UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

September 19, 2013

Mr. Mark A. Satorius
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: DRAFT COMMISSION PAPER, "RECOMMENDATIONS FOR RISK-INFORMING THE REACTOR OVERSIGHT PROCESS FOR NEW REACTORS"

Dear Mr. Satorius:

During the 607th meeting of the Advisory Committee on Reactor Safeguards, September 5-7, 2013, we completed our review of the Draft Commission Paper, "Recommendations for Risk-Informing the Reactor Oversight Process for New Reactors," dated June 24, 2013. Our Reliability and PRA Subcommittee also reviewed this matter during a meeting held on July 22, 2013. During these meetings, we had the benefit of discussions with representatives of the NRC staff and the industry. We also had the benefit of the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. It is essential that the reactor oversight process (ROP) for new reactors remains objective, risk-informed, understandable, and predictable. An increased reliance on qualitative assessments deserves close scrutiny.

2. The staff should develop guidance for the structured evaluation of qualitative measures, regardless of whether absolute or relative measures are used for the quantitative assessment of risk significance.

3. The staff should develop an integrated significance determination process (SDP) that places primary reliance on the use of quantitative measures of the change in risk, supplemented as necessary by qualitative assessments of conditions that are not evaluated fully in the supporting plant risk models. We encourage the staff to continue exploration of relative risk measures.

4. We concur with the staff's recommendation to further analyze the current licensee performance indicators and to develop additional indicators, thresholds, and guidance as appropriate for monitoring the cornerstone performance objectives for new reactors.

BACKGROUND

Our letter reports of April 26, 2012, and July 17, 2012, contained recommendations regarding the risk-informed regulatory framework for new reactors that was discussed in SECY-12-0081. In its Staff Requirements Memorandum (SRM) on SECY-12-0081, the Commission directed the staff to develop a notation vote paper that provides:

1. a technical basis for the staff's proposal for the use of deterministic backstops, including examples;
2. a technical evaluation of the use of relative risk measures, including a reexamination of the pros and cons listed in the staff's 2009 white paper; and
3. a discussion of the appropriateness of the existing performance indicators and the related thresholds for new reactors.

The June 24, 2013 Draft Commission Paper, "Recommendations for Risk-Informing the Reactor Oversight Process for New Reactors," addresses these issues. The draft paper uses the term "qualitative measures" rather than "deterministic backstops" to better characterize the staff's intended use of qualitative considerations in an integrated risk-informed SDP.

The draft paper has concluded that the use of relative measures to evaluate the change in risk is not a viable option for assessing the safety significance of inspection findings. It contains two recommendations for consideration by the Commission:

> “Commission approves the staff's plans to further develop the qualitative measures used to supplement the risk evaluations and the integrated risk-informed approach for evaluating the safety significance of inspection findings to ensure an appropriate regulatory response to performance issues for new reactor designs.”

> “Commission approves the staff’s plans to further analyze the current PIs and thresholds and develop appropriate PIs and thresholds for new reactor applications, particularly for those PIs noted in the Initiating Events and Mitigating Systems cornerstones, or develop additional inspection guidance to address any shortfalls to ensure that all cornerstone objectives are adequately met.”

DISCUSSION

Our review focused primarily on the issues that pertain to items 1 and 2 from the SRM on SECY-12-0081 and the first recommendation in the draft paper (i.e., the use of qualitative measures in the SDP, and the advantages and disadvantages of using absolute or relative quantitative measures of risk significance). Our intention is to preserve the integrated decision making process that is central to Regulatory Guide 1.174.

Qualitative Measures

The staff was directed to determine how the existing SDP should be revised to address issues posed by new reactor plant designs. The proposed qualitative assessment process can be viewed as filling an important gap in the SDP. Some new reactor designs rely on passive safety functions to survive with no active equipment operating. However, they often rely on delicate hydraulic balances and small thermo-hydraulic driving head to achieve success. These new designs have not endured the trials of real-world operation, which often reveal unexpected dependencies and unanticipated failure modes. When inspection findings or emergent conditions raise questions about these safety functions, the regulatory assessment process should account for uncertainty that could affect safety conclusions. The qualitative approach proposed by the staff can serve that purpose, and it is the necessary first step in providing a consistent SDP over all plant designs. Before uncertainties can be analyzed quantitatively, they must be identified, understood, and evaluated qualitatively.

The conceptual framework for the evaluation of qualitative measures that is proposed in Enclosure 2 to the draft paper facilitates consistency and transparency of significance assessments that are not supported fully by quantitative risk evaluations. Qualitative evaluations are an important input to the SDP when the identified conditions affect degradation of structures, systems, and components (SSCs) which are either not included explicitly in the probabilistic risk assessment (PRA) models or whose quantitative evaluations contain very large uncertainties. Qualitative evaluations can provide important insights about the available safety margins for passive plant features and functions whose degree of degradation is not readily quantified in most PRA models (e.g., cracking in concrete structures or piping systems, corrosion, reductions in heat transfer properties, etc.). As demonstrated in Enclosure 2 of the draft paper, qualitative assessments can also be used to provide additional confidence in significance findings that are derived primarily from quantitative risk-informed evaluations.

Moving forward with an SDP supplemented by a qualitative evaluation scheme for issues that are not amenable to analysis using currently applied PRA methods or models provides a way to resolve inspection findings through a synthesis of "rationalist" and "structuralist" concepts, until agreement can be reached on proper quantification approaches. The staff has proposed what is essentially a structuralist framework, via a standardized evaluation matrix, to ensure that potentially important contributors to risk are given due consideration. We expect that the evaluation system would be developed such that the results of this process would be conservative. Instances will occur where disagreement over this conservatism would constitute strong motivation to advance the state-of-the-art of PRA. This should lead to evolutionary development of new tools for evaluation of phenomenological issues of importance to new reactors and possibly applicable to older designs as well. In the interim, a structured qualitative assessment framework will force evaluators to address these potentially important issues, before we learn from bitter experience.

The staff noted that the proposed framework is only a concept to illustrate how qualitative assessments could be integrated with quantitative evaluations. An increased reliance on qualitative assessments deserves close scrutiny. Supporting guidance for that assessment process would need to address several issues that are not developed in the proposed concept, such as:

- unambiguous definitions of the attributes for defense-in-depth, safety margins, condition time, and qualitative credit;
- guidance and examples for assessing the degrees of degradation for each attribute;
- treatment of logical and functional relationships among the qualitative metrics and their degrees of degradation, particularly those affecting defense-in-depth and safety margins and the relationship of those metrics to condition time and qualitative credit; and
- treatment of logical and functional relationships between the qualitative metrics and PRA models for the affected SSCs and personnel actions, when both quantitative and qualitative measures are used to inform the significance determination.

Quantitative Measures

We question the staff's conclusion in the draft paper that the use of relative numerical risk measures is not a viable option for determining the significance of events, emergent plant conditions, and inspection findings. The draft paper recognizes that the fundamental goals of the ROP are to provide a process that is objective, risk-informed, understandable, and predictable. The current SDP places primary emphasis on the use of PRA models and their quantitative results to inform conclusions about plant-specific conditions that merit enhanced regulatory attention. That process has evolved over several years of practical application, and it is well understood by the staff and current licensees. The staff's proposed use of absolute numerical risk measures and increased reliance on qualitative assessments in the SDP is a departure from the ROP goals.

Results from the tabletop exercises and the staff's examples in the draft paper indicate that the significance evaluations for new plants, with much lower frequencies of core damage and large releases, will depart further from an objective quantitative risk-informed assessment and will rely more fundamentally on qualitative judgments. This change is a significant departure from the Commission's policy of integrating quantitative risk information into the regulatory decision making process.

The subsidiary arguments offered in the draft paper about difficulties in performing relative risk evaluations are perplexing. Our proposed use of relative numerical measures of risk significance evolved from the staff's observations that quantitative results from the initial tabletop exercises did not directly elicit the desired degree of enhanced regulatory attention for some degraded safety conditions at new reactors. We noted that a different conceptual construct, namely that of measuring the relative change in risk, could resolve that quandary for many issues that can be readily quantified in the plant risk models.

In our letter report of April 26, 2012, we shared an example construct of a quantitative relative risk-informed approach to the SDP. The intent was to provide a concept for exploring alternatives. As a matter of expedience, our conceptual representation of that construct contained numerical values to facilitate a few illustrative examples of its use. However, those values were not intended to be prescriptive recommendations, and we noted that:

> "This concept should be implemented by consistently extending the decision framework of Regulatory Guide 1.174. Appropriate values for these metrics, the shapes, and the slopes of the significance determination transitions would be developed through stakeholder interactions, informed by the available tabletop exercises or an expanded set of case studies."

The staff performed several tabletop applications using our construct which exhibited an upward shift in their quantified significance. Based on these results, the staff and some stakeholders concluded that a relative quantitative approach is ineffective and insufficient. Those conclusions and parallel criticisms of the qualitative assessment concepts suffer from premature use of simplified conceptual proposals that should not be construed as final guidance.

The notion that significance is characterized by the relative change in risk, compared to a baseline measure of that risk, is consistent with the fundamental decision framework in Regulatory Guide 1.174. The developers of that guidance faced similar challenges to translate their initial concepts into a pragmatic framework that is now well understood and accepted by the staff and licensees. This was achieved by developing an integrated decision making process that allows synthesis of both qualitative and quantitative metrics.

The proposed use of relative risk measures in the SDP is not intended to draw conclusions about the absolute level of safety for any plant. It is intended to provide an objective quantitative risk-informed scale against which the erosion of baseline safety margins can be measured to inform the need for enhanced regulatory attention to the causes for the departure and corrective actions that are planned to restore those margins. In developing this scale, it is important not to unduly penalize good plant designs.

Many of the perceived impediments discussed in Enclosure 3 to the draft paper are not associated uniquely with new reactors or the use of relative risk measures to inform the SDP. For example, differences in the scope, level of detail, assumptions, and data in the staff's Standardized Plant Analysis Risk (SPAR) model and the licensee's PRA may result in differing assessments of the quantitative significance of an identified condition. That situation is often encountered in the current ROP and SDP. The staff and licensees have demonstrated their abilities to use the PRA models to effectively communicate and compare the technical bases for these differences and to reach a common basis for understanding the assessed safety significance. Reliance on objective technical information is a key element that supports confidence in the consistency and predictability of the ROP, and it should remain so in the future. Furthermore, concerns about differences among licensee PRAs and the SPAR models are much less relevant for new plants that are licensed under 10 CFR Part 52, which will have a clearly defined PRA scope and quality by the time that fuel is loaded into each reactor.

Integrated Risk-Informed Significance Determination Approach

We encourage the staff to continue exploration of the use of relative risk measures as the quantitative metrics for evaluating the significance of events, emergent plant conditions, and inspection findings. The staff should develop an integrated SDP that places primary reliance on the use of quantitative measures of the change in risk, supplemented as necessary by qualitative assessments of conditions that are not evaluated fully in the supporting plant risk models.

The proposed framework for assessment of qualitative measures facilitates consistency and transparency of significance determinations that are not supported fully by quantitative risk evaluations. The staff should develop guidance for the structured evaluation of qualitative measures, regardless of whether absolute or relative measures are used for the quantitative assessment of risk significance.

Performance Indicators

We were briefed on the staff's considerations regarding appropriateness of the existing performance indicators and their use for new reactors. We concur with the staff's recommendation to further analyze the current performance indicators and to develop additional indicators, thresholds, and guidance as appropriate for monitoring the cornerstone performance objectives for new reactors.

Sincerely,

/RA/

J. Sam Armijo
Chairman

A perspective on comparative evaluations is provided by the attached paper written by Member Mr. John W. Stetkar.

REFERENCES

1. Memorandum to E. Hackett, “Transmittal of Draft Commission Paper on Recommendations for Risk-Informing the Reactor Oversight Process for New Reactors,” June 24, 2013 (ML13169A406)

2. SECY-12-0081, "Risk-Informed Regulatory Framework for New Reactors," June 6, 2012 (ML12117A012)

3. Letter to R. Borchardt, "Draft Commission Paper, 'Risk-Informed Regulatory Framework for New Reactors’," ACRS Letter Report, April 26, 2012 (ML12107A199)

4. Letter to A. Macfarlane, "Risk-Informed Regulatory Framework for New Reactors," ACRS Letter Report, July 17, 2012 (ML12198A185)

5. Staff Requirements Memorandum on SECY-12-0081, "Risk-Informed Regulatory Framework for New Reactors," October 22, 2012 (ML12296A158)

6. Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Revision 2, U.S. Nuclear Regulatory Commission, Washington, DC, May 2011 (ML100910006)

7. Letter to S. Jackson, “The Role of Defense In Depth in a Risk-informed Regulatory System,” ACRS Letter Report, May 19, 1999 (ML091280427)

White Paper
Some Comparative Evaluations
John W. Stetkar

The numerical examples in this white paper are intended as illustrative counterpoints to two issues that are elaborated in the June 24, 2013, Draft Commission Paper. They admittedly suffer from the pitfalls that are discussed in the main body of the ACRS letter report. In particular, the examples use numerical values from the relative risk measures concept as it is presented in Enclosure 3 of the June 24, 2013, Draft Commission Paper, and they use the specific safety attributes and their assessment matrix from the qualitative measures concept as it is presented in Enclosure 2 of that paper. As in the draft paper, those values are used here as if they were mature elements of an integrated risk-informed decision making process. They are not. They are simply comparative constructs that are intended to prompt reasoned thought and discussion about the more fundamental underlying concepts.

Issue 1
Significance Determinations from Combined Absolute Numerical Risk Measures and Qualitative Measures vs. Significance Determinations from "Purely Relative" Numerical Risk Measures

Table 1 in Enclosure 3 to the June 24, 2013, Draft Commission Paper summarizes the results from several tabletop exercises that compared the use of absolute numerical risk measures and "purely relative" numerical risk measures to evaluate the significance of selected conditions for a variety of new plant designs.

Enclosure 2 to the draft paper contains three examples which illustrate how the proposed use of absolute numerical risk measures in the quantitative risk evaluations, supplemented by a structured assessment of qualitative measures, might be used to provide a composite significance determination. The final significance conclusions for two of the three examples are determined entirely by the qualitative evaluations. The third conclusion depends strongly on the assessment of one qualitative measure.

The following comparisons apply the proposed relative numerical risk measures to the three examples from Enclosure 2 and demonstrate that the same significance conclusions could be reached from a purely quantitative risk-informed assessment, without the supplemental qualitative evaluations. It is thus not apparent why the additional complexity of the qualitative assessments is necessary to elicit the desired degree of enhanced regulatory attention for these specific safety deficiencies.

Example 1 – US-APWR Turbine-Driven Emergency Feedwater Pump

The first example in Enclosure 2 of the draft paper evaluates a condition with one US-APWR turbine-driven emergency feedwater (TDEFW) pump unavailable for 3 months. The quantified ΔCDF from the US-APWR SPAR model (which does not include seismic events) is 7.7E-06 event per year. That numerical value would produce a WHITE significance finding if only the absolute numerical risk thresholds were applied.

The assessment in Enclosure 2 evaluates defense-in-depth as "moderately degraded", safety margins as "degraded", and condition time as "significantly degraded". Two examples are shown for qualitative credit. If qualitative credit is not applied, the overall qualitative rating is "degraded", and the assigned composite significance is YELLOW. If qualitative credit is applied, the overall qualitative rating is "moderately degraded", and the assigned composite significance is WHITE. Thus, in this case, the final determination of YELLOW or WHITE significance depends on the assessment of qualitative credit.

The US-APWR examples in Table 1 of Enclosure 3 do not evaluate precisely the same condition as the example in Enclosure 2. However, if one TDEFW pump fails and is unavailable for 1 year, the quantified ∆CDF value is either 3.4E-06 event per year or 2.2E-05 event per year, depending on the particular PRA model that is used for the analysis (i.e., the MHI model or the SPAR model). Neither of the models used for those analyses include seismic events. From Table 1, it is evident that application of the "purely relative threshold" for an intermediate ∆CDF value of 7.7E-06 event per year would result in an assigned significance near the YELLOW-RED transition. The actual assigned significance depends on the baseline CDF and the reasons for the differences between the two PRA models. Based on the available information, it is likely that the numerical assessment would fall near the high end of the YELLOW significance range.

According to these comparisons, use of the relative risk measures alone would provide quantitative results that directly support a YELLOW significance finding. The same YELLOW significance is derived from the use of absolute risk measures and the performance of additional qualitative assessments, but without the consideration of qualitative credit.

According to the discussion in Enclosure 2, any applied qualitative credit accounts for mitigation equipment and personnel actions that are not evaluated explicitly in the PRA. Therefore, as was done in the qualitative assessment, the evaluators could also apply credit for those features to adjust the significance that was derived directly from the relative risk measures, resulting in a reduction from YELLOW to WHITE. However, in that case, the evaluators would need to conclude that the available qualitative credit is sufficiently robust to reduce the significance from the high end of the YELLOW range, rather than to simply reduce the significance by a single discrete qualitative step.

Example 2 – AP1000 Passive Residual Heat Removal Heat Exchanger

The second example in Enclosure 2 of the draft paper evaluates a condition with the AP1000 passive residual heat removal (PRHR) heat exchanger unavailable for 1 year. The quantified ∆CDF from the AP1000 SPAR model is 2.84E-06 event per year. That numerical value would produce a WHITE significance finding if only the absolute numerical risk thresholds were applied.

The assessment in Enclosure 2 evaluates defense-in-depth as "degraded", safety margins as "degraded", and condition time as "significantly degraded". Qualitative credit is applied. The overall qualitative rating is "degraded", and the assigned composite significance is YELLOW.

Table 1 in Enclosure 3 does not contain an analogous AP1000 example. However, if the AP1000 baseline CDF is on the order of 3E-07 event per year (without the quantification of seismic events), application of the "purely relative threshold" for a ΔCDF value of 2.84E-06 event per year would directly support YELLOW significance without a supplemental qualitative assessment.

Example 3 – ABWR Reactor Core Isolation Cooling Pump

The third example in Enclosure 2 of the draft paper evaluates a condition with the ABWR reactor core isolation cooling (RCIC) pump unavailable for 3 months. The quantified ΔCDF from the ABWR SPAR model is 5.3E-08 event per year. That numerical value would produce a GREEN significance finding if only the absolute numerical risk thresholds were applied.

The assessment in Enclosure 2 evaluates defense-in-depth as "moderately degraded", safety margins as "negligibly degraded", and condition time as "significantly degraded". No additional qualitative credit is applied. The overall qualitative rating is "moderately degraded", and the assigned composite significance is GREEN.

It is not evident why safety margins are assessed as "negligibly degraded" for this condition. If safety margins were assessed as "degraded", the overall qualitative rating would have been "degraded", and the assessment would have increased the nominal GREEN significance to WHITE. Thus, the assigned composite significance from the qualitative evaluation could be GREEN or WHITE, depending on the safety margin assessment.

The ABWR examples in Table 1 of Enclosure 3 do not evaluate precisely the same condition. An example in Table 1 indicates that unavailability of the RCIC pump for 1 year results in a quantified ΔCDF of 4.1E-07 event per year from the ABWR SPAR model. Application of the "purely relative threshold" for a ΔCDF value of 4.1E-07 event per year results in an assigned significance of WHITE. Other ABWR examples in Table 1 indicate that application of the "purely relative threshold" for ΔCDF values of 4.8E-08 event per year and 2.2E-07 event per year result in an assigned significance of GREEN. Based on that information, application of the "purely relative threshold" for a ΔCDF value of 5.3E-08 event per year would directly support an assigned significance in the GREEN range without a supplemental qualitative assessment.

Issue 2
Public Perception of Comparative Plant Risk

The staff and the industry noted that use of relative risk measures could cause public confusion about the meaning of a particular significance finding for plants with very different baseline core damage frequencies (CDFs). For example, according to the illustrative construct in Enclosure 3 of the draft paper, use of the relative risk measures would trigger a WHITE significance finding for the following conditions:

Baseline CDF (event per year)	CDF with the Identified Condition (event per year)	Increase in CDF for WHITE Finding
1E-04	1.01E-04	1 %
1E-06	1.32E-06	32 %
1E-08	1.10E-07	1,000 %

The conditions that trigger a WHITE finding for a plant with a baseline CDF of 1E-04 event per year are consistent with the current SDP, and they would not change with use of the proposed relative risk measures. Progressively larger percentage increases in CDF are needed to trigger the same level of regulatory attention for plants that have much lower overall risk.

Concern was noted that the same WHITE significance finding for three plants with projected CDF values of 1.01E-04, 1.32E-06, and 1.10E-07 event per year could cause public confusion about the risks from those plants. That concern would not be resolved by the proposed use of absolute risk measures, with increased reliance on qualitative evaluations. The examples in Enclosure 2 to the draft paper show that WHITE or YELLOW significance findings could similarly result from that combined assessment process, despite small projected increases in the absolute CDF values.

Public understanding and confidence would be facilitated by explaining that this process raises an early warning if a 1000% increase in CDF occurs at a plant with a very low baseline CDF, and it raises that same early warning if a 1% increase in CDF occurs at a plant with a relatively high baseline CDF. Those differences arise because the second plant has much less available risk margin, compared to the first. The equivalent significance findings are simply used as indicators to trigger consistent levels of progressively enhanced regulatory attention, while each plant continues to maintain an acceptable absolute level of overall safety.

Baseline CDF (event per year)	CDF with the Identified Condition (event per year)	Increase in CDF for WHITE Finding
1E-04	1.01E-04	1 %
1E-06	1.32E-06	32 %
1E-08	1.10E-07	1,000 %

The conditions that trigger a WHITE finding for a plant with a baseline CDF of 1E-04 event per year are consistent with the current SDP, and they would not change with use of the proposed relative risk measures. Progressively larger percentage increases in CDF are needed to trigger the same level of regulatory attention for plants that have much lower overall risk.

Concern was noted that the same WHITE significance finding for three plants with projected CDF values of 1.01E-04, 1.32E-06, and 1.10E-07 event per year could cause public confusion about the risks from those plants. That concern would not be resolved by the proposed use of absolute risk measures, with increased reliance on qualitative evaluations. The examples in Enclosure 2 to the draft paper show that WHITE or YELLOW significance findings could similarly result from that combined assessment process, despite small projected increases in the absolute CDF values.

Public understanding and confidence would be facilitated by explaining that this process raises an early warning if a 1000% increase in CDF occurs at a plant with a very low baseline CDF, and it raises that same early warning if a 1% increase in CDF occurs at a plant with a relatively high baseline CDF. Those differences arise because the second plant has much less available risk margin, compared to the first. The equivalent significance findings are simply used as indicators to trigger consistent levels of progressively enhanced regulatory attention, while each plant continues to maintain an acceptable absolute level of overall safety.

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