Nuclear supply chain challenges and opportunities

Maintaining the spare and replacement items needed to support a nuclear power plant is a significant undertaking. Nuclear licensees and their suppliers are working diligently to meet the challenges of sustaining the flow of replacement items.

By Marc Tannenbaum

With only two new commercial nuclear units under construction in the United States and widespread efforts to reduce costs while maintaining safety, organizations in the U.S. nuclear supply chain are facing challenges. Some of the issues discussed in the Electric Power Research Institute's (EPRI) biannual Joint Utility Task Group (JUTG) meetings on procurement engineering include decreased demand for spare and replacement items purchased as safety related, the impact of obsolescence, and the efficient implementation of engineering processes that support procurement, such as commercial grade dedication, equivalency evaluation, and reverse engineering.

Decreased demand

Decreased demand for spare and replacement items can affect the ability of suppliers to support the nuclear market. In conversations at EPRI JUTG meetings, established nuclear suppliers have mentioned a noticeable decrease in orders for safety-related items, that is, items controlled under the auspices of a supplier's 10 CFR Part 50 Appendix B[1]–compliant quality assurance program. This decrease is consistent with curtailment of new nuclear construction, market pressures, and efforts to reduce generating costs while maintaining nuclear safety. To a certain extent, the decrease in purchasing may reflect efforts by licensees to reduce existing spare parts inventories, as well as improvements in processes used by licensees to request and procure the items necessary to support operations and maintenance. Moving forward, opportunity exists to better understand the demand for spare and replacement items so that procurement can be better focused on items needed for maintenance and operations, and those that might be needed for likely contingencies, as opposed to ordering for every contingency.

EPRI is beginning to explore how historical data can be analyzed to better understand the probability that items requested on a contingency basis will be used, and how this data may inform decisions when ordering contingency items to support planned work. Ways to better understand demand from an industry-wide perspective, and perhaps in turn inform suppliers and enhance their ability to support licensees, are being explored. Established databases that permit licensees, and in some cases suppliers, to share information on items available in-stock are also adding functionality to improve the ability for licensees to share, exchange, and reduce inventory.

Impact of obsolescence

Decreased demand can contribute to obsolescence. In the past year or so, several nuclear suppliers have issued notifications that they intend to discontinue certain product lines or, in some cases, their nuclear quality assurance programs. These notifications usually include the last date to place an order for the products being discontinued. During a discussion at a JUTG meeting, several participants noted that opportunities to place "last orders" were missed when the notification didn't get to the right people in their organization. This prompted the JUTG to initiate a Pending Obsolescence Response Protocol to provide a forum for reporting these types of supplier notifications. When a notification is reported, EPRI contacts the supplier to get an accurate account of what is being discontinued and the associated cutoff dates. Issues such as the supplier's ongoing re-

Marc Tannenbaum, <mtannenbaum@epri.com> is a Technical Executive at the Electric Power Research Institute, responsible for projects associated with procurement engineering and supply chain.

1. U.S. Code of Federal Regulations, Title 10, Part 50, *Domestic Licensing of Production and Utilization Facilities.* Appendix B, *Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.* Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, D.C.

sponsibility to report defects and noncompliance in accordance with 10 CFR Part 21[2] are discussed, as are possibilities for providing technical assistance to suppliers to maintain product availability.

Three nuclear suppliers that currently maintain databases with parts and equipment data, as well as another entity that maintains a list of approved nuclear suppliers, collaborate with EPRI to facilitate the identification of potentially affected licensees and notify key supply chain and procurement engineering contacts. In cases where collaborative development of a replacement solution might be appropriate, the possibility of pursuing such a project is discussed with stakeholders. The decision to proceed depends on the anticipated demand for the replacement solution, the availability of other replacement options, and the willingness of impacted licensees to agree on a standard solution.

Even with a good critical spares and obsolescence management program in place, it is likely that there will be occasions when the first notification that an item is obsolete will occur after a licensee contacts the supplier to order the item.

Nevertheless, obsolescence is a perpetual challenge for licensees and their suppliers. By the time a new unit is fully commissioned, some equipment is essentially obsolete, as updated models have already been introduced to the marketplace. As plants age, it becomes increasingly difficult for manufacturers to support equipment that may be several generations behind current products. Manufacturers need to focus attention on current products to meet current market demand, which can reduce the attention given to less active, aging product lines. Furthermore, difficulties obtaining the raw materials and parts originally used to fabricate aging equipment, and, in some cases, access to the original manufacturing methods, can challenge a manufacturer's ability to support older products.

Strict design control requirements applicable to safety-related items can increase the difficulty of obtaining replacements. The tendency for nuclear specifications to include bespoke material, inspection, and testing requirements make it difficult for manufacturers to fabricate and keep ready-to-ship replacements in inventory, since different customers may call for different builds, in-process inspections, and features.

Although obsolescence cannot be prevented, opportunities exist to reduce its impact. Understanding the plant equipment critical to nuclear safety and generation is a requisite first step that involves identifying critical equipment and associated spare parts and determining whether the original equipment manufacturer or supplier maintains support for spare and replacement items. Implementation of a critical spares program as discussed in EPRI report 3002010685,[3] *Critical Spares Program Implementation and Lessons Learned*, will enable identification of the most important spare and replacement items and facilitate monitoring their availability and maintaining adequate stock. Even with a good critical spares and obsolescence management program in place, it is likely that there will be occasions when the first notification that an item is obsolete will occur after a licensee contacts the supplier to order the item. Licensees are typically very proficient at using engineering processes to address emergent obsolescence issues.

Engineering processes

Engineering processes, such as commercial grade item dedication (CGID) and equivalency evaluation, that support procurement and acceptance of items can be labor intensive and must include considerations for the specific plant applications and conditions being evaluated.

CGID is an acceptance process undertaken to provide reasonable assurance that a commercial grade item to be used as a basic component will perform its intended safety function.[4] Reasonable assurance is an engineering determination premised on a justifiable level of confidence based on objective and measurable facts, actions, or observations from which adequacy of the item for its intended purpose can be inferred. In other words, commercial grade dedication is a process used to accept commercial grade items based on engineering analysis of their end-use applications and identification of characteristics that enable the items to perform their safety-related functions. EPRI developed CGID methodology in the late 1980s to address situations where items used in safety-related applications were no longer available from manufacturers with nuclear quality assurance programs. Although the manufacturers were still willing to furnish the items (without a nuclear pedigree) as commercial grade, they were not willing to provide the detailed, proprietary design information necessary for licensees to accept the items the way that a manufacturer might accept them. CGID methodology provides a way to accept items for safety-related use by developing acceptance criteria based on the items' safety-related functions.

EPRI report 3002002982,[5] *Guideline for the Acceptance of Commercial-Grade Items in Nuclear Safety-Related Applications*, provides a detailed commercial grade dedication process that is endorsed in Nuclear Regulatory Commission Regulatory Guide 1.164.[6] The basic commercial grade dedication process outlined in this report is relatively straightforward. However, commercial grade dedication technical evaluations involve engineering judgment and can therefore be subjective, based on intended applications for the item being evaluated and verification methods available to the dedicating entity. CGID is used by manufacturers, suppliers that specialize in dedicating items for licensees (third-party dedicators), and licensees themselves. For this reason, the types of verifications and criteria performed to accept an item using commercial grade dedication may vary.

EPRI is currently working on a way to develop technical evaluation data for frequently dedicated items to increase the consistency of CGID technical evaluations. A team of JUTG subject-matter experts will be able to analyze an item to determine typical functions. For each function, failure modes and mechanisms can be determined, as can characteristics necessary to prevent these failure modes and mechanisms. This data can then be mapped to a web-based form that provides a framework for quickly completing individual technical evaluations for that item type, improving overall consistency, prompting for evaluation of application-

2. U.S. Code of Federal Regulations, Title 10, Part 21, *Reporting of Defects and Noncompliance*. Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, D.C.

3. EPRI Product ID 3002010685, *Critical Spares: Program Implementation and Lessons Learned*. EPRI, Palo Alto, CA, 2017.

4. Final Regulatory Basis to Clarify 10 CFR Part 21, *Reporting of Defects and Noncompliance*. U.S. Nuclear Regulatory Commission, Washington, D.C., 2015.

5. *Plant Engineering: Guideline for the Acceptance of Commercial-Grade Items in Nuclear Safety-Related Applications: Revision 1 to EPRI NP-5652 and TR-102260*. EPRI, Palo Alto, CA, 2014.

6. Regulatory Guide 1.164, *Dedication of Commercial-Grade Items for Use in Nuclear Power Plants*. U.S. Nuclear Regulatory Commission, Washington, D.C., 2017.

specific considerations, and enabling sharing of evaluations. In addition, this data supports knowledge transfer and retention and provides a means for incorporating lessons-learned or operating experience into future technical evaluations for the affected item type. One third-party dedicating entity is launching an effort to reduce the cost of dedication for certain types of items by dedicating them based on the requirements of end-use application as opposed to certifying them to a standard specification. Approaches such as this could be reviewed by JUTG teams of subject-matter experts and captured as technical evaluation data.

The technical evaluation data could also be used for equivalency evaluations, which assess proposed replacement items when the original item is no longer available to determine whether the alternative item will be capable of satisfactorily performing the design function(s) of the original item. Since these often involve comparing design characteristics of the original item with design characteristics of the proposed replacement item, technical evaluation data could be formatted to provide a consistent framework for equivalency evaluations.

Reverse-engineering techniques are also used to address obsolescence. While these techniques can be used to examine an item to identify acceptance criteria and characteristics pursuant to the CGID process, they can also be applied to recover enough information about a part or component to enable fabrication of a fully functional replacement.

NRC Information Notice 2016-09[7] identified concerns associated with the application of reverse-engineering techniques. EPRI report 3002011678,[8] *Guidance for the Use of Reverse-Engineering Techniques*, provides a process that addresses challenges identified by the NRC and incorporates decades of experience in performing reverse engineering by the suppliers and licensees that participated in the development of the report. EPRI's research found that substantial design information can be recovered through examination of the original item or specimen. However, the use of reverse-engineering techniques for nuclear applications also involves developing an understanding of the item's design functions and specific design requirements, such as the operating environment, and how the device being reverse engineered interacts with interfacing equipment. In addition, items that are reverse-engineered are subject to existing design control processes, and the EPRI process is compatible with the standard design and equivalency evaluation processes developed pursuant to Delivering the Nuclear Promise initiatives.

Reverse-engineering examination methods, such as laser and structured light scanning, when combined with advanced manufacturing techniques like additive manufacturing (3-D printing), offer promise in addressing obsolete or otherwise difficult-to-obtain replacement items. Several licensees in the United States and abroad have successfully used advanced manufacturing methods in support of efforts to obtain replacement items. In some cases, reverse-engineering and additive manufacturing have been used to rapidly prototype and assess replacement-item designs before using traditional machining to manufacture a replacement. In others, additive manufacturing has been used to create the replacement item itself. Additive manufacturing methods are quickly improving and include the ability to use a variety of materials, including metals, ceramics, and polymers.

Counterfeiting and fraud

No conversation about the supply chain is complete without mentioning the continuing threat posed by counterfeiting and fraud. Licensees and suppliers alike must work diligently to prevent and detect fraudulent items from entering the supply chain. EPRI published detailed guidance in EPRI reports 3002002276,[9] *Counterfeit and Fraudulent Items—Mitigating the Increasing Risk*, and 1021493,[10] *Counterfeit and Fraudulent Items, A Self-Assessment Guideline*.

Ongoing work by EPRI and others to better understand the demand for spare and replacement items should enable licensees and their suppliers to better focus available resources. Improving consistency and the ability to share information on the application of commercial grade dedication and equivalency evaluations will help mitigate the impact of obsolescence, as will the application of reverse-engineering techniques and advanced manufacturing technologies. While there is little doubt of the challenges the U.S. nuclear supply chain faces, EPRI and others are collaborating to overcome the challenges while maintaining focus on nuclear safety.

EPRI reports 3002002982, 3002011678, 3002002276, and 1021493 are available to the public at <www.epri.com>. NN

7. Information Notice 2016-09, *Recent Issues Identified When Using Reverse Engineering Techniques in the Procurement of Safety-Related Components*. U.S. Nuclear Regulatory Commission, Government Printing Office, Washington, D.C., July 2016.

8. *Guidance for the Use of Reverse-Engineering Techniques: Revision 1 to EPRI TR-107372*. EPRI, Palo Alto, CA, 2018.

9. *Counterfeit and Fraudulent Items-Mitigating the Increasing Risk, Revision 1 of 1019163*. EPRI, Palo Alto, CA, 2014.

10. *Counterfeit and Fraudulent Items: A Self-Assessment Checklist*. EPRI, Palo Alto, CA, 2010.