INPO’s Approach to Human Performance in the U.S. Commercial Nuclear Industry

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INPO’s Mission

...to promote the highest levels of safety and reliability — to promote excellence — in the operation of nuclear electric generating plants.
Key Messages

- Work Preparation – Performance – Feedback is a **risk-management** process.
- Protect the plant from people by **aggressively** managing defenses.
- Performance improvement should be **systematic** and **systemic** in its approach.
- People must understand the **why’s**, and demonstrate proficiency with Hu tools.
… Nuclear Safety…

1. Tremendous Power – reactivity management
   - Reactivity and power level controls
   - Rod control & drive reliability
   - Instrumentation reliability

2. Decay Heat Load – inventory and cooling
   - Reactor cavity and fuel pool
   - Secondary plant equipment reliability
   - Safety system reliability and controls
   - Plant materials integrity and design margins

3. Radioactive Material – barrier integrity
   - Containment integrity
   - Defect-free fuel
   - Primary systems integrity
Significant Events – USA

An event that caused or had the potential to cause:
• an appreciable reduction in plant safety or reliability
• excessive radiation exposure or the discharge of radioactivity off site or
• serious harm to individuals
What is Managed?

- Assets: people, plant, and property
- Hazard: human error
- Exposure: “People touching equipment”
- Risk: probability and consequences
- Event: ▼ frequency and ▼ severity
- Controls:
  - error rate (frequency) → reduce active errors
  - defense-in-depth (severity) → reduce latent conditions
Error Rate Reduction

Before

Systemic Causes

Random Causes

After

Time

Error Rate
Hazard – Barrier – Asset

Hazard: Human – “touching”
Barrier(s): Less than Adequate or Missing
Asset: Object to Protect

Where’s the risk?!
Strategic Approach to Hu

\[ R_e + M_d \rightarrow \emptyset E \]

Reducing error and Managing defenses leads to ZERO Events

Identify, Analyze, Correct
Anatomy of an Event

Values & Beliefs

Mission Goals
Policies
Processes
Programs

Latent Organizational Weaknesses

Error Precursors

Flawed Defenses

Initiating Action

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Severity Pyramid

Risk-based Approach*

- Human and equipment risk are not the same.
- Process of assigning controls for work activities uses a graded approach.
- Controls are proportionate to the risk or potential consequence.

Positive Control

What is intended to happen is what happens and that is all that happens
Critical Step – a procedure step, series of steps, or action that if done improperly will cause irreversible harm to equipment or people, or significantly impact plant operation.
“S-A-F-E-R”
Task Preview

<table>
<thead>
<tr>
<th>S</th>
<th><strong>Summarize</strong> critical steps</th>
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<tbody>
<tr>
<td>A</td>
<td><strong>Anticipate</strong> errors or mistakes at each critical step</td>
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<tr>
<td>F</td>
<td><strong>Foresee</strong> probable and worst-case consequences</td>
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<tr>
<td>E</td>
<td><strong>Evaluate</strong> defenses, barriers, contingencies, &amp; abort criteria</td>
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<tr>
<td>R</td>
<td><strong>Review</strong> experience relevant to the task</td>
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Managing Defenses

1. **Identify** unsafe condition(s)
2. **Analyze** its cause(s) and extent of condition
3. **Correct** the condition(s)
Work Execution
“touching” equipment

- Work Preparation
  - planning, walkdowns, task assignments and prejob briefings (task preview)

- Work Performance
  - uneasiness, situation awareness, Hu tools, teamwork and supervision

- Work Feedback
  - reporting and observations
Post-Job Reviews

- Can’t afford not to debrief – information fed back into the company processes
- Too narrowly focused on “things done wrong”
- Nameless and rankless – it’s what’s right
- Compared with pre-job briefing (critical steps)
- Causal analysis: what – how – why
- Written feedback – lessons learned (step-by-step fixes)
Defenses

- **Engineered Controls**
  - equipment reliability, software & hardware configuration, human-machine interface

- **Administrative Controls**
  - procedures, training, processes, policies, expectations and standards

- **Cultural Controls**
  - assumptions, values, beliefs, attitudes, work group norms, and leadership

- **Oversight Controls**
  - accountability, performance improvement
## Defense-in-Depth

<table>
<thead>
<tr>
<th>Functions</th>
<th>Engineered Controls</th>
<th>Admin Controls</th>
<th>Cultural Controls</th>
<th>Oversight Controls</th>
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</thead>
<tbody>
<tr>
<td>Inform</td>
<td>Beacon</td>
<td>Sign</td>
<td>Pay attention to sign</td>
<td>Supervision</td>
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<tr>
<td>Detect &amp; Warn</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Protect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recover</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Contain</td>
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<td></td>
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<tr>
<td>Escape</td>
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</table>
Organizational Factors

1. Mission
2. Organizational structure
3. Clear direction
4. Work management
5. Administrative controls
6. Hazard control processes
7. Training & qualification
8. Engineering processes
9. Performance improvement processes
10. Technology
11. Human resources
12. Conservative decision making
13. Communication
14. Managerial/supervisory practices
Performance Model

1. ORG’L FACTORS

2. JOB-SITE CONDITIONS

3. INDIVIDUAL BEHAVIOR

4. PLANT RESULTS
**Behavior Engineering Model - Nuclear (BEM-N)**

<table>
<thead>
<tr>
<th>Environmental Factors</th>
<th>Direction to Act</th>
<th>Opportunity to Act</th>
<th>Willingness to Act</th>
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</thead>
<tbody>
<tr>
<td>Task- or Job-related Information</td>
<td>Resources and Environment</td>
<td>Incentives and Disincentives</td>
<td></td>
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<tr>
<th>Individual Factors</th>
<th>Knowledge and Skills</th>
<th>Capacity and Readiness</th>
<th>Personal Motives</th>
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Source: Adapted with permission of the International Society for Performance Improvement, www.ispi.org.
## Job/Task-related Information

1. Job or task goals, desired results, roles and responsibilities, and criteria for success are clearly identified.
2. The risk importance of the job or task and critical steps, if any, have been denoted and communicated as such.
3. Clear expectations and standards for the conduct of work exist and have been communicated.
4. The usability, accuracy, and availability of procedures support error-free performance.
5. Relevant feedback on previous job or task performance, including opportunities for development, has been given to the individual (if applicable).

## Resources and Job Environment

1. Tools, material, clothing, furniture, facilities, systems, and equipment accommodate human limitations and are available and accessible.
2. Other individuals or organizations are available for support, if needed.
3. Adequate time is allotted, and other work conditions that could hinder performance are eliminated or minimized.
4. The values, attitudes, and beliefs of the person’s immediate work group about hazards in the workplace support safe practices.

## Incentives and Disincentives

1. Financial and non-financial rewards and disincentives are contingent on performance.
2. Competing incentives for poor performance are eliminated.
3. The job or task provides opportunities for success and career advancement, meets employee needs, and result in identifiable pieces of work traceable to the individual.
4. People are treated with honesty, fairness and respect regardless of position in the organization.
5. Work group standards are consistent with the above.

## Environmental Factors

<table>
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<th>Knowledge and Skill</th>
<th>Capacity and Readiness</th>
<th>Motives</th>
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<tr>
<td>Individual is qualified for the job or task and possesses the knowledge, skills, experience, and proficiency necessary to perform the task successfully.</td>
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<td>Individual understands the job or task objective(s), critical steps, and potential consequences if performed improperly.</td>
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<td>Individual understands the roles and responsibilities of others.</td>
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<tr>
<td>Individual possesses the intelligence, sociability, aptitude, size, strength, and dexterity to perform the job or task successfully.</td>
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<tr>
<td>Individual is available for work, undistracted, and fit for duty.</td>
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<td>Individual cares about performing the job or task well.</td>
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<td>Individual possesses a healthy work ethic and is willing to do what is right regardless of what others would do.</td>
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<td>Individual feels that the job or task is meaningful and attainable, progress is recognizable, and the task generates a personal sense of accomplishment.</td>
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Safety Culture Principles*

1. Everyone is personally responsible for nuclear safety.
2. Leaders demonstrate commitment to safety.
3. Trust permeates the organization.
4. Decision-making reflects safety first.
5. Nuclear technology is recognized as special and unique.
6. A questioning attitude is cultivated.
7. Organizational learning is embraced.
8. Nuclear safety undergoes constant examination.

Safety Culture?

In August 2005, two instrument control technicians disconnected the wrong electrical leads during a surveillance test on a steam generator blowdown flow channel, resulting in the blowdown bypass valve opening. The technicians could not locate the terminal board specified in the procedure and did not stop to call their supervisor. The technicians decided to lift leads from another point, resulting in a loss of power to the flow circuit. The change in blowdown flow caused a minimal change in reactor power.
OR.3 Human Performance

“Station personnel select and apply appropriate error prevention techniques commensurate with the importance of assigned tasks to minimize the frequency and consequences of events.”

- Organizational Factors
- Job-Site Conditions
- Individual Behaviors
INPO Performance Improvement Model

Implementing Solutions

Results

Performance Monitoring

Actions

Gaps

Analyzing, Identifying and Planning Solutions

Leadership and Oversight

Knowledge and Skills

Culture

INPO Performance Improvement Model
Leverage – Corrective Actions

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Delivery of Hu Training

- Embed in line training programs
- Accomplish vs. Avoid
- Competence vs. Control
- ‘Real-world’ examples
- Ask ‘Why?’ frequently
- On-the-job training (OJT)
- Dynamic Learning Activities (DLAs)
Strategic Approach to Hu

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