Human Reliability Analysis for Using Portable Equipment

Presented to EPRI HRA for FLEX Workshop

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Background

- Implementation of flexible coping strategies (FLEX) following the accident at Fukushima Dai-ichi resulted in the purchase of portable equipment that was specifically intended to support plant shutdown after extreme external events.
- Much of the FLEX portable equipment has the potential to be used as added defense in depth to mitigate the consequences of normal accident scenarios (involving anticipated internal initiating events) where installed plant equipment fails.
- Many nuclear power plants have considered using the portable equipment during normal accident scenarios and are taking credit for the additional equipment and mitigation strategies in their PRAs.

Challenges using Existing HRA Methods for FLEX

- Current HRA methods were not developed to quantify the HEPs associated with the transportation, placement, connection, or local control of portable equipment.
- Current NRC HRA methods (SPAR-H) often assume that these types of actions are not feasible and cannot be credited in the PRA.
- Existing HRA methods may model certain types of actions and some performance shaping factors similar to those associated with the use of portable equipment but the HEPs were not developed for the context of FLEX actions (e.g., the HEP for a human task in THERP can be very different from the HEP of the same task in the scenario that results in the use of FLEX equipment)

The NRC's Need

- The NRC needs an HRA method capable of quantifying these types of HEPs in our SPAR models in order to support risk-informed license amendment requests (LARs), notice of enforcement discretion (NOED) evaluations, event evaluations, and significance determination process (SDP) evaluations.
- We are developing a stand-alone simplified HRA tool to quantify the HEPs associated with the use of portable equipment.
- This tool will be used by the NRC in SPAR models to quantify the HEPs associated with the use of portable equipment.

Addressing the NRC's Need

- HRA method development for portable equipment

  - NRC and EPRI jointly developed IDHEAS internal at-power event application (NUREG-2199)

  - NRC recently developed the IDHEAS General Methodology (IDHEAS-G) that models any human event from its cognition basis structure

  - NRC is working on a simplified off-the-shelf HRA tool based on IDHEAS-G.

- Expert elicitation to quantify the HEPs associated with the use of portable equipment using the new HRA tool.

Purpose of the Expert Elicitation

- Identify the unique performance shaping factors associated with the use of portable equipment.
- Evaluate the contribution of the these performance shaping factors on the total HEP.
- Quantify the total HEPs associated with a few typical strategies for using portable equipment for added defense in depth during normal accident scenarios and during FLEX-type scenarios (such as transportation, placement, connection, and local control of portable pumps and generators, refilling water storage tanks using alternate water sources, DC load shedding, and restoring equipment from DC load shedding).

Expert Elicitation Process

- Sponsor: NRC

- Process: Use the formal expert elicitation method described in the NRC's White Paper on expert elicitation guidance. The method has been piloted in four PRA projects including estimation of HEPs in IDHEAS at-power application.

- Composition of expert panel: NRC staff and industry experts who are knowledgeable in HRA, implementation of FLEX strategies, and typical maintenance practices at NPPs.

- Timeline:
  - Spring 2018: Elicitation meetings and final workshop
  - May 2018: Internal working draft report
  - Fall 2018: Report available for public comment

Basis for Expert Elicitation

The NRC project team has compiled an information package for the experts to review, evaluate, and use as the basis of their judgment. The package has four parts:

I. Examples of human errors in actions performed external to the main control room at NPPs.

II. HEPs or human error rates for human actions similar to portable equipment actions from other fields (off-shore oil drills, space-shuttle operation, railroad operation, etc).

III. Performance shaping factors that have been demonstrated as important to human actions similar to portable equipment actions.

IV. Quantification of how individual performance shaping factors change human error rates from literature.

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Back-up Slides

Part I: Errors in actions performed external to the control room

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We reviewed 300+ LERs involving personnel errors in external actions. Examples include:

- Inoperable Diesel Generator due to overcurrent logic wiring error
- Loss of Emergency Bus 23-1 due to a shorted cable while performing wiring verification
- Unplanned Diesel Generator ESF actuation when a potential transformer sensing circuit shorted due to personnel error
- Primary Containment System Isolation Valve unable to close fully on automatic signal due to wiring discrepancy
- RHR Reservoir inoperable due to blocked divisional cross-connect line results in condition prohibited by Technical Specifications
- Auxiliary Feedwater Pumps inoperable due to inadvertent blockage of a ventilation flow path assumed to be open in an accident analysis
- Failure to perform Valve Testing Leads To Unit Operation In A Condition Prohibited by Technical Specifications
- Inadvertent Group IV & V isolation when replacing PCIS coils

Part I: Errors in actions performed external to the control room

Examples:

"...(1) the upstream trip isolation valves would require the operator to stand on a piece of angle iron (because the area was too cramped to use a ladder) and (2) the isolation valves for the steam to the turbine driven auxiliary feedwater pump require climbing over hot steam piping. These valves could be operated, but that the hazardous conditions might cause the AO to become incapacitated."

"During containment spray system testing, operators closed a valve in the wrong train rendering both trains inoperable. Access is poor since both heat exchanger valves are operated with reach rods and only magic marker labels with no train identification were present."

Part II: Human error rates for similar actions in other fields

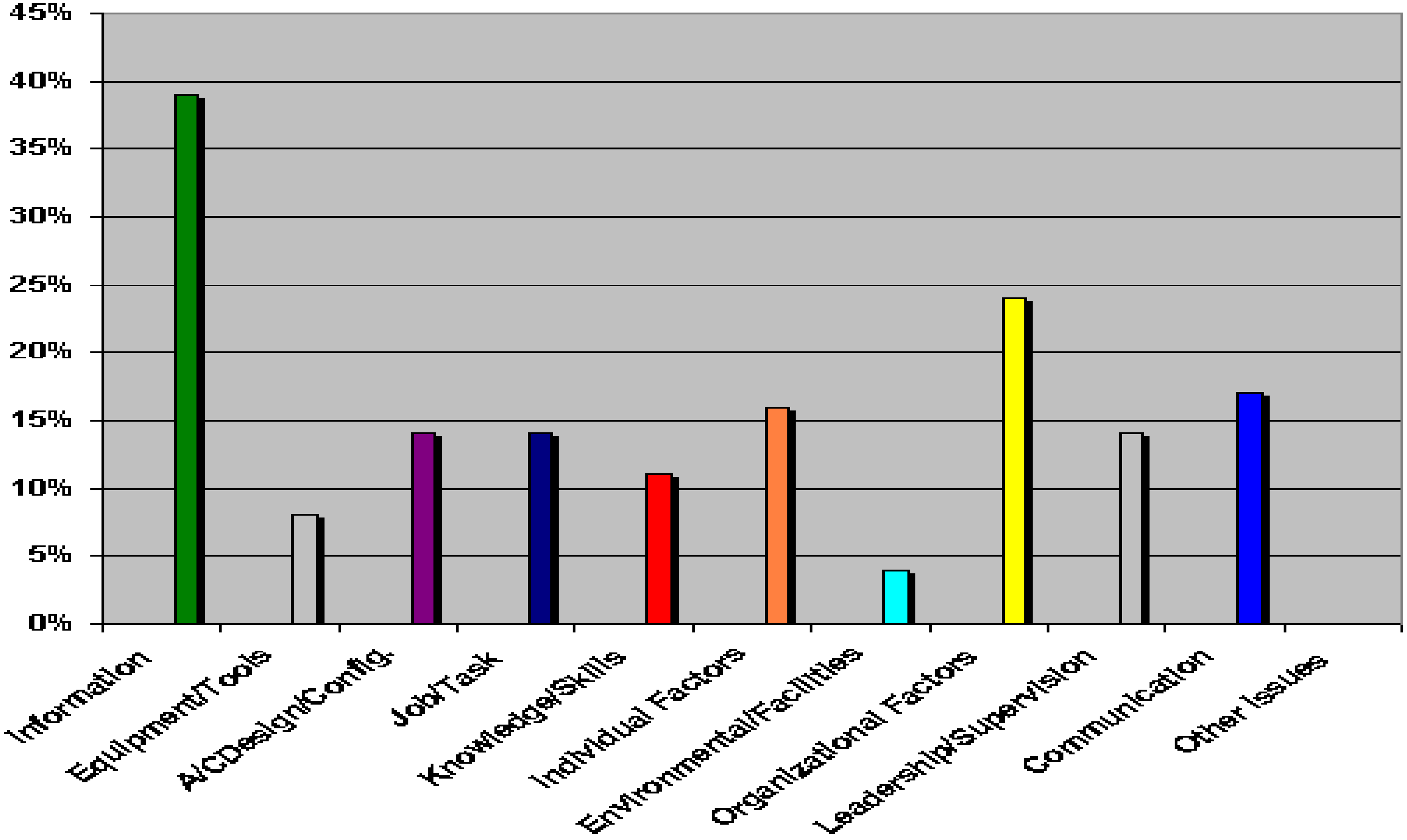
- NUREG/CR-5572 “An Evaluation of the Effects of Local Control Station Design Configurations on Human Performance and Nuclear Power Plant Risk”
  - HEP = 2E-2 for ideal conditions and
  - HEP = 0.57 for challenging conditions

- German maintenance operation database error rates:
  - 1/490 for operating a circuit breaker in a switchgear cabinet under normal conditions;
  - 1/33 for connecting a cable between an external test facility and a control cabinet;
  - 1/36 for reassembly of component elements;
  - 1/7 for transporting fuel assemblies

- HEP for maintenance for process plants:
  - Milling = 5E-1
  - Electric installation = E-1
  - Panel Wiring = 2E-3

Part III: Performance shaping factors important to human actions

Airplane maintenance error contributing factors:

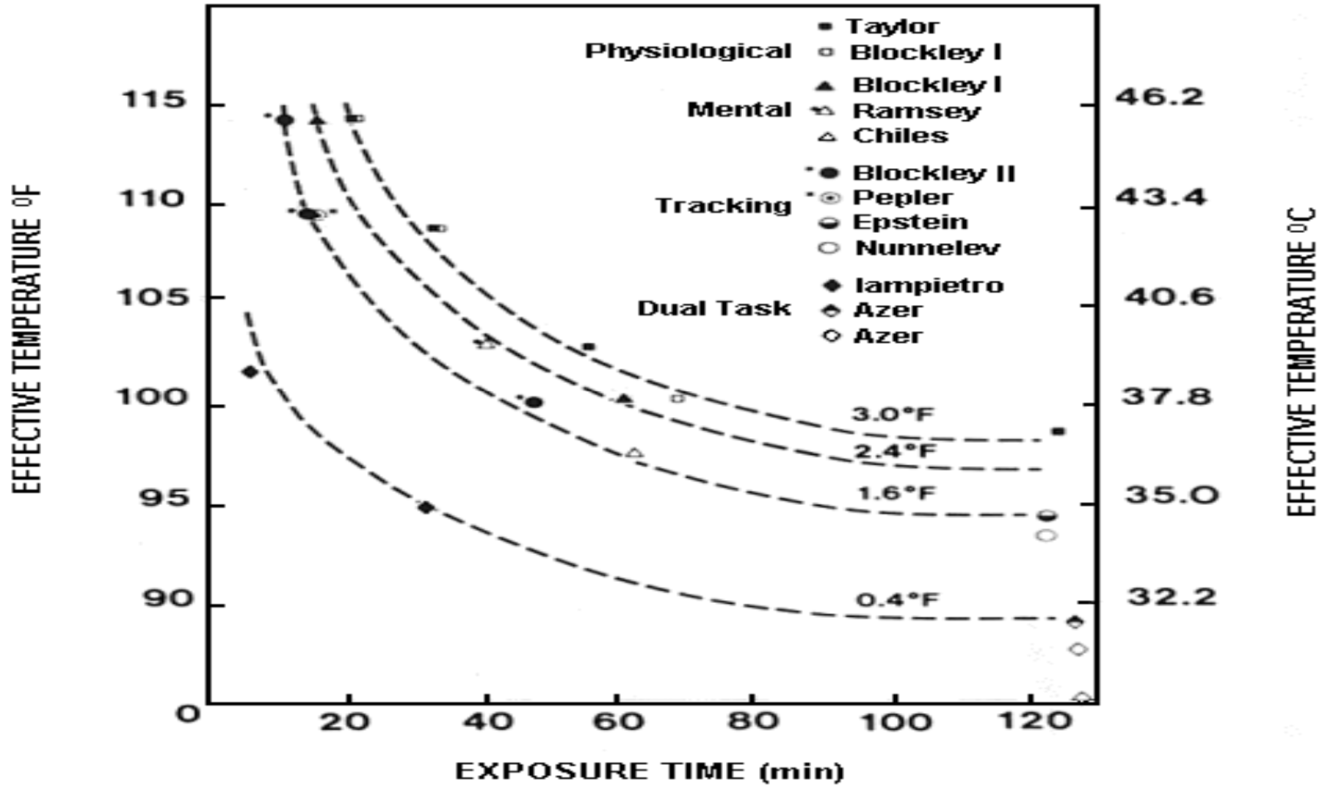


Part IV: How performance shaping factors change human error rates

- Error rates for NPP maintenance tasks:
  - **1/888** for frequently performed tasks
  - **4/173** for rarely performed tasks in normal conditions
  - **3/22** for rarely performed tasks with additional performance shaping factors

- Airplane pilot deicing decision-making errors:
  - **8%** with accurate and adequate information
  - **21%** with accurate but inadequate information
  - **73%** with misleading information

Effect of Temperature on Human Performance



- Hot temperatures of 90 degrees F or above resulted in a **14.88%** decrement in human performance.
- Cold temperatures of 50 degrees F or less resulted in a **13.91%** decrement in human performance.