SUMMARY OF JOINT EPRI/NRC-RES MAIN CONTROL ROOM ABANDONMENT RESEARCH PROJECT

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Main control room (MCR) abandonment is complex to model in Probabilistic Risk Assessment (PRA) because there are a wide range of scenarios to represent and the plant response consists of a collective set of operator actions. While fire human reliability analysis (HRA) guidance was recently published (see EPRI 1023001/NUREG-1921) the focus of this guidance was on modifications to existing human failure events (HFEs) from the internal events (non-fire) PRA to incorporate fire impacts and scenarios as well as the analysis of new fire HFEs to be included in the fire PRA model. It was recognized in the development of that document that MCR abandonment would require separate, dedicated HRA research.

In 2015, EPRI and NRC-RES embarked on a second joint fire HRA project with an overall objective to develop methods and guidance, both qualitative and quantitative, to support the development of HFEs and associated human error probabilities (HEPs) associated with MCR abandonment scenarios. It was decided to address qualitative analysis first and then following up with quantitative analysis guidance. The purpose of this paper is to summarize the status of the current joint EPRI/NCR-RES project and the differences qualitative HRA guidance between MCR abandonment and non-abandonment fire scenarios.

I. INTRODUCTION

Main control room abandonment (MCRA) is complex to model in Probabilistic Risk Assessment (PRA) because there are a wide range of scenarios to represent and the plant response consists of a collective set of operator actions. While fire HRA guidance was recently published (see EPRI 1023001/NUREG-1921, 2012)[1] the focus of this guidance was on modifications to existing HFEs from the internal events (non-fire) PRA to incorporate fire impacts and scenarios as well as the analysis of new fire HFEs to be included in the fire PRA model. It was recognized in the development of that document that MCR abandonment would require further HRA research.

Following publication of NUREG-1921, the industry proposed a fire PRA Frequently Asked Question (FAQ) 13-002[2] to address a long-standing concern regarding the use of "screening" human error probabilities (HEPs) for modeling failure to successfully abandon the MCR due to fire in the MCR and transfer functions necessary to maintain safe shutdown capability to ex-MCR location(s). After considerable effort by both industry and the NRC, the FAQ was closed with the recognition that more research was needed.

In 2015, the joint EPRI/NRC-RES fire HRA team began its latest collaborative effort on MCR abandonment to expedite issuance of expanded fire HRA guidance for MCR abandonment. The team would address qualitative analysis first and then following up with quantitative analysis guidance. The qualitative guidance is being developed using the experience of team members in performing MCR abandonment HRA, interviews with current and former operators to understand different plant responses to MCR abandonment, review of historical events, and review of human factors literature relevant to MCR abandonment scenarios. At the time of PSAM'13 a draft qualitative analysis document completed and is currently undergoing peer review. It is expected that the qualitative analysis document will be published in 2017.

The qualitative guidance document is intended for practitioners of both fire HRA and fire PRA. Since HRA and PRA require close collaboration in the development of MCRA scenarios. In many cases, the HRA must provide input ***before*** MCRA scenarios can be defined and developed for the overall PRA model.

The qualitative guidance document builds upon the fire HRA guidance provided in a previously published joint report, *EPRI/NRC-RES Fire Human Reliability Analysis Guidelines*[1] **and augments** (and sometimes replaces) that given in the overall fire PRA methodology report, *Fire PRA Methodology for Nuclear Power Facilities,* (EPRI 1011989/NUREG/CR-6850)[3].

The fire HRA process steps identified in NUREG-1921 are unchanged for MCRA. Instead, the report expands upon the guidance and discussion given in NUREG-1921 on task interfaces and interactions between HRA and other disciplines in a fire PRA to address additional needs for performing HRA for MCRA. In addition, it focuses on the differences between MCRA scenarios and other fire scenarios and how such differences are treated in HRA/PRA.

II. TECHNICAL APPROACH

The technical approach used to develop this supplement to NUREG-1921 on qualitative HRA for MCRA and modeling MCRA in fire PRAs consisted of:

- Technical exchange among team members on common and dissimilar experiences in performing or reviewing the assessment of HRAs for MCRA scenarios in fire events, encompassing experiences
- Comparing similar or different approaches to MCRA in team discussions
- Development of a common approach for qualitative HRA and logic modeling
- Discussions of operational experience (e.g., significant fire events, other significant NPP events) that related to development of qualitative HRA guidance
- Conduct of supplemental interviews of NRC staff with operational experience on MCRA strategies and training
- Development of a shared view on MCRA HRA regarding:
    - The unique challenges of modeling MCRA HRA and PRA logic modeling
    - Parallels between MCRA HRA and other relatively novel HRAs such a Yucca Mountain Project, or Level 2 HRA.
    - The importance of capturing the current state of knowledge on performing MCRA HRA for both the HRA and PRA communities
    - The importance of properly evaluating and capturing the fire-induced and random failures that can complicate or defeat successful completion of an MCRA scenario
- Review of psychological literature (e.g., NUREG-2114[4] to identify or develop an explanatory model for operator response in MCRA scenarios (which differs from that for internal events, Level 1 HRA/PRA in many important ways).

III. SUMMARY OF QUALITATIVE ANALYSIS DOCUMENT

The draft document consists of eight high level sections and each of these sections is described in detail in the following sub-sections.

III.A Overview of MCRA Qualitative HRA/PRA

This section provides an overview of the qualitative HRA/PRA guidance for MCRA scenarios and how MCRA HRA can be different from internal events and or fire HRA. The high-level reasons for requiring additional guidance for MCRA include:

- The decision to abandon often is captured by a unique procedure that is likely to be separate from the fire response procedure set. The potential for involvement of multiple operators performing distinct but correlated tasks outside the MCR makes the abandonment scenario a challenging analysis for both the fire PRA and HRA.
- There are many implications for HRA when the control room crew leaves the MCR, going well beyond a simple location change for operator actions. Some of these implications are:
    - For US nuclear power plants (NPPs), response to the Three Mile Island 2 (TMI-2) event has resulted in standardized requirements for MCR design, emergency operating procedures (EOPs) (in format, content, etc.), and operator training. As a result, HRA analysts can assume (but should verify) that the MCR environment provides a high-level of support to MCR operator actions. However, that same level of support cannot be expected for MCRA scenarios. As a matter of fact, the HRA analyst should expect that every NPP's remote shutdown panel (RSDP) is unique in its design, capabilities, and limitations.
    - Almost all HRA methods have been based on assumptions related to the fact that decision-making, and most other operator actions, are taken in the MCR. For MCRA most actions are taken outside the MCR and following the decision to abandon all decision-making will be outside the MCRA.
    - When "command-and-control" resides in the MCR, decision-making (and any operator actions taken) is supported by many alarms, indications, and other instrumentation. In addition, decision making by the Shift Supervisor (or Shift Manager) is supported by additional management or staff, either required to be present (e.g., the Shift Technical Advisor [STA]) or expected due to typical response to a serious plant upset. Such support and extra help (as well as probably multiple phones) also eases the burden of necessary communications, whether it be fire brigade updates, notifications to the NRC, or reports back from field operators or health physics. However, in MCR abandonment scenarios, command and control is likely to lose some of these supports. For example, staffing may change during MCRA due to fire brigade responsibilities (although plants are required to ensure that a basic level of staffing is maintained) and procedure assignments, perhaps even increasing for multi-unit sites where an “all hands on deck” approach to severe events is used. Consequently, command-and-control in MCRA scenarios typically must rely upon a different level and mode of information acquisition, staffing and communications.
- Treatment of MCRA may not rely on the typical assumption that fire initiation, reactor trip, and the "start of the scenario" (from an operations perspective) are simultaneous. Instead, proper HRA treatment of MCRA needs to include explicit consideration of these scenario milestones since it is possible they may occur at different times.
- The definition of an MCRA scenario for loss of control (LOC) (if credit can be given) requires significant input from operators and operations personnel who would be making the abandonment decision rather than solely being based on plant conditions, associated engineering calculations, etc. HRA input is crucial for the proper definition of MCRA scenarios, rather than the typical situation in which the PRA analysts have the lead in scenario definition and development.
- The MCRA shutdown strategy almost certainly will involve a greater number of coordinated operator actions at multiple locations than internal events HRA. This means that assessment of the shutdown strategy requires consideration of the feasibility of the coordinated operator response, as well as the feasibility of individual operator actions. The resulting feasibility assessment requires consideration of multiple timelines that represent each operator/operator action, including important coordination points or other intersections.
- With the greater number of local (i.e., "in the field" or outside the control room) operator actions, plant-specific differences with respect to shutdown strategy, overall design (including design of the alternate shutdown panel), plant layout, and equipment are even more important than for those fire scenarios involving principally in-control room operator actions.

- NPP operators are familiar with many "rare events" due to their frequent simulator training, but may consider MCRA scenarios even less credible. To-date, no MCRA events have occurred in the U.S, and realistic simulator training of MCRA scenarios (including representative communications with field operators) is very uncommon. Such limitations in operational experience are likely to change what input can be collected in interviews with operations personnel, how such input can be collected, and how to use such information. (Appendix A provides additional background information on MCR abandonment regulatory requirements and near miss events.)

III.B Modeling MCRA Scenario in Fire PRA

This section describes the modeling of MCRA scenarios in a fire PRA. The objective of this section is to provide a better understanding of how to address the aspects of the various MCRA requirements in the fire scenario selection (FSS, which covers the identification, definition, and fire modeling of fire scenarios) and plant response model (PRM, which covers the fire PRA logic model development and quantification) sections of the ASME/ANS Standard[5] that, by their very nature, apply to MCRA. This is accomplished by expanding on the MCRA procedure and guidance presented in NUREG/CR-6850 [2]. The need for this additional guidance results from experience gained through fire PRA peer reviews and requests for additional information (RAIs) from NRC to licensees on their NFPA 805 Licenses Amendment Requests (LARs). This experience has made clear that, although the HRA associated with MCRA is the single most significant issue, there are important PRA modeling issues that affect the results of the analysis that are often missed or modeled improperly.

Although the primary focus of the section is on the PRA modeling, there is important discussion about the interface between the PRA modeling and HRA. While this need exists in all aspects of PRA, it is perhaps much more acute for MCRA than other aspects. The need for the HRA analyst to understand the needs and limitations of the PRA models so that the HRA can be performed in such a way as to successfully support the model and quantification is very important.

In order to develop the qualitative analysis for any given MCRA scenario, the modeling starts with the fire PRA. The fire PRA provides the inputs to the HRA such as the fire modeling and the subsequent impact on the plant, which is captured as a modeled scenario within the context of the PRA. Specifically, one must first understand how the HRA task for MCR abandonment fits within overall development of the fire PRA development and NUREG/CR-6850 fire PRA process before developing the qualitative and quantitative analyses. It should be noted that these considerations apply to fire areas that lead to MCR abandonment (e.g., fire in cable spreading room) in addition to fires in the MCR.

For fires that progress to the point of requiring MCRA, the design basis plant response is to shut down at a Remote Shutdown Panel (RSDP) or Local Control Stations (LCS) outside of the main control room. The procedure used to accomplish safe shutdown is designed to mitigate most, if not all, of the effects of fire including spurious component operations and to provide sustained decay heat removal. The overall process of abandoning the main control room and re-establishing decay heat removal provides a recovery from the fire and its effects. While fire-damaged components are not repaired, the fire-effects are mitigated.

The modeling guidance considerations that need to be addressed for MCRA are:

1. Define the plant conditions that would constitute a loss of control or loss of habitability for the plant based on the HRA operator interviews and procedure review, and then include appropriate logic in the model to capture when those conditions occur.
2. Based on the fire modeling for main control room fires, determine the scenarios that would result in a loss of habitability and generally only credit abandonment actions for those scenarios (i.e., do not credit actions in the control room that only appear in other procedures).
3. Include random failures of equipment required for remote shutdown (including the controls located at the remote shutdown panel) in the model.
4. Include mitigatable fire-induced failures of equipment required for remote shutdown (including the controls located at the remote shutdown panel) in the model. This requires performing circuit analysis of the remote shutdown panel and control circuits to determine if any abandonment scenarios can cause failure.
5. Include non-mitigatable fire-induced failures of equipment required for remote shutdown in the model. These would include spurious operations that can damage equipment catastrophically before it can be recovered (e.g., diesel overload, pump running with suction closed, etc.).
6. For scenarios modeled with detailed fire modeling, account for detection and suppression to the extent that it is required to ensure realism in the dominant scenarios.

III.C Analysis of the Decision of Decision To Abandon

This section provides guidance for developing the definition and performing the qualitative assessment of the HFEs associated with the cognitive decision to abandon the MCR. When fire-induced conditions in the MCR lead to uninhabitable conditions, due to flames, smoke, or toxic gases, the MCR is abandoned due to Loss of Habitability (LOH). In other instances, plant monitoring and control may not be achievable due to fire-induced damage. These scenarios may occur from fires either in the MCR or in other key plant areas such as the cable spreading room. In this case, the MCR is abandoned due to Loss of Control (LOC).

III.C.1 Loss of Habitability

A loss of habitability in the MCR can result due to a fire in the MCR or due to a fire in a nearby compartment wherein heat and smoke may enter the MCR rendering it uninhabitable. The decision to abandon the MCR is assumed to be forced due to untenable environmental conditions within the MCR. Therefore, it is assumed that there is no contribution from the failure to diagnose and decide to abandon the control room in time to execute a successful shutdown (i.e., the decision to abandon is considered to always be successful). Thus, for LOH, only the failure to shut down after abandonment is modeled in the PRA. Fire modeling is used to determine when LOH conditions will occur. Since there is no “decision process” per se, there is no need to define an HFE for the decision, and no qualitative assessment is necessary.

III.C.2 Loss of Control

In addition to the LOH scenarios, there may be additional scenarios (possibly involving fires in the MCR and other locations within the plant), that contain a sufficient set of cables for redundant components to cause significant loss of function, rendering the MCR ineffective in reaching and maintaining the plant in a safe condition. Fires in these locations also can result in the need for ex-control room plant shutdown (i.e., reliance on alternative shutdown features). In most plants, such locations are known in advance based on the plant's post-fire safe shutdown analysis. Typical examples of such locations include the cable spreading room, auxiliary equipment room and cable tunnels. These locations should be determined on a plant-to-plant basis.

Unlike LOH, where environmental cues like smoke and fire within the MCR are obvious, the cues for LOC in the MCR may not be as clear. Furthermore, entry criteria and/or procedural guidance to abandon the control room given loss of control may be vague or may not exist in the current procedures.

Because of both plant-to-plant variations and the likely lack of explicit cues for the decision to abandon, HRA modeling of the decision to abandon for LOC is typically more challenging than other fire HRA tasks. Consequently, additional guidance is needed to address this context.

It is recommended that the cognitive decision to abandon the MCR on loss of control be developed as a separate HFE. However, modeling such an HFE must be based on a well-understood set of “cues” that the operators use to determine that a LOC condition has occurred. There are two cases for establishing this basis:

- The less common case is that the abandonment procedure contains explicit guidance on the "cues" for abandonment, as is typical in other EOPs. In this case, the cues can be assumed to be well-understood.
- The prevalent case is that such explicit guidance does not exist, and thus a substantial amount of judgment is required, as is typical in the Severe Accident Management Guidelines (SAMGs). In this case, the development of a set of well-understood cues is performed through interviews of operators and trainers, and requires that they provide a consistent message on "this is what we understand to be loss of control."

III.D Identification and Definition for MCRA Scenarios

This section provides guidance on how to identify and define the operator actions credited for MCRA scenarios. The identification and definition tasks work in conjunction with the fire PRA modeling and the MCRA timelines in order for the analyst to understand the expected progression to safe shutdown and to identify the representative set of actions needed in the fire PRA to evaluate the reliability of safe shutdown given an MCRA fire scenario. The following steps are involved:

1. Understand the expected plant response for MCRA scenarios. In order to build this understanding, the deterministic safe shutdown analysis for MCRA is reviewed in conjunction with the fire PRA’s plant response model and timelines, specifically considering the fire progression, accident progression and procedure progression (modeling

the operator actions)[1]. The deterministic safe shutdown analysis begins with the decision to abandon and does not include any actions taken inside the MCRA before the decision to abandon has been made. The fire PRA may consider both actions taken before MCRA occurs, in addition to the actions taken after the decision to abandon the MCR.

2. Review expected plant response with operations
3. Identify actions required for MCRA – There are three groups
    - Actions taken before the decision to abandon has been made
    - Actions taken inside the MCR after the decision to abandon has been made
    - Action taken outside the MCR after the decision to abandon has been made. This includes actions to reach safe and stable as well as action to maintain long term control of the plant parameters.
4. Define MCRA scenarios and MCRA HFEs – For a given fire PRA scenario, the success (and associated failure) criteria need to be defined for each human failure event. This includes the definition of critical tasks and the time window for operator response. Because each HFE is part of a collective set of actions for a given MCRA scenario, part of the definition should include a discussion on dependencies among actions. This includes defining when coordination among actions is required, identifying actions that are based on the same cues and indications, and identifying situations in which actions will be occurring simultaneously. For MCRA actions, the definition goes beyond that typically needed for non-MCRA HFEs, in that it should include a description of the following.
    - Communication strategies that would be employed once outside the MCR,
    - Command and control structure once outside the MCR.
    - For plants that share a MCR between units, the impact on the non-fire damaged unit should be defined.
    - For a shared control room, if both units leave the MCR due to habitability concerns, the impact on staffing, and command and control structure once outside the MCR should be defined.

III.E Feasibility Assessment for MCRA Scenarios

The basic purpose of a feasibility assessment per NUREG-1921 is unchanged for MCRA scenarios. Also, as discussed in NUREG-1921, MCRA feasibility assessment will be an iterative process throughout the MCRA HRA. Feasibility assessments are usually performed at two key points in the development of the PRA models. The feasibility of scenarios is assessed when first developing the accident sequence (event tree) models to determine if potential branches in the tree could occur or were infeasible (and therefore not modeled further). An operator action feasibility assessment is performed once the accident sequences have been developed in the PRA model to determine whether specific operator actions can be considered for detailed assessment using HRA methods or should be not represented since they are infeasible. There are some important differences that are unique to MCRA feasibility. Namely,

1. Because an <u>unfeasible</u> MCRA HFE or scenario may not be an acceptable final result for the HRA/PRA, the HRA analyst maybe involved in identifying and defining what improvements could be made that would change the assessment to "feasible." This role for MCRA HRA analysts is different than that for analysts performing HRA for other fire HRA scenarios and HFEs.
2. Feasibility assessments should be performed at the individual HFE <u>AND</u> at the scenario level for MCRA scenarios.
3. Criteria for MCRA feasibility assessment have been expanded to address two additional factors that are important to the MCRA context: a) the need for a communications plan, and b) the need for a command-and-control plan.
4. In addition, feasibility assessment criteria identified in NUREG-1921 are expanded to address the MCRA scenario context.

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[1] The deterministic safe shutdown analysis is an assessment of the ability of the plant to achieve a safe shutdown given a fire that affects the entirety of a designated fire area. In the United States, these are referred to as the “Appendix R fires,” some of which are fires that assume MCRA is required.

III.F Timing and Timelines for MCRA Scenarios

This section describes the timing considerations associated with MCRA HRA. The timing consideration are different from fire HRA or internal events HRA because there are many overlapping relationships, primarily because multiple operators are involved in a collective, but distributed, response. There are normal fire PRA considerations for fire growth and suppression, plant thermal-hydraulic progression after the initiating event, component failure times (such as time to fire damage or time to battery depletion), and the operator response.

Development of a MCRA timeline helps the HRA analyst understand the complex relationships between fire, plant response and the interactions among operators. By incorporating additional timing considerations into a single “picture”, the HRA analyst will develop a better understanding for the plant response, which will improve the qualitative analysis and provide input to a better operational narrative.

The MCRA timeline collects information from a variety of sources and provides a chronological description of the scenario progression. Each source must be considered with regard to its potential impact as part of the overall MCRA analysis. This timeline, in conjunction with the detailed scenario description, provides the required context for the qualitative analysis.

To understand the collective set of operator actions required for MCRA, the timeline can be conceptualized as consisting of the following three time phases.

- Phase I – Time period before the decision to abandon.
- Phase II – Time period for the decision to abandon
- Phase III – Time period after the decision to abandonment has been made.

Phase I is the time period before the operators recognize that abandonment may be required. This phase begins at the start of the fire and ends when operators recognize the severity of the fire damage. While in the MCR, command and control remains in the MCR and the operators inside the control room will be interacting with the fire brigade and performing any necessary control room actions, such as EOP and plant fire procedure actions.

Phase II is the time period associated with the decision to abandon. This phase starts when the operators receive the cue that indicates the severity of the fire and access the MCRA procedure to evaluate whether the criteria for abandonment have been met. Phase II ends when the decision to abandon has been made.

Phase III starts once the decision to abandon has been made. Most MCRA procedures contain specific actions that are required to be performed just before leaving the MCR. These actions could include reactor trip (if not automatic or already manually done), turbine trip, and isolation of critical MCR panels to allow control to be transferred to the RSDP. The time it takes to perform these actions should be incorporated into the overall operator response timeline and are considered to be in Phase III. When the operators leave the MCR, command and control is moved from the MCR to the RSDP and locally at equipment manipulation points.

III. G Performance Shaping Factors (PSFs) for MCRA Scenarios

Although the core list of PSFs relevant for MCRA is similar to that focused on in NUREG-1921, there are special considerations for each of these PSFs as well as overarching themes that must be considered. Guidance specific to the abandonment cases is identified for each PSFs. In some cases, NUREG-1921 included guidance for abandonment cases, and that is included below as a reminder, along with additional guidance where relevant.

In addition, command and control has been identified as potentially significant to human reliability unique to MCRA and is therefore not discussed in NUREG-1921. It describes the need for a central body of authority to make decisions but have them carried out by a distributed group such as plant operators physically away from the shift supervisor. How this issue will be represented and incorporated in MCRA HRA studies is under development and work continues. In general, assessment of the PSFs for MCRA needs to consider: (1) the decision to abandon the MCR, (2) actions at the RSDP, (3) local actions in the plant, and (4) command and control issues.

III. H Recovery, Dependency and Uncertainty

The HRA process steps for recovery, dependency and uncertainty are based on what is presented in NUREG-1921, but with MCRA-specific considerations. Recovery has two different meanings, both of which are noted in NUREG-1921: 1) the PRA-based version to restore or reconfigure a function, system, or component initially unavailable in the scenario and 2) the recovery *within* an action, such as the self-check by the operator him/herself performing the action or review by other operations crewmembers that catches an error. Recovery according to meaning 1) is not really applicable to MCRA because MCRA itself is fundamentally the recovery from a situation where the normal plant response procedures will not work. Opportunities for meaning 2) of recovery within an HFE do exist for MCRA scenarios, but may be less likely because operators are distributed among multiple locations (rather than all in the MCR).

Regarding dependency, one way in which dependency is qualitatively addressed for MCRA is through the development of the MCRA timeline, as discussed above, to ensure that the combined set of actions is feasible within the total timeframe available to bring the plant to a safe and stable condition. Another facet of dependency is the treatment of recovery within an action, discussed above as meaning 2). Self-checking and peer checking recovery actions are a form of dependence on the initial cognition or execution failure. Finally, another way dependency analysis is evaluated for MCRA is through the definition of HFEs, which reflects how the procedures are organized and implemented and the overall MCRA modeling strategy in the fire PRA.

Uncertainty in the input information to HRA is generally characterized in the qualitative analysis in the form of assumptions. For example, the conditions that lead to a LOC situation involve significant uncertainty, including fire damaged cables and equipment. As a result, the timing of those fire-induced effects “complicates” the plant and operator response and may require assumptions on the part of the HRA analyst. An example of such an assumption that is a significant source of uncertainty is the case where the fire scenario, although eventually requiring abandonment to reach safe shutdown, is mild enough that the overall time window for the decision to abandon and subsequently perform the post-abandonment actions is relatively long. The source of uncertainty in that case is the time window for the decision to abandon, which can be interpreted as a time margin to recover from an incorrect abandonment decision (meaning, the operator decides not to abandon). If the analyst selects a relatively long time (effectively giving the operators additional time for recovery from the decision not to abandon), this shortens the time available for the post-abandonment actions and their own recovery and therefore these actions have a higher probability of failure. Conversely, if the analyst selects a relatively short time window for the decision to abandon, there would be more time available to perform the post-abandonment actions, but the cognitive failure to abandon would have a higher probability.

The MCRA procedures themselves can be a source of uncertainty and assumptions, such as the lack of specific cues for MCRA related to the cognitive HFE for the decision to abandon. The HRA analyst must often take the lead in defining these cues, but the time required for the abandonment decision based upon these cues is still an assumption. Some plants choose to perform an initial MCRA analysis to gain information on the key actions and time constraints, then update their procedures later, stating as an assumption of the preliminary analysis that these procedure changes will have to be made at a later date.

VI. FUTURE WORK

The qualitative analysis guidance document for MCRA is expected to be published in 2017. In 2016, the draft document was reviewed by the NRC’s Advisory Committee on Reactor Safeguards (ACRS) PRA sub-committee and comments were received and addressed. Following the ACRS sub-committee review, document was reviewed and summer 2016 underwent peer review. Following the peer review the will be revised and finalized for publication in 2017as a joint EPRI/NRC-RES report. Following completion of the qualitative analysis document a quantification approach will be developed.

VII. REFERENCES

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