Self-Assessment Guide

Operator Fundamentals

This guide is a product of the industry's Operator Fundamental Focus Group and was developed in May 2006 and revised in 2011. It was revised again in 2013 by WANO for their members use.

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ASSESSING OPERATOR FUNDAMENTALS

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OPERATOR FUNDAMENTALS ASSESSMENT

I. PURPOSE

This document was written to provide generic guidance to facilities on how to perform a thorough self-assessment of the application of operator fundamentals. The assessment criterion for this self-assessment can be found in the operations section of the WANO performance objective and criteria.

II. BACKGROUND

Although nuclear industry performance has improved steadily for many years, some recent events have indicated a decline in the application of operator fundamentals. The most significant events and causes are described in detail in WANO SER 2005-2, *Weakness in Operator Fundamentals*, issued in September 2005.

The events described in the SER indicate weaknesses in all five aspects of operator fundamentals. These aspects are as follows:

- Monitoring plant conditions and indications closely
- Controlling plant evolutions precisely
- Having a conservative bias toward plant operations
- Working effectively as a team
- Having a solid understanding of plant design, engineering principles, and sciences

Key contributors to shortfalls in operator fundamentals include the following:

1. Incomplete approach to task performance

Some operators have approached using human performance tools by focusing solely on the technique or practice, without the appropriate focus on the task at hand. Although the human performance tools that have been developed in the industry over the years are very useful and effective, a lack of operator concentration or focus on the task at hand while using these techniques could cause errors and plant events. The operator who applies solid fundamentals uses the appropriate human performance tools and maintains a high level of concentration and awareness of the task at hand.

Insufficient or ineffective training

The focus on operator understanding of procedure bases, system design and operation, and plant interrelationships has been reduced in some training programs. Contributors to these shortfalls include less time in training and standardized lessons plans, simulator scenarios, and testing. The use of training techniques, such as oral boards, plant walkdowns, and simulator scenarios that more closely resemble actual plant operation, has also been reduced.

3. Overreliance on processes

Detailed processes have improved industry performance significantly. Processes such as work management, reactivity management, and corrective action have improved planning and equipment reliability, enhancing operator ability to monitor and control the plant. However, in some cases, operators have become too dependent on these processes, believing that following the process will ensure the task is completed event free. Similar to the use of human performance tools described above, the operators with solid fundamentals implement these processes with a high level of concentration and awareness of their actions. Therefore, problems that are not covered by the processes or errors made in the processes are more likely to be identified by the operators.

4. Actual plant operating experience is lower

Since the latter half of the 1990s, actual plant transients and reactor shutdowns and startups have decreased. This has caused a reduced level of sensitivity about what could go wrong if the plant is not monitored and controlled closely.

III. SCOPE

The focus of this assessment is the application of operator fundamentals by the operating crews, including licensed and non-licensed operators, shift technical advisors or their equivalent, unit supervisors, and shift managers. Focus areas include the five categories of operator fundamentals. Operational focus items, such as procedure quality, equipment deficiency prioritization, and complicated operational decision-making, are not included in this assessment.

IV. DEFINITION AND CATEGORIES

Operator fundamentals: The essential knowledge, skills, behaviours, and practices that need to be applied by operating crews to operate the plant effectively. Categories of operator fundamentals are as follows:

1. Monitoring the Plant (attentiveness)

- Monitor plant parameters effectively, balancing between scanning general plant parameters and focusing on critical plant parameters.
- Validate the parameter through multiple independent means, if available, avoiding undue focus on any single parameter.
- Seek reasons for unexpected trends, and ask for assistance when needed.
- Use all senses when monitoring equipment.
- Identify and track deficiencies.
- Maintain detailed and accurate operator logs.
- Perform thorough non-licensed operator rounds.

2. Controlling the Plant (deliberate)

- Reactivity manipulations are deliberate, and the expected response is known.
- The plant is operated within technical specifications and design and operating limits. Adverse trends are addressed such that limits will not be exceeded.
- Positive control of the reactor is maintained (turbine, rods, voids, shim, pressure, boration, dilution).

- Human performance tools are used effectively; that is, a graded approach is used.
- Self-checking is an ingrained automatic behaviour.
- The bases of procedures are understood, and each procedure is followed in step-by-step sequence.
- Procedures are performed from memory only for designated activities.
- The effects of component manipulations are fully understood before the manipulations.
- Appropriate manual action is taken when automatic systems do not actuate when required or when the equipment has not responded as expected.
- Plant configuration is controlled through rule-based methodologies.

3. Conservative Bias to Operating Safely

- The plant is placed in a known safe condition when the current condition is unknown.
- Conservative decisions are made, placing nuclear safety first.
- Operators do not proceed in the face of uncertainty.
- Operators question unusual conditions.
- Operators determine contingent action if unexpected results are achieved.
- Operators have a low threshold for identifying problems.

4. Teamwork

- Roles are clearly defined.
 - ⁻ The shift manager (SM) maintains oversight.
 - The control room supervisor (CRS) has command and control.
 - The shift technical advisor or equivalent provides technical advice and contributes to crew oversight.
 - The reactor operator/equipment operator (RO/EO) monitors and controls the plant.
- Information is shared among crewmembers; that is, in the control room and between non-licensed operators and control room personnel.
- Shift turnovers are detailed and accurate.
- Crewmembers provide constructive feedback to each other.

5. Knowledge of Plant Design, Engineering Principles, and Sciences

System design, function, and bases

- Personnel are knowledgeable of the following:
 - key system functions and their interaction with other systems
 - the mechanics of core cooling (safety injection, natural circulation, reflux boiling, steam) and the relation to reactor pressure vessel water level
 - key system interlocks, alarms and automatic functions, as well as their bases
 - key operating, licensing, and safety limits, system interlocks, setpoints, and automatic actions
 - the bases for key procedure steps

Engineering and sciences

- Personnel understand the following:
 - reactor theory, including poisons, control rod worth, decay heat, life cycle changes, and the effects of temperature, pressure, other parameters in reactivity
 - fluid flow, thermodynamics, electrical, chemistry, heat transfer, materials, and so forth
 - pump laws/flow relationships, cavitation
 - flow characteristics of different types of valves
 - instrument and control, including expected response to failures; that is, gas accumulation, failed reference legs, and so forth
 - fracture mechanics, water hammer, and vibration
 - print reading
 - gas law effects (nitrogen bubbles, vacuums) on level/pressure/power indications
 - control rod worth/reactivity potential versus core life conditions
 - reactivity feedback mechanisms above and below the point of adding heat
 - chemical shim reactivity worth changes over core life and why
 - quantitative effects and relative times of reactor poison effects
 - secondary plant efficiency effects on reactor power

V. TEAM COMPOSITION

- 1. Individuals with extensive knowledge of specific power plant design and operation; for example, current or previously licensed senior reactor operators (SROs), and training instructors
- 2. A member of the operations management team, knowledgeable of station operator standards and expectations
- 3. An industry peer who is a current or previously licensed SRO in the same reactor technology, if possible.

VI. INSTRUCTIONS/METHODS

- 1. Pre-assessment activities
 - Review the high-level plant event history and corrective action documents (levels 1 and 2, typically) to determine if the plant has experienced events in which operator fundamentals weaknesses possibly contributed to initiation of the event or the outcome. This population should be the most consequential events and will provide a representative sampling of operator performance.
 - Review performance indicators to determine if the plant has experienced events in which knowledge weaknesses possibly contributed to initiation of the event or the outcome.
 - Review self-assessments, independent oversight reports, and other reports
 to identify operator performance shortfalls or operator-related events that
 may not have been captured in item one. The intent is to identify potential
 operator performance shortfalls, not to check the effectiveness of
 oversight or the corrective action program.
 - Identify common themes of the above items. Separate the items into the five categories of operator fundamentals, and develop focus areas for the assessment. Pick the most important focus areas. Avoid being too process

- oriented, such as ensuring that each category has a focus area; some categories may have more than one focus area, others may have none.
- If this assessment is being performed in conjunction with an assessment of operations training, this activity is not required. Determine if station management is emphasizing operator fundamentals sufficiently in training. Review the two-year training plan, objectives, lesson plans, scenario guides, appropriate testing practices, and copies of tests and results to obtain information related to the methods of evaluating and training on operator fundamentals. The intent is not to bypass the systematic approach to training, but to verify that operator fundamentals are presented sufficiently to maintain operator proficiency.
- Observe a couple of crews respond to simulator scenarios, to identify
 possible weaknesses in fundamentals. For example, reactor startup, low
 power, and secondary upset scenarios are transients that can cause the
 crews to use fundamental concepts/knowledge to analyse and respond to
 the transients.
- Review procedures, plant design specifics, and so forth; and develop interview questions on the basis of key steps, transition points, integrated systems response, interlocks, and other areas, to discuss with operators and to assess their understanding of fundamentals. A review of reactor theory and other engineering/science subjects may be needed to prepare for this assessment.

2. Assessment Activities

- Apply the focus areas from the information review to activities, while ensuring that all aspects of operator fundamentals are assessed. Activities should focus on the practical application of the fundamentals. Operators should understand why they are performing all activities.
- Perform control room and in-field observations. Observe personnel making decisions, and determine the degree to which they openly use fundamental knowledge. Ask operators to explain what indications mean. Focus on integrated plant operations. Look for briefings and other activities to explicitly anticipate plant response. Are operators monitoring indications thoroughly; are they focused on understanding indications; or are they merely scanning panels?
- Observe evaluated simulator scenarios. Use information from the simulator scenarios, such as how well operators anticipate plant response when controlling parameters during transients, to identify fundamental weaknesses. Use predetermined questions to identify operator knowledge gaps. Consider starting with questions on integrated plant response, then questions specific to individual systems, and then lastly questions on theory.
- During area rounds with non-licensed operators, observe monitoring techniques and ask questions to evaluate the practical application of fundamentals, integrated plant and design basis knowledge. Examples include naming four ways to increase pump flow, identifying the impact of component failures on the plant and identifying flow paths.
- Interview specific individuals involved in events to determine if fundamental knowledge weaknesses were a contributor. Ask

probing questions; try to get a good understanding of the level of concentration the individuals had during the event. For example, were there knowledge weaknesses, and did the individuals fully understand the task?

3. Assessment Conclusion

- The results of the assessment of operator fundamentals should enable station management to answer the following questions:
 - Do the operators monitor plant conditions closely?
 - Have the crews been effective in controlling plant evolutions?
 - Have the crews exhibited a bias toward making conservative decisions?
 - Do the operating crews work effectively as teams?
 - Do the operators have a solid understanding of plant design and the theory of operation?
- Focus the conclusion on the specific problem. For example, if a performance gap exists in operator monitoring of plant conditions, what are the specific shortfalls? Is it control room board monitoring, in-field rounds, reactivity, water plant, and so forth? Avoid being too process oriented. Focus on the most important conclusions that relate to safe operation of the plant.
- Determine the key causes of the performance gap. Consider shortfalls in standards, training, supervisory engagement, and so forth. Look at management contributors. Identify the most value-adding causes; focus on identifying the 20 percent of the causes that will solve 80 percent of the problems.
- Develop a focused corrective action plan. These actions should be specific.
- Ensure the actions are targeted to address the causes identified in the previous step. Avoid establishing actions that are off target or that would be "nice to do." The most effective action plans are simple and are focused on the most important causes. Again, take 20 percent of the actions to solve 80 percent of the problems.

VII. SAMPLE QUESTIONS

The following questions are not meant to be all inclusive. They are intended to be a sampling of the type of questions to ask operators to gauge their level of understanding of operator fundamentals. These questions are designed for the knowledgeable and experienced senior reactor operator (SRO), such that correct answers are known and, more importantly, follow-up questions are obvious.

Monitoring the Plant

- What are the most important indications to monitor right now? Why?
- Which indicators are used to verify that you are in compliance with technical specifications?
- If X component just failed in the plant, what would you see on the control room panels? Which alarms should come in?
- What are the indications associated with pump cavitation and runout?
- What are the limits of the indications?
- Which instruments (narrow range or wide range) and indications are most accurate for the given situation?

• Which instruments are independent and redundant?

Controlling the Plant

- While observing an evolution, ask the operator (without distracting them) what will change in the system when the next action is taken. Will flow increase/decrease? Why? What are the limits? What are they based on?
- If this component fails, what is the impact on the system and plant?
- Describe four ways to increase flow in X system.
- Where on the power-to-flow map would the station be if a recirculation pump tripped?
- Describe the basic steps to start the plant up (for example, start circulation water, then condensate, and so forth).
- If X parameter (flow, pressures, and so forth) is changed, how will Y parameter change? What would need to be done to address it?
- How does a lake temperature change impact the reactor coolant system (RCS) and secondary?
- How much rod movement or dilution is required to raise temperature/power 0.5%?

Conservative Bias

- How would you handle X deficiency?
- Is X system operable or available if Y system failed?
- When an operator returns from a task, ask: What was the status of the system when you left it? Is the system stable? Do you need to follow up?
- What are the potential consequences of performing the next step? What could go wrong?
- What are your primary objectives as an operator (that is, try to gauge view of production versus safety)?
- How do you handle schedule pressure? What was the last example where you experienced schedule pressure (either self-imposed or external)? What did you do?
- Ask operators to describe a situation that would have placed them in an
 unknown situation or a place of uncertainty, such as no procedure guidance
 exists or expectations were not clear. Ask them how they handled it. Try to
 avoid asking hypothetical questions, such as "What would you do if...?"
 Use real-life examples and actual actions taken to assess operator
 conservative bias.

Teamwork

- What is your role during plant transients, steady state power?
- What are some of the items you would bring to your peer or supervisor to improve team performance?
- When was the last time you coached a peer team member? What was it about? What was his or her reaction?
- During a loss of vacuum transient, what are your specific duties, what are the supervisor's duties and so forth?
- What is more important as a team member, fulfilling your role on the team or backing up another team member?
- What type of information should you the non-licensed operator (NLO)

- report to the control room? What information do you the licensed operator expect to hear from a field operator? Do you receive it routinely? What is the latest example?
- What are the attributes of an effective one-on-one turnover? What type of information do you normally write down in turnover sheets/logs?
- How do you know your relief actually understands the status of the plant after you finish your turnover?

Knowledge

- Define shutdown margin (SDM). Discuss the reactivity balance associated with SDM.
- Draw a single-line diagram of X system. Where is the containment boundary?
- What is the design basis of X system, and how is it accomplished? Why does it exist?
- What interlocks are associated with the component or system? Why?
- What is the basis of step X in the emergency operating procedures?
- Why do we "stop and prevent" or "terminate and prevent" in response to an anticipated transient without scram?
- How does a jet pump work?
- Why do we add amines to the secondary?
- When would N-16 monitors not be as effective on a steam generator tube leak?
- With valve X 25% open, what percent flow should be expected?
- Describe how a valve positioner works and how a flow control loop works. What does changing the air signal pressure do?
- What is the relationship between voltage and current?