SIGNIFICANCE DETERMINATION PROCESS (SDP) METHODOLOGY FOR SCREENING FIRE PROTECTION INSPECTION FINDINGS

See-Meng Wong, J.S. Hyslop[1]
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
(301) 415-1125

Abstract - *The purpose of this paper is to present a Significance Determination Process (SDP) methodology being used by the U.S. Nuclear Regulatory Commission (USNRC) staff to evaluate the potential risk significance of fire protection inspection findings. Lessons learned from the application of this SDP methodology are used to enhance its current version so that the risk significance of fire protection findings can be efficiently assessed in a timely manner for regulatory decision-making purposes.*

1. INTRODUCTION

Since early 1999, the U.S. Nuclear Regulatory Commission (USNRC) staff has embarked upon a risk-informed approach to assessing the performance of nuclear power plant licensees under the New Reactor Oversight Program [1]. Within the framework of seven cornerstones of safety established under the new reactor oversight process, this risk-informed approach includes NRC review of licensee-supplied information on performance indicators (PI), and NRC evaluation of the risk significance of inspection findings. The Significance Determination Process (SDP) methodology was developed to aid NRC inspectors and staff in assessing the risk significance of inspection findings using risk insights where appropriate [2]. The SDP determinations and PI information are combined for use in evaluating the performance of licensees in day-to-day operation of U.S. nuclear power plants.

Due to the risk significance of fire in general, and the significance of fire protection findings that resulted from earlier NRC Fire Protection Functional Inspections (FPFIs), NRC staff had initiated a fire protection inspection program to be conducted triennially at all nuclear power plants. The SDP methodology presented in this paper, also called as the Fire Protection Risk Significance Screening Methodology (FPRSSM) [3], supports the risk-informed inspection focus of that program. Additionally, this methodology provides a tool to aid NRC resident inspectors to evaluate the potential risk significance of fire protection inspection findings that are identified during routine inspections. Due to conservatism in its design, the Fire Protection SDP methodology screens out fire protection findings with minimal risk significance. It is also useful in focusing NRC resources on monitoring performance and maintaining effectiveness of fire protection mitigation features important to risk. This methodology was developed for use by non-fire PRA analysts in mind; and therefore, avoids much of the complexity associated with full scope fire Probabilistic Risk Assessments

[1] Currently in the Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission

(PRAs).

2. FIRE PROTECTION SDP METHODOLOGY

The Fire Protection SDP methodology utilizes classical fire PRA methods to address degradations in fire protection defense-in-depth (DID) elements. The principal elements are: (1) fire prevention, (2) fire detection and suppression, and (3) protection of structures, systems, and components (SSCs) important to safety against fire damage to accomplish safe shutdown of the plant in the event of fire. In the described methodology, degradations of the DID elements beyond the standard success definitions for fire protection systems and structures meeting code requirements are characterized (e.g., high or medium degradation, or normal operating state). The degradation ratings of the DID elements are then utilized in an integrated assessment of the risk significance of any fire protection DID weaknesses. If there is no degradation in a DID element, then the fire protection feature and system is considered to be capable of performing its intended function and in its normal (or standby) operating state.

Currently, the fire protection SDP methodology is used only when a finding of non-compliance with the fire protection regulations is identified. This SDP methodology consists of two phases of analysis. In Phase 1 analysis, a finding is screened out when the functional capability of the fire protection DID feature is not impacted, or when the fire protection DID features are adequate (based on simplified, conservative Phase 2 analysis assumptions) for the fire area. The Phase 1 analysis requires no calculation of the change in core damage frequency (CDF) by the analyst, and requires no familiarity with the Phase 2 methodology. Therefore, Phase 1 analysis is primarily intended for use by NRC resident inspectors.

Phase 2 of the SDP methodology is entered when the finding does not meet the screening criteria in Phase 1. The current version of the Phase 2 SDP methodology was designed to evaluate the change in risk of a fire area due to fire protection DID weaknesses. In using the Phase 2 fire protection SDP methodology, inspection findings are viewed collectively[2] for a fire area since several findings of fire protection DID weaknesses for a fire area would have an integrated impact on the fire risk. The findings are screened out if the potential for a realistic, challenging[3] fire does not exist since there would be no significant fire damage.

Within the construct of this Phase 2 SDP methodology, expert judgment is used to qualitatively categorize the findings of DID degradations as high, moderate, or normally operating state. In general, the extent of an inspection finding against fire protection DID systems and features is based on the critical performance criteria for the design established by industry fire codes and standards, and the effectiveness of these systems and features in performing their intended functions. A high degradation finding indicates that the DID element is totally ineffective, and a normal operating state finding indicates that the design or performance of the DID element meets the applicable codes and standards. In its current version, an important aspect of the fire protection SDP methodology is that each qualitative degradation rating for a DID element is represented by an assumed failure probability value. The failure probability values for each degradation rating are based on information from USNRC fire risk analyses [4], the IPEEE studies, industry guidelines such as

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[2] Since the figure of merit for the SDP analysis is an increase in the average annual CDF, inspection findings are considered simultaneously in an analysis only when the findings are due to a common cause. Otherwise, the coincidence of the findings would be considered as a random occurrence, and each finding is separately analyzed.

[3] A challenging fire is one that is capable of developing a plume, or initiating an accumulation of hot gases at the ceiling.

the EPRI Fire PRA Implementation Guide [5], and general fire protection experience.

In the current version of the fire protection SDP methodology, realistic fire damage is evaluated in the development of realistic fire scenarios. The ignition frequencies of fire sources in a fire area may be taken from the plant-specific fire IPEEE study, or from generic industry data. However, it is desirable that plant-specific ignition frequency data should be used in the fire protection Phase 2 SDP analysis whenever possible. Finally, credit for safe shutdown capability is determined by utilizing the appropriate plant-specific Phase 2 SDP notebook worksheets and event trees that were developed for the reactor safety SDP analysis.

3. APPLICATION OF METHODOLOGY

In order to calculate the increase in CDF due to fire protection DID inspection findings, the current fire protection SDP methodology requires that the fire mitigation frequency (FMF) to be calculated initially. The FMF is determined by summing the logarithmic value of the fire ignition frequency and the degradation ratings for each of the fire protection DID elements. The equation for determining the FMF was formulated as follows [3]:

$$FMF = \log_{10} (IF) + AS + MS + FB + CC$$

Where IF = fire ignition frequency

AS = automatic suppression/detection

MS = manual suppression/detection

FB = fire barrier

CC= dependencies/common cause contribution (when appropriate)

The concept of the FMF equation was to provide a means to determine an increase in CDF due to the risk impact of fire protection DID elements for a given fire ignition frequency. The calculated increase in CDF allows the inspection finding to be characterized as Green, White, Yellow, or Red significance in the safety significance color scheme used for determining significance of inspection findings.

4. LESSONS LEARNED

Since implementation in April 2000, the current fire protection SDP methodology has been applied successfully to evaluate the significance of numerous fire protection inspection findings at various U.S. nuclear power plants. To date, the described SDP methodology has processed most of the fire protection findings as Green findings (i.e., very low safety significance) with the exception of five cases. However, feedback from NRC staff users (e.g., NRC Regional fire protection engineers and senior reactor analysts) has raised several concerns regarding application of this SDP methodology. The issues are timeliness, complexity, subjectivity, technical defensibility, and resource burdens associated with the use of this methodology in the new NRC reactor oversight process. As a result, there are plans under way to improve the current version of this fire protection SDP methodology based on recommendations from NRC and industry stakeholders. These plans include a coordinated effort to revise the SDP methodology, and clarify the guidance for its use. A task force of experts in fire protection and probabilistic risk analysis has been assembled to carry out this task.

Preliminary results of the improvement initiative indicate several areas for enhancement that require interim and long-term fixes to improve the transparency of the current fire protection SDP methodology. The major areas identified for enhancement of its guidance include: (a) selection of fire ignition frequencies, (b) bases for degradation ratings for DID elements, (c) use of fire severity factors, (d) development of "credible" fire scenarios, and (e) definition of SDP entry conditions in the Phase 1 screening process. Other areas requiring improvement include clearer guidance for credit of:

(a) manual actions for safe shutdown, (b) fire brigade response evaluations, and (c) alternate shutdown capability. Proposed interim and long-term fixes for all of the identified areas needing improvement are being prioritized to produce a fire protection SDP methodology that can be used efficiently to assess the risk significance of fire protection findings in a timely manner.

5. CONCLUSIONS

The current fire protection SDP methodology has been used successfully to evaluate the significance of numerous fire protection inspection findings at various U.S. nuclear power plants. Most of the fire protection findings have been processed as Green findings (i.e., very low safety significance) with the exception of five cases. However, feedback from NRC staff users has raised several concerns regarding application of the current version of this SDP methodology. The main issues are timeliness, complexity, subjectivity, technical defensibility, and resource burdens associated with the use of this methodology. Plans are under way to improve the transparency of the current guidance for using this fire protection SDP methodology. Preliminary results of an improvement initiative have identified several areas that are being prioritized for interim and long-term fixes to revise the SDP methodology.

References:

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