NUMARC/NESP-007
Revision 2

Methodology for Development of Emergency Action Levels

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FOREWORD

Revision 2 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. 2 "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 2 incorporates improvements for clarification and also incorporates errata from the original document. The Appendices included in the original have been deleted 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 ten 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 Draft 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

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 ten 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.

There is a potential for misclassifying an emergency. Additionally, the industry has had over ten 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 ten 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 Draft 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.

- Some initiating conditions (ICs) have been misclassified, some ICs have not been classified at all, and some events should not be classified as emergencies.

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.

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

TABLE 1 GOES HERE

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 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.

- There has not been uniform interpretation of 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 Draft 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, Draft 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

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.

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.

FIGURE 2

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 - refers to the operating mode (PWRs) or operating condition (BWRs) during which the IC/EAL is applicable - Power Operation (includes Startup Mode in PWRs), Hot Standby (includes Hot Standby/Startup Condition 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.

IC MATRIX
ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

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" (site specific monitors)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 operators 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)

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.

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

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 which 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-0578 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).

ABNORMAL RAD LEVELS/RADIOLOGICAL EFFLUENT

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.

IC MATRIX
FISSION PRODUCT BARRIER DEGRADATION

TABLE 3

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 2% to 5% 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 the level which is used in EOPs to indicate challenge of core cooling. Depending on the plant this may be top of active fuel or 2/3 coverage of 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. The potential loss of RCS based on leakage is set at a level indicative of a small breach of the RCS but which is well within the makeup capability of normal and emergency high pressure systems. Core uncovery is not a significant concern for a 50 gpm leak, however, break propagation leading to significantly larger loss of inventory is possible. Many BWRs may be unable to measure an RCS leak of this size because the leak would likely increase drywell pressure above the drywell isolation set point. The system normally used to monitor leakage is typically isolated as part of the drywell isolation and is therefore unavailable. If primary system leak rate information is unavailable, other indicators of RCS leakage should be used. Potential loss of RCS based on primary system leakage outside the drywell 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 set point and indicates a LOCA. A higher value may be used if supporting documentation is provided which indicates the chosen value is less than the pressure which would be reached for a 50 gpm Reactor Coolant System Leak.

   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 level which is used in EOPs to indicate challenge of core cooling. Depending on the plant this may be top of active fuel or 2/3 coverage of 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 the level which is used in EOPs to indicate challenge of core cooling. Depending on the plant this may be top of active fuel or 2/3 coverage of 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

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 2% to 5% 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 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 #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 inventory control capacity such that a loss of subcooling has occurred. The loss of subcooling is the fundamental indication that the inventory control systems are inadequate in maintaining RCS pressure and inventory against the mass loss through the leak.

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 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 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 Thermocouples**

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.

8. **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.)

IC MATRIX
HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

UNUSUAL EVENT

HU1 Natural and Destructive Phenomena Affecting the Protected Area.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4 or 5 or 6 or 7)

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. Report of turbine failure resulting in casing penetration or damage to turbine or generator seals.

7. (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.

For EAL 5 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 is intended to address main turbine rotating component failures of sufficient magnitude to cause observable damage to the turbine casing or to the seals of the turbine generator. Of major concern is the potential for leakage of combustible fluids (lubricating oils) and gases (hydrogen cooling) to the plant environs. Actual fires and flammable gas build up are appropriately classified via HU2 and HU3. This EAL is consistent with the definition of an Unusual Event while maintaining the anticipatory nature desired and recognizing the risk to non-safety related equipment. Escalation of the emergency classification is based on potential damage done by missiles generated by the failure or by the radiological releases for a BWR, or in conjunction with a steam generator tube rupture, for a PWR. These latter events would be classified by the radiological ICs or Fission Product Barrier ICs.

EAL 7 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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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.

- Aircraft crash on-site.
- Train derailment on-site.
- Near-site explosion which may adversely affect normal site activities.
- Near-site release of toxic or flammable gas which may adversely affect normal site activities.
- 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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

ALERT

HA1 Natural and Destructive Phenomena Affecting the Plant Vital Area.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2 or 3 or 4 or 5 or 6 or 7)

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. Turbine failure generated missiles result in any visible structural damage to or penetration of any of the following plant areas: (site-specific) list.

7. (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 is intended to address the threat to safety related equipment imposed by missiles generated by main turbine rotating component failures. This (site specific) list of areas should include all areas containing safety-related equipment, their controls, and their power supplies. This EAL is, therefore, consistent with the definition of an ALERT in that if missiles have damaged or penetrated areas containing safety-related equipment the potential exists for substantial degradation of the level of safety of the plant.

EAL 7 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. The initial "report" 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. 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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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

HA4 Security Event in a Plant Protected Area.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. Intrusion into plant protected 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 Unusual Event. For the purposes of this IC, a civil disturbance which penetrates the protected area boundary can be considered a hostile force. Intrusion into a vital area by a hostile force will escalate this event to a 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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

ALERT

HA6 Other Conditions Existing Which in the Judgement of the Emergency Director Warrant Declaration of an Alert.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. Other conditions exist which in the Judgement of the Emergency Director indicate that plant safety systems may be degraded and that increased monitoring of plant functions is warranted.

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 Alert emergency class.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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

HS2 Control Room Evacuation Has Been Initiated and Plant Control Cannot Be Established.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Control room evacuation has been initiated.

   AND

   b. Control of the plant cannot be established per (site-specific) procedure within (site-specific) minutes.

BASIS:

Expeditious transfer of safety systems has not occurred but fission product barrier damage may not yet be indicated. (Site-specific) time for transfer based on analysis or assessments as to how quickly control must be reestablished without core uncovering and/or core damage. This time should not exceed 15 minutes. In cold shutdown and refueling modes, operator concern is directed toward maintaining core cooling such as is discussed in Generic Letter 88-17, "Loss of Decay Heat Removal." In power operation, hot standby, and hot shutdown modes, operator concern is primarily directed toward maintaining critical safety functions and thereby assuring fission product barrier integrity. Escalation of this event, if appropriate, would be by Fission Product Barrier Degradation, Abnormal Rad Levels/Radiological Effluent, or Emergency Director Judgement ICs.

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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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

HG1 Security Event Resulting in Loss Of Ability to Reach and Maintain Cold Shutdown.

OPERATING MODE APPLICABILITY: All

EXAMPLE EMERGENCY ACTION LEVELS: (1 or 2)

1. Loss of physical control of the control room due to security event.

2. Loss of physical control of the remote shutdown capability due to security event.

BASIS:

This IC encompasses conditions under which a hostile force has taken physical control of vital area required to reach and maintain safe shutdown.

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.

HAZARDS AND OTHER CONDITIONS AFFECTING PLANT SAFETY

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.

SYSTEM MALFUNCTION IC MATRIX

SYSTEM MALFUNCTION

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.

SYSTEM MALFUNCTION

UNUSUAL EVENT

SU2 Inability to Reach Required Shutdown Within Technical Specification Limits.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. Plant is not brought to required operating mode within (site-specific) Technical Specifications LCO Action Statement Time.

BASIS:

Limiting Conditions of Operation (LCOs) require the plant to be brought to a required shutdown mode when the Technical Specification required configuration cannot be restored. Depending on the circumstances, this may or may not be an emergency or precursor to a more severe condition. In any case, the initiation of plant shutdown required by the site Technical Specifications requires a one hour report under 10 CFR 50.72 (b) Non-emergency events. The plant is within its safety envelope when being shut down within the allowable action statement time in the Technical Specifications. An immediate Notification of an Unusual Event is required when the plant is not brought to the required operating mode within the allowable action statement time in the Technical Specifications. **Declaration of an Unusual Event is based on the time at which the LCO-specified action statement time period elapses under the site Technical Specifications and is not related to how long a condition may have existed.** Other required Technical Specification shutdowns that involve precursors to more serious events are addressed by other System Malfunction, Hazards, or Fission Product Barrier Degradation ICs.

SYSTEM MALFUNCTION

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 (startup in BWRs)
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 conditions. This judgement is supported by the specific opinion of the Shift Supervisor that additional operating personnel will be required to provide increased monitoring of system operation to safely operate the unit(s).

It is further recognized that most plant designs provide redundant safety system indication powered from separate uninterruptable power supplies. While failure of a large portion of annunciators is more likely than a failure of a large portion of indications, the concern is included in this EAL due to difficulty associated with assessment of plant conditions. The loss of specific, or several, safety system indicators should remain a function of that specific system or component operability status. This will be addressed by the specific Technical Specification. The initiation of a Technical Specification imposed plant shutdown related to the instrument loss will be reported via 10 CFR 50.72. If the shutdown is not in compliance with the Technical Specification action, the Unusual Event is based on SU2 "Inability to Reach Required Shutdown Within Technical Specification Limits."

(Site-specific) annunciators or indicator for this EAL must include those identified in the Abnormal Operating Procedures, in the Emergency Operating Procedures, and in other EALs (e.g., area, process, and/or effluent rad monitors, etc.).

Fifteen minutes was selected as a threshold to exclude transient or momentary power losses.

Due to the limited number of safety systems in operation during cold shutdown, refueling, and defueled modes, no IC is indicated during these modes of operation.

This Unusual Event will be escalated to an Alert if a transient is in progress during the loss of annunciation or indication.

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.

SYSTEM MALFUNCTION

UNUSUAL EVENT

SU5 RCS Leakage.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Unidentified or pressure boundary leakage greater than 10 gpm.

   OR

   b. Identified leakage greater than 25 gpm.

BASIS:

This IC is included as an Unusual Event because it may be a precursor of more serious conditions and, as result, is considered to be a potential degradation of the level of safety of the plant. The 10 gpm value for the unidentified and pressure boundary leakage was selected as it is observable with normal control room indications. Lesser values must generally be determined through time-consuming surveillance tests (e.g., mass balances). The EAL for identified leakage is set at a higher value due to the lesser significance of identified leakage in comparison to unidentified or pressure boundary leakage. In either case, escalation of this IC to the Alert level is via Fission Product Barrier Degradation ICs or IC SA3, "Inability to Maintain Plant in Cold Shutdown."

Only operating modes in which there is fuel in the reactor coolant system and the system is pressurized are specified.

SYSTEM MALFUNCTION

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 condition 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.).

SYSTEM MALFUNCTION

UNUSUAL EVENT

SU7 Unplanned Loss of Required DC Power During Cold Shutdown or Refueling Mode for Greater than 15 Minutes.

OPERATING MODE APPLICABILITY: Cold Shutdown
Refueling

EXAMPLE EMERGENCY ACTION LEVEL:

1. Either of the following conditions exist:

   a. Unplanned Loss of Vital DC power to required DC busses based on (site-specific) bus voltage indications.

   AND

   b. Failure to restore power to at least one required DC bus within 15 minutes from the time of loss.

BASIS:

The purpose of this IC and its associated EALs is to recognize a loss of DC power compromising the ability to monitor and control the removal of decay heat during Cold Shutdown or Refueling operations. This EAL is intended to be anticipatory in as much as the operating crew may not have necessary indication and control of equipment needed to respond to the loss.

Unplanned is included in this IC and EAL to preclude the declaration of an emergency as a result of planned maintenance activities. Routinely plants will perform maintenance on a Train related basis during shutdown periods. It is intended that the loss of the operating (operable) train is to be considered. If this loss results in the inability to maintain cold shutdown, the escalation to an Alert will be per SA3 "Inability to Maintain Plant in Cold Shutdown."

(Site-specific) bus voltage should be based on the minimum bus voltage necessary for the operation of safety related equipment. This voltage value should incorporate a margin of at least 15 minutes of operation before the onset of inability to operate those loads. This voltage is usually near the minimum voltage selected when battery sizing is performed. Typically the value for the entire battery set is approximately 105 VDC. For a 60 cell string of batteries the cell voltage 1.75 Volts per cell. For a 58 string battery set the minimum voltage is typically 1.81 Volts per cell.

SYSTEM MALFUNCTION

ALERT

SA1 Loss of All Offsite Power and Loss of All Onsite AC Power to Essential Busses 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.

SYSTEM MALFUNCTION

ALERT

SA2 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 Successful.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)

EXAMPLE EMERGENCY ACTION LEVEL:

1. (Site-specific) indication(s) exist that indicate that reactor protection system setpoint was exceeded and automatic scram did not occur, and a successful manual scram occurred.

BASIS:

This condition indicates failure of the automatic protection system to scram the reactor. This condition is more than a potential degradation of a safety system in that a front line automatic protection system did not function in response to a plant transient and thus the plant safety has been compromised, and design limits of the fuel may have been exceeded. An Alert is indicated because conditions exist that lead to potential loss of fuel clad or RCS. Reactor protection system setpoint being exceeded (rather than limiting safety system setpoint being exceeded) is specified here because failure of the automatic protection system is the issue. A manual scram is any set of actions by the reactor operator(s) at the reactor control console which causes control rods to be rapidly inserted into the core and brings the reactor subcritical (e.g., reactor trip button). Failure of manual scram would escalate the event to a Site Area Emergency.

SYSTEM MALFUNCTION

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.

The EAL guidance related to uncontrolled temperature rise is necessary to preserve the anticipatory philosophy of NUREG-0654 for events starting from temperatures much lower than the cold shutdown temperature limit.

Escalation to the Site Area Emergency is by IC SS5, "Loss of Water Level in the Reactor Vessel That Has or Will Uncover Fuel in the Reactor Vessel," or by Abnormal Rad Levels/Radiological Effluent 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

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.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
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 of the instrumentation lost but use the value as a judgement threshold for determining the severity of the plant conditions. This judgement is supported by the specific opinion of the Shift Supervisor that additional operating personnel will be required to provide increased monitoring of system operation to safely operate the unit(s).

It is further recognized that most plant designs provide redundant safety system indication powered from separate uninteruptable power supplies. While failure of a large portion of annunciators is more likely than a failure of a large portion of indications, the concern is included in this EAL due to difficulty associated with assessment of plant conditions. The loss of specific, or several, safety system indicators should remain a function of that specific system or component operability status. This will be addressed by the specific Technical Specification. The initiation of a Technical Specification imposed plant shutdown related to the instrument loss will be reported via 10 CFR 50.72. If the shutdown is not in compliance with the Technical Specification action, the Unusual Event is based on SU2 "Inability to Reach Required Shutdown Within Technical Specification Limits."

(Site-specific) annunciators or indicators for this EAL must include those identified in the Abnormal Operating Procedures, in the Emergency Operating Procedures, and in other EALs (e.g., area, process, and/or effluent rad monitors, etc.).

"Significant Transient" includes response to automatic or manually initiated functions such as scrams, runbacks involving greater than 25% thermal power change, ECCS injections, or thermal power oscillations of 10% or greater.

"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. If both a major portion of the annunciation system and all computer monitoring are unavailable to the extent that the additional operating personnel are required to monitor indications, the Alert is required.

Due to the limited number of safety systems in operation during cold shutdown, refueling and defueled modes. No IC is indicated during these modes of operation.

This Alert will be escalated to a Site Area Emergency if the operating Crew cannot monitor the transient in progress.

SYSTEM MALFUNCTION

ALERT

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

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
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 indication 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.

SYSTEM MALFUNCTION

SITE AREA EMERGENCY

SS1 Loss of All Offsite Power and Loss of All Onsite AC Power to Essential Busses.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. Loss of all offsite and onsite AC power as indicated by:

   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 (site-specific) 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 and the Ultimate Heat Sink. Prolonged loss of all AC power will cause core uncovering and loss of containment integrity, thus this event can escalate to a General Emergency. The (site-specific) time duration should be selected to exclude transient or momentary power losses, but should not exceed 15 minutes.

Escalation to General Emergency is via Fission Product Barrier Degradation or IC SG1, "Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power."

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.

SYSTEM MALFUNCTION

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.

SYSTEM MALFUNCTION

SITE AREA EMERGENCY

SS3 Loss of All Vital DC Power.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. Loss of All Vital DC Power based on (site-specific) bus voltage indications for greater than 15 minutes.

BASIS:

Loss of all DC power compromises ability to monitor and control plant safety functions. Prolonged loss of all DC power will cause core uncovering and loss of containment integrity when there is significant decay heat and sensible heat in the reactor system. Escalation to a General Emergency would occur by Abnormal Rad Levels/Radiological Effluent, Fission Product Barrier Degradation, or Emergency Director Judgement ICs. 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.

SYSTEM MALFUNCTION

SITE AREA EMERGENCY

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

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
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.

SYSTEM MALFUNCTION

SITE AREA EMERGENCY

SS5 Loss of Water Level in the Reactor Vessel That Has or Will Uncover Fuel in the Reactor Vessel.

OPERATING MODE APPLICABILITY: Cold Shutdown
Refueling

EXAMPLE EMERGENCY ACTION LEVEL:

1. Loss of Reactor Vessel Water Level as indicated by:

   a. Loss of all decay heat removal cooling as determined by (site-specific) procedure.

   AND

   b. (Site-specific) indicators that the core is or will be uncovered.

BASIS:

Under the conditions specified by this IC, severe core damage can occur and reactor coolant system pressure boundary integrity may not be assured. For BWRs, it is intended to address concerns raised by NRC Office for Analysis and Evaluation of Operational Data (AEOD) Report AEOD/EG09, "BWR Operating Experience Involving Inadvertent Draining of the Reactor Vessel," dated August 8, 1986. This report states:

> In broadest terms, the dominant causes of inadvertent reactor vessel draining are related to the operational and design problems associated with the residual heat removal system when it is entering into or exiting from the shutdown cooling mode. During this transitional period water is drawn from the reactor vessel, cooled by the residual heat removal system heat exchangers (from the cooling provided by the service water system), and returned to the reactor vessel. First, there are piping and valves in the residual heat removal system which are common to both the shutdown cooling mode and other modes of operation such as low pressure coolant injection and suppression pool cooling. These valves, when improperly positioned, provide a drain path for reactor coolant to flow from the reactor vessel to the suppression pool or the radwaste system. Second, establishing or exiting the shutdown cooling mode of operation is entirely manual, making such evolutions vulnerable to personnel and procedural errors. Third, there is no comprehensive valve interlock arrangement for all the residual heat removal system valves that could be activated during shutdown cooling. Collectively, these factors have contributed to the repetitive occurrences of the operational events involving the inadvertent draining of the reactor vessel.

For PWRs, this IC covers sequences such as prolonged boiling following loss of decay heat removal.

Thus, declaration of a Site Area Emergency is warranted under the conditions specified by the IC. Escalation to a general emergency is via radiological effluence IC AG1.

SITE AREA EMERGENCY

SS6 Inability to Monitor a Significant Transient in Progress.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. The following conditions exist:

   a. Loss of (site-specific) annunciators associated with safety systems.

   AND

   b. Compensatory non-alarming indications are unavailable.

   AND

   c. Indications needed to monitor (site-specific) safety functions are unavailable.

   AND

   d. Transient in progress.

BASIS:

This IC and its associated EAL are intended to recognize the inability of the control room staff to monitor the plant response to a transient. A Site Area Emergency is considered to exist if the control room staff cannot monitor safety functions needed for protection of the public.

(Site-specific) annunciators for this EAL should be limited to include those identified in the Abnormal Operating Procedures, in the Emergency Operating Procedures, and in other EALs (e.g., rad monitors, etc.)

"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.

"Significant Transient" includes response to automatic or manually initiated functions such as scrams, runbacks involving greater than 25% thermal power change, ECCS injections, or thermal power oscillations of 10% of greater.

(Site-specific) indications needed to monitor safety functions necessary for protection of the public must include control room indications, computer generated indications and dedicated annunciation capability. The specific indications should be those used to determine such functions as the ability to 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.

GENERAL EMERGENCY

SG1 Prolonged Loss of All Offsite Power and Prolonged Loss of All Onsite AC Power.

OPERATING MODE APPLICABILITY: Power Operation
Hot Standby (startup in BWRs)
Hot Shutdown

EXAMPLE EMERGENCY ACTION LEVEL:

1. Prolonged loss of all offsite and onsite AC power as indicated by:

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

   AND

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

   AND

   c. At least one of the following conditions exist:

      - Restoration of at least one emergency bus within (site-specific) hours is *NOT* likely

      OR

      - (Site-Specific) Indication of continuing degradation of core cooling based on Fission Product Barrier monitoring.

BASIS:

Loss of all AC power compromises all plant safety systems requiring electric power including RHR, ECCS, Containment Heat Removal and the Ultimate Heat Sink. Prolonged loss of all AC power will lead to loss of fuel clad, RCS, and containment. The (site-specific) hours to restore AC power can be based on a site blackout coping analysis performed in conformance with 10 CFR 50.63 and Regulatory Guide 1.155, "Station Blackout," as available, with appropriate allowance for offsite emergency response. 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.

This IC is specified to assure that in the unlikely event of a prolonged station blackout, timely recognition of the seriousness of the event occurs and that declaration of a General Emergency occurs as early as is appropriate, based on a reasonable assessment of the event trajectory.

The likelihood of restoring at least one emergency bus should be based on a realistic appraisal of the situation since a delay in an upgrade decision based on only a chance of mitigating the event could result in a loss of valuable time in preparing and implementing public protective actions. 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.

SYSTEM MALFUNCTION

GENERAL EMERGENCY

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.

OPERATING MODE APPLICABILITY: Power Operation

EXAMPLE EMERGENCY ACTION LEVEL:

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

AND

2. Either of the following:

   a. (Site-specific) indications exists that the core cooling is extremely challenged.

   OR

   b. (Site-specific) indication exists that heat removal is extremely challenged.

BASIS

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

Under the conditions of this IC and its associated EALs, the efforts to bring the reactor subcritical have been unsuccessful and, as a result, the reactor is producing more heat than the maximum decay heat load for which the safety systems were designed. Although there are capabilities away from the reactor control console, such as emergency boration in PWRs, or standby liquid control in BWRs, the continuing temperature rise indicates that these capabilities are not effective. This situation could be a precursor for a core melt sequence.

For PWRs, the extreme challenge to the ability to cool the core is intended to mean that the core exit temperatures are at or approaching 1200^{o}F or that the reactor vessel water level is below the top of active fuel. For plants using CSFSTs, this EAL equates to a Core Cooling RED condition. For BWRs, the extreme challenge to the ability to cool the core is intended to mean that the reactor vessel water level is below 2/3 coverage of active fuel.

Another consideration is the inability to initially remove heat during the early stages of this sequence. For PWRs, if emergency feedwater flow is insufficient to remove the amount of heat required by design from at least one steam generator, an extreme challenge should be considered to exist. For plants using CSFSTs, this EAL equates to a Heat Sink RED condition. For BWRs, (site-specific) considerations include inability to remove heat via the main 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.