Shutdown Risk Initiative

Background on Shutdown Risk

Power reactor operation at low power and in shutdown conditions is long recognized as posing a risk because of the equipment configurations necessary for the performance of some maintenance actions. Operating experience in the 1980s involving the loss of decay heat removal capabilities resulted in the U.S. Nuclear Regulatory Commission (NRC) issuing several generic communications, culminating in the issuance of Generic Letter (GL) 88-17, "Loss of Decay Heat Removal," dated October 17, 1988 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML031200496). In response to GL 88-17, individual licensees committed to taking certain actions to manage the risk.

In addition to the response by individual licensees to these issues, the Nuclear Management and Resource Council (NUMARC), an organization that represented the nuclear power industry, established a Shutdown Plant Issues Working Group and developed and issued the document, NUMARC 91-06, "Guidelines for Industry Actions to Assess Shutdown Management" (ADAMS Accession No. ML14365A203). On November 20, 1991, the NUMARC Board of Directors adopted this guideline for planning and conducting outages starting after December 31, 1992. Similar to industry practices under the current Nuclear Energy Institute's (NEI's) Nuclear Strategic Issues Advisory Committee (NSIAC), the follow on organizations to NUMARC and its Board of Directors, the adoption of this formal industry position by a specified percentage of the utility members represented on the Board of Directors resulted in the position becoming a utility obligation. The voluntary industry initiative under NUMARC 91-06 is one of the initiatives being considered under Improvement Activity 3 of SECY-13-0132, "U.S. Nuclear Regulatory Commission Staff Recommendation for the Disposition of Recommendation 1 of the Near-Term Task Force Report," dated December 6, 2013 (ADAMS Accession No. ML13277A413), as approved by the Commission in its staff requirements memorandum (SRM) on SECY-13-0132, dated May 19, 2014 (ADAMS Accession No. ML14139A104).

In 1994, the NRC published the proposed rule, "Shutdown and Low-Power Operations for Nuclear Power Reactors," in Volume 59 of the *Federal Register*, page 52707 (59 FR 52707; October 19, 1994). After receiving significant comments on the rulemaking, and in response to Commission guidance on using a risk-informed, performance-based approach for new regulations, the NRC staff in SECY-97-168, "Issuance for Public Comment of Proposed Rulemaking for Shutdown and Fuel Storage Pool Operation," dated July 30, 1997, sought to publish a revised proposed rule on the subject. The SECY-97-168 proposed rulemaking package was intended to support the imposition of a set of requirements justified as a substantial increase in the overall protection of the public health and safety under Title 10 of the *Code of Federal Regulations* (10 CFR) 50.109(a)(3). The package included a regulatory analysis performed using NUREG/BR-0058, Revision 2, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," issued November 1995, which contains the following direction on the treatment of voluntary industry initiatives:

> The NRC encourages voluntary actions that enhance safety.... For purposes of the regulatory analysis however, no credit should be given for the voluntary actions taken by licensees. This means that when calculating the values and impacts of a proposed regulatory requirement and its alternatives, the costs and benefits should not be reduced by the extent to which they may already be lessened by voluntary activities. Since the base case regulatory analysis takes

no credit for voluntary actions, a sensitivity analysis should be performed and the regulatory analysis results displayed reflecting due consideration of voluntary actions.

Table below, an excerpt from the regulatory analysis, was provided to the Commission in SECY-97-168:

Case	Description	Core Damage Frequency per Reactor Year		Unmitigated Release Frequency per Reactor Year	
		PWR	BWR	PWR	BWR
Base	Protection provided by legally enforceable requirements, i.e., current regulations, technical specifications, licensee conditions and orders. No credit for any measure that was voluntary or that could be unilaterally changed by the licensee, such as commitments in response to generic letters and bulletins.[1]	2E-2	1E-3	2E-2	1E-3
Voluntary	Implementation of guidance from NUMARC 91-06 and GL 88-17.[2]	8E-5 to 2E-6	1E-5 to 6E-7	2E-5 to 2E-7	8E-6 to 6E-7
Rule	Protection provided by all plants complying with the requirements of the proposed rule.	1E-5	4E-6	1E-6	4E-6

[1]Required for regulatory analysis. In all cases, action based upon operator judgement and experience provided additional protection that was excluded from the analysis.
[2]The range represents minimal to in-depth implementation. The PRA analysts intended the first value to be representative of many plants during the early 1990s and the second value to be representative of a few plants with outstanding implementation of existing guidance and knowledge.

Based on this analysis, the NRC staff concluded the following in SECY-97-168:

> Current controls have evolved through a series of NRC and industry actions initiated for the most part through NRC generic communications. Although these initiatives have been successful in achieving the acceptable level of risk that now exists at U.S. nuclear power plants, the analysis showed that a significant level of safety is dependent upon measures that are not traceable to specific underlying regulations, and that could, therefore, be withdrawn by licensees without prior staff approval. The practical effect of rule implementation [would be], therefore, not to raise the current level of safety, but rather to ensure that at least the current level of safety will be maintained. This action is considered necessary to

> preclude a withdrawal from current practice in light of continuing economic pressure to increase plant availability through shortened outages.

In the SRM on SECY-97-168, dated December 11, 1997, the Commission withheld authorization to issue the proposed rule.

On February 4, 1999, the NRC published a notice in the *Federal Register* withdrawing the proposed rule "Shutdown and Low-Power Operations for Nuclear Power Reactors" (64 FR 5623).

The NRC staff meets the expectation of the Commission expressed in the SRM on SECY-97-168 that the staff continue to monitor licensee performance, through inspections and other means, in the area of shutdown operations to ensure that the current level of safety is maintained under the Reactor Oversight Process (ROP), through the use of Inspection Procedure (IP) 71111.13, "Maintenance Risk Assessments and Emergent Work Control," dated December 20, 2017 (ADAMS Accession No. ML17194A934), and IP 71111.20, "Refueling and Other Outage Activities," dated November 28, 2017 (ADAMS Accession No. ML17179A651).[1] In addition, the NRC staff monitors licensees' performance by means of operating experience gathered by the Institute of Nuclear Power Operations (INPO) under its programs using INPO 06-008, Revision 1, "Guidelines for the Conduct of Outages at Nuclear Power Plants," issued February 2011 (ADAMS Accession No. ML14297A571) (withheld from public disclosure as proprietary information under 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding").

Evolution of Treatment of Voluntary Initiatives in Regulatory Analysis

SRM-SECY-97-168 further directed the staff to review the current regulatory analysis methodology and submit, for Commission review, options for addressing possible revisions to the methodology, particularly with regard to recognition of existing initiatives and voluntary actions in the cost-benefit analyses. In its current form, NUREG/BR-0058, Revision 4, issued September 2004 (ADAMS Accession No. ML042820192),[2] provides the following guidance on the treatment of industry initiatives:

> 4.3.1 Treatment of Industry Initiatives in Estimation of Values and Impacts
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> Industry initiatives are typically actions performed by licensees that form the bases for either continued compliance with the regulations or obviate the need for new regulations. It must be clear to the public that substituting industry initiatives for NRC regulatory action can provide effective and efficient resolution of issues, will in no way compromise plant safety, and does not represent a reduction in the NRC's commitment to safety and sound regulation. The NRC and the industry are jointly responsible for the long-term success of using industry initiatives as substitutes for NRC regulatory action. Licensees must effectively manage and implement their commitments associated with these

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1 IPs 71111.13 and 71111.20 have included coverage of the shutdown risk initiative since their initial promulgation with the implementation of the ROP. The current revisions of these procedures are cited here for simplicity.

2 In April 2017, the NRC issued NUREG/BR-0058, Draft Revision 5 (ADAMS Accession No. ML17100A480), for public comment, but the revision proposes no changes to the guidance on treatment of industry initiatives.

industry initiatives and the NRC must provide a credible and predictable regulatory response if licensees fail to satisfy these commitments.

Industry initiatives can generally be put into one of the following categories—(1) those put in place in lieu of, or to complement, a regulatory action to ensure that existing requirements are met, (2) those used in lieu of, or to complement, a regulatory action in which a substantial increase in overall protection could be achieved with costs of implementation justifying the increased protection, and (3) those that were initiated to address an issue of concern to the industry but that may or may not be of regulatory concern. Issues related to adequate protection of public health and safety are deemed the responsibility of the NRC and should not be addressed through industry initiatives.

The presence of industry initiatives is potentially very important in the estimation of values and impacts and, as such, its treatment in the regulatory analysis must be explicitly considered. All consequences of a proposed regulatory change are measured relative to the baseline, which is how things would be if the proposed regulation were not imposed. If industry initiatives which complement or substitute for a proposed regulatory action exist, the future role of these industry initiatives must be determined. This determination would affect the baseline, which in turn would affect the calculation of incremental values and impacts. For example, if "full credit" is given to industry initiatives (i.e., it is assumed that complementary industry initiatives will continue in the future), the incremental values attributable to the proposed regulation are diminished. Alternatively, if "no credit" is given, the incremental values assigned to the proposed rule are increased.

For the purposes of the regulatory analysis, value-impact results are to be calculated based, to the extent practical, on varied assumptions concerning the future role of industry initiatives. Initially, two sets of value-impact estimates are to be derived: one based on no credit and the other based on full credit for industry initiatives. These results will have equal weight and will be presented for sensitivity analysis purposes. If the overall value-impact result does not tilt from an overall net cost to an overall net benefit (or vice versa), there is no need to proceed further and the final results would be reported as a range of values that reflect the sensitivity of these results to this assumption. However, if the results are highly sensitive to that level of variation, such that the overall value-impact conclusion shifts or the final recommendation changes, the analyst would proceed to develop a "best-estimate" base case.

Under this best-estimate base case, the staff will evaluate the specific industry initiatives in question to determine how much credit to give to the industry initiatives. The NRC is currently developing guidelines designed to increase the NRC's assurance that industry initiatives will be effective long-term alternatives to regulatory actions. Clearly, the more an industry initiative satisfies these guidelines, the more credit one should give to the industry initiative. Before these guidelines are formally approved, the staff should rely on relevant features and characteristics of the industry initiatives to assess the weight or amount of credit to attach to any given industry initiative. Relevant characteristics would include the following:

- costs associated with the industry initiative (if the dominant costs are fixed costs that have already been expended or the future recurring costs to maintain the industry initiative are minimal it is more likely the industry initiative will continue in the future)
- the extent to which written commitments exist (if written commitments exist it is more likely a licensee will continue that commitment in the future, and the NRC could, if necessary, respond to licensees not adhering to the industry initiative)
- the degree to which the industry initiative is noncontroversial and standard industry practice (if the industry initiative is noncontroversial and standard industry practice, as a function of consistency with provisions of industry codes and standards, the participation rate among relevant licensees, how long the program has been operating, or its effectiveness, the more likely it will continue without the rule change)
- the scope and schedule for industry initiatives that are still pending (for industry initiatives that are still works in progress, the more well defined the scope and the sooner the initiative is expected to be in place, the more likely it will be available in the future)

Based on such an assessment, the regulatory analysis would contain, to the extent practical, a best estimate of the values and impacts of the regulation under consideration. These results would serve as the basis for the staff's recommendations to the Commission. Careful attention is needed when PRA [probabilistic risk assessment] techniques are used to give partial or no credit to industry initiatives, because risk estimates from PRAs are based on existing conditions which typically include credit for any industry initiative that may be in place. When the PRA is modified to eliminate or reduce credit for industry initiatives, the reviewer needs to assure that these changes are properly reflected in the details of the PRA model.

Further Regulatory Actions Affecting Shutdown Risk

On July 19, 1999, the NRC issued a final rulemaking, modifying the Maintenance Rule (64 FR 38557). This rulemaking established requirements under 10 CFR 50.65(a)(4) for the assessment and management of risk associated with maintenance activities and clarified the applicability of the Maintenance Rule to all modes of plant operation. As a result of this rulemaking, industry revised NUMARC 93-01 as follows:

- NUMARC 93-01, Revision 3, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," issued July 2000 (ADAMS Accession No. ML 031500684) was substantially modified to clarify the applicability of the Maintenance Rule to all modes of plant operation.

- NUMARC 93-01, Revision 3, incorporated substantive sections of NUMARC 91-06.

- Section 11.3.6, "Assessment Methods for Shutdown Conditions," of NUMARC 93-01, states the following:

> NUMARC 91-06, Guidelines for Industry Actions to Assess Shutdown Management, Section 4.0, provides a complete discussion of shutdown safety considerations with respect to maintaining key shutdown safety functions, and should be considered in redeveloping an assessment process that meets the requirements of 10 CFR 50.65(a)(4).

These modifications of Revision 3 of NUMARC 93-01 have been carried forward to Revision 4 of NUMARC 93-01(ADAMS Accession No. ML11116A196) and endorsed by Revision 3 to Regulatory Guide 1.160 (ADAMS Accession No. ML113610098).

Following the March 11, 2011, accident at Fukushima Dai-ichi, the NRC issued Order EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012 (ADAMS Accession No. ML12054A735). Known as the Mitigation Strategies Order, it includes requirements for licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool capabilities following a beyond-design-basis external event. The Mitigation Strategies Order requires that licensees be capable of implementing the strategies in all modes. Regulatory guidance on this requirement contained in NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," issued December 2015 (ADAMS Accession No. ML16005A625), Section 3.2.3, as endorsed by Japan Lessons-Learned Division Interim Staff Guidance (JLD-ISG)-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated January 22, 2016 (ADAMS Accession No. ML15357A163), specifies that licensees would enhance existing shutdown risk processes and procedures through incorporation of FLEX equipment acquired to meet the Mitigation Strategies Order. This includes maintaining the equipment necessary to support shutdown risk processes and procedures readily available and determining how it can be deployed or pre-deployed (pre-staged) to support maintaining or restoring the key safety functions during a loss of shutdown cooling.

The NRC required licensees to comply with the Mitigation Strategies Order by December 31, 2016. All operating power reactor licensees have complied with the portions of the Mitigation Strategies Order that affect the shutdown risk processes.[3] The NRC staff has been verifying compliance through inspection of these licensees in the ROP under Temporary Instruction 2515/191, Revision 1, "Inspection of the Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communication/ Staffing/Multi-Unit Dose Assessment Plans," dated December 23, 2015 (ADAMS Accession No. ML15257A188).

Current Status of Shutdown Risk Oversight

The NRC staff has reviewed the last 5 years of inspection results under IP 71111.13 and IP 71111.20 and concluded that those IPs, Regulatory Guide 1.160, and Inspection Manual

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[3] Boiling-water reactor licensees with Mark I and II containments were also subject to Order EA-13-109, "Issuance of Order To Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions," dated June 6, 2013 (ADAMS Accession No. ML13143A321), which has a later compliance date. Because their mitigation strategies during power operation depend on the reliable hardened containment vents being installed or modified under this order, those aspects of the Mitigation Strategies Order were relaxed to match the compliance dates for this order. This does not affect mitigation strategies for shutdown and refueling modes of operation.

Chapter 0609, “Significance Determination Process,” Appendix G, “Shutdown Operations Significance Determination Process,” Phase 1, dated May 9, 2014, need to be augmented with specific guidance for certain voluntary initiatives found in GL 88-17 and NUMARC 91-06. The staff plans to follow up on these activities using currently budgeted resources. Since November 20, 1991, when the NUMARC Board of Directors adopted NUMARC 91-06 for planning and conducting outages starting after December 31, 1992, the NRC staff has the ability to engage licensees that do not follow the guidance in NUMARC 91-06. The obligation of licensees to comply with 10 CFR 50.65(a)(4) (the Maintenance Rule) and the associated NUMARC 93-01 guidance, which incorporates substantive sections of NUMARC 91-06, further enhances oversight of shutdown risk.

Conclusion

The NRC staff has evaluated the industry initiative for shutdown risk under the current regulatory analysis guidance in NUREG/BR-0058, Revision 4, and concluded that a best-estimate base case analysis of this initiative, accomplished using current guidelines, would give significant weight or credit to the shutdown risk initiative under NUMARC 91-06 and GL 88-17. This is because the fixed costs associated with the initiative have already been expended, licensees are obligated to maintain their shutdown risk programs under the NUMARC Board of Directors decision, and the initiative is noncontroversial and has been adopted as a standard industry practice by INPO, as well as by the industry itself. Promulgation of 10 CFR 50.65(a)(4), to require licensees to assess and manage the increase in risk that may result from the proposed maintenance activities and industry’s incorporation of various sections of NUMARC 91-06 in the implementing guidance of 10 CFR 50.65, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants” (NUMARC 93-01), have further enhanced the NRC staff’s ability to oversee licensee activities related to shutdown risk. Therefore, the NRC staff concludes that no changes to the regulatory posture of the initiative are warranted.