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Safety and Operational Benefits of Risk-Informed Initiatives

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Introduction

Risk-informed activities have become ingrained in U.S. nuclear power plant operation over the past 15 years, providing both safety and operational benefits.

- Safety benefits include tangible items, such as measured risk reduction, and intangible items, such as improved safety focus.
- Operational benefits include higher quality, greater plant flexibility, and reduced complexity.

Even more importantly, risk-informed approaches have become a "win-win" for both the regulator and the licensees. The regulator can focus on issues truly important to safety, while licensees gain operational flexibility and an opportunity for cost reductions.

Whether it is the assessment of routine operational and maintenance activities, decision-making on the optimum strategies for inspection, or assessment of emergent conditions or regulatory findings, "risk" has become the context for assessment and communication. With this expanded role, regulatory and utility expectations for the use of risk information have been steadily increasing. This expectation has put pressure on both the industry and the Nuclear Regulatory Commission (NRC) to develop and maintain high-quality probabilistic risk assessment (PRA) models and staffs capable of using and interpreting these models. In short, PRA has come out of the cubicle of a few analysts and into the mainstream of plant operations and regulation.

Safety and Performance Trends

Risk-informed approaches sharpen industry focus on metrics as a measure of plant safety. The primary risk metrics used today are core damage frequency (CDF) and large early release frequency (LERF).

Figure 1 illustrates the steady decline in the industry average CDF[1] since the Individual Plant Examinations (IPEs)[2] were completed in 1992. This improvement has been driven by risk-informed initiatives, continued plant and equipment performance improvements, plant enhancements, and PRA model improvements.

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[1]CDF is often expressed in scientific notation. The CDF value represents the occurrences per reactor year, but can also be stated as occurrences per number of years. That is, 5×10^{-5} or 5E-5 events per reactor year can also be expressed as 5 events per 100,000 years.

[2]IPEs were performed in response to U.S. Nuclear Regulatory Commission Generic Letter 88-20, which requested that licensees identify plant-specific vulnerabilities. Although many utilities performed PRAs in response to the Generic Letter, some of these PRAs were relatively simple analyses capable of identifying insights only.

Overall, industry CDF has dropped by nearly 40% since 2000 and by nearly a factor of five since 1992. Concurrently, the operational performance of the industry remains superior. The downward trend in CDF is borne out by industry performance in preventing significant safety events (Figure 2), while sustaining record-breaking capacity factors (Figure 3).

Industry performance improvements translate directly into reduced plant risk levels. A sensitivity study has been conducted by replacing the generic data used in one of the NRC's PRA models [Ref. 1] with the latest industry performance data [Ref. 2, 3, 4]. The results indicate a four-fold reduction in CDF (Figure 4).

The sensitivity study calculated significant reductions in several initiating event categories shown in the following table.

NUREG/CR-4550 Initiating Event Category	Relative Reduction in CDF Observed
Loss of Offsite Power	Factor of 2
Medium Loss of Coolant Accident (LOCA)	Factor of 3
Large LOCA	Factor of 14
Transients with Power Conversion System Available	Factor of 16
Inadvertently Opened Relief Valve	Factor of 50

One initiating event category not captured in the table, Transients with Power Conversion System Unavailable, shows an increase, but that increase is negligible (that is, on the order of 3×10^{-8}/reactor year).[3] Notably, the sensitivity study only addressed changes in the data, taking no credit for other safety enhancements implemented

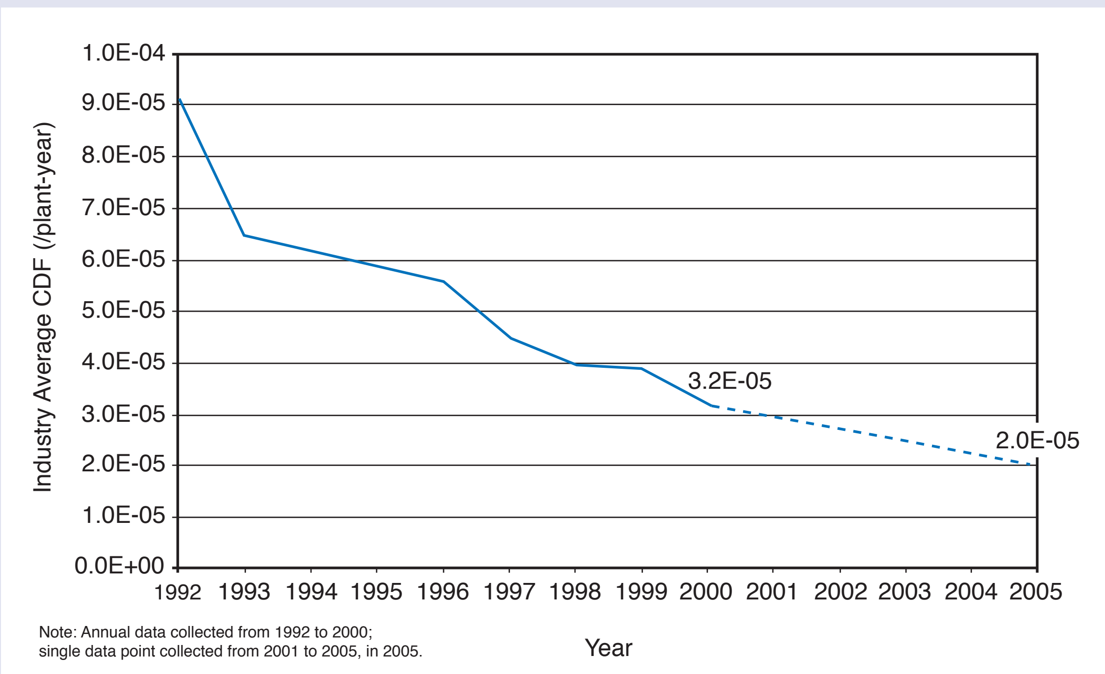

Figure 1
1992 to 2005 Industry Average CDF Trend

[3]As can be seen from Figure 1, the average industry CDF is on the order of 2.0×10^{-5} per reactor year. Values on the order of 1×10^{-7} or less do not significantly contribute to the average CDF and are therefore considered negligible.

over the past 20 years, such as hardware and procedure changes. Such changes would further reduce the estimated CDF. One conclusion from this simple sensitivity study is that the actual performance data drives much of the calculated changes in CDF as opposed to improvements in the PRA model.

Existing Risk-Informed Activities

The nuclear power industry is actively engaged in a wide variety of risk-informed initiatives, spanning day-to-day operational decisions and emergent responses to plant conditions and inspection findings:

- Maintenance Rule (a)(2)
- Maintenance Rule (a)(4) and configuration risk management
- Regulatory Oversight Process
- Individual risk-informed allowed outage time (AOT) changes
- Emergency technical specification (TS) changes
- Risk-informed mode change assessments
- Risk-informed treatment of missed surveillances
- In-service inspection
- Containment testing

Table 1 summarizes the safety and operational benefits of risk-informed activities in each of these areas. The following sections provide additional detail and case study examples to illustrate the benefits of certain risk-informed activities.

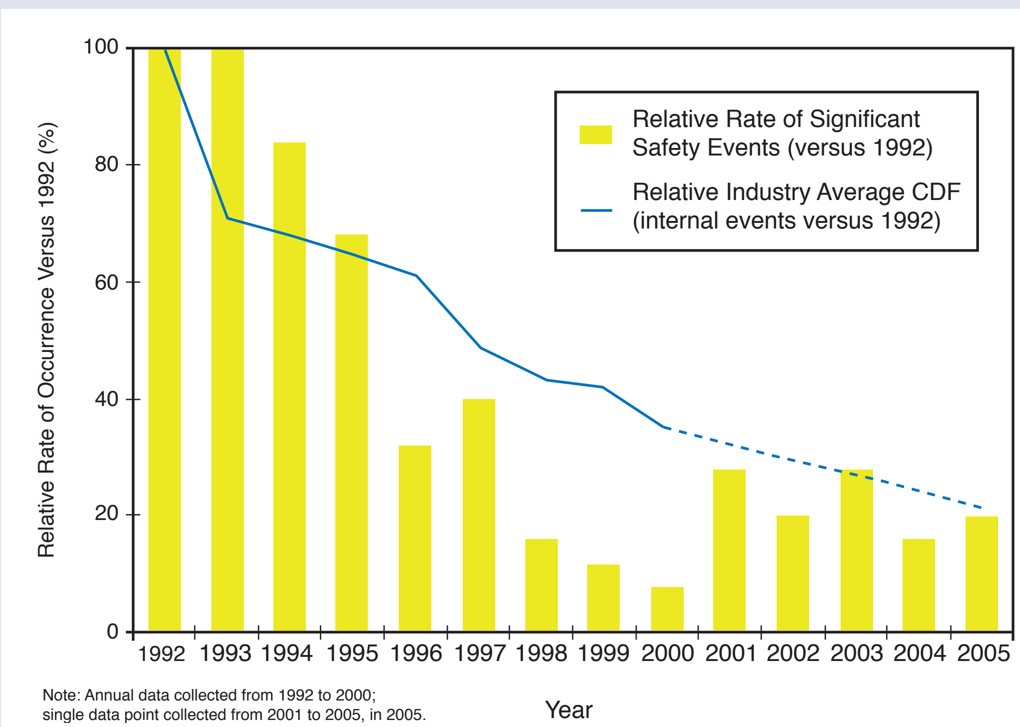

Figure 2
Relative Rate of Significant Safety Events vs. Risk Levels

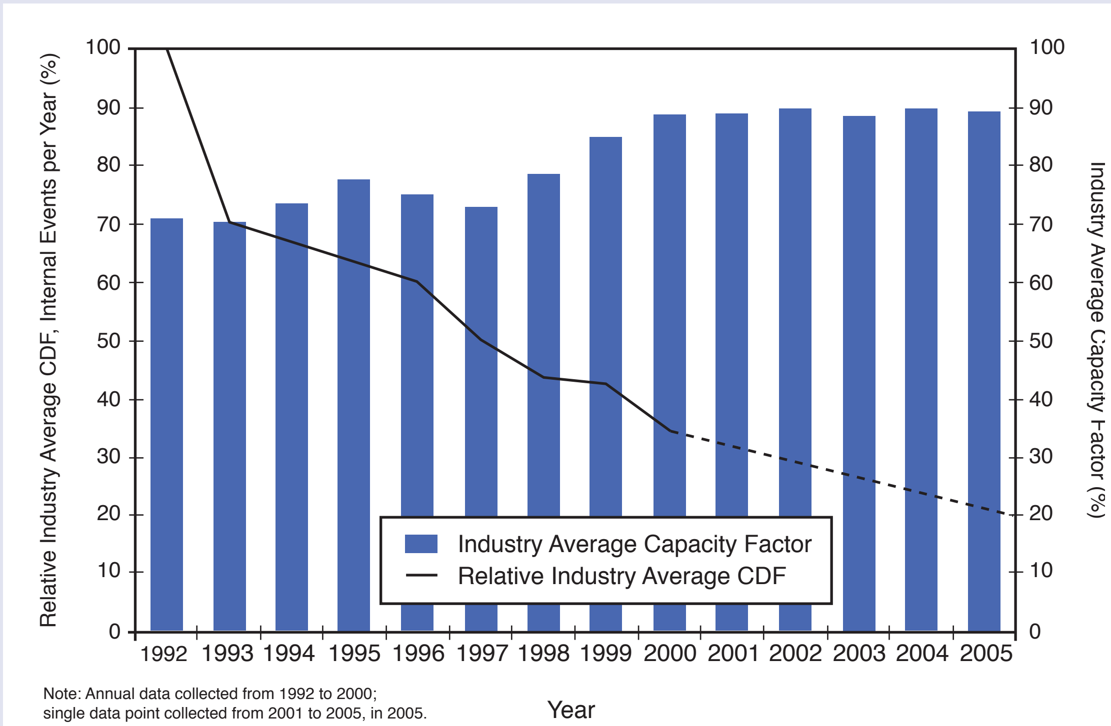

Figure 3
Capacity Factor Performance vs. Risk Levels

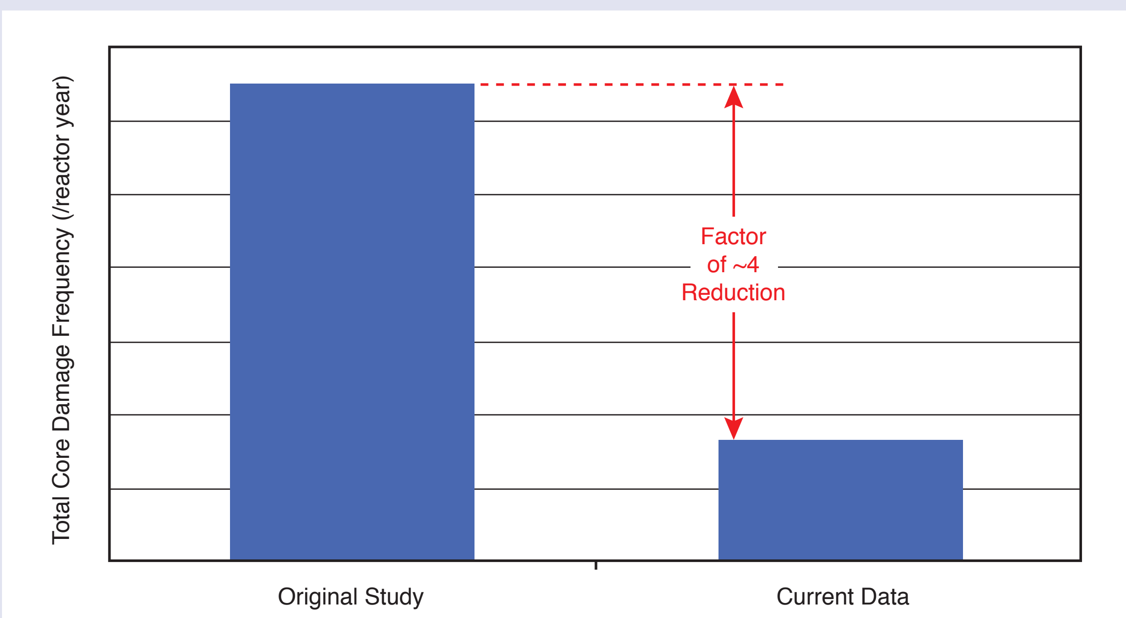

Figure 4
Impact of Improved Industry Performance on Core Damage Frequency

Maintenance Rule (a)(2) and (a)(4)

The Maintenance Rule (10 CFR 50.65) is considered an enabler of risk-informed regulation. The Maintenance Rule brought risk-informed thinking into the plant by requiring that maintenance impacts of "risk-significant" components be considered over the long term by controlling effects on reliability and availability and in the short term by influencing day-to-day maintenance activities.

The core of the Maintenance Rule involves the identification and monitoring of risk-significant structures, systems and components (SSCs). This process involves plant-specific identification of the most safety-significant SSCs based on the plant PRA, and implementation of a monitoring program with defined performance goals. Such monitoring programs have reduced the unavailability and unreliability of many risk-significant SSCs, as reflected in the updated PRA results over the past ten years. Operationally, the focus on safety-significant SSCs led to a decreased focus on unimportant SSCs, which improved operational efficiency and effectiveness. The result has been a net risk reduction across the industry.

Another key part of the Maintenance Rule is contained in paragraph (a)(4), which addresses configuration risk management (CRM). Licensees are required to assess and manage the risk associated with every maintenance activity on a risk-significant SSC. Plant operators, work control personnel, and work planners can focus on the risk implications of maintenance activities in the plant, while gaining flexibility in scheduling maintenance activities. CRM has improved plant safety by focusing on shorter periods of SSC unavailability, especially in higher risk configurations. By reducing the complexity of outages, outages have become safer.

Operationally, (a)(4) has significantly increased the degree of flexibility in scheduling maintenance activities and has supported higher quality maintenance practices. Moving maintenance activities from outages to periods of power operation enables shorter, less complex outages, which improves operational flexibility.

Regulatory Oversight Process (ROP)

A more recent regulatory development is the NRC's Regulatory Oversight Process (ROP), which adopts a risk-informed approach to the oversight and assessment of licensee performance. Here again, the understanding of risk has focused attention on the most safety-significant events and performance deficiencies rather than on obscure design basis conditions that have little real impact on safety.

The numerical orientation of the ROP brings a level of predictability and objectivity lacking in prior oversight methods. The ROP's performance indicator elements drive improvements in risk-significant SSCs by providing a monitoring framework with regulatory responses that encourages high performance across the industry. This performance, in turn, translates to a net risk reduction and greatly reduced focus on non-safety-significant activities so that operational and regulatory resources are focused on the safety-significant activities at the plant.

While substantial resources may be required to resolve potentially safety-significant issues between the regulator and the licensee, the vast majority of NRC inspection findings are readily identified as low safety-significant. This concentrates regulatory and licensee resources on the most significant issues. In addition, the objectivity of the ROP has led to a more tractable enforcement process and a significant reduction in the number of cited violations.

Technical Specification Enhancements

The nuclear power industry and the NRC have worked together to address a large number of TS enhancements that benefit from risk-informed approaches. Some of these risk-informed technical specification (RITS) changes were developed through specific industry initiatives, while others were developed on an ad hoc basis. The TS changes fall into the following broad categories:

- Individual TS Changes
- Emergency TS Changes

- Risk-Informed Mode Changes
- Risk-Informed Treatment of Missed Surveillances

Individual TS Changes

The approach to making individual risk-informed changes to TSs is described in Regulatory Guide 1.177 [Ref. 5]. Nearly 100 risk-informed changes to individual TSs have been submitted and approved in the past ten years. Many of these changes have improved maintenance management on key equipment such as diesel generators, service water systems, and other risk-significant SSCs.

While equipment off-line time has increased in many cases, this increase has been offset by other controls designed to more effectively manage plant risk. CRM requirements dictate proper controls on plant configuration during key maintenance activities to monitor, control, and minimize the safety impact of the out-of-service equipment. These controls do not exist in traditional deterministic TSs. Operationally, risk-informed TSs provide greater flexibility in maintenance scheduling, ensure higher quality maintenance is performed, and enable shorter, less complex outages.

For example, many nuclear power plants have justified extensions to the allowed outage time (AOT)/completion time (CT) for emergency diesel generators (EDGs) using risk-informed approaches. These extensions reference the risk reduction improvements resulting from the Station Blackout Rule (10 CFR 50.63) and other enhancements made as a result of plant-specific PRAs. As part of that justification, the licensee must demonstrate that the incremental risk during the outage is very small, and must take appropriate risk management actions to further control plant configuration and risks, including:

- Limits on additional out-of-service equipment
- Consideration of expected weather and grid conditions
- Operating staff briefings on loss of offsite power response

Many plants were able to justify extensions from three days to 14 days, enabling maintenance activities previously performed during outages to be performed at power. Such a change impacts outage critical path and directly reduces the length of planned outages by several days. In addition, the complexity and work scope of the outage plan is reduced by not having to work around the divisional power unavailability caused by the EDG maintenance.

Risk-informed TS changes can also be used to justify one-time or temporary changes. For example, a twin unit pressurized water reactor (PWR) obtained a temporary TS change to allow an extended completion time for a condition with two of the four available service water pumps out of service. The site justified an extension from the typical 72 hours for this configuration to up to 144 hours in order to allow needed repairs to be performed and avoid a dual unit shutdown. Like the permanent change for EDGs described above, the justification demonstrated that the incremental risk during the outage would be very small.

Emergency TS Changes

Emergency TS changes are typically required when a planned AOT/CT will be exceeded, forcing a plant shutdown. A risk-informed emergency change has many benefits, including the avoided plant shutdown, increased controls on plant configuration during the unavailability, and confirmation of minimal safety impact. Operationally, the emergency change enables plant personnel to focus on restoring affected equipment, rather than dealing with a forced outage. This supports improved planning and performance of repair activities.

Although relatively infrequent, emergency AOT extensions can have substantial benefit. For example, the South Texas Project (STP) received an emergency 99-day AOT extension following a catastrophic failure of one of the Unit 2 EDGs because many replacement parts were either unavailable or obsolete, and thus had to be fabricated. The risk-informed approach used the station's Configuration Risk Management (CRM) Program, which referenced the plant PRA as the technical basis for generating "risk profiles" for equipment out of service. The CRM Program identifies roles and responsibilities for key risk management compensatory actions (both quantitative and qualitative measures) used to manage plant risk levels for the duration of the condition. At STP, this included suspending planned maintenance activities, providing temporary non-safety diesel generators in place of the failed EDG (although not credited in the regulatory submittal), and implementing a number of administrative controls (e.g., increased management and supervisory oversight on plant activities). The plant maintained the cumulative annual average CDF risk below the risk criteria established before the emergency extension.

While unique, this example demonstrates the capability and flexibility provided by risk-informed approaches. In a traditional deterministic analysis, the regulator would have had no basis on which to judge the relative safety implications. The robust plant PRA developed by STP provided the plant staff and regulator with an objective framework from which decisions could be made on the best means to manage plant safety in such a condition. Operationally, STP gained an additional 99 days of full power plant operation.

Risk-Informed Mode Change

As part of an industry RITS initiative, licensees can justify a change in plant mode when all mode change requirements are not met. The justification includes a risk-informed assessment of the safety implications of the mode change for the given condition. The condition must be corrected once the mode change has been completed, in accordance with TSs. The initiative allows the plant startup/shutdown process to safely proceed when the conditions involved are not safety significant. The safety benefits of this initiative accrue from the plant focus remaining on safe operation and not on insignificant constraints to mode change.

Operationally, this process allows concurrent operational activities to continue so that the mode change can be planned effectively. The process also prevents the diversion of resources to less safety-significant activities and supports a controlled change in mode.

Risk-Informed Treatment of Missed Surveillances

Occasionally, a licensee identifies a failure to perform a TS-required surveillance that can only be performed with the plant shut down. Another industry RITS initiative provides a structured, objective process for evaluating the risk implications of the condition. In some cases, the process can be used to justify continued plant operation until the next plant shutdown. Plant operations remain focused on safety-significant activities while confirming that continued operation has minimal safety impact. In addition, continued power production avoids the safety implications associated with the plant transition to shutdown.

Operationally, while an avoided plant shutdown has obvious economic benefits due to increased plant availability and capacity factor, it also avoids the "organizational transient" associated with rapidly planning a forced outage.

In early 2006, the Three Mile Island (TMI) nuclear power station discovered that a required surveillance test on the reactor coolant system vent valves had not been performed during the previous outage. In accordance with the risk-informed missed surveillance process, a risk assessment demonstrated minimal risk in continued unit operation until the next plant outage. Consequently, TMI avoided a three-day shutdown to perform the surveillance and return to power.

In-Service Inspection

One of the most widely adopted risk-informed applications in use today is the risk-informed in-service inspection (RI-ISI) process described in Regulatory Guide 1.178 [Ref. 6]. Traditional ISI programs identify the required inspections based on deterministic criteria including stress analyses, structural discontinuities, and/or random selection processes. RI-ISI uses operating experience and risk insights to target the pipe segments that present the greatest risk, including both the likelihood and consequences of failure. Due to its systematic, risk-informed nature, the RI-ISI process generally identifies few risk-significant welds for inspection. This translates to fewer inspections to be performed during outages and lower personnel exposures.

The safety benefits of an RI-ISI program accrue from focusing on risk-significant inspections, rather than on a deterministically identified set of welds that may or may not have any relationship to plant safety. Operationally, the benefits include fewer inspection tasks, lower personnel exposures, and shorter, less complex outages.

Plant-specific benefits can be substantial. At Calvert Cliffs, RI-ISI eliminated 341 inspections and associated personnel exposures for each ten-year inspection interval [Ref. 7]. At Nine Mile Point Unit 2, RI-ISI eliminated 97 of 135 previously required inspections, along with the associated dose [Ref. 8].

Containment Testing

Integrated leak rate tests (ILRTs) are a time-consuming and involved process. A number of industry studies have demonstrated that ILRTs do not provide significant additional value beyond the required local leak rate testing. This risk-informed application begins with a confirmation of minimal safety impact associated with deferral of the ILRT for an additional five years. Operational benefits include fewer tests, lower personnel exposures, and increased plant availability and capacity factor due to shorter outages. Most plants have experienced a three-day reduction in outage duration, saving millions of dollars. To date, 75 plants have extended their ILRT testing intervals.

Emerging Risk-Informed Activities

A number of new and emerging regulatory applications are amenable to risk-informed approaches:

- Special Treatment Requirements (10 CFR 50.69)
- Surveillance Frequency Control Program
- Fire Protection (NFPA 805)
- Flexible Allowed Outage Time (AOT)/Completion Time (CT)
- Core Cooling System Requirements (10 CFR 50.46a)

Table 2 summarizes the safety and operational benefits of these applications. Additional detail and case study examples are provided below.

Special Treatment Requirements (10 CFR 50.69)

The NRC and nuclear power industry worked for several years to develop a generic special treatment process, which was eventually codified in 2004 via 10 CFR 50.69. NRC issued implementation guidance in 2006 through Regulatory Guide 1.201, which references NEI 00-04 [Ref. 9]. The roots of this risk-informed application go back to the development of the initial risk-informed Regulatory Guides that accompanied Regulatory Guide 1.174 in the form of Graded Quality Assurance.

The 10 CFR 50.69 implementation guidance provides a structure for categorizing SSCs, and based upon the safety-significance determination, provides guidance for the appropriate treatment of safety-significant and low safety-significant SSCs. Under this regulation, the special treatment requirements can be reduced for safety-related SSCs that are determined to be of low safety-significance. This can translate to reductions in in-service testing (IST), local leak-rate testing (LLRT), Maintenance Rule scope, parts procurement, work control, and preventive maintenance tasks.

There are two major costs associated with implementing 10 CFR 50.69. The first involves establishing a robust PRA to support categorization. The 10 CFR 50.69 process has been established so that the more complete the PRA (in terms of scope), the more likely licensees are able to categorize SSCs as low safety significant. The second cost involves implementing the modified special treatment requirements. Licensees must modify their implementation procedures and train personnel on the changes to IST, procurement, quality assurance, and other programs necessary to incorporate the results of the 10 CFR 50.69 categorization.

STP implemented a risk-informed special treatment program through an exemption request granted in late 2001. Over the past four years, STP has embarked on a deliberate implementation approach that assesses feedback to ensure the expected results are achieved. The STP implementation has yielded several interesting insights relative to 10 CFR 50.69 [Ref. 10]:

- Approximately 90% of all components categorized to date are low safety-significant (either RISC-3 or RISC-4) under the 10 CFR 50.69 categorization approach
- For safety-related components only, approximately 25% are safety-significant (RISC-1) while the remaining 75% are low safety-significant (RISC-3)
- Less than 1% of the components are non-safety related yet safety-significant (RISC-2)

To date, STP has noted no adverse equipment performance trends as a result of reducing RISC-3 components' special treatment requirements. An equally important benefit noted by STP is the enhanced safety culture that exists at the plant [Ref. 11].

Surveillance Frequency Control Program

An industry RITS Initiative involves relocating Surveillance Test Intervals from the TSs to a licensee-controlled program. While the requirements for surveillance are retained in the TSs, the licensee is allowed to use a risk-informed process to modify the frequency of those surveillances. The industry has developed a guidance document, NEI 04-10 [Ref. 12], to describe an acceptable method to implement this initiative. Changes to the surveillance intervals are governed by a risk-informed process that builds upon the Maintenance Rule and Regulatory Guide 1.175 for risk-informed IST [Ref. 13]. This process can lead to decreases in test intervals, increases in the test intervals, or no change.

The process maintains focus on plant safety, supporting an improvement in the overall safety culture similar to 10 CFR 50.69. In addition, system availability is improved through more effective surveillance activities. Safety is ensured by confirming that any test interval extension has a minimal safety impact.

This initiative provides significant opportunity to enhance operational flexibility through the elimination of unnecessary tests, reduced operator and maintenance exposures, more efficient coordination of on-line and outage work windows, and shorter, less complex outages.

Limerick Generating Station recently piloted this initiative for six surveillance tests spanning a spectrum of test types in order to exercise the risk-informed process described in NEI 04-10. In five of the six pilot cases, the risk-informed process identified opportunities to reduce testing with negligible risk implications. In the sixth case, the risk-informed process required the collection of additional data to support interval extension. While there were no specific cost savings identified for the six pilot surveillances, one of the five extensions alleviates a significant operational challenge involving back-shift testing of control rod drive notch controls.

Fire Protection (50.48(c)/NFPA 805)

The industry and NRC are rapidly moving toward a more risk-informed, performance-based approach to fire protection under 10 CFR 50.48(c). The new 10 CFR 50.48(c) endorses, with exceptions, the National Fire Protection Association's (NFPA's) 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants – 2001 Edition," [Ref. 14] as a voluntary alternative for demonstrating compliance with 10 CFR 50.48 Section (b) and Section (f). The industry has developed NEI 04-02 [Ref. 15], which provides guidance for implementing the requirements of this rule, and to the degree endorsed by the NRC, represents methods acceptable to the NRC for implementing in whole or in part a risk-informed, performance-based fire protection program.

More than 50 plants are committed to implementing a risk-informed, performance-based program under 50.48(c). In addition to resolving a variety of technical interpretation issues related to existing fire protection regulations, this new risk-informed approach provides a regulatory framework that increases the focus on safety-significant issues. As a result, it will improve safety culture and will provide a context for confirming an acceptable baseline level of safety and the minimal safety impact of any changes or exceptions.

Operationally, the risk-informed, performance-based approach supports a reduced focus on unimportant activities, providing a more cost-effective approach to address evolving fire issues/requirements.

Farley used the risk-informed, performance-based NEI 04-02 process to justify an exemption to current requirements, rather than perform a costly plant modification to replace the existing Kaowool in the Service Water Intake Structure (SWIS) with a different, approved fire barrier material. To support this exemption, Farley performed a detailed review of the SWIS using NFPA 805 methods as part of an NEI 04-02 pilot evaluation with NEI and NRC participation. This evaluation found that some of the conditions in the exemption were unnecessary and other conditions in the exemption could be removed cost-effectively through minor modifications and other program changes.

Flexible Allowed Outage Time/Completion Time

Another industry RITS initiative enhances licensee Configuration Risk Management (CRM) Programs to allow plant-specific PRA analysis to calculate and implement TS AOTs/CTs for returning SSCs to operable status based on planned and actual equipment configuration. This initiative will allow AOT/CT extension from a nominal value up to a predetermined "backstop" maximum using quantitative CRM models and methods.

The safety benefit of this initiative begins with the more comprehensive, integrated safety viewpoint that PRA provides. Unlike the TSs that were developed for each SSC largely on a case-by-case basis, the plant CRM Program can evaluate the safety implications of the plant in an integrated manner, based on plant conditions at the time. This results in increased controls on plant configuration during periods involving unavailability of safety-significant SSCs. Furthermore, the flexible nature of Risk Managed TSs allows a plant to avoid the transient associated with an unnecessary plant shutdown. At all times, overall safety implications of plant configuration are evaluated to confirm a minimal safety impact.

Moving to a more integrated assessment of plant configuration provides increased flexibility in scheduling maintenance, leading to better resource planning and an overall higher quality of maintenance. In addition, the flexibility of the AOT/CTs could support shorter, less complex outages, which may lead to increased plant availability and capacity factor.

Core Cooling System Requirements

The NRC intends to amend its regulations to permit current nuclear power plant licensees to implement a voluntary, risk-informed alternative to the requirements for analyzing the performance of emergency core cooling systems (ECCSs) during LOCAs. In addition to changing the analysis requirements, the proposed rule would establish procedures and criteria for requesting changes in plant design and procedures based upon the results of the new analyses of ECCS performance during LOCAs.

Large break LOCAs are extremely rare events. Requiring reactors to conservatively withstand such events focuses attention and resources on extremely unlikely events, which could have a detrimental effect on mitigating accidents initiated by other more likely events. However, because of the interrelationships between design features and regulatory requirements, changes to ECCS performance regulations can affect many other aspects of plant design and operation. A risk-informed regulatory approach to ECCS requirements, therefore, is very challenging.

The proposed rule would divide the current spectrum of LOCA break sizes into two regions, delineated by a "transition break size" (TBS). The first region includes small size breaks up to and including the TBS. The second region includes breaks larger than the TBS up to and including the double-ended guillotine break (DEGB) of the largest reactor coolant system (RCS) pipe. Pipe breaks in the smaller break size region are considered more likely than pipe breaks in the larger break size region. Consequently, each region will be subject to different ECCS requirements, commensurate with the likelihood of the break size.

Licensees performing LOCA analyses using the risk-informed alternative requirements may find that their plant designs are no longer limited by certain parameters associated with previous DEGB analyses. Reducing the DEGB limitations could enable licensees to propose design or operational changes currently limited by parameters associated with required accident analyses. Potential design changes include optimization of containment spray designs, modifying core peaking factors, optimizing set points on accumulators or removing some from service, eliminating fast starting of one or more EDGs, and increasing power. Some of these design and operational changes would be expected to increase plant safety since a licensee could optimize its systems to better mitigate the more likely LOCAs due to an increase in focus on risk-significant ECCS requirements. Removing some of the extreme performance expectations required for DEGB mitigation may also improve ECCS reliability.

From an operational perspective, the rule change will allow licensees to focus on the safety-significant issues and avoid pre-occupation with low risk design-basis accident (DBA) conditions. In addition, some of the accident analyses may provide additional regulatory margin, which could translate into additional operational flexibility.

Conclusions

Expanded application of PRA and risk-informed initiatives provide nuclear power plants with unprecedented opportunities for improving safety in a cost-effective manner. Successful but limited deployment in the nuclear industry to date has resulted in significant safety and operational benefits:

- Estimated industry average CDFs continue to trend down, with a factor of five decrease shown since IPEs
- Individual plants show that risk-informed relaxation of requirements accompanied by risk management yields no risk increase
- Plant capacity factors are sustained at high levels driven largely by shorter, better managed outages
- Scrams and unplanned outages are fewer and less disruptive

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Table 1
Summary of Value Considerations for Existing Risk-Informed Activities

Risk-Informed Activity	Safety Benefits	Operational Benefits
Maintenance Rule (a)(2)	• Enabled a risk-informed environment • Established a focus on risk significance • Reduced unavailability of risk-significant SSCs • Net risk reduction	• Decreased focus on unimportant SSCs • Minimal direct benefit
Configuration Risk Management and Maintenance Rule (a)(4)	• Focus on plant configuration • Safer outages • Shorter periods of SSC unavailability • Improved SSC performance • Net risk reduction	• Increased flexibility in scheduling of maintenance • Higher quality maintenance • Shorter, less complex outages • Increase in plant availability and capacity factor due to shorter outages • Fewer resources required for outage
ROP	• Established a regulatory focus on risk significance • Reduced unavailability of risk-significant SSCs • Net risk reduction	• Greatly reduced focus on non-safety-significant • Reduced resources expended on unimportant findings • Significant reduction in number of Level IV findings requiring licensee response
Individual Risk-Informed AOT Changes	• Increased controls on plant configuration during key maintenance activities (Tier 2 and 3 controls) • Confirmation of minimal safety impact	• Increased flexibility in scheduling of maintenance • Higher quality maintenance • Shorter, less complex outages • Increase in plant availability and capacity factor due to shorter outages • Fewer resources required for outage
Emergency TS Changes	• Increased controls on plant configuration during unavailability • Avoid plant shutdown • Confirmation of minimal safety impact	• Improved planning of repair activities • Increased plant availability and capacity factor due to avoided plant shutdown
Mode Change (RITS Initiative 3)	• Focus on risk-significant constraints to mode change • Confirmation of minimal safety impact	• Allows concurrent activities to effectively plan mode change, yet rectify constraint • Increase in plant availability and capacity factor due to shortened outage
Treatment of Missed Surveillances (RITS Initiative 2)	• Focus on risk-significant activities • Confirmation of minimal safety impact	• Avoidance of plant shutdown and rapid planning of forced outage • Increased plant availability and capacity factor due to avoided plant shutdown
In-service Inspection	• Focus on risk-significant inspections	• Reduced inspection costs • Lower personnel exposures • Shorter, less complex outages • Increase in plant availability and capacity factor due to shortened outage • Fewer resources required for outage
Containment Testing	• Confirmation of minimal safety impact	• Reduced inspections • Lower personnel exposures • Shorter, less complex outages • Increase in plant availability and capacity factor due to shortened outage

Table 2
Summary of Value Considerations for Emerging Risk-Informed Activities

Risk-Informed Activity	Safety Benefits	Operational Benefits
Special Treatment Requirements (10 CFR 50.69)	• Focus on risk-significant SSCs • Improved Safety Culture • Confirmation of minimal safety impact	• Decreased focus on unimportant SSCs • Reduced procurement cost • Reduced QA and testing cost
TS Surveillance Test Intervals (RITS Initiative 5b)	• Focus on risk-significant SSCs • Improved Safety Culture • Confirmation of minimal safety impact	• Elimination of unnecessary tests • Reduced exposures • Shorter, less complex outages • Reduced risk of plant trip • Increase in plant availability and capacity factor due to shortened outage
Fire Protection (10 CFR 50.48(c)/NFPA 805)	• Focus on risk-significant issues • Improved Safety Culture • Confirmation of minimal safety impact	• Reduced focus on unimportant activities • More cost-effective approach to address evolving fire issues/requirements
Flexible AOTs (RITS Initiative 4b)	• Increased controls on plant configuration during unavailability • Avoid plant shutdown • Confirmation of minimal safety impact	• Increased flexibility in scheduling of maintenance • Higher quality maintenance • Shorter, less complex outages • Increased plant availability and capacity factor due to avoided plant shutdowns and shorter outages
ECCS Requirements (10 CFR 50.46a)	• Focus on risk-significant ECCS requirements • Improved ECCS reliability • Improved diesel generator reliability	• Reduced pre-occupation with DBA conditions • Additional regulatory margin to avoid non-risk-significant expenditures • Optimization of containment spray design • Eliminate diesel generator fast starts • Re-sequence diesel generator loading to address more likely events • Modify core peaking factors to optimize fuel design • Optimize accumulator setpoints • Power uprates

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