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NUCLEAR SAFETY CULTURE

R. A. KNIEF
(Sandia National Laboratories)

Panel Summary

We have witnessed the gaps in safety culture and organizational factors as significant risk contributors to many major accidents such as Three Mile Island and Chernobyl and, the recent disasters at Fukushima and the Macondo well in the Gulf of Mexico. However, there has not yet been any consensus among industry, academia, and regulatory organizations regarding the best approaches to assess safety culture and how to model its impact on technical systems risk. This panel will discuss these challenges and current approaches.

Current PRA models are incapable of “explicitly” covering organizational factors and, therefore currently: (1) It is not possible to assess the risk due to the specific organizational status of technological systems, (2) It is not feasible to locate the organizational root causes of failures to take effective corrective actions, and (3) There is the possibility of underestimating risk.

By incorporating organizational factors into risk frameworks, we can provide more accurate predictions of organizational performances and, in certain cases, relate those to the probabilities for some of the basic events of PRA. Consequently, this will lead to more realistic estimate of system risk and enable management to provide additional and timely provisions for key equipment and functions supporting long-term safe and reliable operations.

Panelist Thread

The nuclear industry has evolved, and with it the recognition of the unique role of organizations and what we now call “nuclear safety culture.”

Of particular importance have been lesson learned from accidents – from SL-1, to TMI-2 & Chernobyl, now Fukushima. Commonality outside the nuclear enterprise is also informative.

Biography

Dr. Ronald A. Knief received the 2012 ANS Training Excellence Award recognizing *"his pioneering contributions as professor, manager, author, consultant, and ardent accident-lesson advocate in blending performance-based training and education for the benefit of the nuclear enterprise."* The award is named in honor of the late Robert L. Long, who, in concert with Ron, initiated the first (this being the fifth) risk management topical meeting.

As a member of this panel, he will emphasize his experience in both training and risk-management during 10 years at Three Mile island, and the on-going interests that continue to this day.

Terminology

- Characteristics – Attitudes [IAEA] (from definition)
- Dimensions – Attributes [IAEA]
- Values - standards – morals – norms
- Indicators [HSE]
- Principles [INPO] – Attributes – Behaviors – Actions

  Affirmation/Commitment

  Executives

  Sr managers

  Manager

  Supervisor

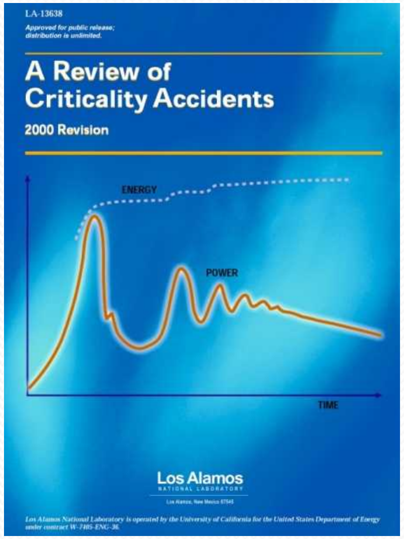
  Individual
- Traits [INPO] – Attributes
- Components [NRC]

Evolution of Nuclear Safety Culture

- International Nuclear Safety Advisory Group (INSAG)
  - Report INSAG – 1 (1986)
    - Report on Chernobyl
    - Term "nuclear safety culture" coined
  - Report INSAG – 3 (1988)
    - Basic Safety Principles for Nuclear Power Plants
    - "Safety culture" listed as one of three fundamental management principles

Critical Assembly, Research Reactor & Process

- LA-13638: *A Review of Criticality Accidents* (LANL, 2000)
  - Overarching Lessons Learned 1945-1999
    - *First and perhaps foremost, the human element was not only present but the dominant cause in all of the accidents . . .*
    - *Second, and not often apparent, there was an element of supervisory, upper–management, and regulatory agency responsibility in all of the accidents*



SL-1 Reactor

- Lessons Learned
  - Technical – Design & Operation
    - Control rods & use
    - Need for containment
    - Procedures
  - Organizational
    - Staffing
    - Design, construction & operation continuity
    - Focused oversight

TMI-2 Lessons Learned

- Although TMI-2 was not considered to the "spawning ground" for nuclear safety culture:
  - The President's Commission on the Accident at Three Mile Island ("Kemeny" Commission)
    - An Overarching Observation:
      - "... fundamental problems are people-related problems ... with the 'system' that manufactures, operates, and regulates nuclear power plants ..."
    - Note: Did not use the term "operator error"
      - Perhaps "Operations Error?"
      - Accident "Errors" Involved Reactor Operator & Supervisor, Utility Management, Vendor, and Regulator Personnel

Post-TMI-2 Improvements

- Operator Perspective
  - Control room re-design
    - Enhanced labeling, displays & mimicking
    - Prioritization of alarm system
  - Real-time, direct process indications
  - System upgrades to "safety grade"
  - Increased staffing
  - Symptom-based procedures
    - Pre-accident - drilled on event-based procedures for routine operations
    - ". . .belief . . .that if something unexpected occurred, the[y] . . .would be able to **improvise a solution**" (i.e., shift to "expert" mode)
  - The Emergency Plan and ERO

Post-TMI-2 Improvements

- Operator Perspective
  - New tools
    - On-site replica simulators mandatory
    - Industry communication tools developed (INPO)
    - Accredited training centers established (INPO Academy of Nuclear Training)
  - Safety Culture - An important component of Operational Excellence that grows slowly. . .
    - Corrective Action System
    - Self Assessment
    - Safety Conscious Work Environment
    - Development of a learning organization
    - Intolerance for known problems

Evolution of Nuclear Safety Culture

- International Nuclear Safety Advisory Group
  - INSAG – 4 (1991)
    - Safety Culture
    - That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance

Accident Causes & Lessons Learned

- Chernobyl

  "*. . . this [TMI-2] accident could only have happened in a capitalist country, where profit is more important than safety.*"

  Academician A. Aleksandrov, President of the USSR Academy of Sciences and Director of the Kurchatov Institute as stated in *Pravda*

  - Sadly, addressing TMI-2 lessons could have prevented the Chernobyl accident
  - Even with the extreme differences in design & operation between the two reactors, the TMI-2 lessons in focusing on understanding of essentially every aspect design and operation were universally applicable . . .

Accident Causes & Lessons Learned

- "Operator Error" ("Operations" Errors*)
  - Ad hoc / improvised actions re: control rods / power/ coolant flow / safety system operation
- Design Deficiencies
  - Individual deficiencies known to designers, not shared with operators (or management)
  - No robust containment building
- Management/"System" Deficiencies
  - System allowed *ad hoc* conditions
  - Test lacked reactor safety review
  - No anticipation of event type by any participants*

Inadequate Safety Culture

* Involved Operators, Designers & Management

Evolution of Nuclear Safety Culture

- Davis-Besse Reactor Vessel Head Degradation (2002)
  - Caused by long-term boric acid corrosion from leakage from head penetrations and CRDM flanges
  - Station staff missed indications that would have revealed problem
  - NRC determined that station staff failed to ensure that plant safety issues received appropriate attention
  - Causal factors included cultural issues

Evolution of Nuclear Safety Culture

- Institute of Nuclear Power Operations (INPO)
  - Formed Safety Culture Advisory Group
  - Group produced Principles for a Strong Nuclear Safety Culture
  - Principles included a definition of safety culture
  - Definition differed from IAEA definition
  - Document included eight principles and corresponding attributes
  - INPO definition of Safety Culture: *An organization's values and behaviors – modeled by its leaders and internalized by its members – that serve to make nuclear safety the overriding priority*

Evolution of Nuclear Safety Culture

- INPO Plant Evaluation Process
  - Added safety culture objective to PO & C in 2005
  - Developed evaluation guidance and training for the evaluators, team leaders, and exit representatives
  - Guidance is available to the industry
  - Developed a pre-evaluation survey to be taken by station staff
- Considerations for a Safety Culture
  AFI: Facts or observed behaviors that are not consistent with a healthy nuclear safety culture
  - Substantial examples with a similar theme, or
  - Pattern of behavior indicates insufficient regard for one or more nuclear safety culture principles and arrogance may be apparent (but necessarily), or

Evolution of Nuclear Safety Culture

- Principles ….. Addendum I
  - Behaviors and Actions That Support a Strong Nuclear Safety Culture
  - Evaluation experience that a number of the attributes are not readily observable
  - Convened another advisory group
  - Developed for executives and senior managers, managers, supervisors, and individual contributors
- Example that resulted in a safety culture AFI
  - WANO international peer review for Paris Center
  - Station stopped doing ECPs for reactor start-ups – corporate reactor engineers supported
  - Operators spent significant time away from their panels during shift briefings
  - Station had expectations for operators to go behind panels for surveillances

Current INPO Paradigm

- Defined by INPO (2012) as the "core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment."
- Three categories and ten traits are identified as follows:

Individual Commitment to Safety

— Personal Accountability

— Questioning Attitude

— Safety Communication

Management Commitment to Safety

— Leadership Accountability

— Decision-Making

— Respectful Work Environment

Management Systems

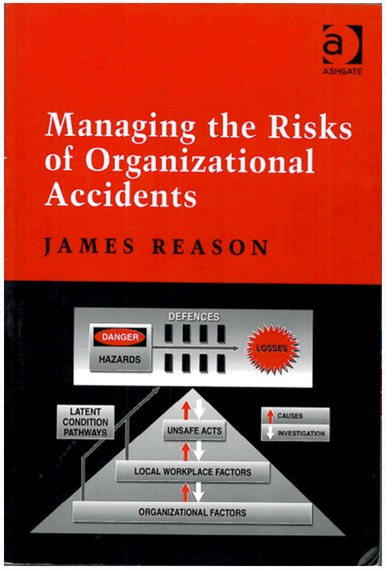
— Continuous Learning

— Problem Identification and Resolution

— Environment for Raising Concerns

— Work Processes

Generic Safety Culture



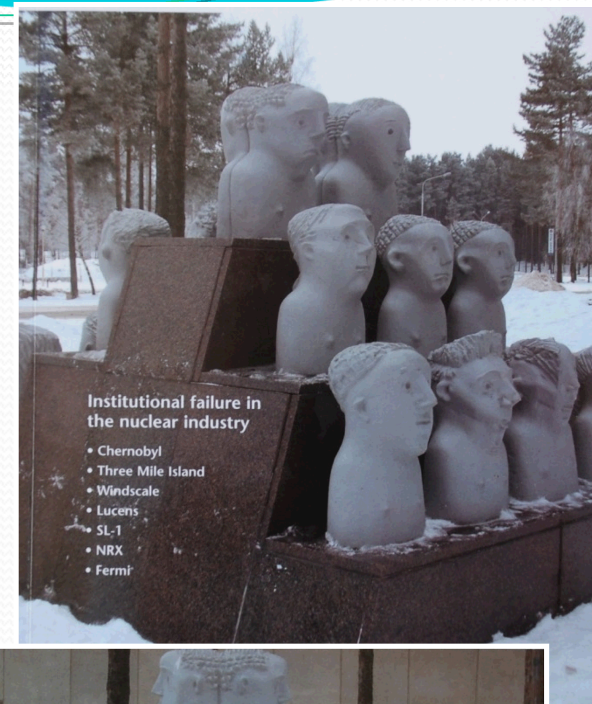
- Shared values (what is important) and beliefs (how things work) that interact with an organization's structures and control systems to produce behavioural norms (the way we do things around here).

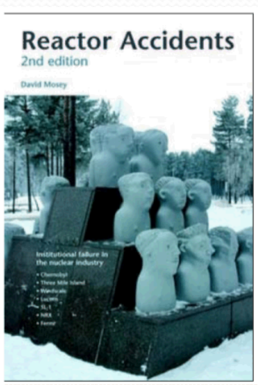
Institutional Failures

- The TMI-2, Chernobyl, and other accidents are failures in managed systems, or "institutional failures," the result of:

  the absence or *malfunction* of *some corporate activity necessary for* safety *as the result of human failure in activities which may not be acknowledged as important to safety and which occur far from the man-machine interface.*

- This failure is a result of human (management) "error," and our interest should be focused on those "errors."





Monument in Visaginas, Lithuania commemorating the Chernobyl accident. Two teams are facing opposite directions signifying a complete lack of communication. [David Mosey]

Common Accident Lessons

[Zebroski]

TMI-2
Bhopal
Challenger
Chernobyl

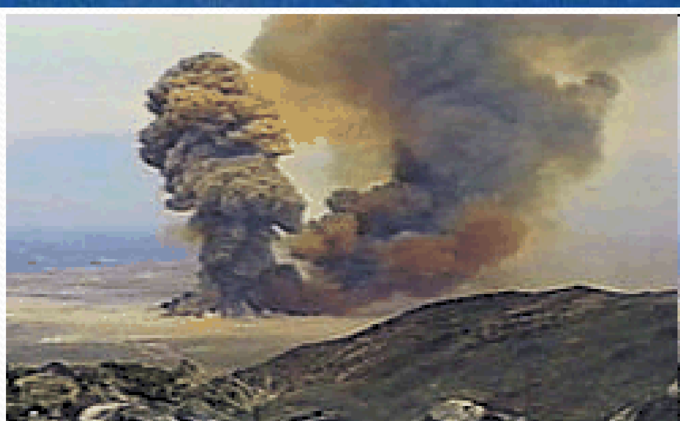
1. Diffuse responsibility with rigid procedures and communication channels; large organizational distances between decision makers and "the plant"
2. "Mindset" that success is inevitable or routine; neglect of severe inherent risks
3. Belief that rule compliance is enough to assure safety
4. Team-player characteristics highly valued, strong emphasis on commonality of experience and viewpoint, and dissent not allowed even for evident risk
5. No systematic review process for relevant experience from elsewhere
6. Lessons learned disregarded and precautions widely adopted elsewhere neglected

Common Accident Lessons

7. Safety analysis and responses subordinate to other performance goals and operating priorities
8. Absence of effective emergency procedures, training, and drills for unusual or severe conditions.
9. Acceptance of design and operating features involving recognized hazards that were controlled or avoided elsewhere
10. Failure to use available project management techniques for systematic risk assessment and control
11. Undefined organizational responsibilities and authorities for recognizing and integrating safety matters

And more . . .

- Piper Alpha
- Shuttle Columbia
- Henderson Rocket-Fuel Plant
- World Trade Center
- Enron
- BCCI



“ACCIDENT-PROOF” NUCLEAR ENERGY

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Seeking “Accident Proof” Reactors

Following each significant reactor accident, there has been optimism that the lessons learned will lead to technical and organization (culture) changes that can more “accident-proof” future reactors. Looking at accidents including at SL-1, TMI-2, and Chernobyl provided such insights on how to proceed, and may also inform identifying and applying lessons from Fukushima.

Dr. Ronald A. Knief spent the 1980s at Three Mile Island where compiled their definitive TMI-2 lessons-learned report, served as training manager implementing most of the related lessons, and was immersed in over-arching corporate risk-management initiatives.

Subsequently, he spent a decade or more each as a “road warrior” consultant and now engineer & nuclear facility training coordinator at Sandia National Laboratories.

As an NE professor pre-TMI-2, he founded the University of New Mexico Nuclear Criticality Safety Short Course programs.

An ANS Fellow, he has chaired ET(WD)D, NCSD, and – by this time next year –NISD. He is author of ANS-published NE and NCS books.

Accident Chronology

- 1945 Critical-Assembly, Research-Reactor & Process Accidents
- 1961 SL-1 Reactor [3 fatalities]
- 1979 Three Mile Island, Unit 2 Reactor [No fatalities]
- 1986 Chernobyl, Unit 4 Reactor [31 fatalities]
- 2011 Fukushima-Daichi Reactors [No fatalities]

Accident Chronology

- 1945 Critical-Assembly, Research-Reactor & Process Accidents

  [5 fatalities]
- 1961 SL-1 Reactor [3 fatalities]

  [6 fatalities]
- 1979 Three Mile Island, Unit 2 Reactor [No fatalities]

  [1 fatality]
- 1986 Chernobyl, Unit 4 Reactor [31 fatalities]

  [4 fatalities]
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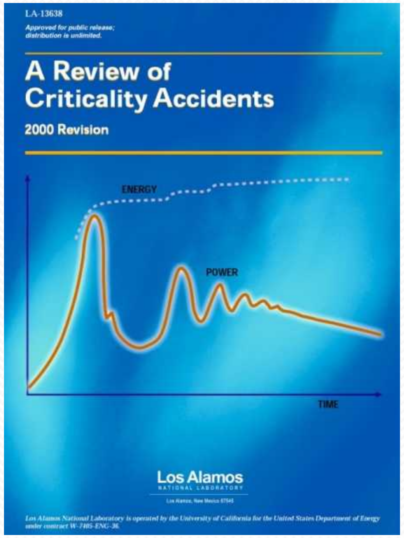

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TMI-2 Lessons Learned

- The US Nuclear Regulatory Commission
  - Reactor Safety Focus
    - All LOCA & Other Accident Scenarios
    - Risk-Informed Regulation
  - Refocused Reactor Operator Licensing – Written/Walk-Around/Replica-Simulator
  - Resident Inspectors
  - Precursors/Lessons Learned (re: Davis-Besse [1977])
- The Utility and Its Suppliers
  - Dramatic change in attitudes toward safety & regulations
  - Self-policing of their own standards of excellence
  - Increased Staffing / Total Re-Organization
  - Guidance for Technical Issues - Shift Turnover / Core Damage Mitigation / Reactor-Coolant-Pump Trip Criteria/ Emergency Preparedness
  - Research (Independent and w/ NRC) – PRA to Plant Simulation

Utility & Suppliers

- The recommendations for the nuclear industry hinged on the perception of an existing *attitude* (or *mind-set,* a term from George Orwell's 1984, used in testimony) that plants are "sufficiently safe."
- The Commission charged that the attitude "must be changed to one that says nuclear power is by its very nature potentially dangerous, and ... one must continually question whether the safeguards already in place are sufficient to prevent major accidents."
- NSAC and INPO, followed later by the Nuclear Utility Management and Resources Council [NUMARC]-with a focus more on personnel-related and licensing issues-supported self-initiated and -policed plant performance and safety improvements.

TMI-2 Lessons Learned

- Training of Operating Personnel
  - Training Developed by Training Staff w/ Input From, and Ownership By, Operations, Engineering, Management (& Industry)
  - Procurement and Use of Control-Room-Replica Simulators
  - Note: In Additions to Operators and other Plant Staff
    - Utility Technical Staff & Management
    - Vendor Staff
    - Regulatory Staff
- Technical Assessment

TMI-2 Lessons Learned

- Emergency Planning and Response
  - Off-Site Emergency Operations Center
  - Comprehensive Individual & Team Training
  - Full Scope Drills/Exercises
    - Control Room
    - Technical Support Center
    - Off-Site Emergency Operations Center
    - State & Federal Regulator Involvement
    - Media Center – Actual Reporters & Simulated Media (e.g., College Students) Involved

Industry Response

- Institute for Nuclear Power Operations (INPO)
  - Membership: All U.S. Nuclear Utilities [Now +Operating Companies] & DOE
  - HQ: Atlanta, GA
  - Role: Industry "Self-Assessment" and "Self-Policing"
    - INPO Staff and Utility Peer Assessors
      - Operations & Maintenance
      - Training & Qualification
      - Radiological Protection
      - . . .
    - Reporting & Lessons Learned

Communitarian Regulation – A system that has a well-defined industrial morality that is backed by enough communal pressure to institutionalize responsibility among its members

– Joseph Rees, *Hostages of Each Other*

Post-TMI-2 Improvements

- Operator Perspective
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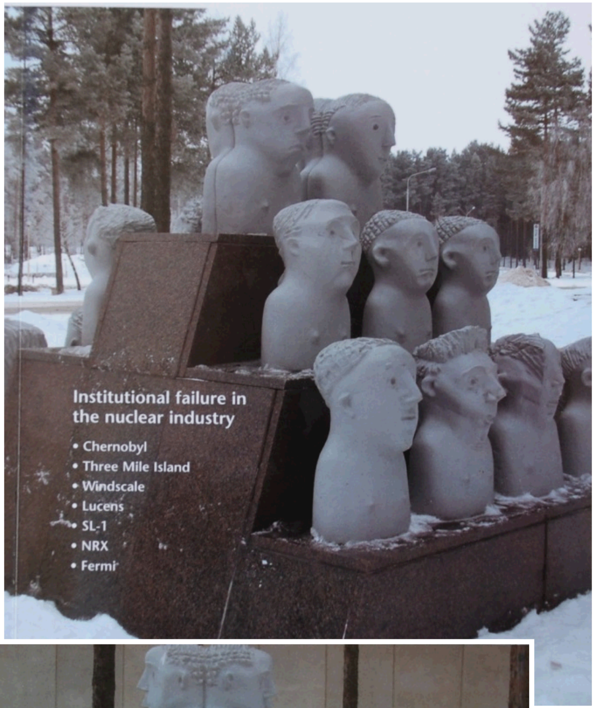

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