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ASSESSING THE IMPACT OF TSTF 505 INITIATIVE 4B RISK-INFORMED COMPLETION TIMES ON BASELINE RISK

2. ADAMS Accession No. (Use Template ADM 039)

ML18352A873

3. AUTHOR(s)

Antonios M. Zoulis

4. NAME OF CONFERENCE, LOCATION, AND DATE(s)

PSA 2019, 16th International Topical Meeting on Probabilistic Safety Assessment and Analysis, Charleston, SC, April 28-May 3, 2019.

5. NAME OF PUBLICATION

2019 International Topical Meeting on Probabilistic Safety Assessment and Analysis (PSA 2019)

6. NAME AND ADDRESS OF THE PUBLISHER

American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526
U.S.A.

7. TELEPHONE NUMBER OF THE PUBLISHER

(708) 352-6611

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NRC FORM 390 (10-2011)

ASSESSING THE IMPACT OF TSTF 505 INITIATIVE 4B RISK-INFORMED COMPLETION TIMES ON BASELINE RISK

Antonios M. Zoulis

U.S. Nuclear Regulatory Commission: Washington, DC 20555-0001

Many US nuclear power plant licensees are adopting risk-informed initiatives such as 10 CFR 50.69 "Risk-informed Categorization and Treatment of Systems, Structures and Components of Nuclear Power Plants," and Technical Specification Task Force (TSTF) Traveler 505 "Risk Initiative 4b - Risk Informed Completion Times." This paper compares the impact from the potential for increase allowed outage times (AOTs) that may result when a licensee adopts risk-informed completion times or RICTs. The analysis was performed on various plant designs and based on a sample of licensees that have or will adopt TSTF 505. The analysis was performed using the Standardized Plant Analysis Risk (SPAR) Models used by the Nuclear Regulatory Commission (NRC), and developed and maintained by the Idaho National Laboratory (INL). The existing at-power SPAR models were modified to assess the impact of extended AOTs by conducting sensitivity studies on existing test and maintenance terms found in the models. This paper provides an overview of TSTF 505 and presents the results and changes observed on the licensee's baseline core damage frequency.

I. INTRODUCTION

With the development of Probabilistic Risk Assessments (PRAs) in the U.S. nuclear industry and the introduction of the NRC's PRA Policy Statement (Ref. 1), NRC staff were encouraged to further the use of PRA in regulatory practices and programs "where practical within the bounds of the state-of-the-art, to reduce unnecessary conservatism associated with current regulatory requirements, regulatory guides, license commitments, and staff practices." The NRC and industry both adopted and developed a number of risk-informed initiatives such as 10 CFR 50.65 "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants" (maintenance rule), 10 CFR 50.69 "Risk-informed Categorization and Treatment of Systems, Structures and Components of Nuclear Power Plants," and Risk Management Technical Specifications of which one initiative, is Initiative 4b "Flexible Completion Times." In this paper, we will attempt to assess the potential impact of Initiative 4b on plant systems unavailability and its overall effects on baseline risk and how those changes compare to NRC guidelines for licensing changes.

II. BACKGROUND

The NRC and the industry developed more fundamental risk-informed improvements to technical specifications. The term "risk management technical specifications" is used to emphasize the goal of constructing technical specifications that reinforce the pro-active management of the total risk presented by the plant configuration and its response to emergent conditions. These improvements are intended to maintain or improve safety while reducing unnecessary burden and to bring technical specification requirements into congruence with the Commission's other risk-informed regulatory requirements, in particular, the maintenance rule. Initiative 4b "Flexible Completion Times" allows the temporary extension of the existing completion times within a limiting condition for operation using a quantitative implementation of 10 CFR 50.65 (a)(4). Licensees must submit a license amendment to be able to implement Initiative 4b which allows them to calculate plant-specific risk-informed completion times. Once approved, a licensee can then utilize their online risk tools to manage the allowed outage times of various plant equipment configurations using their existing work control program.

II.A. Initiative 4b "Flexible Completion Times"

When a licensee implements Risk Management Technical Specifications Initiative 4b "Flexible Completion Times," they modify their existing technical specifications to adjust their limiting condition for operations (LCOs) by evaluating the total real-time plant risk. This is performed by adding a new program to the administrative controls portion of the technical specifications, known as 'risk-informed completion time' or 'RICT' (Table I). The administrative controls consist of three categories as illustrated in Figure 1. The first category is the front-stop which conforms to the original technical specification LCO that exists in their current license. The second is the option to calculate a RICT using their online risk assessment model that accounts for other equipment

that may be out of service at the same time and uses their existing work control processes under 10 CFR 50.65 (a)(4) to assessed and manage the risk. The third category is a 30-day deterministic backstop that prevents any systems structures and components (SSCs) from being inoperable for a period greater than 30 days.

Table I. Example Technical Specification Actions Statement under Initiative 4b

ACTIONS		
CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One subsystem inoperable.	A.1 Restore subsystem to OPERABLE status.	3 days OR In accordance with the Risk Informed Completion Time Program

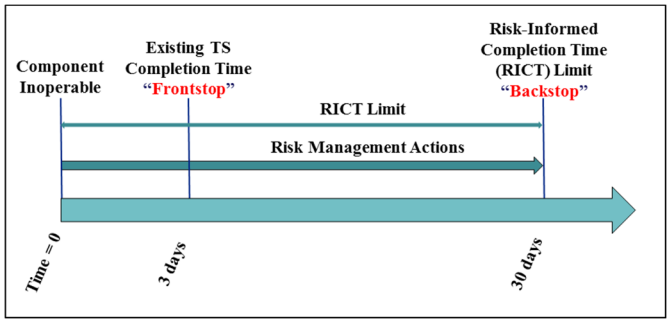

Fig 1. Illustration of Administrative Controls under Initiative 4b

The RICT is calculated using the plant-specific risk assessment model and is limited by two important factors. The overall plant core damage and large early release frequencies, CDF and LERF respectively, and a change in the CDF and LERF for the specific configuration. For example, if the overall CDF is less that 1E-04 CDF/reactor year (ry), then the incremental change in CDF and LERF, cannot exceed 1E-05 and 1E-06 respectively for the inoperable SSCs. The NRC and Industry guidance for Initiative 4b is discussed in more detail in the following section.

II.B. Initiative 4b Applicable Regulatory and Industry Documents

The applicable industry documents that provide the overall guidance and process for implementing Initiative 4b are the Risk-Informed Technical Specifications Task Force Traveler 505 "Provide Risk-Informed Extended Completion Times" (Ref. 2) and Nuclear Energy Institute (NEI) guidance NEI-06-09 "Risk-Managed Technical Specifications (RMTS) Guidelines" (Ref 3.). These documents were reviewed and approved by the NRC, specifically a safety evaluation was written for NEI-06-09 and issued May 17, 2007 (Ref 4). As stated above, a licensee must submit a license amendment to be able to take advantage of Initiative 4b. The PRA model used to calculate the RICTs must conform to requirements of Regulatory Guide (RG) 1.200 "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities" (Ref. 5). Specifically, the model must be peer reviewed and any facts and observations resulting from that peer review must be dispositioned or shown not to impact the results of the application.

III. ANALYSIS AND METHODOLGY

For this analysis, a total of seven licensees were chosen that have or will adopt TSTF 505 Initiative 4b in the near future. The analysis used the Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) software and the plant-specific SPAR models (Ref. 6) used by the NRC, and developed and maintained by INL. Each SPAR model contains test and maintenance terms for specific components that accounts for their unavailability throughout the year due to surveillance testing and scheduled and unscheduled maintenance. For each model, 3 different sensitivity studies were performed on the test and maintenance terms found in the SPAR models. The analysis increased the unavailability by 2-times and 5-times the nominal unavailability. In addition, the unavailability for each test and maintenance term was modified to the backstop limit of 30 days or 8.2% unavailability for a reactor year. The analyst understands that this would be unlikely for many components found in the SPAR model due to the risk significance of those components but this analysis is attempting to calculate a bounding risk increase from such an unavailability due to implementation of Initiative 4b.

III.A. Assumptions

This analysis makes several conservative assumptions that would not occurred under normal plant operations. However, the sensitivity analysis is to illustrate the bounding impact to the baseline risk of the sites selected if these extreme cases were to occur and to assess the significance of the impact to the baseline risk. Many licensees will not enter the RICT LCOs frequently and will attempt to perform maintenance under the existing technical specifications LCOs. Licensees under the Maintenance Rule are required to balance both reliability and availability of their SSCs so cumulating unnecessary unavailability hours would be limited by those restrictions. Therefore, our assumption of increasing the unavailability by 5 times or to the backstop for all components is

conservative. Our analysis does not consider the risk management actions performed and required as part of the 10 CFR 50.65 (a)(4) risk assessment. The overall risk to the plant is mitigated by these actions but is not reflected in the numerical quantification of this analysis.

III.B Model Development

The SPAR models contain test and maintenance terms for systems modeled in the PRA and controlled by the plant-specific technical specifications. For each model used, the test and maintenance terms were modified by changing the unavailability by a factor of 2-times, 5-times and 30 days. The models consisted of both pressurize water reactors and boiling water reactors, the two predominant nuclear power plant designs found in the United States nuclear fleet. Table II provides an example of test and maintenance basic events terms found in the SPAR models that would be modified for this analysis.

III.C. Limitations

The SPAR models contained less basic events than a plant-specific model and in turn less test and maintenance basic events. Therefore, the SPAR model may not be capturing the full scope of basic events that would be modeled in the PRA and that would have test and maintenance terms as part of that modeled. However, the SPAR models do contain the most risk significant systems and components and the models have been benchmarked and compared to licensee's PRA models to ensure consistency in results and resulting accident sequences.

The paper discusses both CDF and LERF limits but for this analysis only CDF was calculated and compared in the results.

Table II. SPAR Sample Test and Maintenance terms

Event	Description
AFW-MDP-TM-PAL01A	AFW MDP PAL01A UNAVAILABLE DUE TO TEST AND MAINTENANCE
AFW-MDP-TM-PAL01B	AFW MDP PAL01B UNAVAILABLE DUE TO TEST AND MAINTENANCE
AFW-MDP-TM-PAP01	NON-SAFETY AFW MDP PAP01 UNAVAILABLE DUE TO TEST AND MAINTENANCE
AFW-TDP-TM-PAL02	FEED PUMP PAL02 IS IN TEST OR MAINTENANCE
CCW-MDP-TM-P1A	CCW MDP P1A UNAVAILABLE DUE TO TEST OR MAINTENANCE
CCW-MDP-TM-P1B	CCW MDP P1B UNAVAILABLE DUE TO TEST OR MAINTENANCE
CCW-MDP-TM-P1C	CCW MDP P1C UNAVAILABLE DUE TO TEST OR MAINTENANCE
CCW-MDP-TM-P1D	CCW MDP P1D UNAVAILABLE DUE TO TEST AND MAINTENANCE
EPS-DGN-TM-NE01	DG NE01 UNAVAILABLE DUE TO TEST AND MAINTENANCE
EPS-DGN-TM-NE02	DG NE02 UNAVAILABLE DUE TO TEST AND MAINTENANCE
EPS-DGN-TM-PA5001	EDG PA5001 UNAVAILABLE DUE TO TEST AND MAINTENANCE
EPS-DGN-TM-PA5002	EDG PA5002 UNAVAILABLE DUE TO TEST AND MAINTENANCE
EPS-DGN-TM-PA5003	EDG PA5003 UNAVAILABLE DUE TO TEST AND MAINTENANCE
EPS-DGN-TM-PA5004	EDG PA5004 UNAVAILABLE DUE TO TEST AND MAINTENANCE
ESW-MDP-TM-1A	ESW TRAIN A MDP 1A UNAVAILABLE DUE TO TEST AND MAINTENANCE
ESW-MDP-TM-1B	ESW TRAIN B MDP 1B UNAVAILABLE DUE TO TEST AND MAINTENANCE
FWS-EDP-TM-PMP	FIREWATER SYSTEM N TEST AND MAINTENANCE
HPI-MDP-TM-P1A	HPI PUMP TRAIN P1A IS IN TEST OR MAINTENANCE
HPI-MDP-TM-P1B	HPI PUMP TRAIN P1B IS IN TEST OR MAINTENANCE
IAS-MDC-TM-CKA01A	INSTRUMENT AIR COMPRESSOR CKA01A UNAVAIL. DUE TO TEST & MAINT.
IAS-MDC-TM-CKA01B	INSTRUMENT AIR COMPRESSOR CKA01B UNAVAIL. DUE TO TEST & MAINT.
IAS-MDC-TM-CKA01C	INSTRUMENT AIR COMPRESSOR CKA01C UNAVAIL. DUE TO TEST & MAINT.
LPI-HTX-TM-HX1A	HEAT EXCHANGER 1A IS IN TEST OR MAINTENANCE
LPI-HTX-TM-HX1B	HEAT EXCHANGER 1B IS IN TEST OR MAINTENANCE
LPI-MDP-TM-P1A	LPI PUMP TRAIN P1A IS IN TEST OR MAINTENANCE
LPI-MDP-TM-P1B	LPI PUMP TRAIN P1B IS IN TEST OR MAINTENANCE
SWS-MDP-TM-1C	SWS MDP 1C UNAVAILABLE DUE TO TEST AND MAINTENANCE

IV. RESULTS

The analysis provided results for both the new baseline CDF as well as the overall change to CDF. The impact to the baseline CDF was calculated for each licensee based on the three sensitivity cases discussed previously. In addition, a comparison of the change in CDF to the guidelines in RG 1.174 "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," (Ref. 7) was also performed.

Table III and Figure 2 show the new baseline CDFs for each of the sensitivity cases that were analyzed. For the cases where unavailability was increased by 2-times and 5-times the nominal unavailability the resultant increase to the baseline CDF in most cases was relatively modest. However, in some SPAR models, the resultant baseline CDF was up to 3 times greater than the nominal CDF. Licensee 2 and 7 are examples of a large increase to the baseline CDF. For the conservative case, where the nominal unavailability was increased to the 30-day backstop or 8.2% unavailability the resultant changed in CDF was much greater.

However, the results were still below 1E-04 CDF which is a threshold for allowing design changes to a plant based on PRA information. It is important to emphasize again that licensees are not allowed and would not routinely allow all SSCs to be unavailable out to the 30 day backstop. Only low safety significant components would be allowed a RICT out to the 30 day backstop. Initiative 4b also contains recommendations to licensee's to monitor cumulative risk. Therefore, unnecessarily allowing equipment to remain unavailable for lengthy amounts of time would be impractical and quickly push against those limitations.

Table IV and Figure 3 show the change in CDF for each of the cases that were analyzed. For the cases where unavailability increased by 2-times and 5-times the nominal unavailability the results were close to the guidelines imposed in RG 1.174 for CDF. RG 1.174 has guidelines for the change in CDF and LERF of 1E-05 and 1E-06, respectively. The risk thresholds found in RG 1.174 are not hard and fast limits and for these cases the change in CDF was at most twice the 1E-5 CDF threshold.

For the conservative case, where the nominal unavailability was increased to the 30-day backstop or 8.2% unavailability the resultant change in CDF was greater. However, the results were in the 5E-05 range in CDF, except for Licensee 1, which is significant but still within the licensee's ability to assess and manage.

Licensee 1, Plant 1 and 2, SPAR results were significant outliers as compared to the other results analyzed in this paper. After reviewing the SPAR model cutsets, it was discovered that some combinations of test and maintenance terms that would be prevented by the licensee's technical specifications and configuration risk management program were present in the results. For example, pumps from opposite trains of one system would not be taken out of service for test and maintenance concurrently. After further review, this was due to process rules used by SAPHIRE and the SPAR models. This results in higher risk results and could account for some of the larger CDF values.

V. FUTURE WORK

The assumptions used to perform this analysis were very conservative, given that many licensees would not exceed their front-stop LCOs unless conditions warranted such action and, in addition, licensees carefully manage the unavailability of safety-related and risk significant SSCs under the maintenance rule. Further analysis of the impacts of Initiative 4b could account for the specific RICTs allowed for each SSCs for a given set of plant designs. In addition, estimates could be performed on the number of surveillance tests for each SSCs. This additional work could result in a more realistic assessment of Initiative 4b's impact on the unavailability of the SSCs for each site.

VI. CONCLUSIONS

The analysis attempted to characterize an assessment of the impact of Initiative 4b to the plant's baseline CDF and to assess the change to CDF against establish NRC guidelines and risk thresholds. Overall, for the sensitivity cases were the unavailability was increased by 2-times and 5-times the nominal unavailability, the increase to the baseline risk and the change in CDF were both within the licensee's ability to assess and manage. However, it has been noted above and warrants noting again that licensee's would not routinely enter the RICT and the impacts to the unavailability of those SSCs would be constrained by the Maintenance Rule and their technical specifications. For the conservative case of extending the unavailability to the 30-day backstop, it was clear that the plant baseline risk and resultant change in CDF were high and would not be acceptable to licensees for normal operations. It is also important to note that the plants would still be safe even under such a conservative assumption and the CDF and change in CDF are still below NRC's risk thresholds.

Table III. Results of increased unavailability to the baseline core damage frequency

CDF of Initiative 4B Plants w/corresponding Unavailability							
Power Plant	Nominal Case	2x the Nominal Unavailability	% Increase 1	5x the Nominal Unavailability	% Increase 2	30 Day Unavailability*	% Increase 3
Licensee 1 Plant 1	9.80E-06	1.10E-05	12.2%	1.51E-05	54.1%	9.19E-05	838%
Licensee 1 Plant 2	9.79E-06	1.10E-05	12.4%	1.80E-05	83.9%	1.08E-04	1003%
Licensee 2	7.23E-06	1.08E-05	49.4%	2.83E-05	291.4%	5.08E-05	603%
Licensee 3	4.93E-06	5.64E-06	14.4%	7.89E-06	60.0%	3.56E-05	622%
Licensee 4 Plant 1	8.69E-06	1.04E-05	19.7%	1.66E-05	91.0%	3.17E-05	265%
Licensee 4 Plant 2	1.70E-05	2.00E-05	17.6%	2.97E-05	74.7%	7.00E-05	312%
Licensee 5	1.10E-05	1.34E-05	21.8%	1.80E-05	63.6%	6.21E-05	465%
Licensee 6	1.94E-06	2.39E-06	23.2%	2.89E-06	49.0%	1.68E-05	766%
Licensee 7	1.04E-05	1.47E-05	41.3%	2.86E-05	175.0%	6.38E-05	513%

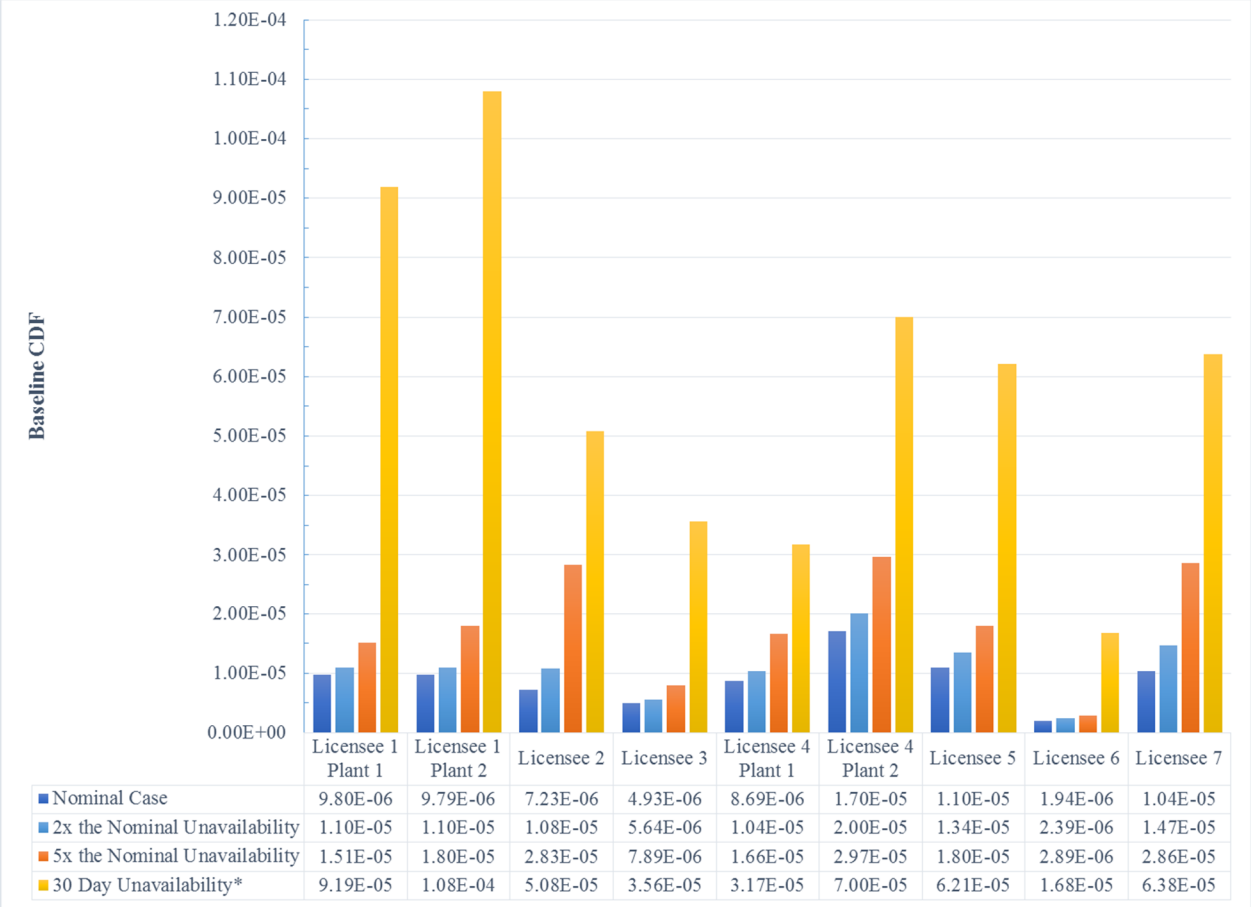

Figure 2. Results of increased unavailability to the baseline core damage frequency
(*Licensees are not allowed and would not routinely allow all SSCs to be unavailable out to the 30 day backstop)

Table IV. Results of increased unavailability to the change in core damage frequency

ΔCDF of Initiative 4B Plants w/corresponding Unavailability							
Power Plant	Nominal Case	2x the Nominal Unavailability	ΔCDF	5x the Nominal Unavailability	ΔCDF	30 Day Unavailability*	ΔCDF
Licensee 1 Plant 1	9.80E-06	1.10E-05	1.20E-06	1.51E-05	5.30E-06	9.19E-05	8.21E-05
Licensee 1 Plant 2	9.79E-06	1.10E-05	1.21E-06	1.80E-05	8.21E-06	1.08E-04	9.82E-05
Licensee 2	7.23E-06	1.08E-05	3.57E-06	2.83E-05	2.11E-05	5.08E-05	4.36E-05
Licensee 3	4.93E-06	5.64E-06	7.10E-07	7.89E-06	2.96E-06	3.56E-05	3.07E-05
Licensee 4 Plant 1	8.69E-06	1.04E-05	1.71E-06	1.66E-05	7.91E-06	3.17E-05	2.30E-05
Licensee 4 Plant 2	1.70E-05	2.00E-05	3.00E-06	2.97E-05	1.27E-05	7.00E-05	5.30E-05
Licensee 5	1.10E-05	1.34E-05	2.40E-06	1.80E-05	7.00E-06	6.21E-05	5.11E-05
Licensee 6	1.94E-06	2.39E-06	4.50E-07	2.89E-06	9.50E-07	1.68E-05	1.49E-05
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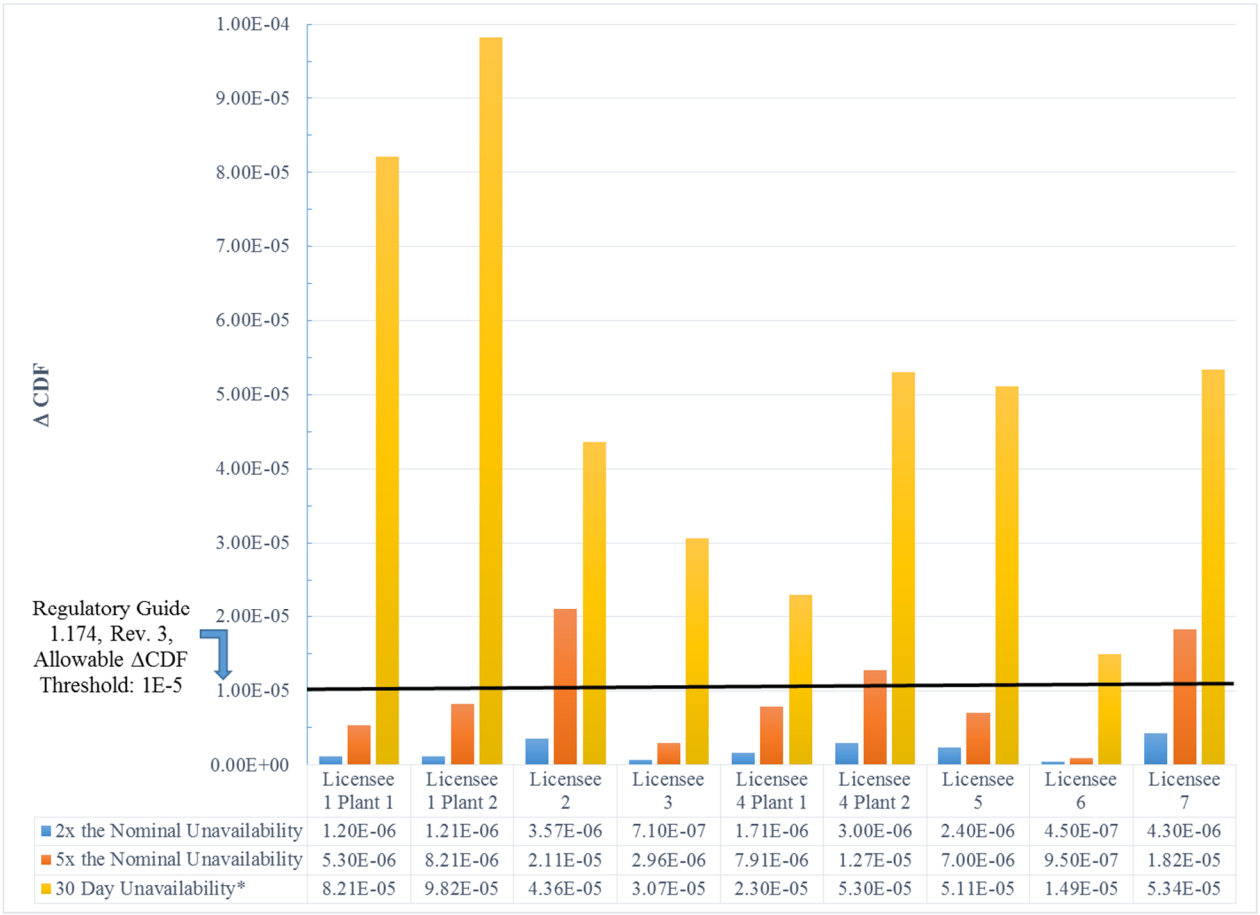

Figure 3. Results of increased unavailability to the change in core damage frequency
(*Licensees are not allowed and would not routinely allow all SSCs to be unavailable out to the 30 day backstop)

ACKNOWLEDGMENTS

The author would like to thank Josiah Bazyler and Candace Spore for their support during the development of this paper.

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