FIRE MAINTENANCE RULE (a)(4) IMPLEMENTATIONS IN US NUCLEAR PLANTS

Dr. Yan Gao (Westinghouse)
Ms. Victoria K Anderson (NEI)
Mr. Anil K. Julka (NextEra Energy)
20 International Drive, Windsor, CT 06095
1201 F Street NW, Washington, DC 20004
700 Universe Blvd, Juno Beach, FL 33408
gaoy@Westinghouse.com
vka@NEI.org
anil.k.Julka@NextEraEnergy.com

ABSTRACT

An overview and lessons learned of the latest 10 CFR50.65(a)(4) guidance update to include fire risk evaluations and its implementations in U.S. nuclear plants are presented. By December 1, 2013, all the US nuclear plants implemented this new NRC requirement for the Maintenance Rule (MR) (a)(4) program to include the fire risk evaluation and management actions as part of the existing at power MR (a)(4) program.

This paper will introduce the background, the need, the requirement, the process and some of the implementation details of incorporating fire risk assessment within the existing MR (a)(4) program. This paper will also discuss some of the applicable program interactions within a nuclear plant, such as the interactions among Fire Protection, Appendix R, PRA and Work Control programs and activities. All of these functions/programs are required to support a successful fire MR (a)(4) implementation.

Some of the technical and implementation issues, such as use of safe shutdown analysis, qualitative and quantitative risk analysis application, equipment scoping and risk management actions are also discussed in the paper.

Some of the lessons learned since the December 1, 2013 implementation of this new program are also presented.

Key Words: Maintenance Rule (a)(4), Fire Risk Assessment, Risk Management Action

1 INTRODUCTION

The objective of this paper is to give an overall introduction of the consideration of fire risk in Maintenance Rule (a)(4) programs implemented in the U.S. nuclear plants on December 1, 2013.

1.1 Background

In 1999, NRC promulgated 10 CFR 50.65(a)(4), which requires U.S. nuclear plant licensees to assess and manage risk due to maintenance activities.

In May 2000, via Regulatory Guide 1.182, NRC endorsed NEI document NUMARC 93-01 Revision 3 which provided guidance relative to paragraph MR (a)(4). Both qualitative and/or quantitative approaches were included in NUMARC 93-01.

The fire risk was not explicitly included in 1999 both in MR (a)(4) and in NUMARC 93-01 Revision 3, mainly due to the technology development was needed to support this, as well as the fact that many elements of fire risk were addressed through 10CFR Appendix R/50.48

In July 2006, optional guidance on qualitative assessment of fire risk and maintenance activities was issued by NEI. The key element of the guidance was that fire protection and maintenance rule personnel should communicate to maintain an integrated perspective and consider fire risk when removing from service the equipment known to have a not-insignificant impact on mitigation of core damage due to fire initiators. In addition, equipment within MR (a)(4) scope that are found to be significant to core damage mitigation for fire initiators was recommended to be identified and if one train of safe shutdown equipment is protected by fire barriers, consider greater risk significance of protected train.

In February 2010, at an NRC public meeting discussing the scope of initiators that should be considered in MR (a)(4) assessments, the NRC staff indicated that lack of consideration of fire events at power as part of MR (a)(4) process was a major gap. Subsequent to the public meeting, industry began efforts to support the approach of revising NUMARC 93-01 to formally include fire risk considerations. This effort resulted in NUMARC 93-01, Revision 4A to include the assessment of fire risk within at power MR (a)(4) process, and qualitative, quantitative, and blended approaches were supported.

NUMARC 93-01 Revision 4A incorporated the additional items applicable to fire risk assessment, such as identification of important equipment for mitigation (scoping), identification and implementation of risk management actions, as appropriate and communication processes and plans.

In March 2012, via Regulatory Guide 1.160 Revision 3, NRC endorsed NUMARC 93-01 Revision 4A (with one exception). RG 1.160 Revision 3 also superseded RG 1.182 Revision 0. For implementation schedule, NRC required that December 1, 2013 as the date by which all licensees shall have fully implemented the changes necessary to effectively consider the risk from internal fires in the conduct of maintenance rule (a)(4) activities.

1.2 Overall Requirement

There are three basic attributes in NUMARC 93-01, Revision 4A, equipment selection (scop ing), risk management actions (RMAs) and implementation, and communication.

Equipment scoping is limited to removal of core damage mitigation equipment from service, and does not involve fire protection equipment in (a)(4) scope, though fire protection program features such as fire watches can be credited as part of the risk management actions as appropriate.

The sources of information for identifying equipment to scope into the process, as listed in NUMARC 93-01, Revision 4A, are Appendix R / Safe Shutdown Analysis and FIVE Screening Analysis / Fire PRA.

For implementation of risk management actions related to fire risk impacts of identified equipment, there were three options identified in the guidance document:

- Option 1: Establish an adjustment factor to the internal events ICDP or raise the risk management action threshold by one level

- Option 2: Use outage time limits to determine the need for risk management actions specific to fire risk when fire risk mitigation equipment is taken out of service

- Option 3: Quantifying the fire risk and internal events risk for the purpose of calculating the ICDP

For communication, it is intended that plant personnel responsible for activities relative to fire protection and MR (a)(4) should communicate and maintain awareness of their respective risk management actions such that an integrated perspective of these activities is maintained.

The key regarding communication is to coordinate activities within the plant that could involve increased fire risk with those maintenance activities involving removal from service of mitigation equipment important to fire risk. This involves coordination of fire protection personnel with the maintenance rule (a)(4) personnel.

1.3 Equipment Selection

Most plants performed equipment scoping by establishing a list of fire-significant equipment based on guidance established in NUMARC 93-01 Revsion 4A, which included equipment that when out-of-service has core damage scenarios with no alternate success paths available. Once the equipment scope is developed, applicable risk management actions can be determined for each equipment-scenario combination as needed.

For equipment selection, one of the approaches many plants have adopted is SSEL based approach, which is to use safe shutdown equipment list (SSEL), as well as to use insights from IPEEE and to use station technical panel to augment and address limitations of IPEEE. For example, one plant reviewed vital equipment from the SSEL and compared to the current scope of (a)(4) to identify overlap and develop the scope of SSCs in the program.

Another approach is using the fire PRA to either identify components important to fire risk using risk importance measures resulted from fire risk relevant cutsets or based on fire PRA based cutset analysis that to identify cutsets which would result in a CCDP of 1. In particular, several plants evaluated the risk achievement worth (RAW) of equipment in the fire PRA and scoped in the highest value equipment for mitigation of fire risk.

While applicable, certain plants used an aggregate quantitative fire and internal events PRA model approach to implement the fire MR (a)(4) requirement. However, this calls for a fire PRA and internal events PRA with comparable level of detail and realism.

1.4 Risk Management Actions (RMAs)

The focus and goal of RMAs is to minimize the likelihood and consequence of a fire in important fire areas based on fire important equipment selected (scoping phase) being unavailable and RMAs can be developed for the fire initiating event whether a deterministic or probabilistic process is used.

RMAs need to provide information on fire risk important systems, structures and components (SSCs) and important areas and to provide emphasis on the spatial aspects of fire events. To account for types of potential fire, RMAs can be developed to consider features applicable to each type of fire scenarios, such as transient combustible fires, bounding Fires, component related fires and electrical panel and arcing fault type fires.

RMAs developed by licensees included a range of actions, ranging to protection of equipment with increased importance given unavailability of a scoped component, to verification of availability of fire suppression and detection in an area affected by unavailability of a scoped component.

Section 11.3.7.3 of NUMARC 93-01 Revision 4A provides a table that gives guidance on when RMAs may be required.

For a configuration where there are no core damage avoidance success paths available:

- For unavailability of less than 3 days, normal work management controls are acceptable
- For a duration of between 3 and 30 days, RMAs are required
- Durations of greater than 30 days should be avoided

1.5 Implementation Example

The fire MR (a)(4) implementation at the NextEra Energy nuclear plants is discussed below as an example.

- Fleet implementation

NextEra Energy fleet contains 5 nuclear sites and multi units at most of these sites. To achieve the goal of successful implementation, fleet approach was utilized to establish a tiered program/project implementation structure and process. The structure was sponsored by fleet senior management and led by fleet risk project management staff. Due to the plant differences among all these sites, the fleet implementation team consisted of staff from PRA, Work Management, Fire Protection Program, Operations and Training from each site.

- Plant specific

The implementation team first identified the appropriate equipment scoping approach suitable for each unit at each site, considering the unit specific conditions, such as reactor type, existing on-line risk management process and program, fire protection and fire protection program differences, PRA model differences and plant design differences. For instance, one of the sites adopted a more quantitative approach and some other sites adopted more qualitative or more blended approaches. The objective is to allow each unit to identify the most effective and efficient approach to meet the requirement and to manage the fire risk.

- Equipment screening

To focus on the right equipment and not to dilute station resources, certain types of conditions were established to screen out that equipment which would meet these conditions. For instance, an equipment would be screened out if the equipment was taken out-of-service, a plant trip would occur; or if an equipment is subject to a less than 72 hour LCO; or if an equipment will only be subjective to maintenance during a plant shutdown.

- Equipment scoping

To ensure broader consideration of fire risk impact, and to consider uncertainties of any given program, process and risk models, a variety of equipment scoping inputs were considered. For instance, system, structure and components incorporated into each of the Appendix R safe shutdown analyses were considered as the initial scope, so are the IPEEE fire PRA analysis and NFPA 805 fire PRA if applicable and station technical panel which represented different functions of fire risk assessment team of a plant, such as Fire Protection, Fire Protection program, PRA, Work Control and Operations.

- Risk management action

Once appropriate equipment scoping approach is identified for each unit, the team for each unit then identified applicable plant procedures to incorporate necessary risk management actions. The risk management actions (RMAs) consisted of both generic and equipment specific features where generic RMAs are for those actions that are applicable cross the board and having common implications and the equipment specific RMAs are for those actions that may only apply to certain types of equipment and/or during certain specific configurations.

In addition, two types of RMAs were considered where applicable, one is protective in nature and one is prevent in nature.

For the protective type of RMAs, the risk management action is designed specifically to protect the certain equipment or trains (such as an opposite train) given a fire risk noteworthy equipment is taken out of service from one train. Such protective actions apply to typical Operations protective process and approaches.

For the preventive type of RMAs, the risk management action is specifically targeted to manage the fire initiating event contributions and impacts given an equipment out of service

and/or maintenance activity is planned and/or emergent issue arises at a given time duration and at a given plant configuration.

- Dry-run

After the applicable procedures were incorporated with fire MR (a)(4) attributes, the implementation team for each unit performed look-back exercises to review past scheduled work week schedules to mock-up review of the proposed procedure changes.

Further, the implementation team performed look-back of past non-scheduled activities and emergent issues to exercise the proposed fire MR (a)(4) procedure changes.

In addition, the implementation team conducted internal and outside independent reviews of the proposed implementation activities and procedure changes.

- Training

As part of the implementation, training was conducted to the impacted station personnel.

1.6 Implementation tools example

Some of the implementation tools are discussed below.

- Qualitative

For the qualitative approach, one of the choices could be to develop deterministic fault tree to mimic applicable portions of a given shutdown logic from a plant fire hazard analysis. Such features could then be linked with on-line risk monitoring and work activity scheduling tool.

- Quantitative

For a quantitative approach, one of the approaches could be to solve fire CDF and combine it with internal event CDF and identify duration where in-scope equipment would be unavailable during planning, scheduling and actual work week windows and apply necessary RMAs where are needed.

2 LESSONS LEARNED

Some of the lessons learned from the fire MR (a)(4) implementations are listed below:

- The equipment selection process can be quantitative, qualitative, or semi-quantitative/blended, such as using fire PRA, IPEEE, SSEL and/or the combinations
- The scope for fire risk monitoring can be limited to an existing (a)(4) scope, and it is therefore not necessary to conduct an exhaustive evaluation of all plant equipment.
- Should focus on core damage mitigation
- RMA starting point, most plants considered RMA less than the guideline stated 72 hours to account for uncertainty and to add administrative margin. Risk management actions should be put in place from the time that it was recognized the SSC OOS duration may exceed the allowable time limit.
- The implementation needs to be site and plant specific
- It may be difficult to differentiate between safe shutdown actions and fire configuration risk management actions and it needs to coordinate fire protection surveillances in zones/areas which overlap fire risk-significant zones in accordance with maintenance activities
- Interfaces and communications among station applicable organizations is the key for continued fire risk management success. Communications among Fire Protection, Operations and Work Control are crucial for complying with 10CFR50.65(a)(4) and RMAs should be tied-in communications aspect. For instance, when and how to know fire risk significant SSC is OOS and RMA is required.
- Implementation asymmetries may exist between units for multi-unit site
- Procedure needs to be streamlined and easy to navigate to mitigate human error and minimize workload