Importance of Human Performance to Safety in Complex Industries

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a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

OVERVIEW OF COMPLEX/ HAZARDOUS INDUSTRIES

- Defense in depth
- Redundant safety features
- Complex plants
- Multiple failures needed for accidents

→ Can result in complacency

ACCIDENT POTENTIAL

- Safe operation requires vigilance:
  - Plant level
  - Corporate level
  - Oversight or regulator
- Without vigilance, factors arise that predispose a plant to an accident
- Initiating event then starts sequence of events

ANALYSIS METHODS

- Post-accident analysis of actual events
- Pre-accident risk assessment

POST-ACCIDENT ANALYSIS

- Selected major accidents: TMI, Bhopal, Chernobyl, Fukushima
- Examination leads to identification of factors present to “set up” accident
- Other key actions during event can either mitigate or exacerbate accident

Key Factors From Examination of Actual Accidents

Design

Organization and Management

Maintenance

Operations (Human Performance)

Full paper has details

Fukushima
Operations/Human Performance Factors

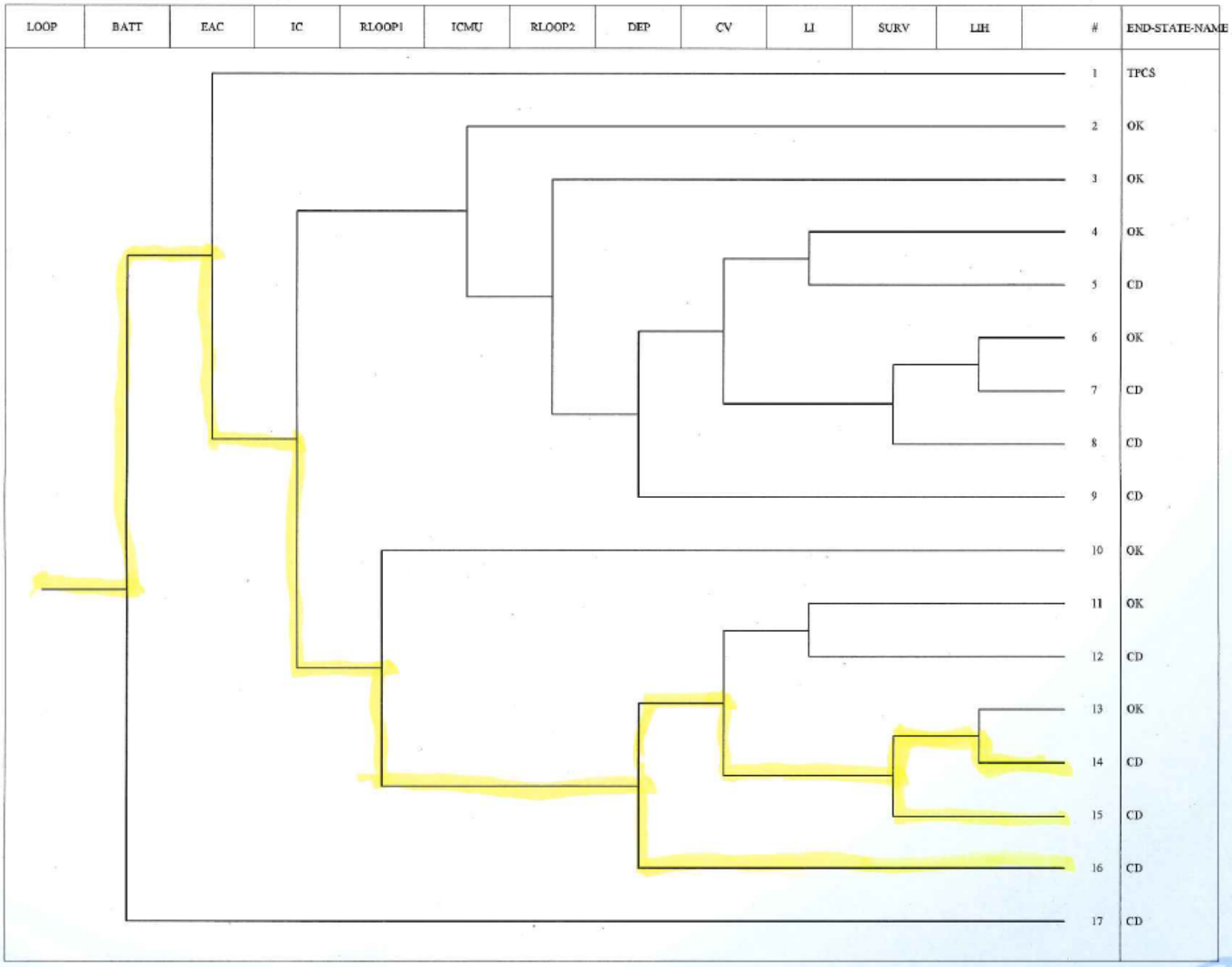
- Operators made some heroic actions under very harsh conditions. Performed innovative actions to try and save plant
- Failed to depressurize reactor (DEP)
- No procedure to vent containment without power
- Problems with being able to vent containment and then having H_2 explosions when they did vent.
- Problems in providing emergency or backup injection water to reactors
- Problems in providing emergency or backup cooling to spent fuel pools

Common Operations / Human Performance Factors

- Lack of needed procedures
- Securing of needed equipment
- Blocking of alarms and auto. actuation

Use of Event trees (ETs)

- Pre-accident for PRAs
- During accident – e. g., by STA to view remaining safe paths and functions needed to avoid CD
- Post-accident for analysis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Key HA failure events at Fukushima 1 on ET

- Failure to ensure IC function
- Failure to DEP the Rx Vessel
- Failure to vent containment (CV)
- Failure to supply late injection to Rx Vessel

PRE-ACCIDENT RISK ASSESSMENT of HAs

- Use of importance calculations and sensitivity evaluations
- Identify key specific errors and important types of errors
- Plant-specific and generic studies both valuable

Generically important HAs at BWRs that impacted Fukushima

- Failure to manually initiate the automatic depressurization system (ADS) to depressurize Rx
- Failure to recover offsite power
- Failure to vent containment (suppression pool) before over-pressurization

Other important BWR HAs that impacted Fukushima

- Failure to manually initiate the Isolation Condenser (IC) – open DC valves, supply makeup water to the shell side of condenser from condensate transfer or fire water
- Failure to reduce DC loads on station blackout
- Failure to cross connect service water or fire water for reactor pressure vessel injection
- Failure to recover failed batteries

Key aspects of Important HA identification

- Scope of PRA used for studies
  - PRA Level 1 and 2; Internal & external events; At power and SD
- Selection of importance measures (IM)
  - Multiple IMs: e. g. RAW and FV
- Threshold values, e. g.,
  - FV > 0.005
  - RAW > 2.0

Use of Important HAs

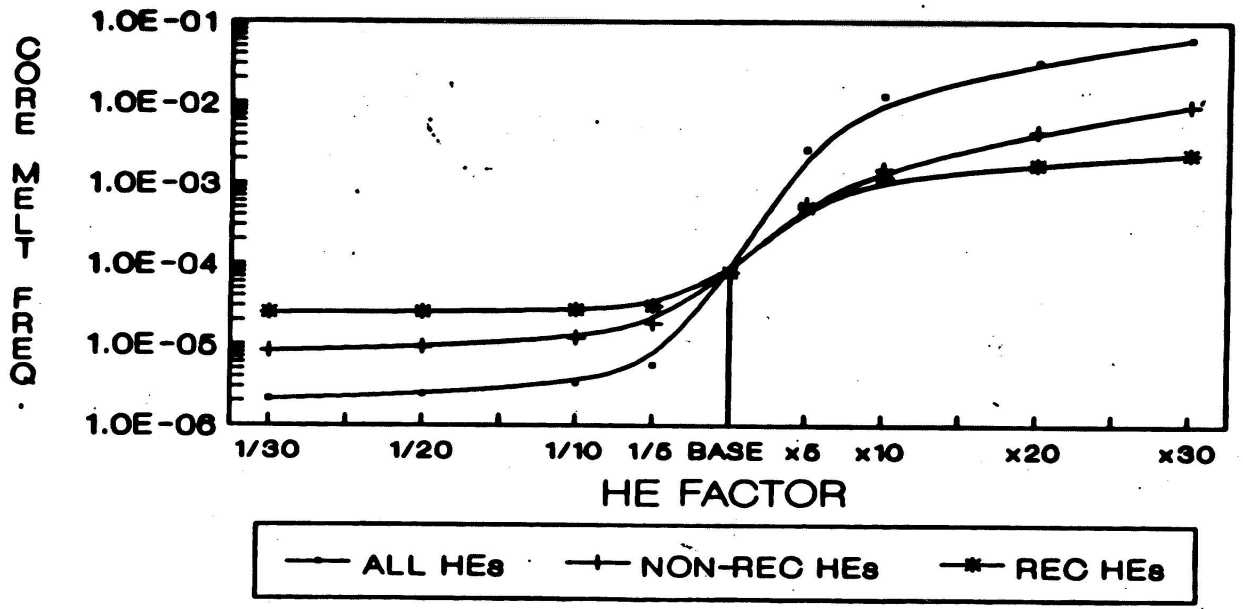
- Improvement to design, procedures, training, human-system interface, and staffing
- Apply to both operating and new plants
- Structured framework for this in NUREG-0711
- Has been applied to all new plant design certification reviews in US

SUMMARY

- Complex industrial plants can be operated safely
- Continued vigilance needed at various levels
- Human actions are shown to be important by various analysis methods
- Structured methods are available to improve safety by improving human performance

Backup Slides

CMF SENSITIVITY TO HUMAN ERROR



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