JENSEN HUGHES

Advancing the Science of Safety

WHERE PSA NUMBERS MATTER IN RISK-INFORMED DECISION-MAKING IN THE US

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OUTLINE

- Background – U.S. Risk-Informed Nuclear Regulatory Framework
- Important Risk-Informed Applications
  - Regulatory-Driven
  - Industry-Driven
- Examples of where discussion occurs about “the numbers”
- Conclusion
- Questions

Acknowledgment: Slides 3, 14, and 15 of this presentation were developed by Doug True and Stuart Lewis of JENSEN HUGHES and have been used in one or more prior presentations, including the 2018 American Nuclear Society Utility Working Conference and 2018 NRC Regulatory Information Conference. They appear here with permission of the authors.

NRC QUANTITATIVE HEALTH OBJECTIVES (QHOS)

Latent Cancer Risk QHO

< One-tenth of one percent (0.1%) of the sum of cancer fatality risks resulting from all other causes.

Margin

Total Plant CDF < 10^{-4}/reactor-year

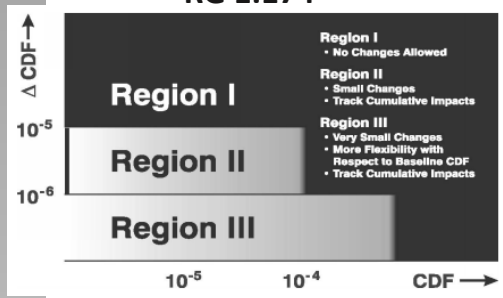
Prompt Fatality Risk QHO

< One-tenth of one percent (0.1%) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed.

Margin

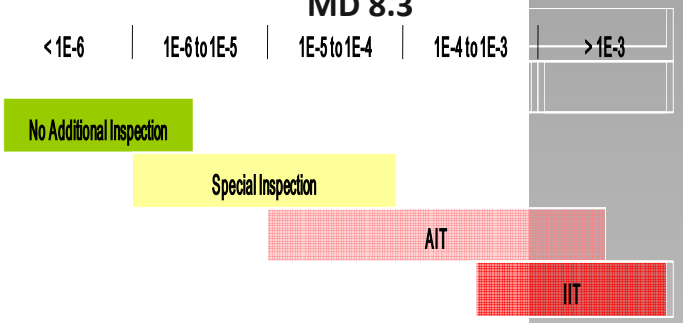
Total Plant LERF < 10^{-5}/reactor-year

RG 1.174



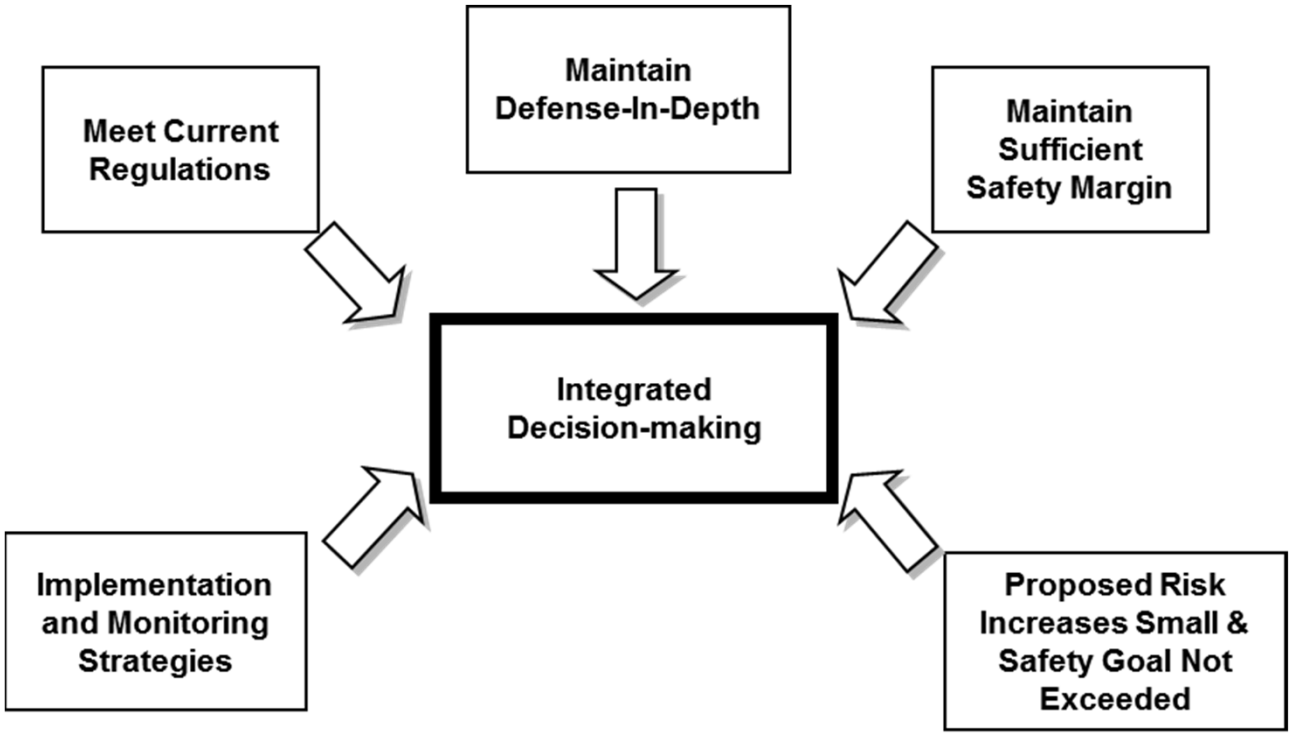
SDP

MD 8.3



RISK INFORMED FRAMEWORK

- Integrated Decision-Making Process Within the Risk-Informed Regulatory Framework, per Regulatory Guide 1.174



RISK INFORMED FRAMEWORK

- Expectations also established for “PSA Quality”
- Guidance for Determining Technical Adequacy of PSA Specified in RG 1.200*
  - Defines “attributes” of a Technically Adequate PSA
  - Provides guidance for necessary PSA Scope
  - Endorses “voluntary consensus” PSA Standards
    - American Society of Mechanical Engineers / American Nuclear Society (ASME/ANS) RA-S-2008 and 2009 Addendum
    - Provides NRC “Clarifications” to requirements in RA-S
- Establishes Expectations for PSA peer review against the PSA Standard

*RG1.200: “An Approach For Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities:, R2 March 2009.

IMPORTANT RISK-INFORMED APPLICATIONS

Risk-Informed Applications tend to be primarily:

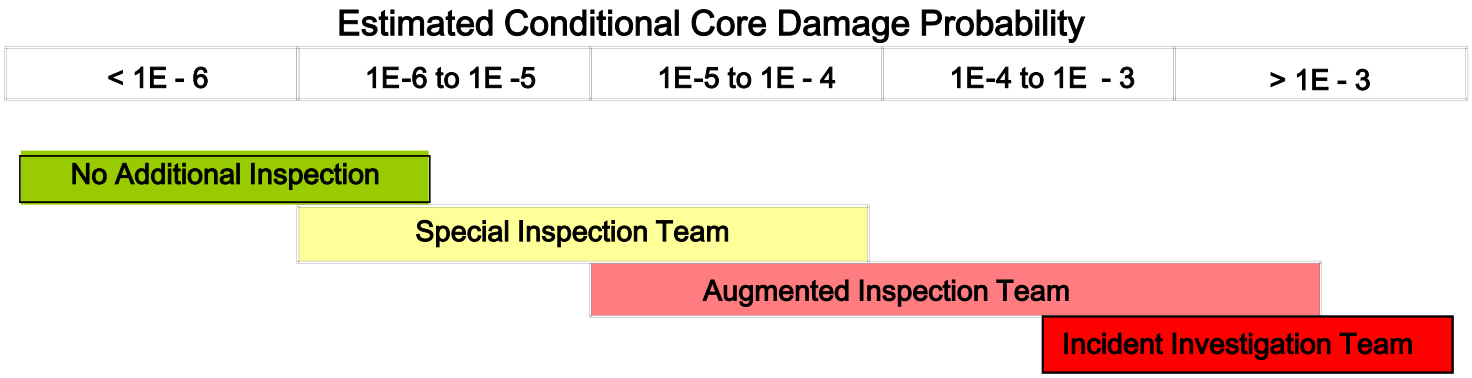
- Regulatory-Driven
  - Configuration Risk Management
  - Plant Performance Indicators
  - Risk Inform the Reactor Oversight Process
- Industry-Driven
  - Achieve operational benefits by prioritizing resources on safety-significant activities
  - Programs promoted in support of US Nuclear Industry's "Delivering the Nuclear Promise" initiative
    - Reduce O&M costs while maintaining safety

EXAMPLE REGULATORY APPLICATIONS

- Maintenance Rule / Configuration Risk Management (10CFR50.65 a(4))
  - NRC requirement to assess/manage risk of configuration changes
- Reactor Oversight Process
  - Mitigating Systems Performance Index (MSPI)
    - NRC required Safety System metric that uses internal event PSA to establish risk significance of specific mitigation system performance.
  - Management Directive 8.3
    - NRC establishes degree of inspection after a plant trip involving other failures based on risk significance
  - Significance Determination Process (SDP)
    - NRC assesses risk significance of “performance deficiencies”
    - Used to establish whether and to what extent NRC applies enhanced oversight and inspection, and financial penalties

NRC MANAGEMENT DIRECTIVE 8.3

- Process Used by NRC to:
  - Investigate operational events (generally other than simple reactor trip)
  - Document information pertaining to each event
  - Ascertain the cause or causes of each event
- Risk is used to help establish which level of onsite inspection

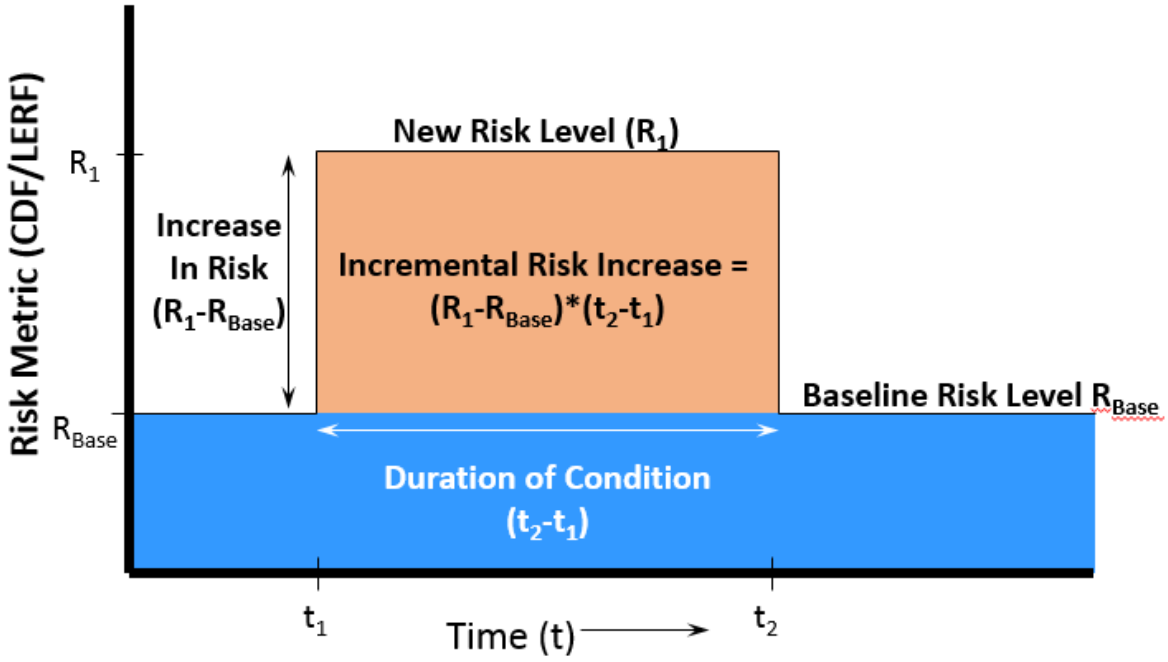


SDP CRITERIA FOR DECISION-MAKING

- Significance Determination Process*
  - NRC investigation of plant event in which a “performance deficiency” has been identified
  - Non-green findings affect “cornerstones of safe operation”
  - Multiple findings in a cornerstone result in increased oversight, possibly fines

*https://www.nrc.gov/reactors/operating/oversight/rop-description.html#cornerstones

ASSESSMENT OF SIGNIFICANCE (ICDP/ICLERP)



MD 8.3 AND SDP

- NRC uses their “SPAR” PSA Models to make initial determination of risk significance of event.
- Requests information from / meetings with licensee to compare results of SPAR and plant-specific PSA.
- Licensee models typically more complete / realistic, but 2 topics typically dominate discussions:
  - Assessment of common cause failure likelihood for the event
  - Assessment of probability of failure of operator response in responding to the event
- Licensees spend significant resources defending against non-green determinations
  - *Sometimes hundreds of thousands of $/£*

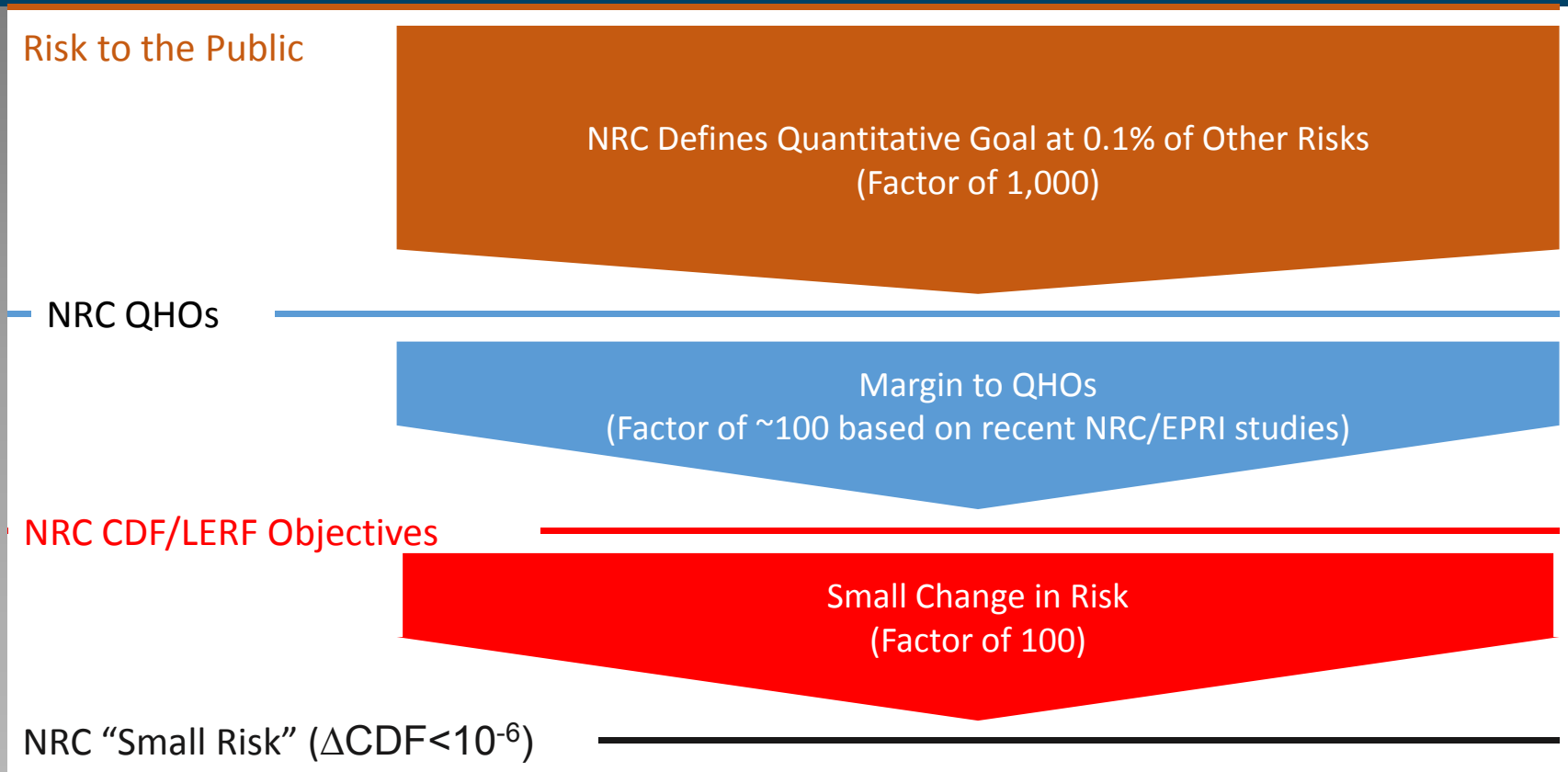
TYPICAL SDP OR MD8.3 (1 OF 2)

- Event occurs, Licensee reports event
  - It's complicated: Somehow both emergency diesel generators were "inoperable" / may not have started on demand for an extended time
- Preliminary assessment by NRC
  - In this case, likely a Performance Deficiency (Configuration should not have been allowed)
  - Likely highly risk significant if both trains of emergency AC power affected
- Licensee mobilizes resources for emergent analyses
  - *"What's the color?"*
  - Root cause evaluation, interviews with on-shift personnel, failure analyses, …
  - Iterate on risk evaluation

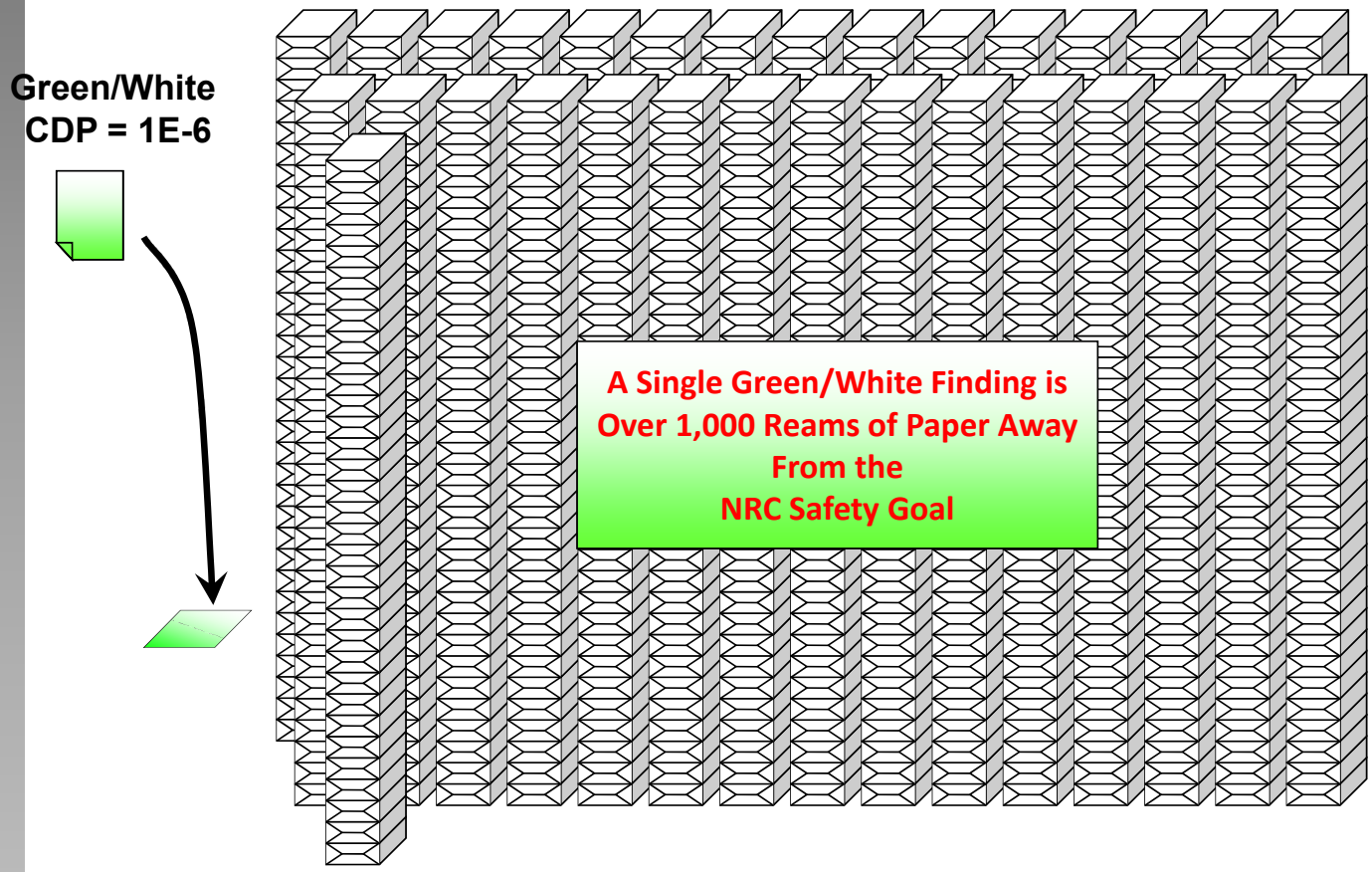
TYPICAL SDP OR MD8.3 (2 OF 2)

- Phone calls with NRC Regional and HQ analysts
  - Initial opportunity to make the case that special inspection or SDP not needed
  - Depends heavily on Regional Sr. Reactor Analyst's risk assessment
  - In this case, unsuccessful (pretty obvious performance deficiency)
- Special inspection, several weeks of information gathering
  - In this case, special focus on credit for Operator Response human error probability (HEP)
  - NRC: HEP no better than 0.1; Licensee: no worse than 1E-3 based on procedures
  - NRC: Little credit for FLEX reliability; Licensee: normal reliability values should apply
- NRC perspective typically wins (but not always)

PERSPECTIVE ON RISK SIGNIFICANCE OF EVENTS



PERSPECTIVE ON GREEN-WHITE SDPS

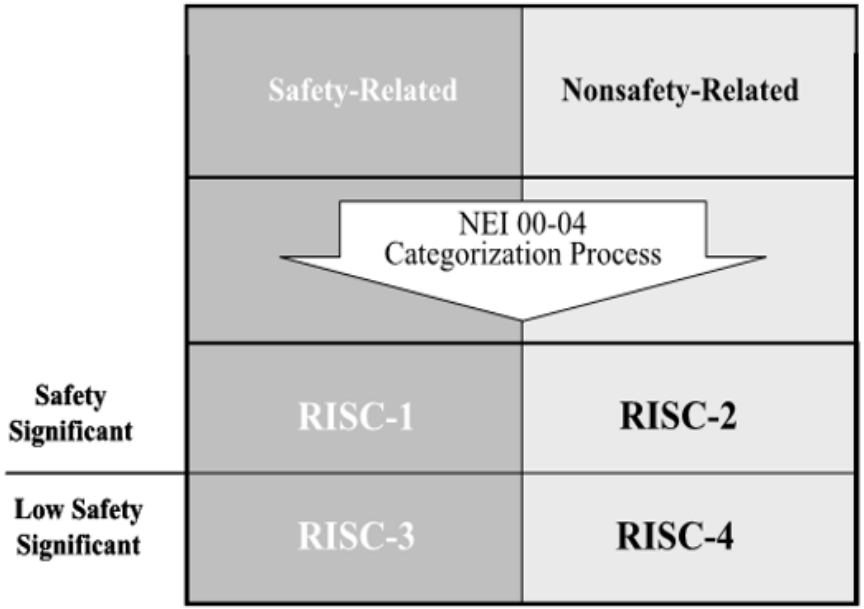


1,000 Reams of Paper
Equivalent to a
15 Story Building

EXAMPLE VOLUNTARY APPLICATIONS

- Operational Flexibility
  - Inservice Testing (IST) (RG1.175)
  - Inservice Inspection (ISI) (RG1.178)
  - Surveillance Test Interval (STI) Extension / Surveillance Frequency Control Program (TSTF-425; R-I Initiative 5b)
- Risk Informed Compliance with Licensing Basis
  - 50.48c - NFPA-805 (Risk Informed Fire Protection)
  - Risk Informed TS Completion Times (TSTF-505; Risk Informed Initiative 4b)
- Alternative Treatments for Safety Related SSCs
  - 50.69 – Relaxation of Special Treatment Requirements (10CFR50.69)

RISK-INFORMED CATEGORIZATION AND TREATMENT OF SSCs – 10 CFR 50.69



- 50.69 Provides a process for categorizing safety-related SSCs as either safety significant or low safety significant
- Same for non-safety-related SSCs
- Alternate treatments are defined for RISC3 and RISC2 SSCs
- Performance monitoring is also required to ensure categorization remains valid

RISK-INFORMED CATEGORIZATION AND TREATMENT OF SSCs – 10 CFR 50.69

Special Treatment Requirements That May Be Removed for Low Risk Safety Related SSCs (RISC-3) Under 10CFR50.69
Maintenance Rule [10 CFR 50.65]
Environmental Qualification [10 CFR 50.49]
Seismic Qualification [Portions of Appendix A to 10 CFR Part 100]
ASME XI repair & replacements, applicable portions, with limitations [10 CFR 50.55a(g)]
Applicable Portions of IEEE standards [10 CFR 50.55a(h)]
In-service Testing [10 CFR 50.55a(f)]
In-service Inspection [10 CFR 50.55a(g)]
Local Leak Rate Testing [10 CFR 50 Appendix J]
Quality Requirements [10 CFR 50 Appendix B]
Deficiency Reporting [10 CFR Part 21]
Event Reporting [10 CFR 50.55(e)]
Notification Requirements [10 CFR 50.72, 50.73]

RISK-INFORMED CATEGORIZATION AND TREATMENT OF SSCs – 10 CFR 50.69 - BENEFITS

- Safety Improvement:
  - Focus on safety significant (not just safety-related) SSCs
  - Enhance plant's safety/risk culture
- Operational:
  - Reduced regulatory attention to low safety significant SSCs
    - Reduced burden on plant staff allows time for attention to safety significant SSCs
  - More efficient processes
  - Less outage burden for regulatory-driven testing/inspections
  - Increased operational flexibility
- Financial Benefit:
  - Reduced procurement costs
    - Many safety-related SSCs can be purchased as with reduced QA
  - Fewer resources required for tests, inspections, oversight

RISK-INFORMED CATEGORIZATION AND TREATMENT OF SSCs – 10 CFR 50.69

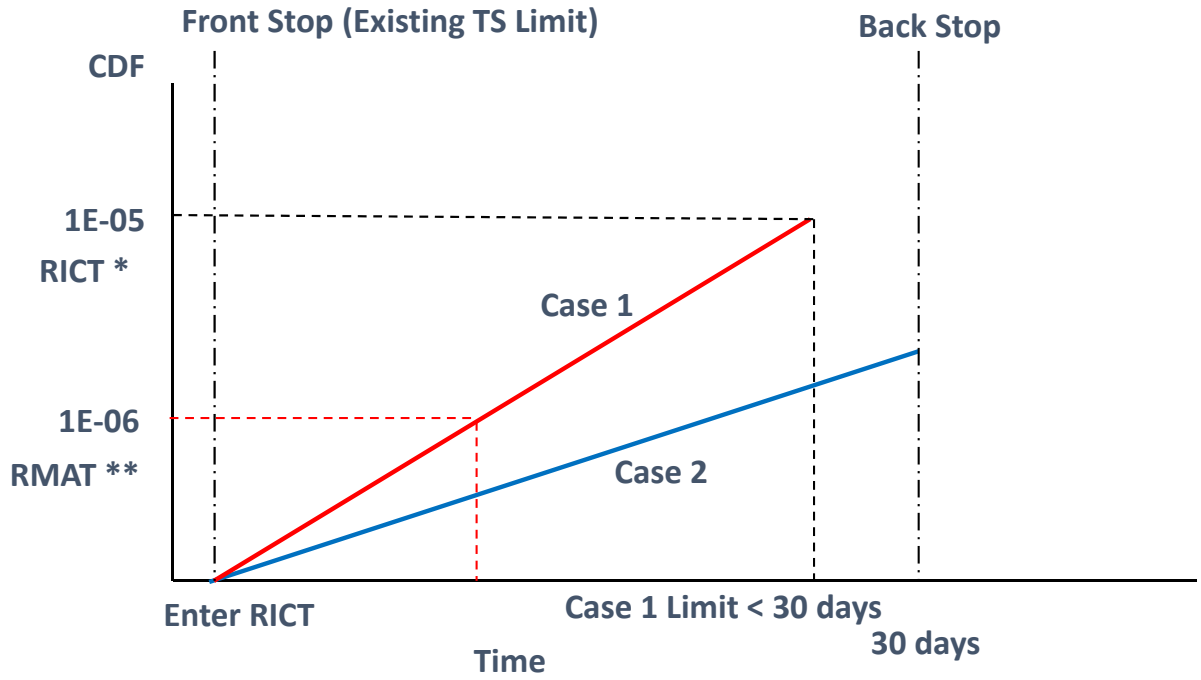
- Categorization and Alternate Treatments:
  - Licensee decides what systems to categorize and where to apply alternate treatments
  - RISC-3 only if component risk importance meets criteria and deterministic criteria are met
    - Core Damage and Containment Defense-in-Depth
    - Shutdown risk considerations
  - RISC-3 components can be removed from scope of many safety related special treatment requirements
    - RISC-3 components must still be able to performing design basis functions
    - Alternative treatments must provide ***"reasonable confidence"*** that RISC-3 SSCs remain capable of performing safety-related functions under design basis conditions throughout their service life
    - Capability must be demonstrated through performance monitoring and testing

RISK INFORMED TS COMPLETION TIMES

- NRC Considers Risk Informed Completion Time Program to be "ultimate" Risk Informed Application:
  - Licensee ability to extend TS limits without situation-specific approval based on risk limits
  - Very significant Reliance on PSA numbers for risk accumulation while in technical specification allowed outage (completion) time
  - Significant focus on PSA technical adequacy
  - Significant focus on sources of model uncertainty
- Industry and NRC have spent better part of 4 years addressing technical / implementation issues
  - TS "Loss of Function"
  - "PSA Functionality Determination"
  - Compensatory Risk Management Actions
  - PSA Technical Adequacy

RISK INFORMED TS COMPLETION TIMES

RICT Risk Accumulation Example



* Incremental configuration risk from all hazards; LERF Limits order of magnitude lower

** Risk Management Action Time – implement mitigative measures

SUMMARY

USE OF PSA IS AN INTEGRAL PART OF PLANT OPERATION

- NRC is driving greater focus on PSA capability through both regulatory-driven processes and review of licensee applications.
- Licensees are pursuing more sophisticated risk-informed applications
  - But also trying to manage ever-increasing costs of attaining and maintaining an appropriate level of PSA scope and technical adequacy.
- Both Industry and NRC spend ***A LOT*** of time “discussing” the numbers.

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