ANS RIPB Community of Practice

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Modernization of the ANS Standard for Meteorological Impacts to the Ultimate Heat Sink

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ANS RIPB Community of Practice -- March 27, 2020

AGENDA

1. ANS-2.21 overview (draft)
2. RIPB knowledge base
3. Traditional methods vs. "Risk-informed"
4. ANS-2.21 WG challenges

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1. ANS-2.21 Overview (Draft)

"Criteria for Assessing Atmospheric Effects on the Ultimate Heat Sink"

- "This standard establishes criteria for the use of meteorological and supporting hydrologic data to determine whether the design water temperature and cooling capacity requirements for the ultimate heat sink (UHS) are adequately established."
- "This standard also describes atmospheric effects for consideration when designing ultimate heat sinks for safety-related systems at nuclear power plants such that cooling capacity requirements are not exceeded during a License Basis Event (LBE)."
- "This standard is intended to apply to new nuclear plants or the redesign of the cooling systems at existing nuclear plants. Risk-informed and performance-based requirements have been incorporated into this standard."

ANS-2.21 **Draft** Contents…

5. Summary of Atmospheric Effects by UHS type

5.1 Common Heat Transfer and Water Balance Processes

5.2 Closed-cycle Systems
(cooling/spray pond and lakes, wet/dry cooling towers)

5.3 Open-cycle Systems
(rivers, reservoirs, lakes, bays, costal waterbodies)

6. Meteorological and Environmental Data for Quantification of Atmospheric Effects

6.1 Data Sources

6.2 Representativeness of Data Obtained from Offsite Sources

6.3 Meteorological and Hydrological Parameters of Interest

6.4 Climate Change Considerations

6.5 Quality Assurance and Required Records

2. RIPB Knowledge Base

- **Added Section 4 to define RIPB and approach**

NRC whitepaper definition (1999):

"… an approach in which risk insights, engineering analysis and judgment (including the principle of defense-in-depth and the incorporation of safety margins), and performance history are used, to (1) focus attention on the most important activities, (2) establish objective criteria for evaluating performance, (3) develop measurable or calculable parameters for monitoring system and licensee performance, (4) provide flexibility to determine how to meet the established performance criteria in a way that will encourage and reward improved outcomes, and (5) focus on the results as the primary basis for regulatory decision-making."

https://www.nrc.gov/about-nrc/regulatory/risk-informed/concept.html

ANS-2.21 Approach (Draft):

As a practical matter, UHS performance can be addressed in two ways:

Deterministic approach: *The analysis can strive to predict the absolute worst outcomes for the performance of the UHS, e.g., maximum return temperature and 30-day water use, taking into account the most severe meteorological conditions, heat loads, and other physical factors, in combination with a conservative safety factor to account for uncertainties in models and parameters, randomness of meteorological data, and climate change.*

Risk-based, probabilistic approach: *Recognize that there would be a range of performances from the UHS, depending on when the accident event occurs, and the randomness of the meteorological input data. Results of calculations of performance can be assigned a probability or a recurrence interval that can be factored into an overall probabilistic performance assessment.*

****NRC Reviewer's concern:** Need to maintain distinction that RIPB applies to engineering, but not to the input data or data quality.

3. Traditional Methods vs. "Risk-informed"

Risk and uncertainty issues:

a. Environmental inputs and assumptions (risk scenarios; frequency and persistence)

b. Climate change (future uncertainty)

"While both the deterministic and probabilistic approaches to performance evaluation require a long meteorological data record to address aleatory, they use those data in different ways.

- The deterministic approach maximizes the anticipated peak temperature so that there would be an extremely small chance that UHS performance will be worse than anticipated.
- <u>The probabilistic approach recognizes that there is a range of performance outcomes and a quantifiable recurrence interval for that range of outcomes.</u>

Both approaches must deal with …uncertainty in their models, often by using factors of safety. A major difference between deterministic and probabilistic approaches however is that the latter generally requires a large number of computer runs that necessitate the use of simpler and fast-running models."

ANS-2.21 **Draft** Contents…

- **Apply either or both RIPB in the data analysis and UHS modeling assessments**.

But, UHS modeling is outside the scope of ANS-2.21.

- **Added Appendix A** to provide examples of deterministic and risk-informed approaches to UHS performance analyses.

<u>Length of Datasets </u>Needed to Quantify Atmospheric Effects:

<u>**Section 6**</u>

- **Input historical datasets** need to be local, continuous, complete and of long duration (**30 or more years).**
- Due to the lengthy period between UHS design…licensing,… construction, and extended lifetime of a plant, **50-100 years of [input] data is recommended** for <u>[future] projections of UHS performance out to 100 years</u>…at the design phase.
- Development of surrogate datasets will likely be necessary, combining data from onsite and offsite sources.

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6.4 Climate Change Considerations

- Recommends making 100 year projections of environmental conditions to capture at least 80 years for the potential operating life of plant, allowing for license renewal.
- Suggests regional downscaling from Global Climate Models by either statistical downscaling, or performing dynamic, nested grid model runs (preferred), which would include local terrain impacts.
- Suggests using either predicted climate data for the UHS performance model inputs, or the observed climate trend(s) and cumulative probability curve from the input data itself.

Appendix A:

- The "**deterministic hypothetical example**" uses a statistical approach that normalizes the input data to remove the climate change trend and then reintroduces the climate trend by adjusting the resulting peak water temperature.

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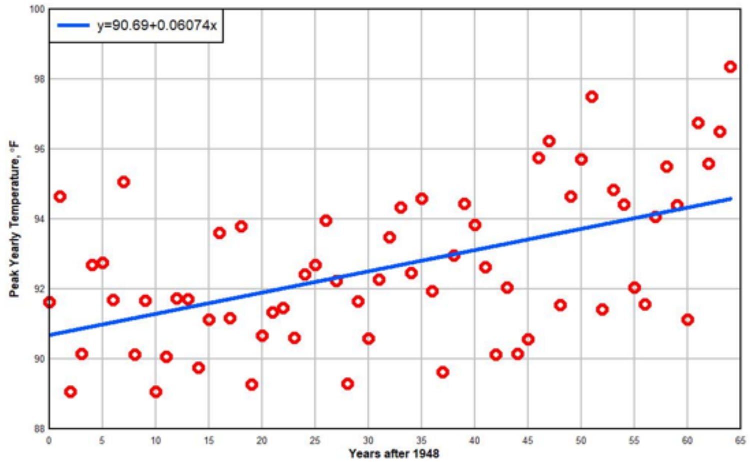

Figure 8-1 Yearly Peak Return Temperatures, with Linear Regression

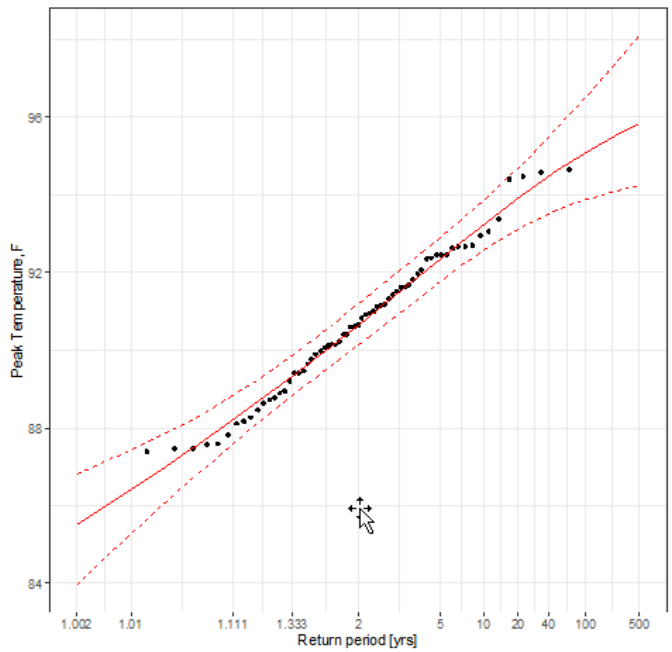

Figure 8-2 Frequency Analysis of Peak Annual De-trended Pond Temperatures with 95% Confidence Intervals

Appendix A

Hypothetical, Deterministic Example

Appendix A – Realistic, Deterministic Example

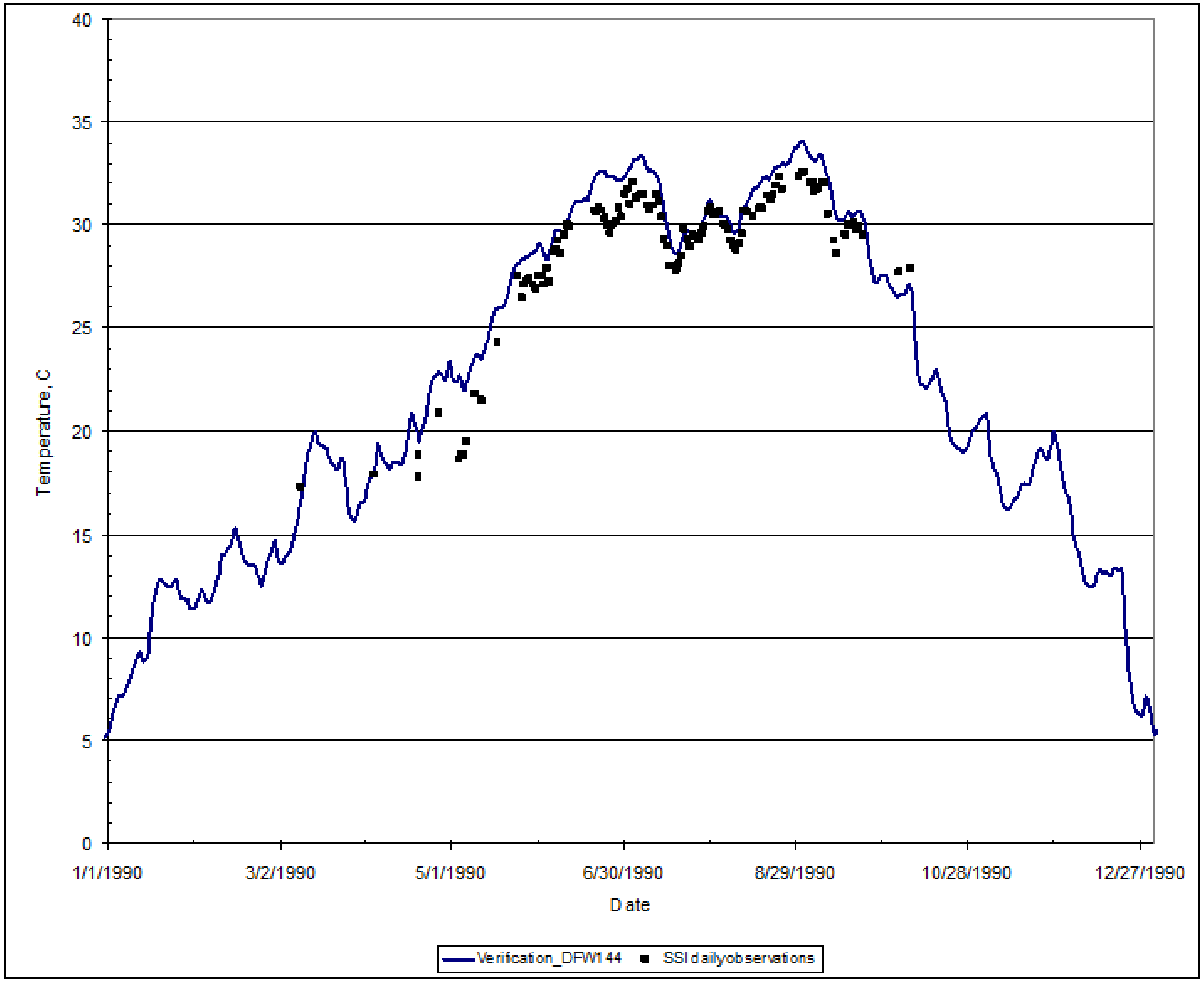

Figure 8-3 Observed and computed pond temperatures for 1990 model verification

Appendix A – Risk Informed Example

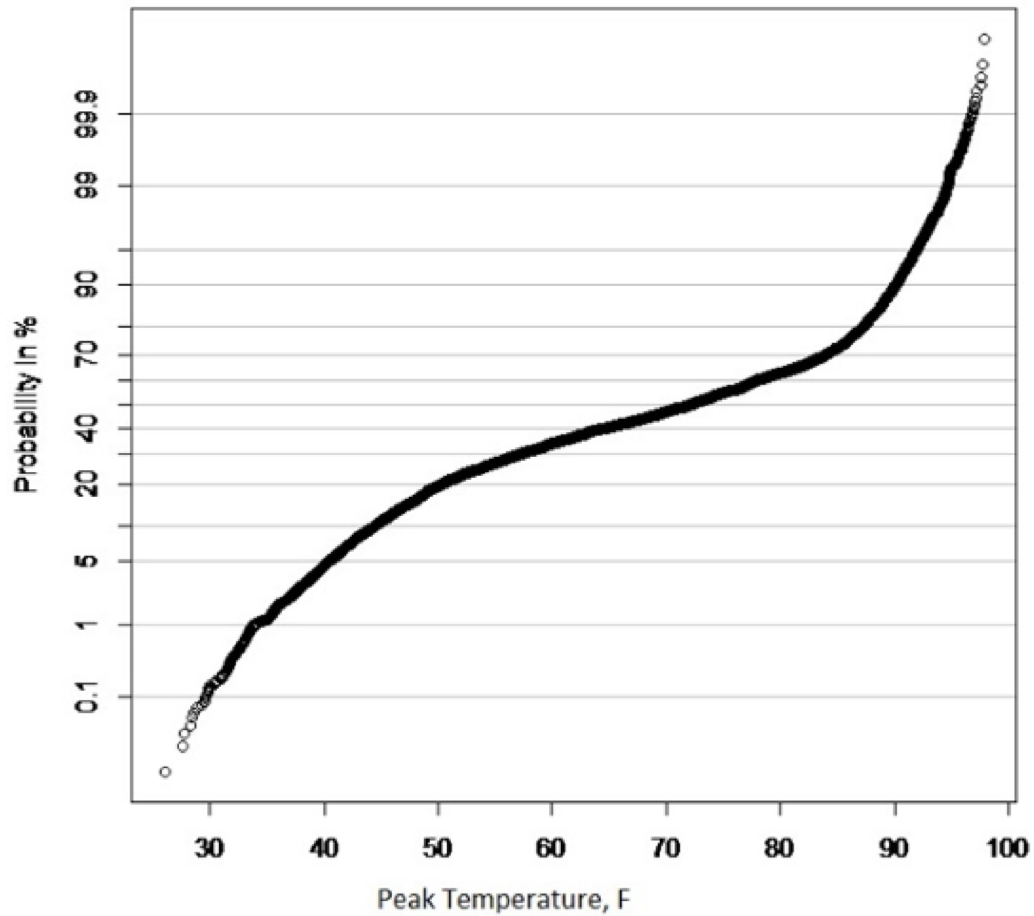

Figure 8-4 Cumulative Probability of Peak Water Temperatures for Entire Meteorological Record

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Environmental or Climate Change Risk:

- The "**risk-informed example**" in **Appendix A** determines the cumulative probability of peak water temperatures and uses the 99th percentile value.
- Assumes climate change is either ongoing and observed, or is projected in the input data for the UHS model.
- Adjustments to a simplistic risk informed model are suggested, based on a more complex model:

"One disadvantage of the risk based approach as applied here is that it must generally rely on simple performance models, as the use of sophisticated multidimensional models as used in the second example would be impractical to use for producing the large number of potential outcomes to make probability estimates. This could be partially overcome by using a combination of models; e.g., a few runs using sophisticated models to adjust the simple models to produce similar results."

4. ANS-2.21 WG Challenges

- Scope & schedule
- Content consistent with literature
- Multiple types of UHS
- Accepted practices
- Diverse user skillsets and experience
- **What are suitable RIPB approaches for the particular situation?**

SOLUTION: Collaboration
(engineers and meteorologists)

- ❑ Identify RISK areas or issues and address them with probabilistic risk analysis or other means.
- ❑ Obtain independent SME feedback from climate change modelers and PRA modelers.

QUESTIONS

&

SUGGESTIONS?

Next CoP Discussion

Date: Friday, April 24, at 3:00 p.m. Eastern

Topic:

Lead:

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RIPB CoP Related Links

- Access the RIPB CoP site on ANS Collaborate at
  https://collaborate.ans.org/communities/group-home?CommunityKey=0984f3cf-63e2-4c9a-8538-84c2c97c034d

  Then look for the "Join Group" button to stay informed of CoP activities and be included in discussions.

- Find CoP presentations posted on RP3C's public website at http://www.ans.org/standards/rp3c/

  Just scroll down the page to find presentations.

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