Handling Room Cooling in PRA

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Overview

- Current Methods
- Proposed Method
- Results
- Final Considerations

Current Methods

- Based on screening
  - Determine whether EQ limits are exceeded at 24 hours
  - Go / No-Go
- Very conservative
  - Assumes all unscreened equipment necessarily fails at time zero when room cooling is lost
- PWROG projects focus on polling or refining screening criteria

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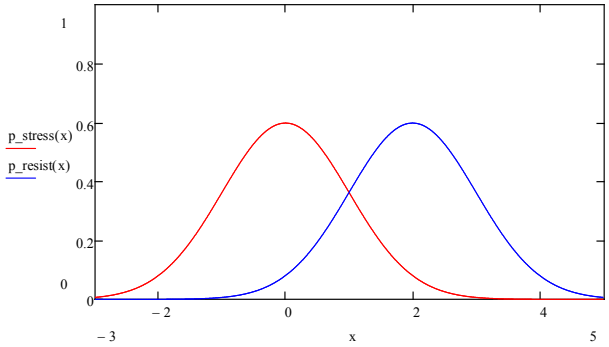
Proposed Method

- Based on interference theory
  - Overlap region between PDFs for *actual* temperatures (stressor) and *allowable* temperatures (resistance)



- Inputs
  - Limiting subcomponent analysis
  - Range of allowable temperatures for the limiting components and expected *heat rise* (difference between the component temperature and ambient)
  - Range of actual temperatures
  - Room heatup curves for several starting room temperatures, for each room

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Analysis

- Analyze the relevant components (pumps, batteries, chargers, switchgear, etc.) for the limiting sub-components and failure modes
- Develop correlations based on heat-up curves for the compartments containing the equipment, including all heat sources, for several starting temperatures
- Generate parameters for PDFs of *allowable* and *actual* component temperatures
- Integrate for the region of failure to develop corresponding probabilities

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Limiting Sub-Components Example

- Technical Specification limitation of 122°F maximum
- Analysis of equipment sub-components for pumps looked at sturdy metallic equipment, lubricants, motor insulation and pump bearings.
  - Need to analyze all components in affected areas for survivability (valves, instrumentation, etc.); example plant limitations were pumps
  - Sturdy components and lubricants were found to be very robust with the limiting components revealed to be the pump bearings
- Bearing failures varied depending on design and installed conditions; oil quality, level of bearing loading (high/light), bearing design (split sleeve/ball bearing), etc.
  - Used to determine the heat rise that bearing would see based on room temperature

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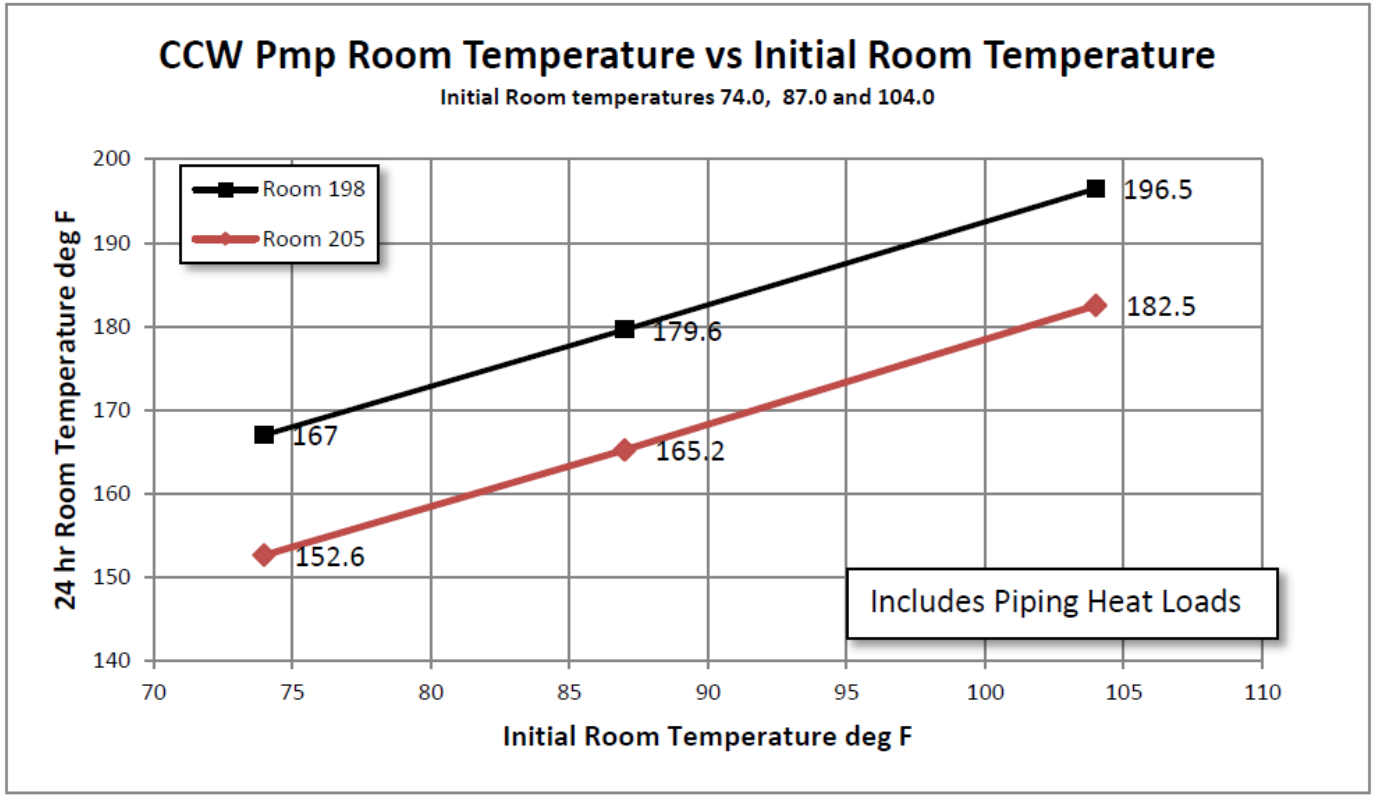
Heatup Calculations

- Used specific initial ambient temperatures over a range of temperatures



Results (Example Plant)

- Most of the final conditional probabilities ranged from about 1E-02 to 0.8
- Median of about 0.2
- One exception for Station Service Water (SW), with a value of 3.68E-03 for each pump, which, for this plant, is reflective of the open pump environment for the SW intake structure

$$P(y>0)=1-\int_{Z}^{\infty}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}z_p^2}dz_p$$

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Final Considerations for the Method

- Has undergone scrutiny from Peer Review and NRC (NOED)
- Promotes realism
- Uncertainties for the inputs should be analyzed
- Dependencies should be addressed
  - We assumed complete dependence for trains of the same system
- Degradation can be accounted for to some extent in the assignment of parameters for the PDFs

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Questions?