APPENDIX H

CONTAINMENT INTEGRITY SIGNIFICANCE DETERMINATION PROCESS

Office of Nuclear Reactor Regulation
Division of Systems Safety and Analysis
Probabilistic Safety Assessment Branch

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1.0 INTRODUCTION

1.1 Background

Core damage accidents that lead to large, unmitigated releases from containment in a time frame prior to effective evacuation of the close-in population have the potential to cause early health effects, e.g. prompt fatalities. The frequency of all accidents of this type is called the large early release frequency (LERF) as described in Regulatory Guide 1.174 (reference 1). Such accidents include unscrubbed releases associated with early containment failure at or shortly after reactor vessel breach, containment bypass events, and loss of containment isolation.

The relationship of LERF thresholds to core damage frequency (CDF) thresholds found in Regulatory Guide 1.174 provides the basis for the risk significant characterizations found in Table 1.1 below. The LERF based approach is one order of magnitude more stringent than the CDF based approach. Therefore, it may be necessary under some circumstances to characterize the risk significance of an inspection finding using the LERF based approach. The purpose of this appendix to provide guidance for assessing the impact of inspection findings in relation to the containment barrier cornerstone of safety. The basis for the guidance presented in this appendix is discussed in IMC-308, Reactor Oversight Process (ROP) Basis Document.

Table 1.1 Risk Significance Based on ΔLERF vs ΔCDF

Frequency Range/ry	SDP Based on ΔCDF	SDP Based on ΔLERF
$\geq 10^{-4}$	Red	Red
$< 10^{-4} - 10^{-5}$	Yellow	Red
$< 10^{-5} - 10^{-6}$	White	Yellow
$< 10^{-6} - 10^{-7}$	Green	White
$<10^{-7}$	Green	Green

The significance determination process (SDP) assigns a risk characterization to inspection findings based on LERF considerations. This process is designed to interface directly with the SDP Phase 2 results for Type A findings, derived from IMC 609, Appendix A (at power) and Appendix G (shutdown), that are important LERF contributors. In addition, the guidance addresses findings related to structures, systems, and components (SSCs) that do not influence CDF determinations but can impact the containment function (i.e., Type B findings). It is recommended that inspectors, working with senior reactor analysts (SRAs) as needed, evaluate both Type A and Type B findings for at power findings. It is further recommended that SRAs evaluate both Type A and Type B findings for shutdown.

1.2 Applicability

The guidance in this SDP is designed to provide NRC inspectors, SRAs and NRC management with a simple probabilistic risk framework for use in identifying which findings are potentially risk-significant from a LERF perspective. Appendix H also helps facilitate communication of the basis for significance between the NRC and licensees. In addition, it identifies findings that do not warrant further NRC engagement, due to very low risk significance, given the findings are entered into the licensee's corrective action program.

1.3 Entry Conditions

The entry conditions for the containment integrity SDP described in this document are related to:

- degraded plant equipment functions, issues that can affect initiating event frequencies, mitigating systems availability/reliability, and RCS barrier integrity (i.e., items that can potentially increase CDF), that have already been evaluated through SDP Phase 2 described in IMC 0609, Appendix A, or

- degraded conditions affecting containment barrier integrity (that can potentially increase LERF without affecting CDF).

Appendix H provides simplified risk-informed guidance for estimating the increase in LERF associated with inspection findings related to deficient licencee performance during full power (see IMC 0609, Appendix A) and shutdown operations (see IMC 0609, Appendix G).

1.4 Appendix H Outline

The guidance presented in this appendix is based on a number of assumptions and modeling approximations. Section 2.0 presents the limitations and precautions that must be considered when evaluating inspection findings. Abbreviations and definitions used in this appendix are presented in Section 3.0. Section 4.0 is an overview of the approach and the procedure. Section 5.0 presents the procedure for analyzing those findings that have an impact on CDF (i.e, Type A findings) and Section 6.0 presents the procedure for analyzing those findings that only impact the containment function (i.e., Type B findings). Findings related to full-power operation and findings related to low-power and shutdown operations are both addressed.

2.0 LIMITATIONS AND PRECAUTIONS

Appendix H generates a reasonably conservative, order-of-magnitude assessment of the risk significance of inspection findings. The intent of Appendix H is to provide guidance for NRC inspectors to easily obtain a quick assessment of risk

significance. If appropriate, a more detailed assessment may be performed in a SDP Phase 3 evaluation.
The approach in this appendix has numerous assumptions and limitations which include the following:

- Since this SDP is focused on LERF, i.e., early fatality risk, long-term risk effects such as population dose and latent cancer fatalities are not addressed in this guidance. In addition, long term accident sequences that involve failure of containment heat removal and ultimately progress to containment failure, e.g., loss of containment heat removal sequences in BWRs, are assumed not to contribute to LERF. It is assumed that effective emergency response actions can be taken within the long time frame of these accident sequences.

- For the evaluation of risk significance during shutdown, only the period within eight days of the beginning of the outage is considered. After eight days, it is assumed that the short-lived, volatile isotopes that are principally responsible for early health effects have decayed sufficiently such that the finding would not contribute to LERF. In addition, all core damage sequences are considered as candidate LERF sequences, because it is not known when evacuation would begin.

- LERF determinations depend on the containment design, plant specific attributes and features, which have considerable variability.

- It was conservatively assumed for all interfacing system loss-of-coolant-accidents (ISLOCAs) that the path outside containment is not submerged (i.e. the release is not scrubbed).

- It was conservatively assumed for all steam generator tube ruptures (SGTRs) that the secondary side is open so that a path outside containment exists and the release is not scrubbed.

- For those findings that impact the containment function (i.e., Type B findings), baseline CDFs for full power were assumed in order to simplify the calculation of the change in risk. The baseline CDFs for full power assumed were10^{-4}/ry for PWRs and 10^{-5}/ry for BWRs.

- It was assumed, conservatively, that a main steam isolation valve (MSIV) leakage rate in excess of 10,000 scfh in BWRs (reference 2) with Mark I and Mark II containments is significant to LERF.

3.0 ABBREVIATIONS AND DEFINITIONS

3.1 Abbreviations

ATWS Anticipated Transient Without Scram

CAP	Corrective Action Program
CCFP	Conditional Containment Failure Probability
CCW	Component Cooling Water
CD	Core Damage
CDF	Core Damage Frequency
DF	Decontamination Factor
DHR	Decay Heat Removal
ECCS	Emergency Core Cooling System
IMC	Inspection Manual Chapter
LER	Licensee Event Report
LERF	Large Early Release Frequency
LOIA	Loss of Instrument Air Initiator
LOOP	Loss of Offsite Power
LORHR	Loss of RHR Initiating Event
LOSW	Loss of Service Water Initiator
LTOP	Low Temperature Over Pressure Events
POS	Plant Operating State
PRA	Probabilistic Risk Assessment
RCS	Reactor Coolant System
RHR	Residual Heat Removal
ROP	Reactor Oversight Process
RPV	Reactor Pressure Vessel
SCFH	Standard Cubic Feet per Hour
SDP	Significance Determination Process
SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SSC	Structure, System, or Component
TS	Technical Specifications
TW	Time Window
TW-E	Early Time Window, before refueling operation
TW-L	Late Time Window, after refueling operation

3.2 Definitions

LERF: The frequency of those accidents leading to significant, unmitigated releases from containment in a time frame prior to effective evacuation of the close-in population such that there is a potential for early health effects.

Appendix H Phases of Significance Determination:

- Phase 1 - Characterization and Initial Screening of Findings: Precise characterization of the finding and an initial screening of very low-significance findings for disposition by the licensee's corrective action program.

  Phase 2 - Initial Risk Significance Approximation and Basis: Initial approximation of the risk significance of the finding and development of the basis for this determination for those findings that are not screened out in Phase 1 screening.

- Phase 3 - Risk Significance Finalization and Justification: Review and as-needed refinement of the risk significance estimation results from Phase 2, or development of any risk analysis outside of this guidance, by an NRC risk analyst (any departure from the guidance provided in this document or IMC 609 Appendix G for Phase 1 or Phase 2 constitutes a Phase 3 analysis and must be performed by an NRC risk analyst).

Condition Findings: Inspection findings that only involve a degradation of the licensee's mitigation capability.

Loss of RHR (LORHR): Includes losses of RHR resulting from failures of the RHR system (such as RHR pump failure) or failures of RHR support systems other than offsite power.

Loss of Offsite Power (LOOP): Includes losses of offsite power which cause a loss of RHR shutdown operations.

Plant Operating States (POSs) During Shutdown:

For BWRs

POS 1: Starts when the RHR system is placed in service and RCS pressure is reduced below 135 psig with the MSIVs closed. The reactor pressure vessel (RPV) head is on. This POS covers part of Hot Shutdown (Mode 3) and Cold Shutdown (Mode 4) of the technical specifications (TS) modes.

POS 2: Represents the shutdown condition when the RPV head is removed and reactor vessel water level is less than the minimum level required for movement of irradiated fuel assemblies within the RPV as defined by TS. This POS occurs during Mode 5.

POS 3: Represents the shutdown condition when the RPV water level is greater than or equal to the minimum level required for movement of irradiated fuel assemblies within the RPV as defined by TS. This POS occurs during Mode 5.

For PWRs

POS 1 - Starts when the RHR system is placed in service. The RCS is closed such that a steam generator could be used for decay heat removal, if the secondary side of a steam generator is filled. The RCS may have a bubble in the pressurizer. This POS ends when the RCS is vented such that the steam generators cannot sustain core heat removal. This POS typically includes Mode 4 (hot shutdown) and portions of Mode 5 (cold shutdown).

POS 2 - Starts when the RCS is vented such that: (1) the steam generators cannot sustain core heat removal and (2) a sufficient vent path exists for feed and bleed. This POS includes portions of Mode 5 (cold shutdown) and

Mode 6 (refueling). Reduced inventory operations and mid-loop operations with a vented RCS are subsets of this POS. Note: performance deficiencies occurring during a vacuum refill of the RCS require use of the POS 1 event trees.

POS 3 - Represents the shutdown condition when the refueling cavity water level is at or above the minimum level required for movement of irradiated fuel assemblies within containment as defined by TS. This POS occurs during Mode 6.

Early Time Window (TW-E): Represents the time before POS 3 is entered. The decay heat is relatively high. The reactor is in POS 1 or 2. Generally, TW-E represents the first eight days after shutdown.

Late Time Window (TW-L): This time window represents the time after POS group 3. The decay heat is relatively low. The reactor is in POS 1, 2, or 3.

Available: An SSC is considered available if it can be placed in service quickly enough to meet its function and all necessary supporting systems are functional (such as AC power, cooling water, and DC control power).

Reduced Inventory Operations (PWR only): Exists whenever the RPV water level is lower than three feet below the reactor vessel flange.

Shutdown Operations: Exists during hot shutdown, cold shutdown, and refueling when more than one fuel assembly is in the RPV and the decay heat removal system is in operation.

4.0 OVERVIEW OF THE APPROACH AND PROCEDURE FOR SIGNIFICANCE DETERMINATION

The guidance described in this section provides an assignment of a significance level (color) to inspection findings based on LERF considerations. This guidance considers findings resulting from deficient licensee performance during full power operations as well as shutdown operations. In Section 4.1, two distinct types of inspection findings that can potentially affect LERF are defined. Section 4.2 provides details of the overall approach taken to the assessment of their significance.

4.1 Types of Findings

An inspection finding associated with a licensee performance deficiency during full power or shutdown operations is characterized by its potential impact on SSCs, by an estimate of the duration of this degradation, and by other information needed to assess the impact on accident likelihood or barrier cornerstone. Two types of findings are encountered:

Type A Findings:

Type A findings can influence the likelihood of accidents leading to core damage that are also identified as contributors to LERF. Such a finding will already have been processed using SDP Phase 2 results using Appendix A of IMC 609 for findings at full power, or IMC 609 Appendix G for findings related to shutdown operations to determine their contributions to ΔCDF.

Type B Findings:

Type B findings are related to a degraded condition that has potentially important implications for the integrity of the containment, without affecting the likelihood of core damage. Table 4.1 shows a list of SSCs (associated with maintaining containment integrity in different containment types). The LERF significance of these SSCs is also addressed in the table.

4.2 LERF-Based Significance Determination Process

Figure 4.1 describes the process flow of typical inspection findings. The process is designed to interface with the existing CDF based SDP plant specific SDP Phase 2 inspection notebooks. All findings that have been processed through the CDF-based notebooks will be assessed for their potential to contribute to ΔLERF, as Type A findings. Findings that only impact the containment function without affected core damage sequences will be processed as Type B findings.

Type A Findings

For type A findings, the CDF based SDP guidance is used to determine the risk significance based on ΔCDF. If the total ΔCDF for the finding is less than 1E-7 per reactor year, then the finding should be assigned a Green significance level.

If the total ΔCDF $\geq$ 1E-7 per reactor-year, then a screening is conducted using LERF screening criteria to assess whether any of the core damage sequences affected by the finding are potential LERF contributors. If none of the sequences is a LERF contributor there is no increase in risk and the risk significance based on ΔCDF applies. If one or more of the affected sequences is identified as a LERF contributor, an assessment is performed to estimate ΔLERF and determine the increase in risk significance based on LERF considerations as discussed in detail in Section 5.

Type B Findings

Type B findings have no impact on the determination of ΔCDF and therefore will not have been processed through the CDF based SDP. These findings, however, are potentially important to ΔLERF contribution and have to be allocated an appropriate risk category based on LERF considerations. As shown in Figure 4.1, an initial screening is conducted to determine if a finding is related to a containment SSC (see Table 4.1) or containment status that has an impact on LERF. If the answer is NO, the finding is Green. If the answer is YES, an assessment of the risk significance is performed using guidance provided in Section 6.0.

Table 4.1 Containment-Related SSCs Considered for LERF Implications[1]

SSC	LERF Significance
Containment penetration seals: – BWR Mark I and II drywell or PWR containment – BWR Mark III wetwell	Failure of penetration seals that form a barrier between the containment and the environment can be important to LERF
Containment isolation valves in lines: – connecting BWR drywell or PWR containment airspace to environment – connecting RCS to environment or open systems outside containment – connected to closed systems inside/outside containment	 Large lines connecting containment airspace to environment (e.g., vent/purge) can contribute to LERF. Small lines (< 1-2 inch dia) and lines connecting to closed systems would not generally contribute to LERF. Isolation valves connecting to RCS can contribute to ISLOCA
Main Steam Isolation Valves	Excessive MSIV leakage can contribute to LERF in high pressure accident sequences in BWR Mark I and II plants
BWR drywell/containment sprays	Mark I and II drywell sprays and Mark III containment sprays are important to preventing liner melt-through and mitigating suppression pool bypass
Containment flooding system(s)	Important to preventing liner melt-through in Mark I's
PWR containment sprays and fan coolers	Impact late containment failure and source terms, but not LERF
Hydrogen control system -igniters -air return fans and hydrogen mixing systems	 Important to LERF in Mark III and ice condenser plants Not essential to hydrogen control if igniters are available
Suppression pool (SP) systems -components important to SP integrity/scrubbing (e.g., vacuum breakers) -suppression pool cooling	 Important to LERF in all BWR plants Impacts late containment failure but not LERF

[1] Some of the listed SSCs could affect the core damage frequency as well as LERF.

Ice condenser system – ice condenser doors and ice bed – air return fans – ice mass air return fans – foreign objects in ice compartment	 Significant flow blockage can be important to LERF Not important to LERF (similar to containment sprays) Deviations in weight of ice not important to LERF Not important to LERF (unless CDF is affected)
Filtration systems – Standby Gas Treatment System – control room ventilation	Not important to LERF due to unavailability in dominant sequences (e.g., SBO), plugging from high aerosol loadings in severe accident, and other considerations
Spent fuel assemblies (individual) – fuel handling accidents within pool – fuel handling accidents outside pool	Not important to LERF due to small fission product inventory contained in single fuel bundle. Scrubbing by water in the spent fuel pool further reduces releases.

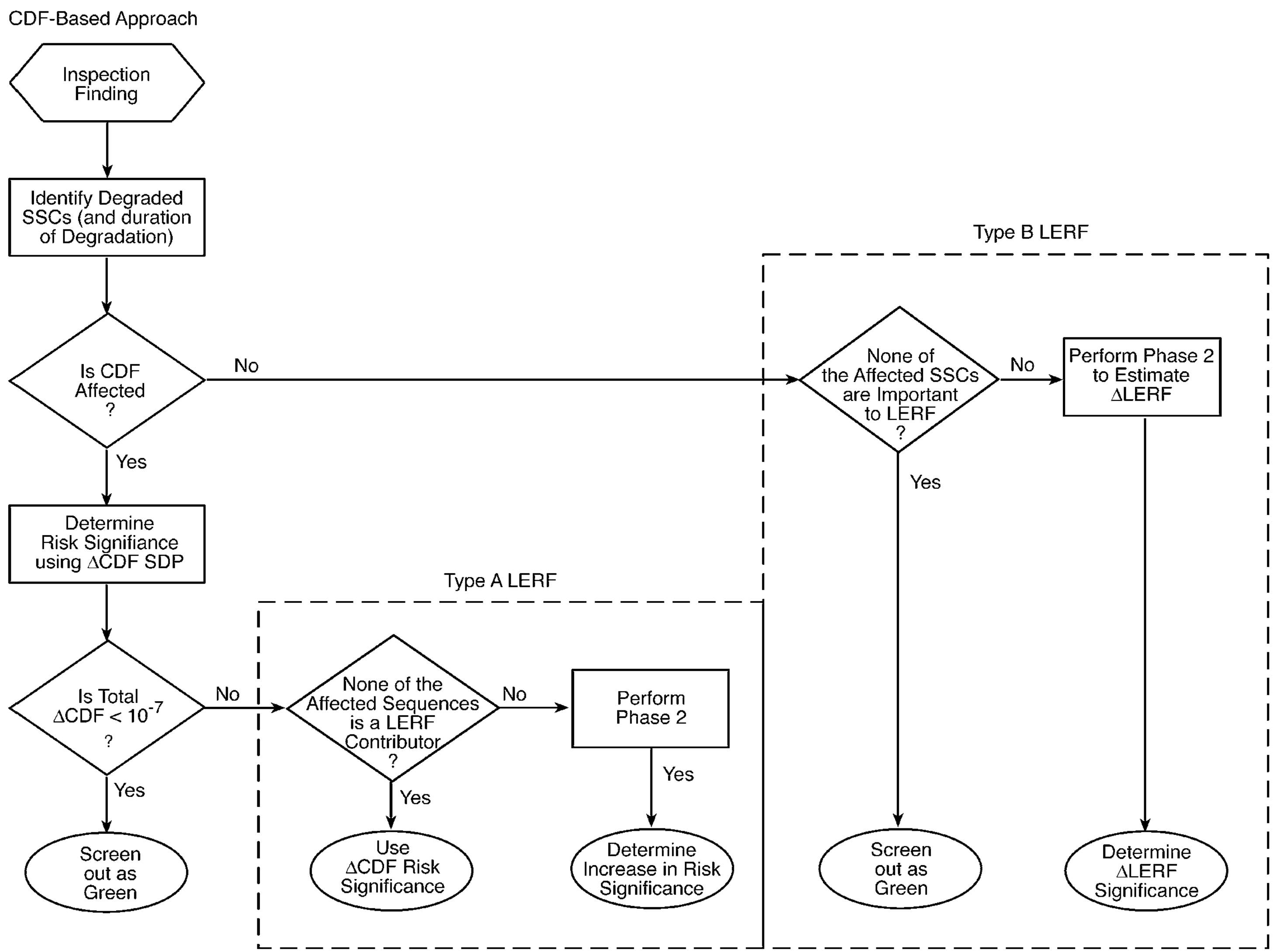

Figure 4.1: LERF-based Significance Determination Process

5.0 PROCEDURE FOR TYPE A FINDINGS

The CDF-based SDP (Appendix A and Appendix G to IMC-0609) provide guidance for assessment of the significance of findings that impact CDF. This leads to identification of CDF sequences associated with each finding, evaluation of the increase in frequency of each of the contributing sequences, and determination of the finding significance to ΔCDF based on all contributing sequences collectively.

Evaluation of the impact of the finding on LERF for these sequences is addressed using this appendix. Section 5.1 presents the procedure for Type A findings at full power, and Section 5.2 presents the procedure for Type A findings at shutdown.

5.1 Approach for Assessing Type A Findings at Full Power

This section provides the step-by-step process (as shown in Figure 5.1) for assessing the risk significance with respect to LERF of Type A findings at full power.

Step 1: Finding Characterization

Review the plant-specific SDP Phase 2 notebook worksheets for the finding to determine the total ΔCDF and to identify the associated CDF sequences which may be LERF contributors.

Step 2: Accident Sequence Screening

Generally, only a subset of those sequences contributing to CDF significance of a finding has the potential to impact LERF. A more detailed discussion of these sequences for each containment type is provided in IMC-308, and briefly summarized below.

<u>BWRs</u>

- For BWR Mark I and Mark II plants, findings related to ISLOCA, ATWS, and accidents with high RCS pressure (i.e., transients and small break LOCA).

- For BWR Mark I plants, accidents that involve a dry drywell floor at vessel breach regardless of whether the RCS is at low or high pressure also need to be evaluated in Phase 2 as indicated in Note 3 to Table 5.1.

- For BWR Mark III plants, findings related to ISLOCA, transients, small break LOCAs, and station blackout (SBO) categories.

<u>PWRs</u>

- For PWR plants with large dry and sub-atmospheric containments, findings related to the accident categories ISLOCA and SGTR.

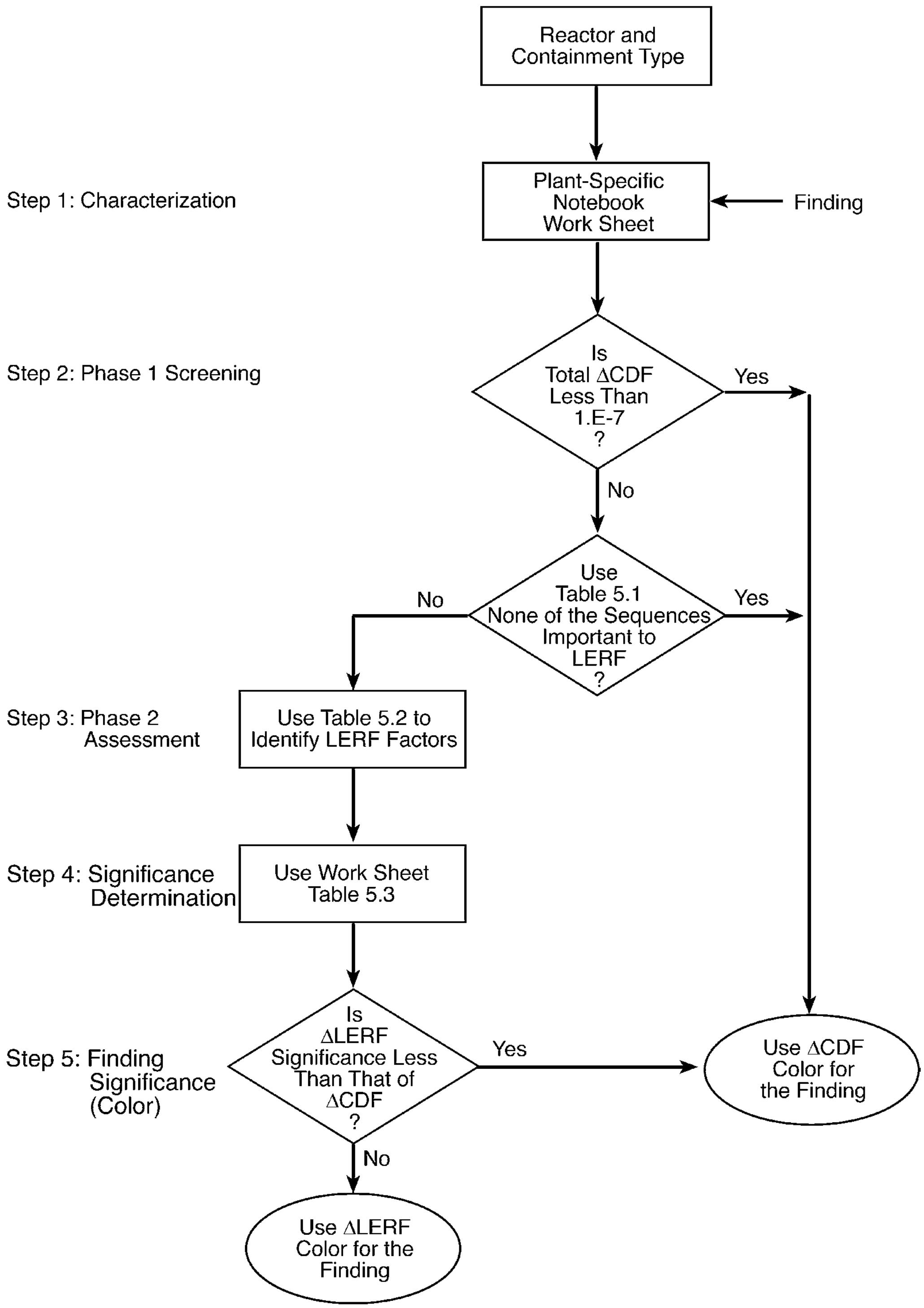

Figure 5.1: Road Map for LERF-based Risk Significance Evaluation for Type A Findings at Fullpower

PWRs (cont.)

- For the PWR plants with ice condenser containments, findings related to ISLOCA, SGTR, and SBO accident categories.

Accident categories that are screened out in Phase 1 include:

- LOOPs with successful emergency AC power operation (non-SBO events).

- LOOPs with failure of emergency AC power in which power is recovered prior to core damage.

In general, sequences with late core damage (i.e., sequences that proceed to core damage due to loss of containment heat removal) will not contribute to LERF. Other sequences that are screened out are summarized below.

BWRs

- ATWS sequences are not important contributors to LERF for BWRs with Mark III containment. Containment failure from ATWS sequences occurs due to gradual overpressurization of containment prior to core damage. However, these sequences leave the drywell and suppression pool intact, hence the releases are scrubbed and a large early release does not occur.

PWRs

- ATWS sequences are not significant contributors to LERF for PWRs. During a PWR ATWS, containment pressure increases slowly and is therefore a late failure mode. The risk significance determined by the CDF based SDP for ATWS events in PWRs is sufficient.

- High and low pressure core damage sequences (in which the containment is not bypassed) are not significant contributors to LERF for PWRs with large dry and sub-atmospheric containments. An important insight from the IPE program and other PRAs is that the conditional probability of early containment failure is less than 0.1 for core damage accident scenarios that leave the RCS at high pressure. If the RCS is depressurized, the probability of early containment failure is less than 0.01.

- In PWRs with ice condenser containments, severe accident studies indicate that the most significant factor is the availability of hydrogen igniters and the ice condenser to mitigate severe accidents. If the igniters are available (i.e., non-SBO accidents), the conditional early containment failure probability is less than 0.1 even during accidents that leave the RCS at high pressure.

The plant-specific SDP Phase 2 notebook worksheets include information related to CDF sequences affected by the finding, score associated with each of these sequences, and the overall CDF significance (color) of the finding. This information is evaluated as follows:

Step 2.1: If the total ΔCDF from the Phase 2 Worksheets (i.e., sum of all sequences) is <1E-7 per year, the LERF significance is Green and further LERF-related evaluation is not needed. Otherwise, proceed to Step 2.2.

Step 2.2: Compare the attributes of all core damage sequences with a ΔCDF of ≥1E-8 per year with those in Table 5.1 to identify those sequences which have the potential to affect LERF. Individual sequence results that are <1-E8 are not significant and are not evaluated further. However, those LERF sequences that are ≥1E-8 (sequence result of 8 or less) are evaluated for the overall LERF contribution. If none of the sequences impacts LERF, the risk significance obtained from the ΔCDF assessment is used for the significance of the finding and no further LERF-related evaluation is necessary. If ΔCDF sequences are identified as having the potential to affect LERF[2], proceed to Step 3.

Step 3: Phase 2 Assessment

For sequences needing Phase 2 analysis, risk significance determination is performed using the following two substeps:

Step 3.1: LERF Factor Determination

Identify the LERF factor associated with each of the sequences remaining after screening using Table 5.2. Document these sequences and their associated LERF factors as discussed in the next substep.

Step 3.2: ΔLERF Significance Evaluation

Document details of LERF significance assessment using the LERF worksheet (Table 5.3). List each sequence assessed in Phase 2 in column 1 together with its CDF score(in column 2) .

Document the sequence attributes that make it a potential LERF contributor (e.g. high RCS pressure, drywell floor status for BWRs, etc.) in column 3.

Document the LERF factor (see Step 3.1) in column 4.

[2]No extra credit should be given for Severe Accident Management operator recovery actions (e.g., actions to depressurize the RCS or to flood Mark I drywell) unless recovery is explicitly modeled in the CDF sequence. Defer such recovery credit to Phase 3 assessment if needed.

Document the LERF score in column 5. The LERF score is calculated by multiplying the ΔCDF score (column 2) by the LERF factor (column 4). For example, if a sequence has a ΔCDF score of 7 (i.e., 1E-7) and the associated LERF factors is 0.4, the LERF score is $4x10^{-8}$.

Step 4: LERF Significance

Sum the scores for all of the LERF contributing sequences associated with the finding and enter the total ΔLERF score in the space below Column 5. Determine ΔLERF by multiplying the total score by a factor of 3.3 (see footnote[3]) and use the numerical result to determine the ΔLERF significance (color), using Table 1.1.

Step 5: Finding Significance

Compare the CDF significance (color) with that for the LERF significance for the same finding. The higher (color) is the preliminary risk significance of the finding.

[3]The factor of 3.3 is an approximation of the geometric average of one order of magnitude. This factor is used to justify that three sequences of the same color are equivalent to one sequence of a higher significance color. For example, three CDF white sequences are equivalent to one yellow sequence.

Table 5.1 Phase 1 Screening-Type A Findings at Full Power							
Reactor Type	Containment Type	Attributes of Accident Sequence Related to Finding					
		ISLOCA	SGTR	ATWS	SBO (Note 1)	High RCS Pressure (Note 2)	All Others
BWR	Mark I	Perform Phase 2	Not Applicable	Perform Phase 2	Perform Phase 2	Perform Phase 2	Note 3
BWR	Mark II	Perform Phase 2	Not Applicable	Perform Phase 2	Perform Phase 2	Perform Phase 2	Screen Out (Note 4)
BWR	Mark III	Perform Phase 2	Not Applicable	Screen Out (Note 4)	Perform Phase 2	Perform Phase 2	Screen Out (Note 4)
PWR	Large Dry and Sub-Atmospheric	Perform Phase 2	Perform Phase 2	Screen Out (Note 4)	Screen Out (Note 4)	Screen Out (Note 4)	Screen Out (Note 4)
PWR	Ice Condenser	Perform Phase 2	Perform Phase 2	Screen Out (Note 4)	Perform Phase 2	Screen Out (Note 4)	Screen Out (Note 4)

Note 1: SBO is defined as a LOOP sequence with loss of emergency AC and failure to recover AC power.

Note 2: High pressure is defined as greater than 250psi at the time of reactor vessel breach. Transients and small break LOCAs (smaller than about 2-inch equivalent break size in BWRs and 0.75 - 1 inch in PWRs) will usually result in pressures in the RCS greater than 250psi at the time of reactor vessel melt-through in the absence of manual depressurization.

Consider a Sequence to be low pressure in case of:
Large or intermediate LOCA
Sequences that include successful depressurization (DEP)
Availability of low pressure injection (LPI) is questioned on sequence branch

Consider a sequence to be high pressure in case of:
The sequence includes failure of depressurization (DEP)
None of the low pressure considerations identified above apply

Note 3: A phase 2 assessment should be performed for any sequences that are expected to proceed to reactor vessel breach into a dry reactor cavity. Therefore, all other transients with successful RCS depressurization should be assessed. Sequences involving LOCAs in the drywell or drywell spray operation are excluded because they result in a flooded drywell floor. LOCAs involving stuck open relief valve sequences do not result in flooded drywell.

Note 4: Screen out means that the accident sequence related to the finding is not significant to LERF and is Green.

Table 5.2 Phase 2 Assessment Factors -Type A Findings at Full Power							
Reactor Type	Containment Type	Attributes of Accident Sequence Related to Finding					
		ISLOCA	SGTR	ATWS	SBO (Note 1)	High RCS Pressure (Note 2)	Low RCS Pressure (Note 2)
BWR	Mark I	1.0	Not Applicable	0.3	(Note 3)	0.6 If drywell is Flooded	<0.1 If drywell is Flooded
						1.0 If drywell is Dry	1.0 If drywell is Dry
BWR	Mark II	1.0	Not Applicable	0.4	(Note 4)	0.3	Screened Out in Phase 1
BWR	Mark III	1.0	Not Applicable	Screened Out in Phase 1	0.2	0.2	Screened Out in Phase 1
PWR	Large Dry and Sub-Atmospheric	1.0	1.0	Screened Out in Phase 1	Screened Out in Phase 1	Screened Out in Phase 1	Screened Out in Phase 1
PWR	Ice Condenser	1.0	1.0	Screened Out in Phase 1	1.0	Screened Out in Phase 1	Screened Out in Phase 1

Note 1: SBO is defined as a LOOP sequence with loss of emergency AC and failure to recover AC power.

Note 2: High pressure is defined as greater than 250psi at the time of reactor vessel breach. Transients and small break LOCAs (smaller than about 2-inch equivalent break size in BWRs and 0.75 - 1 inch in PWRs) will usually result in pressures in the RCS greater than 250psi at the time of reactor vessel melt-through in the absence of manual depressurization.

Note 3: If the RCS is at high pressure during the SBO then the Factors for the high pressure column apply. If the RCS is at low pressure during the SBO, the factors for the low pressure column apply.

Note 4: If the RCS is at high pressure during the SBO then the Factor is 0.3. If the RCS is at low pressure during the SBO, the finding can be screened out.

Table 5.3: Worksheet for ΔLERF

(1) Sequences	(2) ΔCDF Score (X)	(3) Sequence Attributes	(4) LERF Factor (Table 5.2 for full power, Table 5.4 for low power/shutdown) (F)	(5) ΔLERF Score F * ($1x10^{-X}$)
			Total Δ LERF Score	

ΔLERF = 3.3 multiplied by the total ΔLERF score

5.2 Approach for Assessing Type A Findings During Shutdown

This section provides a step-by-step process (shown in Figure 5.2) for assessing the risk significance with respect to LERF of Type A findings applicable to shutdown operation.

Step 1: Finding Characterization

Step 1.1: Review the assessment performed using IMC 609, Appendix G, to identify the sequences affected by the finding, and the POSs and time windows (TWs) applicable to the finding.

Step 1.2: Determine the status of containment when the finding occurred for each POS and TW:

For PWRs and BWR Mark IIIs, the status of containment is either open or intact.

For BWRs Mark I and IIs, the status of containment is either intact, de-inerted, or open.

Step 2: Accident Sequence Screening

Step 2.1: For each shutdown core damage scenario identified in Step 1, determine if the following conditions were met:

- The finding occurred while the plant was in POS 1E or POS 2E.
- The finding occurred within the first eight days of the outage.

Step 2.2: If both conditions in Step 2.1 were met, go to Step 3. Otherwise, the LERF significance is Green and further evaluation for LERF implications is not needed.

Step 3: Phase 2 Assessment

For sequences needing Phase 2 analysis, risk significance determination is performed using the following two substeps:

Step 3.1: Determine the LERF factor for each core damage scenario affected by the finding for the appropriate containment status using Table 5.4.

Step 3.2: Document details of LERF significance assessment for the finding being evaluated using the LERF worksheet (Table 5.3). List each sequence assessed in Phase 2 in column 1 together with its CDF score (in column 2). Since all core damage sequences are potential LERF contributors, column 3 may be left blank. Document the LERF factor (see Step 3.1) in column 4. Document the LERF score in column 5. The LERF score is calculated by multiplying the ΔCDF score (column 2) by the LERF factor (column 4). For example, if a sequence has a ΔCDF score of 7 and the associated LERF factor is 0.2, the LERF score is $2x10^{-8}$.

Step 4: LERF Significance

Sum the scores for all of the LERF contributing sequences associated with the finding being evaluated and enter the total ΔLERF score in the space below column 5 of the completed Table 5.3. Determine ΔLERF by multiplying the total score by a factor of 3.3 and use the numerical result to determine the ΔLERF significance (color), using Table 1.1.

Note that the factor of 3.3 is an approximation of the geometric average of one order of magnitude. This factor is used to justify that three sequences of the same color are equivalent to one sequence of a higher significance color. For example, three CDF white sequences are equivalent to a single yellow sequence.

Step 5: Finding Significance

Compare the CDF significance (color) with that for the LERF significance for the same finding. The higher (color) is the preliminary risk significance of the finding.

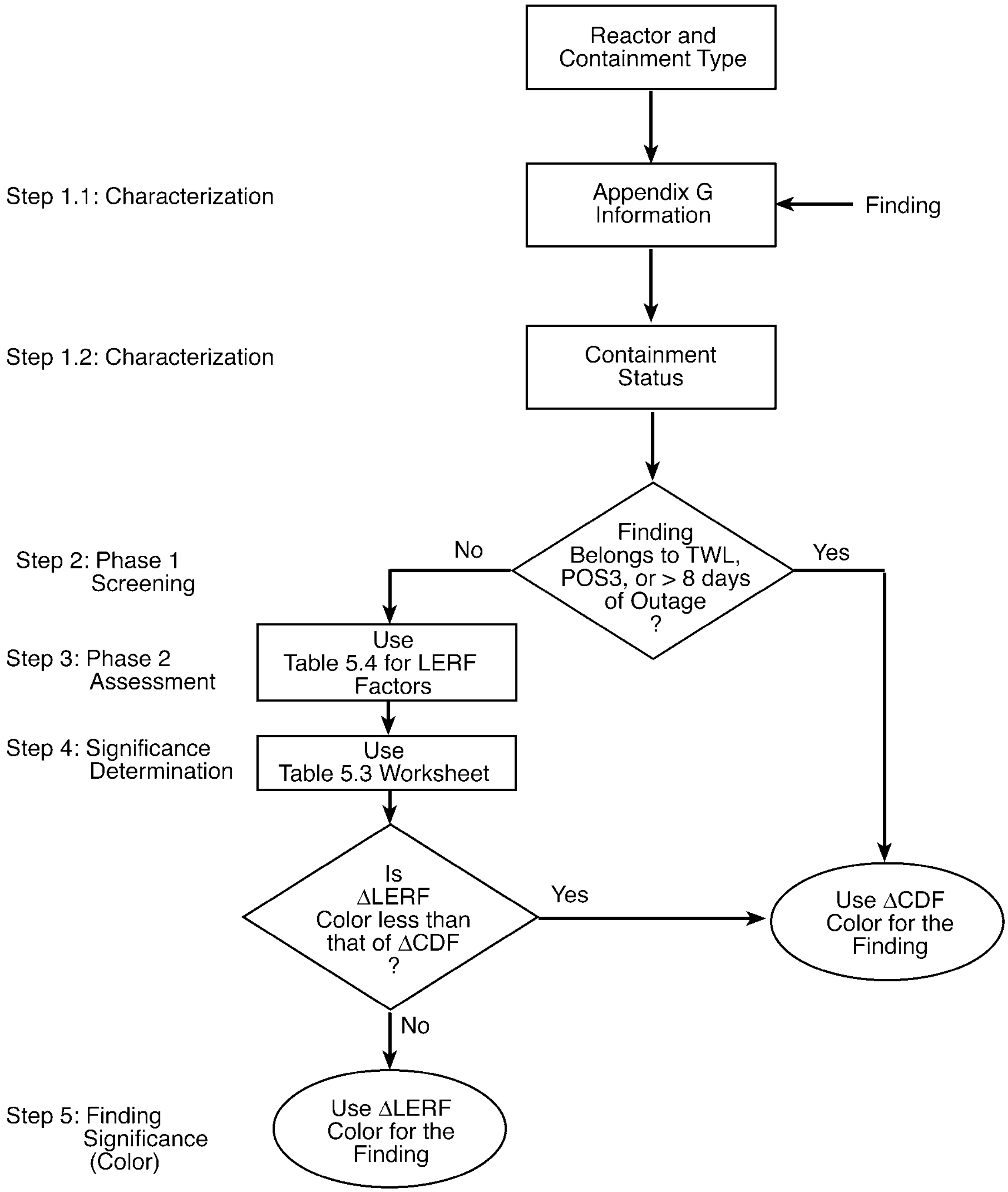

Figure 5.2: Road Map for LERF-based Risk Signifiance Evaluation for Type A Findings at Shutdown

Table 5.4 Phase 2 Assessment Factors -Type A Findings at Shutdown

Reactor/Containment Type	Containmen tStatus (Note 1)	Accident Sequence Related to Finding	
		Finding occurs: (1) in POS 1E or POS 2E within first eight days of outage.	All Others
BWR Mark I and II	De-inerted	1.0	Screened Out
BWR Mark III	Intact	0.2 - if igniters are not available (Note 2)	Screened Out
		Screen Out - if igniters are available (Note 3)	
PWR Large Dry and Sub-Atmospheric	Intact	Screen Out (Note 3)	Screened Out
Ice Condenser	Intact	1.0 - if igniters are not available (Note 2)	Screened Out
		Screen Out if igniters are available (Note 2 and Note 3)	
All	Open	1.0	Screened Out

Note 1: An intact containment is one in which, the licensee intends to: (1) close all containment penetrations with a single barrier or can be closed in time to control the release of radioactive material, and (2) maintain the containment differential pressure capability necessary to stay intact following a severe accident at shutdown. When the RCS is open, an intact containment means that containment can be re-closed prior to boiling the RCS inventory. If the licensee does not intend to maintain an intact containment, then containment is open. If a PWR licensee is not maintaining an intact containment during POS 1E and POS 2E, then this should be reported to NRR/SPSB, so that it can be tracked to meet SRM 97-168.

A de-inerted containment is one in which limits on the primary containment oxygen concentration as defined in TS are not longer met.

Note 2: There are no TS for igniters to be operable during shutdown. However, it is possible that igniters could be recovered by operator action, in which case the finding could be screened out (i.e. not significant to LERF)

Note 3: To screen out the finding, the analyst must verify that the licensee's plans for containment closure consider: 1) time to boiling given a loss of RCS inventory which shortens time to boiling compared to a loss of the operating train of RHR. (NOTE: selecting time to boiling based on RCS level at the bottom of the hotleg should always meet the recommendation) and (2) a potential loss of offsite power and a loss of all vital AC power.

6.0 PROCEDURE FOR TYPE B FINDINGS

Type B findings have no direct impact on the likelihood of core damage but have potentially important implications for containment integrity. This section provides the procedure for evaluation of LERF significance of Type B findings. Similar to the Type A findings approach, a step wise process (Figure 6.1) is used, which leads to a conservative estimate of LERF significance. Section 6.1 presents the procedure for findings at full power, and Section 6.2 for findings at shutdown.

6.1 Approach for Assessing Type B Findings at Full Power

Step 1: Finding Characterization

Characterize the finding in terms of its relationship to the containment barrier function. Collect information needed for significance determination: SSCs affected and the nature of the degradation; the duration (i.e., >30days, 30-3 days, and <3 days) of the degraded condition; information such as the magnitude of the leakage or number and location of inoperable hydrogen igniters. The type of information required can be inferred from Table 6.1 below.

Step 2: Screening of Finding

Determine if the finding is associated with an SSC(s) important to LERF, using Table 6.1. If the finding is screened out then no further assessment is needed and the finding is Green. Otherwise, proceed to Step 3 below. Note that a detailed description of finding to be assessed in Step 3 is included in Table 6.2.

Step 3: Phase 2 Assessment

Use Table 6.2 to provide a significance assignment to a Type B finding. For inspection findings involving leakage rates (e.g., MSIV leakage, containment leakage), if the as-found leakage rate is less than the values listed in Table 6.2, the finding is Green.

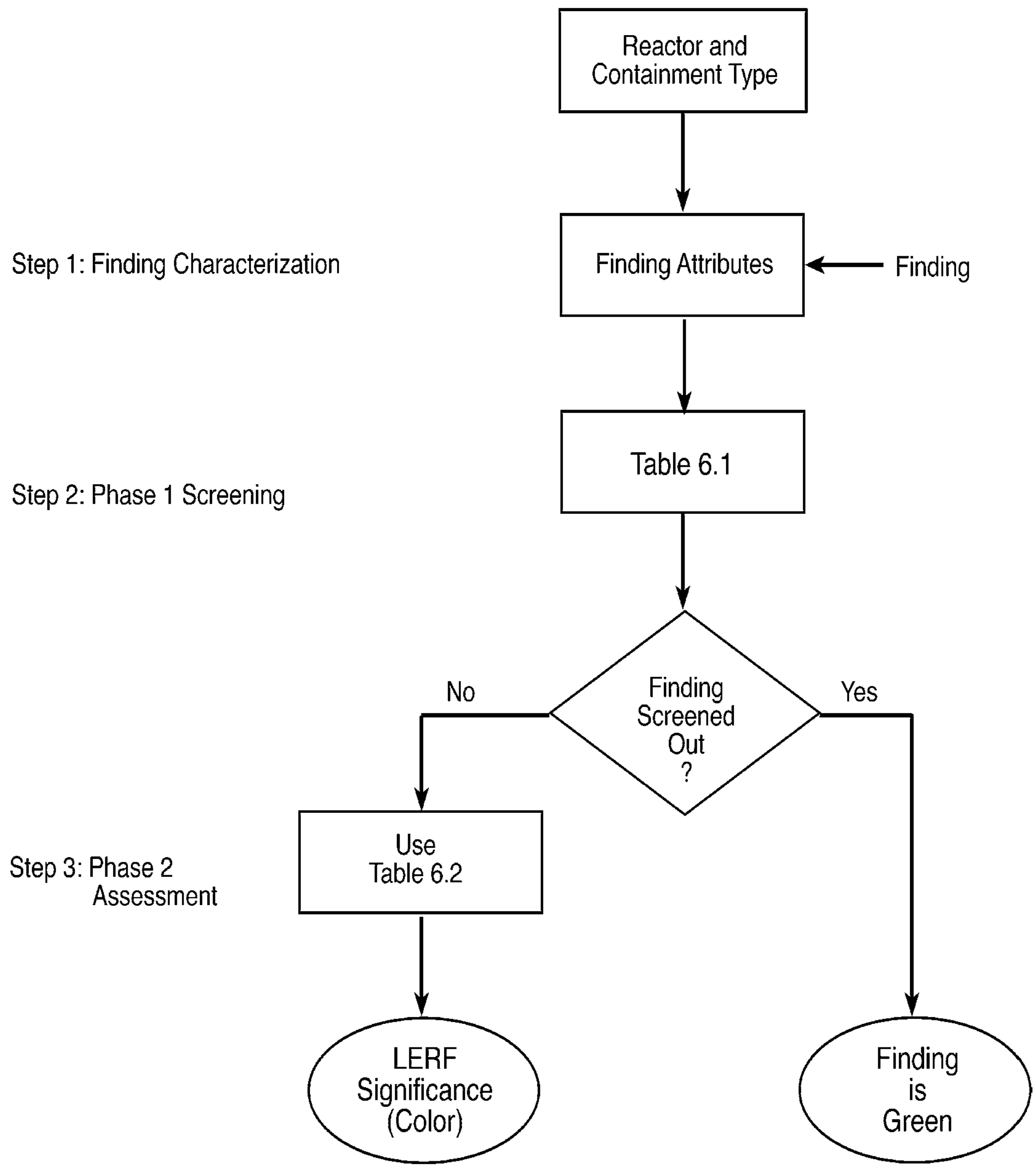

Figure 6.1: Road Map for LERF-based Risk Significance for Evaluation Type B Findings at Fullpower

Table 6.1 Phase 1 Screening-Type B Findings at Full Power							
Reactor Type	Containment Type	SSC Affected by Finding					
		Containment Penetration Seals, Isolation Valves, Vent and Purge Systems	Suppression Pool Integrity	MSIV Leakage	Drywell/ containment Sprays	Igniters	Ice Condenser Integrity
BWR	Mark I	Perform Phase 2	Perform Phase 2	Perform Phase 2	Perform Phase 2	Not Applicable	Not Applicable
BWR	Mark II	Perform Phase 2	Perform Phase 2	Perform Phase 2	Perform Phase 2	Not Applicable	Not Applicable
BWR	Mark III	Perform Phase 2	Perform Phase 2	Not[1] Applicable	Perform Phase 2	Perform Phase 2	Not Applicable
PWR	Large Dry and Sub-Atmospheric	Perform Phase 2	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
PWR	Ice Condenser	Perform Phase 2	Not Applicable	Not Applicable	Not Applicable	Perform Phase 2	Perform Phase 2
Note 1: BWR Mark lll containments have a safety-grade low-leakage Main Steam Shutoff Valve (MSSV) outside of the out-board MSIV. Reference (2)							

Table 6.2 Phase 2 Risk Significance -Type B Findings at Full Power					
Reactor Type	Containment Type	Finding	Risk Significance		
			> 30 days	30 - 3 days	< 3 days
BWR	Mark I and Mark II	Leakage from drywell to environment >100 % containment volume/day through containment penetration seals, isolation valves or vent and purge systems	Yellow	White	Green
		Failure of systems/components critical to suppression pool integrity/scrubbing (vacuum breakers or other bypass mechanisms)	Yellow	White	Green
		Main steam isolation valve leakage >10,000 scfh through the best-sealing valve in any steam line (see Reference 2)	Yellow	White	Green
	Mark I	Drywell sprays unavailable	Yellow	White	Green
	Mark II	Drywell sprays unavailable	White	Green	Green
BWR	Mark III	Leakage from wetwell to environment >1,000 % containment volume/day through containment penetration seals, isolation valves or vent and purge systems	White	Green	Green
		Failure of systems/components critical to suppression pool integrity/scrubbing (vacuum breakers or other bypass mechanisms)	Yellow	White	Green
		Failure of multiple igniters such that coverage is lost in two adjacent compartments	White	Green	Green
		Containment sprays unavailable	White	Green	Green
PWR	Large Dry and Sub-Atmospheric	Leakage from containment to environment >100 % containment volume/day through containment penetration seals, isolation valves or vent and purge systems	Red	Yellow	White
PWR	Ice Condenser	Leakage from containment to environment >100 % containment volume/day through containment penetration seals, isolation valves or vent and purge systems	Red	Yellow	White
		Blockage of more than 15% of the flow passage into or through the ice bed	Red	Yellow	White
		Failure of multiple igniters such that coverage is lost in two adjacent compartments	Red	Yellow	White

6.2 Approach for Assessing Type B Findings at Shutdown

This section provides a step-by-step process (as shown in Figure 6.2) for assessing the risk significance with respect to LERF for Type B finding at shutdown.

Step 1: Finding Characterization

Characterize the finding in terms of its relationship to the containment barrier function. Collect information needed for significance determination, specifically the SSCs affected and the nature of the degradation, the duration of the degraded condition if less than the complete outage and if the condition had existed before shutdown (during power operation), or could exist upon change of plant/containment status (e.g. return to power) and information such as the magnitude of the leakage or the number and location of the inoperable hydrogen igniters. The type of information required can be inferred from Table 6.4 below. In addition, identify each POS(s) and time windows with which the finding is associated.

Step 2: Accident Sequence Screening

Step 2.1 Screen on the Basis of POS and Time Window

If the finding occurs (1) in POS 1 or POS 2 AND (2) in TW-E, AND (3) within eight days of the start of the outage, THEN, go to Step 2.2. Otherwise, screen the finding as Green.

Step 2.2 Screen on the Basis of the Impact of the Finding

Determine if the finding is associated with an SSC(s) important to LERF using Table 6.3. Consideration of items A through D (as applicable) facilitates the use of Table 6.3.

A. Did the finding involve the licensee failing to maintain the capability to close containment (maintain an intact containment) when the licensee planned to maintain an intact containment? This question applies to PWR and BWR Mark III licensees only.

If yes, Go to Table 6.3, containment status is intact. If no, continue with Step B.

B. Did the finding involve hydrogen igniters in a BWR Mark III or a PWR ice condenser containment and the licensee maintained an intact containment?

If yes, Go to Table 6.3, containment status is intact. If no, continue with Step C.

C. Did the finding occur when the containment was de-inerted for a Mark I or Mark II containment?

If yes, go to Table 6.3, containment status is de-inerted. If no, continue with Step D.

D. Did the licensee intend to have an open containment without the capability to reclose containment?

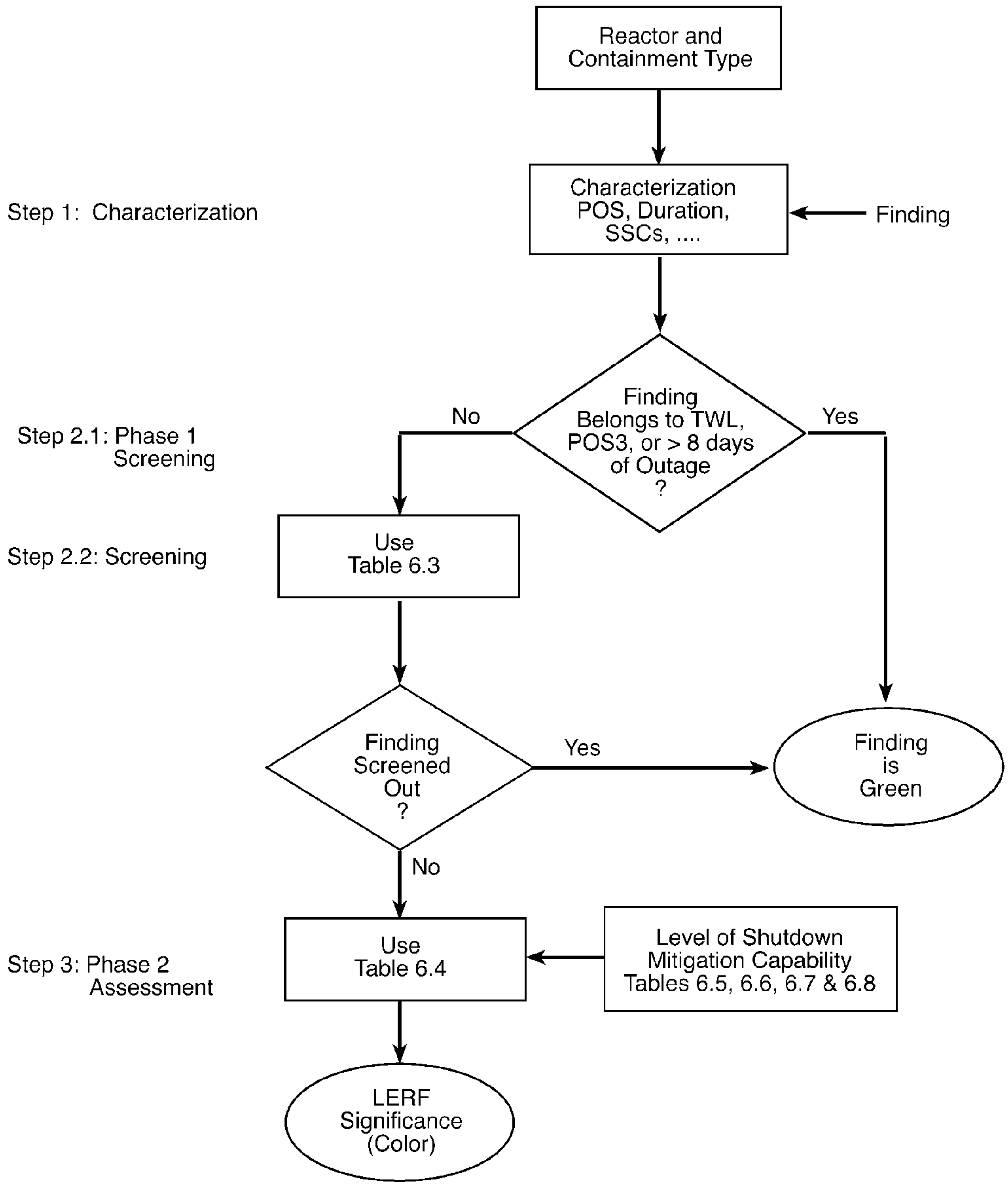

Figure 6.2: Road Map for LERF-based Risk Significance Evaluation for Type B Findings at Shutdown

If yes, Go to Table 6.3, containment status is open.

NOTE: If a PWR licensee is not maintaining an intact containment during POS 1E and POS 2E, this may be a significant finding under the Maintenance Rule. Check with an SRA for further guidance.

If no, Screen out the finding.

If the finding is screened out, it is assigned Green significance, and no further assessment is needed. Otherwise, proceed to Step 3 below.

Step 3: Phase 2 Assessment

Determine if shutdown mitigation capability or closely resembles an in-depth or minimal capability. Use Tables 6.5 and 6.6 for BWRs, or Tables 6.7 and 6.8 for PWRs, to help make this determination.

NOTE: For PWRs, if mitigation capability does not match with the tables, choose between in-depth or minimal capability based on: (1) availability of SGs and (2) availability of ECCS pumps and charging pumps

Use Table 6.4 to determine color of finding.

NOTE: Should the duration of a Type B finding exist for less than eight hours, then the color finding is reduced by one order of magnitude.

NOTE: Findings that may have existed before shutdown (during power operation) or that could impact LERF upon change of plant/containment status (e.g. return to power) should be assessed. In case the finding is judged to impact full power, Section 6.1 guidance should be used in the assessment.

Table 6.3 Phase 1 Screening-Type B Findings at Shutdown						
Reactor/ Containment Type	Contain-ment Status (Note 1)	SSC Affected by Finding				
		Containment Penetration Seals, Isolation Valves, Vent and Purge Systems	Suppression Pool Integrity	Drywell/Contain-ment Sprays	Igniters
BWR Mark I and II	De-inerted	No Type B Findings Important to ΔLERF (Note 2)			
BWR Mark III	Intact	Perform Phase 2	Perform Phase 2	Screen Out (Not important to LERF)	Perform Phase 2
PWR Large Dry and Sub-Atmospheric	Intact	Perform Phase 2	Not Applicable	Screen Out (Not important to LERF)	Not Applicable
PWR Ice Condenser	Intact	Perform Phase 2	Not Applicable	Screen Out (Not important to LERF)	Perform Phase 2
All	Open	No Type B Findings Important to Δ LERF (Note 3)			

Note 1: An intact containment is one in which, the licensee intends to: (1) close all containment penetrations with a single barrier or can be closed in time to control the release of radioactive material, and (2) maintain the containment differential pressure capability necessary to stay intact following a severe accident at shutdown. When the RCS is open, an intact containment means that containment can be reclosed prior RCS boiling. A Type B performance deficiency results when a licensee intends to have an intact containment but cannot maintain that capability due to a performance deficiency. For Mark III containments, the definition of intact containment applies to primary containment.

If the licensee does not intend to maintain an intact containment, then containment is open. If a PWR licensee is not maintaining an intact containment during POS 1E and POS 2E, then this observation could be risk significant under the Maintenance Rule and should be reported to an SRA.

A de-inerted containment is one in which limits on the primary containment oxygen concentration as defined in TS are no longer maintained.

Note 2: Type B findings would be unimportant to ΔLERF because containment would be deinerted and expected to fail due to hydrogen combustion, regardless of Type B finding. However, findings that may have existed before shutdown or that could impact LERF upon change of plant/containment status (e.g. return to power) should be assessed.

Note 3: Type B findings would be unimportant to Δ LERF because containment is already open and cannot be re-closed. However, findings that may have existed before shutdown or that could impact LERF upon change of plant/containment status (e.g. return to power) should be assessed. If a PWR licensee is not maintaining an intact containment during POS 1E and POS 2E, then this observation could be risk significant under the Maintenance Rule and should be reported to an SRA.

Table 6.4 Phase 2 Risk Significance -Type B Findings at Shutdown (For POS 1/TW-E and POS 2/TW-E in which the finding occurs during the first eight days of the outage)				
Reactor/ Containment Type	Containment Status (NOTE 1)	Finding	Risk Significance (NOTE 2)	
			Minimal Capability	In-depth Capability
BWR Mark I, II	De-inerted	Screened Out in Phase 1	N/A	N/A
BWR Mark III	Intact	Leakage from containment to environment > 1000 % containment volume/day through containment penetration seals, isolation valves or vent and purge systems with suppression pool integrity (NOTE 3)	POS 1E -Yellow	POS 1E- White
			POS 2E - Yellow	POS 2E - Green
BWR Mark III	Intact	Loss of suppression pool integrity (NOTE 4)	POS 1E -Yellow	POS 1E- White
			POS 2E - Yellow	POS 2E - Green
BWR Mark III	Intact	Failure of multiple igniters such that coverage is lost in two adjacent compartments given that primary containment is intact	POS 1E - White	POS 2E- Green
			POS 2E - White	POS 2E - Green
PWR Large Dry and Sub-Atmospheric	Intact	Leakage from containment to environment > 100 % containment volume/day through containment penetration seals, isolation valves or vent and purge systems	POS 1E -Yellow	POS 1E - White
			POS 2E - Red	POS 2E - White
PWR Ice Condenser	Intact	Leakage from containment to environment >100 % containment volume/day through containment penetration seals, isolation valves or vent and purge systems	POS 1E - Yellow	POS 1E - White
			POS 2E - Red	POS 2E - White
		Failure of multiple igniters such that coverage is lost in two adjacent compartments	POS 1E - Yellow	POS 1E - White
			POS 2E - Red	POS 2E - White
All	Open	Screened Out in Phase 1	Green	Green

Note 1: An intact containment is one in which, the licensee intends to: (1) close all containment penetrations with a single barrier or can be closed in time to control the release of radioactive material, and (2) maintain the containment differential pressure capability necessary to stay intact following a severe accident at shutdown. When the RCS is open, an intact containment means that containment can be re-closed prior to RCS boiling. A type B performance deficiency results when a licensee intends to have an intact containment but cannot maintain that capability due to a performance deficiency. For Mark III containments, the definition of intact applies to primary containment

If the licensee does not intend to maintain an intact containment, then containment is open. If a PWR licensee is not maintaining an intact containment during POS 1E and POS 2E, then this observation could be risk significant under the Maintenance Rule and should be reported to a SRA.

A de-inerted containment is one in which limits on the primary containment oxygen concentration as defined in Technical Specifications are no longer maintained.

Note 2: The results assume that each shutdown scenario results in a LERF if the licensee fails to maintain an intact containment or the containment fails due to loss of hydrogen control in Ice Condenser and Mark III containments. In phase 3 analysis, if a licensee can show that failures involving long term cooling can be eliminated from LERF because the licensee would have evacuated given successful short term cooling, then the color of the finding would be reduced.

When using this table, there are no duration factors associated with findings at shutdown. The generic shutdown CDFs include the frequency and duration that POS 1 and PO2 are entered into per calender year for both PWRs and BWRs. For BWRs, POS 1 is assumed to last four days; POS 2 is assumed to last two days. For PWRs, POS 1 is assumed to last two days; POS 2 is assumed to last six days. Should the duration of a type B finding exist for less than eight hours, then the color finding is reduced by one order of magnitude.

Note 3: As discussed in Regulatory Guide 1.174, releases that pass through the pool would be scrubbed and would not contribute to LERF. Rather than crediting the pool with completely eliminating LERF, a decontamination factor (DF) of 10 is assigned to pool scrubbing in the SDP. This DF results in the LERF-significant leak rate increased from 100% containment volume per day to 1000% containment volume per day

Note 4: With the suppression pool unavailable, fission products will not be scrubbed and steam generated by decay heat is assumed to lead to gradual over-pressurization of containment and the need to vent prior to effective evacuation. Thus, the finding could be LERF significant even if leak rate is less than 100% containment volume per day.

Table 6.5 BWRs With Minimal Shutdown Mitigation Capability	
Total Annualized CDF Head on: 3E-6 (per calender year) Total Annualized CDF Head off: 9E-7 (per calender year)	
Item	**Value**
RHR pumps	2 (shared with ECCS)
Other heat removal pumps	0
ECCS pumps (in standby)	2 (Shared with RHR)
SRVs for Power Operated Relief Mode	2
CCW pumps/trains	1 train with 2 pumps
SW pumps/trains	1 train with 2 pumps
Containment Spray pumps	0
Fire Water	No
SW Injection into RCS	No
Path to Suppression Pool	Yes
Suppression Pool	Yes
Other Water sources	No
Other means of removing heat	None
Offsite power sources	2
EDGs	1
other onsite power sources	0
Level instruments	Yes
Vessel Temperature Instruments	No
Level 3 RHR Isolation	Sometimes Not Used

Tables 6.6 BWRs With In-depth Shutdown Mitigation Capability	
Total Annualized CDF RCS Head on: 2E-7 (per calender year) Total Annualized CDF RCS Head off: 4E-8 (per calender year)	
Item	**Value**
RHR pumps	2 (Shared with ECCS
Other heat removal pumps	0
ECCS pumps	2 (shared with RHR pumps)
SRVs (in Power Operated Relief mode)	2
CCW pumps/trains	1 train with pumps
SW pumps/trains	1 train with pumps
Containment Spray Pumps	0
Fire Water	Yes
SW Injection into the RCS	Yes
Path to the Suppression Pools	Yes
Suppression Pool	Yes
Other water sources	No
Other means of removing heat	None
Offsite power sources	2
EDGs	2
Other onsite power sources	0
Level instruments	Yes
Vessel temperature Instruments	Yes
Level 3 RHR isolation	Always

Table 6.7 PWRs With Minimal Shutdown Mitigation Capability	
Total Annaulized CDF RCS open: 3E-5 (per calender year) Total Annaulized CDF RCS closed:3E-6 (per calender year)	
Item	**Value**
RHR pumps	2
Other heat removal pumps	0
ECCS pumps (in standby)	1
RCS vents and pressure control	Yes
CCW pumps/trains	2 trains
SW pumps/trains	2 trains
Containment Spray pumps (as back up to the RHR pumps)	0
Gravity Feed	Yes
Accumulators	0
Steam Generators	Yes
Containment sumps	Yes, but not fully reliable
other borated water sources	0
other means of removing heat	0
Offsite power sources	2
EDGs	1
other onsite power sources	0
Level instruments	2 some of time
Vessel temperature Instruments	2 some of time

Table 6.8 PWRs With In-depth Shutdown Mitigation Capability	
Total Annualized CDF RCS open: 1E-7 (per calender year) Total Annualized CDF RCS closed: 8E-7 (per calender year)	
Item	**Value**
RHR pumps	2
Other heat removal pumps	0
Charging Pumps	1
ECCS pumps (in standby)	1
RCS vents and pressure control	Yes
CCW pumps/trains	2 trains
SW pumps/trains	2 trains
Containment Spray pumps	2 as piggy back to the RHR pumps
Gravity Feed	Yes
Accumulators	0
Steam Generators	Yes
Containment sumps	Yes, enhanced reliability
other borated water sources	0
other means of removing heat	0
Offsite power sources	2
EDGs	2
other onsite power sources	0
Level instruments	2 at all times
Vessel temperature Instruments	2 at all times

7.0 REFERENCES

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4. Risk-Informed Inspection Template for a PWR During Shutdown, Draft, NRC, Office of Nuclear Reactor Regulation, August 8, 2002.

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