Minutes.

   AND

   b. Onsite Power Capability has been Degraded to one (Train of) Emergency Bus(ses) Powered From a Single Onsite Power Source due to the Loss of:

      <site-specific list>

BASIS:

This IC and the associated EALs are intended to provide an escalation from IC SU1, "Loss of All Offsite Power To Essential Busses for Greater Than 15 Minutes." The condition indicated by this IC is the degradation of the offsite and onsite power systems such that any additional single failure would result in a station blackout. This condition could occur due to a loss of offsite power with a concurrent failure of one emergency generator to supply power to its emergency busses. Another related condition could be the loss of all offsite power and loss of onsite emergency diesels with only one train of emergency busses being backfed from the unit main generator, or the loss of onsite emergency diesels with only one train of emergency busses being backfed from offsite power. The subsequent loss of this single power source would escalate the event to a Site Area Emergency in accordance with IC SS1, "Loss of All Offsite and Loss of All Onsite AC Power to Essential Busses."

Example EAL 1b should be expanded to identify the control room indicating of the status offsite-specific power sources and distribution busses that, if unavailable, establish a single failure vulnerability.

At multi-unit stations, the EALs should allow credit for operation of installed design features, such as cross-ties or swing diesels, provided that abnormal or emergency operating procedures address their use. However, these stations must also consider the impact of this condition on other shared safety functions in developing the site specific EAL.

SITE AREA EMERGENCY

SS2 Failure of Reactor Protection System Instrumentation to Complete or Initiate an Automatic Reactor Scram Once a Reactor Protection System Setpoint Has Been Exceeded and Manual Scram Was NOT Successful.

OPERATING MODE APPLICABILITY: Power Operation

EXAMPLE EMERGENCY ACTION LEVEL:

1. (Site-specific) indications exist that automatic and manual scram were not successful.

BASIS:

Automatic and manual scram are not considered successful if action away from the reactor control console was required to scram the reactor.

Under these conditions, the reactor is producing more heat than the maximum decay heat load for which the safety systems are designed. A Site Area Emergency is indicated because conditions exist that lead to imminent loss or potential loss of both fuel clad and RCS. Although this IC may be viewed as redundant to the Fission Product Barrier Degradation IC, its inclusion is necessary to better assure timely recognition and emergency response. Escalation of this event to a General Emergency would be via Fission Product Barrier Degradation or Emergency Director Judgement ICs.

SITE AREA EMERGENCY

SS4 Complete Loss of Function Needed to Achieve or Maintain Hot Shutdown.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. Complete loss of any (site-specific) function required for hot shutdown.

BASIS:

This EAL addresses complete loss of functions, including ultimate heat sink and reactivity control, required for hot shutdown with the reactor at pressure and temperature. Under these conditions, there is an actual major failure of a system intended for protection of the public. Thus, declaration of a Site Area Emergency is warranted. Escalation to General Emergency would be via Abnormal Rad Levels/Radiological Effluent, Emergency Director Judgement, or Fission Product Barrier Degradation ICs.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

specified by the IC. Escalation to a general emergency is via radiological effluence IC AG1.

shut down the reactor, maintain the core cooled and in a coolable geometry, to remove heat from the core, to maintain the reactor coolant system intact, and to maintain containment intact.

"Planned" actions are excluded from this EAL since the loss of instrumentation of this magnitude is of such significance during a transient that the cause of the loss is not an ameliorating factor.

In addition, under these conditions, fission product barrier monitoring capability may be degraded. Although it may be difficult to predict when power can be restored, it is necessary to give the Emergency Director a reasonable idea of how quickly (s)he may need to declare a General Emergency based on two major considerations:

1. Are there any present indications that core cooling is already degraded to the point that Loss or Potential Loss of Fission Product Barriers is IMMINENT? (Refer to Tables 3 and 4 for more information.)

2. If there are no present indications of such core cooling degradation, how likely is it that power can be restored in time to assure that a loss of two barriers with a potential loss of the third barrier can be prevented?

Thus, indication of continuing core cooling degradation must be based on Fission Product Barrier monitoring with particular emphasis on Emergency Director judgement as it relates to IMMINENT Loss or Potential Loss of fission product barriers and degraded ability to monitor fission product barriers.

Multi-unit stations with shared safety functions should further consider how this IC may affect more than one unit and how this may be a factor in escalating the emergency class.

condenser, or via the suppression pool or torus (e.g., due to high pool water temperature.

In the event either of these challenges exist at a time that the reactor has not been brought below the power associated with the safety system design (typically 3 to 5% power) a core melt sequence exists. In this situation, core degradation can occur rapidly. For this reason, the General Emergency declaration is intended to be anticipatory of the fission product barrier matrix declaration to permit maximum offsite intervention time.

Emergency," and IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power."

Other NUMARC ICs under this emergency class addressing events not addressed by the example ICs listed in NUREG-0654 include the following:

SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power"

The NUMARC Fission Product Barrier Matrix allows for more combinations of events than are specifically identified in NUREG-0654.

REGULATORY ANALYSIS

REVISION OF REGULATORY GUIDE 1.101 TO ACCEPT THE GUIDANCE IN NUMARC/NESP-007, REV. 1. AS AN ALTERNATIVE METHODOLOGY FOR THE DEVELOPMENT OF EMERGENCY ACTION LEVELS

1. STATEMENT OF THE PROBLEM

1.1 Background

Paragraph (a)(1) of § 50.47, *Emergency Plans*, of 10 CFR Part 50 states that no operating license for a nuclear power reactor will be issued unless a finding is made by NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Section 50.47 also establishes standards that must be met by the onsite and offsite emergency response plan for NRC staff to make a positive finding that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Part 50, Appendix E, Section IV.B provides that emergency plans are to include emergency action levels (EALs), which are to be used as criteria for determining the need for notification and participation of local and state agencies and which are to be used for determining when and what type of protective measures should be considered within and without the site boundary to protect health and safety. Emergency action levels are to be based on in-plant conditions and instrumentation, and also on onsite and offsite monitoring. Section IV.B of Appendix E also provides that EALs shall be discussed and agreed on by the applicant and State and local authorities and be approved by NRC; and be reviewed annually with State and local authorities.

Part 50, Appendix E, Section IV.E provides that there are emergency classification levels (ECLs) that determine the extent of the participation of the emergency response organization; and that the ECLs include: (1) notification of unusual event; (2) alert; (3) site area emergency; and (4) general emergency. The consequence of an emergency action level (EAL) being exceeded is that the licensee will declare a more severe emergency classification level and the degree of participation and readiness of the emergency response organization will increase.

Revision 1 to NUREG-0654/FEMA-REP-1, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants*, ("NUREG-0654") was published in October 1980

ENCL 3

to provide specific acceptance criteria for complying with the standards set forth in §50.47 of 10 CFR Part 50. Appendix 1 of NUREG-0654 contain example EALs for each of the four emergency classification levels (ECLs) that are used to initiate different levels of emergency response offsite. Revision 2 of Regulatory Guide 1.101, *Emergency Planning and Preparedness of Nuclear Reactors*, endorsed NUREG-0654.

The purpose of declaring an emergency classification level is to initiate an emergency response, or a higher level of emergency response. Appendix 1 to NUREG-0654 contains a description and the purpose of each ECL, and which licensee and offsite emergency response authority actions should be initiated or ongoing at each ECL. The higher the ECL, the greater the effort (and the cost) required of the licensee and offsite emergency response authorities to respond to the ECL.

A goal of ECLs is to have offsite emergency response authorities prepared to take actions to protect the health and safety of the public in the event of a radiological release offsite. These "protective actions" are usually to evacuate, or to shelter-in-place, the population in parts of, or in all of, an emergency planning zone (EPZ) with a radius of 10 miles centered on the nuclear plant. If ECLs are declared too early or when not warranted by plant conditions, licensees and offsite emergency response authorities may incur unnecessary expenses. On the other hand, if ECLs are declared later than when appropriate or are not declared, there may be undue risk of radiological exposure to the public. There may be large costs to the public in taking protective actions, especially the economic costs of evacuation (e.g., businesses in the evacuated area would be shut down). However, these economic cost would not depend on precisely when ECLs are declared.

1.2 Need for Further Guidance

NRC has provided guidance on emergency action levels in only two documents. Revision 2 of Regulatory Guide 1.101 endorsed NUREG-0654. In October of 1981, NUREG-0818, "Emergency Action Levels for Light Water Reactors" was published. In NUREG-0818, the application of the EALs of NUREG-0654 were studied and improvements were suggested. The nuclear utility industry has now a decade of experience in adapting the NRC guidelines to develop sets of site-specific EALs and in using these EALs in exercises and under actual accident conditions.

During this period, licensees have developed, offsite emergency response authorities have agreed upon, the NRC has approved sets of EALs that represent broad variations in the ways the guidance in NUREG-0654 can be applied. It is

possible that two plants, faced with identical conditions and applying their EAL schemes, would declare different levels of emergency (different ECLs). Also, there have been situations that were not contemplated when the guidelines were written and plant personnel were without specific guidance on which ECL to declare. Appendix 1 of NUREG-0654 does not contain example EALs for each ECL, but rather initiating conditions (i.e., plant conditions that indicate that a radiological emergency, or events that could lead to a radiological emergency, has occurred). NUREG-0654 notes that the initiating conditions (ICs) form the basis for establishment by a licensee of the specific plant instrumentation readings (as applicable) which, if exceeded, would initiate the emergency class. Thus, it is the specific instrument readings that would be the emergency action levels. In some cases, inconsistencies among initiating conditions together with broad ranges of risks with an initiating condition have resulted in some licensees declaring inappropriate ECLs.

In view of this experience, The Nuclear Management and Resource Council, Inc. (NUMARC) formed a task force to conduct a study to develop a systematic approach and support basis for development of emergency action levels. The methodology that was developed from this effort is described in NUMARC NESP-007, Rev. 1, *Methodology for Development of Emergency Action Levels*, February 1991. NRC staff has reviewed the NUMARC methodology and considers it to be a generally acceptable alternative method to that described in NUREG-0654.

2. OBJECTIVES

The objective of this action is to update NRC's guidance on development of emergency action levels (EAL's) that are required by 10 CFR Part 50 Appendix E Section IV.B. NRC's current guidance in NUREG-0654 and NUREG-0818 is a decade old. There has been instances when emergencies have been declared when they should not have; when emergencies have not been declared when they should have; and when inappropriate levels of emergency have been declared. NUMARC has published a methodology for development of EALs. NRC staff has reviewed the NUMARC methodology and considers it to be a generally acceptable alternative method to that described in NUREG-0654. The objective of the proposed revision 3 to Regulatory Guide 1.101 is to inform Part 50 applicants and licensees of NRC's regulatory position.

3. ALTERNATIVES

The alternatives to be considered are: (1) to take no action (i.e., to maintain the status quo); and (2) to adopt the regulatory position that the guidance contained in NUMARC/NESP-007 is considered to be a generally

acceptable alternative method to that described in NUREG-0654 for developing emergency action levels (EALs).

It should be remembered that neither alternative, mandates any particular methodology for developing emergency action levels. According to 10 CFR Part 50 Appendix E Section IV.B, emergency actions developed by licensees must be agreed on by offsite emergency response authorities and approved by NRC. The NUMARC methodology is in a published report and licensees may use it to develop EALs that are agreeable to offsite emergency response authorities and acceptable to NRC, regardless of which alternative is chosen. However, adoption of alternative 2 would be expected to foster use of the NUMARC methodology by eliminating uncertainty as to whether the methodology is acceptable to NRC.

3.1 Description of the NUREG Methodology

For each emergency classification level (notification of unusual event, alert, site area emergency, and general emergency), Appendix 1 to NUREG-0654 contains a list of example initiating conditions. These initiating condition "are to form the basis for establishment by each licensee of the specific plant instrumentation readings (as applicable) which, if exceeded, will initiate the emergency class."

3.2 Description of the NUMARC Methodology

The methodology for developing emergency action levels described in NUMARC/NESP-007 ("NUMARC methodology") defines initiating conditions and emergency action levels based on regulatory intent and industry usage. These definitions are:

> **INITIATING CONDITION (IC):** One of a predetermined subset of nuclear power plant conditions where either the potential exists for a radiological emergency, or such an emergency has occurred.
>
> **EMERGENCY ACTION LEVEL (EAL):** A pre-determined, site-specific, observable threshold for a plant initiating condition that places the plant in a given emergency class. An EAL can be: an instrument reading; an equipment status indicator; a measurable parameter (onsite or offsite); a discrete, observable event; results of analyses; entry into specific emergency operating procedures; or another phenomenon which, if it occurs, indicates entry into a particular emergency class.

The NUMARC methodology has three kinds of ICs and EALs: (1) symptom-based; (2) event-based; and (3) barrier-based. The symptom-based class refers

to those indicators that are measurable over a continuous spectrum, e.g., core temperature, coolant level, radiation meter readings. Off-normal readings on such indicators are symptoms of problems. The seriousness of a symptom depends on such factors as the degree to technical specifications are exceeded and the capability of licensed operators to gain control and bring the indicators back to safe levels. Event based ICs and EALs refer to discrete occurrences with potential safety significance such as a fire or a high-pressure safety injection pump failure. Barrier-based ICs and EALs refer to the level of challenge to the principal barriers used to assure containment of radioactive materials within a nuclear plant. For the most important type of radioactive material, fission products, there are three principal barriers: fuel cladding; reactor coolant system (RCS) pressure boundary; and containment. Barrier-based ECLs are a subset of symptom-based EALs that are related to indications of challenges to fission product barriers. Add shutdowns DS

In the NUMARC methodology, the operating modes (power operation, hot standby, hot shutdown, cold shutdown, refueling, and defueled) to which individual ICs apply are specified. As a plant moves through the decay heat removal process toward cold shutdown and refueling, barriers to release of fission products may be reduced, instrumentation to detect symptom may not be fully effective and partial disabling of safety systems may be permitted by technical specifications. For such operations, ICs and EALs tend, therefore, to be event-based rather than symptom-based or barrier-based.

Initiating conditions and EALs are divided into four classes, or "recognition categories." These are:

- A - Abnormal Rad Levels/Radiological Effluent
- F - Fission Product Barrier Degradation
- H - Hazards or Other Conditions Affecting Plant Safety
- S - System Malfunction

For recognition categories A, H, and S, initiating conditions and associated EALs, are developed for each emergency classification level (as in the NUREG scheme): unusual event (U), alert (A), site area emergency (s), general emergency (G). For these recognition categories, initiating conditions are identified by a three-character acronym (recognition category, ECL, sequence number). Thus, AU2 and SS3, are the second unusual event IC in the abnormal radiation level recognition category and the third site area emergency IC in the systems malfunction recognition category, respectively.

For recognition category F (fission product barrier degradation), there are three initiating conditions: (1) loss or potential loss of the containment barrier; (2) loss or potential loss of the fuel clad barrier; and (3) loss or potential loss of the reactor coolant system (RCS) barrier. The EALs for each of these initiating conditions depend on whether the reactor is a PWR or a BWR. The ECL resulting from fission product barrier degradation depends upon the number of barriers loss (or potentially lost) and which ones they are:

UNUSUAL EVENT	Any loss or potential of containment
ALERT	Any loss or any potential loss of either fuel clad or RCS.
SITE AREA EMERGENCY	Loss of both fuel clad and RCS; or Potential loss of both fuel clad and RCS; or Potential loss of either fuel clad or RCS, and loss of any additional barrier.
GENERAL EMERGENCY	Loss of any two barriers and potential loss of the third barrier.

4. CONSEQUENCES

This regulatory analysis follows the guidance found in the NUREG/BR-0058 (May 1984), *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*, (the Guidelines) and NUREG/CR-3568 (Dec. 1983), *A Handbook for Value-Impact Analysis*, (the Handbook). One of the conventions of regulatory analyses is that costs and benefits are defined in terms of changes from the status quo. Alternative 1 would continue the status quo; application of the convention means that there are neither costs or benefits associated with Alternative 1.

As was discussed in Section 3, regardless of whether NRC decides on Alternative 1 or Alternative 2, licensees are free to adopt the NUMARC methodology. If a licensee uses the NUMARC methodology to develop a comprehensive set of EALs, those EALs would be effective only if offsite emergency response authorities agree to them and NRC approves them. NRC's approval of site-specific EALs is not linked to adoption of Alternative 2. Therefore, it can not be said with certainty that adoption of Alternative 2 will have any consequences (even if a licensee uses the NUMARC methodology, one cannot be certain it was attributable to NRC's decision to find the NUMARC methodology an acceptable alternative to the NUREG methodology for developing

EALs). However, for the purposes of exploring further in this regulatory analysis, potential consequences of using the NUMARC methodology, it will be assumed that one or more licensees would switch from a set of EALs based purely on the NUREG methodology to a set of EALs based on the NUMARC methodology as a result of a decision in favor of Alternative 2.

The purpose of an emergency action level (EAL) is to trigger the declaration of an emergency classification level (ECL), which in turn triggers a certain level of emergency response offsite. Appendix 1 to NUREG-0654 identifies the offsite activities initiated by or ongoing at each ECL. These licensee actions are directed toward providing information to offsite emergency response authorities and federal agencies (e.g., plant conditions, meteorological conditions, radiological field monitoring results). Licensee actions to respond directly to the onsite situation are governed by emergency operating procedures (EOPs). In the NUMARC methodology, EALs are defined to be consistent with EOPs, but EOPs are not affected by EALs. The course of the accident, and the extent of plant damage and offsite releases may depend on the quality of EOPs and how well they are implemented, but not on EALs. Therefore, several of the attributes as defined in the Handbook, those related to how the regulatory action affects accident frequency and accident severity, are not relevant. These non-relevant attributes are: occupational exposure (both routine and accidental); offsite property; onsite property; regulatory efficiency; improvements to knowledge; and NRC development.

The Handbook notes that the definition of attributes can be modified or extended if appropriate for the issues being studied. In this case, it is appropriate to extend the definition of the offsite property attribute to includes the costs to the offsite emergency response organizations to take the actions required by the ECLs.

It is not feasible to assess quantitatively the consequences of a licensee switching a pure NUREG-0654 system of EALs to a pure NUMARC system of EALs, with only generic information. Site-specific indicator readings that trigger EALs are needed. Even if site-specific EALs were available, it would still be beyond the scope of a regulatory analysis to make quantitative assessments as will now be explained.

Lets consider a scenario in which an accident escalates through the four classification levels under both EAL methodologies and culminates in a release, and an evacuation. The only effect of the EAL methodology on the offsite emergency response would be on when the ECLs are declared. As the scope of the emergency response is dependent on ECL, the cost of the emergency

response (offsite property attribute) is dependent on the length of time each ECL is in effect. The public health effects (dose received during evacuation) would depend when the evacuation begins relative to when the release begins and the speed of the evacuation. Both of these factors depend on the offsite response organization's preparedness, which depends on when ECLs are declared. To quantitatively assess consequences, it would be necessary to estimate the public health and offsite property costs under the NUREG system and the NUMARC system of EALs for each possible accident scenario, weight these consequences by the probability of the scenario and then add over scenarios. The scenarios would have to be extremely detailed and specify the times when indicator readings that exceed EAL thresholds would occur. Clearly, this is not feasible.

Instead, in Section 4.1, the consequences of NRC choosing Alternative 2 or a licensee adopting a set of EALs based on the NUMARC methodology are discussed qualitatively in terms of how consequences attributes could be affected. Also, some rough cost estimates are made.

4.1 How Consequences Attributes Could Be Affected

4.1.1 Public Health

Public health could be affected from exposure to offsite releases of radioactive material from an accident at a licensed nuclear plant. Such exposure could be from two pathways: (1) the plume exposure pathway; and (2) the ingestion pathway. Exposure to the plume exposure pathway is predominantly due to exposure from the passing airborne radioactive plume. The exposure can be mitigated from sheltering-in-place or evacuating before the plume passes by. Exposure from the ingestion pathway comes from drinking contaminated water, eating contaminated fruits and vegetables, eating dairy products or meat from cattle that have eaten contaminated vegetation, or eating contaminated aquatic foods. Exposure from the plume is contemporaneous with the release; exposure from and protective actions for the ingestion pathway occurs days to weeks after the release. The EAL system used would be expected to affect the timing of declaration of ECLs by minutes, or at the most a few hours. Because of the expanded ingestion pathway time scale, exposure from the ingestion pathway, and its mitigation, are only weakly affected, if affected at all, by the exact time that ECLs are declared. Therefore, it is assumed that the EAL system does not affect exposure from the ingestion pathway.

The effectiveness of evacuation in minimizing exposure to the airborne plume depends on when it begins relative to a significant release and the

speed of the evacuation. For example, NUREG-1150 (Dec. 1990), *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants*, considers, interalia, the offsite consequences of such accidents. Table 13-5 of NUREG-1150, contains estimates of the probability of exceeding 200-rem red marrow dose (a dose likely to result in an early fatality) for early containment failure at the Zion nuclear plant. The table shows that this probability is strongly dependent upon when the evacuation begins relative to the release for residents within 5 miles of the plant. For this particular site, it was estimated that if the evacuation begins an hour before the release, evacuation is more effective (lower probability of 200-rem red bone marrow dose) than either sheltering in basements or in large buildings; however, if evacuation were to begin at the release or 1 hour after the release began, evacuation would be only slightly more effective than sheltering in basements and would be less effective than sheltering in large buildings.

Chapter 11 of NUREG-1150 considers the sensitivity of early fatality complementary cumulative distribution function (CCDF) to emergency response for early containment failure accidents. Table 11.6, gives estimates of early fatalities for four different emergency responses as a function of the exceedance frequency of the CCDF. For Zion, for an exceedance frequency of 10^{-7}/reactor-yr, the difference between the number of early fatalities for sheltering and a timely evacuation is 500 persons. For an exceedance frequency of 10^{-6} per reactor-yr, the difference between the number of early fatalities for sheltering and a timely evacuation is 3,000 persons. These estimates indicate that if evacuation is the most effective protective action is protecting the public health, and if the evacuation is delayed or if sheltering is implemented instead, there could be significant numbers of extra early fatalities for incredibly rare, high-consequence accidents.

Effect of Declaration of the General Emergency ECL Being Overdue

Appendix 1 of NUREG-0654 notes that the general emergency ECL is declared when there is actual or imminent substantial core degradation or melting with potential for loss of containment, and releases can reasonably be expected to exceed protective active guides (PAGs) developed by the U.S. Environmental Protection Agency (EPA) for mitigation of exposure of the public to the plume (see EPA/520/1-75-001-A (1990), *Manual of Protective Actions for Nuclear Incidents*). NUREG-0654 notes that the immediate action for this class is sheltering-in-place (with 2 miles of the plant in all directions and within 5 miles of the plant downwind) until an assessment can be made that (1) an evacuation is indicated and (2) an, evacuation, if indicated, can be completed prior to significant release and transport of radioactive material to the affected areas.

If the declaration of the general emergency ECL is overdue, the public health could be compromised in several ways. The sheltering-in-place may be late so it cannot be completed before some members are exposed to the passing radioactive plume. Emergency workers should be dispatched to duty stations to ensure that a prompt and orderly evacuation can be accomplished and that relocation centers are staffed to receive evacuees. If the declaration of the general emergency ECL is overdue, the ability to effect an orderly evacuation when evacuation is indicated could be impaired. As a consequence, the less efficacious sheltering-in-place protective action could be decided upon; or if evacuation is decided upon, its start could be delayed and dose to evacuees could increase.

Effect of Declaration of Lower Level ECLs Being Overdue

One of the purposes of each ECL is for the offsite emergency response organization to take actions, appropriate to the risk of a significant release. If declaration of one ECL is overdue in a rapidly developing accident when there is to a higher ECL, the offsite emergency response organization may not be prepared to carry out the actions required by the higher ECL. For example, during the site area emergency ECL, emergency workers should be on stand-by status so that they can be dispatched in the event that the situation worsens. These emergency worker include law enforcement officers who would set up traffic control points on evacuation routes; highway department personnel who would use heavy duty vehicles to remove traffic impediments on evacuation routes; and bus drivers who would be dispatched to staging preliminary to the evacuation of school children and transit-dependent persons. Also, at the site area emergency ECL, radiological field monitoring teams are deployed so that they will be in place and able to map the plume if a significant release becomes imminent.

In a rapidly developing accident, an overdue declaration of site area emergency ECL could hinder an emergency response organization's preparedness to implement protective actions. The time at which the offsite organizations would be ready to manage an evacuation could be affected and the evacuation could be slower, especially if the deployment of vehicles to remove traffic impediments is delayed. Again, the decision whether to evacuate or to shelter-in-place could be affected by an overdue declaration of site area emergency ECL.

4.1.2 Offsite Property

The scope of the offsite emergency response, and therefore its cost, depends on the current emergency classification level (ECL). The total cost of each offsite emergency response organization depends on the length of time

each ECL is in effect. As the specific system for developing emergency action levels (EALs) affects when ECLs are declared, it would affect the duration that each ECL is in effect and therefore the costs of offsite emergency response. Because, the set of EALs developed by a licensee and agreed to by offsite emergency response authorities, must be approved by NRC, it is unlikely that an ECL above a notification of unusual event or alert ECL would be declared under one system and not under the other. It is far more likely that the timing of the declaration would be affected by whether EALs based on the NUREG-0654 methodology or on the NUMARC methodology is used.

Appendix 1 of NUREG-0654 gives the offsite emergency response actions associated with each ECL. A qualitative discussion of these actions for each ECL is given below.

Notification of Unusual Event

For the notification of unusual event ECL to be declared, unusual events are in process or have occurred which indicate a potential degradation of the level of safety of the plant. Releases of radioactive material requiring offsite response are not expected unless there is further degradation of safety systems. Usually, a few key persons in State and county response organizations are notified of the unusual event by the licensee. No action is required of the offsite emergency response organization other than providing fire and security assistance to the licensee, if requested. There is very little, if any, expense to offsite authorities in responding to this ECL.

Alert

For an alert ECL to be declared, an event should be in process or have occurred that involves an actual or potential substantial degradation of the plant. Releases of radioactive material are expected to be limited to small fractions of the EPA protective action guidelines. Each offsite jurisdiction with emergency response responsibilities (States and counties, and municipalities in some States) would set up or activation an emergency operations center (EOC) and at the alert ECL would notify key members of the staff of the EOC to report. Other EOC staff would be put on standby notice and field emergency workers would be alerted of the incident. Activation of a joint news center where public information officers from the licensee and offsite emergency response authorities would compose messages to be broadcast on the emergency broadcast system (EBS), and news releases could begin. Also, media briefing would take place at the joint media center. Confirmatory radiological field monitoring may be required if there is an actual release.

Depending on the number of jurisdiction involved, as many as 100 persons, mainly at State and county EOCs, could be working on the emergency response and many other emergency workers could have been notified of the incident. If it is assumed that the cost of the workers is $50/hour, then cost of the actions for the alert ECL could be as high as $5,000/hr.

Site Area Emergency

For a site area emergency ECL to be declared, events should be in progress or have occurred that involve actual or likely major failures of plant functions needed for protection of the public. Any releases are not expected to exceed EPA protective action guides. After this ECL is declared State and local EOCs and the joint news center should be fully staffed. Emergency workers who would be needed for an evacuation would be alerted to a standby status. Any of these emergency workers who work some distance from the EPZ (e.g., state police officers) should be dispatched to near-site duty stations. Activation of facilities for radiological monitoring and decontamination of evacuees and their vehicles (reception centers) and activation of facilities for congregate care of evacuees after they leave reception centers could being. Because of special concern for the safety of children, there may be a precautionary evacuation of schools during the site area emergency ECL. Also, evacuating schools early could free up school buses to evacuate the transit-dependent general population, if an evacuation of the general population is recommend if the accident worsens.

As emergency workers needed for evacuation start to become involved at the site area emergency ECL, the effort required for offsite actions would depend primarily on the number of persons who might be evacuated as well as on the number of jurisdiction involved. There could be 2-3 times as many emergency workers involved as during the alert ECL, on up to 200-300. At a cost of $50/hour, the cost of offsite emergency response organizations responding to a site area emergency ECL could be as high as $15,000/hr.

General Emergency

For a general emergency ECL to be declared, events are in progress or have occurred which involve actual or imminent substantial core degradation or melting with potential for loss of containment integrity. Releases can be reasonably expected to exceed EPA Protection Action Guideline exposure levels offsite for more than the immediate site area. After the general emergency ECL is declared, emergency workers needed for evacuation should be at their duty stations. These include: traffic control points, radiological field monitoring points, reception centers, congregate care centers, and emergency worker decontamination centers, and staging areas for general population

evacuation buses and emergency vehicles to keep evacuation routes clear (e.g., tow trucks and snow plows).

The cost of preparedness at the general emergency ECL for an evacuation could be substantial, especially for a jurisdiction with a high population. For example, consider as an extreme, Westchester County, N.Y., one of four counties within the plume exposure EPZ for the Indian Point Nuclear Power Station. In 1987, the resident and summer transient population of Westchester County within the EPZ was 173,500, of which 10,500 were estimated to be transit-dependent (i.e., rely on means other that the family automobile for transportation to evacuate). The reception centers should have the capability to monitor 20% of the population of the EPZ for radiological contamination within 12 hours of arrival. If each personnel monitor processes 33 evacuees per hour, then 88 personnel monitors per shift would needed. Emergency workers to monitor and decontaminate vehicles, to decontaminate evacuees, to record monitoring readings, to register evacuees, and to direct vehicular traffic are also needed at reception centers. About 150 workers would have to be ready after declaration of the general emergency ECL in reception centers to serve evacuees from Westchester County. If the transit-dependent population would be evacuated in one wave in buses with a capacity of 50 persons, then 210 buses and drivers would be staged Other facilities and functions that would be fully staffed would include the county EOC, the joint news center, emergency worker decontamination centers, congregate care centers, and traffic control points. Overall, 600-800 emergency workers could be involved for Westchester County. These activities would be duplicated, on a smaller scale perhaps, for the other three risk counties (Rockland, Orange and Putnam). The State Emergency Management Office and Health Department would be involved also. After declaration of a general emergency ECL at Indian Point, several thousand emergency workers would be involved. At many sites, at least a thousand emergency workers would be involved. If we assume that 1,000 workers are involved at $50/hr per worker, then the cost of responding to a general emergency ECL for personnel would be $50,000/hr. There could be additional costs for contracted vehicles (e.g., tow trucks, ambulances, evacuation buses).

Agreement with Modified EALs

Section IV.B of Appendix E to 10 CFR Part 50 provides that the licensee and State and local authorities shall agree to EALs, and that the EALs shall be reviewed annually with State and local authorities. Adoption of a set of EALs based on the NUMARC methodology would require review and agreement by the offsite authorities. Although these EALs could be proposed and reviewed in the context of the annual review, the review effort would be magnified when a

completely new set of EALs are under consideration. Offsite emergency response authorities have health physics expertise that is used in accident assessment (i.e., assessing doses from release, meteorological, and other information). However, offsite authorities may not staff with expertise in nuclear power plant safety, and may have to rely on consultants to review and give advise on a proposed set of EALs. A comprehensive review many require 2 to 4 weeks of consultant effect. If the cost of an expert consultant in nuclear safety is $100/hr, then agreeing to a set of EALs based on the NUMARC methodology may cost offsite authorities $8,000 to $16,000.

4.1.3 Industry Implementation

Implementation of a set of EALs based on the NUMARC methodology by a licensee would involve: (1) developing a comprehensive set of site-specific EALs from the generic guidance in NUMARC NESP-007; (2) getting offsite emergency response authorities to agree to them and NRC to approve them; and (3) retraining reactor plant staff. The cost of developing a comprehensive set of EALs can be considered to be akin to developing a complex and lengthy operating procedure. Abstract 2.2.2 of 1988 update to NUREG/CR-4627, *Generic Cost Estimates*, considers the costs to industry to write or rewrite procedures. It estimates that the cost of revision of 10 pages of an operating procedure that requires considerable research and some innovative analysis ranges on the average from $3,100 to $4,100. Developing a set of ECLs could be considered an activity "requiring considerable research and some innovative analysis." However, the effort involved would be far greater than involved in revising 10 pages. In NUMARC NESP-007, 81 pages are required to describe generic EAL guidance. This guidance includes statement of initiating events, example EALs indicating the need for site-specific indicator readings, and comments discussing the basis of the EALs. Adopting the NUMARC methodology would involve transforming the generic guidance into site-specific EALs and comments. It is estimated that the length of a document describing the site-specific set of EALs would be twice the length of the description of the generic guidance, or 160 pages. The cost of developing an EAL document 160 pages in length is assumed to cost 16 times the cost of writing or rewriting 10 pages of text for a complex change in operating procedures, of $50,000 to $66,000. However, the costs in Abstract 2.2.2 are based on 1986 salaries. Escalating these salaries to 1992 at 5%/yr, would increase the cost by 34% to $67,000 to $88,000.

A second cost to the licensee in adopting a comprehensive set of EALs is the expense in getting offsite emergency response authorities to agree to them and NRC to approve them. Public Law 101-508, *The Omnibus Budget Reconciliation Act of 1990*, requires that the NRC to recover 100% of its

budget authority (less the amount appropriated from the DOE administered Nuclear Waste Fund) by assessing license, inspection, and annual fees (NRC's final rule implementing that act is found at 56 FR 31472). Review and approval of EALs for a nuclear plant is an activity that is directly attributable to the nuclear plant and therefore is the type of approval for which the licensee would be expected to be billed the NRC full cost under 10 CFR §170.12(e). The fee for NRC's review and approval (for FY 1991) is based on the professional staff-hr rate of $115/hr. We estimate that 2-4 weeks of professional staff effort are required for NRC's review and approval of the EALs. There is also the cost of the licensee's staff effort involved in getting agreement to the EALs from offsite authorities and approval from NRC. It is estimated that this requires 2-4 weeks of effort of reactor engineers. in ONRL/TM-10071/R1, *Cost Estimate Guidelines for Advanced Nuclear Power Technologies*, the annual salary of a reactor engineer is estimated to be $51,000 in 1987. Adding 70% for fringe benefits and 5%/yr for salary increases, the cost of a reactor engineer-year of effort in 1992 would be $105,000. If a year of the effort is 48 weeks, then the cost of supervising the agreement and approval process would be $4,400 to $8,800, in 1992.

A third cost in implementing a set of EALs based on the NUMARC methodology is that of retraining affected plant staff on the use of the new EALs. Lets assume that the training about EALs is incorporated into a periodic retaining program, and that the length of the program is increased by one and shift operators. The cost of training would be the cost providing the training plus the cost of the trainees attending the training. It will be assumed that because EALs are associated with indicator readings that the means of instruction is "in-house simulator". For this means of instruction, Abstract 2.2.3 of *Generic Cost Estimates*, estimate costs per student in 1986 of $29 to $37. Assuming 5% escalation in costs per year, the price range in 1992 would be $37 to $47 per student-hr. Lets assume that there are 50 trainees, 5 supervisors and 45 operators. Then there would be 400 student-hrs and the cost of providing training would range between $14,800 and $18,800. Attending the incremental training would involve 1 week of supervisor effect and 9 weeks of operator effort. *Cost Estimates Guidelines for Advanced Nuclear Power Technologies* estimates that in 1987 operations supervisors were paid $51,000 and shift operators $43,000. Adding 70% of fringe benefits and 5%/yr for increase in salary, the annual costs in 1992 for operations supervisors and shift operators would be $105,000 and $89,000, respectively. If a working year is assumed to be 48 weeks, then the cost of plant personnel attending the incremental training would be $105,000/48 for supervisors and $83,000 x 9/48 for shift operators, or $17,800. The total training costs would then be between $32,000 and $38,600.

4.1.4 Industry Operations

As was discussed earlier, most onsite activities during an accident, are directed toward bringing the situation under control and minimizing plant damage. These activities are governed by emergency operating procedures. Onsite activities that may be affected by EALs are those related to the ECLs and offsite emergency response. These activities are described as "Licensee Actions" in Appendix 1 of NUREG-0654. Just as the extent of offsite authority actions (see Section 4.1.2) are dependent on ECL, so is the extent of licensee actions. Therefore, the cost of industry operations could be affected by the duration that each ECL is in effect. A qualitative discussion of licensee actions at each ECL is given below and rough estimates of the licensees hourly costs are given below. It should be remembered that differences in the duration of ECLs resulting from the use of EALs based on one methodology rather than the other would probably be measured in minutes, not hours.

Notification of Unusual Event

The only action required of the licensee is to promptly inform offsite emergency response authorities of the nature of the unusual conditions (A similar notification is required for each ECL). This action has negligible cost.

Alert

Besides notifying offsite authorities of the declaration of the alert ECL, the licensee should provide periodic plant status updates and meteorological assessments. Onsite radiological monitoring teams should be deployed to help determine if there is a release. If any releases are occurring, offsite authorities should be provided with dose estimates. These actions require activation of radiological monitoring teams and a dose assessment capability. Lets assume that the radiological monitoring team members are 4 health physicists and that the dose assessment is done by 4 reactor engineers. From Abstract 2.1.6 of *Generic Costs Estimates*, the cost of utility health physicists including fringe benefits was $35/hr in 1984. Assuming this cost escalates by 5% per year, the cost in 1992 would be $49/hr. The annual cost of a reactor engineer in 1992 was estimated earlier to be $105,000. Assuming a working year is 48 weeks, or 1,920 hours, the cost per hour for a reactor engineer would be $55. The cost to the licensee for its actions would be minimally that of 4 health physicists and 4 reactor engineers, or approximately $400/hr.

Site Area Emergency

During the site area emergency ECL, the licensee would minimally take the following additional actions: dispatch offsite radiological monitoring teams; dedicate an individual for plant status updates to offsite authorities; have staff at the joint news center; provide release and dose projections based on available plant condition information and foreseeable contingencies; and make senior technical and management staff available for consultant with NRC and offsite authorities. Lets assume that 4 health physicists are dispatched to do radiological monitoring offsite, that 2 public relations specialists and a reactor engineer are dispatched to the joint news center, that 2 reactor engineers are added to the dose assessment capability; that the equivalent of a fulltime senior technical or management person is dedicated for consultation; that an operations supervisor is dedicated to giving plant updates; that 4 administrative services persons become involved; and that 4 communications specialists are dedicated to maintaining communications with offsite authorities and monitoring teams. Therefore, during the site area emergency licensee personnel involved the offsite response would minimally be: 8 health physicists ($49/hr each), 7 reactor engineers ($55/hr), 4 administrative services persons; and 4 communications technicians. The hourly costs in 1992 of these positions are estimated from the information in *Cost Estimate Guidelines for Advanced Nuclear Power Technologies* on annual salaries in 1987, and the assumptions of fringe benefits of 70% of base salary, salary escalations of 5% per year, and 1,920 working hours in a year. The 1987 annual salaries and 1992 hourly costs for the positions not previously considered are public relations specialists ($44,000/yr, $47/hr); senior person ($70,000/yr, $75/hr); administrative services ($27,000/yr, $29/hr); and technicians ($36,000/yr, $39/hr). The cost of the licensee's personnel devoted to actions related to the site area emergency ECL would then be;

8 x ($55/hr + $49/hr) + 4 x ($39/hr + $29/hr) + 2 x $44/hr + $75/hr = $1,267/hr

General Emergency

The licensee actions indicated in Appendix 1 of NUREG-0654 for the general emergency ECL are the same as for the site area emergency ECL. However, one would expect some intensification of the effort (e.g., more senior utility officers becoming involved). We will assume that the licensee effort is augmented by 2 senior persons, to bring the cost to about $1,400/hr.

4.1.5 NRC Costs

Costs to the NRC from adoption of Alternative 2 would be two types: (1) the costs to notify licensees, and possible offsite authorities of its action; and (2) the cost of reviewing and approving the set of EALs developed by a licensee. The draft of Revision 3 to Regulatory Guide 1.101 is 4 pages

in length. Acceptance of Revision 3 (Alternative 2) would reasonably involve actions such as publishing notice in NRC's weekly News Releases and mailing a copy of Revision 3 to each licensee and State emergency response authority. Assuming that the cost of mailing a copy is $1.00 ($.52 for postage and $.48 for handling) and that 200 copies are mailed, then the cost of notifying licensees and offsite authorities would be approximately $200.

If a licensee decides to adopt a set of EALs based on the NUMARC methodology and that decision is attributable to NRC's adoption of Revision 3 of Regulatory Guide 1.101, then the cost of NRC's review and acceptable of the set of EALs is relevant. This process was estimated to involve 80 to 160 hours of professional staff effort at a cost of $115/professional staff-hr. However, as acceptance of a set EALs appears to be a type of acceptance for which NRC can charge a fee to the licensee that covers its full costs under 10 CFR 170.12(e), this cost was discussed under the industry implementation attribute in Section 4.1.3.

4.1.6 Summary of Consequences

There are two classes of cost-related consequences associated with adoption of a set of emergency action levels (EALs). One class contains those costs and estimates of the dollar amounts for this class are: cost to licensee to develop EALs ($67,000 to $88,000); cost to licensee for NRC review and approval ($4,400 to $8,800); cost to licensee to train plant personnel on new EALs ($32,600 to $38,600); and cost to offsite emergency response authorities to review proposed EALs ($8,000 to $16,000). The total costs of a licensee adopting a new set of EALs is then estimated to be between $112,000 to $151,000.

The second class of costs are those associated with the actions required by offsite emergency response authorities and the licensee for each EAL. These costs are contingent on there being an accident. These costs depend on the length of time each EAL is in effect. They are also strongly site dependent as they depend on the population within the plume exposure EPZ and the number of offsite emergency response organizations. Some rough estimates of the cost per hour to the offsite authorities and the licensee have been made. For both the offsite authorities and the licensee, the cost of responding to the notification of unusual event ECL is negligible. The cost of responding to an alert ECL was estimated to be as high as $5,000/hr for offsite authorities and about $400/hr for a licensee. The cost of responding to a site area emergency ECL was estimated to be as high as $15,000/hr for offsite authorities and about $1,250 for a licensee. Finally, the cost of responding to a general emergency ECL was estimated to be about $50,000/hr for

offsite authorities and about $1,400 for a licensee. It should be remembered that these costs are not consequences of adopting EALs based on the NUMARC methodology. Consequences are associated with differences in the duration of ECLs under the two methodologies. Consequences are associated with differences in the duration of ECLs under the two methodologies. For example, if for a given accident scenario, the only difference in the timing of the declaration of ECLs, it that the site area emergency is declared 20 minutes sooner under the NUMARC system, then the consequences would be $5,400 weighted by the probability of the scenario.

Finally, the choice of EAL system potentially can have public health consequences if there is a significant radiological release that extends beyond the site boundary. There would be public health consequences if an evacuation is delayed or is slower from the offsite emergency response authorities having reduced preparedness because the declaration of the EALs were overdue. There would also be consequences if evacuation would have been the preferred protection action, but because an evacuation could not be accomplished in a timely manner from ECLs being overdue, sheltering-in-place would be recommended.

4.2 Comparison of the NUREG and the NUMARC Methodologies

The Nuclear Management and Resources Council (NUMARC) has developed a system for classifying abnormal occurrences at nuclear power plants which is documented in NUMARC/NESP-007, Rev.1, "Methodology for Development of Emergency Action Levels." In developing this system, NUMARC identified the initiating conditions (ICs) for each such event and placed the event in one of four categories or "emergency classification levels" (ECLs):

Notification of Unusual Event
Alert
Site Area Emergency
General Emergency

NUMARC then identified the types of plant instrument readings, called Emergency Action Levels (EALs), which would correspond with each IC. The Nuclear Regulatory Commission (NRC) staff reviewed NUMARC's methodology for developing these action levels by performing the following actions:

1. Compared the NUMARC methodology to the guidance in NUREG-0654/FEMA-REP-1, "Criteria for the preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," Revision 1, November 1980.

2. Considered refinements in the guidance in NUREG-0654 that have been developed based on experience gained and lessons learned in using NUREG-0654.

3. Participated in February 1991 with representatives from NUMARC and the utilities in a "table-top" review of plant events and emergency exercises to determine the classifica-tions that the licensees would most likely adopt in implementing the NUMARC proposal. The participants reviewed various event scenarios used in past emergency exercises to determine if NUMARC's methodology provided for adequate emergency classifications and for properly timed declarations.

NUMARC incorporated in its classification system several improvements suggested from the staff's review. The participants in the table-top exercise agreed that use of the improved classification system would result in higher level emergency classifications (site area and general emergencies) being made at the same time or earlier than they would be based on NUREG-0654 criteria.

After NUMARC made the improvements to its methodology, the NRC staff performed a regulatory analysis of these EAL guidelines by comparing the ICs identified by NUMARC with the examples of ICs shown in Appendix 1 to NUREG-0654. The staff compared the ICs according to the following:

NUMARC's interpretation of emergency class descriptions. (See Sections 3.7, "Emergency Class Descriptions," and 3.8, "Emergency Class Thresholds," of the NUMARC document).

NUMARC's EAL guidance and basis information. (See Section 5.0, "Generic EAL Guidance," of the NUMARC document).

The staff identified NUMARC ICs that corresponded or related to each IC in NUREG-0654. If no equivalent NUMARC IC was found, the staff analyzed NUMARC's basis for the omission to ensure that the NUMARC scheme still met the original intent of NUREG-0654. The staff concluded that, except as noted herein, the NUMARC ICs were more comprehensive than the NUREG-0654 ICs.

The staff is providing its regulatory analysis of the NUMARC methodology, arranged according to IC. The staff organized each section in the following format:

Definition of emergency classification as it appears in NUREG-0654
The NUMARC's disposition of the NUREG-0654 ICs for that classification

Title of NUREG-065 IC
Disposition
Regulatory Analysis

Emergency Classification: Notification of Unusual Event
Definition in NUREG-0654:

"Unusual Events are in process or have occurred which indicate a potential degradation of level of the safety of the plant. No releases of radioactive material requiring offsite response or monitoring is expected unless further degradation of safety systems occurs."

Disposition Of NUREG-0654 Example ICs Under This Emergency Class:
NUMARC reviewed each of the example ICs in NUREG-0654 against three main criteria:

- Is the event a reasonable precursor to a potential loss or loss of one or more of the fission product barriers?

  NUMARC included in its examples ICs for precursor events. NUMARC made some changes to clarify the ICs.

- Is the event reportable under the requirements of 10 CFR 50.72?

  The similarity between the NUREG-0654 unusual event ICs and the reportable events of 10 CFR 50.72 had previously prompted the staff to consider a modification to the emergency classification guidance of NUREG-0654. However, this similarity remained because the staff did not make this modification. NUMARC included this similarity as part of its justification for not including some NUREG-0654 unusual event ICs in the proposed methodology. Those NUREG-0654 unusual event ICs which have proved not to be precursors to more serious events were removed from the NUMARC methodology. The reporting requirements of 10 CFR 50.72 will satisfy the NRC's concern that it be notified of these "non-emergency" events.

- Is the event addressed within technical specification limiting conditions of operation (LCO)?

  A number of example ICs in NUREG-0654 addressed conditions that are controlled by the plant's technical specifications. NUMARC noted that operation within the boundaries of the technical specifications, including the specified action statements and

restoration times, represented an analyzed and approved situation. NUMARC concluded that an emergency condition could only exist if operation occurred outside these boundaries, that is, if required mode changes were not completed in the times specified.

1. "The emergency core cooling system (ECCS) initiated and discharged to the vessel."

Disposition:
The concerns addressed by this Initiating Condition (IC) have been integrated into several NUMARC ICs.

Regulatory Analysis:
NUMARC differentiates between the inadvertent discharge of ECCS into the vessel and the valid discharge of ECCS into the vessel. Inadvertent discharge of the ECCS to the vessel, in and of itself, does not constitute an emergency. ECCS actuation events are reportable under 10 CFR 50.72 b.1.iv and b.2.ii as non-emergency events. However, NUREG-0654 did not distinguish between the inadvertent and the valid discharge of ECCS and thus would classify any discharge of ECCS into the vessel as an unusual event. Many licensees have recognized the need for this distinction and have submitted modifications to their EALs and NRC has approved EALs, with such modifications.

NUMARC has integrated the valid ECCS discharge, which is a response to a (RCS) barrier challenge, into its fission product barrier degradation ICs or system malfunction ICs. The Fission Product Barrier Scheme offers a set of ICs that are connected to consequences of events that may challenge the integrity of the principal barriers. This is better than developing ICs connected to the individual events themselves. The alert IC, FA1, in the NUMARC scheme applies to those conditions in which the RCS or the fuel cladding barrier may be threatened. Under these conditions, NUMARC recognizes the level of severity needed to call for an alert. NUMARC further refined this scheme in ICs SU4 and SU5, where early signs of fuel degradation or RCS leakage would prompt the licensee to declare an unusual event.

Therefore, the NUMARC approach for this IC is acceptable because it provides a more accurate classification which meets the intent of NUREG-0654.

2. "Radiological effluent technical specification limits exceeded"

Disposition:
This IC is listed as an unusual event under NUMARC IC AU1, "Any Unplanned Release of Gaseous or Liquid Radioactivity to the Environment that Exceeds Two Times the Radiological Technical Specifications for 60 Minutes or Longer." The NUMARC IC contains a provision for licensees that have removed effluent limits from their technical specifications. For these, NUMARC specifies the use of the upper limits in the facility's Offsite Dose Calculation Manual (ODCM).

Regulatory Analysis:
10 CFR 50.72 requires a four-hour report whenever gaseous effluents exceed 2 times MPCs for unrestricted areas averaged over a period of an hour. The NUMARC IC considers a release to be an uncontrolled situation meeting the threshold of an unusual event if this release is greater than two times the technical specifications and if it continues unisolated for at least 60 minutes (no averaging). The concern in this IC is the degradation in plant control and not the dose at the site boundary. NUMARC stated in the basis of this IC, that once the Emergency Director recognizes that an uncontrolled situation might exist, the licensee should declare an unusual event before the 60 minutes have elapsed.

The NUMARC IC is acceptable because it defines the threshold for unusual events by discerning clearly between non-emergency, reportable events and those that qualify as potential emergencies.

3. "Fuel damage indication."

Disposition:
This IC is listed as an unusual event in NUMARC IC SU4,"Fuel Clad Degradation."

Regulatory Analysis:
The NUMARC IC SU4 is acceptable, as it addresses fully the key concerns of NUREG-0654. This IC is considered to be a precursor to a challenge to the fuel cladding barrier and as such the escalation path to higher classification is provided by way of the Fission Product Barrier scheme.

4. "Abnormal coolant temperature and/or pressure or abnormal fuel temperature outside technical specification limits."

Disposition:
The parts of this IC are considered as individual unusual events under the NUMARC ICs, SU2, "Inability to Reach Required Shutdown within Technical Specification Limits" and SU4, "Fuel Clad Degradation".

Regulatory Analysis:
NUMARC addresses fuel status under IC SU4 "Fuel Clad Degradation." Generally, NUMARC does not treat entry into a technical specification action statement as an emergency. However, NUMARC considers indications of fuel cladding degradation exceeding technical specification allowable limits to be a precursor of more serious problems and therefore calls for the licensee to declare an unusual event.

The NUREG-0654 guidance and the NUMARC approach differ fundamentally regarding the abnormal coolant temperature or pressure that is outside the technical specification limits. NUREG-0654 guidance calls for an unusual event to be declared when the technical specifications require the licensee to shutdown the plant. NUMARC proposes that the licensee declare an unusual event only if the plant had not been brought to the required operating mode (usually hot shutdown) within the time limits of the technical specification action statement. The initiation of a plant shutdown required by technical specification requires a one-hour report under 10 CFR 50.72. The NRC agrees that a controlled plant shutdown in compliance with a technical specification action statement is not a potential emergency and, therefore, need not be classified as an unusual event. NUMARC proposes to require the licensee to declare an unusual event when the plant is <u>not brought to the required operating mode within the allowable action statement time in technical specifications</u>.

5. "Exceeding either primary/secondary leak rate technical specification or primary system leak rate technical specification."

Disposition:
NUMARC included this IC as an unusual event in IC SU5, "RCS Leakage," and under the RCS barrier ICs as part of Fission Product Barrier Matrix. NUMARC addressed secondary leakage for pressurized water reactors (PWRs) in IC SU5 and under the RCS barrier and Containment barrier monitoring in the Fission Product Barrier Degradation ICs.

Regulatory Analysis:
Although the NUMARC proposes a numeric threshold in IC SU5 for RCS leakage which is higher than that implied in NUREG-0654, the NRC staff considers the NUMARC ICs to adequately address the primary concerns of NUREG-0654. Leakage exceeding the limit specified in the technical specifications will require a shutdown. IC SU2 covers those conditions in which the required shutdown within the technical specifications was not reached. NUMARC proposes leakage rates, that are readily observable with normal control room indications (i.e. for PWRs, greater than 10 gpm for unidentified or pressure boundary leakage or 25 gpm for identified leakage). The difference between the two leakage rates is justified based on their relative risk significance. The values provided in SU5 will provide early indication of leakage which could be a precursor to the more severe events addressed in the Fission Product Barrier Degradation ICs.

This change is acceptable and is consistent with NUMARC's plan to separate non-emergency reportable events from its EAL scheme.

6. "Failure of a safety relief valve in a safety system to close following reduction of pressure."

Disposition:
NUMARC has integrated this IC into unusual event IC SU5, "RCS Leakage" and into ICs for RCS barrier fission product barrier degradation.

Regulatory Analysis:
The NUMARC IC SU5 applies to this situation. The licensee would raise the event to a higher classification by determining the status of the RCS barrier using IC FA1 in the Fission Product Barrier Matrix. The NUMARC scheme adequately addresses this NUREG-0654 IC.

7. "Loss of offsite power or loss of onsite AC capability."

Disposition:
NUMARC addressed this IC in unusual event IC SU1, "Loss of All Offsite Power to Essential Busses for Greater Than 15 Minutes," and IC SU2, "Inability to Reach Required Shutdown within Technical Specification Limits." NUMARC specified that the licensee would also declare an alert under IC SA5, "AC Power Capability to Essential Buses Reduced to a Single Power Source for Greater than 15 Minutes Such That any Additional Single Failure Would Result in Station Blackout."

Regulatory Analysis:

NUMARC retained the loss of offsite power event (with emergency generators available) as a precursor to station blackout. A prolonged loss of offsite power reduces power redundancy and could degrade the level of safety of the plant by rendering the plant more vulnerable to a station blackout. This condition would require the licensee to rely solely on the plant equipment powered through emergency buses by the emergency generator in order to control and safely shut down the plant. NUMARC IC SU1 addresses this condition by classifying as an unusual event a loss of offsite power for more than 15 minutes while onsite emergency generators are available. NUMARC included the 15-minute duration to discriminate against transient and momentary power losses. NUMARC IC SA5 escalates the EAL to an Alert if the power supply becomes degraded further.

While a loss of onsite power capability (with offsite power available) reduces redundancy, all normal electrical buses would continue to be powered and all plant equipment would continue to be available. The condition is addressed by the plant's technical specifications and is not considered to be an emergency. The onsite power capability loss IC is addressed in NUMARC IC SU2, "Inability to Reach Required Shutdown within Technical Specification Limits." In the basis section of IC SA5, NUMARC stated that escalation to an alert occurs when, with the loss of onsite emergency generators, further degradation results in only one train of emergency busses being fed from offsite power.

The NUMARC ICs adequately addresses the conditions specified in the NUREG-0654 IC.

8. "Loss of containment integrity requiring shutdown by technical specifications."

Disposition:

NUMARC did not view this IC as an emergency in the proposal. However, recognizing that it may lead to complications, NUMARC listed it as an unusual event in IC SU2, "Inability to Reach Required Shutdown with Technical Specification Limits," and in the containment barrier ICs pertaining to degradation of the fission product barrier.

Regulatory Analysis:

This IC results in entry into a technical specification action statement. A loss of containment integrity as it is defined and

Detection," and as an alert in NUMARC IC HA2, "Fire Affecting the Operability of Plant Safety Systems Required for the Current Operating Mode."

Regulatory Analysis:
By using the 15-minute time constraint, NUMARC clarified a point of confusion in EAL schemes that licensees currently use. NUMARC also clarified that the clock starts when the control room is notified or the control room alarm has been verified. NUMARC selected 15 minutes for the interval so that the IC would be consistent with other ICs addressing events that could cause damage to the plant. In IC HA2, NUMARC provided a means for escalating the event to a higher classification. The NUMARC ICs adequately cover the NUREG-0654 IC.

11. "Indications or alarms on process or effluent parameters not found functional in the control room to an extent requiring plant shutdown or significant loss of assessment or communi-cation capability (e.g., plant computer, Safety Parameter Display System, all meteorological instrumentation)."

Disposition:
NUMARC addressed this IC as the following two unusual event ICs: IC SU3, "Unplanned Loss of Most or All Safety System Annunciation or Indication in the Control Room for Greater Than 15 Minutes," and NUMARC IC SU6, "Unplanned Loss of All Onsite or Offsite Communications Capabilities."

Regulatory Analysis:
In IC SU3, NUMARC considered the declaration of an unusual event in which the licensee loses most annunciators associated with safety systems for more than 15 minutes, but has available compensatory non-alarming indicators, such as the SPDS and the plant computer. NUMARC did not address the loss of meteorological instrumentation in the ICs due to the shift in emphasis from dose assessment to plant status assessments since the issuance of NUREG-0654. IC SU6 addresses those situations in which a loss of communications capability hampers plant operations or renders routine communications with offsite officials ineffective.

The NUMARC ICs adequately address the intent of this NUREG-0654 IC.

interpreted in the technical specifications may not be a precursor to a more serious event. The initiation of a plant shutdown required by the technical specification requires a 1-hour report under 10 CFR 50.72. The licensee must declare an unusual event when the plant is not brought to the required operating mode within the allowable action statement time in the technical specifications.

NUMARC's IC FU1 recognizes that any loss or possible loss of containment function, in and of itself, constitutes an unusual event. NUMARC addressed explicitly the significant containment leak rates associated with plant events in the Fission Product Barrier Degradation EALs.

The NRC concurs with NUMARC's change.

9. "Loss of ESF or Fire protection system function requiring plant shutdown by technical specifications (e.g., because of malfunction, personnel error or procedural inadequacy)."

Disposition:
NUMARC addressed this IC as an unusual event in NUMARC IC SU2, "Inability to Reach Required Shutdown within Technical Specification Limits."

Regulatory Analysis:
This IC results in entry into a technical specification action statement. The loss of these functions as they are defined and interpreted in the technical specifications may not be a precursor to a more serious event. To begin to shut down the plant as required by the technical specification, the licensee must issue a 1-hour report under 10 CFR 50.72. The licensee must declare an unusual event when the plant is not brought to the required operating mode within the allowable action statement time in technical specifications. Loss of certain ESF functions that are associated with plant events are covered by System Malfunction, Hazards, and Fission Product Barrier Degradation ICs.

The NUMARC change is acceptable as it meets the intent of NUREG-0654.

10. "Fire within the plant lasting more than 10 minutes" ECT

Disposition:
NUMARC addressed this IC as an unusual event in NUMARC IC HU2, "Fire Within Protected Area Boundary Not Extinguished Within 15 Minutes of

Add w/ footnote

12. "Security threat or attempted entry or attempted sabotage."

Disposition:
NUMARC addressed this IC as an unusual event in IC HU4, "Confirmed Security Event Which Indicates a Potential Degradation of the Level of Safety of the Plant."

Regulatory Analysis:
The NUMARC IC addresses the key concerns of NUREG-0654.

13. "Natural phenomenon being experienced or projected beyond usual levels."
   a. Any earthquake detected at the station with seismic instrumentation
   b. A 50-year flood or low water, tsunami, hurricane surge, seiche
   c. Any tornado at the site
   d. Any hurricane

Disposition:
NUMARC addressed this IC as an unusual event in IC HU1, "Natural and Destructive Phenomena Occurring Within the Protected Area."

Regulatory Analysis:
The NUMARC IC and example EALs address the key concerns of NUREG-0654.

14. "Other hazards being experienced or projected."
   a. Aircraft crash at the site or unusual aircraft activity over the facility
   b. Train derailment on site
   c. Near or onsite explosion
   d. Near or onsite toxic or flammable gas release
   e. Turbine rotating components failure causing rapid plant shutdown.

Disposition:
NUMARC addressed Items "a" through "d" of the IC as unusual events in IC HU1, "Natural and Destructive Phenomena Occurring Within the Protected Area," and IC HU3, "Release Of Toxic Or Flammable Gases Deemed Detrimental to Safe Operation of the Plant."

Regulatory Analysis:
NUMARC did not address item "e" as a possible degradation of the level of safety of the plant since plants are designed to adequately handle a

turbine trip and the resultant rapid shutdown of the plant. The licensee must report this event under 10 CFR 50.72.

This proposed change is acceptable.

15. "Other plant conditions exist that warrant increased awareness on the part of plant operating staff or state and/or local offsite authorities or required plant shutdown under technical specification requirements or involve other than normal controlled shutdown (e.g., cooldown rate exceeding technical specification limits, pipe cracking found during operation)."

Disposition:
NUMARC addressed this IC as an unusual event in IC HU5, "Other Conditions Which in the Judgment of the Emergency Director Warrant Declaration of an Unusual Event."

Regulatory Analysis:
Most of the conditions listed in this IC are reportable under 10 CFR 50.72 and State and local agreements. However, the NUMARC IC addresses the key concerns that apply to emergency classification.

This change meets the intent of NUREG-0654. Licensees should be instructed to include in the guidance for the emergency director a list of the example EALs in this IC.

16. "Transportation of contaminated injured individual from site to offsite."

Disposition:
Deleted.

Regulatory Analysis:
This event does not meet the threshold for the emergency class description and is not a precursor to a more serious event. This event is reportable under 10 CFR 50.72 as a non-emergency.

The NRC staff accepts the deletion of this IC. No longer [illegible] & St/L/Gen

17. "Rapid depressurization of PWR secondary side."

Disposition:
NUMARC addressed this IC as an example EAL under IC HU5, "Other Conditions Which in the Judgment of the Emergency Director Warrant Declaration of an Unusual Event."

Regulatory Analysis:
Rapid depressurization may cause the RCS inventory to be reduced, reactivity to increase, and the risk of pressurized thermal shock to increase. Each of these conditions requires the licensee to escalate an event to a higher classification. NUMARC addressed each of these conditions in the Fission Product Barrier Degradation ICs, if the performance of safety systems, such as core injection, becomes degraded.

In NUREG-0654, the staff did not include example ICs to address the following NUMARC ICs in this emergency class:

AU2, "Unexpected Increase in Plant Radiation Levels or Airborne Concentration"

SU6, "Unplanned Loss of All Onsite or Offsite Communications Capabilities"

Emergency Classification: ALERT

Definition in NUREG-0654:
"Events are in process or have occurred which involve actual or potential substantial degradation in the level of safety of the plant. Any releases are expected to be limited to small fractions of the exposure levels provided in the EPA Protective Action Guidelines."

Disposition Of NUREG-0654 Example ICs Under This Emergency Class:
NUMARC addressed a number of the NUREG-0654 ICs in the Fission Product Barrier Degradation ICs. If NUMARC found that the matrix did not adequately describe an event or did not anticipate it in a timely manner, NUMARC provided a separate IC for that event. The matrix is better than the individual events identified in NUREG-0654 because it considers the effect of multiple events or conditions in determining the classification. In comparing the individual NUREG-0654 ICs to the NUMARC matrix, it is important to recognize that the individual events often can be detected by more than one monitored parameter and that the individual events may affect more than one barrier. For example, a loss-of-coolant accident in a PWR affecting the RCS barrier could affect both the fuel cladding and containment barriers. The NUMARC Fission Product Barrier Matrix, recognizing these relationships, properly escalates the emergency classification as the additional barriers are challenged or lost.

I. "Severe loss of fuel cladding."

Disposition:
NUMARC identified this IC as an alert in Fission Product Barrier Degradation IC FA1, as an indicator of a loss of the fuel cladding barrier.

Regulatory Analysis:
As an indicator of a loss of the Fuel Clad barrier, the NUMARC ICs will result in no lower than an Alert declaration, and may result in higher declarations if warranted by the status of other barriers. The activity threshold level of 300 uCi/gm dose equivalent I-131 used in the NUMARC methodology is identical to that used in NUREG-0654. The NUMARC IC does not explicitly identify BWR offgas or PWR failed fuel monitors (as does NUREG-0654) as these features may vary between plants. The NUMARC methodology requires users to identify additional indicators for specific sites as appropriate.

The NUMARC scheme offers equivalent thresholds for the degradation of fuel cladding and also considers the fuel barrier together with the other barriers. The escalation path is thus provided using the barrier matrix. The NRC staff finds the NUMARC approach for this IC acceptable.

2. "Rapid gross failure of one steam generator tube with loss of offsite power.

Disposition:
NUMARC addressed this IC in the Fission Product Barrier Degradation ICs, as an indicator of a loss of the RCS barrier and, depending on steam generator isolation, a loss of the Containment barrier.

Regulatory Analysis:
NUMARC treated challenges to the RCS barrier in the Fission Product Barrier Matrix. NUMARC treated a loss of offsite power separately under System Malfunction ICs.

The licensee would have difficulty in determining accurately and rapidly the threshold for this NUREG-0654 IC from the control room because it would not know the size of the break. In the ICs, NUMARC indicated that the rupture of a steam generator tube could constitute a loss of the RCS barrier if the rupture requires the licensee to start a second charging pump in the normal charging mode of the RCS barrier. In IC FA1, this condition qualifies as an Alert. NUMARC classified the following as a site area emergency because it constitutes the loss of two of the three fission product barriers: contaminated steam is released to the atmosphere because of a cooldown or secondary line break, if this release occurs simultaneously with the rapid gross failure of one steam generator tube (loss of both RCS and Containment). The loss of offsite power may necessitate the release of contaminated steam to the atmosphere as part of the cooldown process. Thus, the NUMARC methodology recognizes the containment bypass that this event represents. In any case, the NUMARC IC would require no less than an alert emergency and could require a site area emergency.

The NRC staff believes that this NUREG-0654 IC includes a rare combination of unrelated events that NUMARC addressed adequately and individually. NUMARC also allows the licensee to diagnose the symptoms of events that occur simultaneously.

3. "Rapid failure of steam generator tubes (e.g., several hundred gpm primary to secondary leak rate)."

Disposition:
NUMARC addressed this IC in Fission Product Barrier Degradation alert IC FA1 as a possible loss of the RCS barrier.

Regulatory Analysis:
The licensee would have difficulty determining accurately and rapidly the threshold for this NUREG-0654 IC from the control room. Thus, NUMARC revised this IC to reflect symptoms rather than specific postulated cause or break size and to address the key concerns of NUREG-0654. In FA1, NUMARC treated any breach of the RCS barrier as an alert. See also the disposition for Alert #2.

The NRC staff concurs with this change.

4. "Steam line break with significant (e.g., greater than 10 gpm) primary to secondary leak rate (PWR) or MSIV malfunction causing leakage (BWR)."

Disposition:
NUMARC classified this condition as an unusual event under either IC SU5, "RCS Leakage," or under IC HU5, "Other conditions existing which in the judgement of the Emergency Director warrant the declaration of an Unusual Event" for a PWR. NUMARC classified this event for a BWR as an alert under IC FA1, "Potential Loss of RCS."

Regulatory Analysis: PWR
IC HU5 includes an "Uncontrolled RCS cooldown due to secondary depressurization" as an example EAL. In IC HU5, the licensee would declare an unusual event if a steam line break results in no other condition other than an uncontrolled cooldown of the RCS. The primary-to-secondary leakage of 10 gpm or greater would also qualify at least as an unusual event. The licensee would not consider the two events, when concurrent, under the Fission Barrier Matrix, to meet the conditions to qualify as an alert without other conditions such as if the licensee could not isolate the steam line break or if the primary-to-secondary leak rate exceeded the capacity of one charging pump in the normal charging mode.

Regulatory Analysis: BWR
A BWR steam line break with a MSIV malfunction causing leakage outside the primary containment would require the licensee to declare an alert. This

declaration is appropriate because two barriers would be lost in an event of this nature.

The NUMARC scheme provides an escalation path for operators to follow if plant conditions degrade further. The NRC staff concurs with this change.

5. "Primary coolant leak rate greater than 50 gpm."

Disposition:
NUMARC identified this IC as an alert in Fission Product Barrier Degradation IC FA1.

Regulatory Analysis:
The NUMARC Fission Product Barrier Matrix includes an IC for BWRs as specified in NUREG-0654 as an indicator that the RCS barrier could be lost. The loss of this barrier could, by itself, constitute an alert. The corresponding IC for PWRs is a condition that requires the licensee to start a second charging pump in the normal charging alignment. While this IC differs in magnitude from the NUREG-0654 IC, the change is justified in that the IC is based on a readily observable condition directly related to safety function performance, rather than on the 50 gpm value which has been difficult to observe and measure in a timely manner.

The NRC staff believes that NUMARC has adequately addressed the key concerns of this IC.

6. "Radiation levels or airborne contamination which indicate a severe degradation in the control of radioactive materials."

Disposition:
This IC is covered as an alert under NUMARC IC AA3, "Loss of Control of Radioactive Material or Increases in Radiation Levels Within the Facility That Impedes Operation of Systems Required to Maintain Safe Operations or to Establish or Maintain Cold Shutdown."

Regulatory Analysis:
The NUMARC IC defines a severe degradation in the control of radioactive materials to be a condition that impedes access of facility personnel to plant areas where performance of remote operations or surveillance is necessary for safe operations or shutdown. This impaired ability to operate the plant could degrade substantially the level of safety of the plant. Thus, NUMARC proposed a two-tiered system for the radiation levels

within the facility. NUMARC proposed that the exposure rate for the alert classification be greater than 15 mR per hour in areas requiring continuous occupancy (such as the control room), and be determined by site for areas requiring infrequent access. The Fission Product Barrier Matrix contains ICs based on area dose rates that could escalate the event as indication of failed fission product barriers.

The NUMARC IC addresses the key concerns of NUREG-0654.

7. "Loss of offsite power and loss of all onsite AC power."

Disposition:
NUMARC addressed this IC as an alert in IC SA1, "Loss of All Offsite AC Power and Loss of All Onsite Power During Cold Shutdown or Refueling Mode." NUMARC would escalate this IC to a site area emergency under IC SS1, "Loss of All Offsite Power and Loss of All Onsite AC Power to Essential Buses," if the event occurs during power operations, hot standby mode or hot shutdown mode.

Regulatory Analysis:
NUMARC recognized that the mode of operation affects severity of this condition. During the cold shutdown and refueling modes, NUMARC views this IC as meeting the definition of an alert. However, NUMARC has escalated this condition to the level of a site area emergency for hot shutdown through power operation because of the much greater potential for core damage and fission product barrier challenges.

The NRC staff agrees with NUMARC.

8. "Loss of all onsite DC power."

Disposition:
This IC is an alert for cold shutdown and refueling modes under NUMARC IC SA3, "Inability to Maintain Plant In Cold Shutdown." NUMARC escalated this IC for hot shutdown through power operation to a site area emergency under NUMARC IC SS3, "Loss of All Vital DC Power."

Regulatory Analysis:
NUMARC recognized that the mode of operation affects the severity of this condition. A loss of dc power could affect significantly the ability of the licensee to maintain the plant in a safe condition. In IC SA3 NUMARC would have the licensee declare an alert during cold shutdown and refueling

modes, once the loss of dc power has prevented the licensee from removing decay heat. A loss of dc power is only one of several conditions that could cause the licensee to loose the ability to remove decay heat. The NUMARC EAL addresses the ability to remove decay heat rather than the root cause.

NUMARC proposed to require the licensee to escalate this IC to a site area emergency for hot shutdown mode through power operation mode because of the effects of loss of vital dc power on the control and monitoring functions necessary to maintain the critical safety functions (CSFs). The increased anticipation implied by this escalation is consistent with the increased amount of sensible and decay heat available.

The NRC staff agrees that this IC and the proposed scheme should depend on the mode of operation.

9. "Coolant pump seizure leading to fuel failure."

Disposition:
NUMARC did not develop an equivalent IC. The severity of the symptoms of failed fuel would determine if the licensee chose to declare an unusual event or an alert using NUMARC IC SU4, "Fuel Clad Degradation," and the NUMARC Fission Product Barrier Degradation IC, FA1, respectively.

Regulatory Analysis:
This IC is not necessary because the key concern is the fuel failure and not the seizure of the coolant pump. NUMARC addressed fuel failure in IC SU4, "Fuel Clad Degradation," and the Fission Product Barrier Degradation ICs. Under the NUMARC scheme, any indication of a possible or actual loss of the fuel cladding barrier qualifies as an alert.

The NRC staff accepts this approach.

10 "Complete loss of any function needed for plant cold shutdown."

Disposition:
NUMARC addressed his IC as an alert, but only when the plant is in cold shutdown mode or refueling mode, under IC SA3, "Inability to Maintain Plant In Cold Shutdown."

Regulatory Analysis:
NUMARC differentiates between plant modes and proposes classifications for

this IC that depend on the mode of operation. The licensee would escalate the condition to a higher classification by following the ICs for abnormal radiation levels and radiological effluents.

The staff is studying shutdown risk to gain more insight on the risks associated with shutdown and to provide the basis for developing a comprehensive set of shutdown EALs. The NRC staff concurs with this approach until it can review the findings of the shutdown risk studies.

I1 "Failure of the reactor protection system to initiate and complete a scram which brings the reactor subcritical."

Disposition:
NUMARC addressed this as an alert in IC SA2, "Failure of the Reactor Protection System Instrumentation to Complete or Initiate an Automatic Scram Once a Reactor Protection System Setpoint Has Been Exceeded and Manual Scram Was Successful."

Regulatory Analysis:
NUMARC recognized that this condition is a compromise of the plant safety system because the system could not automatically shut down the reactor in response to a valid signal from the reactor protection system (RPS) signal. The NUMARC IC provides credit for manual scrams initiated by the operator. The verification of scram is an initial action in reactor trip emergency operating procedures. If the manual trip fails (i.e. ATWS) NUMARC IC SS2 specifies that the event escalates to a site area emergency, NUMARC IC SS2.

The NUMARC IC addresses the key concerns of NUREG-0654.

I2 "Fuel damage accident with release of radioactivity to containment or fuel handling building."

Disposition:
NUMARC addressed this IC as an alert in IC AA2, "Major Damage to Irradiated Fuel or Loss of Water Level that Has or Will Result in Uncovering of Irradiated Fuel Outside the Reactor Vessel."

Regulatory Analysis:
The NUMARC IC addresses the key concerns of NUREG-0654. The licensee would also escalate this condition to a higher classification in the ICs for abnormal radiation levels and radiological effluent.

13 "Fire potentially affecting safety system."

Disposition:
NUMARC addressed this IC as an alert in IC HA2, "Fire or Explosion Affecting the Operability of Plant Safety Systems Required to Establish or Maintain Safe Shutdown."

Regulatory Analysis:
The NUMARC IC addresses the key concerns of NUREG-0654.

14 "Most or all alarms (annunciators) lost."

Disposition:
NUMARC addressed this IC as an alert IC SA4, "Unplanned Loss of Most or All Safety System Annunciation or Indication in Control Room with Either (1) a Significant Transient in Progress, or (2) Compensatory Non-Alarming Indicators are Unavailable," and as an unusual event under IC SU3, "Unplanned Loss of Most or All Safety System Annunciation or Indication in the Control Room for Greater Than 15 Minutes."

Regulatory Analysis:
NUMARC divided this IC into two ICs: an unusual event and an alert. NUMARC made this decision because of redundant systems such as the safety parameter display system (SPDS) and because of passive, non-annunciating systems, both of which backup the plant annunciators. If compensatory indication is available, this IC does not meet the emergency class description for an alert. However, when this IC is a precursor, it should have the classification of an unusual event. If the compensatory indication is inoperable, or if it occurs during a significant transient, the IC should be an alert.

The NRC staff finds this approach acceptable.

15 "Radiological effluent greater than 10 times technical specification instantaneous limits (an instantaneous rate, which if continued over two hours, would result in about 1 mr at the site boundary under average meteorological conditions)."

Disposition:

NUMARC classified this IC as an alert in IC AA1, "Any Unplanned Release of Gaseous or Liquid Radioactivity that Exceeds 200 Times Radiological Technical Specifications for 15 Minutes or Longer." The NUMARC IC contains a provision for plants that have removed effluent limits from their technical specifications. For these, NUMARC specifies the use of the upper limits in the facility's Offsite Dose Calculation Manual (ODCM).

Regulatory Analysis:

The value in the NUMARC IC compares with the value in NUREG-0654, because the present technical specifications for radiological effluents (or the limits in the facility's ODCM) are calculated by dosage. This NUMARC IC value is also consistent with the definition of an alert. Radioactivity releases of lesser magnitude can not degrade substantially the level of safety of the plant. Instantaneous limits identified in the NUREG-0654 IC have since been replaced with effluent control measures releases based primarily on dose per calendar period (e.g., month, quarter, year). The NUMARC IC reflects this change in control strategy and addresses the key concerns of NUREG-0654.

The NRC staff finds this approach acceptable.

16 "Ongoing security compromise."

Disposition:

NUMARC identified this IC an alert in IC HA4, "Security Event in a Plant Protected Area."

Regulatory Analysis:

The NUMARC IC addresses the key concerns of NUREG-0654.

17 "Severe natural phenomena experienced or projected."

a. Earthquake greater than OBE levels
b. Flood, low water, tsunami, hurricane surge, or seiche near design levels
c. Any tornado striking the facility
d. Hurricane winds near the design basis level

Disposition:

NUMARC identified this IC as an alert under IC HA1, "Natural and Destructive Phenomena Occurring Within Plant Vital Area."

Compare with p. 19

Regulatory Analysis:
The NUMARC IC addresses the key concerns of NUREG-0654.

18 "Other hazards being experienced or projected."
a. Aircraft crash on facility
b. Missile impacts from whatever source on the facility
c. Known explosion damage to facility affecting plant operation
d. Entry into facility environs of uncontrolled toxic or flammable gases
e. Turbine failure casing penetration

Disposition:
NUMARC identified this IC as an alert under the following NUMARC ICs:
HA1, "Natural and Destructive Phenomena Occurring within Plant Vital Area"
HA2, "Fire or Explosion Affecting the Operability of Plant Safety Systems Required to Establish or Maintain Safe Shutdown"
HA3, "Release of Toxic or Flammable Gases within a Facility Structure Which Jeopardizes Operation of Systems Required to Maintain Safe Operations or to Establish or Maintain Cold Shutdown"

Regulatory Analysis:
These NUMARC ICs address the key concerns of NUREG-0654 regarding items "a," "c," and "d." NUMARC will address items "b" and "e" according to their consequences to the plant under ICs regarding hazards, system malfunction, or fission product barrier degradation.

The NRC staff accepts this approach.

19 "Other plant conditions exist that warrant precautionary activation of technical support center and placing near-site Emergency Operations Facility and other key emergency personnel on standby."

Disposition:
NUMARC proposed IC HA6, "Other Conditions Existing Which in the Judgment of the Emergency Director Warrant Declaration of an Alert," to cover this and all other conditions not mentioned specifically in other ICs. NUMARC identified this IC as an alert.

Regulatory Analysis:
NUMARC restated this IC to clarify that the basis for these actions is consistent with the emergency class description and is not merely added for other administrative reasons.

NUMARC should add this NUREG-0654 IC as an example EAL under HA6.

20 "Evacuation of control room anticipated or required with control of shutdown system established from local station."

Disposition:
This IC is covered as an alert in NUMARC IC HA5, "Control Room Evacuation Has Been Initiated."

Regulatory Analysis:
The NUMARC IC addresses the key concerns of NUREG-0654. NUMARC need not reference plant control because the licensee, if unable to establish control must escalate the condition to a site area emergency under NUMARC IC HS2, "Control Room Evacuation Has Been Initiated and Plant Control Cannot be Established."

NUMARC added no ICs to this emergency class for events not addressed by the example ICs in NUREG-0654.

Emergency Classification: SITE AREA EMERGENCY

Definition in NUREG-0654:
"Events are in process or have occurred which involve actual or likely major failures of plant functions needed for protection of the public. Any releases are not expected to result in exposures which exceed EPA Protective Action Guideline exposure levels except near the site boundary."

Disposition Of NUREG-0654 Example ICs Under This Emergency Class:
NUMARC addressed a number of the NUREG-0654 ICs in the Fission Product Barrier Degradation ICs. If NUMARC found that the matrix did not adequately describe an event or did not anticipate it in a timely manner, NUMARC provided a separate IC for that event. The matrix is better than the individual events identified in NUREG-0654 because it considers the effect of multiple events or conditions in determining the classification. In comparing the individual NUREG-0654 ICs to the NUMARC matrix, it is important to recognize that the individual events often can be detected by more than one monitored parameter and that the individual events may affect more than one barrier. For example, a loss-of-coolant accident in a PWR affecting the RCS barrier will, if large enough, affect both the fuel clad and containment barriers. The NUMARC Fission Product Barrier Matrix, recognizing these relationships, properly escalates the emergency classification as the additional barriers are challenged or lost.

1. "Known loss of coolant accident greater than make up pump capacity."

Disposition:
NUMARC identified this IC as a site area emergency in Fission Product Barrier Degradation IC FS1.

Regulatory Analysis: PWR
The licensee would declare a loss of RCS on a "Greater than available make-up capacity as indicated by a loss of RCS subcooling." NUMARC defined the "Available make-up capacity" to include charging and ECCS. The NRC staff believes that "available" excludes out-of-service equipment and systems, and any other equipment or system that under those conditions, cannot perform its function. The loss of subcooling prevents the adequate removal of decay heat and will challenge the core cooling critical safety function. In this case, two barriers are challenged or lost and, following

IC FS1, the licensee would declare a site area emergency. Other combinations are possible.

The NUMARC IC meets the concerns of the NUREG-0654 IC in a more comprehensive manner, in that it addresses multiple events and sequences according to the barriers they affect and offers an escalation path to higher classifications.

Regulatory Analysis: BWR

The licensee would declare that the RCS barrier could be lost if the RCS leakage exceeds 50 gpm inside the drywell or unisolable primary system leakage occurs outside the drywell. The licensee would declare a loss of the RCS barrier on a Main Steam Line Break or Reactor Vessel Water Level low. Either of these events would prompt the licensee to declare an alert. However, the reduction of Reactor Vessel Water Level also indicates that the integrity of the fuel cladding could be lost. Thus, two barriers would be challenged or lost which, by the NUMARC scheme, warrants the declaration of a site area emergency. Other combinations are possible.

The NUMARC IC meets the concerns of the NUREG-0654 IC in a more comprehensive manner, in that it addresses multiple events and sequences according to the barriers they affect and offers an escalation path to higher classifications.

2. "Degraded core with possible loss of coolable geometry."

Disposition:

NUMARC identified this IC as either a site area emergency or a general emergency depending on other conditions surrounding this event, and listed it among the ICs for Fission Product Barrier Degradation.

Regulatory Analysis:

A degraded core implies a prior event that perhaps should have been classified as a general emergency. The NUMARC Fission Product Barrier Matrix contains ICs regarding core cooling for all three barriers. Thus, such an event may be classified as a site area emergency or a general emergency, depending on the coolant temperature (PWR), the coolant level (BWR), the duration of core uncovery, the containment radiation levels, and RCS activity.

The NUMARC IC addresses the key concerns of NUREG-0654.

3. "Rapid failure of steam generator tubes (several hundred gpm leakage) with loss of offsite power.

Disposition:
NUMARC integrated this IC into the ICs for fission product barrier degradation.

Regulatory Analysis:
The licensee could not rapidly and accurately determine the threshold of this NUREG-0654 IC from the control room. NUMARC determined to categorize this condition according to symptom rather than according to the specific postulated cause or size of the break. In the Fission Product Barrier Matrix, NUMARC identified this event as a loss of the RCS barrier and a loss of the containment barrier (a site area emergency) if the licensee can not isolate the ruptured steam generator or if contaminated steam continues to be released to the environment.

NUMARC addressed the loss of offsite/onsite power events separately in the ICs for system malfunction. The effect that the loss of offsite power may have on the rapid failure of steam generator tubes will appear as a challenge to the fission product barriers. NUMARC addressed this effect in the ICs for fission product barrier degradation.

The NRC staff accepts this approach.

4. "BWR steam line break outside containment without isolation."

Disposition:
NUMARC identified this IC as a site area emergency and integrated it into the fission product barrier degradation IC, FS1.

Regulatory Analysis:
In the Fission Product Barrier Matrix, NUMARC identified this event as a loss of the RCS barrier. Unisolable primary system leakage outside the drywell constitutes a loss of the containment barrier. The loss of two barriers would require the licensee to declare a site area emergency.

The NUMARC IC adequately addresses the key concerns of NUREG-0654.

5. "PWR steam line break with greater than 50 gpm primary to secondary leakage and indication of fuel damage."

Disposition:
NUMARC classified this IC as at least as a site area emergency and maybe higher under the ICs for Fission Product Barrier Degradation.

Regulatory Analysis:
NUMARC proposed that the licensee classify this event as a site area emergency only if the steam line break is within the containment. Under the following conditions, NUMARC would classify the event as a general emergency because all three barriers would be challenged or lost: (1) the steam line break is outside of the containment or (2) a prolonged release to the environment will occur (i.e., because of a loss of ac power requiring cooldown of ruptured steam generator by atmospheric steam dump, or a relief valve that is stuck open).

The NUMARC approach adequately addresses the key concerns of NUREG-0654.

6. "Loss of offsite power and loss of onsite AC power for more than 15 minutes."

Disposition:
NUMARC identified this IC as a site area emergency in IC SS1, "Loss of All Offsite Power and Loss of All Onsite AC Power to Essential Buses," and an alert in IC SA1, "Loss of All Offsite AC Power and Loss of All Onsite Power During Cold Shutdown or Refueling Mode."

Regulatory Analysis:
NUMARC recognized that the severity of this condition depends on the mode of operation. NUMARC classified this condition as an alert for the cold shutdown and refueling modes. NUMARC retained this IC as an alert because it meets the emergency class description by virtue of the decreased sensible and decay heat, and substantially increased times for cladding damage and radiological releases. However, NUMARC proposes a site area emergency classification for hot shutdown through power operation because of the much greater potential for core damage and fission product barrier challenges resulting from the increased risk associated with the removal of the sensible and decay heat.

The staff is studying shutdown risk to gain more insight on the risks associated with shutdown and to provide the basis for developing a comprehensive set of shutdown EALs. The NRC staff concurs with this approach until it can review the findings of the shutdown risk studies.

7. "Loss of all onsite DC power."

Disposition:
NUMARC identified this IC as a site area emergency IC SS3, "Loss of All Vital DC Power," and an alert in IC SA3, "Inability to Maintain Plant In Cold Shutdown."

Regulatory Analysis:
NUMARC recognized that the severity of this condition depends on the mode of operation. A loss of DC power is significant because it affects the ability of the licensee to maintain the plant in a safe condition.

In IC SA3, NUMARC proposed that the licensee declare an alert when the loss of dc power results in an inability to remove decay heat during the cold shutdown and refueling modes. However, a loss of dc power is only one of the conditions that can cause the licensee to lose the ability to remove decay heat. The NUMARC EAL addresses the consequence rather than the root cause.

This condition is classified as a site area emergency for the hot shutdown through power operation modes because of the effects the loss of vital dc power has on controlling and monitoring functions necessary to maintain CSFs.

The NRC concurs with this approach.

8. "Complete loss of any plant function needed for hot shutdown."

Disposition:
This IC results in a site area emergency under NUMARC IC SS4, "Complete Loss of Function Required to Achieve or Maintain Hot Shutdown."

Regulatory Analysis:
In the basis of this IC, NUMARC clarified that the complete loss of <u>any</u> function required to achieve or maintain hot shutdown qualifies as this IC.

The NRC staff agrees that this IC adequately covers the key concerns of NUREG-0654.

9. "Transient requiring operation of shutdown systems with failure to scram (continued power generation but no core damage immediately evident)."

Disposition:
This IC would require the licensee to declare a site area emergency under NUMARC IC SS2, "Failure of Reactor Protection System Instrumentation to Complete or Initiate an Automatic Scram Once a Reactor Protection System Setpoint Has Been Exceeded and Manual Scram Was NOT Successful."

Regulatory Analysis:
NUMARC SS2 is the logical escalation path of SA2 if the plant's automatic scram system does not respond to a valid scram signal and the manual scram fails to bring the reactor to a subcritical state (ATWS condition).

The NRC staff accepts the NUMARC approach.

10 "Major damage to spent fuel in containment or fuel handling building (e.g., large object damages fuel or water loss below fuel level)."

Disposition:
This IC would require the licensee to declare a site area emergency under NUMARC IC SS5, "Loss of Water Level in the Reactor Vessel That Has or Will Uncover Fuel in the Reactor Vessel." If this IC involves fuel outside the reactor vessel in PWRs and BWRs, the licensee would declare an alert under NUMARC IC AA2, "Major Damage to Irradiated Fuel or Loss of Water Level that Has or Will Result in Uncovering of Irradiated Fuel Outside the Reactor Vessel."

Regulatory Analysis:
The manner in which NUMARC treats this condition depends on the location of the fuel at the time of this event.

NUMARC chose to decrease the severity of the fuel incident outside of the reactor vessel to follow the guidance in NUREG/
CR-4982, "Severe Accident in Spent Fuel Pools in Support of Generic Safety Issue 82." In NUREG/CR-4982, the NRC concluded that the probability of injury would be low and that no fatalities would result even if corrective actions were not taken. These conclusions and the amount of time that would lapse after these events before the fuel would be damaged significantly indicate that the threshold for a site area emergency is not exceeded for events outside of the reactor vessel. The quantity of decay heat could increase if the event occurred inside the reactor vessel, which would warrant declaring a site area emergency as an anticipatory response. Further escalation would be by radiation monitor ICs.

The NRC staff concurs with this change.

11 "Fire compromising the functions of safety systems."

Disposition:
NUMARC identified fire in vital areas of the plant as an alert in IC HA2, "Fire Affecting the Operability of Plant Safety Systems Required for the Current Operating Mode," unless other ICs stipulate that the consequences of the fire warrant classifying the condition as a site area emergency.

Regulatory Analysis:
By declaring the alert, the licensee would ensure that it receives support from the Technical Support Center and that it increases the plant monitoring capability. To address the large number of fire-initiated damage scenarios that could result from fire, all with varying levels of consequences, the NUMARC methodology provides that the licensee would escalate the condition according to the consequential damages and their effect on the performance of critical safety functions, as stated in other NUMARC event ICs and in the Fission Product Barrier Matrix.

The NRC staff concurs with this change.

OK

12 "Most or all alarms (annunciators) lost and plant transient in progress."

Disposition:
NUMARC identified this IC as a site area emergency in IC SS6, "Inability to Monitor a Significant Transient in Progress" and as an alert in IC SA4, "Unplanned Loss of Most or All Safety System Annunciation or Indication in Control Room with Either (1) a Significant Transient in Progress, or (2) Compensatory Non-Alarming Indicators are Unavailable."

Regulatory Analysis:
In IC SS6, NUMARC proposed that the licensee declare a site area emergency when a transient is in progress and the operating crew can not monitor the plant response.

NUMARC recognizes that redundant systems such as SPDS and the passive, non-annunciating systems as backup to plant annunciators should ensure that the operator has the ability to monitor a transient. Under these circumstances, the licensee should declare an alert to ensure that it receives support from the Technical Support Center and has increased plant monitoring capability.

The discriminating factor between an alert and a site area emergency is the ability of the operator to monitor the transient in progress.

This is an acceptable change.

13 "a. Effluent monitors detect levels corresponding to greater than 50 mr/hr for 1/2 hour or greater than 500 mr/hr W.B. for two minutes (or five times these levels to the thyroid) at the site boundary for adverse meteorology

b. These dose rates are projected based on other plant parameters (e.g., radiation level in containment with leak rate appropriate for existing containment pressure) or are measured in the environs

c. EPA Protective Action Guidelines are projected to be exceeded outside the site boundary."

Disposition:

NUMARC classified Part "c" of this NUREG-0654 as a general emergency under IC AG1. NUMARC modified the remaining conditions and classified them as a site area emergency under IC AS1, "Site Boundary Dose Resulting from an Actual or Imminent Release of Gaseous Radioactivity Exceeds 100 mR Whole Body or 500 mR Child Thyroid for the Actual or Projected Duration of the Release."

Regulatory Analysis:

Exceeding Environmental Protection Agency (EPA) Protective Action Guidelines (PAGs) outside the site boundary has become, by exercise practice, the threshold for a general emergency. Therefore, NUMARC addressed part "c" under AG1, which results in a higher emergency class.

The dose rates identified in part "a," which indicate failures of equipment necessary to protect the public, lacked clarity. Instead of using the specified dose rates for specified duration, NUMARC chose criteria based on dose. The 100 mR whole body and 500 mR child thyroid values are 10 percent of the EPA Protective Action Guides. These values are appropriate thresholds for a site area emergency because 100 mR whole body is the non-occupational annual radiation exposure limit in the revised 10 CFR 20.

The NRC staff agrees with this approach.

14 "Imminent loss of physical control of the facility."

Disposition:

This IC would require the licensee to declare one of the following:

a. A general emergency under NUMARC IC HG1, "Security Threat Resulting in Loss of Ability to Reach and Maintain Cold Shutdown," NUMARC IC HG2, "Other Conditions Which in the Judgment of the Emergency Director Warrant Declaration of a General Emergency"

b. A site area emergency under NUMARC IC HS1, "Security Event in a Vital Area," NUMARC IC HS2, "Control Room Evacuation Has Been Initiated and Plant Control Cannot Be Established," and NUMARC IC HS3, "Other Conditions which in the Judgment of the Emergency Director Warrant Declaration of a Site Area Emergency."

Regulatory Analysis:

NUMARC recognized the severity of this condition in classifying it as either a general emergency or a site area emergency. If the plant staff will not be able to control the facility and thus lose the ability to maintain fission product barriers, the licensee should declare a general emergency. Those conditions not immediately threatening a loss of physical control of the entire facility meet the definition of site area emergency.

The NRC staff agrees.

15 "Severe natural phenomena being experienced or projected with the plant not in cold shutdown."

a. Earthquake greater than SSE levels

b. Flood, low water, tsunami, hurricane surge, seiche greater than design levels of failure of protection of vital equipment at lower levels

c. Sustained winds or tornadoes in excess of design levels

Disposition:

NUMARC proposed that the licensee declare a site area emergency for these events only if they adversely affect the Fission Product barriers under the Fission Product Barrier Degradation ICs, the System Malfunction ICs, and HS3, "Other conditions existing which in the judgement of the Emergency Director warrant the Declaration of a Site Area Emergency." Otherwise, these events, which would cause no consequential damage, would warrant that the licensee declare an alert under the NUMARC IC HA1, "Natural and Destructive Phenomena Occurring Within Plant Vital Area."

Regulatory Analysis:
Consequential damage to safety systems as a result of these hazards would prompt the licensee to declare a site area emergency under other NUMARC ICs, depending on specific circumstances. The ICs for the fission product barrier would most likely be the NUMARC ICs to address the effects of such events and provide for the appropriate classification. The NUMARC approach anticipates these events sufficiently to address the results of multiple failures, whether they have a common cause or not.

NUMARC proposed that, if the licensee does not find an indication of consequential damage, these events would warrant an alert, thus ensuring that the licensee receives support from the Technical Support Center for an increased plant monitoring capability.

The NRC staff agrees.

16 "Other hazards being experienced or projected with the plant not in cold shutdown."

a. Aircraft crash affecting vital structures by impact or fire.
b. Severe damage to safe shutdown equipment from missiles or explosion.
c. Entry of uncontrolled flammable gases in vital areas. Entry of uncontrolled toxic gases into vital areas where lack of access to the area constitutes a safety problem.

Disposition:
NUMARC classified these events as warranting a site area emergency only if consequential damage could cause the loss of two fission product barriers under the fission product barrier matrix, the System Malfunction ICs, or HS3, "Other conditions existing which in the judgement of the Emergency Director warrant the Declaration of a Site Area Emergency." Without such consequences, such events are classified as alerts under the NUMARC IC HA1, "Natural and Destructive Phenomena Occurring within Plant Vital Areas," and NUMARC IC HA3, "Release of Toxic or Flammable Gases within a Facility Structure Which Jeopardizes Operation of Systems Required to Establish and Maintain Cold Shutdown."

Regulatory Analysis:
Consequential damage to safety systems from these hazards could prompt the licensee to declare a site area emergency under other NUMARC ICs, depending on specific circumstances.
The results of this IC only qualify as an alert unless two Fission Product barriers could be lost, the System Malfunction ICs are met, or the

Emergency Director determines otherwise. This classification ensures that the licensee would receive support from the Technical Support Center and increased plant monitoring capability. As stated on page 5-2, NUMARC ICs anticipate these events sufficiently to address the results of multiple failures, regardless of whether or not they have a common cause.

The NRC staff agrees.

17 "Other plant conditions exist that warrant activation of emergency centers and monitoring teams or a precautionary notification to the public near the site."

Disposition:
NUMARC provided that, if conditions warrant the declaration of a site area emergency, the emergency director can use discretion in IC HS3, "Other Conditions Which in the Judgment of the Emergency Director Warrant Declaration of a Site Area Emergency."

Regulatory Analysis:
The NUMARC IC addresses the key concerns of NUREG-0654.

The NRC staff agrees.

(18) DS
"Evacuation of control room and control of shutdown systems not established from local stations in 15 minutes."

Not if control room evacuated & can declare Emergency

Disposition:
This IC would prompt the licensee to declare a site area emergency in IC HS2, "Control Room Evacuation Has Been Initiated and Plant Control Cannot be Established."

Regulatory Analysis:
The NUMARC IC addresses the key concerns of NUREG-0654.

The NRC staff agrees.

Other NUMARC ICs in this emergency class for events not addressed by the example ICs listed in NUREG-0654 include the following:

The NUMARC Fission Product Barrier Matrix allow for more combinations of events than are specifically identified in NUREG-0654.

Emergency Classification: GENERAL EMERGENCY

Definition in NUREG-0654:
"Events are in process or have occurred which involve actual or imminent substantial core degradation with potential for loss of containment integrity. Releases from these events can be reasonably expected to exceed EPA Protective Action Guideline exposure levels offsite for more than the immediate site area."

Disposition of NUREG-0654 Example ICs Under This Emergency Class:
NUMARC addressed a number of the NUREG-0654 ICs in the NUMARC Fission Product Barrier Degradation ICs. If NUMARC found that the matrix did not adequately describe an event or did not anticipate it in a timely manner, NUMARC provided a separate IC for that event. The matrix is better than the individual events identified in NUREG-0654 because the matrix considers the effect of multiple events or conditions in determining the classification. In comparing the individual NUREG-0654 ICs to the NUMARC matrix, it is important to recognize that the individual events often can be detected by more than one monitored parameter and that the individual events may affect more than one barrier. For example, a loss of coolant accident in a PWR affecting the RCS barrier could affect both the fuel cladding and containment barriers. The NUMARC Fission Product Barrier Matrix, recognizing these relationships, properly escalates the emergency classification as the additional barriers are challenged or lost.

I. "Example radiation monitoring and dose assessment initiating conditions:
   a. Effluent monitors detect levels corresponding to 1 rem/hr W.B. or 5 rem/hr thyroid at the site boundary under actual meteorological conditions.
   b. These dose rates are projected based on other plant parameters (e.g., radiation levels in containment with leak rate appropriate for existing containment pressure with some confirmation from effluent monitors) or are measured in the environs."

Disposition:
This IC would prompt the licensee to declare a general emergency. NUMARC addressed this IC in IC AG1, "Site Boundary Dose Resulting from an Actual or Imminent Release of Gaseous Radioactivity that Exceeds 1000 mR Whole Body or 5000 mR Child Thyroid for the Actual or Projected Duration of the Release Using Actual Meteorology."

Regulatory Analysis:
The NUMARC IC fully addresses the NUREG-0654 IC.

The NRC staff agrees.

2. "Loss of 2 of 3 fission product barriers with a potential loss of 3rd barrier, (e.g., loss of primary coolant boundary, clad failure, and high potential for loss of containment."

Disposition:
NUMARC fully addressed this IC in the Fission Product Barrier Matrix as the fundamental definition of a general emergency.

Regulatory Analysis:
The FG1 IC fully addresses all the permutations for the loss of two of the three fission product barriers with the potential loss for the third barrier. NUMARC offered a whole range of ICs based on the status of the three major Fission Product barriers. Thus, NUMARC is providing the operator with an escalation path to higher classifications according to the effect of the event(s) on particular barriers. NUREG 0654 does not provide the operator with this ability.

The NRC staff finds the barrier approach in NUMARC to be a significant improvement.

3. "Loss of Physical Control of the Facility."

Disposition:
This IC would prompt the licensee to declare a general emergency. NUMARC addressed this IC in IC HG1, "Security Event Resulting in Loss of Ability to Reach and Maintain Cold Shutdown," and IC HG2, "Other Conditions Which in the Judgment of the Emergency Director Warrant Declaration of a General Emergency."

Regulatory Analysis:
The NUMARC ICs address the NUREG-0654 IC.

The NRC staff agrees.

4. "Other plant conditions exist, from whatever source, that make release of large amounts of radioactivity in a short time possible, e.g., any core melt situation."

and

5. "Example PWR Sequences"

and

6. "Example BWR Sequences"

Disposition:
This IC would prompt the licensee to declare a general emergency in the Fission Product Barrier Matrix, NUMARC IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power," and NUMARC IC SG2, "Failure of the Reactor Protection System to Complete an Automatic Scram and Manual Scram was NOT Successful and There is Indication of an Extreme Challenge to the Ability to Cool the Core."

Regulatory Analysis:
NUMARC developed the fission product barrier matrix, which allows for many more permutations than could be included in a list of specific sequences. This matrix reflects the belief of the industry that no list could be all inclusive. In developing the matrix, NUMARC used fundamental indications of core melt sequences as the basis for declaring a general emergency. The matrix encompasses in the general emergency classification those sequences that could result in offsite radiological releases. Indicators of potential and actual losses of the Containment barrier do not indicate directly the status of the containment barrier. Instead, they indicate core melt sequences that could result in significant offsite radiological consequences.

NUMARC determined that the containment barrier in a PWR could be lost if, for any reason, the core exit thermocouple readings exceeded 1200°F (or exceeded 700°F with the level below top of active fuel) and the restoration procedures were not effective within 15 minutes. Core exit thermocouple readings of greater than 1200°F regardless of duration, mean that the Fuel cladding barrier is lost. The saturation pressure corresponding to 1200°F would cause subcooling to be lost. A loss of subcooling is a loss of the RCS barrier. This results in a loss of two barriers and could cause the third to be lost. The improbable pressurized vessel sequence analyzed in

severe accident studies is possible only with a station blackout, which under these conditions would be declared as a general emergency under NUMARC IC SG1.

NUMARC determined that the containment barrier for a BWR could be lost if the water level in the reactor vessel is less than a (site specific) value and if the core remains uncovered for longer than the maximum core uncovery time. If the water level in the reactor vessel covers less than 2/3 of the core for even a brief period, the fuel cladding barrier and the RCS barrier would both be lost. Thus, two barriers would be lost and the third could be lost.

NUMARC provided IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power," recognizing the importance of ac power in restoring challenged or lost critical safety functions. NUMARC developed IC SG2, "Failure of the Reactor Protection System to Complete an Automatic Scram and Manual Scram was NOT Successful and There is Indication of an Extreme Challenge to the Ability to Cool the Core," recognizing that emergency core cooling systems can not remove greater than decay heat.

The NUMARC IC addresses the key concerns of NUREG-0654.

The NRC staff accepts this NUMARC approach.

7. "Any major internal or external events (e.g., fires, earthquakes, substantially beyond design basis) which could cause massive common damage to plant systems resulting in any of the above."

Disposition:
NUMARC deleted this IC because this type of event would better be addressed under symptom-based and barrier-based ICs.

Regulatory Analysis:
NUMARC did not provide an IC for this event in particular. However, to respond to the consequences of such events when challenging the integrity of the fission product barriers, the licensee would likely declare a general emergency under NUMARC IC FG1, "Loss of ANY Two Barriers and Potential Loss of Third Barrier." Other NUMARC ICs which could consequences of such events and would prompt the licensee to declare a general emergency are IC HG1, "Security Event Resulting in Loss of Ability to Reach and Maintain Cold Shutdown," IC HG2, "Other Conditions Which in the Judgment of the Emergency Director Warrant Declaration of a General