# Valve selection and reliability improvement in the nuclear industry:

## Incorporating equipment reliability improvement processes

**The bulk of the US commercial nuclear power stations began operating between the mid-1970s and the late 1980s. As such, their design phase was primarily in the 1970s, with an initial Operating License for 40 years. Maintaining and upgrading this 30-year-old valve technology presents a unique set of challenges. Given the regulatory requirements for nuclear plants, valve upgrades are a costly and time-consuming process. Furthermore, many of these plants have been approved for an Operating License extension for another 20 years beyond the original 40-year license. The focus of this article centers on methods being used in the US to prioritize critical valves and improve their performance via the application of preventive maintenance, diagnostic testing, and upgrades.**

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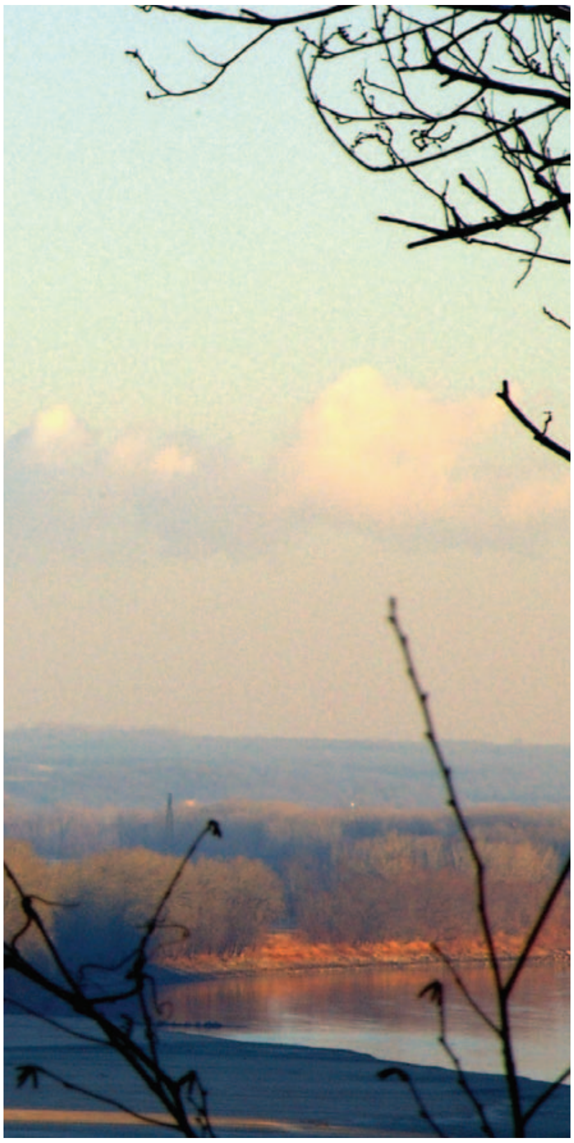
### Equipment reliability process via INPO AP-913

The equipment reliability process represents the integration and coordination of a broad range of equipment reliability activities into one process for plant personnel to evaluate important station equipment, develop and implement long-term equipment health plans, monitor equipment performance and condition, and make continuing adjustments to preventive maintenance tasks and frequencies based on equipment operating experience. This process includes activities normally associated with such programs as reliability-centered maintenance (RCM), preventive maintenance (periodic, predictive, and planned), maintenance rule, surveillance and testing, life-cycle management (LCM) planning, and equipment performance and condition monitoring. The ultimate performance goals of this process are to (1) Ensure that equipment performs reliably through the operating cycle, (2) Make certain that standby safety equipment operates properly on demand, and (3) Confirm that equipment is capable of satisfactory performance under all design conditions. Some of the primary equipment performance objectives of AP-913 are as follows: Critical equipment is identified



based on importance to safety function, safe shutdown capability, and power generation capability. Insight from probabilistic assessment techniques is considered in this determination. Equipment and system performance criteria are established, performance is monitored, adverse trends are identified, and corrective actions are implemented and verified for effectiveness. Failures and failure causes of concern are identified for critical equipment, and measures are established to prevent them. Predictive maintenance technologies are implemented to detect equipment degradation well in advance of potential failure and to optimize equipment performance. Equipment aging is managed using preventive maintenance techniques and life-cycle management, including mitigation of environmental stressors (such as temperature, radiation, and moisture) or operating stressors (such as duty cycles and vibration).

## Prioritizing critical valves

First, the plant system functions that are important to maintaining safety, reliability, and power generation are defined using an integrated screening method that includes all relevant criteria. Next, the importance of each function is determined. Probabilistic Safety Assessment (PSA) modeling is one of the tools used to perform this evaluation. If a function is required for nuclear safety, reliability, or power generation; then it is considered an important function. If a failure of the component or its structural supports defeats or degrades an important function or a function that is redundant to an important function, then it is a critical component. Valves meeting the definition of a critical component are the ones where the highest levels of resources (testing, trending, preventive maintenance, etc.) are expended.

The next category of components is termed non-critical. This category is a level between the categories of critical and run-to-failure for which cost-effective preventive maintenance makes sense. Non-critical components are defined as those components not meeting the screening criteria of critical components, yet whose failure results in one of more of the following:

(1) An unacceptable increase in personnel, industrial, environmental, or radiological safety hazard.

(2) The component has a history of unacceptably high repair, replacement, or operational cost.

(3) Component failure represents an operator or maintenance burden.

(4) The component is obsolete, in short supply, or very expensive to repair or replace.

(5) There is a long lead time for replacement parts, which prevents a required component from being repaired in a timely fashion.

(6) The component is necessary for work on critical equipment (for example, isolation valve).

(7) Component failure promotes failure of other components.

(8) There is a potential for new risks from hazardous chemicals or environmental concerns.

For valves not meeting the definition of either critical or non-critical, a third classification termed run-to-failure is designated. A run-to-failure component is one for which the risks and consequences of failure are acceptable without any predictive or repetitive maintenance being performed and there is not a simple, cost-effective method to extend the useful life of the component. The component should be run until corrective maintenance is required. Use of this third category of components eliminates unnecessary preventive maintenance tasks and allows the plant personnel to focus their resources only the components that are truly needed for safety and production.

## Reliability issues and obsolescence

During recent years, some of the more common issues impacting valve reliability in the US commercial nuclear industry were on the secondary side (turbine-generator side) of the power plant as documented in INPO Topical Report TR4-42. Among those, several have contributed to lost generation, including malfunctions of valves in the following applications:

(1) Main feedwater regulating valves

(2) Feedwater heater drain level control & dump valves

(3) Moisture separator level control valves

(4) Pressurizer spray valves (primary side valves)

(5) Steam bypass valves (condenser dump valves)

As mentioned earlier, the predominant application of valves causing lost generation issues are on the secondary side of the plant. Historically, the primary

(safety-related) side of the plant has had more rigorous preventive maintenance and testing, as would be expected, and has thus experienced a high degree of reliability. In addition, there are specific component programs such as the MOV Program (NRC Generic Letter 89-10 Program) and the AOV Program (INPO NX-1018) that impose testing, trending, and preventive maintenance requirements on these safety significant valves. The equipment reliability process and reports such as TR4-42 have helped point out the opportunity for megawatt recovery and improvements to generation capacity factor via increased attention to important secondary side valves.
Specific issues experienced in the above listed applications include:

(1) Failures of valve positioners

(2) Valve packing leaks on control valves

(3) Seat leakage and resultant seat/body erosion

(4) Inadequate seat load for air-to-close valves

(5) Improper valve installation/rebuild (training issue)

(6) Inadequate work instructions

The majority of failures were found to involve valve positioners. In order of prevalence, the positioner problems encountered were:

- Missing or loose parts
- Material seizure/fracture/shearing
- Vibration or oscillation
- Overheating/hot environment
- Improper assembly or shipping by manufacturer
- Diaphragm failure
- Foreign material intrusion
- Internal pilot breakdown
- Fretting
- Calibration issues

The next most common sub-component group involved in these failures were for the valve actuators and stem/disc assemblies. Those failures involved the following degradations in order of prevalence:

- Valve actuator
  - O-ring/seal failure
  - Improper assembly by manufacturer
  - Inadequate parts/subcomponents
  - Material failure
  - Inadequate clearances
- Stem/disc assembly
  - Worn stem and/or disc
  - Vibration-induced fatigue
  - Missing or loose parts/subcomponents
  - Inadequate stem restraint
  - Stem/disc separation
  - Inadequate assembly

As mentioned in the introduction, most of the US commercial nuclear plants were designed approximately 30 years ago. As such, obsolescence is now becoming an issue we are faced with more frequently each year. Many times, these issues are handled on a case-by-case basis; however, we have begun to focus more attention on obsolescence in a programmatic fashion as part of our life cycle management strategies. For instance, one active group in our industry is the Nuclear Utility Obsolescence Group (NUOG). In addition to NUOG, we have also had good success in the valve arena by increasing the involvement of our valve manufacturers in internal reviews of our valve spare parts, with specific focus obsolete or near-term obsolete components.

## Unique situation

In summary, when it comes to incorporating upgrades and improved components, commercial nuclear plants are in a unique situation due to our regulations and design basis documentation requirements. However, our approach to improved equipment reliability is not unique to nuclear. Many other industries can benefit from an equipment reliability process that identifies the most important components and then incorporates a structure approach to testing, trending, and preventive maintenance for those components. As this approach is implemented, success can be measured in process control improvements, increased reliability, lower maintenance costs, and fewer parts expediting situations.

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