Procurement Engineering and Supply Chain Guidelines in Support of Operation and Maintenance of Nuclear Facilities
FOREWORD

One of the IAEA’s statutory objectives is to “seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world”. One way this objective is achieved is through the publication of a range of technical series. Two of these are the IAEA Nuclear Energy Series and the IAEA Safety Standards Series.

According to Statute Article III, A.6, the IAEA safety standards establish “standards of safety for protection of health and minimization of danger to life and property.” The safety standards include the Safety Fundamentals, Safety Requirements and Safety Guides. These standards are written primarily in a regulatory style, and are binding on the IAEA for its own programmes. The principal users are the regulatory bodies in Member States and other national authorities.

The IAEA Nuclear Energy Series comprises reports designed to encourage and assist R&D on and practical application of, nuclear energy for peaceful uses. This includes practical examples to be used by owners and operators of utilities in Member States, implementing organizations, academia, and government officials, among others. This information is presented in guides, reports on technology status and advances, and best practices for peaceful uses of nuclear energy based on inputs from international experts. The IAEA Nuclear Energy Series complements the IAEA Safety Standards Series.

At present, there are over four hundred operational nuclear power plants (NPPs) in IAEA Member States, with over sixty under construction. Operating experience (OPEX) has shown that ineffective control of the procurement process can jeopardize plant safety and has resulted in increased costs to plant utilities. Procurement must be, therefore, effectively managed to ensure availability of design functions throughout plant service life. From the safety perspective, this means controlling plant configuration so that adequate safety margins remain, i.e. integrity and functional capability in excess of normal operating requirements.

This document is an update to and expansion of IAEA TECDOC-919 [1] originally published in 1996. Current practices for major procurement functions and special implications for NPPs are documented. This information is intended to help all involved directly and indirectly in ensuring the safe operation of NPPs; and also to provide a common technical basis for dialogue between plant operators and regulators when dealing with procurement issues.

The target audience of the reports consists of technical experts from NPPs and from regulatory, plant design, manufacturing and technical support organizations dealing with procurement.

The contributors to the drafting and review of this document are identified at the end of this publication. Their work and that of the authors of the original TECDOC-919 are greatly appreciated. The IAEA officer who directed the preparation of this report was John H. Moore of the Division of Nuclear Power.
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1 INTRODUCTION

1.1 OBJECTIVE

This document provides information regarding good practices for management of procurement and supply chain activities related to the operation and maintenance of nuclear facilities. This includes typical activities such as needs identification, requirements development, value analysis, supplier research, negotiation, buying activities, establishing acceptance criteria, contract administration, inventory control, transportation, receiving, warehousing, and others. Although targeted at operating NPPs, the principles and processes described are generally applicable to new build NPP projects and other nuclear facilities. This document supersedes IAEA-TECDOC-919 Management of Procurement Activities in a Nuclear Installation [1], which was published in 1996.

In recent years plant operation has been impacted by significant procurement related events and concerns. There have been temporary and permanent shutdowns of NPPs due to installation of counterfeit, sub-standard or fraudulent items (CSFIs), and issues related to increased reliance on digital equipment and components containing software, computer-security, and increased globalization of the nuclear supply chain. Obsolescence and component ageing issues increasingly need to be addressed by NPP procurement organizations. These have led to new actions by both NPP operators and regulators.

A significant number of NPPs in some jurisdictions are near their original design life or have had life extensions. As plants age there can be increased difficulty in sourcing parts to support operations and maintenance. Over 20% of NPP equipment in some jurisdictions is obsolete [2]. Original suppliers may have gone out of business entirely, consolidated with other companies, or may have made business decisions (typically due to reduced market demand) not to produce particular items or not to supply them with nuclear grade certifications.

There can be limited information available to support procurement of an exact original component. As consolidations occur, technical information and expertise related to certain items can be reduced or lost. This is particularly true for products accounting for a small portion of the supplier’s revenue stream and for older equipment that are not currently manufactured. This can pose a possible safety and economic risk to operations and outage planning due to safety related equipment not being available when required. A procurement engineering function has originated as a result of this. The main functions of procurement engineering are to identify item technical and commercial requirements, and perform item equivalency evaluations and commercial grade dedications in a timely manner.

Specifically, this document includes information on:

- typical procurement processes;
- considerations of special importance and lessons learned;
- procurement of services;
- procurement of software and items containing software;
- counterfeit, fraudulent or sub-standard items;
- proactive methods for new NPPs to avoid procurement related issues.

There is a separate section that deals with procurement of services in Section 4 of the document. The document does not describe procurement processes and strategies for new-build NPPs, but does outline considerations that should be taken into account to ensure there is a sustainable market and information available over the lifetime of new NPPs.
This report is intended for NPP owners/operators, designers, engineers and specialists to:

- establish, implement, and improve procurement practises for NPPs;
- facilitate dialogue between owners / operators and regulators when dealing with procurement-related issues; and
- consider procurement related concerns that are impactful to routine plant operation when contracting for new NPP construction, and during the transition from the construction to the operating phases of an NPP’s lifetime.

1.2 BACKGROUND

1.2.1 Safety aspects related to procurement

Accident consequences at an NPP can be severe if the plant does not operate as designed under accident scenarios. An important aspect of safe operation is ensuring that SR components operate as intended; thereby ensuring SR systems perform their intended safety function. To facilitate this, operators must ensure that items procured for maintenance of SR systems meet original design requirements.

The procurement function for NPPs plays a key role in nuclear safety. Beyond ensuring that required parts are available when needed for operations and maintenance activities, the procurement function helps ensure that correct equipment and components are installed in the correct locations in the plant, helping to maintain proper configuration management (CM) and safety functions. The procurement organization is typically the interface between the nuclear facility and the “outside world”, and thus to organizations that might not share the same values and commitment to nuclear safety and security, continuous improvement, defence in depth, corrective action, and the required nuclear safety and security culture.

IAEA Safety Standard SSR-2/2 on Commissioning and Operation of NPPs [3] requires that operating organizations establish suitable arrangements to procure, receive, control, store and issue materials (including supplies), spare parts and components, and to use these arrangements to ensure that their characteristics are consistent with applicable safety standards and with the plant design.

IAEA Safety Report Series No. 65 on application of configuration management [4] emphasizes the need to maintain plant configuration to support design basis maintenance, stating that:

“The fundamental concept of configuration management is to provide assurance to the owner, operator and regulator that a plant is designed, operated and maintained in accordance with the actual licensing and design basis, complying with the commitments for the safety of the public and protection of the environment.”

Many design and licensing basis requirements of an NPP are enacted through specifications for equipment to be installed in the plant. Failure to ensure that suppliers fulfil these requirements, or that facility warehousing, operations, and maintenance staff do not take action contrary to such requirements, can lead to equipment to fail or not function as required during design basis accidents.

Lack of confidence by a regulator in a plant’s control of purchasing and configuration related processes can lead to costly plant shutdowns. Lack of confidence in a single component such as particular relay module or type of cable can lead to its need to be replaced in a large number of equipment locations and systems.
1.2.2 Need for management of procurement activities

Besides the safety needs identified in the previous section, procurement activities are required to be carefully managed to maintain economic and financial viability of nuclear facilities. Procurement has a direct connection to product costs, in that cost of materials, spare parts, inventory, staffing and processes required to support procurement activities all add to facility operating costs.

Procurement touches on all parts of a nuclear facility’s life. During initial design the designers specify material to be purchased for the facility. These decisions have long-term consequences for supply chain participants and for future operating costs. During construction and commissioning service contracts are set up to obtain personnel and related services. During operation spare parts and maintenance, engineering, and other services are procured, and smaller design changes (with associated material purchases) are made. Material inventory levels can impact on facility operating costs. During decommissioning major contracts are let for decommissioning and site restoration activities.

As NPPs age obsolescence of original equipment is increasingly a concern. This increases demands on plant engineering and procurement organizations for equivalent replacement parts. This is in contrast to the desire (as expressed in section 1.2.1) to maintain NPPs in the exact same configuration as originally designed (i.e. to minimize change), thereby eliminating any chance of inadvertently altering the design basis or invalidating assumptions regarding safety system equipment performance or failure modes. Where originally equipment manufacturers are unavailable (and sometimes even when they are), such replacement or parts substitutions can require complex engineering assessments, reverse engineering, or associated design changes in order to ensure needed requirements are met.

Procurement itself is becoming increasingly complex. There is a changing marketplace in many NPP operating countries. Many former nuclear suppliers may have gone out of business or have withdrawn from the nuclear business, either via a decision not to supply material or to simply to let their nuclear quality assurance programme or management system lapse. This in turn has made it more difficult for nuclear operators to identify and procure replacement components and parts that meet original design and quality requirements. Original vendors themselves have tended to increase their numbers of sub-suppliers, making tracking and auditing of parts production more difficult.

Plants have found that increased detail is often required for procurement activities associated with maintenance as opposed to that required for new construction. Fewer large components or integrated systems or skids are purchased. More items tend to be individually purchased (for spare parts) as plants age, and if not managed this can drive inventory levels higher to unsustainable levels.

As a result of the need for configuration and design control, along with economic viability, NPPs have found it necessary to carefully manage procurement activities. Additional functions and processes beyond those typically found for many non-nuclear facilities have needed to be developed. Some of these have included vendor quality assurance audits, source inspections, receipt inspections, commercial grade dedication processes, item equivalency evaluations, procurement engineering (PE) functional groups, and others. Such activities will be described later in this document.
2 MANAGEMENT SYSTEMS FOR PROCUREMENT

2.1 INTEGRATED MANAGEMENT SYSTEM REQUIREMENTS

Materials, fuel and services are essential to NPP operation and maintenance, and their proper procurement contributes to safety and reliability. It is fundamental to NPP safety and for prevention of accidents that defense in depth is provided by an effective management system. Such a system should include a strong management commitment to safety and a strong safety culture. This includes ensuring plant materials are of high quality and reliability (IAEA Safety Fundamentals para. 3.32 [5, p. 13]).

A key safety fundamental of all NPPs is the fact that “the person or organization responsible for any facility or activity that gives rise to the radiation risks…has the prime responsibility for safety” (para. 3.3 of IAEA Fundamental Safety Principles document [5]). This means that an NPP owner, when purchasing items or services that can affect nuclear safety, still retains responsibility for that safety and needs to have processes in place to maintain safety under all conditions. This prime responsibility cannot be transferred or delegated to suppliers.

Management systems are a set of interrelated or interacting elements for establishing policies and objectives and enabling objectives to be achieved in an efficient and effective way. They have evolved over time from pure quality control systems (e.g. via simple checks such as inspections and tests), to quality assurance and quality management systems (such as ISO standards), to more recently integrated management system (IMS) approaches like that described in IAEA Safety Requirements GS-R3 [6] and Safety Guides GS-G-3.1 [7] and GS-G-3.5 [8]. The key difference with the IMS approach is that safety is incorporated into the management system. This is included in every aspect of the organisation and particularly for procurement specifications, and evaluations of suppliers and supplier requirements.

It should be noted that IAEA GS-R3 is in the process of being updated to GSR Part 2 (current draft DS456). The new GSR Part 2 incorporates a systemic approach to safety and will include a specific requirement #11 surrounding control of suppliers that will require organizations to put in place effective arrangements with suppliers to specify, monitor and control the supply of items, products and services that may affect safety.

NPPs are required by national regulators to have a documented management system that governs the performance of their work. Specific requirements can vary, however most regulations are aligned with GS-R-3 [6], GS-G-3.1 [7], GS-G-3.5 [8]. Safety Requirements document GS-R3 is the higher level requirements document, with GS-G-3.1 applying more specific guidance for operating facilities and activities, and with GS-G-3.5 applying even more specific guidance for NPPs.

A strong safety culture is a key requirement in a nuclear organisation to ensure that a highly sensitive catastrophic situation is not achieved due to lack of discipline or human or equipment error. Figure 1 shows the standard IAEA model showing how a management system is used to contribute to a healthy safety culture in an organization.
Table 1 below summarizes key items from these IAEA management system documents related to the procurement and material supply functions. Not every clause from these documents has been included in the table so users should refer to the original documents for a complete description of all management system requirements related to an NPP.

Table 2 that follows lists examples of standards and requirements from various countries and international organizations applicable to these areas. The IAEA regularly publishes reports [10] [11] comparing detailed requirements from IAEA GS-R-3 [6] with other common systems such as ASME NQA-1 [12], and ISO 9001 [13]. Differences between GS-R-3 and ISO 9001 exist, as objectives, approaches and perspectives adopted in developing the requirements in each standard are different. GS-R-3 requires that health, environmental, security, quality and economic requirements be considered in conjunction with safety requirements, to help preclude possible negative impacts on safety. The approach used in ISO standards is to develop requirements specific to a given area (e.g. quality management or environmental management) and leave it to an organization to select and use the set of ISO standards relevant to its areas of operation.

**TABLE 1. IAEA MANAGEMENT SYSTEM REQUIREMENT AND GUIDANCE CLAUSES RELATED TO PROCUREMENT.**

<table>
<thead>
<tr>
<th>IAEA Document</th>
<th>Para.</th>
<th>Requirement or recommendation (summarized; see original document for complete text)</th>
<th>Comment</th>
<th>Applicable sections of this document</th>
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</thead>
<tbody>
<tr>
<td>GS-R3</td>
<td>2.1, 6.1 to 6.16, 6.17, 6.18</td>
<td>Management system shall be established, implemented, assessed and continually improved.</td>
<td>Procurement organization at NPP to take part in these improvement activities.</td>
<td>2.1, 5.9</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>6</td>
<td>Management system shall be established, implemented, assessed and continually improved.</td>
<td>Procurement organization at NPP to take part in these improvement activities.</td>
<td>2.1, 5.9</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>6</td>
<td>Management system shall be established, implemented, assessed and continually improved. This includes assessment of safety culture, and a corrective action programme.</td>
<td>Procurement organization at NPP to take part in these improvement activities and actively use the corrective action programme.</td>
<td>2.1, 5.9</td>
</tr>
<tr>
<td>IAEA Document</td>
<td>Para.</td>
<td>Requirement or recommendation (summarized; see original document for complete text)</td>
<td>Comment</td>
<td>Applicable sections of this document</td>
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<tr>
<td>GS-R3</td>
<td>2.2</td>
<td>Safety shall be paramount within the management system, overriding all other demands.</td>
<td></td>
<td>1.2.1</td>
</tr>
<tr>
<td>GS-R3</td>
<td>2.5</td>
<td>Management system shall be used to promote and support a strong safety culture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GS-R3</td>
<td>2.6/2.7</td>
<td>Application of management system requirements shall be graded</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>2.41 to 2.44</td>
<td>Grading process. For procurement the following are identified:</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Expectations of suppliers for assessment, evaluation and qualification.</td>
<td></td>
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<td></td>
<td></td>
<td>• Scope and level of detail of procurement specification;</td>
<td></td>
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<td></td>
<td></td>
<td>• Need for and scope of supplier quality plans;</td>
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<tr>
<td></td>
<td></td>
<td>• Extent of inspection, surveillance and audit activities for suppliers;</td>
<td></td>
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<td></td>
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<td>• Scope of documents to be submitted by supplier and approved by the organization;</td>
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<td></td>
<td></td>
<td>• Records to be provided or stored and preserved</td>
<td></td>
<td></td>
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<tr>
<td>GS-G-3.5</td>
<td>2.41</td>
<td>Type and level of detail in procurement documents can use a graded approach.</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>GS-R3</td>
<td>2.8-2.10</td>
<td>Documentation of MS</td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>2.37 to 2.62</td>
<td>Documentation of MS (provides structure of typical MS)</td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>GS-R3</td>
<td>4.1 to 4.4</td>
<td>Provision of human resources</td>
<td></td>
<td>5.8</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>3.5, 4.1, 4.6, 4.8 to 4.25</td>
<td>Individuals concerned to have capabilities and appropriate resources to discharge their responsibilities effectively, including awareness and other training.</td>
<td></td>
<td>5.8</td>
</tr>
<tr>
<td>GS-R3</td>
<td>5.1 to 5.6</td>
<td>Processes to be defined and continually improved.</td>
<td></td>
<td>2.1, 5.9</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>5.1 to 5.17 (especially 5.6)</td>
<td>Processes need to be developed and maintained. Processes should be considered for control of products, purchasing, and other MS areas.</td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>5.18 to 5.23</td>
<td>Outsourced processes need to be controlled with interfaces to the NPP’s MS.</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GS-R3</td>
<td>5.7 to 5.10</td>
<td>Inspection, testing, verification and validation, their acceptance criteria and responsibilities for carrying out these activities shall be specified. Processes used to be controlled and improved.</td>
<td></td>
<td>3.3, 4, 5.9</td>
</tr>
<tr>
<td>GS-R3</td>
<td>5.12/5.13, 5.21/5.22</td>
<td>Documents and records to be controlled</td>
<td></td>
<td>5.7</td>
</tr>
<tr>
<td>IAEA Document</td>
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<tr>
<td>GS-G-3.1</td>
<td>5.24 to 5.28, 5.35 to 5.49</td>
<td>Documents and records to be controlled via processes.</td>
<td>Procurement management related documents and records to follow a managed process for production, categorization, retrieval, storage and disposal.</td>
<td>5.7</td>
</tr>
<tr>
<td>GS-R3</td>
<td>5.14 to 5.20</td>
<td>Products are to be controlled (spec.’s produced, inspected and tested successfully prior to use, traceable, handled and stored to prevent damage).</td>
<td></td>
<td>3.2, 3.6</td>
</tr>
<tr>
<td>GS-R3</td>
<td>5.23</td>
<td>Suppliers of products selected on basis of specified criteria and their performance shall be evaluated.</td>
<td></td>
<td>3.3</td>
</tr>
</tbody>
</table>
| GS-G-3.1      | 5.50 | Procurement organization should:  
• ensure information provided to suppliers is clear, concise, and unambiguous, fully describes products and services necessary, and includes technical and quality requirements;  
• ensure supplier is capable of supplying products and services as specified;  
• monitor suppliers to confirm continued satisfactorily performance  
• products and services conform to requirements of procurement documents and perform as expected;  
• specify contact individual for all communications on procurement with the supplier;  
• define interfaces between organization and suppliers and between different suppliers to ensure that key dates for supply are met. | Defines key procurement organization duties. | 3.2, 3.3, 3.3.3, 3.3.4, 3.5, 3.6, 3.8, 3.9, 3.15 |
<p>| GS-G-3.1      | 5.51 | Relationships should be established with suppliers to promote communication, to improve effectiveness and efficiency of processes on both sides. | Feedback to suppliers is key to optimizing and improving performance. | 3.15.2 |
| GS-G-3.5      | Appendix V.5 | Interface arrangements should be agreed in writing between the construction organization, suppliers and other organizational units performing the work, including suppliers with sub-suppliers. | Communications are critical to successful procurement. Documented roles and responsibilities assist in work. | 3.15.2 |
| GS-R3         | 5.24 | Purchasing requirements shall be developed and specified in procurement documents. Evidence that products meet requirements shall be available to the organization before the product is used. | | 3.2, 3.6 |
| GS-R3         | 5.25 | Requirements for the reporting and resolution of non-conformances shall be specified in procurement documents. | | 3.15 |
| GS-R3         | 6.11 to 6.16 | Non-conformances to be addressed and corrective actions taken; non-conforming product to be not used and segregated; preventive actions to be taken to prevent reoccurrence. | | 3.10.4, 3.11 |
| GS-G-3.5      | 4.5 | It may be beneficial to maintain an approved suppliers list whose performance has been verified by means of selection criteria and/or experience. | ASL is seen as a good practice. | 3.3.4 |
| GS-G-3.1      | 5.29 | Items requiring inspection, testing, verification and validation are to be defined with processes to be used. | Requires defined process when items like ITPs are to be produced. | 3.3.4 |
| GS-G-3.5      | 5.14 to 5.22 | Guidance on inspection and testing, including information to be included in ITPs | Provides guidance in ITP preparation | 3.3.4 |</p>
<table>
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<tbody>
<tr>
<td>GS-G-3.5</td>
<td>5.24 to 5.30</td>
<td>Guidance on measurement and test equipment (selection, control, calibration etc.).</td>
<td>Guidance on measurement and test equipment. Testing done by vendors should be confirmed to a similar standard.</td>
<td>5.1.4</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.35</td>
<td>Proven commercial products may be used with assurance that correct product is supplied.</td>
<td>Allows use of commercial products with some controls.</td>
<td>5.1.4</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.36</td>
<td>Commercial grade product may need to undergo confirmatory analysis or testing to demonstrate product adequacy to perform its intended function.</td>
<td>Commercial products may need supplementary inspection or testing. CGD process required for SR applications of commercial products.</td>
<td>5.1.4</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.37</td>
<td>When a commercial grade product is proposed for any safety function, a process should be used to determine the product’s suitability; this is sometimes referred to as a ‘dedication’ process in some States.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.62 to 5.64</td>
<td>Work planning process required for safety and efficiency. Systems need to track status of work requests on hold for spare parts or other reasons. Work reports to specify spare parts used</td>
<td>Spare parts are critical to plant success. Systems need to track parts used to their end locations.</td>
<td>5.11</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.79 to 5.83</td>
<td>A defined process is needed for using contractors, including confirmation of competency, adequate training, and in some cases an intelligent customer oversight function.</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.84 to 5.140</td>
<td>General design information / process steps. Some pertinent ones are:</td>
<td>Process needed to differentiate parts replacements with design changes. Q-list can be useful tool for classification;</td>
<td>3.2, 3.4, 3.15.1, 5.2, 5.8, 6</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.141 to 5.147</td>
<td>Configuration management is critical for safe operation (to maintain conformance with design requirements), especially when changes are made.</td>
<td>Configuration can be lost if parts replacements or other procurement activities are not properly controlled within the NPP or by suppliers. Control of materials and procurement activities supporting modifications and maintenance supports this (and control of plant configuration).</td>
<td>5.2</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.148 &amp; 5.149</td>
<td>Plants modifications and maintenance need to be controlled</td>
<td></td>
<td>5.2</td>
</tr>
<tr>
<td>IAEA Document</td>
<td>Para.</td>
<td>Requirement or recommendation (summarized; see original document for complete text)</td>
<td>Comment</td>
<td>Applicable sections of this document</td>
</tr>
<tr>
<td>---------------</td>
<td>-------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.150 to 5.159</td>
<td>Housekeeping, handling, and storage are essential to ensure safety and that correct, functional parts are used in the plant. Storage needs to address issues of identification, prevention of damage, in-storage maintenance, maintaining proper inventory levels, shelf life management, special storage arrangements, and field storage.</td>
<td></td>
<td>3.10</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.160 to 5.162</td>
<td>Inventory levels and spare parts need to be managed based on such things as demand and delivery times. Replacement items require evaluation to confirm they meet original requirements.</td>
<td></td>
<td>3.10.4, 5.1.3</td>
</tr>
<tr>
<td>GS-G-3.5</td>
<td>5.176 to 5.179</td>
<td>Requirements surrounding configuration control, validation and mitigation of risk for IT systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>Appendix III.2</td>
<td>Preparation of procurement document contents (recommendations for sample content: scope of work, technical requirements, training requirements, inspection and test requirements, access to facilities, standards applicable, document requirements).</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>Appendix III.3 &amp; III.4</td>
<td>Review, approval, and changes to procurement document processes to be defined. Documents to be approved before use and only changed in a controlled manner.</td>
<td></td>
<td>5.7</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>Appendix III.5 to III.11</td>
<td>Suppliers must be selected and contracts awarded on basis of ability to provide products or services specified. Supplier evaluation should consider history and management system. A team approach should be taken in evaluating quotations.</td>
<td></td>
<td>3.3</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>Appendix III.12 to III.16, III.19 and III.20</td>
<td>Supplier performance should be evaluated and assessed regularly and non-conformances addressed.</td>
<td></td>
<td>3.15</td>
</tr>
<tr>
<td>GS-G-3.1</td>
<td>Appendix III.17</td>
<td>Receipt inspection should be performed promptly. Items should not be released for use until inspections have been completed and documents received and checked.</td>
<td></td>
<td>3.4.2.3</td>
</tr>
<tr>
<td>Country</td>
<td>National code or standard related to procurement</td>
<td>Comment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------------</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
| Canada   | N286.1, Procurement QA for Nuclear Power Plants [15]; now part of N286-12 - Management system requirements for nuclear facilities [16] | N286.1 was a separate procurement related management system requirements document now incorporated into N286-12. N286-12 has specific procurement requirements related to:  
- Specification of purchasing requirements;  
- Supplier acceptability;  
- Provision of purchasing requirements to suppliers;  
- Supplier selection and award;  
- Supplier-customer relationship;  
- Verification of services;  
- Receipt and inspection of items;  
- Segregation and disposition of problem items;  
- Storage and handling;  
- Planning for replacement parts. |
|          | CSA CAN3-Z299 Series:  
CAN3-Z299.0-86: Guide for Selecting and Implementing the CAN3-Z299-85 Quality Assurance Program Standards [17];  
CAN3-Z299.4-85: Quality Assurance Program – Category 4 [18],  
CAN3-Z299.3-85: Quality Assurance Program – Category 3 [19],  
CAN3-Z299.2-85: Quality Assurance Program – Category 2 [20],  
CAN3-Z299.1-85: Quality Assurance Program – Category 1 [21] | QA standards originally developed in 1970s as part of Ontario Hydro CANDU related procurement. They were used in developing international ISO 9000 series standards, and are no longer being developed. They are however still utilized in some operating organization nuclear management systems. Z299.4 is appropriate for mass produced products designed to ordinary technical standards, or high volume services. Z299.3 is appropriate for products or services involving some complex processes (adds in control of procurement, traceability and other requirements). Z299.2 is for products or services with complex processes and technology, requiring planning in production and design verification (adds in need for corrective action program, control of handling and storage, and other requirements). Z299.1 is suitable for custom designed products or services with a high degree of technology (adds in design control through procedures and independent audits). A main difference between ISO and Z299 and early ISO standards is that Z299 required ITPs be submitted to the purchaser by the vendor, and independent inspection and testing. |
<p>| Finland  | YVL 1.4 Management Systems for Nuclear Facilities [22] | Licensee responsible for ensuring compliance to regulatory requirements and guides for product procurement having a bearing on nuclear and radiation safety. |
| France   | RCC-E Design and Conception Rules for Electrical Equipments of Nuclear Islands [23] | Section A3300 has requirements surrounding procurement related documents (specifications). A 3710 has requirements surrounding monitoring files covering manufacturing processes. Other sections provide guidance (e.g. selection of suppliers, sampling methods, inspections etc.) for specific components. |</p>
<table>
<thead>
<tr>
<th>Country</th>
<th>National code or standard related to procurement</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>AERB/NPP/SC/QA (Rev. 1) AERB SAFETY CODE Quality Assurance in Nuclear Power Plants [25]</td>
<td>Section 3.2.1.3 covers procurement specifically and requires procured items and services meet established requirements and perform as specified, supplier evaluation based on defined criteria, development of requirements necessary to ensure quality, evidence that purchased items and services meet requirements before use, and requirements for reporting deviations from procurement requirements in procurement documents, and processes for non-conformance control and corrective actions.</td>
</tr>
<tr>
<td>India</td>
<td>AERB/SG/QA-2- Quality assurance in the procurement of items and services for nuclear power plants [26]</td>
<td>Provide requirements and recommendations related to implementation and administration of procurement activities in all phases of an NPP’s life. Sections cover planning, document preparation, shortlisting of suppliers, bid evaluation and award, performance evaluation, verification, corrective functions, item acceptance, commercial grade items, spares, storage, records, and audits.</td>
</tr>
<tr>
<td>India</td>
<td>AERB-SG-QA-2/SG-QA-3 - Quality assurance in the procurement of items/ In the manufacture of items [27]</td>
<td>Provides recommendations on how to fulfil Code requirements related to manufacture of items important to safety at NPPs. Sections included for management, performance, verification and corrective functions. Appendices provide examples of QA levels, QA plans, transportation controls (including packaging), design concessions etc.</td>
</tr>
<tr>
<td>Nuclear Quality Standards Association (NSQA)</td>
<td>NSQ-100 Nuclear Safety and Quality Management System Requirements [30]</td>
<td>Industry led initiative open to major nuclear utilities, nuclear engineers and manufacturers designed to produce a common quality standard based on IAEA GS-R-3:2006, ISO 9001:2008 and ASME NQA-1-2008 (and addenda 2009). Document layout is similar to ISO 9001:2008. Correspondence matrices to various QA standards are also published [31] [32] [33].</td>
</tr>
<tr>
<td>Country</td>
<td>National code or standard related to procurement</td>
<td>Comment</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>OPB -88/97 NP-001-97 (PNAE G- 01 011-97) General Regulations on Ensuring Safety of Nuclear Power Plants [34]</td>
<td>Requires safety classes of NPP elements be designated by design (4 classes defined), and quality assurance requirements assigned to safety Classes 1, 2, and 3 be specified in regulatory documents.</td>
</tr>
<tr>
<td></td>
<td>NP-082-07 Nuclear Safety Rules for Reactor Installations of Nuclear Power Plants [35]</td>
<td>Requires (among other things) quality assurance programs be developed for all stages of NPP life, safety important components be subjected to inspections and tests during manufacturing to verify design characteristics, and that designs contain lists of systems and components whose performance and characteristics are to be verified.</td>
</tr>
<tr>
<td></td>
<td>RD EO 1.1.2.05.0929-2013 Guidance on performance of acceptance inspections at the manufacturers and incoming inspection on nuclear power equipment of safety classes 1, 2 and 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NP-061-05 Safety Rules for Storage and Transportation of Nuclear Fuel at Nuclear Facilities [36]</td>
<td>Establishes technical and organizational requirements for nuclear fuel storage and transportation systems at NPPs, including separate storage on NPP sites, off-site facilities, nuclear research installations, on-shore and floating nuclear fuel storage facilities.</td>
</tr>
<tr>
<td>South Africa</td>
<td>RD-0034: Quality and Safety Management Requirements for Nuclear Installations [37]</td>
<td>Details regulatory requirements for quality and safety management system requirements for licensees, including procurement requirements, utilizing ISO 9001 as a basis.</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>NG-TAST-GD-077 Rev 2 : Procurement of Nuclear Safety Related Items or Services [38]</td>
<td>Informs regulatory assessment of supply chain arrangements which are particularly important to supply of items or services significant to nuclear safety designated for use in the UK. Covers requirements on purchasers, supplier selection, procurement documents, quality plans, contract variations, competence, deviations and technical query, records, inspection and surveillance activities, non-conforming counterfeit and suspect items, and management system certification.</td>
</tr>
<tr>
<td></td>
<td>NS-TAST-GD-049 Rev. 4 Licensee Core and Intelligent Customer Capabilities [39].</td>
<td>Helps regulatory inspectors assess suitability of approaches a licensee may take to maintenance of in-house expertise to maintain control and oversight of nuclear safety at all times, and use and oversight of contractors whose work has potential to impact nuclear safety.</td>
</tr>
<tr>
<td></td>
<td>BS OHSAS 18001:2007 Occupational health and safety management systems. Requirements [40]</td>
<td>Defines requirements for an occupational health and safety management system. It is going through process of becoming ISO 45001.</td>
</tr>
<tr>
<td>Country</td>
<td>National code or standard related to procurement</td>
<td>Comment</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>United States of America</td>
<td>10 CFR Part 50 Appendix B Quality Assurance Criteria for Nuclear Power Plants [41]</td>
<td>Regulation requiring control of procurement of SR items. Includes specific requirements surrounding procurement document control, control of purchased items and services, inspection and test control, control of MTE, handling storage and shipping, non-conformances and corrective action, and others.</td>
</tr>
<tr>
<td></td>
<td>10 CFR Part 21 Reporting of defects and noncompliance [42]</td>
<td>Section 21.31 procurement documents specifically indicates that Part 21 reporting of defect requirements apply to procurement participants. This includes such things as maintaining records, providing access to the NRC, reporting defects to the NRC, etc.</td>
</tr>
<tr>
<td></td>
<td>EPRI : Analysis and Comparison of ANSI/ISO/ASQ Q9001:2000 with 10CFR50, Appendix B (report 1007937) [44]</td>
<td>Analyzes quality requirements in ANSI/ISO/ASQ Q9001:2000 with those of 10CFR50 Appendix B, as they apply to suppliers / manufacturers / service providers to the nuclear industry. Findings were that there was one gap related to independent inspection, and that ASME has more explicit requirements regarding independence of design verification than defined in ISO.</td>
</tr>
<tr>
<td></td>
<td>EPRI : An Overview of Other Industry Experience with the ISO 9000 Quality Management System, (report 1008258) [45]</td>
<td>Presents results of EPRI studies in support of determining how the US nuclear industry can more broadly employ suppliers certified to ISO 9000. Identified OPEX from automotive, aerospace, telecommunications, and other industries promoting ISO, and regulated industries without a sector specific ISO programme. Also reviews Canadian experience and IAEA comparisons of standards. Concluded that quantified experience contributed by licensees thus far has not led to conclusive evidence that would suggest product quality is solely dependent on a supplier’s particular QA programme, but rather the implementation of a quality programme.</td>
</tr>
<tr>
<td></td>
<td>NEI 06-14A Revision 7 Quality Assurance Program Description [46]</td>
<td>Provides template for applicants to implement applicable requirements of a QA programme meeting 10 CFR 50, Appendix B, and 10 CFR Part 52.</td>
</tr>
</tbody>
</table>

2.2 INTELLIGENT CUSTOMER ROLE

NPP owners and regulators often use the concept of the “intelligent customer” (sometimes referred to as a “knowledgeable customer” or “smart buyer”) when developing
their management system for dealing with service or major equipment suppliers. GSG-4 [47] defines ‘intelligent customer’ capability as the capability of the organization to have a clear understanding and knowledge of the product or service being supplied. The concept relates mainly to a capability required of organizations when using contractors or external expert support. It allows for discrete, “hands-on” oversight of critical activities where outcomes can be less well-defined.

Some characteristics of an intelligent customer are (adapted from GSG-4 [47]):

- Full understanding of the need for an external expert’s services and context in which work is performed;
- Knowing what is required and how the work will be used;
- Knowledge surrounding proper specification of objectives, scope and requirements of the work so that the product will meet needs;
- Knowledge of reasonable time frames for delivery of the work consistent with proper quality;
- Knowledge and provision of site specific information that could be useful to the external expert;
- Understanding of expected outcomes of the work;
- Ability to not inappropriately influence work outcomes or advice from the external supplier or to allow any other body to do so, in order that the supplier advice reflects its own technical opinion;
- Ability to oversee the work in accordance with the owner’s procedures and management system, and to perform technical reviews the work when necessary;
- Able to ensure regular interaction with supplier and facilitate interaction with other parties relevant to the task if necessary.

The UK’s Office of Nuclear Regulation has produced a guidance document on assessment of the intelligent customer role [39], which documents a number of useful principles on use of contractors. Among these are that licensees should maintain an intelligent customer capability for all work carried out on its behalf by contractors that may impact upon nuclear safety; should ensure that it only lets contracts for work with nuclear safety significance to contractors with suitable competence, safety standards, management systems, culture and resources; should ensure that all contractor staff are familiar with the nuclear safety implications of their work and interact in a well-coordinated manner with its own staff; and that the licensee should ensure that contractors’ work is carried out to the required level of safety and quality in practice.

2.3 SUPPLY CHAIN MANAGEMENT PROCESSES

Supply chain management (SCM) is a relatively recent term encompassing the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management (according to the Council of Supply Chain Management Professionals (CSCMP)). It also includes coordination and collaboration with channel partners, which may be suppliers, intermediaries, third-party service providers, or customers. Supply chain management integrates supply and demand management within and across companies.

In the context of nuclear facilities SCM implies an active role for the procurement and supply chain organizations within an operating organization, as opposed to a relatively passive role of simply issuing procurement specifications and responding to bids.

Typical nuclear supply chain tiers are shown in Fig. 2. New build projects are typically concerned with how the tier 1 technology vendor sets up and manages its supply chain, while operating plants typically deal directly with tiers 3 and below for spare parts associated with operating and maintenance activities. The two activities are invariably linked, as decisions
and procurement choices made by the technology vendor (e.g. choice and location of key suppliers) will have implications for the supply chain throughout a plant’s life.

An example of an SCM activity for an operating facility is the analysis of commodities purchased and preparing a strategic positioning action plan for each of them. The Scottish government for example recommends categorizing commodity types for its public procurement activities into routine, bottleneck, leverage and strategic categories (Fig. 3) and suggests typical actions to take to manage the relationship with suppliers in each category (Table 3). An assessment tool [48] is available to assist in this evaluation approach. NPPs have thousands of such commodities and can benefit from similar methods. The careful development and management of strategic suppliers, including monitoring their financial and business health, should be a key supply chain activity.

![Typical nuclear supply chain tiers](image-url)  
**FIG. 2. Typical nuclear supply chain tiers (courtesy WNA).**

<table>
<thead>
<tr>
<th>LEVERAGE</th>
<th>STRATEGIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>High expenditure area</td>
<td>Strategic to operations</td>
</tr>
<tr>
<td>Many existing alternative products/services</td>
<td>Few qualified supply sources</td>
</tr>
<tr>
<td>Many qualified supply sources</td>
<td>Large expenditures</td>
</tr>
<tr>
<td>Design in supply critical</td>
<td>Complex specifications</td>
</tr>
<tr>
<td>Commercial involvement can significantly impact price</td>
<td></td>
</tr>
</tbody>
</table>

![Strategic commodity positioning](image-url)  
**FIG. 3. Strategic commodity positioning [49].**
TABLE 3. TYPICAL SCM ACTION PLAN FOR VARIOUS COMMODITY TYPES (ADAPTED FROM [50]).

<table>
<thead>
<tr>
<th>Commodity Position</th>
<th>Examples of commodity</th>
<th>Recommended approach</th>
<th>Typical action plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>Office supplies, desktops, laptops etc.</td>
<td>Should take up minimal time and effort. Minimize management attention and investment.</td>
<td>Mid-term contracts; Utilise supplier own specifications; Offer supplier incentives to substitute; Reduce inventory – supplier managed; Relationship owned by budget holder/end-user; Simple performance measurement process with focus on reliability; Monitor internal time spent resolving problems.</td>
</tr>
<tr>
<td>Bottleneck</td>
<td>Complex specification products.</td>
<td>Should ultimately be transitioned into another commodity position. Ensure supply of critical items</td>
<td>Long-term contracts; Ensure supplier is motivated to provide quality service; Look at developing new suppliers; Consider buffer stocks for additional security; Measure supplier performance to identify potential interruptions to supply; Move to generic specifications where appropriate; Manage entire supply chain.</td>
</tr>
<tr>
<td>Leverage</td>
<td>Commodities (gravel, soil, courier services, etc.)</td>
<td>Leverage relationships are built solely around price. Cut cost using innovation and competition</td>
<td>Short-term contracts; Focus on price; Pursue a very active sourcing policy; Look for continued cost-reduction; Reduce stockholding; Consider the use of e-Auctions; Pursue value add services from supplier which reduce total cost; Manage transportation costs separately.</td>
</tr>
<tr>
<td>Strategic</td>
<td>Most direct commodities.</td>
<td>Strategic relationships must be partnerships with mutual benefits. Actively manage the relationship.</td>
<td>Consider long-term contracts or service-life agreements; Work closely with suppliers in product innovation and process; Joint product/process design and planning; Integrated systems; Supplier manages product/service; Consider on-site representation; Contingency planning.</td>
</tr>
</tbody>
</table>
3 PROCUREMENT PROCESS

A typical procurement process is listed below and shown schematically in Fig. 4. It is a combination of the model identified in Appendix III of IAEA safety guide GS-G-3.1 [7] (reproduced below as Fig. 5) and those adopted by many utilities such as the EPRI process model as defined in [51], the NEI process described in [52], or process maps defined by the Construction Industry Institute (CII) [53].

The process consists of the following activities divided into the major categories of defining what is needed, getting it, using it, and taking corrective action as required:

- Need identification;
- Establishing requirements;
- Potential procurement scenarios and supplier selection;
- Defining acceptance criteria and methods;
- Bidding, evaluation, and placement of purchase order (PO);
- Contract execution, component fabrication and performing source surveillance;
- Packaging and transportation;
- Expediting;
- Acceptance and receipt;
- Storage and warehousing;
- Item installation or use;
- Repair, refurbish, and return to stock;
- Disposing unused material;
- Contract closeout;
- Non-conformance control and supplier feedback.

**FIG. 4. Nuclear procurement model.**
FIG. 5. Procurement process (from GS-G-3.1 [7]).

The following sections further describe each of these items.

3.1 NEED IDENTIFICATION

3.1.1 Source of need

This step involves an individual or organization identifying that an item or service should be purchased for an NPP. Information needed is what is required, where that item will be used in the station, and for what purpose. Information may be very detailed (e.g. specific make and model of a part to be purchased), or be more in the form of a general requirement or description that might be filled in a variety of ways. Depending on the operating organization, different levels of financial approval (individual, supervisor, budget holder etc.) may be required before the purchasing organization can act upon an identified need.

Requests for specific items needed for an NPP can come from a variety of sources. Some of these include:

- New items identified by plant organizations related to plant design changes, modifications, major projects, or part replacements;
- Spare parts required to be purchased for maintenance activities as a result of planning for or performance of maintenance;
• Strategic spare parts identified to be purchased for major components or to address single-point vulnerabilities (e.g. spare transformers, diesel generators, entire valve assemblies etc.);
• Automatic replenishment of warehouse or stores stock (typically automatically generated via a low stock condition).

3.1.2 Demand from major projects

Major modifications, refurbishments and complex equipment or service purchases are often managed as special projects. Good project management requires identification of a specific need or goal of the project to be documented, often in a project charter document, needs statement, or scope of work. Reaching an agreement on the nature of a new project, including its scope, objectives, and constraints can be a difficult but healthy process for stakeholders in a corporate environment. A typical project charter might contain the following sections, each of which requires definition and agreement for the project to proceed.

• Project overview;
  o Problem statement;
  o Project description;
  o Project goals;
  o Project scope (and exclusions);
  o Critical success factors;
  o Assumptions;
  o Constraints;

• Project authority and milestones;
  o Funding authority;
  o Project oversight authority;
  o Major project milestones;

• Project organization;
  o Project structure;
  o Roles and responsibilities;
  o Facilities and resources;
  o Points of contact.

Following agreement on the project charter and release of funding, a project can commence. During the project numerous specific items or services to be purchased will be identified. Each of these in turn will require to be addressed through the procurement organization. As many items can have long lead times, early identification of procurement needs can contribute to the success of such projects.

3.1.3 Demand analysis

Demand analysis and management is useful in maintaining stock levels at optimum values while maintaining plant safety. Both proactive and reactive methods should be used to anticipate and prioritize required material demand. Sources to be analyzed can include:

• Specific material requests entered by staff;
• Minimum reorder points (ROPs) reached for stocked items (predetermined inventory level that triggers a need to place an order considering safety stock and delivery time);
• Projection of future demand based on known work (routine maintenance, planned outages or major refurbishments at site or on similar units);
- Company stocking plans or maintenance philosophies (guidelines for adding new items to inventory, identifying unneeded items already in inventory, and establishing stock levels);
- Current in process orders;
- Lead times (time from date of need identification to date of delivery, encompassing both operating organization and vendor activities);
- Company business plans and priorities;
- Item cost;
- Item shelf life;
- Alternate options available for item (item already in stock, readily available from other sources, or less hazardous item possible to substitute for item).

Analysis should be performed on historical parts usage and projected future demand to minimize transaction costs related to the stocking process. Establishment of proper reorder points, reorder quantities (ROQs), and safety stock levels is important to efficient operation, as excessive numbers of transactions can slow down purchasing of other important items. Appendix IV shows some examples of such calculations.

Attention should be given to ordering contingency parts by maintenance work planners. Distinguishing between required parts (those absolutely needed to complete a work task) and contingency parts (those that may be needed if the defined work scope increases or changes) within ordering systems is an important step. EPRI has proposed a process [54] whereby contingency parts are analyzed and only purchased (after a challenge process) if they have greater than a 50% chance of being used or would have a high impact on plant operations if not available. Roll-up of all contingency parts for a given outage or maintenance window can result in fewer parts being purchased (a potential of say 10 contingency parts might result in an actual order of only 2 or 3 items). When reviewing past work order material usage history, work planners should consider both materials that were issued and those that were returned when not used. Issued material by itself may not accurately reflect in-plant material usage.

3.2 ESTABLISHING REQUIREMENTS

IAEA GS-R3, The Management System for Facilities and Systems [6] para. 5.2.4 indicates that purchasing requirements shall be developed and specified in procurement documents.

This step involves establishment of technical, quality and commercial procurement requirements for the item to be purchased, and well as any administrative controls related to the procurement process. It is the most important step in the procurement process and it determines the ultimate product desired to be received (i.e. its functional and performance characteristics and quality).

Technical and quality requirements provide the ability to define what attributes are to be imparted on the item being purchased, and are the foundation for subsequent activities in the procurement process. Such requirements are typically tied to a unique number such as a stock code, catalogue identification number, or stock item number. Such a number is typically generated following a screening process that confirms that the requested item is legitimate and not duplicated within the operating organization’s purchasing system (see Appendix I section I.3).

Technical requirements include properties essential for the item’s form, fit, or functional performance. Quality requirements are associated activities needed to ensure these properties or attributes. While technical and quality requirements may change, properties or attributes of importance (i.e. critical design characteristics) do not. Any revised technical and quality requirements should still assure that these properties of importance are imparted on the item.
Processes for items to be purchased can be graded between safety-related (SR) and non-safety-related (non-SR). This risk-based approach drives quality requirements, acceptance criteria and methods, and the extent and rigour of verification activities during the procurement process. EPRI reports for example that a typical US plant would have 80% non-SR components [55], indicating that significant procurement process savings can be made for such items.

Safety related procurement necessitates a systematic process, which can be further graded based on such items as safety significance and risk, supplier expectations, scope and detail of procurement specifications provided, need for and scope of supplier quality plans, extent of supplier inspection, surveillance and audit activities, scope of documents and records provided by suppliers, and need for document storage or preservation (see IAEA Safety Guide GS-G-3.1 [7] paras. 2.41 to 2.44). Processes for non-SR equipment can depend on economic or production impacts of the equipment, item complexity, and other factors. Processes for significant non-SR equipment can end up being similar to those of SR equipment.

Many operating organizations establish a complete list of all equipment in their facilities as to whether they are safety-related (SR) or not. This is often called a “Q-list” (for “quality list”). Such a list aids the procurement function by increasing productivity in identification of purchasing requirements, and can reduce costs by helping to minimize purchasing of SR components. Often components associated with a single piece of major equipment can have both SR and non-SR sub-components. For example a major pump/motor set can have a SR function to deliver water or provide a pressure boundary, however system sub-components added to monitor vibration or bearing temperatures for maintenance purposes only may not be considered SR, and if so could be purchased using non-SR processes.

Having a complete Q-list for a plant is important, so as to not miss the existence of SR item end uses in a plant when ordering items. A breaker or relay for example that is thought to have only non-SR end uses might be purchased and placed into plant inventory with no specific quality requirements, and later inadvertently used in a SR application. Commodity materials or other items with broad application (e.g. with both SR and non-SR end uses) should normally have the most restrictive requirements identified so item may be used anywhere within that range.

Requestors need to identify what specific item is needed and the specific application where it will be used. For new and many existing items adequate technical and quality procurement requirements may not exist or be poorly documented. Individuals requesting an item can often only partially establish adequate technical and quality procurement requirements, or may inadvertently attempt to purchase items with incorrect requirements or in contravention of previous business decisions.

Some areas where requestors may be deficient include:

- Requestor may not be fully aware of how to provide a detailed technical description of the item (applicable codes, code effective dates, standards, available options etc.),
- Requestor may not be aware of identical or acceptable substitutes already in an operating organization’s warehouse or already successfully purchased;
- Requestor may not be fully aware of other end uses for the item at the NPP that may impact on required stock levels or quality requirements (e.g. for an item used in both safety and non-safety applications);
- Requestor may be attempting to purchase a specific item for which there is no supplier on the market with an acceptable quality programme;
- Requestor may be attempting to purchase an item than is on an industry list of items with known quality issues (sometimes called a restricted equipment list);
• Requestor may not be aware of costs or implications associated with purchase of a hazardous substance (industrial safety or environmental impacts of a chemical or other substance);
• Requestor may not be fully aware of preferred supplier arrangements, blanket purchase orders, contracts, or master agreements established with certain vendors or purchasing groups;
• Requestor may not be fully aware of stocking and inventory level management strategies, and arrangement with certain vendors for just-in-time or expedited delivery times;
• Requestor might be attempting to purchase spare parts for which a strategic decision has been on economic grounds to replace the item if it fails rather than attempt repairs of it.

A process should be in place to ensure requirements to purchase an item are adequate. Due to volumes of work involved and its specialized nature, many utilities establish separate PE organizations dedicated to such activities (see Section 5.1).

When ordering an identical replacement part from the original supplier, establishment of requirements can be straightforward. However if alternate replacement parts are being ordered the problem becomes more complex.

### 3.2.1 Technical requirements

Technical requirements are established to assure that properties or attributes of importance are conveyed to the item. These may include:

- Correct and complete identification of the item or scope of service, including properties essential for an item’s form, fit or functional performance.
- Technical features desired but not essential to an items’ form, fit, or functional design (e.g. colour of coating, expandability features, etc.),
- Applicable standards and codes.

Technical requirements may be achieved via purchase of a number of different specific items from a number of suppliers.

When identifying components or items, technical descriptions typically need to contain the following information (adapted from [56]). Utilities often develop standard procurement clauses that can be involved to address many of these items in a consistent manner.

- Part numbers, model numbers, mark numbers;
- Noun description of items with modifiers sufficient to distinguish item from other similar items (e.g. “1-K ohm ±5%, 5-watt, axial-lead, wire-wound resistor” versus “resistor”). Catalogue descriptions may be used;
- Plant-specific or supplier drawings and revision level;
- Codes and standards to be applied, including revision level and applicable sections whenever possible (this may be done by indicating applicable safety classification or quality group of the item);
- Qualification parameters to maintain compliance to a qualification report or environmental and seismic conditions;
- Industrial safety, chemical, and environmental protection requirements;
- Plant-specific conditions;
- Material specifications (including the requirement to provide analysis results demonstrating the product meets specifications for all chemical parameters);
- Painting or coating requirements;
- Transportation limitations;
• Packaging requirements (see section 3.7);
• Storage requirements to prevent degradation (see section 3.10.1);
• Storage maintenance requirements (see section 3.10.2);
• Shelf life requirements (see section 3.10.3).

Extent of the technical description is driven by procurement conditions, role of the supplier in equipment design, item complexity, the item’s role in performing safety functions, manufacturing processes used in item production, and bounding conditions that the item is required to satisfy. A sample technical specification template adapted from one used by a nuclear operating organization for engineered products or services is given in Appendix VII.

Commonly sourced items (e.g. cables, electrical switchgear, piping, connectors, bulk chemicals, bulk material etc.) can benefit from having standard technical requirements prepared in advance. EPRI has prepared sample procurement requirements for bulk chemicals [57].

### 3.2.2 Quality requirements

Quality requirements are programmes and activities needed to assure properties or attributes imparted to an item. If procuring an identical replacement item from the original supplier with an approved quality assurance program, existing requirements included in the design documents when supplied may be adequate. However if procuring an identical item from a new supplier, it will more likely be necessary to provide detailed requirements such as detailed dimensions, materials of construction, special testing and inspection requirements, etc. Another consideration is whether changes have occurred which may have an effect on existing requirements; for example new licensing commitments or plant modifications.

Some items to consider with respect to quality requirements include:

- Management system programme requirements;
- Applicable inspection, examination and test requirements;
- Documentation submission requirements;
- Other applicable requirements such as purchaser’s right of access to the manufacturing facility, non-conformance reporting, identification and availability of spare parts, shelf life clauses, packaging and labelling requirements, and other related data required for ordering.

Utilities and suppliers typically grade quality requirements based on the SR importance of an item. Table 4 shows a simple grading system utilized by AREVA NP as an example.

<table>
<thead>
<tr>
<th>Quality grading</th>
<th>Component Status</th>
<th>QA requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety grade</td>
<td>Products and services SR.</td>
<td>ISO-9001 complemented by nuclear specific requirements.</td>
</tr>
<tr>
<td>Standard grade</td>
<td>Products and services not SR but important for construction and/or operation.</td>
<td>ISO-9001.</td>
</tr>
<tr>
<td>Not classified</td>
<td>Other products and services.</td>
<td>No specific requirements.</td>
</tr>
</tbody>
</table>

**TABLE 4. AREVA NP QUALITY REQUIREMENTS BASED ON COMPONENT OR SERVICE IMPORTANCE TO SAFETY [58].**

### 3.2.3 Commercial requirements

Along with technical and quality requirements, purchasers need to define acceptable commercial requirements related to the item(s) or services to be purchased. Acceptable price is one consideration, as is the relative importance of pricing into the ultimate purchase
decision. For simple items with limited numbers of suppliers pricing may not be a key factor, while for large capital projects with different methods of approach pricing and related commercial conditions can play a large role.

Various contracting strategies can be employed for large projects and services. The operating organization can act as a general contractor and hire companies for various roles (engineering, procurement, or construction), or an integrated EPC approach can be taken where a prime contractor takes on responsibility for many or all of the project roles. In no case however can the operating organization delegate their prime role in ensuring nuclear safety to a contractor. Service procurement is more fully discussed in Section 4.

Some commercial conditions of importance other than price are those related to incentives and penalties, performance guarantees, and insurance to be carried by the supplier, warranties of products delivered, holdbacks, and financing requirements. Ownership and further use of intellectual property is also of concern, and payment terms may be a consideration. Companies need to define any requirements that they may have such items in purchasing requirement documents.

Incentives and penalties are a part of many industrial contracts. Set up correctly they can help drive desired behaviour and mutual benefit. Provisions that are overly broad, purely punitive, or poorly thought out however will be ineffective or injurious to the business relationship, and can lead to undesirable outcomes such as premature delivery of poor quality product.

Performance guarantees are promises made either that a service lives up to certain expectations, or that a product will continue to perform well over a stated period. In the business world, there are many such guarantees, each created in individual ways to define a company's commitment and extent of future responsibility. Sometimes third parties can guarantee performance, especially when employing subcontractors. Performance bonds are examples of such guarantees, and are typically issued by an insurance company or bank to guarantee satisfactory completion of a project by a contractor. The insurance company promises to pay the owner a certain amount if the contractor fails to meet an obligation.

Insurance is used as a risk mitigation tool. In the context of the delivery of a good or service, insurance can be used to provide financial compensation to an owner in the event of failure, bankruptcy, or other conditions impacting the supplying company that might prevent it from delivering the product. Insurance may also cover cargo insurance during transit. Owners are typically interested in the coverage levels, limits of liability, and deductible amounts carried by suppliers. Supplemental insurance may be desirable to cover cost exposure due to large deductibles. It may be also desirable to request additional errors and omissions liability insurance in services contracts in addition to minimum national requirements for professional or other liability insurance. Owner requirements may be more demanding than legally required and some consultants may not have the additional coverage available.

Warranties are guarantees or promises which provide assurance by one party to the other that specific facts or conditions are true or will happen. They are generally associated with material supply, but can also be associated with delivery of a service (e.g. can be associated with installation, maintenance, or design quality). Specifications should include either the take-over date or in-service date after which the warranty period begins. Standard commercial conditions should be established within a company for purchasing purposes to deem when warranty periods will start (e.g. 6 months after product delivery, or otherwise). Warranties have both technical and commercial aspects, and are typically evaluated in both areas.

Some contracts will involve work that includes a high level of specialized knowledge and proprietary technology. Provisions should be included in specifications to provide on-site support for a period of time. Also, contracts should include provisions to transfer sufficient
knowledge from the design agencies to owner staff before deliverables arrive at site. This can be done in various ways including special courses for staff or special assignments of owner staff as “trainees” to work in the contractor’s office under direction of their supervisor. This later approach is most effective when the systems are large and complex.

Holdbacks may be required by law or may be suitable for contracts when products delivered require a period of use to demonstrate that they are error free. Holdbacks often vary between about 5% and 10% and may extend to the end of the warranty period. Financing costs of holdbacks (time value of money) are generally included in quoted prices of fixed price contracts or in rates of cost plus contracts. The contractor will object to a holdback if the product will sit for an extended period before it is used, installed or operated.

Financing is increasingly a part of large international nuclear projects, with suppliers increasingly being asked to finance substantial portions of such projects. It is more fully discussed in IAEA NE Series NG-T-4.1 [59] and NG-T-4.2 [60]. Acceptable or desired financing arrangement should be described as part of commercial requirements.

Requirements and contracts need to identify who owns intellectual property at conclusion of work. This is of great importance to NPPs, who require access to and the ability to modify equipment and system designs over an extended period of time. Requirements clauses that allow an NPP to use and modify supplied drawings and other documents for their own internal use are important to ensure this.

Payment terms may be part of the competitive process. A low price with progress payments may not be cheaper on a net present value basis than a higher price requiring payment upon completion. If payment terms are important to the contract, the desired terms need to be defined as part of commercial requirements, along with an indication as to whether different or innovative proposals will be accepted or considered. Payments should be tied to items that can be clearly inspected or documented, with examples being issuance of drawing or design documents, delivery of goods, completion of work or beneficial occupation, project completion (including documentation), or following satisfying certain performance criteria. Earlier payments always increase the risk to the client, with greatest risk occurring when a substantial portion of a contract’s value is paid out prior to “useful” product being received by the client.

Common commercial terminology related to tasks, costs and risks involved in delivery of goods from sellers to buyers are defined in 11 Incoterms® or International Commercial Terms. Incoterms® are used worldwide in international and domestic contracts for the sale of goods, and were first published in 1936. Incoterms® abbreviations are shown in Fig. 6 below. Greatest risk to the client is for acceptance of delivery outside of the factory gate (EXW), and lowest risk is for acceptance on the job site (DPP).
3.2.4 Administrative controls

Administrative controls for an item to be purchased need to be defined for prospective suppliers. These can include:

- Controls related to the bidding or quotation process for the item in question. This might include a need to submit sealed (possibly double sealed inside a second envelope) tenders/bids (to ensure that information from all prospective contractors is treated equally) quoting any reference number on the outside of the package to aid identification, time and dates for proposal submission, number of copies required, language of submission, publicity approvals required, etc.;
- Format of breaking down of prices and currencies within the tender document (to aid in comparison);
- Need for all prospective suppliers to respond to all sections of the enquiry, with any alternatives to requested work (i.e. potential improvements, different ways of working, etc.) being separately identified. This will ease comparison between all tenders/bids;
- Formal requirements concerning access to the nuclear installation for inspection of the work area;
- How questions or requested clarifications are to be handled (e.g. typically in writing through the procurement organization / buyer).

3.2.5 Additional considerations

Some additional items to consider when establishing procurement requirements are:

- Specify only applicable quality assurance criteria in procurement documents (to avoid confusing the supplier with inapplicable or contradictory requirements);
- Do not repeat as separate requirements any specifications, codes or standards that are referenced on the purchase order;
• Do not reference unique nuclear standards when procuring a commercial grade item (CGI) for SR applications. Applicable requirement clauses derived from a nuclear standard such as those for labelling, handling, packaging or shipping (e.g. ASME NQA-1 [12] section 13) may be specified to ensure suppliers are aware of nuclear specific needs;
• If conditioning was performed on the item originally procured, ensure that the replacement item receives equivalent conditioning;
• Ensure exceptions to technical and quality procurement requirements requested by a supplier are reviewed and approved by the operating organization’s technical organisation prior to issuing changes to a purchase order.

3.3 POTENTIAL PROCUREMENT SCENARIOS AND SUPPLIER IDENTIFICATION

Sourcing and qualification for new suppliers in an open market for complex equipment can take six to twelve months or even longer to complete. Steps involved typically include a sourcing request for interest (RFI), supplier pre-selection based on RFI feedback and supplier interest, a pre-qualification process whereby preselected vendors go through an audit process of product or process qualification tests as necessary, and then a qualification step prior to contract award when the qualification is confirmed satisfactory and the supplier is added to the purchaser’s approved supplier list (ASL).

3.3.1 Procurement scenarios

Supplier identification involves determining what suppliers on the market can meet the procurement requirements defined in the previous step. An important consideration in this phase is the quality programme that will be applicable to the purchase, and whether the operating organization’s or the supplier’s programme will be used.

These considerations depend on the procurement scenario planned for the item, which is derived from the item’s safety function and availability of suppliers in the marketplace for that item with acceptable quality programmes. Four basic procurement scenarios exist for SR and augmented quality items:

Scenario A: item procured under supplier’s management system.
- Supplier responsible for assuring quality of item under a management system which includes processes for reporting of defects and non-compliances;
- Operating organization is responsible for approving the supplier’s management system;
- Suppliers do not always consider all parts or items to be SR, in such a case the operating organization should either use a different procurement scenario or procure from a supplier with an approved management system applied to all parts and not from one only with only a partial programme (covering for example only pressure retaining parts).
- In order to assure no misunderstanding of supplier responsibilities, utilities should consider adding a statement in their procurement documents stating that the operating organization considers all parts of an item procured to be SR unless otherwise stated.

Scenario B: item procured as a CGI for dedication under the operating organization’s management system.
- If an item is procured as a CGI intended for use in a SR application it is the operating organization’s responsibility for dedicating the item and assuring quality under the operating organization’s management system. Guidance is contained in IAEA GS-G-
3.5 [8] section 5 and EPRI NP-5652 [62]. CGD is discussed more thoroughly in section 5.1.4.

**Scenario C**: Item procured under operating organization’s management system.

- When an item intended for use in a SR application does not meet the definition of a CGI and a qualified supplier cannot be identified or is not capable of meeting commercial or schedule requirements, an operating organization may procure the item under its management system which may be extended to monitor item production.

**Scenario D**: Item procured as an augmented quality item. The operating organization is responsible for assuring that item quality meets requirements.

- Augmented quality items are non-SR and unless the operating organization has made specific commitments to the contrary, are not required to be procured under a qualified nuclear management system. The operating organization should produce a document or other guidance detailing what components it considers augmented quality and any requirements specific to such items.

A review by EPRI in the 1990’s indicated that a typical operating NPP in the USA or Canada orders (measured by PO line items) approximately 10% of its material as SR (scenario A or C), 7% as CGD items (scenario B), 3% as augmented quality (scenario D), and 80% as non-SR [55].

### 3.3.2 Supplier identification considerations

A supplier may have an approved management system; however buyers must continue to take care to select only suppliers with capability to meet procurement requirements specific to the items being procured. Suppliers may not have technical or production capability or experience to produce the item desired to an acceptable quality level, or qualification limits of their management system may not allow for the full scope of work desired under the procurement requirements. For example a manufacturer may be qualified to produce a particular type of valve but not to produce a design package to integrate the valve into a SR system.

Suppliers often go through a process of pre-qualification for major contracts designed to filter those who will be asked to submit a tender or bid. A questionnaire is typically sent to the supplier that asks questions surrounding the supplier’s williness to submit a tender on the terms indicated, and whether the contractor has the experience, expertise, capability, and financial resources to support the project or to supply the item in question. Specific items might include questions surrounding the company’s key personnel, management structure, procedures, safety record, sub-contracting strategies, anticipation of problem areas, experience with a particular technology or in a particular region, and production capability under different conditions. If too many companies pass the pre-qualification process (typically three to six bidders is optimal), then choosing the companies that demonstrate that they most want the work is recommended, as they are most likely to submit competitive bids.

**Ahmed to add info re strategic sourcing, mitigating risk by using multiple vendors, etc.**

### 3.3.3 Quality assurance supplier audits

Franck to revise/update.

- IAEA GS-R3 5.23 (supplier performance shall be evaluated)
- Assure safety related items are procured from Qualified Vendors
- Third Party Auditors (e.g. NUPIC, CANPAC etc.)
- Use and auditing of sub-suppliers
• Ever changing marketplace
• QA programs lapse
• Auditing becomes a burden

• Auditing by Regulatory Bodies
  • NRC doing some
  • Others?

• EPRI Audit of CGD Programs 1016157
• EPRI Guide to Performance Based Supplier Audits NP-6630
• USNRC IN 88-35 Inadequate Licensee performed vendor audits
• WNA presentation at OECD-NEA re possibility of Global NUPIC, NSQ-100, possibility of a “Nuclear NADCAP” similar to that in aerospace (http://www.pri-network.org/nadcap/)
• Use of graded approaches (TECDOC-1740)

Audits help ensure that agreed-to quality systems, processes and procedures are being implemented and to ensure their effectiveness [53]. Effective supplier audits have included consideration of audit approach, depth of audit, and audit team composition and have included appropriate engineering/technical representatives. Comprehensive multi-NPP audit teams have also been found to be effective [63]. Performance-based methods (e.g. following a specific product or group of items during its production and auditing supplier processes of interest) have been shown to be effective in performing these activities, rather than reliance on programmatic reviews alone [64, pp. 6-3]. EPRI has produced a guide [65] for performing such audits.

USNRC information notice IN 88-35 [66] provides some OPEX on inadequately performed vendor audits. Examples are noted of numerous issues with vendors that had previous successful audits, indicating issues with the effectiveness of audit efforts.

Appendix III provides information on a common Nadcap approach to auditing in aerospace industries that might be a model for future nuclear industry cooperation. Nadcap audits are performed on an industry wide basis, and have an opportunity for review by an industry task force prior to their formal certification.

Supplier Approval Process
• Operating organization Only Audit ($$$ + Time Consuming)
• Planning & Scheduling
• Assemble Auditors & Technical Specialist
• Perform Audit
• Issue Report and Any Findings
• Approval Type & Supplier Notification
• Procurement May Now Commence
• Update NUPIC Database
  Alternate process?
• Audit/Survey Exists ($ + Fairly Quick)
• Source: NUPIC/Shared/One operating organization
• Obtain Audit File & QA Manual
• Perform 3rd Party Review
• Scope of Supply/Location
• Findings and Significance
• Approval Type & Supplier Notification
• Procurement May Now Commence
• Update NUPIC Database

Table 5 provides typical attributes of top suppliers as adapted from NUPIC and other sources.

**TABLE 5. ATTRIBUTES OF TOP SUPPLIERS.**

<table>
<thead>
<tr>
<th><strong>Strong Quality Culture</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Satisfactory implementation of management system;</td>
<td></td>
</tr>
<tr>
<td>• Management embraces &amp; leverages audit team input and experience;</td>
<td></td>
</tr>
<tr>
<td>• Readiness for audit through detail planning, records retrievability and staff availability.</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th><strong>QA manual revisions</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clear description of changes made;</td>
<td></td>
</tr>
<tr>
<td>• Highlighted text of changes made.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Order entry review and final certification</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Detail review of technical and quality requirements;</td>
<td></td>
</tr>
<tr>
<td>• Well defined exception process;</td>
<td></td>
</tr>
<tr>
<td>• Detail final review prior to shipment.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Commercial grade dedication</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Well documented CGD process;</td>
<td></td>
</tr>
<tr>
<td>• Clear identification of critical characteristics adequately tied to safety function;</td>
<td></td>
</tr>
<tr>
<td>• Adequate verification &amp; justification.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Robust internal audit</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Comprehensive system of planned and periodic internal audits;</td>
<td></td>
</tr>
<tr>
<td>• Qualified audit participants have no direct responsibility in the areas being audited;</td>
<td></td>
</tr>
<tr>
<td>• Checklists/procedures used with documented objective evidence;</td>
<td></td>
</tr>
<tr>
<td>• Intrusive;</td>
<td></td>
</tr>
<tr>
<td>• Follow-up action taken where needed.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Robust sub-supplier audits and surveys</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Effective control and release of procurement documents including changes;</td>
<td></td>
</tr>
<tr>
<td>• Effective evaluation, selection and assessment of sub-suppliers with clear programme distinction between audit versus commercial grade survey;</td>
<td></td>
</tr>
<tr>
<td>• Comprehensive and intrusive audits;</td>
<td></td>
</tr>
<tr>
<td>• Qualified audit participants have no direct responsibility in the areas audited;</td>
<td></td>
</tr>
<tr>
<td>• Checklists/procedures used with documented objective evidence;</td>
<td></td>
</tr>
<tr>
<td>• Follow-up action is taken where needed.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Strong corrective action programme</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low threshold to identify issues and proper significance classification;</td>
<td></td>
</tr>
<tr>
<td>• Clear connection between the non-conformance and corrective action processes and management system;</td>
<td></td>
</tr>
<tr>
<td>• Measures Established and Implemented to assure conditions adverse to quality are promptly identified and corrected;</td>
<td></td>
</tr>
<tr>
<td>• Adequate actions taken to prevent recurrence for any significant conditions adverse to quality;</td>
<td></td>
</tr>
<tr>
<td>• Deficiencies identified by customers are adequately assessed and entered into the non-conformance/corrective action programme.</td>
<td></td>
</tr>
</tbody>
</table>

### 3.3.4 Approved supplier lists (ASL)

To facilitate ease of potential supplier identification, many operating organizations maintain an approved supplier list (ASL) of suppliers that have been evaluated and deemed capable of satisfactory performance. These are sometimes referred to as qualified suppliers lists or evaluated supplier lists.

Such a list would be used for example in procurement Scenario A of Section 3.3.1, where suppliers would need to have an audited acceptable management system in place prior to placement of an order.

An ASL typically provides the following information:

1. Suppliers name, address, facility location(s), e-mail address, and phone number;
2. Items or scope of supply the supplier is qualified to provide under the approved quality assurance programme(s) scope;
3. Expiration date of qualification;
4. Restrictions on supplier qualifications (e.g. certain product line, or from a specific facility);
5. Approved quality assurance programmes.

When using procurement scenario B of Section 3.3.1 (commercial grade dedication), the major consideration is which method of acceptance, or combination of methods, is practical for the operating organization. Operating organizations should consider maintaining a list of CGI dedicators similar to or as part of their ASL.

Procurement scenario C of Section 3.3.1 (use of operating organization management system to procure the item) is used when an item does not meet commercial grade, and is only available from a sole supplier without an approved nuclear management system.

When using procurement scenario D of Section 3.3.1 (augmented quality item) usually a larger choice of suppliers who can meet established technical and quality procurement requirements. Acceptance criteria are not as stringent as the items are not SR.

Utilities often also maintain an approved vendor list (AVL) of acceptable suppliers for

3.4 DEFINING ACCEPTANCE CRITERIA AND METHODS

IAEA Safety Requirements document GS-R3 [6] para. 5.24 states that evidence that purchasing requirements have been met shall be available to the organization before the product is used. This is normally accomplished by a combination of methods performed at the fabrication plant or factory, and at the NPP site following delivery. Factory activities include items generic to the fabricator’s management system (typically covered by supplier audits as described in Section 3.3.3), and the specific item to be purchased. Both supplier and NPP (customer) are involved. Acceptance criteria are needed for each purchasing requirement to ensure that there is common understanding around the specifics of each requirement and to allow the organization to readily determine than a purchased item meets its requirements as defined in section 3.2. The ways in which these criteria are confirmed are called acceptance methods.

The USNRC identified some attributes of effective product acceptance in GL 89-02 [63]. There programmes typically include receipt/source inspection with appropriate testing criteria, effective vendor audits, special tests and inspections and post-installation tests. Inspection and testing criteria are applied to products procured for SR systems and for all CG products being evaluated for suitability in SR systems. Inspection and testing criteria also require identification and verification of product critical characteristics. In selecting critical characteristics to be verified, consideration may be given to the safety significance, complexity, and application of the various products. For suppliers with acceptable QA programs, as confirmed by audits, sampling plans are often utilized to perform required inspections and tests. In addition to these receipt/source inspections and tests, effective licensee programmes normally verify traceability to original manufacturers of procured materials, equipment, and components in those cases where original manufacturer's certifications are elements of the SR procurement or CGD programme.

3.4.1 Acceptance criteria

3.4.1.1 Criteria establishment

Once an item to be procured is clearly defined, acceptance criteria must be established to ensure the plant receives what was asked for. Acceptance criteria and acceptance methods are established to provide assurance that desired technical and quality requirements have been met.
Establishment of acceptance criteria is an engineering function. Acceptance criteria are items such as defined measurements, inspections, or test results that can be objectively verified. As measurements can never be exact, tolerances should be given for all measured criteria. A good rule of thumb is to select at least one acceptance criteria to address each safety function.

Criteria established should once verified provide reasonable assurance the item meets all technical and quality procurement requirements. These criteria may change between purchases if the item is procured from a different supplier, or changes are made in a supplier’s quality assurance programme.

Figure 7 illustrates that critical characteristics for acceptance are a subset of critical design characteristics. Critical design characteristics are a further subset of item characteristics. Critical characteristics for acceptance are typically those important for item to perform its safety function, and besides performance attributes include such items as seismic (seismic safety function(s) and any postulated seismic failure mechanisms) and environmental qualifications.

Factors to be considered include in developing acceptance criteria include:

- Potential consequence of item failure. Both nuclear safety and plant operability should be considered;
- Historical performance of supplier in providing item which meet established requirements;
- Historical performance of item in service;
- Complexity of design;
- Complexity of manufacturing process;
- Industry experience;
- Effect that verifying acceptance criteria has on item operability (e.g. possibility of item damage due to testing);
- Cost of verifying acceptance criteria in relative to increased assurance provided by verification;
- Access to supplier facilities;
- Is item available stock or will be manufactured when purchase order received;
- Is supplier a manufacturer or third party;
- Availability of design information;
- Periodic oversight / reviews being applied;
- Capability of plant staff to conduct post installation testing;
- Supplier documentation confidence;
- Practicality of performing source verification;

FIG. 7. Critical characteristics for acceptance (courtesy EPRI).
• Operating organization receipt inspection and testing capability.

### 3.4.1.2 Inspection and test plans (ITPs)

Inspection and test plans (ITPs) are used to plan and manage test and inspection activities to provide assurance, control and documented evidence that the supplied product meets the defined acceptance criteria.

ITPs are normally prepared by the supplier following contract award based on procurement requirements defined in step 3.2, their own knowledge of the product to be supplied, codes and standards applicable to the work, and their own internal quality management system. They are typically accepted by a responsible engineer or other designated individual within the operating organization. Acceptance signifies that the agreed to inspections and tests will confirm that the product will meet required procurement requirements. Such acceptance should be complete prior to start of manufacturing to ensure that no required checks are missed.

IAEA Safety Guide GS-G-3.5 [8] para 5.19 describes typical content of an ITP. These include:

(a) General information (name of installation, product or system reference, procurement document reference, document reference number and status, associated procedures and drawings etc.).

(b) Sequential list of all inspection and testing activities;

(c) Procedure, to be followed in for each operation, inspection or test;

(d) Relevant acceptance criteria;

(e) Who will perform each inspection and test;

(f) Provision for recording satisfactory performance of each inspection and test;

(g) Hold points beyond which work may not proceed without recorded approval of designated individuals or organizations;

(h) Witness points where an assigned individual or organization can check activities but where work need not be stopped if inspector is not present;

(i) Hold points for inspection and testing by an external organization that is independent of the installation, e.g. the regulatory body or a third party inspector;

(j) Type of record to be prepared for each inspection or test;

(k) Number of products to be inspected or tested when multiple products or repeat operations are involved;

(l) Individuals or organizations having authority for final acceptance of the product.

### 3.4.2 Acceptance methods

Acceptance methods are the ways utilized to verify acceptance criteria. Depending on item importance and procurement requirements, the methods may involve any or all of reviews of supplier documentation, item receipt inspection upon delivery, source inspection (factory inspections and tests), and post-installation site acceptance testing. Testing activities may involve chemical, physical, or performance tests.

#### 3.4.2.1 Supplier documentation reviews

Supplier documentation reviews involve confirmation that the supplier has effectively implemented a management system containing elements required for the item(s) being procured.

Supplier audits with engineering involvement are typically performed to evaluate supplier processes (see Section 3.3.3). Such audits should be supplemented with other
acceptance methods where audits have not verified implementation of all areas of the supplier management system, where the supplier has had findings in certain areas that have been agreed to be corrected; or where the operating organization has information indicating that the supplier may have deficiencies in supplied items.

3.4.2.2 Source inspection

Source inspection is typical when a procured item is vital to plant safety, complex in design or manufacture, difficult or complicated to test, difficult to verify acceptance criteria upon receipt (after delivery), or when a supplier management system has not been directly observed and audited.

Source and post-installation inspections should be planned in writing, and typically involve establishment of witness and hold points for associated factory or site acceptance testing. All findings and test results should be documented.

For critical equipment being assembled far from the operating organization’s location, consideration should be given to establishing resident oversight personnel at the factory location during component fabrication.

(a) Witness and hold points

Suppliers follow a process of self-inspection where they verify quality of their work progressively under requirements of their own management system - often with the aid of checklists.

Hold points and witness points are production stages at which the customer (NPP operating organization) may need additional inspection, verification or documentation to ensure that the product meets their quality or other requirements prior to proceeding. Once these requirements have been satisfied, the next stage of production can be completed. Suppliers typically make agreements with customer organizations to provide advance notice of the timing of such points so that arrangements can be made for availability of required inspectors. Typically, such agreements also allow for access to and regular surveillance of a manufacturing facility. This allows for intermittent monitoring of any stage of the work in progress by the customer and in some cases the NPP regulator.

Verification measures will vary with the product specification method. For performance specifications, verification involves testing. For specifying by reference, verification is to a standard, or through third-party certification to that standard. Verification procedures are documented in the procurement requirements or ITP as hold points and witness points.

A hold point is a mandatory verification point beyond which a work process cannot proceed without authorization by a designated person. Hold points are usually assigned to critical aspects of the work that cannot be inspected or corrected at a later stage because they will no longer be accessible or would cost significant rework. Work cannot proceed until the designated person is able to verify quality of the completed work and releases the hold.

Hold points should be used sparingly as each potentially introduces production delays that can be caused by delays in scheduling of the required inspections.

A witness point is an identified point in the process where the designated person may review, witness, inspect or undertake tests on any component, method or process. The manufacturer is required to notify the designated person who may or may not take the opportunity to witness the specific test. If the designated person declines the opportunity to attend, the testing and any further manufacturing steps can proceed.

Where the physical presence of the designated person may not be required as part of an ITP, a review point may be established whereby a responsible entity such as a designer
should review results of a test/inspection prior to the manufacturer proceeding to the next stage of manufacturing.

(b) Factory acceptance testing (FAT)

Factory acceptance tests (FATs) are done at the factory to make sure that requirements are met. Tests are normally done in the presence of a customer designated representative, and in some cases with a third party inspection agency. FATs should be specified for products if it is possible to physically test the product at the production facility prior to shipment. Tests should be comprehensive, test both hardware and software components as an integrated unit, and should use equipment that is identical to that at the plant where practical.

It is good practice that individuals involved in future commissioning or site testing of the equipment attend FATs. This allows them to learn about the equipment at a detailed level and provide any feedback on it prior to its shipment.

FATs are typically a sub-part of the product’s ITP and thus follow a pre-approved procedure. Typical content of a FAT procedure is [67]:

- Statement of location and dates of the FAT.
- Description of general approach.
- Description of method of logging errors or concerns raised during the FAT;
- Specification of revision levels of hardware and software to be tested.
- Specification of exact configuration of equipment being tested.
- Personnel safety issues that may apply during testing;
- Specific steps and sequence of testing.

Some items typically checked during a comprehensive FAT are:

- Equipment hardware and software versions are per documented requirements;
- Fabrication and installation is per approved drawings;
- Inputs and outputs are connected as per approved drawings;
- Equipment calibration is correct;
- Trips, bypasses, manual shutdowns, alarms, and diagnostic functions operate per design;
- Equipment outputs, computations, timing, and operator functions behave as per design;
- Equipment response to failures (loss of air or electrical power supply etc.) is as per design.

Following the FAT test results are documented. If failures were encountered then the reasons for failure should be recorded and corrective actions taken. Applicable parts of the FAT that were affected by the failure or could have been affected by equipment changes or other remedial measures made to address the failure will then need to be repeated as necessary.

3.4.2.3 Receipt inspection

Receipt inspection is the review of received material when it is delivered into the operating organization’s care and control at its warehouse. This is an important point at which procured items can be stopped from entering the plant for use if they do not have necessary assurances that quality and technical requirements have been met.

A key aspect of receipt inspection is verifying identity of the incoming item. This ensures any assumptions made surrounding like-for-like versus equivalent or alternate item replacements are correct, links the item to corresponding procurement documents and enterprise part tracking systems (which may use part number, serial number, and/or a receiver
applied unique identification system), provides some assurance that changes or errors have not occurred with the shipment, and confirms identify of the item prior to proceeding with acceptance testing.

Standard inspections involve simple checks for shipping damage and that the received item is the item ordered and matches the delivery paperwork (item identification and quantities shipped). Such inspections are suitable for situations where the act of inspection would not adversely affect integrity, function, or cleanliness of the item, where its design is simple, and acceptance criteria are readily verified by other means. Individuals performing inspections should be aware of (and trained in identifying) possible signs of counterfeit or fraudulent items (see Section 7).

For some items more advanced receipt inspection is necessary. This may include use of special test and inspection equipment such as metal alloy analysers, hardness testers, etc. These can verify material properties that would be expensive to correct if discovered following installation. From the supplier’s perspective the process of site acceptance testing (see next section 3.4.2.4) is often considered a form of advanced receipt inspection, in that it is required to be successfully completed prior to final acceptance of the item by the operating organization.

Items that fail receipt inspection or arrive with incomplete documentation are required to be segregated from normal stock and quarantined so that they are not utilized by accident in the NPP.

3.4.2.4 Post installation testing / site acceptance testing (SAT)

Post installation or site acceptance tests (SATs) are used when it is difficult to verify acceptance criteria without the item being installed and in use. They are done at the NPP following installation, often as part of the commissioning process. The tests confirm acceptance criteria that cannot be confirmed in the factory, and can be used to validate that no damage has occurred to the items during shipping or storage. Commissioning tests usually envelop SATs as they often are required to confirm the integrated (entire) system meets its design requirements, not just to confirm that a particular component or set of components from a supplier meet their procurement requirements. Commissioning guidance is provided in IAEA Safety Requirements document SSR-2/2 [3], Safety Guide NS-G-2.9 [68], and NE series guide NP-T-2.10 [69].

Some items that cannot be factory confirmed might include interfaces between the new equipment with other already installed or new plant equipment, suitability of maintenance tooling (access availability or usability), or responses to in plant disturbances.

Like FAT testing, SATs are typically a sub-part of a product’s ITP and thus should follow a pre-approved procedure.

3.5 BIDDING, EVALUATION, AND PLACEMENT OF PURCHASE ORDER

3.5.1 Establish quotations or bids (enquiry methods)

Once approved suppliers have been identified and acceptance criteria established, a process is required for obtaining final quotations or bids for the items to be purchased and a supplier selected. Various terms can be applied to this request process (each with slightly different meaning by different organizations) including an invitation to tender, request for proposal, request for quotation, invitation to bid, or expression of interest.

A bid invitation specification or other enquiry document is assembled. It typically includes an invitation transmittal letter, contact information, project, facility, and coordination
detail, and the specific job requirements as were defined in Section 3.2. The size and scope of the documents involved will depend on such things as type of contract, size and scope of project/item purchased, work complexity, project controls, financing requirements, type of contractor, and resources available to prepare the documents. For project or services work, information from potential bidders should be requested as to how they would mobilize, organize, staff and control the project, procedures to be used, industrial safety programme employed, corrective action programme, and any measures as required to meet a compressed schedule. Information on jobs of a similar nature should also be sought, as should be detailed information on cost rates of personnel by function, additional costs (travel, training, administrative costs etc.), and mark-ups on direct costs for profits or fees.

There are two basic methods of obtaining bids: open tendering and selective tendering. In open tendering any interested party can submit bids, with the client advertising locally, nationally or internationally. To ensure serious bids potential suppliers may be asked to purchase the tender documents or deposit money in the form of a bank guarantee or bid bond. The tender process may be two-stage (bidders submit technical bids first exclusive of price, then technically acceptable proposals submit full bids with pricing later), use the two-envelope method (separate sealed technical and economic bids are submitted at the same time and evaluated separately), or use a “three-envelope” process in which following initial bid evaluation (using the standard two-envelope process) a request to bidders is made for final pricing to take into consideration differences between the received bids. That is an attempt is made to levelize differences in approach so that a consistent basis for price comparison can be made.

Open tendering provides transparency to the procurement process, ensures good competition and minimizes potential for collusion. It does tend however to drive decision makers to a lowest (apparent or submitted) cost solution if care is not taken to careful evaluate all factors (reliability of bidders, quality, lifetime or life cycle costs etc.). Some jurisdictions require all public sector procurement to follow an open process (e.g. the European Union Directive covering procurement).

Selective or restrictive tendering is a process whereby only specific bidders are invited to submit tenders. Such a process is more favoured by the private sector, and has the advantages of having reduced costs and duration of tendering, ensures only capable contractors bid (assuming there is a track record of successful work between the customer and client), and helps maintains the contractors economically viable through a regular stream of work. It does however have the disadvantages of potentially introducing complacency into the bidding process if selected contractors are routinely successful (prices may rise, less attention given to the work, etc.), misses the potential for new (more eager or otherwise better) suppliers, and increases risks of collusion among routinely successful contractors (may keep prices high or divide up work among themselves). “Single source” requests for quotations are a sub-set of this process. Such a selective or single-source process is becoming more common for nuclear projects in the form of inter-governmental agreements, but does carry these increased risks.

Negotiated tenders or contracts are another variation on selective tendering. In this process a contractor with proven experience with a client is chosen early in the design stage and performs preliminary work on the project (depending on scope definition it may be on a fixed price or time and materials basis). Once detailed design information is available, the contract is renegotiated on typically a fixed price basis. Such models are good at obtaining constructability input early in a project’s life, can shorten lead times, and can minimize financial commitments until full scope definition is obtained. Some organizations utilize two organizations at the preliminary stage and select a single company to proceed with for the detailed design.
Where competitive bidding is used, questions or requests for clarifications or exceptions by suppliers should be formally controlled. This ensures all requests are recorded and reviewed by suitable personnel for their effect(s) on procurement requirements. Any response to one prospective supplier should be provided to all bidders to aid in bid comparison and to ensure fair treatment.

Procurement organizations should establish controls related to the security and opening of sealed bids. These are typically categorized by bid value, with low value bids having minimal controls and higher value bids having more stringent controls. For example low value bids might be opened by person in procurement group who would record details such as date received, prices, durations, alternatives offered etc., medium bids might have the opening being witnessed by another staff person, and higher value bids might be witnessed by an independent senior staff member recording all suppliers who tendered, submitted prices, whether the tender was received on time or late, any suppliers who did not tender (and reasons, if possible, for addition to the supplier database), and comments on omissions or non-conformance with the procurement requirements.

3.5.2 Bidding and selection of supplier

Bid evaluation can be said to need to adequately weigh the relative importance of functional (technical) requirements, cost and schedule requirements, and operating costs (both economic requirements). It also can be said that for equipment the manufacturer is most concerned with the first, the engineering contractor with the second, and the end user the third [70, p. 144]. It is important that the evaluation process be done as objectively as possible and that all participants appreciate the issues involved in each area.

Evaluation generically can take a number of forms, from just “choosing whom you want”, negotiating with a preferred tenderer, choosing the lowest price from well recognized brands, throwing out the lowest and highest prices, methods that attempt to evaluate “value for money” or life cycle costs, or others that use a combination of formal technical and economic evaluation (often within a defined points system). A most economically advantageous tender or lowest evaluated tender methodology is one of the latter methods. It seeks to evaluate all aspects of a submission (e.g. schedule, management commitment, personnel, capability, etc.) after evaluating its technical acceptability.

Even if the potentially successful bidder is practically chosen in advance (e.g. via a single source selection or inter-governmental agreement), there should be an evaluation done to confirm the proposal meets minimum technical, quality, and commercial requirements, and is superior than a “do-nothing” option or other alternative.

A typical bid evaluation process using separate technical and economic evaluation steps is described below in conjunction with a framework adapted from NG-T-3.9 [71]. The process includes both technical and economic bid evaluation. These evaluations are done separately and then combined as a decision to proceed with contract negotiation is made.

3.5.2.1 Technical bid evaluation

For technical bid evaluation the following areas can be evaluated, and each will be discussed in turn:

- Scope of supply and features;
- Technical and quality features;
- Implementation method;
- Warranties;
- National participation and technology transfer;
- Alternatives and options.
(a) **Scope of supply and features**

This evaluation area would cover the ability of the bidder to meet the scope of supply as defined in the procurement requirements.

(b) **Technical and quality features**

This area evaluates the ability of the bidding organization to technically meet the desired scope of work. Some areas for specific evaluation should include a review of past performance with the owner’s organization and with other references, the breadth and depth of items or services that can be provided by the bidder, and the bidder’s management system, including training and qualification requirements. In some cases where nuclear management systems are not in place in the supplier community, a CGD process may be proposed and need to be evaluated.

Evaluation of key staff and provisions for their retention is an often overlooked area of bid evaluation. Certain specific technical staff may be critical to aspects of a project, and the experience of competence of the bidder’s leadership team is critical to driving a project to its successful completion. In fact the leadership team can often be the main differentiator between competitors working in a similar industry, as working level staff tend to move between these competitors as new large contracts are signed.

Culture and past history of the project team is a related issue that should be evaluated (with respect to their ability to work together). Groups or joint ventures that have worked together before successfully are preferred.

(c) **Implementation method**

This area evaluates how the bidding organization intends to manage the work scope to be contracted. Some areas to consider include the structure and organization of the bidding company (e.g. roles and responsibilities, experience and availability of key personnel, plans for sub-contracting, etc.), quality of provided schedule (degree of integration of vendor schedules with operating organization schedules; level and detail of schedules provided, consistency of dates and milestones within the bid), ability to provide construction and commissioning support (engineering only or turn-key full service; industrial safety programmes (and previous safety record), roles and responsibilities for directing field staff and authorizing design changes, etc.), documentation and configuration management (do vendor systems integrate with operating organization systems; is document management well handled in the bidder’s management system; are there well defined interfaces for document transfer, are intellectual property issues clear), management system (consistent with IAEA GS-R-3 [6]; including promotion of safety culture and continuous improvement/corrective action processes), and risk management (vendor provides a comprehensive risk mitigation plan and understands and accounts for applicable risks). The supplier’s current workload should also be evaluated, as the new work to needs to be achievable with some reserve ability to adjust for unforeseen issues.

(d) **Warranties**

As discussed in 3.2.3 provisions for “correction of defects” need to be included in contracts. The technical aspects of proposed warranties would be evaluated in this section (e.g. scope, duration, response time, conditions for remedies). The operating organization is generally most protected if such warranties start with the placing of applicable item into service (i.e. not upon equipment delivery).

Suppliers typically will not accept financial accountability for “force majeure” (extreme weather, political demonstrations, equipment supplier issues etc.) or resulting consequential damages to an operating organization (e.g. loss of electricity generation). Good contract
management can ensure some of these are covered in written agreements by documenting what is reasonable in certain circumstances (e.g. expected productivity losses due to “normal” bad weather etc.).

(e) National participation and technology transfer

National participation and technology transfer may or may not be a concern for an operating organization. If it is of concern, items to consider include the technical feasibility of national participation and technology transfer conditions, potential quality or schedule impacts of the offered participation, potential advantages for plant operation and maintenance with having national suppliers, and any differences in scope among the service providers. IAEA NE Series document NX_T_XX (Yagi’s draft) covers developing industrial involvement for an NPP programme in some detail.

(f) Alternatives and options

Bidders will often provide alternate arrangement possibilities that are slightly different that requested in requirements document they responded to. If certain offers are appealing, consideration should be made to have other bidders provide an equivalent scope proposal.

3.5.2.2 Economic bid evaluation

Economic bid evaluation combines the results of the technical bid evaluation (section 3.5.2.1) with a review of the following areas, each of which will be discussed in turn.

• Commercial and contractual terms and conditions;
• Economic parameters;
• Financing terms and conditions;
• National participation and technology transfer;
• Owner’s costs.

(a) Commercial and contractual terms and conditions

Evaluating commercial terms and conditions is very complex. For important contracts the entire operating organization’s team (engineering, finance, legal, supply chain etc.) should be involved to bring their particular expertise to the table. External help should be sought and acquired if needed.

Suppliers operate regularly in a commercial environment, and will know their cost structures at a very detailed level, and specifically where they make or lose money. Operating organization staff, if not experienced in the area, may be at a disadvantage in evaluating specific terms and conditions.

Experience has shown that it is usually best for the owner if framework commercial terms and conditions are written in advance by the owner, with bidders requesting changes or exceptions are required. The owner is advised to request information on such things as bidder cost structures, and how suppliers build up costs to their customers (pay, benefits, expenses, profit margin, administration costs, travel costs etc.). If not sought at the contract evaluation and negotiation stage these are unlikely to be received later.

Some terms and conditions of particular importance are provisions for intellectual property, correction of defects, liability, payment schedules, charge out rates and inclusions, use of and approval processes for sub-suppliers (including their commercial terms and contractual arrangements), and dispute resolution provisions.
(b) Economic parameters

Beside the provided bid price, some economic parameters to be documented and evaluated are the reference date of prices (often the bid date), provisions for review or increases in price schedules during the life of agreement, provisions for project-specific prices (e.g. fixed price sub-projects), and exchange rate provisions (reference currency versus foreign currencies).

A detailed review of pricing would include reviews that pricing is in the correct format and arithmetically correct, a review for scope omissions, excess charges for changes or spares, tax impacts, impacts of delivery terms, review of reimbursable costs versus overhead rates, overheads and profits on overtime (should be none; overhead and profit should be recovered through agreed to normal working hours), payment terms, and others.

Incentive and liquidated damages should also be evaluated, as should provisions for performance guarantees, warranties, or holdbacks.

(c) Financing terms & conditions

Financing costs is an important area to be evaluated. The supplier or the operating organizations can be the financer of equipment purchases or entire capital projects. Depending on the relative size and financial strength of the two parties lower financing rates and ultimately project costs will dictate the most optimal arrangement. Smaller suppliers or engineering firms may not have the ability to finance the construction phase of large projects, and may develop joint ventures with construction firms.

Security of financing and insurance provisions are typically an area of evaluation in this part of the economic analysis.

(d) National participation & technology transfer

For government owned or influenced utilities, a review of national benefits and technology transfer may be made that is complementary to the previous technical evaluation in this area. If this area is a concern, a quantification of such benefits and impacts on the operating organization is needed to the extent possible.

(e) Owner costs

Bids are typically never exactly the same in terms of their supply of scope. Depending on the bid, operating organizations will have more or less incurred costs for such things as staffing, records, administration, contract management, and support services. Operating costs of cheaper, inefficient equipment where chosen by a supplier can also increase owner costs. Bid comparison requires that any differences in owner costs be evaluated to ensure bids are compared on an equivalent basis.

3.5.2.3 Completing the bid evaluation

Where goods or services are purchased using a bidding process, a formal method of bid evaluation is typically used. A team typically completes the evaluation using a predefined evaluation template. Often weights for the individual bid elements being evaluated are assigned in such a template.

Typically, the technical bid is evaluated separately from and without knowledge of the economic bid to ensure that technical features are evaluated fairly and without prejudice. This is known as a “two-envelope” process since the technical and economic portions of the bid are opened and evaluated separately. A variation to this process is a “three-envelope” process in which following initial bid evaluation (using the standard two-envelope process) a request to bidders is made for final pricing to take into consideration differences between the received
bids. That is an attempt is made to levelize differences in approach so that a consistent basis for price comparison can be made.

Owners should consider sharing their evaluation template with suppliers as part of bid process to help ensure that suppliers are aware of the importance that the owner places on the individual elements. Templates can include mandatory (go/no-go) criteria that can disqualify a bid from further evaluation.

A sample portion of a bid evaluation template is shown in Table 6 below.

**TABLE 6. SAMPLE PORTION OF BID EVALUATION TEMPLATE.**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>Vendor 1</th>
<th>Vendor 2</th>
<th>Vendor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Understanding of scope of</td>
<td>10%</td>
<td>5 – Appears supplier cannot provide refuelling support.</td>
<td>9- All bid areas responded to with minor exceptions taken.</td>
<td>8 – Need for seismic analysis capability not included in bid.</td>
</tr>
<tr>
<td>work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical-Experience of Key Personnel</td>
<td>10%</td>
<td>7 – General manager assigned to project was formerly Construction Manager of Bredonia NPP</td>
<td>2 – No managers with former experience at Bredonia NPP</td>
<td>5 – Some Bredonia NPP experience. Civil/seismic area appears weak.</td>
</tr>
<tr>
<td>Technical - Knowledge of Bredonian NPP</td>
<td>8%</td>
<td>9 – Original NPP plant supplier. Has all design information except for minor site-implemented modifications.</td>
<td>8 – Some former Bredonia NPP engineers on staff. Well experienced technical staff on a variety of similar plants.</td>
<td>7 – Several former Bredonia NPP engineers on staff.</td>
</tr>
<tr>
<td>Design Basis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

etc.

It is important to appreciate that in evaluating different products or services different items become more or less important. A goal is to reduce or eliminate risks to the purchaser. Table 7 below illustrates some of the issues involved, adapted from text in Chapter 11 of [70].

Owners should take adequate time to evaluate bids, and to use a challenge process to ensure bids evaluated fairly. A typical challenge process would involve a team of senior managers or individuals not involved in the evaluation questioning the bid evaluation team on the rationale for their rankings. Reaching a conclusion can be difficult; for instance in balancing a contractor’s project management capability against a different company’s superior technical solution, or in balancing an established organization against an aggressive, innovative newcomer.

Often for projects and services the experience and quality of a project manager becomes the deciding factor. Ref. [70] provides data on buying factors influencing choices of engineering and construction companies in a variety of countries. In two separate surveys the experience and quality of the project manager was the most significant buying factor, while in a third survey it ranked just behind understanding of the project scope and commitment and interest shown the client.
TABLE 7. IMPORTANT EVALUATION CRITERIA OR STRATEGIES FOR DIFFERENT PURCHASES.

<table>
<thead>
<tr>
<th>Material, equipment or service being purchased</th>
<th>Important evaluation criteria or approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials on fixed price basis</td>
<td>Check materials conform to requirements;</td>
</tr>
<tr>
<td></td>
<td>Check supplier has agreed to commercial terms;</td>
</tr>
<tr>
<td></td>
<td>Check delivery acceptable;</td>
</tr>
<tr>
<td></td>
<td>Take lowest price.</td>
</tr>
<tr>
<td>Material requisitions for commodities (pipe,</td>
<td>Request individual and grouped pricing from various</td>
</tr>
<tr>
<td>fittings, etc.)</td>
<td>mills/suppliers;</td>
</tr>
<tr>
<td></td>
<td>“Cherry pick” best combinations of group and individual</td>
</tr>
<tr>
<td></td>
<td>prices from a number of suppliers.</td>
</tr>
<tr>
<td>Equipment with functional or performance</td>
<td>Evaluate technical and economic features of competing</td>
</tr>
<tr>
<td>specifications</td>
<td>designs.</td>
</tr>
<tr>
<td>Project on fixed price.</td>
<td>Check compliance with scope and specification and</td>
</tr>
<tr>
<td></td>
<td>schedule;</td>
</tr>
<tr>
<td></td>
<td>Incorporate costs and schedule impacts for omissions of</td>
</tr>
<tr>
<td></td>
<td>differences in scope into evaluation;</td>
</tr>
<tr>
<td></td>
<td>Evaluate contractor execution capability (plans, schedules,</td>
</tr>
<tr>
<td></td>
<td>organization, key personnel, resource availability).</td>
</tr>
<tr>
<td>Project with reimbursable service terms</td>
<td>Evaluate strengths and weaknesses of contractor personnel</td>
</tr>
<tr>
<td></td>
<td>and organization (technical, project management expertise,</td>
</tr>
<tr>
<td></td>
<td>existence of competing demands, etc.).</td>
</tr>
</tbody>
</table>

3.5.3 Negotiation with supplier

The negotiation process for major equipment or complicated contracts can take substantial time, sometimes months or years depending on complexity. Owners typically pick the highest ranked bidder from the evaluation process (section 3.5.2) for negotiation, with one or more as back-up. Proper negotiation requires technical, financial, legal and commercial staff allocated to negotiation team, and such people need to must have adequate authority to conduct the negotiation.

Substantial changes in contract terms and conditions can occur as part of the negotiation process as trade-offs are made and information is shared between parties. A final agreement is one that should provide benefits and fairness to both organizations. Lopsided agreements typically are of no benefit to either party, as difficulties will most certainly become apparent during subsequent contract execution.

3.5.4 Preparation and placement of PO

Once a supplier is decided upon required purchase information in its final form is needed to be formally transmitted. In this step technical, quality and commercial procurement requirements (applicable to the supplier) are transferred to a purchase order, which is then sent to the supplier. A purchase order is a written contractual document prepared by a buyer to describe all terms and conditions of a purchase [52].

Verbal POs are normally discouraged as they may result in procurement requirements not being clearly transmitted to suppliers. If a verbal PO is used the procurement person from the operating organization should read the complete technical and quality requirements to the supplier, with a written confirming PO immediately following. Similarly issuances of a notice to proceed in advance of a PO, such as a letter of intent, are discouraged as they can reduce negotiation advantage before the PO is signed. They may however be required to obtain a slot in a supplier’s production schedule prior to all PO conditions having been agreed to.
Appendix III.2 of GS-G-3.1 [7] lists typical content to be included in procurement documents to be transferred to the supplier at this stage to ensure complete definition of the purchase. These include the following:

- **Scope of work**: Full description of work to be undertaken by a supplier, including interfaces with other work, so that intent is clearly understood and prospective suppliers can deliver products or services as specified (see Section 3.1).
- **Technical requirements**: Technical requirements for products or services (see Section 3.2.1)
- **Training requirements**: Needs and requirements and necessary resources to be provided (e.g., need for nuclear facility induction training to enable individuals to work and move around the site unescorted, training to be provided by supplier on new equipment etc.; see Section 5.8).
- **Inspection and testing requirements and acceptance criteria**: (see section 3.3.4).
- **Access to supplier facilities**: Conditions of access to supplier’s premises to carry out activities such as inspections, audits and surveillance. These activities may be performed by the organization or by other authorized parties acting on its behalf (see Sections 3.3.3. and 3.4.2.2).
- **Identification of standards applicable to the management system**: Management system standards to be complied with (see Section 2.1 and 3.2.2).
- **Document requirements**: Specific documents required to be submitted for approval or comment.
- **Record requirements**: Requirements on records (e.g. by providing or requiring a record schedule detailing all record requirements to be submitted).
- **Instructions for retention by or transfer of records from supplier**: These should include requested records to ensure that the products or services have met or will meet requirements. Retention periods and responsibilities for maintenance of records by the supplier should also be specified.
- **Timing of submissions**: Clear instructions regarding times when necessary documents and records should be submitted.
- **Non-conformance reporting**: Non-conformance control process, including which party may sanction which type of non-conformance (see section 3.15).
- **Subsidiary supplier controls**: Unless otherwise specified by the organization, the supplier should be responsible for control of sub-suppliers and to secure from them all rights of access, to impose management system requirements consistent with the importance of the subcontracted product, and to monitor and evaluate performance of the sub-supplier.

The above list covers mainly quality related requirements. Additional agreed commercial and administrative clauses should also be transferred as part of the PO. These include clauses associated with indemnity, warranty, insurance, payment terms, change mechanisms to the PO/contract, termination provisions (for default or convenience), liens, dispute resolution, waivers, confidential information, stop work provisions, work suspension provisions, compliance with local and national laws, health, safety and environmental requirements, transportation charges, delivery requirements, invoicing instructions, patent ownership, work on owner’s property, and incentives and penalties.

PO’s and related documents are increasingly being transmitted directly between purchaser and supplier computers or into a third-party network for processing. This is known as electronic data interchange (EDI) and can increase the speed and efficiency of order processing. Electronic funds transfer is a form of EDI whereby funds (or payments) are electronically exchanged from one party to another.
3.6 CONTRACT EXECUTION, COMPONENT FABRICATION AND PERFORMING SOURCE SURVEILLANCE

Follow PO award, activities associated with item production or services provision are completed by the supplier, and source inspection activities discussed in Section 3.4.2.2 occur. The contract execution phase is often as important as the contract negotiation phase for the two parties. During contract execution suppliers will often request contract changes or additions, which may or may not be justified. Contract managers for both parties need to be engaged in the process, aware of the detailed contract terms and conditions, attentive to progress of the work, and committed to finding equitable solutions to contract disputes.

3.6.1 Kick-off meeting

Prior to start of major contract execution a pre-work authorization meeting is recommended to ensure that contract and process requirements are fully understood by the contractor and operating organization staff. Individuals from all parties affected by the work should be present. Some items for discussion at such a meeting could include the following:

- Review of final signed contract and scope of PO;
- Roles and responsibilities of contract manager, contract administrator, and contractor staff;
- Processes for contract and written procedure deviations;
- Progress reporting, regular meetings, and lines of communication;
- Contract schedule and work control processes;
- For on-site work: site industrial and radiological safety rules, security access, and fitness for duty requirements;
- Required training qualifications;
- Project deliverables (documents);

Following the meeting any operating organization-provided training (e.g. site specific radiation protection or safety training) would need to be delivered, and then contract execution could begin. Specially trained owner contract administrators or monitors would typically be assigned to interface with the supplier as required, ensure the supplier meets contractual and regulatory requirements, and monitor activities to ensure they are carried out in a productive manner, that standards stipulated in contractual obligations are maintained, and to ensure technical acceptance of contract deliverables is completed.

High risk work (nuclear reactor risk, occupational safety risk, radiological safety risk, significant cost risk and outage duration risk) needs to be managed more carefully than low risk work. The amount of due diligence that the owner undertakes in reviewing and checking the contractor’s work will depend directly on the risks associated with the assigned work and the previous experience of the contractor with such work.

3.6.2 Providing contractor direction and feedback

When a contractor is responsible for a contract, the operating organization does not have the contractual right to tell the contractor how to do the work unless the operating organization wants to relieve the contractor from its responsibility and liability for the work. Direction of a contractor to take specific action that contractually falls within the responsibility of the contractor causes the contractual responsibility and legal liability for the consequences to be transferred back to the operating organization. The operating organization does however have the right to require the contractor to perform the work in accordance with the approved quality processes. When something looks amiss, it is far better to ask probing and focused questions that bring out the problem. Also, by asking questions, the contractor is
forced to get to the bottom of the problem. The contractor retains the responsibility to both identify the root cause and find a solution. Any adverse consequences of the solution are also the responsibility of the contractor and their elimination must typically be done at no cost to the operating organization. A further advantage of asking probing and focused questions rather than identifying solutions is that the contractor staff becomes less dependent on the client and increasingly capable of finding and solving problems on their own as the contract progresses.

Review and approval of a contractor’s deliverable products is usually the operating organization’s last opportunity to spot a problem before the errors cause problems with the operating organization’s work processes and plant equipment and systems. In a technical contract, contractor supervisors typically approve work of their staff from a technical point of view. Typically a comment and disposition process is followed to ensure the operating organization is satisfied with the deliverables provided. This process can be expensive in both labour hours and schedule for both the operating organization and contractor. Experienced staff should thus be employed to make the comments.

Comments can be categorized into 4 basic categories:

- Technical problems or deficiencies that make the work non-compliant with the specification;
- Editorial comments (poor grammar, cross referencing errors, etc.);
- Requests for clarification; and
- Suggestions or preferences, if they can be accommodated.

Addressing the first two categories would typically be mandatory, while the last two categories would need to be reviewed on a case by case basis. It is important for the operating organization (not the contractor) to differentiate among these four types of comments to avoid misunderstandings with the contractor as to the urgency and need to address the comment.

3.7 PACKAGING AND TRANSPORTATION

Once a manufacturer completes FAT testing and other final quality checks, items are required to be packaged and shipped to the operating organization. Methods of packaging and transportation methods chosen are based on consideration of the method and duration of transportation, any intermediate inspection points (e.g. customs checkpoints or transfer points to other methods of transport), and the potential for damage or loss to the item shipped.

Effective contract planning for transportation and logistics services would include specifics surrounding cargo marshalling, export preparation, freight forwarding, customs clearances, heavy hauling, ship chartering, multi-modal moves, courier services, intermediate storage, insurance during transport, and personnel movement and transportation [53].

The point of transfer of ownership of items being transported would have been documented as part of the contract commercial terms (see section 3.2.3 re Incoterms®). Care must be taken to manage both the risk on equipment loss or damage during transport, and the project impacts of delayed delivery that any such loss or damage might entail.

Large or heavy items will require special planning for transportation. Special air, rail, barge, or road transportation may be necessary depending on the size or weight of the objects involved and the urgency of receipt. Coordination with local transportation and police authorities along the road route may be required, and international brokers may be needed to assist in customs clearances. There is a trend for new construction to increase levels of modularization and off-site assembly, which increases size and weight of goods shipped. IAEA NE Series document on construction technologies [72] sections 3.2.3 and 8 discuss some of the issues involved.

Transportation and logistics companies increasingly utilize GPS based tracking devices during shipment. By providing a tracking number, purchasers can be provided with the ability
to view online the physical location of their purchased item while it is en route. This can assist
a facility in planning for the arrival of key items.

Arrival of large equipment on a job site is an opportunity for project publicity and
celebration, so involvement of site public relations staff is recommended.

Radioactive material transport and related security issues have specific management
system requirements and national regulations. Refer to IAEA Specific Safety Requirements
SSR-6, for regulations [73], Safety Guide No. TS-G-1.4 on management systems [74], and
security implementing guide [75] for security related details. Other hazardous goods (e.g.
chemicals, fuel, etc.) will have other specific management system requirements and national
regulations.

EPRI has produced a detailed guide on packaging, shipping, storage and handling
guidelines for NPPs [76]. The guide contains recommendations for recommended shipping
packaging and shipping guidelines for typical NPP component types that can be used as a
basis for internal operating organization practices and standard instructions that can be sent to
suppliers.

3.8 EXPEDITING

Expediting can be associated with any phase of the supply process. The process should
guarantee delivery of materials, engineering submittals, technical data, and equipment in a
timely manner [53]. Expediting can consist of simple status reporting, or more intrusive
methods such as performing shop visits to physically verify item status, or performing
forward looking supplier management activities such as reviewing PO schedules in detail,
comparing schedules against knowledge of supplier and sub-supplier capabilities, assessing
fabricator shop schedules, and monitoring supplier production of interim deliverables. The
degree of intrusiveness is dependent upon item criticality, with more experienced and trained
personnel performing the more intrusive duties. In some cases the expediting function will be
required to go further down the supply chain and expedite second and third-tier suppliers, or
to coordinate between other separate suppliers.

Expediting functions benefit from having defined procedures, schedules, and common
expectations surrounding roles and responsibilities. Some typical outputs from an expediting
organization include delinquent item reports, delivery slippage reports, and equipment status
reports.

Increasingly third-party providers are becoming available to assist the in-house
expediting function on a contract basis. These companies can be used to facilitate supplier
visits in remote or foreign locations or to otherwise supplement in-house personnel.

3.9 ACCEPTANCE AND RECEIPT

Acceptance and receipt is the process of ensuring by objective evidence that the
received item or service meets acceptance criteria (that were defined in step 3.3.4) following
the agreed to acceptance methods¹. Services typically are evaluated by the organization
receiving the service (e.g. engineering for technical services/ reports, maintenance or
construction organizations for maintenance or installation contracts), while materials are
typically evaluated by procurement organization warehouse staff via the receiving process.

¹ Some organizations differentiate between inspections performed to confirm correct
quantities and types of material having been shipped and to ascertain general material
condition with respect to damage, with the technical inspections required to confirm all
acceptance criteria have been met. The document does not make that distinction.
Receiving is the function of receiving and processing incoming materials [52]. All items typically undergo some level of receipt inspection. This step typically ends with item placement into a secure warehouse for later installation, however in some cases SAT testing or commissioning of the item may be required to complete the full item acceptance process. Issues with shipping damage, shipping too many or too few items, shipment foreign material concerns, or incomplete documentation would be detected at this stage.

Personnel performing receipt inspection should be alert to any indication that item is provided is not sub-standard or that certifications provided are fraudulent. Table 21 in Section 7 of this document and Appendix C of EPRI guide [51] have a list of things for receipt inspectors to look for to help in identifying substandard or fraudulent items. This includes things like altered or incomplete labelling, obvious attempts at beautification, evidence of hand cut materials, poor fit up with items from the same manufacturer, and documentation discrepancies or illegibility. Specific training is recommended for warehouse and other NPP staff in detection of such items. Counterfeiting is further discussed in section 7 of this document.

Items failing receipt inspection should have an evaluation to determine if the deficiency can be resolved. This may involve a technical (engineering) review to determine if the item can be accepted, reworked, repaired or rejected.

Following receipt inspection item tagging is typically performed by the receipt inspector. A unique tag or label is affixed to the item and entered into the operating organization’s electronic tracking system. Such labelling, which can be just alphanumeric (Fig. 8) or use more modern techniques such as bar coding, laser engraving (Fig. 9), radio frequency identification (RFID) (Figs 10 and 11), or near field communication (NFC), allows item tracking and traceability back to the purchase order and ultimately to the source and conditions of fabrication. RFID or NFC integrated with geographic information system (GIS) and global positioning system (GPS) technologies can allow for detailed material tracking throughout an NPP site, providing better transparency, efficiency, and accuracy.

FIG. 8. Sample of tags applied at receipt (courtesy KHNP).
Enterprise systems used for tracking material can facilitate management of item shelf life, and identification of specific product location within the NPP in the event of item recalls or adverse performance trends.

Specialty labelling such as material safety data sheet (MSDS) labels on chemicals (Fig. 12) would also be confirmed to be in place at this receipt inspection stage. If hazardous items are transferred or decanted to a smaller container for field use, field labels would need to be applied to the smaller container.
3.10 STORAGE AND WAREHOUSING

This step involves the placement of the item into the operating organization’s secure storage and warehousing system until it is needed to be installed in the plant. Of concern in this step are issues with required environmental and storage conditions, in-storage maintenance, shelf life, configuration control, segregation of non-conforming items, and security.

IAEA Safety Requirements document GS-R3 [6] provides information pertinent to storage and warehousing. Para. 5.19 speaks to the need to maintain item traceability, that is from manufacturer, to shipper, to warehouse, to laydown area, to installation in a particular plant location. Para.5.20 speaks to proper handling, transportation, and storage, to prevent damage, loss, deterioration or inadvertent use.

IAEA Safety Guide GS-G-3.5 [8] paras 5.151 to 5.159 cover numerous aspects of handling and storage, including the need to:

- Ensure critical, sensitive, perishable or high value items are stored in appropriate environments (temperature and humidity control; inert gas storage etc.);
- Perform in-storage maintenance as required on items that require it (e.g. large rotating equipment, batteries, etc.);
- Perform shelf life management activities as required (e.g. ensuring items such as elastomers or capacitors are discarded prior to their life expiry);
- Ensure only correct items are used for installation;
- Ensure stores inventory is accurately known, and ensure non-conforming items are properly segregated;
- Prevent damage, deterioration or loss of items;
- Ensure field storage locations such as laydown areas, chemical storage cabinets and the like are formally included in storage processes and appropriately addressed (e.g. fire prevention and housekeeping requirements).

These and other related topics will be covered in some further detail below. The EPRI guide discussed in Section 3.6 [76] contains detailed storage instructions for typical NPP component types that can be used as a basis for internal operating organization practices. Typical packaging types used in industry are listed along with what protection they offer. In general the more packaging that is applied during storage the less impact the storage location will have on an item (less likelihood of damage).

Some lessons learned with respect to packaging for storage reported by EPRI include:

- Physical protection is more important during transit than while in storage; thus packages levels can often be reduced once an item is in an operating organization warehouse;
- Retaining manufacturer’s packages is often advantageous for warehouse storage;
- Manufacturer’s labels should be retained during long term storage;
• Processes for handing outside stored components should be developed (weatherproof tagging, matching of unique ID numbers to shipping tags which are kept indoors, review of damage potential of any chemicals used for control of weed growth in outdoor laydown areas, etc.);
• Warehouse logistics should be carefully considered (standard pallets, crates, facility for moving long pipe lengths etc.);
• Consider material incompatibility of carbon steel forklift forks with materials to be carried (e.g. use stainless steel sleeve for lifting stainless steel components);
• Consider carefully requirements for pipe storage (indoor versus outdoor, incline to allow drainage, ensure properly supported etc.)
• Ensure in-storage maintenance is possible;
• Use end caps, plugs, or seals (bags, boxes, tape, cabinets etc.) appropriately to protect against foreign material or thread damage;
• Take care with non-metallic items to avoid bending, stretching, or other damage;
• Ensure any preservatives used during shipment are appropriate for long term storage;
• Ensure proper storage and handling requirements are transferred to any temporary laydown areas and personnel receiving the item are aware of them;
• Ensure items returned to the warehouse are repackaged in a manner equivalent to the original packaging.

The above guide identifies that storage and handling requirements (location and conditions of storage) are based on an assessment of an item’s susceptibility for damage, the need to maintain clear identification of the item (ease of identification while in storage, chance of loss of ID tag etc.), and other factors such as shelf life, in storage maintenance, need for frequent handling (for in storage maintenance), and personnel protection requirements. Flammable, hazardous, and radioactive substances, and incompatible chemicals will require special attention.

3.10.1 Environmental and storage conditions

Items may be damaged by a number of conditions, including exposure to humidity/moisture (causing corrosion, mould or mildew damage), chemicals, airborne contamination, light/ultra-violet radiation, magnetic fields, static electricity, fires, radiation, or high or low temperature. Physical damage can also be encountered due to drops, falls, or vibration. Rodents or insects may damage packing materials or the item itself.

Desiccants are used for certain items to absorb moisture during storage or transit. Once in humidity controlled storage such desiccants may not be necessary and may be discarded with supplier concurrence.

Bulk chemicals should be protected from freezing and/or prolonged exposure to excessive heat that could result in chemical decomposition, polymerization, etc., loss of physical characteristics important to the chemical application, container bulging and/or leakage. Incompatible chemicals (e.g. acids and bases) should not be stored together.

3.10.2 In-storage maintenance

In-storage maintenance may be needed for certain items to ensure that they do not degrade in storage prior to plant installation. Some examples of such maintenance include lubrication, oil level checks, shaft rotation, exercising of moving parts, use of space heaters to keep motor windings dry, keeping batteries on charge or in a dry state while in storage, or in some cases cycle charging them. Connecting gel type capacitors to a power source can help maintain their dielectric strength while in storage.
EPRI has produced guidance for in-storage guidance in report NP-6896 [77]. It identifies factors and conditions related to in-storage degradation such as humidity, friction, gravity and loss of electric capacity.

### 3.10.3 Shelf life

Shelf life is the length of time a manufacturer will guarantee the usability of a product during warehouse storage. It is the predetermined period between the date of manufacture and installation [52]. Shelf life can be impacted by such items as temperature, humidity, pressure, UV light exposure, ozone, and airborne contaminants.

Procurement requirement clauses can address shelf life issues by requesting specific information from suppliers regarding material of construction, manufacturer date, batch numbers, and/or recommended shelf life. Shelf life information, including expiration dates, and cure or batch dates, should be marked on items or included as a separate certification. Shelf life marking should be confirmed as part of receipt inspection and should be added to the operating organization’s enterprise management system (i.e. confirmed marked on item and/or electronically recorded against specific item number). Items typically should have no less than 70% of their recommended shelf life remaining prior to being shipped, unless otherwise specified in the purchase order or contract. Items should be packaged by the vendor to minimize degradation from humidity, UV light, ozone, and oxygen.

Processes should be put in place to track and maintain material within a site’s shelf life programme. This typically would involve reviewing items due to will expire within a specified time frame (e.g. within the next one or two months) to ensure material availability and suitability when needed.

EPRI shelf life guidance is given in report NP-6408 [78]. NP-6408 provides a generic shelf life programme for various components such as types of batteries, elastomers, electronic components, reactive liquids and semi-solids (e.g. coatings, sealants), resins, plastics, and lubricants. NP-6608 [79] is a background study that was used in the development of NP-6408. Other shelf life data for elastomeric products can be obtained from [80] and [81]. French standard RCC-E [23, p. 202] requires storage period for electronic components shall be preferably less than two years.

### 3.10.4 Segregation of non-conforming items

A key warehouse function is to physically separate non-conforming product from product that is acceptable for use in the facility. Non-conforming items can be those that are received as damaged, incomplete, delivered in error, or delivered without required quality assurance paperwork. Once it is determined that the material cannot be made useable in the facility (i.e. for irreparably damaged items or items received in error) the items should be returned to the supplier.

Generally, a physically separate quarantine area is preferred to minimize the potential for inadvertent use of the non-conforming items. Care must be taken to ensure proper storage conditions to prevent material degradation while the non-conformance is being addressed.

### 3.10.5 Stores inventory management

If not managed stores inventory can grow to unsustainable levels. Inventory carrying cost is an important consideration as associated activities do not produce any revenue for operating organizations. Inventory carrying cost includes the costs of warehousing (direct costs for space rental, utility costs, staff costs, etc., plus the opportunity cost of invested funds; taxes, insurance, shrinkage, and obsolescence-risk costs etc.).
A sound stocking strategy allows for prudent financial management consistent with reliable plant operation. Optimized inventory strategies place greater emphasis on engineered spare parts availability, reducing consumable item process costs while maintaining adequate stock for plant use and elimination of excess obsolete inventories. NEI indicates [52] that an inventory optimization strategy can include the following optimization methods:

- Standardizing parts;
- Reducing duplications;
- Identifying exchangeable parts;
- Integrating supply chain with work control practices;
- Supporting work control scheduling processes;
- Maintaining data integrity of stock item information;
- Stratifying inventory (consumable, chemical, repairable, critical, etc.);
- Measuring performance;
- Partnering with suppliers;
- Partnering with alliances, inter-utility, intra-utility;
- Identifying obsolescence;
- Ensuring compliance and consistent supply chain processes through the use of procedures and guidelines;
- Utilizing industry standards and operational experience;
- Developing a stocking plan that supports the business plan;
- Analyzing usage patterns;
- Applying total cost of ownership philosophy;
- Utilizing inventory analysis tools;
- Participating in the design change process early in the process/schedule;
- Encouraging use of existing inventory.

Robust IT systems are a necessity for proper control of the large amount of data associated with NPP inventory. Such systems should incorporate such features as a single source of data entry, requisition entry, demand planning, material tracking (including need dates), interfaces with engineering design systems, interfaces with expediting personnel, control of materials at multiple receipt and storage locations, recording of material status (e.g. damaged, awaiting inspection, quarantined, issuable etc.), allocation of material to installation work orders, tracking of individual components to storage locations and end locations (for recall purposes), inventory management, material recipient, material substitutions, and payment functions. Various in-house and commercial solutions are available in industry, including enterprise resource planning systems and materials management software. Examples include SAP, Ventyx Asset Suite (PassPort), Areva VPRM, Intergraph SmartPlant Materials, Maximo, and many others.

Numerous methods and technologies are increasingly available to assist in managing inventory. Material tagging systems applied at receipt, and sophisticated tracking systems (e.g. GIS/GPS) discussed in section 3.9 allow for better and more accurate control of individual items. Unique identification numbers (see Appendix I.10) can be assigned to items to ease their location in the warehouse or the nuclear facility. Material analysts are typically assigned groups of items or commodities and perform demand analysis and set optimum reorder points and reorder quantities (see 3.1.3 and Appendix IV) based on known and forecast demand. Finally supply chain management strategies (see section 2.3) along with defined maintenance and procurement strategies (see Appendix I sections I.12 and I.13) can help to reduce the overall number of suppliers, amounts of duplicate materials, and overall inventory levels.
3.10.6 Prevent damage, deterioration or loss of items

Movement of material from its secure warehouse to the location of ultimate use introduces risks of item damage, deterioration, or loss. Damage during transport may occur, and items may deteriorate due to environmental exposure (see 3.10.1) or other adverse conditions (e.g. storage batteries being off charge for extended periods can degrade, shelf life continues to be reduced etc.). Unattended or unsecured items can be subject to theft or sabotage, which can both delay field work and introduce safety concerns.

Adequate security and tracking mechanisms should be in place for items being moved to end locations. Methods to transfer care and control of items in a secure and recorded manner between warehouse staff to end users (maintenance staff, contractors etc.) need to be in place. GIS and GPS systems discussed in section 3.8 can assist.

3.10.7 Field storage

Just prior to use material is typically collected by work management job (all material for a job gathered together) and staged in a special warehouse location or in the plant on a short-term basis close to the end use location. This allows for physical verification of the material by the end user. Field storage locations for staging have similar requirements as those for long-term storage, in that they need to be able to prevent damage, deterioration, loss of items stored, or creation of hazardous conditions due to item incompatibility.

3.10.8 Inter-utility transfer of material

Occasionally it may be beneficial to transfer material between operating organizations (e.g. between NPP, companies, utilities etc.). An operating organization may have an urgent need for an item, and a willing supplying operating organization may be identified. Shared inventory and co-operative warehousing arrangements are increasingly being developed. EPRI has produced a guide to some of the considerations involved with inter-utility transfers [82]. The receiver needs to provide itself assurance that the received item will meet its own requirements. This may involve such activities such as reviewing the sellers original procurement specifications, review seller audit reports, performing a CGD process after item receipt (if not transferred as SR), notifying the original supplier of the transaction (to ensure notification of any original supplier identified defects or recalls), and performing appropriate receipt inspection.

3.10.9 Alternate warehousing and supply strategies

Operating of warehouses and storing inventory is a bottom line cost for operating organizations. Increasingly alternate warehousing arrangements are becoming more practical. Just-in time deliveries, supplier-managed inventory and supplier-owned inventory all have the ability to decrease NPP costs. In some cases warehouse operation services or warehouses themselves can be contracted out.

Just-in-time (JIT) is an operation management philosophies whose objectives are to reduce waste and to increase productivity. Developed extensively in the automotive industry, JIT inventory systems focus on having “the right material, at the right time, at the right place, and in the exact amount”, without the safety net of inventory. Having local suppliers with fast delivery capability is typically necessary to implement JIT. JIT should be considered carefully, and the use of an effective stocking plan is necessary to compensate for the weakness of JIT [52].
Supplier-managed inventory is the practice of making suppliers responsible for determining order size and timing, usually based on receipt of inventory data. The inventory is generally located on site but managed by the supplier [52].

Supplier-owned inventory are items which a supplier owns and maintains inventory on the premises of the purchaser. This can also be known as consignment inventory [52]. Payment is not made to the supplier until an item is used.

3.11 ITEM INSTALLATION OR USE

When items are installed in the NPP a key activity to be performed is to update enterprise tracking systems to record that the specific item has been installed in the power plant, and that the replaced item has been removed from the plant. This allows tracking of the items in the event of a supplier recall or other discovered adverse condition related to the item(s). Processes related to this typically involve the maintenance organization updating (or requesting updating) the enterprise computer system to indicate the unique item now installed in an equipment location as part of work task closeout activities. See Appendix I section I.10 for further details.

3.12 REPAIR, REFURBISH, AND RETURN TO STOCK

Items returned to stock must follow a defined process similar to incoming receipt inspections. Following their original issuance from stock an item might have been stored in a laydown area, used in a maintenance shop, or installed in the plant. Damage may have occurred to the item, modifications made, sub-components partly removed, or (if long periods of time have elapsed) the item may have aged.

Items returned to a warehouse should be screened to ensure the following information is provided (adapted from [52]):

- Work order or modification number;
- Quantity returned;
- Stock number / catalogue identification number;
- Unique identification number (e.g. serial number, UTC etc.);
- Indication if item was installed/used, removed from service, repaired or cannibalized;
- Reason for return;
- Statement of acceptability / documentation of identified material discrepancies;
- Original issue number if available.

Items should be inspected for any damage or tampering, partial use, adequate packaging to allow for storage, proper identification, and cleanliness. Remaining shelf life should be evaluated and tracking systems updated.

An evaluation should be performed as to whether the material return to stock is justified. Such an evaluation can consider whether there is a future need for the material, current stock levels, material obsolescence, material cost, whether the item is a critical spare, and disposal versus storage costs. If the item appears repairable, an evaluation as to whether a repair should proceed should be done considering parts availability, cost of repair (internally or externally), and a comparison to purchasing the item new.

3.13 DISPOSING UNUSED MATERIAL

Utilities should have processes in place to identify potential unneeded spare parts in inventory due to modifications (obsolete material), as well as material identified as excess stock, damaged, or with low-turnover. Evaluations need to be made regarding the possibility of redeploying the material at another location, and risks associated with disposal. Items
planned for disposal need to be first confirmed as not being on NPP critical or strategic spares lists.

Some disposal risks include the potential that the material is obtained by unscrupulous individuals who might convert the material to a fraudulent item for sale on the open market (see Section 7), as well as other potential environmental, legal, political, and safety concerns. This can include inappropriate waste disposal that can have an impact on public health or company reputation. Cost of disposal and item hazardous characteristics should be weighed against ongoing company liabilities in maintaining items on site. Only qualified disposal companies should be used for hazardous materials.

3.14 CONTRACT CLOSEOUT

After completion of all contract deliverables, a formal process of contract closeout is completed. Closeout ensures that all deliverables have been completed as contracted, and provides an opportunity to accurately assess contractor performance based on the criteria on which they were chosen. This information should also be shared with the contractor in order that they can improve their processes. They may be given both positive and negative feedback. It is also the opportunity for the contractor to provide positive and negative feedback on how the owner administered the contract such that the owner is also given an opportunity to improve. Further details on supplier feedback are discussed in the next section.

3.15 NON-CONFORMANCE CONTROL AND SUPPLIER FEEDBACK

3.15.1 Non-conformances

Non-conformances are normally documented whenever an acceptance criterion or supplier management system requirement is detected as not being met. Non-conformances can be defined as supply of products or services that do not meet technical or quality requirements specified in procurement documentation. A key element in the procurement process is formal means of identifying, tracking assessing and initiating corrective actions as a result of non-conformances. IAEA safety requirements document GS-R3 [6] item 5.25 indicates that requirements for reporting non-conformances shall be specified.

Non-conformance reporting processes are invoked to correct the immediate non-conforming condition in a timely and systematic manner, determine cause(s) of the non-conformance to prevent reoccurrence in other circumstances, evaluate extent of condition (i.e. review possibility that the conformance exists elsewhere), and to initiate corrective actions. A key attribute of any good non-conformance reporting process is the ability of anyone discovering a non-conformance to be able to report it easily and without repercussions.

An issue with nuclear procurement is ensuring the non-conformance process is extended throughout all supply chain participants, including sub-suppliers. Sub-supplier processes need to connect in a timely manner with top level supplier processes and those of the operating organization. To achieve this NPP non-conformance processes and databases are recommended to incorporate the ability to track specific non-conformances against specific manufacturers or suppliers.

3.15.2 Supplier feedback

Supplier evaluation involves objective analysis of existing suppliers by evaluating past performance. Suppliers typically are evaluated based on their technical quality, delivery, service, cost, and management capabilities [52]. In order for suppliers to improve, it is essential to provide feedback from such evaluations to the suppliers involved.
Supplier feedback can take many forms, and metrics should be developed to allow comparisons and identification of trends. Formal reporting or scorecard processes are useful for suppliers and owners in long term business relationships. Developing metrics for what an owner values as good performance can help both parties communicate expectations and areas where improvement may be needed. Mutual development of such a scorecard can make its implementation easier, as the measures developed will be perceived as more balanced. Metrics can be in the categories of safety, quality, cost, schedule, or general management, and may contain both quantitative and qualitative measures. It is most important that the parties have regular, honest communications surrounding measured and perceived performance.

Some possible metrics for material suppliers are described in Table 8. Service supplier metrics are discussed in Section 4.3 and associated Table 9.

TABLE 8. MATERIAL SUPPLIER POTENTIAL METRICS.

<table>
<thead>
<tr>
<th>Metric Category</th>
<th>Definition</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery performance</td>
<td>% shipments received early, on time, or late</td>
<td></td>
</tr>
<tr>
<td>Overages / shortages</td>
<td>% shipments received with too much or too few items</td>
<td></td>
</tr>
<tr>
<td>Damaged items</td>
<td>% items received with damaged due to poor packaging or handling.</td>
<td></td>
</tr>
<tr>
<td>Receipt inspection metrics</td>
<td>% items accepted for use, rejected, discarded, used as is;</td>
<td></td>
</tr>
<tr>
<td>Documentation issues</td>
<td>% items received with incomplete or erroneous documentation;</td>
<td></td>
</tr>
<tr>
<td>Problems identified during PO formulation and implementation</td>
<td>Issues documented during PO formulation and implementation.</td>
<td>Evaluate as number or as % of POs placed.</td>
</tr>
<tr>
<td>Parts / material problems identified during installation or operation as a result of supplier error or quality issue.</td>
<td>Number of parts / material problems identified during installation or operation as a result of supplier error or quality issue.</td>
<td>Evaluate as number or as % of POs placed.</td>
</tr>
</tbody>
</table>

3.15.3 Supplier claims

Suppliers can make claims for additional costs related to the supply for a good or service, often at inopportune times such as during a critical installation or commissioning phase or just prior to contract closeout. Assigning an independent claim team leader on the client side to evaluate such issues is good practice as it removes the project manager and project team members from the equation, who otherwise would likely passionately defend their position.

Data should be provided by the contractor to provide factual evidence support the claim, with reference to the specific contract terms that apply. The quality of records on both sides can be critical to the success or failure of the claims process. Many claims fail on the basis on inadequate factual support (as much as 2/3 according to one estimate [70, p. 199]), however often there is some validity on both sides (i.e. both sides have failed to perform in strict accordance with the contract). In these latter cases a negotiated settlement is preferred to free up the project team for more productive work and to maintain the working relationship between the contracting parties.
4 SERVICE PROCUREMENT

John – include new TSO doc by Ness (if issued when this document is ready)

4.1 BACKGROUND AND DRIVERS

NPPs have a need for a variety of services. These can include contracts for plant maintenance, cleaning, transportation, technical or administrative support. The scope of contracting can be for small “one-off” activities, larger scopes of outage or backlog reduction work, or a complete outsourcing of specific functions (e.g. a company doing all maintenance for an NPP). Procurement of services for NPPs has taken on additional importance for many NPP operators. Many operators have business drivers to outsource certain aspects of NPP operation, whether it is for construction, maintenance work, technical support, or other functions. Drivers may be financial (cost savings), need for specific expertise, need for flexibility in staffing, need to address temporary work increases, or to complete work that is not core to the operation of an NPP. This trend has been increasing in some jurisdictions, and is more likely to be the case for newcomer or developing nuclear countries without large national nuclear workforces. NPPs built under an engineer-procure-construct (EPC) or build-own-operate (BOO) models tend to operate with higher levels of non-owner service contracts.

4.2 RESPONSIBILITY FOR SAFETY AND MANAGEMENT SYSTEM

As discussed in Section 2.1 NPP operating organizations retain the prime responsibility for nuclear safety and cannot transfer or delegate this to suppliers. They fulfil this responsibility in accordance with national regulations via implementation of a management system (para. 3.6 of [5]). This can be more difficult for services for a number of reasons:

- Individuals outside of the owner’s company are not under direct managerial oversight and control of owner supervision (e.g. cannot control resource decisions, more difficult to provide fast direction);
- Outside companies may work in non-nuclear industries, may not be fully aware of nuclear requirements, and may not be as fully engaged with or trained in human performance tools or in a nuclear safety culture;
- Key activities related to quality (inspections, tests etc.) may be unseen or not witnessed to the owner (making errors, omissions, or fraud less likely to be detected);
- Levels of training and qualification may be lower in outside workforces;
- Outside workforce may be more transient, leading to lower levels of experience at the NPP in question, and unexpected changes in personnel (an experienced person can be replaced by inexperienced person suddenly);
- Owner oversight of outside work force can be difficult or resource intensive if many suppliers and supporting management systems are present (e.g. auditing and oversight costs rise);
- Excessive owner outsourcing can reduce skill levels within owner to manage external suppliers (e.g. no “intelligent customer” or “smart buyer” capability developed);
- Owner oversight costs and resources applied to outside workforce oversight increase costs to owner and reduce benefits of outsourcing, thus tend to be discouraged by owner management;
- Economic pressures may be present to deliver services to lower quality levels or with higher risks to owner (use less experienced personnel, minimized redundancy in skill sets, less emphasis on corrective action resolution/reporting of defects, etc.);
- Economic disputes can delay responses to important activities;
Contract arrangements can contribute to making accountability for overall quality difficult to determine (e.g. contracting engineering for an project separate from construction and separate from material supply). IAEA General Safety Guide No. GSG-4 [47] covers use of external experts by regulatory bodies. In such a context external suppliers need to ensure that they do not compromise the independence of the regulator, be technically competent, have a management system, maintain confidentiality, and support the regulator’s safety culture.

4.3 SERVICE PROCUREMENT PROCESS

Procuring services follow the same general approach as has been documented for purchasing an entire NPP, with some differences in focus. Inviting and evaluating bids for an NPP project is covered in NG-T-3.9 [71], and is similar in many respects to inviting and evaluating bids for a service. The purchaser first needs to prepare a specification for the work (typically called a bid invitation specification or BIS) that is analogous to the purchasing requirements described in Section 3.2. Bidders then prepare formal bids, the operating organization evaluates bids against certain criteria, and a process of contract negotiation and signature takes place. Following signature of the contract the work covered under the contract is executed by the successful bidder under the oversight of an operating organization’s contract manager.

Services can be provided by a supplier with an accredited nuclear management system, or require a CGD process where they might potentially impact on a SR function. Section 4 of [83] contains information on CGD of services.

Additional information on technical support for nuclear operations is contained in IAEA TECDOC-1078 [84]. This section will provide an overview of issues unique to service contracts.

Services can be approached from either a single project approach or in a relationship approach. In the latter approach the parties contract for a period of time for a particular type of work (construction, engineering etc.) over a number of smaller scope projects.

Suppliers can be turnkey / full service / general-purpose suppliers (able to do a wide variety of tasks), or be contracted for specific projects or roles depending on their expertise. Turnkey suppliers tend to develop more plant specific knowledge, but can cost more if competition and oversight are not maintained. Companies need to develop a clear strategy for engagement of service suppliers to ensure company strategy remains consistent and expertise is maintained. Some possible strategies are listed below. These should be shared at a high level with potential suppliers to allow them to efficiently plan and use their resources to better meet operating organization needs in a timely manner.

- Some key work always kept within the owner’s company (i.e. in-house);
- Supplier used for overflow work only;
- Supplier used only for balance of plant or non-SR work;
- Supplier used only for specialty work;
- Multiple suppliers used dependent on work / specialty.

Newcomer countries typically rely on their NPP supplier for most engineering design and installation support, especially in early stages of the NPPs life. It is normally necessary however, due to the different business drivers and possible motivations of the operating organization and supplier, to develop a “utility engineer” oversight role in order to ensure:

- The supplier understands peculiarities of the specific NPP(s);
- Correct problem definition where problems and solutions may not be clear;
- Value for money is obtained for a particular project;
- NPP is not adversely impacted by installed modifications;
- Nuclear safety implications for the NPP are understood and addressed;
• NPP personnel understand implications of installed modifications.

The utility engineer would provide oversight and management of engineering vendors, and in doing so perform such functions as owning and approving project design requirements, providing oversight and acceptance of engineered products (drawings, reports, calculations, modification packages etc.), and performing contract and project management on behalf of the operating organization. Several operating organizations have found this to be a unique skill set that needs development and aptitude that can be different that that needed by staff doing strictly in-house work. Individuals in this role need to be able to plan work effectively, be able to work through others, and be able to mentor, coach, and provide feedback to suppliers without providing specific direction to supplier staff.

Initial contracting for services typically starts with a bid invitation specification. Such a specification would contain the following information:

• Type of work the service provider will do (general support, specific project, specific scope of technical work, etc.);
• Expected volume / amount of work;
• Process for individual sub-projects (how scope is defined, financial arrangements such as need to rebid on sub-projects with fixed price, use of draw down contracts etc.);
• Availability / response requirements for emergent work;
• Owner’s engineering and acceptance processes to be followed and committed turnaround times (it is useful for clarity and efficiency to formally identify processes, roles, and responsibilities for acceptance and approval of each document type (e.g. drawing, report, calculation, software, etc.);
• Owner support to be provided (training, licensing support, administrative support, etc.);
• Accountabilities with respect to reporting of defects and corrective action programmes (including interfaces between service provider and owner programmes);
• Commercial / financial expectations;
• Need to provide references for past work.

The specification author needs to be sufficiently experienced in that area of work to define the technical requirements and incorporate appropriate monitoring points to allow effective contract monitoring after award of the contract. To prepare a clear and complete specification requires a number of preconditions. These include:

• Sufficient time to study project requirements and convert them to specification language;
• Sufficient knowledge and experience by the author with respect to contract law and contract administration;
• Sufficient knowledge and experience by the author with respect to laws, and industry codes and standards related to the work that is being contracted;
• Sufficient knowledge and experience by the author with respect to the specific system and equipment and area of expertise for the work that is being contracted (including documents, drawings, computer code and other items to be provided to the bidders);
• Sufficient foresight to consider what can go wrong and what may change so that appropriate language can be included in the specification to allow for these risks;
• Sufficient knowledge of the plant design, installation, commissioning, maintenance and operating practices to ensure that any constraint on the work is reflected in the specification;
• Sufficient knowledge of the proponents’ strengths and weaknesses so that appropriate levels of responsibility and owner support, respectively, are included in the specification.
Following specification development, bid evaluation, negotiation for services, and contract execution follows the processes described earlier in Sections 3.5 and 3.6.

4.4 SERVICE SUPPLIER FEEDBACK

As discussed in section 3.15.2, good and regular communication that includes formal reporting or scorecard processes are useful for suppliers and operating organizations in long term business relationships. This is especially important for services as discrepancies in perceptions of what “good” services entail can easily occur.

Some metric topics that might be considered for service supplier performance are listed in Table 9 below. These should be reported on a routine basis (e.g. monthly or quarterly) and be reviewed by senior management of the owner and supplier regularly. A sample set of reports generated from such metrics similar to that used at an operating organization is shown in Figs 13 and 14.

<table>
<thead>
<tr>
<th>Metric category</th>
<th>Metric topic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Safety</td>
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<td></td>
<td>Safety</td>
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<td></td>
<td>Safety</td>
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<tr>
<td></td>
<td>Quality</td>
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<td>Quality</td>
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<td></td>
<td>Quality</td>
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<tr>
<td></td>
<td>Cost</td>
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<tr>
<td></td>
<td>Cost</td>
</tr>
<tr>
<td></td>
<td>Schedule / work control</td>
</tr>
<tr>
<td></td>
<td>Schedule / work control</td>
</tr>
<tr>
<td></td>
<td>Project management</td>
</tr>
<tr>
<td>Safety</td>
<td>Industrial safety performance (lost time accident rates, injuries per person-hours, housekeeping) See Appendix IX.</td>
</tr>
<tr>
<td>Safety</td>
<td>Work-site housekeeping</td>
</tr>
<tr>
<td>Safety</td>
<td>Nuclear safety performance (no attributable events)</td>
</tr>
<tr>
<td>Safety</td>
<td>Environmental performance (no attributable events)</td>
</tr>
<tr>
<td>Safety</td>
<td>Quality of training</td>
</tr>
<tr>
<td>Safety</td>
<td>Radiation safety (e.g. personnel contamination events / collective exposure / rad work planning compliance);</td>
</tr>
<tr>
<td>Quality</td>
<td>Customer / contract manager satisfaction</td>
</tr>
<tr>
<td>Quality</td>
<td>Final quality of product or service (deliverables provided at various phases such as preliminary engineering, detailed design, installation, commissioning and closeout);</td>
</tr>
<tr>
<td>Quality</td>
<td>Technical accuracy</td>
</tr>
<tr>
<td>Quality</td>
<td>Configuration management (maintaining plant design basis documents and enterprise systems up to date)</td>
</tr>
<tr>
<td>Quality</td>
<td>Clarity and editorial accuracy</td>
</tr>
<tr>
<td>Quality</td>
<td>Rework metrics (e.g. documents / products returned for revision or rework, trades rework)</td>
</tr>
<tr>
<td>Quality</td>
<td>Non-conformances observed</td>
</tr>
<tr>
<td>Quality</td>
<td>Procedural compliance, including maintaining internal procedures up to date</td>
</tr>
<tr>
<td>Quality</td>
<td>Warranty claims</td>
</tr>
<tr>
<td>Quality</td>
<td>Unplanned field change rates</td>
</tr>
<tr>
<td>Quality</td>
<td>Records maintained accurately and submitted as required</td>
</tr>
<tr>
<td>Quality</td>
<td>Use of trained, qualified personnel</td>
</tr>
<tr>
<td>Cost</td>
<td>Cost control / budget</td>
</tr>
<tr>
<td>Cost</td>
<td>Project cost growth rates</td>
</tr>
<tr>
<td>Cost</td>
<td>Billing / invoicing accuracy</td>
</tr>
<tr>
<td>Cost</td>
<td>No non-justified claims or additional charges</td>
</tr>
<tr>
<td>Cost</td>
<td>Value added by supplier (e.g. cost savings identified or better solution)</td>
</tr>
<tr>
<td>Cost</td>
<td>Care of items or material supplied by owner (no loss or damage)</td>
</tr>
<tr>
<td>Schedule / work control</td>
<td>Schedule adherence</td>
</tr>
<tr>
<td>Schedule / work control</td>
<td>Milestone performance</td>
</tr>
<tr>
<td>Schedule / work control</td>
<td>Earned value performance</td>
</tr>
<tr>
<td>Schedule / work control</td>
<td>Timely reporting of schedule deviations</td>
</tr>
<tr>
<td>Schedule / work control</td>
<td>Document turn-around time</td>
</tr>
<tr>
<td>Schedule / work control</td>
<td>Document / project closeouts completed within acceptable time frame</td>
</tr>
<tr>
<td>Project management</td>
<td>Responsiveness (when faced with critical situations), flexibility, and co-operation</td>
</tr>
<tr>
<td>Project management</td>
<td>Independence and interface management (e.g. communications / reporting timeliness, clarity, accuracy, doing independent work)</td>
</tr>
<tr>
<td>Project management</td>
<td>Project predictability</td>
</tr>
<tr>
<td>Project management</td>
<td>Leadership behaviours (e.g. supervisory oversight, accountability, and engagement)</td>
</tr>
<tr>
<td>Project management</td>
<td>Corrective action and audit programme implementation</td>
</tr>
<tr>
<td>Project management</td>
<td>Documentation of lessons learned</td>
</tr>
</tbody>
</table>
4.5 SERVICES LESSONS LEARNED

As discussed in section 2.2, a key lesson learned related to services is the need for an “intelligent customer” role within the operating organization to manage the interface with a service provider. This role assists integration of the service provider into the nuclear facility’s team, facilitates communication and training, and helps ensure that appropriate levels of oversight are in place. Individuals from service providers do not come with the nuclear
facility knowledge and experience typically found in operating organizations, and thus need to be managed more carefully, especially when performing SR activities. Individuals performing the intelligent customer role need knowledge of the activities that they are overseeing, and so opportunities must be given for them to gain such knowledge. Such opportunities will need to be incorporated into individual training and qualification plans, and may ultimately affect the quantity of services being contracted out.

The UK’s Royal Academy of Engineering in its Nuclear Lessons Learned report [85] identified some recommendations related to services. These included the need to incorporate lessons learned from similar projects, maintaining a risk register reviewed at senior levels, ensure high-calibre managerial and engineering people are used and led by a person with the authority to act, and to incorporate high quality control and assurance processes throughout the whole supply chain.

EPRI has identified [83] some examples of potential failures in performance of different types of services related to commercial grade dedication that can affect SR equipment functions. These are shown in Table 16. If a service procured can impact a SR function, the report recommends that critical characteristics for the service be identified which once selected, provide reasonable assurance that the service provided meets specified requirements. Acceptance criteria would then be selected to ensure the criteria are met. Some specific issues or guidance identified for CG services are:

- Services of outside testing laboratories should be treated as any other service the user is procuring;
- Instances have occurred where operations or maintenance personnel have waived a post installation test which was to be included in a commercial grade acceptance. Administrative mechanisms such as witness/hold/notification points or database flags should be implemented to preclude these types of occurrences.
- Special care must be exercised when repairs are made on SR components by a commercial service supplier (commercial service suppliers, unlike most original equipment manufacturers, do not have an approved nuclear management system).

Commercial grade dedication is discussed more fully in section 5.1.4.
<table>
<thead>
<tr>
<th><strong>TABLE 10. POTENTIAL FAILURES IN SERVICE PERFORMANCE (ADAPTED FROM [83])</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Testing</strong></td>
</tr>
<tr>
<td>Use of uncalibrated test equipment</td>
</tr>
<tr>
<td>Technician inadequacies in performing the test</td>
</tr>
<tr>
<td>Improper test specimen preparation</td>
</tr>
<tr>
<td>Improper calculation of test results</td>
</tr>
<tr>
<td><strong>Fabrication/Machining/Cleaning/Unique Manufacturing Processes</strong></td>
</tr>
<tr>
<td>Failure to meet dimensional requirements</td>
</tr>
<tr>
<td>Material contamination</td>
</tr>
<tr>
<td><strong>Training</strong></td>
</tr>
<tr>
<td>Errors in instruction material used by trainees to perform a SR activity</td>
</tr>
<tr>
<td><strong>Engineering/Technical Services</strong></td>
</tr>
<tr>
<td>Incorrect voltage drop calculations</td>
</tr>
<tr>
<td>Failure to confirm initial assumptions</td>
</tr>
<tr>
<td><strong>Calibration</strong></td>
</tr>
<tr>
<td>Equipment out of calibration causing failure to accurately measure or actuate at proper time</td>
</tr>
<tr>
<td>Plant equipment calibrated incorrectly by maintenance because measuring and testing equipment has not been properly calibrated</td>
</tr>
</tbody>
</table>
5 CONSIDERATIONS AND LESSONS LEARNED FOR NUCLEAR

5.1 PROCUREMENT ENGINEERING FUNCTION

The procurement process requires technical information as an input to ensure procured items will perform their intended design functions.

Because of potential complexity in translating such technical information (such as design specifications, codes and standards, etc.) into procurement instructions for suppliers (particularly with changes in the supplier marketplace with passage of time), many operators have created a procurement engineering (PE) group/function.

The PE function is an integration between design engineering (responsible for technical specifications and acceptance criteria) and purchasing (responsible for issuing requests for quotations and purchase orders, and managing suppliers) and often serves as a bridge between those functions. In some organizations the PE function resides with the design group, while in others within the procurement/supply chain organization.

Purchasing specifications extend beyond technical requirements to include quality and commercial requirements. These include acceptance criteria, applicable hold points, acceptance testing and documentation requirements, packaging, shipping, handling and storage requirements, intellectual property use and protection, and required commercial conditions.

These purchasing or procurement specifications are typically included in solicitations such as request for quotation (RFQ) or request for proposal (RFP) documentation sent to equipment suppliers. This is in accordance with IAEA GS-R3 [6] para. 5.24, which states that “purchasing requirements shall be developed and specified in procurement documents”.

For illustration, Fig. 15 provides high level responsibilities of the design engineering, PE, and purchasing functions. It should be noted that there are some areas of overlap.

Major activities within PE are to:

- Establish procurement technical and quality requirements (section 3.2 and 5.1.1);
- Establish acceptance criteria (section 3.3.4 and 5.1.1);
- Evaluate item equivalency (section 5.1.3); and
- Perform or manage commercial grade dedications (section 5.1.4).

5.1.1 Establishing technical and quality requirements

As discussed in Section 3.2, a key activity in the procurement process is establishment of technical and quality requirements for items. As a requestor may not have full knowledge of all procurement process requirements and data needs, PE staff are trained especially to be able to clearly and correctly articulate such requirements. This function also generally
includes screening of setting up of new catalogue IDs for items to be purchased, and linking them to the items requirements. As part of this process end use analysis of items is performed to determine whether the item needs to be purchased as SR or not.

5.1.2 Establishing acceptance criteria and methods

Following establishment of requirements, and supplier selection, acceptance criteria for the item, as well and the methods by which they will be confirmed, need to be defined and documented. As described in Section 3.4, acceptance criteria and methods are designed to ensure that purchasing requirements have been met before the product is used. PE staff are trained especially to be able to clearly establish such criteria, or to translate criteria developed by design staff into a standard format understandable by the vendor community.

5.1.3 Item replacement evaluations

As NPPs age greater difficulty is typically experienced in obtaining identical spare parts. Marketplace changes can cause original equipment manufacturers to go out of business, or they may decide to discontinue products or replace products with improved models, or may decide to discontinue their nuclear management system or quality programme. With plants now targeted for 60 or more years of operation this trend is expected to continue and escalate. Utilities may also wish to initiate parts changes due to dissatisfaction with the in-service performance of a particular part, and thus seek more reliable alternates.

NPPs need methodologies and staff to locate replacement items and evaluate them against original requirements (critical design characteristics). This can be complicated by the fact that a particular item can be utilized in a number of end uses and locations in an NPP, including both SR and non-SR applications. A documented technical evaluation process is required for this to assure that replacement items procured are equivalent to the original items for identified end uses. When a plant is relatively new and the volume of such work is small, plant designers may be able to address such evaluations on a case by case basis; however as plants age dedicated PE staff are often assigned this role.

IAEA Safety Guide related to modifications of NPPs [86] para. 4.1 indicates that plant modifications do not include replacement of a component by an equivalent component in recognized maintenance activities. That is item replacement processes are different from design changes or modifications.

Equivalent components are those that are either identical with the original component or those for which a safety assessment has previously been made and confirmed, so that they can be considered equivalent replacements for the original component.

Replacement with an identical component is often called a “like-for-like” replacement. Such replacements are those involving absolutely no physical changes since the last procurement, and no changes in procurement requirements, although some administrative details or changes may need evaluation.

Item equivalency or alternate-item replacements are those where some changes may be allowed however where the item still meets original requirements and has been evaluated as equivalent in terms of required physical and performance characteristics. Item equivalency is suitable when equipment level technical specifications are not being modified. Some potential examples of IEEs might include internal piece-part material substitutions made by a vendor to an item, changing of sub-components in a motor or power-supply by an original equipment manufacturer during a rewind or refurbishment, upgrade of a solid state relay to a new model with new features with no impact on original functionality or dimensions.

Design changes or modifications by contrast involve making some type of change to the design basis, and often carry their own set of modification design requirements. They also
often make substantial differences on interfacing systems, processes, and plant operations. In operating nuclear plants, a formal engineering change control process is used to assess the impact of modifications on design basis, interfacing SSCs, and operability. Some utilities have developed special modification processes addressing non-identical component replacements for items not meeting IEE requirements and thus require some customization or low-impact modification to allow for their use in the NPP.

Item replacement processes are contrasted with design changes in Table 11.

**TABLE 11. COMPARISON DESIGN CHANGES TO PARTS REPLACEMENT PROCESSES**

<table>
<thead>
<tr>
<th>NPP Process</th>
<th>Characteristics</th>
</tr>
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</table>
| Modification / design change       | - Discrete set of design requirements  
|                                    | - Impact on interfacing systems, structures and components  
|                                    | - Physical and performance characteristics may be different  
|                                    | - Technical specification may be different  
|                                    | - Formal engineering change process required  |
| Item equivalency replacement       | - No change in design requirement or technical specification  
|                                    | - Equivalent in terms of physical and performance characteristics  
|                                    | - Minimal engineering change control invoked since impact on interfaces negligible |
| Like for like replacements         | - No physical changes from last procurement;  
|                                    | - No change in design requirements or technical specifications  
|                                    | - May require careful evaluation of administrative changes related to item (e.g. supplier part number changes, use of alternate or sub-tier supplier.  

IAEA Safety Report Series 65 on configuration management [4] recommends that an effective, documented process be used for evaluating replacements to confirm component equivalency. These can be through PE methodologies such as an item equivalency evaluation (IEE) or manufacturer/vendor catalogue part number analyses. Manufacturer/vendor catalogue part number analysis is an example of a possible like-for-like replacement identified in Table 11.

IEEs allow for replacement of parts with equivalents. New items are evaluated against and must be found equivalent in terms of form, fit, and function (performance characteristics). Form, fit, and function are identifiable and/or measurable attributes of a replacement item that provide assurance that the item will perform its design function and is equivalent in physical and performance characteristics. Form and fit are the physical characteristics of the item such as materials of construction, dimensions, mass, or connection points. Function is the functional or performance requirements of the equipment such as voltage, current or temperature ratings, capacity, operating time, stroke time, seismic capabilities, or environmental qualification. Form, fit, and function requirements are often referred to as the critical characteristics for design, and are part of an item’s technical requirements (see section 3.2.1).

EPRI report 1008256 [56] provides a documented methodology for replacement items, including both like-for-like replacements and IEEs. Figure 16 outlines the process. The assessment model confirms the safety classification of an item by looking at all its end uses in an NPP, looks at differences between the old and replacement item, documents such differences, and if deemed equivalent develops requirements for the replacement item. Of particular importance is analysis of failure modes and effects of the replacement item (e.g. impact of failures due to corrosion, shorts, open circuits, vibration, fatigue etc.) and if the item responds in an identical way to the original. This completed assessment is used to determine if equivalent replacement or design change/modification should be used for replacement of the
item. If a design change or modification is required the IEE process stops and a design change or modification process is initiated.

EPRI [56] reports that for efficiency reasons some utilities have developed processes for generic IEEs that look at worst-case design functions for commodity based items (e.g. resistors, capacitors, O-rings, lubricants, fasteners, and, in some cases, even more complex devices such as relays and breakers). These evaluations identify critical design characteristics applicable to the items in a bounded set of applications, thus relieving the operating organization of repeating the process on a case-by-case basis. Comparison of design parameters for the specific items being evaluated is still needed when a particular substitution is later required.

Utilities often decide to extend application of replacement item processes to non-SR items or systems. This depends on such factors as risk significance, importance to plant reliability, item cost, maintenance and/or installation cost, and impacts on personnel safety and/or plant security.

\[\text{FIG. 16. Assessment process for evaluation of replacement items for NPP equipment [56].}\]

### 5.1.4 Commercial grade dedication

Commercial grade dedication (CGD) is a process used to enhance quality and therefore provide reasonable assurance that commercial items designed and manufactured outside of a nuclear quality programme meet technical and quality requirements for SR end use(s) in an NPP.

The process has been necessitated in many jurisdictions due to a reduction in NPP construction, which has caused many suppliers to not maintain their nuclear management systems or quality programmes. Parts may no longer be available, or even if available not with required nuclear quality programme documentation. Because of this, there is no supplier assurance that component design is controlled, and it is also possible that sub-standard items may be manufactured due to lack of quality control in manufacturing. The CGD process is designed to allow the purchase of such commercially produced items and perform additional quality checks on them to ensure they are acceptable in SR applications.
One definition of a CGI is an item that exhibits all the following criteria [62]:

- Not subject to design or specification requirements that are unique to nuclear facilities;
- Used in applications other than nuclear facilities;
- Ordered from a manufacturer/supplier on the basis of specifications set forth in manufacturer's published descriptions (e.g. a catalogue);

IAEA Safety Guide GS-G-3.5 [8] para. 5.35 to 5.37 covers the CGD process and requires that:

“5.35. Certain products with a proven record may be available from commercial stock. Procurement documents should provide sufficient information from catalogues and suppliers’ specifications to enable the correct product to be supplied.

5.36. Relevant technical data and trial information regarding the product should be requested from the manufacturer as necessary. Where appropriate, a commercial grade product may need to undergo confirmatory analysis or testing to demonstrate the adequacy of the product to perform its intended function.

5.37. When a commercial grade product is proposed for any safety function, a process should be used to determine the product’s suitability; this is sometimes referred to as a ‘dedication’ process in some States. This process should identify whether the following activities are required:

(a) A thorough technical evaluation of critical characteristics such as reliability and failure modes.
(b) Verification of compliance of the product with requirements that are safety significant.
(c) Determination of specific tests, inspections and verification activities to ensure the capability of the product to meet requirements for any critical characteristics.
(d) Performance of tests and acceptance of results on the basis of criteria. The critical characteristics required for any safety function should be included as acceptance criteria in the procurement documents.
(e) The need to conduct verification or inspection of the product at the supplier’s facility prior to authorization for delivery.
(f) Evaluation of the capability of, and the controls applied by, the suppliers of the product.
(g) Retention of records and documents that substantiate the product’s conformity and history.”

The CGD process can thus be separated into activities as shown in Fig. 17. The basic process is similar to that of purchasing non-CGD equipment as was described in section 3 (defining requirements, supplier selection, acceptance criteria, filing a purchase order, performing item acceptance and receipt). A key difference is which organization performs the acceptance and under whose management system. For CGD it is typically not the original equipment manufacturer providing the quality assurance function, but the operating organization itself or a third party CGD organization.
The CGD process typically involves:

- Producing a list of critical characteristics of the item to be dedicated (e.g. part number, physical characteristics, identification markings, or performance characteristics). For example for a fuse critical characteristics might be fuse configuration, current rating, interrupt rating, time/current response, dimensions and seismic qualification.

- Defining and implementing an appropriate method of acceptance to confirm such critical characteristics. Fig. 17 shows four such methods which are: special tests and inspection, commercial grade supplier surveys, source verification, and acceptable supplier/item performance records. Characteristics of each method and their uses are shown in Table 13.

EPRI and other organizations have produced numerous guidance documents covering the CGD process. Key references are provided in Table 12.

Of special note is the difference between a vendor audit as described in section 3.3.3 and a commercial grade survey. A commercial grade survey focuses on supplier controls related to specific critical characteristics identified in a dedication technical evaluation, while a vendor audit looks at all aspects of the vendor’s management system (typically ISO 9000).
<table>
<thead>
<tr>
<th>Country</th>
<th>Organization</th>
<th>Document</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>AERB</td>
<td>AERB-SG-QA-3 - Quality assurance in the procurement of items and services for nuclear power plants [26]</td>
<td>Section 10 covers commercial grade stock items. Allows items “with a proven record” to be used providing sufficient information is available on the item, confirmatory testing or analysis demonstrates adequacy, and for SR items the design authority evaluates safety significance and the responsible organization evaluates critical characteristics and includes acceptance criteria in procurement documents.</td>
</tr>
<tr>
<td>United States of America</td>
<td>EPRI</td>
<td>NP-5652 Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications (NCIG-07) [62]</td>
<td>Provides a generic process for CGD and guidance on acceptance methods. Specific appendices provided for performing technical evaluations, classifying parts, confirming if an item is a CGI, establishing procurement requirements, use of national codes and standards, maintaining seismic and equipment qualification, and using CGD items in specific versus generic applications.</td>
</tr>
<tr>
<td>United States of America</td>
<td>EPRI</td>
<td>Supplemental Guidance for the Application of EPRI Report NP-5652 on the Utilization of Commercial Grade Items (TR-102260) [83]</td>
<td>Provides supplemental implementation guidance to NP-5652 related to achieving reasonable component performance assurance, the relationship between technical evaluation for replacement items and CGI acceptance processes, equipment qualification versus CGI acceptance, acceptance methods, handling non-conformances, supplier dedication issues, and CGD of services (repair, testing, engineering etc.).</td>
</tr>
<tr>
<td>United States of America</td>
<td>EPRI</td>
<td>NP-6629 Guidelines for the Procurement and Receipt of Items for Nuclear Power Plants (NCIG-15) [51]</td>
<td>Defines purchasing a commercial grade item, using a utility quality assurance programme as a possible procurement scenario. Points to NP-5652 [62] (see above) for detailed requirements.</td>
</tr>
<tr>
<td>United States of America</td>
<td>EPRI</td>
<td>Critical Characteristics for Acceptance of Seismically Sensitive Items (CCASSI) (TR-112579) [87]</td>
<td>Provides methods for selection and verification of critical characteristics related to seismic performance. Verification methods presented are consistent with those suggested in ANSI N45.2.13 and EPRI Reports NP-5652 and TR-102260.</td>
</tr>
<tr>
<td>United States of America</td>
<td>EPRI</td>
<td>Dedicating Commercial-Grade Items Procured From ISO 9000 Suppliers 1003105 [88]</td>
<td>Documents to what extent licensees can credit ISO 9000 QMS registrar accreditation and supplier certification processes as part of CGD processes within US regulatory framework. Provides guidance on how to take credit for a supplier’s ISO 9000 QMS in support of dedication activities.</td>
</tr>
<tr>
<td>United States of America</td>
<td>EPRI</td>
<td>Guide For Sampling in the Commercial-Grade Item Acceptance Process TR-017218-R1 [89]</td>
<td>Provides methodology for use of sampling in accepting/dedicating CGIs. Discusses issues such as lot homogeneity versus lot size, destructive versus NDT, and tightened and reduced sampling.</td>
</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>Inspection Procedure 38703, “Commercial Grade Dedication” [90]</td>
<td>Regulator inspection procedure use to determine whether a failure of a SR item was a result of a deficient CGD process, or verify a licensee’s CGD process meets requirements.</td>
</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>Inspection Procedure 43004, “Inspection of Commercial Grade Dedication Programs” [91]</td>
<td>Regulator inspection procedure to verify a dedicater’s CDG programme satisfies requirements</td>
</tr>
<tr>
<td>Country</td>
<td>Organization</td>
<td>Document</td>
<td>Comment</td>
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</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>NRC Information Notice No. 83-79: Apparently Improper Use of Commercial Grade Components in Safety-Related Systems [92]</td>
<td>Heat exchanger outlet valve at D.C. Cook U2 removed from service because of leakage. Valve manufacturer determined that elastomer seat had not been properly bonded to the valve body at the time of manufacture. Neither purchase order nor valve specification required valve fabrication under an approved nuclear QA programme.</td>
</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>NRC Information Notice IN 87-66 Inappropriate application of CGD at Sequoyah and Farley NPPs [93]</td>
<td>Identifies problems resulting from inappropriate application of CGIs within Class 1E electrical panels (differences in quality and qualified life expectancy {10 years vs. 2 years} between a particular manufacturer's nuclear and commercial-grade relays).</td>
</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>NRC Information Notice IN 88-95 Inadequate Procurement Requirements Imposed by Licensees on Vendors [94]</td>
<td>Supplier QA programme does not address procurement and QA controls of ASME Code exempt load-bearing parts. In another case cracks discovered in spare safety valve guide and bearing assemblies in storage that was inappropriately procured as commercial grade.</td>
</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>NRC Information Notice IN 92-51 Misapplication and Inadequate Testing of Molded-Case Circuit Breakers</td>
<td>IN documented several issues with MCCB testing. One of these was that a supplier indicated instantaneous trip setpoints of commercial grade MCCBs with nonadjustable magnetic trips are not normally verified at the factory. Field testing had identified cases of premature tripping. However upon request, the supplier could verify that instantaneous magnetic trip points of their commercial grade MCCBs with nonadjustable magnetic trips supplied to nuclear utilities fall within the appropriate design band. IN highlights need and importance of determining critical characteristics and testing for them.</td>
</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>NRC Information Notice IN 96-40 [96] (with supplement 1)</td>
<td>Deficiencies in material dedication and procurement practices and in audits of vendors. Deficiencies noted in dedication practices of manufacturers and suppliers of CGIs such as fasteners, pipe, fittings, and structural shapes that are supplied as components of more complex equipment. Issues noted with identification of critical characteristics, use of indirect verification methods, poor heat traceability, ineffective audits, and confusing POs. In highlights the need for attention to detail in CDG processes.</td>
</tr>
<tr>
<td>United States of America</td>
<td>USNRC</td>
<td>NRC Information Notice 2011-01: Commercial Grade Dedication Issues Identified During NRC Inspections [97]</td>
<td>Summarizes NRC staff findings in area of CGD over 2 yr period. Findings included observations of lack of engineering judgement being applied, documentation deficiencies; vendor audits being used instead of CG surveys, and improper sampling plans. Specific examples of findings are included.</td>
</tr>
<tr>
<td>Country</td>
<td>Organization</td>
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</tr>
<tr>
<td>United States of America</td>
<td>Office of the Federal Register, National Archives and Records Administration</td>
<td>10 CFR Part 21 Reporting of defects and noncompliance [42]</td>
<td>Section 21.7 indicates that suppliers of commercial grade items are exempt from the provisions of this part to the extent that they supply commercial grade items.</td>
</tr>
</tbody>
</table>
**TABLE 13. CGD ACCEPTANCE METHODS AND SUITABILITY (ADAPTED FROM [62]).**

<table>
<thead>
<tr>
<th>Acceptance Method</th>
<th>Specific operating activities</th>
<th>Specific supplier activities</th>
<th>Most suitable for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1 - Special tests and inspections</td>
<td>Determine sample size Determine post-installation testing requirements. Determine special receipt tests and inspections Accept item via special receipt inspections Accept item via post-installation testing.</td>
<td>Furnish technical design information to enable operating organization to verify critical characteristics.</td>
<td>Items furnished from multiple suppliers; Items relatively simple in nature; Items on which post-installation tests can be conducted to verify critical characteristics.</td>
</tr>
<tr>
<td>Method 2 - Commercial grade supplier survey</td>
<td>Conduct survey of CG program. Require supplier to invoke controls necessary to verify critical characteristics. Accept item based on supplier Certificate of Conformance verified by CG survey.</td>
<td>Implement controls necessary to verify critical characteristics; Provide operating organization with a Certificate of Conformance (as requested).</td>
<td>A single supplier of CG item is being used; Required technical information cannot be obtained from supplier; A large group of items are repeatedly procured from a supplier for an entire line of components; CG item is an assembly of many parts; Purchaser cannot easily verify critical characteristics by inspections or tests.</td>
</tr>
<tr>
<td>Method 3 - Source verification</td>
<td>Conduct source verification. Accept item based on documented source verification results.</td>
<td>Implement item-specific design, fabrication, assembly, manufacturing, testing, or inspection controls substantiated by the source verification for a particular CGI. Allow operating organization access to facilities to conduct source verification.</td>
<td>A single item or shipment of items purchased on an infrequent or expedited basis.</td>
</tr>
<tr>
<td>Method 4 - Acceptable supplier / item performance</td>
<td>Establish documented performance record. Monitor performance of item. Confirm applicability of independent product test results, nuclear component reliability databases, commercial programme audits/surveys conducted by industry groups, utilization of national codes and standards, supplier responses to CG programme controls, results of periodic maintenance surveillance, results of successfully employing other acceptance methods. Accept item by issuing certification which is based on supplier/item performance record.</td>
<td>Respond to CG programme controls questionnaire (supplier indicates via response to questionnaire what would result in a part number change, material change, or a change to the manufacturing process etc.). Ensure item complies with national codes and standards, if applicable.</td>
<td>Items where results of historical performance can be compiled utilizing: 1. Monitored item performance; 2. Industry product tests; 3. National codes and standards (not specific to nuclear); 4. Other industry data bases (military, aerospace, etc.).</td>
</tr>
</tbody>
</table>
5.1.5 Buyer enquiry handling

As attempts to procure items run into difficulty, purchasing organizations may require technical assistance to disposition issues with suppliers. The PE function supports resolution of such technical issues.

Some obvious scenarios may occur. For example, when specified items are discovered to be obsolete, a supplier may propose an alternate item, requiring an evaluation by engineering as to its equivalency to the original item (typically called an “item equivalency evaluation” (IEE)) and the documentation of technical and quality requirements for the alternate item. Similarly a supplier may no longer have a specified nuclear quality program, requiring commercial dedication processes to be applied to the item (section 5.1.4) or an alternate solution found. Finally the buyer may not understand particular wording in the written requirements, and may be seeking clarification or a clearer explanation.

Quite often other issues may arise where refinement of the technical and quality requirements are required in order to facilitate purchase under given supplier conditions. The PE function can refine requirements while ensuring characteristics of importance are adequately imparted on the item.

5.2 CONFIGURATION MANAGEMENT, DESIGN BASIS, AND MODIFICATIONS

5.2.1 Maintaining plant configuration

The IAEA Safety Standard Safety on NPP operation [99] includes many requirements related to plant configuration. These requirements emphasize the need to maintain plant configuration documentation in strict accordance with the actual physical configuration. IAEA TECDOC-1335 [100] presents a basic approach to CM and describes how many plants have worked to improve their CM processes.

INPO has produced a process description AP-929 [101] related to the configuration control process that links to materials and services processes [52]. It shows how the processes related to procurement of services, engineered and long-lead items all link to the maintenance of plant configuration documentation.

Plant configuration is maintained when the correct item is installed in the correct location in the power plant. Processes described in this document (e.g. defining requirements, ensuring items meet acceptance criteria, tracking items to specific NPP end use locations, maintaining proper records, ensuring no counterfeit items enter the plant, etc.) all support maintaining this plant configuration. Where NPP configuration is inadvertently lost, plants can be shut down or require extensive efforts to re-establish adequate configuration.

Modern enterprise computer systems can help automatically perform many process actions for maintaining CM. They allow easier identification of information that requires updating because of a proposed design change, and can assist in evaluating design acceptability before implementation. Equipment lists in such models can link to information related to component design bases, design requirements, probabilistic risk analysis (PRA), calculations, drawings, bills of material, spare parts, vendor information, system descriptions, and maintenance and operating procedures. Changes only have to be entered once into the computer when changes are made; as linked information is automatically updated.

Due to the complex data requirements surrounding plant configuration (see Appendix I), it is essential to ensure such data is set up at the time of plant turnover where feasible (see Section 5.10). During operation, careful control of modifications (and low tolerance for unapproved modifications) is needed to ensure proper updates are made to original configuration information.
5.2.2 Design assistance for modifications

Beyond the need to maintain plant configuration discussed above, the modifications process places many demands on designers. The primary goal is to address the desired outcomes of the modification (i.e. functional and performance requirements), and so secondary procurement related issues (e.g. standardizing or reducing numbers of suppliers, optimizing reorder points, addressing longer term spare parts issues etc.) can be more difficult and be given lesser attention due to time or other pressures. As discussed in 3.1.2 major projects and modifications are one of the key sources of procurement demand, and if not addressed systematically can be a source of procurement and plant related issues (e.g. increased inventory levels, lack of spare parts etc.)

Operating organizations can facilitate addressing procurement related issues during modifications by producing guidance or management system processes related to addressing these issues in a standard manner. Some of these can include:

- Guidance and assistance from supply chain organizations in evaluating market conditions (e.g. potential suppliers and their capabilities);
- Guidance on preferred standard commodities to use for design (e.g. standard common mechanical or electrical components to use such as piping, cabling, fittings, connectors etc.), and on preferred suppliers;
- Processes and tools for creation of new catalogue numbers (filtering of new numbers to encourage use of existing inventory; linking technical and quality requirements), setting up of new spare parts, set-up of standard reorder points and quantities, and for setting up other equipment data required for the procurement process (see Appendix I).

5.3 OBSOLECTENCE AND MODERNIZATION

IAEA’s safety guide on ageing management NS-G-2.12 [102] identifies that safety can be impaired if obsolescence of SSCs is not identified in advance and corrective actions are not taken before associated declines occur in reliability or availability. Technological obsolescence in particular can lead to increasing failure rates, decreasing reliability, and reduced capability for long-term operation.

INPO defines obsolete equipment is “an item in plant service that is no longer manufactured or is otherwise difficult to procure and qualify”. This is in contrast to the lesser concern of obsolescence caused by a plant, in which for example an NPP does not need a part any more due to a modification or modernization project.

 Longer operating lifetimes, or planning are envisaged as NPPs age and undergo life extensions. NPPs thus increasing need to cope with instances of obsolete equipment. Early in plant life such issues are often dealt with on a case by case basis, however as time progresses more strategic efforts are needed. These typically consist of making lists of currently or soon-to-be obsolete components, prioritizing the list via component criticality, and then working to address the items in the priority sequence in a timely manner.

Instrumentation and control components are of special concern. Demand for I&C components and the range of SR components are relatively small and qualification costs therefore high, and thus there are relatively few nuclear-qualified I&C manufacturers in traditional markets. In these markets many manufacturers are no longer interested in producing analogue I&C, resulting in a diminished inventory of analogue equipment. Obsolescence is not as serious an issue for NPP sensors and transmitters because they are still based on conventional sensing technologies that are not becoming outmoded. Nevertheless, many electronic pressure, flow, and level sensors used in NPPs are based on designs from the 1970s and have obsolescence concerns To avoid obsolescence, the nuclear industry has to
select modern designs of these sensors featuring digital electronics, and have them qualified for use in NPPs.

Some methods that can be used to address pending obsolescence can include:

- hoarding stock (buying large quantities of key items, especially in the context of a manufacturer announcing end-of-production);
- subsidizing companies (to maintain production capacity for key items);
- find alternative vendors (developing item equivalency or low cost modifications that allow other manufacturer’s products to be used);
- ensure contracts are given to companies with key capabilities (support smaller companies with regular purchasing; potentially even buying such companies if they fall into financial difficulty);
- pooling inventory with similar facilities;
- protection via contract technology transfer contract provisions (see Section 8.3.3);
- reverse engineering (Section 5.3.2);
- modernization programmes (Section 5.3.3).

A possible programmatic approach to address obsolescence on a facility wide basis is described in the next section.

EPRI has identified a number of initiatives under way in the USA to address obsolescence in report 1015391 [103]. These include pooled inventory management (PIM), RapidPartSmart (RAPID), obsolete items replacement database (OIRD), proactive obsolescence management system (POMS), and POMS preventive maintenance forecasting (POMS PM).

POMS is a collaborative effort involving many operating organizations to procure and store long lead-time and high cost equipment. A separate management company was set up to do the purchasing and member utilities have access to the stock that is stored in a central warehouse. A similar more recent initiative by the USA/STARS Alliance started in 2010 is called “Engineered Obsolescence Solutions” and is targeting a number of obsolescence issues [104].

RAPID is a database set up by a number of operating organizations to pool their on-hand nuclear plant inventory and when necessary, make it available to “participants in need.”

OIRD was a database developed in 2000 by the Nuclear Utility Obsolescence Group (NUOG) and Scientech. It was designed to be seamlessly integrated with the inventory databases in RAPID. Initial utility data entered in OIRD were the contents of the EPRI Obsolete Item Database (OID), and consisted of item equivalency evaluation information provided by EPRI members.

POMS is a service designed to determine what installed equipment is no longer supported by the manufacturer. This is done by collecting equipment information from member utilities and by contacting each manufacturer of installed equipment on a regular basis to determine if the model number is still supported. Information provided by vendors is used to populate and update POMS, and supplied to each participating utility.

POMS PM forecasting is used to determine when the available stock of a specific obsolete part or piece of equipment will be depleted based on planned PM activities.

EPRI report 1019161 [105] provides more detail on the above resources, and includes sample key performance indicators for obsolescence programmes, including such items as operator workarounds, work orders, or deferrals associated with obsolete equipment, costs associated with addressing obsolescence issues, and the average age of a facility’s top 10 obsolescence issues.

Obsolescence issues can be identified by almost any part of an operating organization, including supply chain, operations, maintenance, design, plant engineering, and planning. Supply chain has a key role in assisting to address obsolescence issues. Staff can flag obsolete
items in enterprise data systems and prompt action when inventory of obsolete items falls below needed levels, link obsolete items with recommended replacement items, identify potential solutions to obsolescence issues prior to their occurrence, address emergent obsolescence issues using industry-wide data sources, provide market intelligence regarding potential supplier failures or support of product lines, and identify near-term obsolescence issues based on projected usage data.

See INPO NX-1037, Nuclear Utility Obsolescence Group (NUOG) Program Guideline (don't have copy yet)

5.3.1 Programmatic approach to obsolescence management

A programmatic approach to address obsolescence would start by preparing a target list of equipment to be addressed. This can be done by identifying critical end uses (using defined criticality coding; see Appendix I, section I.8) and eliminating equipment types where maintenance is not normally performed or where parts are otherwise unlikely to be needed. Targeted equipment would then be reviewed against enterprise system bills of material, producing a list of targeted catalogue ID #’s with manufacturer and model information. Manufacturers would then be contacted to identify whether the components are still available as well as their piece parts. In the event of obsolescence, information on potential alternate components would be collected. This provides then a list of all targeted obsolescence issues. Further prioritization can be performed on the basis of known plant issues or ease of addressing the issue before pursuing resolution.

Prioritized obsolescence issues would be addressed by pursuing alternate components via station modification or parts substitution processes. Failing this, engineering resources would consider reverse engineering options with manufacturers (section 5.3.2) or more significant modification programmes (section 5.3.3). Consideration should be made for adding incremental resources required by other support organizations (e.g. purchasing, vendor audits, etc.) into the obsolescence team to maximize its effectiveness.

5.3.2 Reverse engineering

EPRI defines reverse engineering (RE) as the process of developing technical information sufficient to duplicate an item by physically examining, measuring or testing existing items; reviewing technical data; and/or performing engineering analysis [106, pp. 2-2]. It may be used to:

- address an obsolescence situation;
- achieve cost savings by purchasing from an alternate supplier;
- address issues with lapses in quality programme from an original supplier;
- resolve lead-time concerns; or
- improve item performance.

Although the intent of reverse engineering is to obtain an item essential identical to the original, based upon the nature of a reverse engineered item, both design and manufacturing of the new item will inherently change. Thus such replacements typically cannot be considered like-for-like replacements but rather IEEs, and thus follow the process described in section 5.1.3.

Reverse engineering does have legal implications in the areas of patent protection, intellectual property, trade secrets, copyright protection, and theft. When performed ethically reverse engineering is legal in most jurisdictions, and is not considered a form of design infringement or theft. Legal concerns about reverse engineering should be addressed on a case-by-case basis with the legal department, and proprietary data and intellectual property
rights need to be respected (e.g. OEM drawings are not to be sent to a RE vendor however pertinent data can often be transcribed).

EPRI has produced a guide to RE for NPPs [106]. RE is started in a similar manner to procurement of any item. That is technical and quality requirements need to be defined. As part of this end use applications and functions are identified, analysis of failure modes and effects is performed, and the item’s critical design characteristics are identified.

Design data related to the original item is then collected. This can include component/item drawings, system drawings, vendor specifications, vendor procedures, vendor manual information, station procedures and original procurement specifications.

The original item is then inspected and measured, and pertinent data recorded. Service time and conditions are also useful for evaluation of critical characteristics. Interfaces (both mechanical and electrical) including fit-ups, tolerances, inputs and outputs are then evaluated. If a vendor is assisting in the RE, interfacing item data or actual interfacing parts may need to be supplied to the vendor. Any history or operating experience related to the item should be forwarded to the vendor to help the vendor address any previous concerns.

The next step in the RE process is to establish the item’s design, including drawings and design requirements. Design documents and any special tests, inspections, or procedures required to demonstrate the replacement item will perform acceptably should be site-approved prior to manufacturing. It is often beneficial produce a prototype for evaluation prior to full production,

Once it has been determined to proceed with the RE item, engineering approval for the replacement item is required, typically via an IEE (as per section 5.1.3).

5.3.3 Modernization programmes

In some cases operating organizations have embarked on modernizations programmes in part to address obsolescence concerns. Digital upgrades for example can often replace a large number of separate analogue components with a single digital multi-function controller. Control room upgrades can replace a large number of obsolete components at once. Such changes can reduce both inventory and maintenance requirements and address large numbers of plant obsolescence issues. The IAEA has produced guides related to digital upgrades, including NP-T-1.4 [107] and TECDOC-1389 [108].

On-line monitoring (OLM) equipment can also help to identify obsolescence issues and maintain some older equipment in service longer. OLM technologies provide plants with the information to evaluate I&C sensors using applications that identify drifting instruments, alert plant personnel of unusual process conditions, predict impending failures of plant equipment, and improve efficiency. OLM systems can use both the static (DC) and dynamic (AC) components of output from existing process sensors to gain aging-related information about I&C sensors. New sensors can be installed to help monitor installed equipment [109].

5.4 HIGH RISK AND CRITICAL EQUIPMENT PROCUREMENT PROGRAMMES

Several utilities have implemented special programmes to address procurement aspects involved in the repair, refurbishment, or initial purchase of high risk or high value equipment such as large pumps, motors, or engineered equipment [110], [111]. Poor experiences with vendor repairs and an increased focus on equipment reliability and availability (stemming from shorter outages and longer operating cycles) have been the primary drivers for these initiatives. Experience has shown that repair and fabrication of critical equipment and major purchases can have a significant impact to NPP outage/operating schedules if non-conforming or unacceptable conditions are identified during the fabrication, receiving, pre-installation review or installation processes.
Similar approaches have been taken to address procurement of safety or economically important spare parts such as those that might address single point vulnerabilities (SPVs).

Such initiatives attempt to proactively schedule and determine quality assurance measures to be implemented prior to sending high risk critical equipment out for repair or acquiring new high risk critical equipment. This helps ensure critical equipment and major purchases are repaired or purchased and received in a timely manner. The actual procurement steps are not any different than those shown in the general procurement process description in Section 3; however the degree of oversight, rigour, and attention given to these items is heightened.

Engagement and ownership of vendor quality by plant engineering, maintenance, and purchasing organizations is seen as the most important factor for these programmes to be successful. Organizations attempt to work together to clearly and proactively communicate expectations of internal organizations and the vendor (i.e. providing clear and accurate requirements), ensure the vendor has internalized these expectations (i.e. people actually performing the work understand the expectations as opposed to simply a sales representative), and provide feedback and hold the vendor accountable if performance does not meet expectations.

Formal repair specifications (technical and quality requirements for a repair) and process checklists are notable documentation often produced as a result of such initiatives. Initiatives can result in improved vendor performance including decreasing trends in vendor quality non-conformances and observed deficiencies during receipt inspection [111].

INPO has produced guidance for owner oversight of new plant component fabrication [112]. The document is applicable to both new plant construction and replacement and repair activities. It describes attributes that should be considered for an owner oversight programme to ensure products that are important to plant safety and power production are of high quality and perform as designed. The document includes OPEX related to oversight, owner oversight programme attributes, common attributes to observe and inspect during oversight (general attributes and specific attributes for mechanical, electrical, and instrumentation and control components), and component oversight attributes (typical types of components to observe such as large pumps, generators, power transformers, reactor components, and heat exchangers).

5.5 STORES INVENTORY GROWTH

As utilities age spare parts issues in support of plant maintenance can increase. This can lead to increased inventory levels as numbers of contingency spares are purchased or stocked. These demands can come from specific maintenance work being assessed, programmes to reduce instances where work is dropped due to lack of spare parts, engineering staff evaluating available spares for their systems, modifications, or other sources. Where not tied to a specific need such requests can be for material that ultimately may never be used in the power plant. For example one might order all possible piece parts for a valve on a contingency basis, but later find that for a typical maintenance activity only a small subset of such parts would ever be used in maintenance.

Poor planning can contribute to inventory growth. When work scope is poorly defined, a work planner is more likely to identify more required parts for purchasing than are actually needed, and is less able to identify contingency parts [54]. Contingency part purchases should follow the analysis and challenge process described in Section 3.1.3.

As demand for new parts occurs there can be unexpected effects on a plant’s supply chain processes, which typically have a finite capacity to deal with such requests within a given time frame. Numbers of requests can go up, creating backlogs within engineering, purchasing, receipt inspection, and other functions. Time to deal with any individual request
can increase (due to the backlogs), making end users (typically maintenance) frustrated with the delays. The frustration can lead to even more parts being specified on work tasks in an attempt to ensure workers won’t need to wait for follow-up item purchases. Finally the operating organization can see the cost of carrying inventory increase as levels of material stored increases.

Operating organizations should have processes in place to manage inventory levels in a sustainable manner. This will contribute to NPP efficiency and economic operation. These processes can include demand side initiatives (i.e. challenge or screen addition of newly stocked items; see Appendix I section I.3), methods to pool or share inventory (sharing costs with other organizations), methods to have suppliers hold inventory (e.g. supplier held inventory with JIT delivery methods as needed), reviews of usage patterns to review stock levels, and measures to surplus or sell unneeded inventory excesses.

5.6 INTERNATIONALIZATION OF SUPPLY CHAIN

The nuclear supply chain for reactor construction was relatively nationally-based, but has been on a trend toward longer term consolidation, with a smaller number of internationally recognized reactor models on the market. As nuclear power has expanded into new markets, numbers of countries supplying nuclear equipment and components have increased, and national barriers to entry have come down in many jurisdictions. The World Nuclear Association has performed a review of the nuclear supply chain outlook up to the year 2030 [113], and reported for example that the number of ASME N-stamp holders as of 2009 is greater outside of the US and Canada than within (69 in US and Canada, 74 in the EU and Asia) [113, p. 67].

Global supply and production networks should result in expanded markets and business opportunities for suppliers, and lower prices for utilities. Global suppliers may have better access to lower raw material, energy, or labour costs. An international supply chain can thus help deliver high-quality, reliable and cost-competitive components. This internationalization of the supply chain does present several challenges however. Increasing numbers of foreign or off-shore suppliers can increase the complexity and expense of auditing, source inspection, shipping (longer distances, need for multiple freight modes, customs clearance complexity, etc.), and material tracking activities. Risks associated with counterfeit, fraudulent and sub-standard items (see Section 7), intellectual property theft, communications (language and culture), responsiveness (longer delivery and response times, potential for accidents and loss etc.), macroeconomics (exchange rates etc.), and geopolitics can increase.

This is consist with concerns raised by the Construction Industry Institute in its International Project Risk Assessment guide [114]. This guide indicates that “proper planning and follow through on determining the source of materials and supplies are critical to meet the challenges of international projects. Managing supply, equipment, and material logistics for international capital facilities is complicated by factors such as in-country availability, customs requirements, delivery lead times, local purchase requirements, knowledge of local conditions and workforce skill and ability issues”

Certification of suppliers to international standards for quality control of manufacturing and construction processes, and establishing more common regulatory and technical frameworks, are issues being worked on by industry and government [115].

Localization desires by countries for NPP equipment supply run somewhat counter to the increasing globalization of the nuclear supply chain. The WNA suggests an approach [115] whereby there is close collaboration between the main NPP supplier, the relevant national economic development agency, and the operating organization on procurement procedures to be followed. Realistic opportunities for increasing local content can be identified and followed up by a joint task force, so that requirements can be announced well in
advance of tendering, giving local companies the chance to pre-qualify and compete. Complementary measures are necessary by the economic development agency to promote capacity upgrading among local companies and to help them achieve necessary quality certifications.

Need more (maybe something in EPRI 3002000521 – supplier QM for new NPP construction {don’t have copy} anyone have access to this?)

5.7 RECORDS CONTROL

As was discussed in section 2.1 records need to be kept for procurement related activities. Records allow demonstration to regulators and other stakeholders that quality processes have been followed for procurement related activities, and will assist with later facility operations and maintenance.

Some procurement related records include equipment, material order or contract numbers, design documents, manufacturing drawings, procurement specifications, quality plans (for each process from raw material production to final product quality inspection and test records), raw material and purchased part quality records (e.g. material quality certificates, chemical composition certificates, material property tests, NDT test records, factory acceptance test records, repair or material substitution records, and other inspection records), fabrication records (weld procedures, weld electrodes used, personnel qualification, supplier materials approvals (including furnace number, batch number), welding material batch, NDT inspection results, destructive test records), manufacturing process test reports and records (e.g. heat treatment, NDT, pressure tests, seal tests, electrical performance tests, instrument calibration, equipment functional tests, stability tests, cleanliness inspections, final dimension checks, etc.).

Procurement document approval and change procedures should be defined. Documents should be able to be validated as being in accordance with provisions of the product’s quality assurance program, quality inspection standards and procedures, personnel qualification requirements, inspection requirements, and measurement and test equipment calibration requirements.

Enterprise systems should be developed to codify and store procurement records in an easy-to-retrieve format that is linked to appropriate related items (e.g. purchase orders, technical specifications, UTCs etc.).

5.8 HUMAN RESOURCES AND TRAINING

Training is a key aspect of NPP operation, and individuals are required to have received appropriate education and training, and have acquired suitable skills, knowledge and experience to ensure their competence (para. 10 of [6]).

Individuals involved in procurement are no different. The UK Royal Academy of Engineering identified in a lessons learned document for nuclear new build [85] that establishment of a highly qualified team is necessary to (among other things) plan the procurement for a new NPP in collaboration with the main contractors.

“This emphasis on highly-qualified teams and collaboration is essential for large, capital intensive, complex and technologically sophisticated projects. It does not necessarily imply less competition except when specialist skills are in very short supply. A commitment to collaborate and provide a high quality team for the duration of the project must be a requirement of the competitive process with contract and procurement strategies to achieve this.”

The NEI has identified some specific training areas for individuals involved in the procurement process [52, pp. D-1/2]. These include contract administration, contract
management, purchasing, procurement engineering, inspection, parts planning, expediting; material receipt, warehousing, inventory analysis, and investment recovery.

While commercial terms typically place the onus to meet legal requirements on the contractor, it is also important that the owner contract administrator clearly understand applicable legal and industry code requirements related to the work. This knowledge makes it easier to spot problems before they become embedded into the work and cause significant delays and rework.

As will be discussed in section 6.4, specialized training within the procurement and contracts organizations is necessary for computer and digital system purchases to address cyber-security related issues.

Individuals involved in inspection and auditing activities are key to procurement quality. Within a given jurisdiction, multiple NPP designs may be present, and with global supply chains several different national standards may be employed for manufacturing or testing. Inspectors must be fully familiar with equipment and standards being applied, fabrication and manufacturing processes, applicable technical, commercial and other requirements, and quality surveillance practices. Training or experience may be required on such items as nuclear safety culture, quality assurance, industrial safety, mechanical machining and assembly, metal materials and testing, quality inspection of castings and forgings, welding and NDT, heat treatment and surface treatment inspection, testing and inspection of electrical equipment, and on identification and addressing of counterfeit, fraudulent or sub-standard items.

The IAEA has published a number of documents related to NPP training, and advocates that operating organizations adopt a systematic approach to training as described in [116].

5.9 RECALL OF MATERIAL BY SUPPLIERS

Recalls are request to return to a supplier a batch or an entire production run of a product, usually due to the discovery of safety issues or a product defect. For NPPs the main issue of concern is how to quickly identify where in the power plant the material or item has been installed, and to assess the urgency of the need to replace the material and the safety implications of operating with the material installed.

The ease with which this is accomplished is highly dependent upon the level of detail maintained within plant records systems as to the locations of items installed. If plants assign unique tracking numbers to parts upon receipt and update enterprise systems with their locations at all times (e.g. warehouse, laydown area, or installed in the plant at a particular equipment location) then this process can be quite simple. Where plants do not have such systems in place the process can be both time and labour intensive as manuals records searches and physical plant inspections may be required to locate the substandard material.

5.10 MANAGING THE TRANSITION FROM CONSTRUCTION TO OPERATION FOR PROCUREMENT ACTIVITIES

For turn-key or EPC projects there may be little operating organization purchasing activities going on during construction. Thus the turnover period from construction to commissioning and operations may be when the operating organization purchasing organization begins functioning. Prior to this phase the operating organization will need to establish it processes and procedures, train staff, set up warehousing and delivery methods, qualify suppliers, and ensure its materials and procurement databases are ready to support plant operation. Working with the NPP vendor prior to this phase can help expedite performance of these steps.

A careful review of data required to support future procurement is recommended as part of system and area turnovers (see Section 4.2 of [117]) for new NPP projects. Appendix I
describes specific data needs for procurement (master equipment list, bills materials, spare parts lists etc.), which have substantial linkages to plant design configuration data. For new plant engineering design information, such as design bases, calculations, and specifications, is typically electronically linked to 3-D models to ensure consistency with design requirements.

Such data sources provide easy access to design requirements throughout the plant life cycle. Depending on contractual arrangements the NPP vendor or the operating organization may be responsible to input the required data into the operating organization’s enterprise computer systems. With tens or hundreds of thousands of plant components, this can take substantial time and effort. The process should thus begin well before the expected time of turnover, preferably as a formal part of the plant’s design process.

At the time of turnover it should be confirmed that the NPP vendor has fully provided the required data, and that enterprise systems supporting design configuration and procurement data are fully populated and able to support procurement, engineering, operations, and maintenance activities post-turnover.

Material ordered as part of NPP construction as spares will need to be transferred to the operating organization and placed in its secure warehouse. A methodology for this will need to be developed in advance, which may be somewhat like the inter-utility transfer process described in Section 3.10.8.

Warrantees or guarantees obtained from suppliers by the NPP vendor regarding specific equipment performance will need to be transferred to the operating organization at this stage. This may not be necessary if the NPP vendor has provided the operating organization with an overall guarantee for plant operation for a period of time that exceeds all warrantee periods, or will be operating the plant itself during such period.

Following plant turnover procurement volumes and their character both will change when compared to the construction period. Overall volume of purchased items goes down, the number of source surveillance staff goes down, and purchases tend to change from being for entire large assemblies or systems to smaller piece parts that support maintenance (item average cost goes down). Resources for development and revision of standard purchasing specifications or requirements tend to be reduced. Since the average component tends to be smaller and of lower value and complexity, there tends to be more reliance on supplier management systems to ensure quality than on purchaser source surveillance activities. Operating organizations need to be aware of such changes and put measures in place to maximize the transfer of knowledge from the NPP vendor and its procurement organization to that of the operating organization. Section 8.2 discusses some proactive measures that operating organizations can take during the contract negotiation stage to help in this area.

5.11 MEASUREMENT, ASSESSMENT, AND PROCESS IMPROVEMENT

Measurement, assessment, and process improvement are an important part of any management system. IAEA safety requirements document GS-R3 [6] section 6 indicates that nuclear facilities should have processes in place for monitoring, self-assessment, independent assessment, management system review, and methods to address non-conformances via corrective and preventive actions.

Section 5 of GS-R3 [6] furthermore has some specific requirements around purchasing. Paragraph 5.23 requires that supplier performance be evaluated, and para. 5.25 specifies that requirements for reporting and resolution of non-conformances be included in procurement documents.

The above requirements are further expanded upon in IAEA safety requirements document covering management systems for nuclear installations GS-G-3.5 [8]. Section 6 describes typical attributes of a good system. These include regular management oversight reviews, self-assessments by senior managers, managers, and individuals; independent
assessments by peers and technical experts, assessments of safety culture, reviews of the management system to look for areas of improvement, and reviews of non-conformances, and corrective and preventative actions.

A difficulty with the procurement function at NPPs is that many critical functions are dependent upon individuals and organizations outside of the NPP or its owner’s organization. Owners need to establish processes to monitor and assess performance of these entities (as well as internal organizations), encourage development of a strong nuclear safety culture within them, and take corrective action when needed. The large numbers of organizations and people involved can make this problematic, however each operating organization needs to develop a system to do so adapted to its own particular circumstances.

The audit function as described in section 3.3.3 is one input into this process. Auditing can provide assurance that vendors and suppliers are following prescribed processes and agreed to management system steps as part of the process of supplying components or services.

The NEI has developed a number of process diagnostic indicators [52, p. App. E] for assessing materials and services processes. Some of these include demand counts (e.g. numbers of requests), differences in request lead time (need date minus identification date), demand quality (completeness of requests), new stock code generation rates, demand filled by inventory versus not, critical spares availability, on time parts availability, PE workloads, supplier performance, completion of in storage maintenance activities, percent items returned to stores, total material spends, total inventory values, stockouts, and others. IAEA safety guide GS-G-3.5 [8] para. 5.63 recommends establishment of similar metrics surrounding the work planning process, including tracking the status of work requests on hold for spare parts.

EPRI has developed a model for measuring effectiveness of identifying and meeting required material demands (Fig. 18) based on part availability versus need. A similar model is available for contingency parts. NPPs are encouraged to develop ways to measure outcomes of each quadrant as a method of trending the effectiveness of identifying and meeting parts needs. Special programmes such as obsolescence management (section 5.3) should develop their own metrics.

\[
\text{FIG. 18. Model for measuring effectiveness of identifying and meeting required material demands [54].}
\]
Some utilities have found it useful or necessary to take proactive steps in managing their supplier relationships and performance more closely. One method would be to ensure NPP component failures or other non-conformances are tied to supplier identifying information when such information is entered into an NPP’s corrective action system. In such a way trends over a period of time or across units or even multiple sites can be detected more readily and acted upon. Without supplier identifying information being embedded in the corrective action system, it can be difficult to determine what organization or company that corrective actions should be focused upon. One may be aware that an NPP is having issues with “valves”, but not knowledgeable as to whether one has a generic issue with multiple suppliers, or with a particular valve supplier.

Such data and trends focused on individual suppliers can be effective tools when reviewing actual performance and NPP plan consequences with suppliers.

Key suppliers can be invited to take part in regular performance meetings, where individual performance metrics, issues, and corrective actions can be discussed. The suppliers can be invited to present lessons learned from their own corrective action programmes. This can be particular useful for regular service providers, as will be discussed later in section 4.

Examples of metrics packages?

- Supplier and Procurement Process Metrics
- Self-Assessment and Peer Evaluation
- Lessons Learned and Operating Experience Sharing
6 PROCUREMENT OF SOFTWARE AND ITEMS CONTAINING SOFTWARE

6.1 BACKGROUND

While the general principles for procurement are the same, special attention is required when specifying and procuring software and equipment with embedded software or firmware. This is particularly relevant for instrumentation, control and monitoring equipment with the advances in electronics and computer technology. Inadequate control of software can compromise plant safety or operation, disrupt operation or maintenance, allow unauthorized access to locations or documentation, provide information that could be used for attacks, or simply add extra administrative burden.

Both nuclear safety and security concerns are important. Nuclear safety concerns are relevant to the performance of nuclear safety functions during normal operation or design basis events. Nuclear security concerns ensure confidentiality, integrity, and availability of required data within station computer systems.

6.2 NUCLEAR SAFETY AND SOFTWARE CHALLENGES

A difficulty with specifying and procuring instrumentation, control and monitoring equipment today is the proliferation of embedded software in components that previously did not require or utilize it. In some cases individuals specifying and purchasing instrumentation may not be aware that a supplier’s product contains embedded software, and product manuals may not clearly indicate that fact. Additionally procurement of instrumentation and control devices without embedded software is becoming increasingly difficult, as many manufacturers stop production of older analogue devices. Devices may have software/firmware used for actual control functions or for less intrusive diagnostic functions.

Whereas hardware components can be tested using conventional methods such as factory testing, inspection and testing, check and test, and commissioning; software can only be tested by conformance to defined performance criteria. This requires careful analysis and assessment to provide reasonable assurance that items will perform intended functions.

The IAEA safety guide for computer based systems [118] indicates that “software faults may result from either bad or unclear specification of requirements (which gives rise to errors in the logical design or implementation) or errors introduced during the implementation phase or maintenance phase” (para. 2.1 from [118]). This indicates the clear need for proper transmission of software requirements to the supplier during the procurement phase.

The challenge with equipment with software is that verification of physical attributes is very difficult and in some cases not possible. For example access to source code may not be unavailable, making its direct review impossible. Similarly, software version changes can have significant impacts on item operation and failure modes, neither of which can be observed by visually inspecting the item. Such changes can be introduced unexpectedly by vendors shipping digital components with “updated” firmware when replacement parts are ordered. As a result, increased emphasis on testing of software under all representative conditions, and careful control of software changes is required.

Components containing software require additional assurance that the equipment will respond in the desired manner. As a result, in addition to typical factory testing, installation testing, and commissioning, a software qualification process is typically invoked. This qualification provides additional assurance that equipment with embedded software or firmware will perform the intended function for NPP operations.

Software qualification processes are defined in various standards and guides such as ASME NQA-1 Subpart 2.7 [119], CSA N290.14 [120], COG-95-179-STD [121], RCC-E Section C 5200 [122] and IEC 61226 [123], 60880 [124], and 62138 [125].
Software qualification involves two discrete steps:

1. Software categorization / classification based on system and equipment operation:
   - Identify software of firmware in equipment;
   - Establish software function – safety related, control, monitoring, annunciation;
   - Assess impact of software failure;
   This step corresponds to the IAEA software safety classification described in para. 3.7 of [118].

2. Software qualification commensurate with the risk based categorization (item 1 above). This includes:
   - Configuration scope;
   - Required documentation;
   - Testing protocols and acceptance criteria;
   - Version and revisions.
   This step corresponds to the IAEA software safety verification and validation steps described in paras 4.12 to 4.18 of [118] and in [126].

6.3 CGD OF DIGITAL TECHNOLOGY

Upgrades to nuclear instrumentation and control equipment increasingly are required at older NPPs. Original designs typically used analogue technology, while preferred replacement equipment often applies digital technology due to its ready availability and potential for performance and reliability improvements. In some cases analogue equipment may no longer be available. Mature commercial digital products may be able to be used, however to incorporate them operating organizations need to perform special tests, do vendor assessments, and employ other methods to confirm that the commercial item has adequate quality and will perform intended safety functions.

CGD of digital technology follows the same general process as that for non-digital technology (see section 5.1.4). Applying digital expertise in evaluating equipment is critical; and procurement personnel may not have this expertise, particularly for early digital upgrades at an NPP. Items such as failure or startup modes for new digital equipment can be completely different than those of their analogue equivalents. For example on restoration of power following an interruption an analogue controller might return to its previous control setpoint, while a digital controller may reset to a (often different) predefined factory setpoint. The presence of a battery in the digital controller to ride out power disturbances can also affect response. Software errors can remain dormant, and equipment may not be fully verifiable by testing. Designers or outside sources often need to be utilized and work closely with procurement staff to address such subtle or unexpected differences and achieve successful replacements.

EPRI has produced a guide for CGD of digital equipment in SR applications TR-106439 [127]. The guide refers to other EPRI CGD documents and provides additional guidance and examples for digital equipment in small-scope and larger changes. A supplementary report to TR-106439 [128] provides additional guidance for high-integrity applications. EPRI has also published information related to lessons learned with qualification of commercial grade digital devices [129], which identified electro-magnetic testing as an area that required particular focus, often with the need to add additional filters to commercially procured equipment.
6.4 COMPUTER-SECURITY

Protecting computer systems and the information they contain from sabotage or malicious use is called computer or cyber-security. An IAEA guidance document for computer security [130] details some of the special considerations respect to such protection.

Nuclear facilities use digital and analogue systems to monitor and operate equipment, and to obtain and store vital information. Analogue systems do their job by following “hard-wired” instructions, while digital computer-based systems follow instructions (software) stored in memory. In addition, many plant computer systems are now linked to digital networks that extend across the plant, performing safety, security, accident mitigation, and emergency preparedness functions. These linkages now often extend outside of the NPP.

In the IT industry, the attack surface of a system is considered the sum of different points, also known as attack vectors – where an unauthorized user, the attacker, can try to enter data, extract data, or take control. Adding more internet-based devices can make the attack surface larger for predators. Cyber-attacks on commercial industrial production environments have increased dramatically, including unintentional breaches, industrial espionage, or state-sponsored attacks. These attacks can result in unscheduled downtime, interruptions in equipment availability, and production disruptions [131].

IAEA safety guides and security recommendations point to the need for computer security. Table 14 lists some applicable IAEA document clauses.

An effective way to reduce computer-security risks is to reduce the degree to which other systems can affect NPP computer assets and to minimize their potential effect on other systems. This can be done by technology choices or by reducing connectedness of assets as much as possible.

<table>
<thead>
<tr>
<th>IAEA Document</th>
<th>Clause</th>
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</thead>
<tbody>
<tr>
<td>IAEA Safety Guide No. NS-G-1.1 Software for Computer Based Systems Important to Safety in Nuclear Power Plants [118] para. 3.15</td>
<td>It should be demonstrated that measures have been taken to protect the computer based system throughout its entire lifetime against physical attack, intentional and non-intentional intrusion, fraud, viruses and so on. Safety systems should not be connected to external networks when justification cannot be made that it is safe to do so.</td>
</tr>
<tr>
<td>IAEA Nuclear Security Series No. 13, Nuclear Security Recommendations on Physical Protection of Nuclear Materials and Nuclear Facilities (INFCIRC/225/Revision 5) [132] para. 4.10</td>
<td>Computer based systems used for physical protection, nuclear safety, and nuclear material accountancy and control should be protected against compromise (e.g. cyber-attack, manipulation or falsification) consistent with the threat assessment or design basis threat.</td>
</tr>
<tr>
<td>IAEA Specific Safety Requirements No. SSR-2/1 Safety of Nuclear Power Plants : Design [133] requirement # 39</td>
<td>Unauthorized access to, or interference with, items important to safety, including computer hardware and software, shall be prevented.</td>
</tr>
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</table>

Computer security standards have been produced to counter threats to business and process control networks. Operating organizations have established computer security programmes to ensure compliance with various international security standards, some of which are listed in Table 15. Commercial software vendors have produced tools to assist companies to ensure computer-security requirements are met (e.g. data gathering, tabletop reviews, walk-downs, controls assessment, attack vector analysis, records management, external threat management, etc.).

Of particular note to the procurement function is the importance of including computer security related clauses into procurement requirements prior to transmitting such requirements to vendors. Standard procurement clauses for this topic have been found effective in ensuring
correct and complete information is provided to vendors. Table 16 identifies typical topic areas for standard clauses that could be developed at NPPs to address computer security related procurement. Some specific language is available in Ref. [134].

EPRI has been developing a methodology [135] for procuring digital instrumentation and control (I&C) systems, which are classified as critical assets, with necessary computer security controls. Steps are shown below in Table 17, and it should be noted that a substantial number of these steps need to be taken prior to finalizing purchase of such an asset. Specific examples of use of the methodology have been published for single loop controllers [136], feed pump turbine speed control [137], and digital feedwater control [138]. A separate document [139] has been published for the power delivery and utilization (non-generation) sector.

Within this EPRI methodology the PE specialist within the contracts or procurement department has certain key required knowledge and responsibilities. These include:

- Experience with digital I&C systems and component procurement;
- Understanding and ability to apply procurement requirements in accordance with existing policies and procedures;
- Access to and familiarity with facility cyber security strategy;
- Working with cyber security expert, I&C engineer, and other subject matter experts to evaluate and analyze supplier responses and procurement options.

<table>
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<tr>
<th>Table 15. Selected Computer Safety and Security Documents and Standards.</th>
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<tbody>
<tr>
<td><strong>Country/Organization</strong></td>
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<tr>
<td>Canada (Canadian Standards Association)</td>
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<td>Country/Organization</td>
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<td>---------------------------------------------</td>
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<tr>
<td>International Society of Automation (ISA)</td>
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<td>North American Electric Reliability Corporation (NERC),</td>
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<td>United States of America (IEEE)</td>
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<td>United States of America (Industrial Society for Automation (ISA))</td>
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<td>United States of America (Nuclear Energy Institute NEI)</td>
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<td>United States of America (Nuclear Energy Institute NEI)</td>
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### United States of America (USNRC)

**10 CFR 73.54 “Protection of Digital Computer and Communications Systems and Networks”**

Requires licensees to submit a cyber-security plan and an implementation timeline for NRC approval. Plan must show how facility identified (or would identify) critical digital assets and describe its protective strategy, among other requirements.

**RG 5.71, “Cyber Security Programs for Nuclear Facilities” [150]**

Provides approach that USNRC staff deems acceptable for complying with regulations regarding protection of digital computers, communications systems, and networks from a cyber-attack as defined by 10 CFR 73.1. Includes general requirements, elements of and how to maintain a cyber-security plan.

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**TABLE 16. TYPICAL TOPICS FOR COMPUTER SECURITY RELATED STANDARD PROCUREMENT CLAUSES.**

<table>
<thead>
<tr>
<th>Standard clause topic</th>
<th>Explanation</th>
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<tbody>
<tr>
<td>Access ports</td>
<td>Ensures only ports or services required for functionality (operation or monitoring) are enabled, and those not required are disabled (e.g. lockable drive bays, physically blocking USB or RJ45 ports, locked application screens with passwords, disabling non-essential operating system services).</td>
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<tr>
<td>Malicious software prevention</td>
<td>Anti-virus or malware detection software should not impact real time process control software used in an NPP (due to need for deterministic behaviour of the software). Vendors should apply verification and validation activities to any incorporated anti-virus or malware features to the same level as the software and systems being protected.</td>
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<tr>
<td>Security management</td>
<td>Vendors should do security reviews of all issued software, provide guidance regarding the removal of unneeded software services and components, and provide guidance on alternative methods of mitigation.</td>
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<tr>
<td>Systems as access points</td>
<td>Ensure systems requiring access to the external environment (i.e. beyond an NPPs electronic security perimeter) have technical controls in place to control access. Examples might include unidirectional communications, having access denied by default, user ID and password control via authenticated work stations, continual logging of access, intrusion detection systems, banner messages containing warnings regarding such things as software usage (may be used by authorized users and company business use only), systems monitoring (no expectation of privacy information including data transfer or storage, electronic mail and internet usage), and warnings against action to be taken for unauthorized use (e.g. disciplinary action, criminal prosecution, or lawsuit).</td>
</tr>
<tr>
<td>Physical access requirements</td>
<td>Describe graded requirements for physical protection of systems when not to be installed in an already secure area (e.g. to be installed outside an NPP’s protected area).</td>
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<tr>
<td>Account management</td>
<td>Ensure controls for enforcement of access authentication and accountability of user activity, minimizing risk of unauthorized system access, ensure access permissions are consistent with “need to know” concept, generating logs to provide audit trails of individual user access activity, do not include generic administrator or shared accounts, ensure regular password changes.</td>
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<tr>
<td><strong>Procurement and cyber security programme</strong></td>
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<td>---------------------------------------------</td>
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<tr>
<td>Know organization and facility cyber security strategy</td>
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<td>Incorporate cyber security into existing processes</td>
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<tr>
<td>Identify roles and responsibilities</td>
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<th><strong>Specification development</strong></th>
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<tbody>
<tr>
<td>Determine type of purchase</td>
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<tr>
<td>Determine use case, data flow, and access points</td>
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<tr>
<td>Determine security controls required for use case</td>
</tr>
<tr>
<td>Establish owner/operator and supplier responsibilities</td>
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<tr>
<td>Develop system/component specification based on security controls determined to be supplier’s responsibility</td>
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<table>
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<tr>
<th><strong>Development of general cyber security specifications</strong></th>
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<tbody>
<tr>
<td>Confirm use case and data flow</td>
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<tr>
<td>Map to required security controls</td>
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<tr>
<td>Identify potential conflicts</td>
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<tr>
<td>Identify negotiable or optional security controls or configurations</td>
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<tr>
<td>Identify possible design modifications</td>
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<tr>
<td>Identify unused alternate features, functions, and configurations</td>
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<tr>
<td>Identify product or development environment certifications.</td>
</tr>
<tr>
<td>Describe supplier’s secure development environment</td>
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<tr>
<td>Consider additional supply chain considerations</td>
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<tr>
<td>Supply field engineering services.</td>
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<tr>
<th><strong>Evaluation and incorporation with procurement procedures</strong></th>
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<tr>
<td>Evaluate responses and determine gaps</td>
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<tr>
<td>Identify potential conflicts</td>
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<td>Identify compensating controls</td>
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<tr>
<td>Analyze risks and cost/benefit</td>
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<tr>
<td>Apply cyber security in selecting supplier</td>
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<tr>
<td>Perform oversight of cyber security requirements</td>
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<td>Receive component or system</td>
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<td>Maintain configuration control</td>
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7 COUNTERFEIT, FRAUDULENT, AND SUB-STANDARD ITEMS

7.1 BACKGROUND AND OPERATING EXPERIENCE

Supply chain and procurement processes have a role in detecting and preventing the entry of counterfeit, fraudulent, and substandard items (CFSIs) into nuclear facilities. Items can be classified according to the categories shown in Fig 19. **Counterfeit** items are intentionally manufactured or altered to imitate original products in order to pass themselves off as genuine. **Fraudulent** items are misrepresented with intent to deceive, including items with incorrect identification of false certifications. They may also include items sold by entities that have acquired the legal right to manufacture a specified quantity of an item but produce a larger quantity than authorized and sell the excess as legitimate inventory. **Sub-standard** or **non-conforming** items are simply those that do not meet intended requirements or function, and may be provided by legitimate suppliers without intent to deceive. Non-conformances can emerge at any stage of the supply chain, including design, manufacturing, storage, and transportation. **Suspect** items are those about which there is an indication by visual inspection, testing, or other preliminary information that they may not conform to the accepted standards, specifications and/or technical requirements and there is a suspicion that the item may be counterfeit, fraudulent, or non-conforming. Additional information or investigation is needed to determine whether the suspect item is acceptable, nonconforming, counterfeit or fraudulent.

![FIG. 19. CFSI classification.](image)

CFSIs are covered in some detail in IAEA TECDOC-1169 [151] which is currently under revision. CFSIs of concern to NPPs are those that look nearly identical to original items, but contain sub-standard, poorly assembled, or aged components or material. They can be difficult to detect by standard industrial quality assurance inspections but can cause catastrophic failures or loss of SR functional capability when needed. Generally counterfeiters go after recognized, high-demand items to maximize their profit, which in some way has insulated older nuclear fleets from major issues. In the construction industry steel items (plate, pipe, fasteners and valves) are the most counterfeited, followed by electrical devices such as circuit breakers, and then rotating equipment [152, p. 27] Some photos of documented counterfeited articles are shown in Figs 20, 21, 22 and 23.
FIG. 20. Counterfeit (left) and legitimate breaker (right) supplied to hospital in Montréal (courtesy CSA Group Inc.) [153]

FIG. 21. Flanges received as “new” at Savannah River - note clamp marks, different rivet sizes clamp marks, different rivet sizes [154].

FIG. 22. Suspected counterfeit capacitors intercepted due to awareness training (courtesy EPRI [155]).
The US Department of Commerce reports that there was a 140% increase in counterfeit incidents amongst suppliers of industrial parts to the US Department of Defense, from 2006 through 2009 [156, p. 84]. The value of counterfeit goods seized by the RCMP in Canada increased by 500 per cent in less than a decade, according to 2012 intellectual property crime statistics [157]. Governments in many jurisdictions have been active in the area, with one example being an anti-counterfeiting trade agreement negotiated between Australia, Canada, EU, Japan, Korea, Mexico, Morocco, New Zealand, Singapore, Switzerland and USA [158]. EPRI has documented cases of recent counterfeiting in the nuclear and other industries [159], some of which have resulted in deaths. Although large increases in confirmed counterfeit instances have not been evidenced in the commercial nuclear power industry, general industry and nuclear power share many of the same types of components, and significant increases are viewed with concern and suspicion. Certain utilities have created awareness and training programmes for supply chain and other personnel (on early detection and what to look for) on the subject of counterfeit items.

Electronic parts are increasingly subject to counterfeiting. Global trade in recycled electronics parts is enormous and growing rapidly, driven by a confluence of cost pressures, increasingly complex supply chains, and huge growth in electronic waste sent for disposal around the world. It is estimated that 80 to 90% of counterfeit parts in circulation are recycled. The remainder includes parts that are made in authorized production runs but fail testing and are sold anyway instead of being destroyed, excess inventory intended for scrap that isn’t disposed of properly, and some parts that are simply phony and don’t work at all [160]. Industries such as nuclear and defence are particularly vulnerable to recycled parts due to the long service lives of installed equipment (when compared to for example the consumer electronics industry), and their need to address obsolescence of parts that may no longer be in production.
The harvesting process by recyclers can heat circuit boards to high temperatures (sometimes up to 400 °C) to melt solder that attaches items to the boards, with little concern for how components will later be used. They may then bang the boards repeatedly against a hard object to dislodge the parts, which they clean and sort by size, package style, number of pins, part number, and manufacturer name [160].

Electronics counterfeits, hidden within products and systems, are not easy to detect. Receipt inspectors can scrutinize packages for signs that pins have been straightened or indications that labels have been sanded or repainted. Advanced detection techniques such as X-ray, scanning electron, or acoustic imaging are increasingly becoming available from specialized companies to perform more detailed analyses, or look inside components for such things as improper placement of a chip within its package. Electrical behaviour can also be evaluated, with statistical analysis of signal path delays and other attributes being a method of counterfeit detection.

Some examples of electronic counterfeits are shown in Fig. 24.

![Fig. 24. Electronic counterfeit examples (left: date code changes, centre: tampering detected via acoustic microscope, right: blacktopping detected by heated solvent test) (courtesy SMT Corp.)](image)

The OECD-NEA has issued a report on NPP operating experience related to CFSIs [156]. Table 18 below documents a number of these and other issues that have become public in the nuclear industry (those related specifically for the CGD process Table 12 are not repeated). Table 19 lists additional CSFI incidents reported in IAEA TECDOC-1169 in 2000 and some lessons learned [151]. It should be noted that reporting mechanisms for such issues have not been evenly nor well developed in general throughout the industry, and few national regulators have specific requirements as of yet in place to address CFSIs.
### TABLE 18. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT AND FRAUDULENT ITEMS IN THE NUCLEAR INDUSTRY.

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<tr>
<th>Country/Source</th>
<th>Document</th>
<th>Issue</th>
<th>Lessons Learned</th>
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<tr>
<td>Canada</td>
<td>REGDOC-3.1.1 Reporting Requirements for Nuclear Power Plants [161] (supersedes S-99)</td>
<td>Licensee shall report on the discovery of counterfeit, fraudulent, or suspect items during the conduct of licensed activities.</td>
<td>All discoveries to be reported to regulator (not just those installed in plant).</td>
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<tr>
<td>Finland</td>
<td>Requirements in STUK’s regulation (YVL Guides) to prevent and respond to the use of CSFI</td>
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<tr>
<td>IAEA</td>
<td>IAEA-TECDOC-1169 [151]</td>
<td>Provides examples of known CSFIs for specific types of components and lessons learned following their identification as of the year 2000. OPEX provided for fasteners, refurbished CBs, metal struts and fittings, steels, pump shafts, throttle valves and piping, rubber gasket, swing type check valves, seal injection filters, reactor vessel guide studs, reactor coolant pump seal housing bolts, chemical waste drain tanks, flange bolts of tank, electrical and instrumentation and control cables – fire retardant, transformers, electronic cards in logic loops, liquid relief valves, identification and markings.</td>
<td>See Table 19.</td>
</tr>
<tr>
<td>Organization for Economic Co-operation and Development – Nuclear Energy Agency (OECD-NEA)</td>
<td>CNRA regulatory guidance booklet on the Regulator’s Role in Assessing the Licensee’s Oversight of Vendor and Other Contracted Services (NEA/CNRA/R(2011)4). [162]</td>
<td>Booklet aimed at all types of contracted services; however, prevention of CSFI and other sub-standard items is part of this overarching topic.</td>
<td>As contracted services change and licensees modify their oversight and procurement practices, regulators must also continually adapt to maintain effectiveness in assessment of licensees’ contracting practices in an increasingly international supply market.</td>
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See Table 19.
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<th>Country/Source</th>
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<tr>
<td>Organization for Economic Co-operation and Development – Nuclear Energy Agency (OECD-NEA)</td>
<td>Regulatory oversight of Non-conforming, Counterfeit, Fraudulent and Suspect Items (NCFSI) [163]</td>
<td>Provides insights that should be useful to regulators and others in the nuclear safety community for addressing the issue of CFSI within the nuclear industry’s supply chain.</td>
<td>Each SC tier relies on preceding suppliers to verify and document item quality before it is passed along. Each tier in-turn performs a receipt inspection to assure the item meets their technical and quality requirements. Accompanying documentation plays a vital role in these decisions, but item quality can only be achieved through verification. The more the validity and capabilities of the supply chain is verified, the more trust can be given to documentation. When any of these processes are violated, as is the case with counterfeit or fraudulent items, that developed trust that has become inherent to the programme is lost, and the risk the item will not perform its intended functions, either in-service or during a postulated event is also lost. Unquestionably, a distinction exists between poor performance from a conscientious supplier and a wilful intent to deceive the purchaser from an unscrupulous one. It is precisely for this reason that the non-conformance process must take two equally distinct resolution paths. Regulators were recommended to consider the impact of NCFSIs on their current regulations and revise them if necessary, and also to consider methods for inspecting NCFSI controls.</td>
</tr>
<tr>
<td>South Korea (KHNP)</td>
<td>Managing the supply chain : Challenges and Overcoming in Korean nuclear industry [164]</td>
<td>In November 2012 KHNP confirmed some suppliers had supplied items by falsifying foreign dedication entities’ quality certificates for CGIs, such as fuses, relays, diodes, etc. Comprehensive inspections expanded to all Q-class QVD (Quality Verification Document) items supplied to KHNP over past 10 years for Korean NPPs while investigating certificates for CGD. Permission given for restart in January 2013.</td>
<td>Don’t be overconfident and complacent if experiencing excellent NPP performance for a long time period. Be transparent and open in quality and procurement activities (nuclear industry is easy to be closed due to the nature). Encourage anonymous reporting (counterfeits and scandals was revealed by an anonymous tip).</td>
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<td>South Korea (KHNP)</td>
<td>Managing the supply chain : Challenges and Overcoming in Korean nuclear industry [164]</td>
<td>In May 2013 falsification of equipment qualification (EQ) certificates of control cables supplied to Shin-Kori #1, 2, 3, 4 and Shin-Wolsong #1, 2 was uncovered. SR function in severe environments such as LOCA, fire, etc. was called into question. KHNP immediately shut down affected NPPs to replace related parts. Regulator investigation was expanded to all NPP EQ certificates. Component with falsified certificates were replaced or retested. NSSC permit restart of the plants in January 2014. Six nuclear engineers and equipment suppliers were handed prison sentences. Don’t be overconfident and complacent if experiencing excellent NPP performance for a long time period. Be transparent and open in quality and procurement activities (nuclear industry is easy to be closed due to the nature). Encourage anonymous reporting (counterfeits and scandals was revealed by an anonymous tip).</td>
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<tr>
<td>United Kingdom</td>
<td>Nuclear Safety Technical Assessment Guide NS-TAST-GD-077 Revision 2 [38]</td>
<td>Requires purchasers to have processes in place and support of suppliers to investigate examples found of non-conforming suspected fraudulent items.</td>
<td>Example of national regulations related to CFSIs.</td>
</tr>
<tr>
<td>United States of America (Construction Industry Institute)</td>
<td>Product Integrity Concerns in Low-Cost Sourcing Countries: Counterfeiting in the Construction Industry [152].</td>
<td>Consensus of 187 industry and government leaders from eight countries interviewed, was that magnitude of counterfeiting problem has grown from “big” to “very big.”</td>
<td>CII identified the following lessons: • Maintain integrity of supply chain • Adopt a zero tolerance policy; • Train/educate procurement, quality management, and field personnel on counterfeit good dangers. • Train/educate customs officials and other law enforcement agency personnel; • Establish more stringent supply chain activities • Use effective positive materials identification (PMI) processes; • Put more emphasis on documenting the quality and integrity of the sourcing of raw materials and commodity items.</td>
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<tr>
<td>United States of America (EPRI)</td>
<td>Plant Support Engineering: Counterfeit, Fraudulent, and Substandard Items [159, pp. 5-6]</td>
<td>[2008] Discovery of counterfeit integrated circuits and electrolytic capacitors at Millstone NPP. ICs discovered when portal monitor could not be calibrated. Capacitors discovered through dimensional checks and subsequent investigation. Electronic counterfeiting becoming an issue.</td>
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<tr>
<td>United States of America (EPRI)</td>
<td>Plant Support Engineering: Counterfeit, Fraudulent, and Substandard Items [159, pp. 5-1]</td>
<td>[2009] NPP instrument manufacturer questioned validity of several phototransistor optocouplers used in timers for several NPP customers. Date code on device was after OEM had stopped production of the item.</td>
<td>Electronic counterfeiting becoming an issue.</td>
</tr>
<tr>
<td>United States of America (NUMARC)</td>
<td>NUMARC 90-03 Nuclear Procurement Program Improvements [165]</td>
<td>Recommended putting more emphasis on technical verification product quality than on relying on supplier documentation.</td>
<td>Recommendations to:</td>
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<td>• Increasing engineering involvement;</td>
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<td>• Increasing awareness of CSFIs;</td>
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<td>• Share information via industry OPEX forums;</td>
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<td>• Procure items from OEMs or authorized distributors whenever possible;</td>
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<td>• Establish performance via traceability with OEM or authorized distributor purchasing is not possible;</td>
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<td>• Establish acceptance criteria for items at start of procurement process.</td>
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<td>United States of America (USNRC)</td>
<td>ABB Capacitors [Oct. 2008] – Identified during CGD activities. Capacitors were procured from a commercial distributor. No actual failures or damage occurred. [156, p. 82]</td>
<td>Apparently fraudulent products sold by Ray Miller, Inc. Unauthorized substitutions or modifications were made to a variety of materials (e.g. welded pipe substituted for seamless, standard grades of stainless steel substituted for low carbon or in some cases the reverse, foreign-made substituted for domestic-made etc.).</td>
<td>Existence of companies and individuals willing to counterfeit.</td>
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<tr>
<td>United States of America (USNRC)</td>
<td>IN 83-01 [166] and Bulletin 83-07 [167] (including supplements)</td>
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<td>United States of America (USNRC)</td>
<td>Bulletin 87-02 [168] (with supplements)</td>
<td>Fastener testing to determine conformance with applicable material specifications Over several years, counterfeit fasteners have been identified throughout various industries, associations, and US federal agencies. Fasteners had been mismarked to indicate a material content and composition different from actual bolt content. Bulletin requested NPPs review their receipt inspection requirements and internal controls for fasteners and 2) independently determine, through testing, whether fasteners (studs, bolts, cap screws and nuts) in stores facilities meet required mechanical and chemical specification requirements.</td>
<td>Counterfeiting of fasteners had reached sufficient state that country wide review of situation was warranted.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>Bulletin 88-05 [169] (with supplements)</td>
<td>Non-conforming material supplied by Piping Supplies Inc. at Foshum, NJ and West New Jersey manufacturing company and Williamstown, NJ. A number of test reports were apparently used to certify commercial-grade, foreign steel meets ASME requirements by using a domestic forging company’s letterhead. Bulletin required NPPs submit information regarding materials supplied by 2 companies and request actions be taken to assure materials comply with ASME Code and design specification requirements or are suitable for their intended service, or 2) replace such material.</td>
<td>Issues with refurbished molded case CBs had reached sufficient state that country wide action was warranted Refurbished CBs may not have been refurbished under controlled conditions to conform to a proven design, thus destructively testing selected breakers will not infer anything about a other refurbished CBs</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>Bulletin 88-10 [170] (with supplement 1)</td>
<td>Non-conforming molded case circuit breakers. Related to IN 88-46. Bulletin requested NPPs take actions to provide reasonable assurance that molded-case CBs, including CBs used with motor controllers, purchased for SR applications without verifiable traceability to the circuit breaker manufacturer perform their safety functions. Untraceable CBs were required to be tested or replaced (see specific details in bulletin).</td>
<td>Issues with refurbished molded case CBs had reached sufficient state that country wide action was warranted Refurbished CBs may not have been refurbished under controlled conditions to conform to a proven design, thus destructively testing selected breakers will not infer anything about a other refurbished CBs</td>
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<tr>
<td>United States of America (USNRC)</td>
<td>Cooper Busmann Fuses [156, p. 82]</td>
<td>[Oct. 2009] Identified CGD activities associated with a lot/batch of fuses. Affected fuses contained an underlying defect consisting of a missing internal fuse link.</td>
<td>Importance of CGD activities.</td>
</tr>
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<td>United States of America (USNRC)</td>
<td>DeKalb Y-Globe Valve [156, p. 83] (see also [159, pp. 5-6])</td>
<td>DeKalb Y-Globe Valve, ½ NPS Class 1500 [Oct. 2006] – Discovered in NPP warehouse. Valve, reportedly made of stainless steel, exhibited extensive rust blooms and magnetic properties. Valve was in fact constructed of carbon steel. No additional counterfeits were detected</td>
<td>Importance of personnel training in detection of counterfeit items.</td>
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| United States of America (USNRC) | GL 89-02 [63] | Actions to improve detection of counterfeit and fraudulently marketed products. Focused on effectiveness of CGD programs. Shared NRC perspectives on ways to address concerns with dedication and counterfeit products. | Identified 3 characteristics of an effective procurement and dedication plan:  
  - Involvement of engineering in procurement and acceptance process  
  - Effective source inspection, receipt inspection, and testing programmes;  
  - Thorough engineering based programmes for testing and dedication of CGD products for suitability in SR applications |
<p>| United States of America (USNRC) | GL 89-09 [171] | ASME Section III Component Replacements. Utilities experiencing difficulties in obtaining replacements for components originally constructed to ASME Section III (companies not holding onto their nuclear certificates of authorization). Consideration may be given to procurement of replacements from an OEM to avoid an adverse impact on existing components or systems. However, it is necessary to obtain objective evidence that quality of replacement is adequate. | Decline in number of qualified nuclear suppliers is impacting NPPs. |
| United States of America (USNRC) | GL 91-05 [172] | Licensee commercial grade procurement and dedication programmes. Identifies a number of failures in CGD programmes identified during 13 inspections. In a number of cases, NPPs had failed to maintain programmes as required to assure suitability of CGIs for their SR applications. Some equipment of indeterminate quality was also found installed. GL was intended to further clarify information provided in GL 89-02. | Reduction in number of qualified nuclear-grade vendors and an increasing number of CGI replacement parts being used in SR applications was noted, thus increasing importance of CGD programmes. |
| United States of America (USNRC) | IN 83-07 [173] and Bulletin 83-06 [174] | Nonconformities with materials supplied by Tube Line Corporation. Items found identified to have been shipped from an unapproved nuclear source, not having had proper heat treatment, and not meeting ASME Code requirements for NDE. Sub-supplier had purchased material foreign stock material suppliers without appropriate QA programme and not performed required heat treatment. | Sub-supplier performance is important to nuclear quality. |</p>
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| United States of America (USNRC) | IN 84-52 (including supplement 1) | Inadequate material procurement controls on the part of licensees and vendors. NRC inspections unveiled a large number of quality-related supplier deficiencies such as:  
- Improper certification of stock materials as being fabricated and/or upgraded in accordance with ASME Code requirements.  
- Inadequate inspection of materials received.  
- Failure to ensure satisfactory performance of required mechanical testing and NDE.  
- Inadequate and/or incomplete survey and audit records.  
- Breakdown of procurement controls with respect to requirements of 10 CFR 21, Appendix B to 10 CFR 50, and ASME Code.  
Licensee deficiencies included:  
- Inadequate specification of code requirements on P0s and other documents.  
- Failure to develop and monitor an approved vendor list.  
- Inadequate inspection of materials and components when received.  
- Inadequate survey and auditing of vendor QA programs.  
- Failure to perform adequate internal audits of the procurement process.  
- Insufficient management attention to procurement activities | Attention on behalf of suppliers and purchasers is important. |
<p>| United States of America (USNRC) | IN 88-19 [175] | Questionable certification of Class 1E components supplied to Wolf creek NPP. Supplier records did not support statement on certificate of compliance that all PO requirements had been met. | Importance of review of supplier documentation provided with order. |</p>
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<tr>
<td>United States of America (USNRC)</td>
<td>IN 88-46 [176] (including supplements)</td>
<td>Licensee report of defective refurbished circuit breakers. Surplus or refurbished electrical equipment, such as circuit breakers (CBs) or CB parts was supplied to NPPs but was portrayed as new. Examples provided of some physical identifying differences noted (e.g. photocopied labels, rough, worn appearance etc.).</td>
<td>Importance of receipt inspection programmes to catch potential CFSIs.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 88-48 [177] (including supplement 1)</td>
<td>Report of defective refurbished 2” valves (leaking steam at bonnet and packing) at Diablo Canyon NPP. Valves were purchased from a local supplier. OEM reviewed and indicated valves were likely counterfeit and not refurbished.</td>
<td>Need knowledge of suppliers and source of supply.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 88-97 [178] (including supplement 1)</td>
<td>Potentially Substandard Valve Replacement Parts. Valve internals at Palisades NPP were found not to be manufactured by an authorized manufacturer (65 questionable valve internals identified). Issue was first identified by an OEM field service representative. Valve had been refurbished at an OEM-authorized facility using parts from Palisades NPP stores. Parts had been procured as non-SR from an OEM authorized sales representative. Parts were found to be dimensionally and, in some cases, metallurgically incorrect. NPP and supplier both failed to adequately verify that the parts would perform their function.</td>
<td>Substandard items can enter NPP stores. Suppliers need good control over sub-supplier activities.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 89-03 [179]</td>
<td>Possible electrical equipment problems. Inspection findings showed counterfeit, substandard, or questionable electrical equipment or components had been used in NPPs. Several electrical suppliers identified as refurbishing and selling defective equipment components to nuclear and non-nuclear industries</td>
<td>CFSI issue is not confined to nuclear. Licensees were asked to review procurement procedures and practices, especially in areas such as purchase orders, materials requirements, vendor qualifications, and receipt inspections, to ensure quality control and compliance</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 89-39 [180]</td>
<td>List of parties excluded from US federal procurement or non-procurement programs. Information provided on a database of parties (manufacturers, vendors and contractors) excluded from receiving federal contracts or assistance due a variety or practices including poorly manufactured or fraudulent/counterfeit parts being used in the nuclear industry.</td>
<td>Importance of having an up to date database of acceptable and unacceptable suppliers.</td>
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<td>United States of America (USNRC)</td>
<td>IN 89-45 [181] (with supplements)</td>
<td>Metalclad, LV power circuit breakers refurbished with sub-standard parts. Discovery of defects in metalclad, low-voltage power circuit breakers at Quad Cities NPP including missing, non-standard, and substandard parts, and improper assembly and misadjustment. Deficiencies were discovered when breakers were shipped to OEM facility for overhaul, and some devices had failed in service or testing. Items were purchased as CG, had been taken from non-OEM supplier from supposedly “new” stock, and had been maintained in the meantime by Quad Cities staff. It had not determined who was responsible for CB condition at Quad Cities or why the conditions remained undetected during maintenance activities. Other NPPs found to have defective equipment from this supplier.</td>
<td>Importance of proper control around CG material and knowledge of suppliers.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 89-56 [182] (with supplements)</td>
<td>Questionable certification of material supplied to Department of Defense Department by Nuclear Suppliers. Corporate officers for PVN and ALLOY indicted and later pleaded guilty for their roles in selling CG steel as military-grade steel which was used to build and repair U.S. Navy submarines and surface ships. Suppliers had provided steel to some NPPs, and audits revealed issues with these suppliers.</td>
<td>Existence of companies and individuals willing to counterfeit documents.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 89-59 [183] (with supplements)</td>
<td>Suppliers of Potentially Misrepresented Fasteners. Provided addressees of names of suppliers and/or manufacturers of suspected counterfeit fasteners that were identified in NRC Bulletin No. 87-02</td>
<td>See bulletin 87-02 above.</td>
</tr>
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<td>Country/Source</td>
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<tr>
<td>United States of America (USNRC)</td>
<td>IN 89-70 [184]</td>
<td>Possible Indicators of Misrepresented Vendor Products. Increased number of instances of misrepresented vendor products being supplied to the nuclear industry. General indications may be found early in the procurement process, beginning with price quotes and scheduled delivery time. Some things found present when misrepresented products were identified are: (1) vendor name – several instances of counterfeit and fraud involved vendors who were not authorized distributors for products supplied, (2) price – quoting prices significantly lower than those of competition, (3) delivery schedule – shorter delivery time than that of competition; (4) source of item – drop shipment of items noted in several cases of misrepresentation where quoted supplier subcontracted order to another company and had subcontractor ship product directly to purchaser. Quoted supplier never saw or verified quality of product which, in some cases, has been substandard. At receipt inspection labels in wrong location or appearing different, or if tags attached with screws rather than rivets is a potential indicator of a CFSI. Measurement and testing during receipt inspection is also important.</td>
<td>Provides example of areas of interest in reviewing quotations and performing receipt inspection for possible CFSIs.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 90-46 [185]</td>
<td>Criminal prosecution and conviction of wrongdoing by suppliers of molded case circuit breakers and related components. Two individuals pleaded guilty to two counts of directing their corporations to use counterfeit CB labels for companies such as GE and Square D to deceive buyers of those circuit breakers and switches, some of which were sold to NPPs.</td>
<td>Existence of companies and individuals willing to counterfeit product.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 90-57 [186] (with supplement 1)</td>
<td>Substandard refurbished Potter and Brumfield relays represented as new. Company had modified and/or refurbished 22 rotary, non-latching MDR-type Potter &amp; Brumfield (P&amp;B) relays and supplied them to Harris NPP and the US DOD for use on submarines. Company president had directed employees to make relays appear new and affix counterfeit labels. President was fined $7,500 and ordered to make restitution to the U.S. Government of $350,000. Company had to pay $30,000 ($10,000 for each count) and restitution of $2,501,000, less amount paid by the President.</td>
<td>Existence of companies and individuals willing to counterfeit product.</td>
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<td>Country/Source</td>
<td>Document</td>
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<tr>
<td>United States of America (USNRC)</td>
<td>IN 90-60 [187]</td>
<td>Availability of Failure Data in the Government-Industry Data Exchange Program. NRC provided information relative to availability of data on engineering, metrology, material problems (failure experience), and reliability/maintainability through the Government-Industry Data Exchange Program (GIDEP).</td>
<td>Databases prepared on a national, industry or international basis related to CFSIs are useful.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 91-09 [188]</td>
<td>Counterfeiting of Crane valves. Valves purchased for a chemical plant near Houston, TX were found to be counterfeited (manufactured in Taiwan and subsequently had Crane company identification welded on). Note that following investigation there was no evidence of valves from the supplier ending up in a nuclear facility, although the supplier did have some contracts within the nuclear industry.</td>
<td>Items can go through two or more distributors before reaching an end-user facility. NPPs could buy a CGI item from a distributor for the purpose of dedicating the item for SR use. Establishment and verification of procedures to trace procured equipment and material to the OEM is important to meaningful inspection and testing which may be employed in the dedication process. Inadequate verification of traceability of procured equipment may result in counterfeit or fraudulent equipment being installed.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 92-22 [189]</td>
<td>Criminal prosecution and conviction of wrongdoing by a CGI valve supplier. President of company who supplied counterfeit valves under IN 88-48 (see above) pleaded guilty on charges that the company sold counterfeit valves ultimately installed at Diablo Canyon and Vogtle NPPs, and a U.S. Marine Corps military base in Quantico, Virginia. Individual was sentenced to 3 years imprisonment, and company was ordered to pay restitution of $213,825.03 to NRC' licensees.</td>
<td>Need knowledge of suppliers and source of supply. Existence of companies and individuals willing to counterfeit product.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 92-56 [190]</td>
<td>Counterfeit valves in commercial grade supply system. Supplier purchased approximately 7500 nameplate labels from a label manufacturer, which were imprinted with several valve manufacturers’ names (including Crane, Pacific, Walworth, Powell, and Lunkenheimer). Company confirmed to have supplied 2 counterfeit CGI valves to Indian Point 2.</td>
<td>Existence of companies and individuals willing to counterfeit product.</td>
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<td>Country/Source</td>
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<tr>
<td>United States of America (USNRC)</td>
<td>IN 92-68 [191] (with supplements)</td>
<td>Potentially sub-standard slip-on, welding neck, and blind flanges. Numerous reports of flanges supplied to U.S. suppliers through several trading companies marked “China” that contain cracks, inclusions, and slugged weld repairs, and that were constructed from two pieces of material. Neither welding nor the two-piece construction would be detected during a visual inspection. Flanges all had ASTM Standard A-105 markings. One Chinese manufacturer was confirmed to have shipped more than 110 tons of flanges to the US. Instances of flanges at two US NPPs were confirmed (at Seabrook 1 had been installed in a safety system and 20 in non-SR applications; at Browns Ferry flanges were caught at the RI stage).</td>
<td>Possible for an NPP to install potentially substandard or defective equipment or material if it does not adequately verify that product can be traced to original manufacturer.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 93-43 [192]</td>
<td>Use of inappropriate lubrication oils in SR applications. Supplier affixed a wrong label on a drum of lube oil and as a result a different/wrong type of oil was used in SR equipment (18 of 33 samples taken). NPP had not sampled the oil when it was delivered to verify that it had received the oil it had ordered.</td>
<td>Importance of receipt inspection activities to confirm critical characteristics, including chemical composition.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 93-73 [193]</td>
<td>Criminal prosecution of Nuclear suppliers for Wrongdoing. Cases documented of prosecution of owners of companies engaged in provision of counterfeit CBs and valves. Much of the equipment found to have been sold in unsatisfactory condition, or to contain substandard parts, manufacturing processes or workmanship.</td>
<td>Existence of companies and individuals willing to counterfeit product.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 95-12 [194]</td>
<td>Potentially non-conforming fasteners supplied by A&amp;G Engineering IL, Inc. Company had provided substandard fastener products obtained from foreign suppliers and falsely certified such products. Company records systems were in disarray, and documentation available at A&amp;G was not adequate to support the material certifications issued.</td>
<td>Importance of supply chain audits to validate records management practices of suppliers.</td>
</tr>
<tr>
<td>United States of America (USNRC)</td>
<td>IN 2007-19 [195]</td>
<td>Fire protection equipment recalls and counterfeit notices. Documents fire protection equipment recalls and counterfeit notices issued by various manufacturers. Counterfeit sprinkler heads were manufactured with a slot-head screw instead of a hex-head screw, and in a separate case without a date code or identification number.</td>
<td>Importance of receipt inspection activities.</td>
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<td>Country/Source</td>
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| United States of America (USNRC) | IN 2008-04 [196] and [156, p. 83] | Counterfeit parts supplied to NPPs. Documents cases of supplying counterfeits part to NPPs (e.g. Ladish stop check valves at Hatch installed in a non-SR system during maintenance activities on a similar valve in vicinity of installed counterfeit (see also [159, pp. 5-2]; possibly counterfeit Square D circuit breakers removed from warehouse at Catawba (see also [159, pp. 5-3]).) | Identified 3 characteristics of an effective procurement and dedication plan:  
- Involvement of engineering in procurement and acceptance process  
- Effective source inspection, receipt inspection, and testing programmes;  
- Thorough engineering based programmes for testing and dedication of CGD products for suitability in SR applications |
| United States of America (USNRC) | IN 2012-22 [197] | Counterfeit, fraudulent, suspect item (CFSI) training offerings, Provided list of available training | Emphasizes regulator interest in training for detection of counterfeit items. |
| United States of America (USNRC) | IN 2013-02 [198] | Issues potentially affecting nuclear facility fire safety. Counterfeit single-jacketed fire hose, fire extinguishers, fire pipe hangers, and sprinklers discovered in non-nuclear applications in US industry. IN issued to warn US nuclear industry re issue. | Emphasizes existence of counterfeit items in industry and potential for nuclear safety impacts. |
| United States of America (USNRC) | IN 2013-15 [199]. | Wilful misconduct record falsification and nuclear safety culture | Documents several incidences of records falsification at and related to US NPPs, including a case of an owner/president of a supplier directing an employee to switch a broken display on a Peach Bottom NPP steam leak detector monitor with a working display unit from Brunswick NPP. Before its shipment, the owner also instructed an employee to file down the serial number on the substitute display to conceal its identity and to ship the working display to Peach Bottom without informing that site of the switch. The president was prosecuted and pleaded guilty to the offence.  
NRC indicated licensees and suppliers need to implement an effective nuclear safety-culture. |
<p>| United States of America (USNRC) | Summary of Event and Plant Conditions (as of May 16, 2013) [200] | San Onofre Units 2 and 3 shut down due to steam generator leaks. SCE replaced Unit 2 SGs in January 2010 and Unit 3 SGs in January 2011. Each replacement SG experienced severe leakage during its first cycle of operation. Plant was eventually decided to be permanently shut down due to cost of replacement. | Identifies risk of sub-standard major components being installed even when provided by experienced vendors. |</p>
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<th>Country/Source</th>
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<th>Lessons Learned</th>
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<tr>
<td>United States of</td>
<td>Part 21 (non-conformance) report 1997-06-0 : Limitorque counterfeit</td>
<td>Counterfeit component installed in a non-SR Limitorque actuator</td>
<td>Surplus parts market has higher chance of CFSIs.</td>
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<td>America (USNRC)</td>
<td>component purchased from a “surplus” market in an NPP.</td>
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<td>United States of</td>
<td>Part 21 (non-conformance) reports 1995-212 and 1996-06-04 Aerofin</td>
<td>Inadequate heat treatment resulting in bolt mechanical properties</td>
<td>Records and regulatory processes for reporting supplier</td>
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<tr>
<td>America (USNRC)</td>
<td>Cardinal industrial products capscrews</td>
<td>below required minimums (used in SR cooler at Palisades NPP). Initial</td>
<td>defects are important.</td>
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<td>bolt problem had been identified by a different customer and supplier</td>
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<td>reported issue to other customers and the NRC. Investigation and</td>
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<td>testing traced problem to heat treating furnace at the manufacturing</td>
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<td>facility</td>
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<td>United States of</td>
<td>SECY 89-010</td>
<td>Advance notice of proposed rulemaking “ Acceptance of Products</td>
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<tr>
<td>America (USNRC)</td>
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<td>Purchased for use in Nuclear Plant Structures, Systems, and Components”</td>
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<td>Document requested public comment on whether or how NRC regulations</td>
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<td>should be revised to provide increased assurance that counterfeit or</td>
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<td>misrepresented vendor products are not installed in NPPs</td>
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<td>America (USNRC)</td>
<td>station receipt inspector after comparison made to similar valves in</td>
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<td>inventory, OEM confirmed counterfeits.</td>
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<td>Type of Item</td>
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<td>Fasteners</td>
<td>CSFI high strength bolts were evaluated as being acceptable in applications where normally lower strength bolts were used, but were not identified or marked as such, leading to potential that they could be re-used in applications where genuine high-strength bolts were required.</td>
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<td>Stainless steel bolts were hand-stamped to indicate they met a different standard.</td>
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<td>• Method of identifying bolts allowed for raised or depressed head markings which would enable someone to add stamping after production. Reliance on head stamping to identify bolts could lead to potential problems without manufacturer certification.</td>
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<td>Circuit breakers</td>
<td>Refurbished moulded-case electric circuit breakers continue to be widely counterfeited and misrepresented as new. Moulded-case circuit breakers should not be taken apart and serviced or refurbished except by the original manufacturer or qualified supplier.</td>
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<td>Lessons learned</td>
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<tr>
<td></td>
<td>• Refurbished moulded-case circuit breakers should not be accepted without original manufacturers or qualified suppliers’ certification.</td>
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<td>Metal struts and fittings</td>
<td>Vendors have been found who mix unmarked substitute struts and fittings with properly identified products and ship the parts in the original manufacturer’s box. This practice misrepresents the product as being from the original manufacturer.</td>
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<td>Lesson learned</td>
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<td>• Facilities should use metal strut materials purchased for structural applications from reputable manufacturers that will have the manufacturer’s name, logo, or part number on the part for ease of identification. Markings also identify the load capacity that the part is designed and rated to withstand.</td>
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<td>Steels</td>
<td>Procured during construction:</td>
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<td>• Steels were ordered to a specific standard but were supplied to another standard, for financial gain.</td>
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<td>• Suspicion aroused when material test reports were checked.</td>
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<td>• Solution: Additional Charpy impact tests were performed, absorbed energy met the original acceptance criteria, and the steels manufactured to the other standard were accepted.</td>
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<td></td>
<td>Lesson learned</td>
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<td></td>
<td>• Receipt inspection should be performed thoroughly to detect suspect items.</td>
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<td></td>
<td>• Supplier should be monitored and controlled more strictly</td>
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<td>Pump shafts</td>
<td>Used for spare parts of fire protection pumps, procured during operation:</td>
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<td>• Suspicion identified when the run-out check of the pump shafts was performed at the receiving inspection.</td>
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<td>• Solution: engineering decision made to discard the shafts and purchase new ones.</td>
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<td>Lessons learned</td>
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<tr>
<td></td>
<td>• Receipt inspection should be performed thoroughly to detect suspect items.</td>
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<td>• Run-out of pump shaft should be checked before installation because misalignment or run-out of pump shaft can be induced by improper handling, shipping, transportation, or manufacturing.</td>
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<td>Type of Item</td>
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| Throttle valves and p piping | Used in rear side of component cooling water heat exchangers, procured during construction and installed:  
• Suspicion appeared when throttle valves and rubber-lined piping was damaged by cavitation as a result of sudden throttling during the commissioning test.  
• Solution: to avoid cavitation and optimize the efficiency of heat exchanger design was changed by installing a cone type orifice in the rear side of the throttle valve and changing the valve size; damaged valves and pipes were replaced with larger ones.  
Lessons learned  
• Anti-cavitation design should be considered in the throttle line.  
• Experience and design changes were incorporated into next plant design. |
| Rubber gaskets        | Used on fuel handling pit gate, procured during construction and installed:  
• Suspicion appeared when a leakage from the gate was detected; the leakage came through damaged gasket as a result of inappropriate installation of a clamp to fix the gasket and unexpected ageing of gasket  
• Solution: damaged parts of gasket repaired and leak-tested.  
Lessons learned  
• Installation should adhere to the technical specification.  
• Spare parts inventory updated to consider replacing the suspect items more frequently.  
• Preventive maintenance methods established and implemented as follows: daily check for leakage of gasket considering ageing effect; visual inspection of gasket during annual outage; detail check every five years in accordance with manufacturer’s instruction. |
| Swing type check valves | Procured during construction and installed next to the orifice of the discharge side of motor operated auxiliary feed water pumps:  
• During preventive maintenance, it was discovered that the disc bolt was ruptured and the detached bolt, nut, washer, and fixing pin had disappeared into the feed water system.  
• Solution: Eddy Current Testing and engineering evaluation were performed to assess effect of loose parts on steam generator; disc bolt was replaced with a thicker one; weak parts of valve were reinforced.  
Lessons learned  
• Similar valves supplied by same supplier should be checked periodically during annual outage or, if necessary, normal operation. |
| Seal injection filter | Used on front side of reactor coolant pump, procured during construction and installed:  
• Suspicion aroused when seal injection flow “low” signal alarm was initiated as a result of blocking of seal injection flow by a build up of filtering material in seal housing of reactor coolant pump  
• Solution: Impurities in seal housing and system were removed by flushing; the location of differential pressure gauge was moved to a low radiation area by design change to allow frequent check of differential pressure.  
Lessons learned  
• Filtering material should be replaced periodically taking into account any unforeseen ageing effect caused by use in a differential pressure environment, regardless of manufacturer’s instruction.  
• Differential pressure of filter should be checked frequently. |
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| Reactor vessel guide studs       | Used when assembling and disassembling reactor vessel, procured for construction in accordance with thread type design and installed:  
• Suspicion aroused when threads of guide stud and stud hole were damaged during commissioning tests.  
• Solution: design change from thread type to sleeve type was made, damaged thread of guide stud was discarded and stud hole thread was bored.  
Lesson learned  
• Experience and design change was incorporated into next plant design                                                                 |
| Reactor coolant pump seal housing bolts | Procured during construction and installed:  
• During annual outage, suspicion aroused when a leakage between the seal housing and the bolt ring of a reactor coolant pump was detected. The disassembly of the seal housing revealed all bolts were corroded or rusted by boric acid leaked into the seal housing.  
• Solution: corroded bolts replaced with new; non-destructive examination (NDE) and engineering evaluation on rusted bolts performed and a leakage check was performed after bolting.  
Lessons learned  
• Maintenance procedure for reactor coolant pump seal housing was revised to prevent inflow of boric acid into the seal housing.  
• Periodic check performed to identify leakage.                                                                 |
| Chemical waste drain tank        | Used in liquid radwaste system, procured during construction:  
• Suspicion aroused when NDE was not carried out on nozzle welds as a result of misinterpretation of NDE requirements in procurement specification.  
• Solution: liquid penetrant examination performed in accordance with specification and tank accepted.  
Lesson learned  
• Receipt inspection should be performed thoroughly to ensure all tests have been carried out in accordance with procurement specifications. |
| Flange bolts of tank             | Procured during construction and installed:  
• Suspicion discovered when quality surveillance identified flange bolts were not fully engaged with nuts.  
• Solution: all bolts replaced with longer ones to allow full engagement.  
Lesson learned  
• Receipt inspection should be performed thoroughly to check full bolt engagement in nuts on assemblies                                                                 |
| Electrical and instrumentation and control cables – fire retardancy | Procured during construction:  
• Supplied from warehouse of an NPP from a utility in another country.  
• Suspicion aroused when test certificates were checked (cable specifications and tests were in accordance with country’s national, obsolete standards).  
• Supply accepted due to financial benefits and impact on work schedules.  
• Solution: tests repeated to current standards, cables were installed in unit, engineering assessment established compensatory measures (fire detection system, sprinklers for extinguishing fires, protection of structural steel with intumescent paints, fire barriers on cable trays).  
Lesson learned  
• Some documents sent with items might also be suspect; documents confirming design features of item should be signed by a neutral evaluator.  
• Use of suspect items is permissible, if appropriate compensatory measures are taken.                                                                 |
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<th>Type of Item</th>
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<td>Transformers</td>
<td>Procured during construction:</td>
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<td>• Stored for a long time in conditions (variable temperatures and humidities) that were not strictly controlled; possible insulation/paper degradation occurred.</td>
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<td>• Installed in unit.</td>
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<td>• Suspicion aroused when several transformers failed during commissioning (short circuits, fires).</td>
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<td>• Solution: new transformers ordered (insulation: moulded resin) and stored on site in suitable conditions, to enable immediate replacement of failed transformers in future.</td>
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<td>Lessons learned</td>
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<td>• Evaluation/inspection of item status should be carried out prior to installation, to assess effect of storage conditions on item.</td>
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<td>• Spare parts and components inventory should take into account necessity to replace any installed suspect items when they fail.</td>
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<td>Electronic cards in logic loops</td>
<td>Procured during construction and installed:</td>
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<td>• Suspicion aroused when spurious trip signals were generated in some pins on card, when card failed (situation generated a reactor trip during commissioning tests). Manufacturer confirmed failure as being generic in nature following a request by NPP to carry out an investigation.</td>
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<td>• Solution: modification implemented in loops which used such pins and which had an impact on other similar logic; balance of the cards were kept unchanged.</td>
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<td>Lessons learned</td>
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<td>• Approach to disposition of suspect items should be related to importance of the item for safety, or for plant availability.</td>
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<td>• Any suspicions should be identified at an early stage, during commissioning tests, if possible (schedule special tests for CSFIs).</td>
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<td>• Ask for information and clarification from supplier together with an investigation on any faults identified in order to simplify engineering evaluation</td>
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<td>Liquid relief valves</td>
<td>Used in degasser-condenser, operating in tandem with the pressurizer, procured for construction, in accordance with the standard design, and installed.</td>
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<td>• Suspicion aroused through feedback that suggested that other NPPs of same design replaced these valves with new ones, with better dampening features.</td>
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<td>• Suspicion confirmed during a transient, when unit was shut down, and valves operated, but did not close properly (they “chattered”), generating heavy water losses.</td>
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<td>• Solution: repair of valves (for short term); order of new valves similar to those utilized by other NPP’s with installation to occur during annual outage.</td>
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<td>Lessons learned</td>
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<td>• Database” of CSFIs should be permanently monitored, to take into account operating experience of other NPPs.</td>
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<td>• Replacement of such items should be considered as an important part of annual outage work.</td>
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<td>• Replacement of suspect items could be implemented with co-operation of other NPP’s interested in such work.</td>
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<td>Identification and markings</td>
<td>The following are examples of CSFIs that were discovered as a result of improper markings:</td>
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<td>• Metal flanges stamped as forgings when other markings on face of flange indicated that parts were cold rolled.</td>
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<td>• Metal flanges as part of fabricated assemblies without any required markings on the flanges, such as manufacturer, material type, specification or dimension.</td>
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<td>• Metal eyebolts either with no manufacturer’s markings or with markings indicating that parts were made in a country other than specified. eyebolt dimensions had not met specifications and material types were indeterminate.</td>
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<td></td>
<td>• Metal piping and pipefittings requested from national manufacturers received from foreign manufacturers.</td>
</tr>
<tr>
<td></td>
<td>• Lifting devices purchased with procurement credit cards had been visibly altered, as evidenced by over-stamping or striking through original information and adding new markings.</td>
</tr>
</tbody>
</table>
7.2 TOOLS TO ADDRESS COUNTERFEIT AND FRAUDULENT ITEMS

EPRI has developed a risk mitigation document [159] and self-assessment checklist [201] to provide utilities with a means to assess existing anti-counterfeiting measures and a tool to identify opportunities to improve anti-counterfeiting measures in existing processes and programs. The checklist can be shared with all supply chain tiers to raise awareness of the counterfeiting issue and communicate effective means to minimize risk.

Some tools to counteract counterfeiting include:

(a) Appropriate engineering involvement with procurement and product acceptance processes, including testing.

Inadequate engineering involvement is a common weakness in procurement programmes, particularly for CGI procurement. Involvement of engineering staff would normally include (1) development of procurement requirements, (2) determination of critical characteristics of selected products that are to be verified during product acceptance, (3) determination of specific testing applicable to selected products, and (4) evaluation of test results);

(b) Detailed knowledge of suppliers, including reducing use of independent distributers and parts brokers, and effective supplier audits (see Section 3.3.3 and (m) below);

Knowledge of a supplier’s operations and practices is key to gaining confidence in their ability to avoid CSFI issues. This is obtained via a process of assessments and audits, regular communication (including requesting of CSFI data from suppliers), and by experience with the supplier over a period of time. Efforts to minimize the number of suppliers that a nuclear facility deals with can make such efforts more practical. Changes in supplier ownership or financial position should trigger a reassessment as to whether such changes require increased scrutiny for a time period until such confidence can be re-established. Using only original manufacturer approved distributers wherever practical is recommended, as is verifying supplier-provided data such as address, ISO certification, authorized distributer status, etc.

(c) Identification of “at-risk” procurement;

Staff within procurement organizations should have necessary training and experience, and process controls should be in place to assist in recognizing at-risk procurement scenarios. These would include procurement of components that are known to have counterfeits in industry, use of new suppliers, equipment brokers, independent distributers, or internet exclusive suppliers, not buying from authorized distributers, expedited schedules, highly discounted pricing, supplier refusals to offer a traceable source, or refusals to provide or be accountable for certification, and other scenarios. Location of sourcing can also be a trigger for a potential at-risk procurement scenario, with some sourcing jurisdictions have larger numbers of reported issues.

A process of formal supplier risk assessment could be employed to help in this process. This might be in conjunction with supplier assessments and audits are described below in (n). SAE International for example has produced standard SAE ARP6178 [202] on performing risk assessments of electronics distributers related to CSFIs.

Such procurement scenarios can trigger additional inspections and oversight actions as necessary.

(d) Clear and complete procurement requirements;

Clear procurement requirements are important to both receipt of the required product and in avoiding CSFIs. Descriptions should include important characteristics of the item as opposed to just model numbers. Contractual requirements pertaining to disposal of rejected
and surplus items (item (i) below), provision of counterfeit or fraudulent items (item (e) below), communication of actions that will be taken if counterfeit or fraudulent items are provided (item (g) below), provision of product certifications, use of escrow payments when appropriate, and with clear, detailed descriptions of the item, applicable standards, and its acceptance criteria are desired.

**Procurement clauses and standard contract language addressing counterfeit and fraudulent items;**

EPRI has proposed the following standard procurement clause to help address CFSIs [159] [203]:

“Vendor is hereby notified that the delivery of suspect/counterfeit items is of special concern to (Buyer’s Name). If any parts covered by this Order are described using a manufacturer part number or using a product description and/or specified using an industry standard, Seller shall be responsible to assure that the replacement parts supplied by Seller meet all requirements of the latest version of the applicable manufacturer data sheet, description, and/or industry standard. If the Seller is not the manufacturer of the goods, the Seller shall make all reasonable efforts to assure that the replacement parts supplied under this Order are made by the Original Equipment Manufacturer (OEM) and meet the applicable manufacturer data sheet or industry standard. Should Seller desire to supply a replacement part that may not meet the requirements of this paragraph, Seller shall notify Purchaser of any exceptions and receive Purchaser’s written approval prior to shipment of the replacement parts to Purchaser. If suspect/counterfeit parts are furnished under this order or are found in any of the goods delivered hereunder, such items will be dispositioned by (Buyer’s Name) and / or the Original Equipment Manufacturer, and may be returned to the vendor. The Vendor shall promptly replace such suspect/counterfeit parts with parts acceptable to (Buyer’s Name) and the Vendor shall be liable for all costs, including but not limited to (Buyer’s Name)’s internal and external costs, relating to the removal and replacement of said parts.”

**Bid evaluation processes accounting for CSFI concerns**

Policies that require selection of lowest-cost bids can contribute to more at-risk procurement scenarios and CSFI incidents. Bid evaluation criteria that addresses the type of supplier (i.e. internet, broker, authorized distributor, original manufacturer, etc.), level of experience with the supplier, and their historical performance is recommended.

**Zero tolerance policies for vendor counterfeiting;**

Zero tolerance policies by utilities, regulators or standards organizations are designed to ensure that unscrupulous suppliers understand that if they are discovered that the parties will effectively prosecute illegal activities to the fullest extent of the law. This requires an appropriate legal framework within the jurisdiction involved, which can be an issue in some locations. Underwriter’s Laboratories for example has established a team dedicated to counterfeiting issues that work towards evolving UL Marks to make them harder to counterfeit, training customs and border protection agents to identify counterfeit UL marks before they can enter the marketplace, educating manufacturers and retailers to help them identify counterfeit products, providing real time support for customs and law enforcement officials, and producing detailed enforcement manuals and reference materials [204].

**Safeguarding of protection of intellectual property;**

Intellectual property received from suppliers and OEMs for the purpose of nuclear facility operation (e.g. drawings, manuals, specifications, capability curves etc.) should be access controlled on a need to know basis by physical and electronic means. Not only is this
good and lawful business practice, but also helps prevent this information from falling into the hands of counterfeiters.

(i) Sensitive scrap and disposal policies;

These policies ensure “seconds”, production overruns, and defective items do not fall into hands of potential counterfeiters who may attempt to pass them as new, certified parts. Proper destruction and disposal of all unsalable or unusable items, surplus and scrap by suppliers, distributors, and end users can help reduce their unauthorized reuse.

(j) Thorough receipt inspections (see section 3.4.2.3);

Receipt inspectors should be aware of things to look for in detecting potential CFSIs. Table 21 below provides some specifics.

For “at-risk” procurement scenarios (item (c) above) enhanced inspection (including destructive) may be appropriate. This can include such activities as requesting inspection and testing criteria from the original equipment component or equipment manufacturer, using photographs of authentic items to aid authentication when performing receipt inspection (verify manufacturer and certification organization markings are correct), consulting available industry data on known counterfeits when performing receipt inspection, and for electronics, consider implementing guidance in SAE AS5553 [205] and IDEA-STD-1010 [206].

(k) Training programmes on recognizing counterfeit parts;

Training is typically required in the recognition of CSFIs. Training raises awareness levels and increases significantly the possibility of detection of CFSIs. Vigilant inspections at the source (factory), at the warehouse (receipt inspection) and preinstallation (by the installers) are a key barrier to CSFIs. Management, engineering, procurement, maintenance, receipt inspectors, auditors, source inspectors, and warehouse staff are all candidates for such training. A wide number of commercial providers offer training in CFSI detection, and EPRI has produced a computer based course for this purpose [207].

(l) Procedures for addressing suspected CSFI incidents, which include engagement of OEMs;

Processes need to be set up in advance for addressing suspected CSFI incidents. This is to ensure that staff is aware of the importance of reporting such incidents and quarantining suspected items, including their packaging and supporting documentation, to allow for a full and effective investigation with the OEM, the supplier, and potentially with law enforcement authorities. Such processes should be integrated with a site’s normal corrective action programme and include reporting mechanisms to the wider nuclear and non-nuclear industry.

Steps would typically include:

- Quarantine suspect item;
- Gather information;
- Add incident to facility corrective action programme;
- Consider reporting to industry databases;
- Contact original equipment manufacturer or supplier for information about related incidents or any ongoing investigations;
- Carefully decide if item supplier should be notified (may tip off counterfeiter who may destroy evidence) and if item should be returned;
- Notify regulators and other appropriate agencies as required;
- Notify national customs agencies and law enforcement as required.
Use of more difficult to counterfeit, positive ID tools on items such as barcodes, RFID chips, holograms, or other manufactured in features;

NEMA has produced a document [208] listing certain anti-counterfeiting and authentication technologies that can be used in industry. These include a variety of security inks and coating (e.g. intaglio inks that provide a distinctive feel like on a passport, inks only visible under ultraviolet, fluorescent, or infrared light or when heated, optically variable inks, pearlescent varnishes, inks tagged with microscopic or nanoscopic particles, machine readable inks, conductive inks, or photochromatic inks), difficult to mimic security printing (microtext, nanotext or guilloche), using security paper (designed for tamper resistance or containing security threads, fibres, or other embedded features), optical technologies (holograms, films etc.), chemical and molecular tag and nanotechnologies, and electronic tracking and tracing systems (bar codes etc.) that can track an item through the supply chain. Existing inventory can be back-fitted with such markings where not already applied.

Questions regarding CSFI identification methods and programmes within supplier audit checklists;

Suppliers regularly undergo assessments and audits related to their management systems / quality programmes. Good practice is to include an assessment of their documented measures and practices related to CSFI identification and notification methods and programmes within the scope of these assessments and audits.

Part of such assessments should be reviews of supplier return policies. Such policies should include inspections of returned items, and prohibitions on returning greater quantities than were purchased.

Industry databases of incident data;

Incident data related to CSFIs has been recorded by a number of organizations, both inside and outside of the nuclear industry. Regular review of and contribution to such databases can lower risks associated with inadvertent purchases of CFSI’s. Some sources of information are shown in Table 20 below.

<table>
<thead>
<tr>
<th>Topic covered</th>
<th>Organization</th>
<th>Link</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics</td>
<td>ERAI</td>
<td><a href="http://www.erai.com">www.erai.com</a></td>
<td>Provides ability to report and search for electronic counterfeit items.</td>
</tr>
<tr>
<td>General</td>
<td>EPRI</td>
<td><a href="http://scfi.epri.com/">http://scfi.epri.com/</a></td>
<td>Suspect counterfeit/fraudulent item data (SCFI) database being developed. To be available to and input by EPRI members.</td>
</tr>
<tr>
<td>Topic covered</td>
<td>Organization</td>
<td>Link</td>
<td>Comment</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------</td>
<td>------</td>
<td>---------</td>
</tr>
<tr>
<td>General</td>
<td>Government-Industry Data Exchange Program</td>
<td><a href="http://www.gidep.org">http://www.gidep.org</a></td>
<td>Organization for U.S. or Canadian organizations which directly or indirectly provide products or services to the U.S. or Canadian governments. Maintains database with ability of members to submit data for exchange of technical information (including re counterfeit items) with other GIDEP participants.</td>
</tr>
</tbody>
</table>

**Human performance tools;**

Standard nuclear industry human performance tools [209] [210] can be utilized to help in the detection of CSFIs. Pre-job briefings for receipt inspectors, warehouse staff, and maintenance staff for example can cover CSFI detection. Encouraging a questioning attitude or stopping when unsure can facilitate individuals stopping jobs when they are concerned if an item to be installed in genuine or not. Procedure use and adherence can encourage staff to fully complete any checklists, processes, or other activities designed to assist in CSFI detection or prevention. Other human performance tools can be utilized or adapted to assist.

**Participation in industry peer groups related to the subject (with voluntary reporting of incidents to a centralized database);**

Industry peer groups are a method to help share knowledge and experience related to CSFIs on a regional basis. Some groups in operation include EPRI's Joint Utility Task Group on procurement engineering as well as the Nuclear Procurement Issues Committee (NUPIC).

**Mandatory reporting to regulators of discovered items.**

Many jurisdictions increasingly are requiring mandatory reporting of discovered CSFI items to regulators or other central organizations for wider information sharing within utilities and other industrial participants. This helps to better protect all participants involved by making it harder for unscrupulous suppliers to “shop around” their CSFIs.

An example of such a requirement is in the USA, where contractors subject to the Cost Accounting Standards under section 26 of the Office of Federal Procurement Policy Act (41 U.S.C. section 422) and that supply electronic parts or products that include electronic parts — must establish and maintain a counterfeit electronic part detection and avoidance system in compliance with the new rule. The rule contains flow-down provisions requiring that all subcontractors at all tiers, including subcontractors for commercial items and commercial-off-the-shelf items, must establish and maintain counterfeit electronic part detection and avoidance systems.

Member States are encouraged to report CSFI incidents to the IAEA through the incident reporting system [211].
<table>
<thead>
<tr>
<th>General</th>
<th>Documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Nameplates, labels or tags altered, photocopied, silkscreened, painted over, not secured well, show incomplete data, or missing. Preprinted labels will normally show typed entries.</td>
<td>• Use of correction fluid or correction tape evident. Type style, size: or pitch change evident.</td>
</tr>
<tr>
<td>• Obvious attempts at beautification made, such as: excess painting or wire brushing, hand painting (touch-up), stainless steel painted, non-ferrous metals (copper, brass, bronze, etc.) clean and bright indicating recent polishing.</td>
<td>• Document not signed, initialed when required, excessively faded or unclear (indicating multiple, sequential copying) or missing data.</td>
</tr>
<tr>
<td>• Handmade parts evident, such as: rough cut gaskets, shims and thin metal part edges showing evidence of cutting or dressing by hand tools (filing, hacksaw marking, use of tin snips or nippers).</td>
<td>• Name of document approver or title cannot be determined or typed approval name and signature do not match.</td>
</tr>
<tr>
<td>• Hand tool marks on fasteners or other assembly parts (upset metal exists on screw or bolt head) or dissimilar parts evident (seven of eight bolts of same material; one of different material).</td>
<td>• Technical data inconsistent with code or standard requirements (e.g. no impact test results provided when impact testing required, physical test data indicates no heat treatment and heat treatment required, chemical analysis indicates one material, physical tests indicate another, etc.).</td>
</tr>
<tr>
<td>• Assembled items fit poorly.</td>
<td>• Certification or test results identical between items when normal variations should be expected.</td>
</tr>
<tr>
<td>• Configuration not consistent with other items from supplier or varies from supplier literature or drawing.</td>
<td>• Unusual disclaimers or denials of responsibility for the accuracy of test results, etc.</td>
</tr>
<tr>
<td>• Inconsistency between vendor name on item and shipping container.</td>
<td>• Document traceability not clear. Documentation should be traceable to items procured.</td>
</tr>
<tr>
<td>• Nameplates attached with inconsistent fasteners, such as: screws instead of rivets or rivets and screws.</td>
<td>• Documentation not delivered as required on purchase order or in an unusual format.</td>
</tr>
<tr>
<td>• Nameplates attached in a different location than normal.</td>
<td>• Documents ‘XEROXED’ or copied.</td>
</tr>
<tr>
<td>• Nameplates appearing old or worn, with paint on them, and look newer than component.</td>
<td>• Corrections not properly lined-out, initialed and dated.</td>
</tr>
<tr>
<td>• Metallic items are pitted or corroded.</td>
<td>• Text on page ends abruptly and number of pages conflicts with transmittal.</td>
</tr>
<tr>
<td>• Nameplates missing manufactures standard markings, stamps, or logos and with irregular stamping or inconsistent type style.</td>
<td>• Required watermarks missing.</td>
</tr>
<tr>
<td>• Different appearance of items in same shipment.</td>
<td>• Inconsistent configuration between product and product literature or between other items from same supplier.</td>
</tr>
<tr>
<td>• Dimensions of item inconsistent with specification requested on purchase order and those provided by supplier at time of shipment;</td>
<td>• Lines on forms bent, broken, or interrupted indicating data has been deleted or exchanged (cut and paste).</td>
</tr>
<tr>
<td>• Evidence of previous bolt head scoring on backsides of flanges or evidence that area has been ground;</td>
<td>• Data on a single line is located at different heights</td>
</tr>
<tr>
<td>• Loose or missing fasteners;</td>
<td>• Item or component matches description of one that is on a Member State list of CSFIs.</td>
</tr>
<tr>
<td>• Evidence of marring, tool impressions, traces of Prussian blue or lapping compound, or other evidence of previous attempts at fit-up;</td>
<td></td>
</tr>
<tr>
<td>• Heat discoloration evident;</td>
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Specific
Valves:

- **Paint**
  - Valve appears freshly painted and valve stem has paint on it;
  - Wear marks or scratches on any painted surface;
  - Valve stem protected, but protection has paint on it;
  - Paint does not match standard OEM colour;
  - Exterior evidence of attempted repairs i.e. brush marks to repair spray paint;
  - Inconsistent shades on painted surfaces;

- **Tags**
  - Tags attached with different method or location than normal (e.g. screws instead of rivets);
  - Tags appear old, worn, or newer than valve;
  - Tags with paint on them;
  - Tags with no part numbers;
  - Tags with irregular stamping;
  - Tags without manufacturing logos;
  - Tag attachment screws marred from use;

- **Hand wheels**
  - Old looking hand wheel on new looking valves;
  - Hand wheel looks sandblasted or newer than valve;
  - Different types of handwheels on valves of same manufacturer;

- **Bolts and nuts**
  - Bolts and nuts have a used appearance (wrench marks on flats);
  - Improper bolt and nut material (e.g., a bronze nut on stainless stem);
  - Bolts with different size or grade markings;

- **Body**
  - Ground off casting mark with other markings stamped in area (OEM markings are nearly always raised, not stamped);
  - Signs of weld repairs;
  - Incorrect dimensions;
  - Fresh sand-blasted appearance including eye bolts, grease fittings, stem, etc.;
  - Evidence of previous bolt head scoring on backsides of flanges, or evidence that area has been ground to remove such marks;
  - On a stainless valve, an unusually shiny finish indicates bead-blasting. An unusually dull finish indicates sand-blasting. Finish on a new valve is in-between;

- **Manufacturer’s logo**
  - Missing;
  - Logo plate looks newer than valve;
  - Logo plate shows signs of discoloration from previous use;

- **Other**
  - Foreign material inside valve (e.g., metal shavings, dirt, lapping compound);
  - Valve stem packing that shows all the adjustments have been run out;
  - In gate valves, an off-centre gate when checked through open end of valve;
  - Obvious differences between valves in same shipment;
  - Improper materials (e.g., bronze nut on a stainless stem);
  - Wrench marks on valve packing glands, nuts, and bolts.

**Fasteners:**

- Head markings marred, missing, or appear to have been altered;
- Threads show evidence of dressing or wear (threads should have uniform colour and finish);
- Head markings inconsistent within a heat lot or appear to be impression stamped after production;
- Mixed grade on manufacturer head marks in same lot or shipment;
Circuit breakers

- Case cracked or appears used.
- Laboratory product testing authority label/mark, or the original manufacturer’s label/mark shows signs of alteration or copying (e.g., black and white, poor legibility).
- CB rating shows signs of alteration (e.g. rating painted on instead of being impressed into the case) or contradictory amperage ratings appear on different parts of same refurbished breaker.
- Rivets or other connectors used to hold case together are not proper type or size, or rivets having been removed; case may be held together with wood screws, metal screws, or nuts and bolts.
- Certificates copied or show evidence of falsification (where possible, original certificates should be obtained from distributor).
- Style of breaker no longer manufactured or is old.
- Breaker comes in cheap, generic-type packaging (e.g., bulk-packaged in plastic bags, brown paper bags, or cardboard boxes with hand-written labels) instead of manufacturer’s original boxes.
- Data on carton or label have been altered or are inconsistent.
- MCCBs may be labelled with the refurbisher’s name rather than the label of a known manufacturer.
- Manufacturer’s seal across two halves of breaker case breaker broken or missing.
- Manufacturer’s date code not stamped on breaker.
- Wire lugs show evidence of tampering.
- Surface of circuit breaker may be nicked or scratched yet has a high gloss.
- Rating stamp in wrong place.
- Third-party markings on item.
- Terminal lugs on both ends.
- Terminal hardware wrong size or type or mismatched.
- Cover screw seals missing or rough or poorly resealed.

Electrical devices

- Connections show evidence of previous attachment (metal upset or marring, screwdriver marks);
- Electrical leads are of different lengths or are not as long as stated in vendor product catalogue.
- Connections show arcing or discoloration;
- Metal colour inconsistencies;
- Plastic parts of different colours;
- Pitted or worn contacts and lugs;
- Contact surfaces that do not mate properly;
- Broken or damaged solder terminations;
- Lubrication which appears to be old;
- Fasteners loose, missing or show metal upset;
- Molded case circuit breakers not consistent with manufacturer provided checklists for detecting substandard/fraudulent breakers;
- Products requiring testing by an independent authority are missing labels or labels appear to be photocopied;
- Manufacturer’s labels discoloured or faded, indicating they may have been photocopied.
- Item shows evidence of wear or prior use.
- Item has scratches or nicks in factory paint or coating;
- Rivets missing and screws used in place of where rivets normally used; or rivets look to be reused;
- Molded case circuit breakers shiny or appear painted with lacquer;
- Past due calibration stickers (internal and external);

Rotating machinery and valve internal parts:

- Shows marring, tool impressions, wear marks, traces of engineer’s / Prussian blue or lapping compound or other evidence of previous attempts at fit-up or assembly;
- Heat discoloration evident;
- Evidence of erosion, corrosion, wire-drawing or “dimples” (inverted cone-shaped impressions) on valve discs or seats or pump impellers.
Piping and Piping Components:

- Used component appearance;
- Unusual or inadequate packaging;
- Foreign newspapers used as packaging;
- Scratches on component outer surface;
- Evidence of tampering on body, screws, tags, or nameplates;
- Components with no markings;
- Pitting or corrosion;
- External weld or heat indications;
- Questionable or meaningless numbers;
- Typed labels;
- Evidence of hand made parts;
- Painted stainless steel, freshly painted parts, mismatched colours;
- Ferrous metals that are clean and bright;
- Excess wire brushing or painting;
- Ground off casting marks with stamped marks in the vicinity;
- Signs of weld repairs;
- Threads showing evidence of wear or dressing;
- Inconsistency between labels;
- Old or worn nameplates;
- Nameplates which look newer than the component;
- Missing manufacturer’s standard markings and logos;
- Traces of Prussian Blue;
- Markings not legible;
- Evidence of re-stamping;
- No specification number;
- No size designation;
- Missing pressure class rating;
- Disclaimers on certifications that disclaim any obligation or liability for non-conformances or specification failure of items to conform to the state specification.
8 PROACTIVE METHODS FOR NEW FACILITIES TO AVOID PROCUREMENT ISSUES DURING OPERATION AND MAINTENANCE

8.1 BACKGROUND

Given the requirements to control SR procurement over time for a nuclear facility, there are lessons learned to effectively enable procurement to support facility maintenance. These include the following:

- Additional procurement processes are needed to support SR procurement; however, operating organizations typically have limited resources and capabilities to meet all identified needs. Q-lists allow procurement groups to focus in on only items used on SR end uses, and thus make best use of available resources.
- Changes in marketplace will occur (e.g. companies dropping QA programmes etc.). Procurement organizations can utilize Q-lists to focus on those changes for SR suppliers only.
- Processes to identify critical equipment for facilities (e.g. INPO’s AP-913 Equipment Reliability Process [214]) may result in treating some materials used on critical end uses (e.g. production or economically significant material) that are not SR the same as SR.
- When implementing a nuclear programme and or new nuclear facilities, it is recommended to incorporate the above items (establishment of Q-list and critical equipment lists), and build into supplier contracts the provision of procurement related data requirements (see section 8.2 below and Appendix I).
- Efforts to sustain the nuclear marketplace over a facility’s life can be difficult but should be made. Plants where the original technology provider takes an equity interest in the plant are less likely to have issues (i.e. the original supplier will typically support maintenance, parts availability, auditing of sub-suppliers etc.).

Lessons Learned from North America: Much of the North American lessons learned experience has been a result of substandard configuration and inventory management from the time of original construction (typically 1970’s and 1980s). This invoked the need for expensive and invasive configuration management restoration (CMR) and design basis reconstitution (DBR) programmes. Much of this effort was spent re-establishing:

- Clear design basis for NPP systems and components (technical specifications, bills of materials, etc.);
- Master equipment lists categorized by equipment criticality to safety or economics, in order to provide a priority system for maintenance and procurement;
- Equipment bill of materials to allow components and piece part maintenance in a targeted effective and efficient manner;
- Preventative maintenance strategies and programmes for SR and equipment critical to operation where failure would cause safety or economic risk to the nuclear power plant.

Approach for New NPPs: For new NPPs it is critical to undertake these activities as part of the design engineering phase and ensure that the following procurement related data is available to the eventual operating organization:

- Specifications for engineering flow diagrams, operational flowsheets, and equipment tags;
• Design bills of materials with clear manufacturer, model, part numbers and descriptions;
• Equipment bills of material and critical spare parts for equipment;
• Single failure analysis to minimize single points of vulnerability for economic reasons;
• Preventative maintenance strategies to maintain critical spares for SR equipment.

For greater clarity, these elements should be specified in detail and included in statements of work or specifications for any engineering, supply, and installation contracts. See section 8.2 below and Appendix I for further details.

**Need for effective contract strategies and incentives:** The UK Royal Academy of Engineering reviewed lessons learned for new nuclear construction [85]. It emphasized the need to ensure contract strategies reflect the risk being carried by each party. Such contracts must clearly define the scope and responsibilities of contractors, and most importantly, that the work must be placed with quality contractors. The report stated that competitive tendering works well for procurement of many goods and services but is not a panacea. For more complex and technically challenging tasks which require a range of special skills, an arrangement is required which provides for incentives for specialist contractors to collaborate and innovate for the duration of the project.

### 8.2 ITEMS TO BE INCLUDED IN NEW NPP CONTRACT REQUIREMENTS RELATED TO OPERATIONS AND MAINTENANCE DATA NEEDS

Procurement documentation for SR and other critical components and structures needs to be available and be stored physically and electronically for a facility’s lifetime. It is vital for these components to remain as close as possible to original specifications to ensure that incidents impacting on safety or production do not occur. Lack of such information on components has led operating organizations to take urgent and costly action in the event that procurement needs arise.

Contracts for new NPPs and other nuclear facilities provide an opportunity to readily obtain required information that can be used throughout a facility’s life. The operating organization at the time of new build contract negotiations has greater leverage over the facility vendor, and thus is in a better position to demand that such information be provided as part of the facility contract. There is industry experience where new operating organizations did not initially obtain this information from their facility supplier, and suffered numerous procurement related difficulties during early plant operation.

There is a distinct value proposition for future operating organizations to fix requirements for their operating phase enterprise data systems prior to these new build contracts being finalized, and include a requirement for the facility supplier and commissioning organizations (as part of their contractual requirements) to populate initial data and utilize such systems. This will prevent development of interim solutions that are later replaced by operating phase systems, minimize duplication of time and effort needed to implement the duplicate system(s), and place the bulk of the cost and effort of system development and implementation at the time when there are most resources available (both time and money) for successful implementation.

The following are examples of documentation to be included at handover of the plant by the facility vendor. Appendix I provides details regarding the specifics of some of this data and some related example enterprise database screens.

- Equipment lists;
- Bills of materials;
- Spare parts lists;
- Q-List (whether item is safety related or not);
- Vendor manuals;
- Criticality codes (item critical to safety or production or not, e.g. AP-913 process [214]);
- Equipment and material specifications;
- Material traceability requirements (UTCs etc.);
- Enterprise database for equipment and materials;
- Spare parts availability guarantees;
- Plant engineering models or simulation tools (including design databases which can include quantity surveying information such as bill of materials quantities);
- Maintenance manuals;
- List of sub suppliers for components and contact details;
- Operations manuals;
- Plant system classification / configuration information (system lists, coding systems used, etc.);
- Lead time of equipment and materials;
- Sub supplier quality control plans;
- Process and instrumentation diagrams for systems;
- Instrument calibration settings (set points, tolerances, and as-left values);
- Electrical models, drawings, and relay settings (set points, tolerances, and as-left values);
- Design calculations;
- Design requirements;
- Design descriptions;
- Inspection and test plans;
- Vendor material and test records;
- Installation records;
- Commissioning records.

Of particular importance for procurement is the grading of items into SR or not (via a Q-list or similar process) or critical or not (via criticality codes or a similar process). This grading drives procurement requirements and thus future efforts needed to purchase parts. By focussing on such lists operating organizations can prioritize their efforts on the most important items and any vendor issues (e.g. financial viability, quality programme maintenance, obsolescence issues etc.) related to such items.

In addition to component data and records, attention should be paid to component related commercial arrangements such as warranties, guarantees, and technology transfer arrangements. Contract language should be developed to ensure that these are in place for critical components, and that they can be transferred to the operating organization upon plant or equipment turnover. Technology transfer agreements are discussed later in section 8.3.3

8.3 SUPPLY CHAIN SUSTAINABILITY

Supply chain sustainability is an issue for new facility construction, and should be taken into consideration when developing business cases, evaluation criteria, and procurement strategies for such projects. The size of the construction programme, contract arrangements,
technology transfer agreements, supply chain of the technology provider, and the extent to which they use standard or readily available components can affect future procurement during a facility’s lifetime, and thus lifetime costs. The follow sections discuss some of the issues.

8.3.1 Size of construction programme

Component suppliers require long-term demand for their products to ensure their financial viability and sustainability. The average life of a new NPP is around 60 years, and so require that components be available over that extended period. The bulk of component purchases for an NPP is however during the initial construction phase, and so single-unit or limited construction programmes run the risk of having limited supplier support over the remainder of their operating life. A single plant in a remote area will be dependent on the vendor organization for parts and equipment for the lifetime of the plant, and delivery lead times will typically be longer. Even countries with large fleets of installed reactors have had to deal with obsolescence and vendor support issues in the absence of robust new build programmes.

A fleet of the same or similar technology within a region helps ensure that suppliers have a secure demand for their components, lowers the average cost of implement nuclear quality management systems, and thus encourages the building of local manufacturing facilities to meet that demand. Jurisdictions with large planned construction programmes have more leverage with suppliers to facilitate more local manufacturing and/or technology transfer agreements.

8.3.2 Contract arrangements

Technology owners are experts in the field of their technology and usually own the intellectual property (IP) related to plant design. Traditional contract models for NPP construction require a transfer of data and other intellectual property related to procurement and other areas (see section 8.2) to the eventual owner/ operator to allow for safe, reliable, and economic plant operation. The extent of such transfers (and their cost) can be an area of dispute between the vendor and the owner/ operator if not negotiated up front.

An equity partnership model where technology owners build, own, operate (BOO), and possibly transfer (BOOT) a nuclear facility can help alleviate some of these concerns. Such models mean that the technology owner shares risk with the owner, and thus typically has fewer issues with sharing IP if it makes plant operation more efficient. Technology owners additionally have long-standing relationships with specific vendors within their respective supply chains, and have access to a fleet of power stations worldwide that provide demand sufficient to maintain the sustainability of required components.

8.3.3 Technology transfer agreements

Technology transfer agreements are designed to ensure that should a manufacturer decide to close down a facility or no longer produce an item, that the owner/ operator would be able to re-engineer or manufacture the component locally. It allows for the IP related to manufacturing the item be transferred to the owner/ operator. The owner/ operator would then contract a different organization to produce the item.

Such agreements are particularly important for SR components and equipment, especially strategic spares. Quality assurance information, quality control plans and testing information can also be transferred as part of this exercise to ensure that there is a smooth transition should the components have to be manufactured in this manner.
New build facility contract language should be developed to ensure that such agreements are in place for critical components, and that they can be transferred to the operating organization upon plant or equipment turnover.

8.3.4 Supply chain of technology provider

When evaluating facility suppliers potential owners need to look at the financial health of suppliers and sub-suppliers, as well as the current technology supply market. First of a kind technology brings additional risk, as lessons learned with the new technology may not yet be incorporated, and a mature, sustainable chain may not yet be present.

It is important to look at vendor and sub supplier liquidity to ensure that component delivery in the immediate to short term is not jeopardized. If sub suppliers show significant losses, it should be a warning that the market may not be sustainable. Possible solutions for these components or suppliers could be negotiated before contract signature.

Such reviews can follow a graded approach based on criticality of the components provided. Sub supplier management and databases, non-conformance reports, lessons learned reports, documentation control, can be prioritized to ensure that they are receiving the attention deserved. Industry databases that monitor financial positions of sub-suppliers (e.g. credit rating agencies) can be used to identify and track risk profiles.

8.3.5 Standardized choice of components

Nuclear facilities use a combination of custom and standard “off-the shelf” items. The extent to which local, readily available, standard items are used can be a vendor evaluation criterion. Nuclear does have very specific requirements, but off-the-shelf items do allow for a more sustainable supply market that can support local manufacturing facilities and demand.

8.4 HARMONIZATION EFFORTS

It may be noted that complementary to the IAEA initiatives to support the safe, secure and peaceful use of nuclear energy, other organizations are also active in supporting its members for the benefit of the whole community. New owner operators should become aware of such initiatives, support them actively, and seek to develop them further in their jurisdictions.

8.4.1 World Nuclear Association

The World Nuclear Association is the international private-sector organization supporting the people, technology, and enterprises that comprise the global nuclear energy industry. WNA members include the full range of enterprises involved in producing nuclear power – from uranium miners to equipment suppliers to generators of electricity.

Since 2007, the WNA “Cooperation in Reactor Design Evaluation and Licensing Working Group” (CORDEL WG) has promoted standardization of nuclear reactor designs. This can only be achieved by development of a worldwide regulatory environment where internationally-accepted standardized reactor designs, certified and approved by a recognized competent authority in the country of origin, can be widely deployed without major design changes due to national regulations. There is no doubt that additional to safety benefits for the whole community, harmonization of practices (including regulatory practices) and standardization will contribute to establishing and maintaining a robust supply chain that will facilitate effective and efficient management of procurement activities.
WNA has also established a “Supply Chain Working Group” that cooperates closely with the CORDEL WG, given that the main goals of this group are tied closely with those of the CORDEL WG in various aspects of nuclear safety. The Supply Chain WG is devoting increased attention to supporting companies in building the complex supply chains needed to ensure timely project realization, while satisfying safety, quality and other procurement and regulatory requirements. The ‘Vendor Oversight and Control of Suppliers’ Task Force (VOCS) is examining the scope for cooperation between vendors in developing common core standards for quality management systems, and in control of critical production processes. Such initiatives are expected to contribute facilitating the increased application of the “off-the-shelf” approach discussed in section 8.3.5 above.

The WNA “Nuclear Law and Contracting Working Group” addresses legal issues facing the nuclear industry. It is an expansion of a previously constituted task force on nuclear liability and has a broader scope of work. The group focusses on key legal, regulatory and procurement aspects of nuclear new build that are of concern to the nuclear industry. As an additional function, the working group will engage with other working groups and offer assistance when necessary on ways to respond to related challenges.

8.4.2 Quality assurance audits

As discussed in 3.3.3 sharing quality assurance audit findings is useful and virtually necessary in the current global nuclear supply market. New owner operators are encouraged to join and participate in industry common auditing organizations, and actively report adverse findings with their suppliers to such organizations. Efforts to standardize quality programmes should also be encouraged.

Pat to add a few lines on collaboration in NA utilities on QA audits

8.4.3 Sharing of spare parts

New owner operators are at a disadvantage in that they need to maintain an adequate level of parts inventory for a single or small number of operating units. Many operating organizations have taken steps to collaborate on spare parts, by taking such actions as sharing strategic spares, forming purchasing alliances with other operating organizations, or even sharing centralized warehouse facilities. An example of a purchasing alliance in the USA is the STARS Alliance, which includes the Callaway, Comanche Peak, Diablo Canyon, Palo Verde, and Wolf Creek NPPs [215]. They cooperating organizations all operate large, Westinghouse designed, relatively new, PWRs in NRC Region IV.

Technology vendors or technology specific organizations (e.g. CANDU Owner’s Group, BWR Owner’s Group, PWR Owner’s Group, etc.) often can assist in these arrangements.

Mention collaboration on spare parts (e.g. China sharing of spares) – need details from Cai

Pat to add a few lines on collaboration in NA utilities on sharing of components between utilities.
9 SUMMARY AND CONCLUSIONS

Procurement related activities have a key impact on safety. Graded approaches allow utilities to focus efforts on critical equipment and ensure that supply chain processes do not adversely affect safe operation of an NPP.

Documentation needs to support the procurement process are large. These typically include a full list of components installed in the NPP, their criticality to plant safety or economic operation, and their supporting bills of material, spare parts listings, drawings, specifications, and maintenance manuals. The ability to track items from original suppliers through to plant installation locations needs to be established. Such data needs for should anticipated at the contractual stage for new NPPs, and included in formal documentation to be turned over to the NPP operator by the NPP vendor.

In some jurisdictions a dedicated PE organization has been found to be useful to execute PE related activities. Such activities are specialized in nature, and a dedicated organization can be more efficient and produce higher quality product in a shorter time.

Operating organizations should not take it for granted that a robust supply chain will be available for their plant equipment over extended plant lifetimes. They need to take proactive steps to understand national and global procurement marketplaces, analyse critical plant equipment that is either low purchasing volume or has few known suppliers, and take appropriate actions to ensure required items are available. Collaboration among operating organizations is recommended and has been shown to be useful in other industries.

Software and digital equipment is increasingly found in industry. NPPs need to be aware and put processes in place to request declaration of any software or digital equipment included within vendor products, qualify and control such software, and address computer security issues within procurement requirements.

Counterfeit or fraudulent items are an increasing problem for industry. NPPs need to be aware and put processes in place to detect and report suspected CFSIs. These include ensuring good knowledge of supply chain participants, and putting processes in place to transmit requirements down the supply chain, and monitor and evaluate SC performance.

Unplanned changes in NPPs caused by marketplace forces are not desirable. Such changes can have undesirable safety or economic impacts. Inevitably however there will be changes in the marketplace over the period of plant operation. NPPs need to continuously anticipate and manage such changes to ensure that quality parts and services are available on an ongoing basis to support safe and economic operation.
APPENDIX I. PROCUREMENT RELATED DATA NEEDS

I.1. BACKGROUND

As discussed in section 5.10 NPPs have large data needs associated with procurement and supply chain processes. Although much of this data was generated via paper systems for older NPPs, most utilities have or are moving to systems whereby most or all of such data is stored in integrated enterprise database systems. For new plants engineering design information, such as design bases, calculations, and specifications, is typically electronically linked to 3-D models to ensure consistency with design requirements.

Such data sources provide easy access to design requirements throughout the plant life cycle. This provides the benefit of being a “single source of truth” for NPP staff where accurate, current data can be obtained surrounding plant equipment, materials, approved design configurations, and work tasks. The rest of this Appendix describes what some of the data needs are supporting typically NPP procurement functions.

I.2. EQUIPMENT LISTS

The master equipment list (MEL), also known as the material equipment list, contains information on a facility at the component level relating component function to the design basis. In enterprise systems each plant item (equipment location) is linked to plant documentation such as drawings, bills of material, spare parts, work orders, calibration settings, calibration records, maintenance call-ups etc. Each location is identified with an “equipment tag” which uniquely identifies the location. Typical schemes include a unit number, system code, equipment type, and a number. For example “3-33120-PM1” might refer to unit 3, heat transport system {system code 33120}, pump motor #1. Indications as to whether the equipment is safety-related, seismically or environmentally qualified, or a critical spare is also often provided in the MEL and linked to the equipment location.

The relationship between equipment tags, stock codes (section I.3) and bills of material, (section I.4) is shown in Fig. 25 below. In the example there are six equipment tags (i.e. six field locations) using two BOM headers (i.e. three equipment locations use one BOM header assembly and the other three use the second BOM header). Each of the two BOM headers has some unique and some common individual piece parts (e.g. in the example “Part 3” is used in each assembly).

![Fig. 25. Relationship between equipment tags, bills of material, and stock codes.](image-url)
Fig. 26 shows an example enterprise MEL application for the Dukovany NPP unit 3 with a filtered list of equipment (all equipment beginning with “3RA” – armatures). This panel allows users to select the equipment of interest and to look for its components (i.e. to drill down in the structure).

I.3. CATALOGUE ID / STOCK CODE NUMBER

A catalogue ID (CAT ID) or stock code number represents a unique equipment assembly or piece part used at a facility. It is the typical item that is ordered from a supplier as a purchase order line item (e.g. a valve, motor, electronic device, reel of cable, spare part, etc.), or simply a convenient way to represent an assembly of items that might be bought separately (see Fig. 25). CAT IDs are linked to a description of the item’s technical and quality requirements (see section 3.2). CAT IDs may be used in multiple locations and on multiple systems in an NPP.

Unique numbers for CAT IDs are produced and controlled by operating organizations since vendors or suppliers may utilize duplicate numbers or may perform substitutions of components or make other changes within their internal number systems. A screening process for new CAT ID creation within the procurement organization is often useful to minimize the chances of producing duplicate CAT IDS and thus stocking excess material.

Figure 27 shows a catalogue ID description for a handswitch and related equipment that use the catalogue ID number (i.e. where the item is installed) at an Ontario Power Generation (Canada) NPP. Note that the same catalogue item has both SR and non-SR applications.
FIG. 27. Catalogue description for a handswitch and related equipment that use the catalogue number (courtesy Ontario Power Generation).

I.4. BILLS OF MATERIALS

A bill of material (BOM) is a list containing the quantity and description of all materials required to construct a component [52]. In this context a BOM is and “equipment BOM” or E-BOM in that it applies to an equipment assembly. This is in contrast to a “construction” or “design” BOM used to list all material to be purchased for a portion of a project (which might include typical “non-equipment” coded items such as connectors, cable trays, construction spares, etc.). E-BOMs are typically hierarchical in nature with the top level representing the entire component (for example a valve assembly), lower tiers representing major sub-components (e.g. valve actuator, valve itself), and even lower tiers detailing individual parts that make up the item separately (Fig. 25). Not all items on a BOM may be stocked as spare parts, and the top level item or some lower tiers may not be stocked as assemblies.

A BOM is a description of an equipment hierarchy, and can be applicable to multiple locations / equipment tags within an NPP. Additionally multiple BOMs may be acceptable for a given equipment location (e.g. two acceptable but different valves may be used in a given location). Plant enterprise systems would keep track of which approved BOM is installed at a given location.

Figure 28 shows a typical bill of material headers within an NPP’s enterprise system (“top level” BOM). Selecting one of the rows of the BOM would drill down to a lower tier. A sample level 2 BOM for the item shown in Fig. 28 is shown in Fig. 29. A similar application at Dukovny is shown in Fig. 30.
FIG. 28. Top level ("level 1") BOM for an annunciator (courtesy Ontario Power Generation).

FIG. 29. Lower level ("level 2") BOM for annunciator spare parts (courtesy Ontario Power Generation).
I.5. SPARE PARTS LISTS

Spare parts lists are the identified recommended spare parts that an operating organization has decided to stock. Such lists are typically derived considering manufacturer recommendations, maintenance feedback and strategies from the operating organization, supply chain stocking strategies, usage data from similar plant components, and engineering judgement.

In enterprise systems spare parts lists are often integrated with BOMs by linking approved reorder points and reorder quantities for restocking to individual BOM items. Some systems have the capability to develop a parts list based on past parts usage/issues for a given component.

I.6. Q-LIST

As described in Section 3.2, a Q-list describes whether equipment in an NPP is safety-related (SR) or not. It is frequently derived from an equipment tag database field in the MEL (i.e. a Yes/No flag for being SR or not).

Figures 31 and 32 illustrate how this information can be coded in an enterprise application. The "Safety Class" field of Fig. 31 shows an item as being safety related (denoted as “SR”) with a quality level (Q-level) of “1”. The equivalent safety class field in Fig. 32 (“Bezpečnostní třída”) shows the safety classification directly (“2” in the example); also shown is seismic class information (in this case seismic class “1A”), and component criticality (“A” in this example).
FIG. 31. Sample Q-list information with safety class = SR and Q-level = 1 together with critical equipment code = 1 (courtesy Ontario Power Generation).

FIG. 32. Equipment data panel for Dukovny NPP showing seismic class data, criticality level (based on risk classification), and safety level (according to legislation) (courtesy CEZ Group).

I.7. VENDOR MANUALS

Vendor or maintenance manuals are instructions provided by suppliers as to how to properly maintain (and often install or operate) their supplied equipment. In enterprise systems they are typically scanned, treated like other controlled documents, and linked to applicable equipment. Figs. 33, 34 and 35 show how such manuals can be linked to equipment in an enterprise system. Many jurisdictions have required extensive efforts to recontact vendors to reconstitute plant vendor manuals to an acceptable state.
FIG. 33. Vendor manual document number linked to equipment tag (courtesy Ontario Power Generation).

FIG. 34. Reference to maintenance manual in Dukovny NPP enterprise system (courtesy CEZ group).

FIG. 35. Maintenance manual referred to in Fig. 34 (courtesy CEZ Group).
I.8. CRITICALITY CODES / CRITICAL EQUIPMENT LISTS

A list of critical equipment is typically identified based on importance to safety function, safe shutdown capability, and power generation capability. Insight from probabilistic assessment techniques is considered in this determination [214]. Plants often define such list (in part) to be able to grade purchasing and other requirements related to the equipment in question. A set of codes can be developed to further refine the list. The INPO AP-913 equipment reliability process [214] defines one such methodology and divides equipment into categories of highly critical, low critical, non-critical, and run-to-maintenance. An EPRI report [216] provides some examples of how criticality coding has been implemented at some NPPs. Enterprise systems would include such criticality coding into the information stored against each equipment item.

Figures 31 and 32 in section I.6 above shows how criticality information can be stored in an enterprise system by using a “critical equipment” field.

I.9. EQUIPMENT AND MATERIAL SPECIFICATIONS

Equipment or material specifications are the technical requirements produced by design and/or procurement engineering to order the equipment or material in question. Such specifications would be linked in enterprise systems to the applicable equipment tags.

Figures 36 and 37 shows some such equipment specification data stored in an enterprise system (type, class, and specification). Depending on an organization’s management system the information can be directly stored in the database (i.e. the database itself is the approved specification), or be transferred or cross-referenced to the database based on an approved (separate) specification document. Increasingly the trend is toward the former type of system as it allows details to be more readily accessible by facility staff.

FIG. 36. Equipment specification linked to equipment tag sample (courtesy Ontario Power Generation).
I.10. MATERIAL TRACEABILITY CONTROLS

As described in section 3.11 NPPs need the ability to track individual items purchased to specific end locations in a plant to allow for retrieval of items later found to be non-confirming or deficient. As stock codes are not specific to a single individual item purchased, serial numbers may not be present on some items, and serial numbers may be duplicated by different manufactures, enterprise systems often assign a unique number to items that is applied by the plant upon receipt. Such numbers are often called UTCs for uniquely tracked commodity. To use UTCs effectively processes need to be in place for staff to update the enterprise system when items with UTCs assigned are installed or removed from the power plant.

Figure. 38 shows a UTC assignment field for a component that is filled in upon receipt by the receiving organization. It includes information on the producer/supplier, internal producer/supplier tracing numbers (e.g. serial numbers), and other tracing references. When the device is installed in the plant the applicable equipment tag is updated to reflect the item’s installation (i.e. UTC number is linked to equipment tag).
I.11. WAREHOUSE CONTROLS

As part of their tracking functions, good warehousing tools are needed to support NPP operations. Such tools would allow for item tracking to specific storage locations (including temporary storage areas like those for items awaiting receipt inspection or items in quarantine), shelf life tracking, in-storage maintenance, and required environmental and storage conditions.

Fig. 40 shows an example list of predefined warehouse storage conditions for an NPP (letters H-Z represent different conditions such as temperature controlled warehouse, moisture control, fire protection required, nuclear safety requirements, chemical, etc.). Figure 41 indicates stock availability levels for a component (potentially divided in a number of locations or on order), and Fig. 42 shows a specific warehouse location for an item.
FIG. 40. Dukovny NPP warehouse storage conditions (courtesy CEZ Group).

FIG. 41. Dukovny NPP available stock for high-pressure 7-step horizontal pump (courtesy CEZ Group).
I.12. MAINTENANCE STRATEGIES

Maintenance strategies are published guidance at NPPs regarding maintenance practices to be performed on a class of components. They are used to assist and align the efforts of work planners, engineers, and the procurement organization. For example some plants may promote policies of component replacement instead of component repair based on replacement cost of the component when compared to a typical repair cost. An example might be any valve 50 mm or smaller in size might be replaced in its entirety and not repaired with spare parts.

I.13. PROCUREMENT SOURCING STRATEGIES

A procurement sourcing strategy is a document which contains tactical and operational information to guide future procurement decisions. NEI defines strategic sourcing as a systematic process that directs purchasing and supply managers to plan, manage, and develop the supply base to accomplish site and company strategic objectives while at the same time managing business risks [52]. Sourcing strategies are based upon assessments of historical and forecast spending, the supply market, total costs, and supplier availability. Strategies should provide guidance as to where to purchase, considering demand and supply situations, while minimizing risk and total costs. Such a plan may identify key suppliers that an NPP
wishes to do business with for cost or item criticality reasons, and as such is needed by individuals placing orders for an NPP.

I.14. VENDOR MATERIAL AND TEST RECORDS

NPPs typically are required to verify that documents attesting to the quality of components used in the manufacturing process, including material certifications, test reports, receiving inspections, evaluations, and audit results are maintained to indicate that quality requirements have been met. Vendor material and test records thus need to be retained and be retrievable by NPP staff. Enterprise systems typically provide capability of such records to be electronically scanned and stored upon receipt for the life of the facility.

Fig. 44 illustrates how documents such as vendor material can be linked in enterprise systems to an equipment tag or location. In this case eight different documents are shown as related to the equipment in question.

FIG. 44. Documents related to an equipment tag / location (courtesy CEZ Group).
APPENDIX II. PROCUREMENT RELATED EXPERIENCE AT NPPS (OPEX)

II.1. CANADA

Canada has 19 operating NPPs at four sites, with three operating organizations (Ontario Power Generation, Bruce Power, and New Brunswick Power). All stations are PHWRs of CANDU design, and went into service between 1971 and 1993. Some units have undergone major mid-life refurbishments. The following describes typical procurement issues that have and continue to impact the installed fleet.

II.1.1. QA vendor programme decline and implications

Declining QA programmes decreases efficiency: From the time NPPs were built to the time they came into operation, overall demand for components/parts declined. Numerous vendors responded by not maintaining their vendor QA programmes, since it is not beneficial for them to do so. As a result, a number of changes have occurred.

Decline of vendor QA programmes inherently decreases efficiency and increases risks as operating organizations shift from reliance of vendors avoiding mistakes (via QA programmes) to one of catching mistakes (via commercial grade dedication (CGD)). It can be said that “most manufacturers are good but do less QA or the least QA they can document”.

CGD is expensive: There is a greater reliance on commercial grade dedication (CGD). As operating organizations attempted to implement/improve the PE function, CGD plans were prepared by the operating organizations and were initially somewhat crude. Costly source surveillance may have been utilized, and testing was either performed at the operating organization or outsourced. As time progressed, operating organizations switched to relying more on third party dedicators to plan and perform the dedication. These dedicators tend to be costly, and there are limited choices for third party dedicators in Canada in comparison to USA.

Initially, difficult to execute necessary number of audits for vendor QA programmes: When the PE function was first implemented; there was a drive to rely more on QA vendor programmes (as opposed to source surveillance). As a result and with increasing rigour, those vendors identified as having reliable vendor QA programmes would need to have their programmes audited. Previously audits may not have been performed in a timely fashion or perhaps not even done at all. This resulted in a difficult to manage and large backlog of audits. For some time, SR items were procured from vendors with expired or non-existent audits.

To address this audit backlog, operating organizations began to accept audits conducted by others, e.g. CANPAC and NUPIC instead of solely relying on their own audit teams. This helped ensure timely audits were conducted.

Obsolescence continues to be an issue: As the fleet aged, changes in the marketplace occurred (component design changes were made by vendors, manufacturers went out of business, etc.) and obsolescence became a larger issue. Operating organizations have to rely on their engineering organizations to disposition obsolescence on a case by case basis. Electronic parts in particular predominate these issues.

Decreased and optimized the number of vendors on the ASL: Over time, operating organizations reduced their number of vendors that required vendor QA programmes (or the vendor ceased to maintain it) to a more optimized level. This allowed greater focus, enabling more effective and timely audits.

Utilities have reduced costly source surveillance: Where QA vendor programmes have been maintained, operating organizations rely further on those programs and less on source surveillance. During construction, operating organizations relied heavily on source
surveillance (whether or not QA programmes existed) conducted by the operating organizations themselves. This bias towards source surveillance, although declined after construction, and declined again after the PE function was implemented (where PE was predisposed to specifying QA requirements including vendor QA programmes), persisted until the last several years. Utilities have reduced source surveillance to a minimum the last several years. Money was being spent on to ‘double check’ vendors via source surveillance even though vendor QA programmes had been audited and premiums were paid for components/parts with the necessary pedigree.

II.1.2. Other Items

Receipt Inspection is good: It appears that receipt inspection has been and continues to be performed well by operating organizations. With the implementation of PE, receipt inspection rigour was increased, particularly in terms of documenting receipt inspection activities (both in plan and execution).

Non safety-related, trust vendors: For components that are not SR (or augmented quality), operating organizations now rely on vendors more to provide correct and satisfactory materials. In the past, non-SR materials may have received equivalent procurement rigour (buy everything with the same methodology).

Equivalency vs design change: As change occurs, e.g. obsolescence, the need to perform a design change versus an item equivalency will come up. If an item is equivalent, approvals are normally easier, quicker and less costly. ‘Production pressures’ will often drive towards equivalency when in fact the change may actually be a design change.

Counterfeit, new concerns: Counterfeit items is a topic gaining more interest by regulators. Counterfeit items do not appear to be an issue yet but supply chains have become more global and more complex, and regulators are proactively focusing on this. Recent regulatory changes have required counterfeit item reporting to the regulator. Currently utilities are creating awareness and training supply chain personnel (on early detection and what to look for) on the subject of counterfeit items.

II.1.3. Configuration Management

With the implementation of the PE function in the 1990s, in response to regulatory pressures to improve procurement rigour, it became apparent the necessary constructs to execute the PE function effectively were not in place. These constructs were also fundamental to executing other aspects of the nuclear business in a safe and effective way. They included data sources such as equipment list, bills of material for sustaining maintenance, associated warehouse and procurement information. These data sets are inter-related and necessary for PE to identify end uses of the items that are procured. This is a necessary first step in determining if items are SR, and an input to what if any quality and technical requirements are required. Reconstituting these data sets via configuration management restoration projects was a costly yet necessary first step in ensuring procurement (among other things) could be done effectively. This subject was more thoroughly discussed in section 8.1.

II.1.4. Supply Chain ‘volume flow rate’

Piece part warehouse stock was not always supportive of timely maintenance. A number of variables contributed to not having the correct stock for maintenance activities. Variables included; changing maintenance strategies resulting in changing warehouse stock needs, backlogged supply chain due to new processes (e.g. implementation of the PE function), obsolescence, unqualified vendors, etc.
In response to limited stock availability, maintenance organizations would attempt to pro-actively order any and all parts that could conceivably be needed at some time in the future. Unfortunately, this aggravated conditions further.

As it pertains to material procurement, it began to be understood that the volume flow rate of the procurement process organization is limited (analogous to a piping system). If one orders more than the capacity of the process, one will not get all the material requested. This flow rate is limited by the most resource-constrained activity (i.e. the most “bottlenecked” organization). Priority alignment is critical for the various backlogs. On the assumption that material needs are greater than capacity of the process, without good priority alignment, it is uncertain that the most important material will actually be procured in a timely fashion. Much effort has gone into systems to streamline and align the various players (e.g. PE, designers, buyers, expediter, warehouse staff, work packages assessors etc.) that are needed to perform all the activities required to identify and obtain items from suppliers for use in the plant.

II.2. CHINA

Cai/Anqi

II.3. RUSSIAN FEDERATION

Tepkyan

II.4. SLOVAKIA

Jana

II.5. SOUTH AFRICA

Ahmed

II.6. SOUTH KOREA

Ko

II.7. USA

EPRI/ Tannenbaum?
APPENDIX III. NON-NUCLEAR INDUSTRY EXPERIENCE

Nuclear is not the only industry that has safety and quality as shared goals. Aerospace, defence, transportation and medical devices are notable examples that have developed auditing processes that provide potential lessons for nuclear.

For example like NPPs, aircraft are designed to perform for long periods of time (50 years or more), and properly maintaining aircraft is essential for their continued safe operation. Major aerospace manufacturers typically source supplies globally, making standardization of quality programmes and sharing of auditing results beneficial.

Within aerospace, an industry wide programme called Nadcap was set up in 1989 administered by the not-for-profit Performance Review Institute (PRI) to establish requirements for accreditation, accredit suppliers, and define operational programme requirements. All major aerospace companies (e.g. Boeing, Airbus, Bombardier, Embraer, and others) participate, and approximately 5000 supplier audits are performed each year. Non-conformances are responded to in a similar way as one might expect in nuclear, with auditees needing to provide information on immediate corrective actions taken, root cause of the non-conformance, impact of all identified causes and the root cause, action taken to prevent reoccurrence, objective evidence related to all findings, and effectivity date [217]. Nadcap allows for extended frequency audits (audits may take place up to every 24 months although the initial period of accreditation is 12 months) depending on audit performance.

An interesting feature of the Nadcap audit process (Fig. 45) is the step where by an industry wide task group has the opportunity to review audit results. Task force members have 14 days to approve the audit for accreditation or raise additional questions. In case of questions, the responsibility passes back to the PRI staff engineer to resolve with the supplier. The vast majority of the time, however, because of the work put in by the supplier and staff engineer, the task group supports accreditation and PRI sends out a certificate to the supplier.

Prior to Nadcap, aerospace companies audited their own suppliers to their own process requirements to verify compliance. Many audits were consequently duplicates or redundant and simply added to everyone’s workload and costs without adding value.

AS9100 [218] is a common quality management standard for aviation, space and defense organizations developed by SAE International. It incorporates ISO 9000, while adding additional requirements relating to quality and safety. Major aerospace manufacturers and suppliers worldwide require compliance and/or registration to AS9100 as a condition of doing business with them. Having such a standard quality management system throughout the industry simplifies auditing and facilities globalization of the supply chain.

Within transportation, PRI is developing an accreditation programme based on the aerospace industry’s Nadcap programme. The programme is intended to, like Nadcap, have broad participation from all industry stakeholders. PRI has worked with GE Transportation to develop the initial implementation. GE Transportation, as part of its commitment to high quality standards, has begun requiring that its special process suppliers obtain a transportation and power generation accreditation.
Similar within the medical devices industry, PRI is administers the MedAccred industry-managed supply chain oversight programme that reduces risk to patient safety by addressing many of the challenges posed by today’s global, multitiered supply chain. Regulatory requirements addressed include US Food and Drug Administration (FDA) requirements, the ISO 13485 medical devices quality management system [220], and the European Medical Device Directive (MDD) [221]. In the USA purchasing controls is one of the top cited FDA inspection observations for medical device quality system, and such violations has been included as an element of several enforcement actions (warning letters, consent decrees etc.) [222].
APPENDIX IV. INVENTORY DEMAND MANAGEMENT CALCULATIONS

Analysis can be performed on historical parts usage and projected future demand to minimize transaction costs related to the stocking process. Establishment of proper reorder points, reorder quantities (ROQs), and safety stock levels is important to efficient operation. This Appendix provides some examples of calculations that can be performed.

With constant demand and known lead time, the ROP is calculated as follows:

\[ \text{ROP} = [\text{Daily usage} \times \text{Lead time (in days)}] + \text{safety stock} \]

Safety stocks are designed to address unusually high usage conditions or delays in vendor delivery. For NPPs a key issue is the appropriate levels of safety stock. Item criticality to plant safety or economics should be used to help determine adequate safety stock levels.

The appropriate economic order quantity (EOQ) is a well-known inventory concept and is calculated by the following formula [223].

\[ \text{EOQ} = \sqrt{\frac{2DQ}{Hc}} \]

where,

- \( \text{EOQ} \) = economic order quantity;
- \( D \) = annual product demand in quantity per unit time. This can also be known as a rate;
- \( S \) = product order cost. This is the cost of making an order and is independent of EOQ;
- \( C \) = unit cost;
- \( H \) = holding cost per unit as a fraction of product cost.

Typically the ROQ in an operating organization purchasing system would be set to the EOQ. Lowest costs for a company occur at the EOQ where the holding cost of an item (H) equals the order cost (S). More advanced methods of forecasting including annual or seasonal trends or known major activities such as outages or refurbishments can be used to refine ROQ calculations for specific purchases and to minimize costs even further.

The above equation is adjusted if an item has an established shelf life. For such items the benefits of reducing fixed costs are eliminated if the ROQ is set so large that stock will reach the end of shelf life before issue. Thus it is required to determine the largest quantity of stock that can be used before the end of shelf life.

\[ \text{ROQ} = SL \times UR \]

where:

- \( \text{ROQ} \) = reorder quantity (based on shelf life and usage)
- \( SL \) = shelf life in years
- \( UR \) = long-term average usage rate in number used per year or cycle

The proper order quantity ROQ is now the lower quantity calculated via the two methods. However, if a minimum order quantity larger than ROQ is required by a supplier, ROQ may need to be increased to this minimum order size.
APPENDIX V. SAMPLE PO PARAGRAPHS

EPRI has defined a number of standard clauses related to procurement of items and delivery of substandard and counterfeit items (Appendix A of [51] and other sources). These have been adapted below for an international audience and updated. The list is not intended to be all-inclusive. Operating organizations may wish to consider use of similar paragraphs in their procurement documents, with wording modified to meet requirements and policies specific to each operating organization.

V.1. MANAGEMENT SYSTEM

The items/services shall be provided in accordance with the Supplier's/Manufacturer's management system, Rev. No., dated which has been approved by the Buyer's quality organization at the following location:

The supplier shall maintain and implement this management system in accordance with ________________ (applicable standard) and allow access to his facility and records pertaining to this purchase order for the purpose of quality assurance audits/surveillances at mutually agreed times. The supplier shall extend applicable requirements to lower tier subcontractors and suppliers, including the buyer's right of access to those facilities and records. The Supplier's approved management system shall be applied to all safety related parts regardless of other requirements.

V.2. RIGHTS OF ACCESS

The Buyer shall have rights of access to the Supplier's and any sub tier supplier's facilities and records for inspection or audit by the Buyer, their designated representative and/or other parties authorized by the Buyer. This shall include, but is not limited to, the right to audit material, test, inspection, services, and quality records; make surveillance visits during manufacturing; and witness tests to the extent the Buyer deems necessary to assure that work is being performed in accordance with all product design and manufacturing requirements.

V.3. ADDITIONAL MANAGEMENT SYSTEM REQUIREMENTS

Additional management system requirements: ________________

V.4. NATIONAL NON-CONFORMANCE REPORTING REQUIREMENTS

The requirements of ________________ (national non-conformance reporting requirements, where applicable, e.g. 10 CFR 21) apply to this Purchase Order. If you or one of your suppliers identifies a condition requiring evaluation by the Buyer to make a determination regarding reportability under these national non-conformance reporting requirements, you are requested to immediately contact the following:

Manager, Nuclear Quality
(Purchasing Utility Name, Address, and Phone No.)

V.5. COMMERCIAL GRADE AND NON-SAFETY RELATED ITEMS

All items, and parts thereof, supplied to this Purchase Order are considered to safety related items when shipped by the Supplier unless otherwise stated by the Supplier. When a safety
related item supplied on this Purchase Order incorporates one or more commercial grade parts in its construction, the Supplier shall maintain traceability to the appropriate commercial grade dedication documentation demonstrating acceptability of the commercial grade part(s) for use in that safety related item and shall provide the Buyer access to such documentation upon request.

Parts of safety related item the Supplier considers to not be safety related shall be listed and the basis of this determination shall be documented and maintained by the Supplier. The Buyer shall have access to such documentation upon request.

The Supplier shall specifically identify those items, or parts thereof, which are commercial grade and have been accepted for use as safety-related (i.e., commercial grade items dedicated for use as safety related items) and shall transmit this information in writing to the Buyer, prior to acceptance of the Purchase Order. This information shall be transmitted to:

(Purchasing Organization Name and Address)

The Supplier shall specifically identify those items, or parts thereof, which are non-safety related items when supplied and shall transmit this information in writing to the Buyer, prior to acceptance of the Purchase Order. This information shall be transmitted to:

(Purchasing Organization Name and Address)

V.6. ENVIRONMENTALLY QUALIFIED ITEMS

The items on this Purchase Order are replacements for items that have been environmentally qualified. Replacements must be the same (same materials; model, functional properties, etc.) as those originally qualified per _____________________________.

If a change or substitution is proposed, an evaluation must be completed and submitted to the Buyer to determine if the item is environmentally adequate and approve the substitution prior to shipment.

V.7. NO SUBSTITUTIONS

The Supplier shall not substitute other items for the items requested without specific written approval of the Buyer prior to shipment.

If the Supplier identifies changes, non-conformances, or seeks waivers from other requirements of this Purchase Order, the Supplier shall describe such conditions and this information shall be transmitted, in writing, to the Buyer at the following address:

(Purchasing Organization Name and Address)

If the requested information is approved by the Buyer, the Supplier shall include an approved copy of the information statement with the items shipped.

The Supplier shall identify any change made to upgrade any item on this purchase order as a result of regulatory correspondence. Changes as part of the Supplier’s product improvement programme shall also be identified and transmitted in writing to the Buyer's purchasing department for approval.

V.8. NON-CONFORMANCE REPORTS

The Supplier shall provide a copy of all non-conformance reports dispositioned as repair or use-as-is generated during manufacture or processing of this order. This report shall include technical justification for non-conformance dispositions. All dispositions which do
not return an item to the conditions stated in an approved drawing or specification shall be approved by the Buyer prior to the shipment of the affected item.

V.9. MATERIAL COMPATIBILITY REVIEW

Materials may be supplied to a later revision of the applicable standard provided that the later revision meets or exceeds the requirements of the revision year cited. The material standard compatibility review shall be conducted and maintained by the supplier.

V.10. PRESSURE BOUNDARY CODE REQUIREMENTS

Applicable pressure boundary code items shall meet: Code Edition: ____________

Material for items governed by the rules of (applicable pressure boundary code) may be supplied to a later Code Edition or Addenda provided that all the requirements of the original Code Edition and Addenda of (applicable pressure boundary code) are met and the material is certified accordingly. In addition, the Supplier shall provide the Buyer with a statement of code reconciliation, if required.

V.11. QUALITY SYSTEM CERTIFICATES

(Applicable pressure boundary code) Material Procurement for Material Manufacturers or Material Suppliers with (applicable) Quality System Certificates:

☐ Material shall be supplied in accordance with (applicable pressure boundary code) under an approved management system by a Material Manufacturer (MM) or Material Supplier (MS) having an (applicable certification);

☐ The Material Manufacturer shall include his Certificate Number and expiration date on the CMTR or Certificate of Compliance as required by (applicable pressure boundary code).

V.12. PROCEDURE/CERTIFICATION APPROVAL

Suppliers performing work on site at the utility who plan to use their own procedures shall submit the procedures to the designated representative listed below for review and approval.
Name: _______________ Phone: _______________ Ext: __________

Supplier shall not commence work until such procedures have been approved.

Suppliers who propose to use their own measuring and test equipment shall have calibration certificates traceable to a national certification organization acceptable to the Buyer or other documentation establishing the basis for calibration. All questions regarding measuring and test equipment shall be directed to the designated representative.

Contractor shall provide the following personnel certifications prior to the start of work:

__________________________________________
__________________________________________

V.13. SOURCE INSPECTION/SURVEILLANCE NOTIFICATION

The Supplier shall provide access to the Supplier's plant facilities and records pertaining to this purchase order for the purpose of planning and performing source inspection/
surveillance activities. The Buyer requires days advance notice for the purpose of establishing hold points and hours advance notice that the Buyer witness or hold points have been reached.

The Supplier shall contact the Buyer's designated representative when a witness or hold point has been reached and the Supplier will not proceed past that point until inspection has been established or waived by the Buyer.

Contact: ______________ Phone Number: ____________________

V.14. WITNESS/HOLD POINTS

The following witness/hold points apply:

____________________________________

____________________________________

V.15. RECORD RETENTION

Documented records shall be maintained to show objective evidence of quality. Quality records shall not be destroyed or disposed of without authorization from the Buyer. After completion of work, the Buyer shall have the opportunity to take possession of such records.

V.16. DOCUMENTATION

The following documents shall be shipped with items supplied. Every page of each document shall be traceable to the Buyer's purchase order and applicable item(s) number.

Documents submitted prior to shipment or subsequent to shipment including revisions of these documents, shall be directed to the following:

(Purchasing organization name and address)

☐ Statements;
  o Statement of identification as commercial grade item;
  o Statement of conformance with suppliers management system;
  o Quality programme / management system;
  o Statement of approved change, non-conformance or waiver;
  o Statement of code (pressure boundary) reconciliation (if required);
  o Shelf life;
  o Statement of: ________________;

☐ Certifications;
  o Certificate of conformance (C of C) with purchase order requirements;
  o C of C with IEEE-344 (Seismic);
  o C of C with IEEE-323 (EQ);
  o Certificate of equivalency with items originally supplied;
    ▪ Make: ________________;
    ▪ Model: ________________;
    ▪ Serial No: ________________;
    ▪ Original Specification: ________________;
  o C of C to time-current curve;

☐ Test Records;
  o Non-destructive Examinations;
    ▪ Ultrasonic (UT);
    ▪ Eddy current (ET);
- Radiographic (RT);
- Hardness;
- Magnetic particle (MT);
- Liquid penetrant (LPT);
- Other:____________________;

○ Material Properties;
  - Impact (Charpy v-notch, drop weight) at temp:____°C;
  - Dielectric strength;
  - Flattening;
  - Welding;
  - Bend;
  - Flame (IEEE-383);
  - Proof load (fasteners);
  - Insulation resistance;
  - Other:____________________;

○ Design/Fabrication;
  - Pneumatic pressure;
  - Performance/functional;
  - Hydrostatic pressure;
  - Calibration;
  - Leakage;
  - Equipment qualification (EQ);
  - Electrical continuity;
  - Other:____________________;

□ Reports;
  ○ Heat treatment;
  ○ Failure analysis;
  ○ Certified material tests;
    - Physical (may include test records);
    - Chemical;
  ○ Pressure boundary supplemental tests;
  ○ Pressure boundary code data;
  ○ Other:____________________;
  ○ Cable specification data;

□ Design documentation;
  ○ Drawings;
    - As-built ;
    - Bill of material;
    - Assembly ;
    - Other:____________________;
  ○ Manuals and instructions:
    - Operations and maintenance;
    - Handling and installation;
    - Long term storage;
    - Other:____________________;
    - Recommended spare parts;

□ Inspection or test plans:
  ○ Special inspection plan;
  ○ Verification plan;
  ○ Other:____________________;

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V.17. CERTIFICATE OF CONFORMANCE

The Certificate of Conformance shall satisfy the following criteria:

- Identify purchase order number, including item numbers and change order number applicable to the item being certified.
- A person identified in the Supplier's quality assurance programme description as responsible for certification shall attest to the certificate by signature, title and date of signing.

The Buyer reserves the right to determine validity of the Certificate of Conformance by an audit of the Supplier or by an inspection or test of the item(s).

V.18. HANDLING. PACKAGING AND SHIPPING

Handling, packaging and shipping of the item supplied under this purchase order shall be in accordance with _____________________ (company or national standard such as ANSI N45.2.2- Level: _____).

Supplier shall provide packaging and shipping methods for protection from the effects of temperature extremes, humidity and in-transit shocks and jarring.

Material and all certifications or accompanying documentation supplied under this order shall be directly shipped from the Supplier/Manufacturer to the Buyer. The Distributor shall not take possession of material or documentation.

The Buyer's authorized source inspectors have the right to hold shipment if purchase order requirements are not met.

Additional Shipping Requirements:

V.19. CONTAINER/ITEM MARKING

Shipping containers or cartons are to be clearly marked or tagged with the Purchase Order number and:

- Shipping container/package;
- Material specification;
- Heat no. or code;
- Lot or batch no.;
- Serial no.;
- Other: ____________________ .

Packing slips are to be shipped with order.

All items are to be packaged individually and identified with the specific part number, or all items of a given part number to be packaged together and identified with the specific part number and the following:

- Individual Items
  - Code stamp;
  - Grade;
  - Heat number or code;
V.20. SHELF LIFE

Shelf Life - Supplier shall not ship any item that has less than __________ remaining shelf life at time of shipment. The Supplier shall provide shelf life data by one of the following methods:

- Expiration date, or
- Cure date and material composition

If the above requirements are not met, the material will be shipped back to the supplier at the Supplier's expense.

The Supplier shall provide the identity of the material(s) so that shelf life may be determined by the Buyer.

V.21. SUBSTANDARD AND COUNTERFEIT ITEMS

Vendor is hereby notified that the delivery of substandard/counterfeit items is of special concern to (Buyer’s Name). If any parts covered by this Order are described using a manufacturer part number or using a product description and/or specified using an industry standard, Seller shall be responsible to assure that the replacement parts supplied by the Seller meet all requirements of the latest version of the applicable manufacturer data sheet description and/or industry standard. If the Seller is not the manufacturer of the goods, the Seller shall make all reasonable efforts to assure that the replacement parts supplied under this Order are made by the Original Equipment Manufacturer (OEM) and meet the applicable manufacturer data sheet or industry standard. Should Seller decide to supply a replacement part that may not meet the requirements of this paragraph, Seller shall notify the Purchaser of any exceptions and receive Purchaser’s written approval prior to shipment of the replacement parts to Purchaser. If suspect/counterfeit parts are furnished under this order or are found to be in any of the goods delivered hereunder, such items will be dispositioned by (Buyer’s Name) and/or the Original Equipment Manufacturer and may be returned to the vendor. The
Vendor shall promptly replace such suspect/counterfeit parts with parts acceptable to (Buyer’s Name) and the Vendor shall be liable for all costs, including but not limited to (Buyer’s Name) internal and external costs, relating to the removal and replacement of such parts.

V.22. NEW ITEMS

All item(s) provided on this purchase order shall be supplied in the new condition (not used or refurbished in any way). Factory acceptance tested material, if shipped to site with the Purchaser’s agreement, must be individually identified to differentiate them from new, unused parts.
APPENDIX VI. SAMPLE RECEIPT INSPECTION CHECKLIST

This Appendix provides a sample generic receipt inspection checklist based on Appendix B of [51] that might be used during a quality control receiving inspection. It is not intended to be an all-inclusive list. Operating organizations may wish to consider use of a similar list in their acceptance process, and also include specific checks for potential counterfeit items are were described earlier in Table 21. The wording may be modified to meet requirements and policies specific to each utility.

☐ Typical Data Entries:
  o Operating organization contacts
  o For special tests or inspection: ____________/ext. ____________
  o For documentation acceptance: ____________/ext. ____________
  o For item acceptance: ____________/ext. ____________
  o Other: ____________/ext. ____________

☐ Identification and marking
  (As Applicable)
  o Shipping container/package
    • Material specification; ____________
    • Lot or batch no.; ____________
    • Heat no. or code.; ____________
    • Serial no.; ____________
    • Purchase order no.; ____________
    • Other: ____________
  o Individual Items;
    • PO item no.; ____________
    • Code stamp; ____________
    • Heat no. or code. -; ____________
    • Manufacturer name or code; ____________
    • Size.; ____________
    • Grade; ____________
    • Rating; ____________
    • Material specification; ____________
    • Length or dimensions; ____________
    • Cable reel rim or tag;
      • Contract or PO; ____________
      • PO item no.; ____________
      • Reel no.; ____________
      • Cable length ____________
      • Conductor size; ____________
    • Measurement and test equipment identification no.; ____________
    • Calibration due date; ____________
    • Serial no.; ____________
    • Part no.; ____________
    • Hydrostatic test pressure; ____________
    • Schedule; ____________
    • Testing lab (e.g. UL, CSA, DIN etc.) label/stamp; ____________
    • Other ____________
☐ Mechanical inspection;
  ○ Visual Inspection
    - Protective coverings;
    - Coatings or preservatives;
    - Workmanship;
    - Weld preparation;
    - Desiccant installed;
    - Inert gas blanket intact;
    - Other:____________________;
  ○ Measurements
    - Dimensions, nominal per PO;
    - Dimensions, special;
    - Material constituents nominal per PO;
    - Material hardness nominal per PO;
    - Material hardness;
    - Physical properties;
    - Thread pitch nominal per PO;
    - Other:____________________;

☐ Electrical Inspection;
  ○ Visual Inspection;
    - Protective coverings;
    - Coatings or preservatives;
    - Workmanship, general;
    - Workmanship, soldering;
    - Workmanship, PC boards;
    - No overheat discoloration;
    - Desiccant installed;
    - Other:____________________;
  ○ Measurements;
    - Dimensions, nominal per PO;
    - Dimensions, special;
    - Electrical resistance, nominal per PO;
    - Electrical resistance, special;
    - Electrical continuity;
    - Physical properties;
    - Other:____________________;

☐ Documentation;
  ☐ Statements;
    - Statement of identification as commercial grade item;
    - Statement of conformance with suppliers management system;
    - Quality programme / management system;
    - Statement of approved change, non-conformance or waiver;
    - Statement of code (pressure boundary) reconciliation (if required);
    - Shelf life;
    - Statement of:____________________;

☐ Certifications;
  ○ Certificate of conformance (C of C) with purchase order requirements;
  ○ C of C with IEEE-344 (seismic);
  ○ C of C with IEEE-323 (EQ);
  ○ Certificate of equivalency with items originally supplied;
- Make: ___________
- Model: ______________
- Serial no: ___________
- Original specification: ______________
  - C of C to time-current curve;

☐ Test Records;
  - Non-destructive examinations:
    - Ultrasonic (UT);
    - Eddy current (ET);
    - Radiographic (RT);
    - Hardness;
    - Magnetic particle (MT);
    - Liquid penetrant (LPT);
    - Other: ______________
  - Material properties:
    - Impact (Charpy v-notch, drop weight) at temp: ____ °C;
    - Dielectric strength;
    - Flattening;
    - Welding;
    - Bend;
    - Flame (IEEE-383);
    - Proof load (fasteners);
    - Insulation resistance;
    - Other: ______________
  - Design/Fabrication:
    - Pneumatic pressure;
    - Performance/functional;
    - Hydrostatic pressure;
    - Calibration;
    - Leakage;
    - Equipment qualification (EQ);
    - Electrical continuity;
    - Other: ______________

☐ Reports
  - Heat treatment;
  - Failure analysis;
  - Certified material test:
    - Physical (may include test records);
    - Chemical;
  - Pressure boundary supplemental tests;
  - Pressure boundary code data;
  - Other: ______________
  - Cable specification data;

☐ Design Documentation;
  - Drawings:
    - As-built;
    - Bill of material;
    - Assembly;
    - Other: ______________
  - Manuals and instructions;
- Operations and maintenance;
- Handling and installation;
- Long term storage;
- Other: ____________________;
- Recommended spare parts;

☐ Inspection or test plans:
  - Special inspection plan;
  - Verification plan;
  - Other: ____________________;

☐ Other: ____________________

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APPENDIX VII. SAMPLE TECHNICAL SPECIFICATION TEMPLATE

The following is a typical technical specification format adopted by an operating organization.

Foreword

Provides introductory or background information which helps the reader understand the purpose and requirements of the document.

Revision Summary

Lists specifics of all revisions to the document.

1.0 SCOPE

Describes intent of subject or activity, and intent of document. Indicate how document is to be used.

1.1 Scope of Vendor Proposal

Describes work that the vendor, as minimum, shall include in the proposal to assist the evaluation of their proposal.

2.0 REFERENCE

Lists developmental or performance references. Identify each reference by its document title and document number if applicable. If there are no references, state “None”.

3.0 QUALITY ASSURANCE (VENDOR AND MANUFACTURER)

Specifies applicable quality requirements, in accordance with national regulatory requirements, to be imposed on the supplier of the materials or services.

4.0 GENERAL

Provides applicable requirements for materials or services being purchased. This includes work to be done, purpose, laws, standards, and codes (specific section, step, or clause of the document, including the applicable edition of the code), interface requirements (to other systems, equipment, and components; modification of physical boundaries needed), registration or certification requirements, operating organization/site specific drawings, specifications and data, spare parts requirements, commercial requirements (e.g. warranties, guarantees etc. where not stated elsewhere) and training requirements. Supplementary specification data sheets may be referenced.

5.0 DESIGN AND FABRICATION REQUIREMENTS

Specifies design and fabrication requirements, where they are not specified in laws, standards, and codes, to adequately ensure that the integrity of the material or service meets the intent of the laws, standards, and codes (specify applicable section, step or clause of the document used). Any critical characteristics (if applicable) of system, parts or components, should be clearly specified so the vendor can recognize their importance.

Typical structure for this section contains component descriptions, design requirements, performance (operating) requirements, fabrication and material requirements including common clauses and clause(s) that materials and equipment be free of any foreign materials, equipment qualification requirements, supplementary specifications, reliability and maintainability requirements, safety requirements, seismic qualification requirements, diversification requirements (e.g. clauses and guidelines regarding Group I and Group II systems diversification requirements), radiation safety requirements, industrial safety requirements, human factors requirements, protective coating requirements, workmanship, including clause(s) that attention shall be paid to Foreign Material Exclusion (FME) while manufacturing. If an optional engineering specification
If all examination and test requirements are specified by applicable codes, state "Examination and test requirements are specified by the applicable codes (refer to Section 4.0)". If all aspects of this section are covered by an (optional) separate specification data sheet provide a reference to location of the data sheet (e.g., in Section 5, as an Appendix, as an attachment). Detail any aspects not covered by a data sheet. Where examination and test requirements are not specified by applicable codes, the Author should establish and specify examination and test requirements to adequately ensure integrity or performance of the material or service. Any critical characteristics (if applicable) of system, parts or components should be specified so the vendor can recognize their importance. Acceptance criteria are required to be clearly stated such as non-destructive testing and examinations, pressure test requirements, performance test requirements, leak test requirements, seismic qualification test requirements, dimensional examination requirements, inaugural or periodic inspection requirements, equipment qualification test requirements, reliability and maintainability test requirements, type tests (testing of a representative sample of material or equipment, factory acceptance tests), including clause(s) for Foreign Material Exclusion (FME), production tests, including clause(s) for Foreign Material Exclusion (FME), test and non-destructive examination documentation requirements, and commissioning and integration requirements. Note that material or equipment that was actually tested (FAT parts) are not to be shipped to site unless specifically agreed to in the specification, and identified as such to differentiate them from new, unused parts.

7.0 PRODUCT FORM AND IDENTIFICATION

This section identifies applicable form and/or identification requirements to be imposed on supplied material. Factory Acceptance Tested (FAT) material, if shipped to site with the agreement of the operating organization, should be individually identified to differentiate them from new, un-used parts. If there are no form and/or identification requirements, state "None".

8.0 SPECIAL PACKAGING AND SHIPPING, HANDLING AND STORAGE

This section defines applicable requirements for: packaging and marking (identification) for shipping, shipping and handling requirements (including any shelf life or maintenance requirements applicable to its storage), Foreign Material Exclusion (FME) methods, and related documentation. Note that Factory Acceptance Tested (FAT) material, if shipped to site with the operating organization agreement, must be individually identified to differentiate them from new, un-used parts. Foreign Material Exclusion (FME) methods should include the requirement to make any FME covers easily visible and to provide a listing of FME covers to assist in complete removal of all covers. Requirements should include clauses for the vendor to provide a detailed vendor bill of materials with the shipped package(s) in circumstances where material or equipment is ordered under a single item number but consists of multiple, easily separated components, which could potentially be shipped in multiple packages, or where the PO includes many components. The vendor bill of materials should identify each component's description, vendor part number or model number as applicable, catalogue item numbers of component(s) and quantity of each component shipped.
9.0 MATERIAL SAFETY DATA SHEET (MSDS)
This section specifies submittal requirements for all applicable MSDS Sheets. If there are MSDS requirements state YES, if they are not required state NO.

10.0 DOCUMENTATION REQUIREMENTS
Specifies supplier documentation to be submitted (includes required documentation, delivery location, quantity of copies required, media type, size, quality standards, timing schedule for submittals and reviews, and conditions for rejection). Note that if Factory Acceptance Tested (FAT) material is shipped to site, appropriate documentation must be enclosed with the shipment to make clear that the shipment includes FAT material.
APPENDIX VIII.  SAMPLE NUCLEAR QA PURCHASE SPECIFICATION

The following is a sample generic purchase specification related to management system activities developed in the 1990’s as part of IAEA TECDOC-919 [1] development. It can service as an aid for organizations developing their own specifications.

The contractor shall establish and implement an acceptable management system in accordance with this specification’s requirements.

1.0 General Requirement

1.1 The contractor shall perform management system activities in accordance with the following criteria, and if domestic and foreign requirements are in conflict, the domestic requirement shall prevail.

1) Enforcement regulation of 00000 Atomic Energy act. Article 000
2) Management system requirements described in technical specification

1.2 Upon contract award, the contractor shall submit to the buyer the following documents (3 copies) for the buyer’s review, within four (4) months after award.

When the contractor needs to change or revise the documents, he shall submit to the buyer revised documents for the buyer’s review, and incorporate the buyer’s comments if any.

1) Management system programme manual and procedures;
2) Quality inspection and test plan and/or quality plan.

1.3 The contractor shall review, approve, and verify implementation of the subcontractor’s management system, and shall transmit the provisions of this specification to its subcontractors and shall require conformity with its provisions in the scopes for which they are responsible.

1.4 In the event that significant defects or deficiencies are found while contractor’s performing quality related activities, the buyer has a right to request a stop in work for appropriate corrective actions as necessary. When the contractor receives a stop-work request from the buyer, he shall stop the work, take any necessary action, and then report the results to the buyer. The contractor shall not forfeit the responsibility for the supply of a good quality product in accordance with the purchase specification.

1.5 Upon completion of work, the contractor shall submit to the buyer all quality records, which is to be filed, indexed, and collected in accordance with procedures approved by the buyer. Control measures for QA records shall be established at the outset to provide for traceability of work processes, structures, systems, and equipment.

1.6 The contractor shall assure that his persons or organizations performing quality assurance functions have sufficient authority and organizational freedom, and quality control/inspection activities shall be performed by qualified personnel who have sufficient experience and competence in the field in which they perform.

1.7 The contractor shall assign a quality control manager who is competent and has the necessary knowledge and experience to execute his responsibility, and whose position level shall be equal to or above any other department manager.

2.0 Quality Assurance Audit, Surveillance, Inspection Requirements

2.1 The buyer or his representative (including the regulatory body) shall have the right to perform periodic audits, surveys, and inspections to verify that the contractor or his sub-contractor implement their management system adequately.

2.2 The buyer or his representative shall be allowed free access to the contractor’s or sub-contractor’s facilities, work site, quality records, etc., for the buyer’s audit, surveillance and inspection. The contractor shall provide the buyer with help (office, telephone, etc.) without any extra charge.

2.3 The contractor’s procedures, including management system manual, shall be made available to the buyer in order that the buyer may consult them at any time to verify the contractor’s QA programme implementation capability and status.
Audit, surveillance, and inspection by the buyer or his representative shall not relieve the contractor of responsibility to implement the defined management system.

2.4 The contractor shall submit to the buyer a quality plan, or an inspection and test plan before the predetermined date specified in the contract document for the buyer’s selection of the witness point and hold point. The contractor shall request the buyer to witness the process within five (5) days prior to commencement of the work.

2.5 Regarding implementation of these specification requirements, the contractor shall perform necessary inspection and tests required by the technical specification, design criteria, manufacturing, construction, and contract documents at his own expense.

2.6 In the event that the contractor can’t afford to perform tests on his own facilities, he may delegate the test to any authorized agency or special experimental agency deemed acceptable by the buyer.

2.7 If the contractor determines a need for repair, maintenance, or any correction based on the buyer’s completed inspection, the contractor shall take corrective action before the buyer’s re-inspection without any extra charge.

2.8 The contractor shall submit to the buyer the result of corrective action, or a plan in the event that corrective action cannot be taken immediately, within thirty (30) days after receiving finding reports from the buyer’s audit, surveillance, or inspection results.

2.9 The contractor shall submit to the buyer an annual audit plan for internal/external organization, and report the audit results to the buyer every year.

3.0 Site Inspection and Test

If the site inspection and test requirements are specified in contract documents, the following requirements shall be observed.

3.1 The contractor shall submit to the buyer a site acceptance inspection and test plan within the dates specified in the contract documents for the buyer’s approval, and shall perform site test and inspection with responsible technical engineer dispatched to verify the performance of the contractor’s supplied facilities after completion of installation, or shall provide necessary technical support for performance.

3.2 Site inspection testing shall be performed after both the buyer and the contractor verify that all prerequisites have been satisfactorily met, and may be postponed at the buyer’s request if necessary.

3.3 The contractor shall perform necessary adjustments and pre-operational modulation, etc., required for equipment, instruments, the system, and circuits during preventive maintenance and the start-up test.

3.4 The buyer will provide the contractor with the electricity, fuel, and water necessary for site inspection and test of equipment supplied by the contractor.

4.0 Notification of Significant Deficiency

Upon recognizing the following significant deficiencies, the contractor shall immediately notify the buyer verbally, and within seven (7) working days, shall submit to the buyer documents describing the type and nature of the deficiencies, technical review results, and a disposition plan for the buyer’s review and approval.

1) Significant deficiencies in the management system manual (not including usual non-conformances)

2) Conditions adverse to quality against preliminary safety analysis report (PSAR), as significant deficiencies for final design admitted for construction.

3) Significant deficiencies in structure, system, and/or construction that require comprehensive evaluation, design change, and repair.
APPENDIX IX. SAMPLE SUPPLIER SAFETY PERFORMANCE ASSESSMENT

Suggested questions to be used for contractor safety assessment upon contract completion:

1. Which senior person in the company responsible for safety has been involved in our contract?

2. Was contractor's local safety statement provided to all employees?

3. What safety surveillance of our contract by the contractor's company safety organization was carried out during the contract period? Did we receive any copies of reports generated?

4. How many persons on average were employed by the contractor on our site? What was the contractor’s accident frequency rate during the contract period:

\[
\text{e.g., Number of lost time accidents} - \frac{\text{Person Hours worked}}{	ext{Person Hours worked}}
\]

How many minor (i.e. no lost-time) accidents occurred during the contract?

5. Did any major injuries or fatal accidents occur to contractor personnel during the contract period? If so, how many?

6. Did the contractor carry out any specific safety training of personnel other than our "site orientation training"?

7. Did you receive any safety publications issued by the contractor to personnel?

8. Were contractor vehicles and plant in good, well maintained condition throughout the contract?

9. How well did the contractor comply with assessment of substances harmful to health requirements?
   a. Did you receive information on all hazardous materials he brought onto site?
   b. Did you have copies of assessments of effects of potentially hazardous substances and necessary precautions?
   c. Did contractor comply with assessments and any additional requirements required to ensure safety of contractor and other personnel
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[143] INTERNATIONAL SOCIETY OF AUTOMATION (ISA), ANSI/ISA-62443-2-1 (99.02.01)-2009 Security for Industrial Automation and Control Systems: Establishing an Industrial Automation and


UNITED STATES NUCLEAR REGULATORY COMMISSION, “ASME Section III Component Replacements (Generic Letter 89-09),” USNRC, Washington, 1989.


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DEFINITIONS

**Buyer.** A professional buying specialist, typically specialized in a given group of materials or commodities, who is responsible for market analysis, purchase planning, coordination with key users, supplier qualification and selection, order placement, and follow-up activities [52].

**Carrying cost (inventory holding cost).** The cost of keeping inventory on hand, including the opportunity cost of invested funds; storage and handling costs; and taxes, insurance, shrinkage, and obsolescence-risk costs. Firms usually state an item’s holding cost per time period as a percentage of the item’s value, typically between 20 and 40 percent per year [52].

**Competitive bidding.** A common method of source selection; the offer of prices and specified elements of performance by firms competing for a contract [52].

**Critical spare.** A spare part deemed essential to support the maintenance philosophy developed for a critical component according to AP-913 [214].

**Inventory control.** The effective management of inventories, including decisions about which items to stock at each location, how much stock to keep on hand at various levels of operation, when to buy, how much to buy, controlling pilferage and damage, and managing shortages and backorders [52].

**Inventory turnover.** A measure of the velocity of total inventory movement through the firm, found by dividing annual sales (at cost) by the average aggregate inventory value maintained during the year. Many firms calculate production inventory turnover rate as the annual inventory purchase value divided by the average production inventory value [52].

**Investment recovery.** A systematic organizational effort to manage the surplus equipment and material and recovery items/marketing/disposition activities in a manner that recovers as much of the original capital investment as possible [52].

**Materials management.** A managerial and organizational approach used to integrate the supply management function in an organization. It involves planning, acquisition, flow, and distribution of product materials from the raw material to the finished product. Activities typically included are procurement, inventory management, receiving, stores and warehousing, in-plant materials handling, production planning and control, traffic, and surplus and salvage [52].

**Materials requirements planning (MRP).** A system application for single-point demand visibility [52].

**Process.** 1. A course of action or proceeding, especially a series of progressive stages in the manufacture of a product or some other operation. 2. A set of interrelated or interacting activities that transforms inputs into outputs [224].

**Quality assurance.** 1. The function of a management system that provides confidence that specified requirements will be fulfilled. 2. A systematic programme of controls and inspections applied by any organization or body involved in the transport of radioactive material which is aimed at providing adequate confidence that the standard of safety prescribed in [the Transport] Regulations is achieved in practice. 3. All those planned and systematic actions necessary to provide confidence that a structure, system or component will perform satisfactorily in service [224].

**Quality control.** Part of quality assurance intended to verify that structures, systems and components correspond to predetermined requirements [224].

**Quality level.** The level of activities required for each procurement method to obtain qualified items or services for their identified safety classification (called procurement quality level in [52]).

**Safety related.** Of significance or importance because it applies to:

- SSCs designed to perform a nuclear safety function.
• Services to design, purchase, fabricate, handle, ship, store, clean, erect, install, test, operate, maintain, repair, refuel, and modify SSCs that are designed to perform a nuclear safety function [52].

**Stock level.** The desired quantity of stock to be carried [52].

**Supply chain management.** A systems management concept designed to optimize material costs, quality, and service. This is accomplished by consolidating the following operating activities: purchasing, transportation, warehousing, and quality assurance for incoming materials inventory management and internal distribution. These activities normally are combined in a single department, similar to the arrangement under a materials management organization [52].

**Time and materials contracts.** Such contracts typically provide for the acquisition of services on the basis of 1) direct labour hours at specified fixed hourly rates that include wages, overhead, general and administrative expenses, and profit and 2) materials, generally at cost, including (if appropriate) material handling costs [52].

**Work instruction.** Instructions for performance of the work to be accomplished, the level of detail of which depends on the assigned planning level. When applicable, approved procedures may be referenced and may suffice as work instructions.

**Work order.** A document used to control work and/or testing activities.

**Work package.** A compilation of documents that includes the work order, work instructions, and any other supporting material (such as drawings, vendor manuals, weld process sheets, operating experience [OE], safety analysis, and permits).
# ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
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<tr>
<td>ASL</td>
<td>Approved suppliers list</td>
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<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers (former name; now known as ASME International)</td>
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<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials (former name; now known as ASTM International)</td>
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<tr>
<td>BIS</td>
<td>Bid invitation specification</td>
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<tr>
<td>BOM</td>
<td>Bill of material</td>
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<tr>
<td>CAT-ID</td>
<td>Catalogue identification</td>
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<td>BS</td>
<td>British Standard</td>
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<td>BSI</td>
<td>British Standards Institute</td>
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<tr>
<td>CEA</td>
<td>Commissariat à l’énergie atomique et aux énergies alternatives</td>
</tr>
<tr>
<td>CEN</td>
<td>Comité Européen de Normalisation (European Committee for Standardization)</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations (USA)</td>
</tr>
<tr>
<td>CG</td>
<td>Commercial grade</td>
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<tr>
<td>CGD</td>
<td>Commercial grade dedication</td>
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<td>CGI</td>
<td>Commercial grade item</td>
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<tr>
<td>CII</td>
<td>Construction Industry Institute</td>
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<td>CM</td>
<td>Configuration management</td>
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<td>CNSC</td>
<td>Canadian Nuclear Safety Commission</td>
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<td>CSA</td>
<td>Canadian Standards Association</td>
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<tr>
<td>CSFI</td>
<td>Counterfeit, fraudulent, or sub-standard item</td>
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<tr>
<td>CNS</td>
<td>Czech Standards Institute</td>
</tr>
<tr>
<td>DIN</td>
<td>Deutsches Institut für Normung e.V. (German Institute for Standardization)</td>
</tr>
<tr>
<td>DOE</td>
<td>Department of Energy (USA)</td>
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<tr>
<td>EdF</td>
<td>Electricité de France</td>
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<tr>
<td>EDI</td>
<td>Electronic data interchange</td>
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<tr>
<td>EN</td>
<td>Européen Norme (European Standard)</td>
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<tr>
<td>EN-ISO</td>
<td>ISO standard written for European Union (regional standard)</td>
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<tr>
<td>EPC</td>
<td>Engineer-procure-construct</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<td>FDA</td>
<td>US Food and Drug Administration</td>
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<tr>
<td>FMEA</td>
<td>Failure modes and effects analysis</td>
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<tr>
<td>GIS</td>
<td>Geographic information system</td>
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<tr>
<td>GPS</td>
<td>Global positioning system</td>
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<tr>
<td>HSE</td>
<td>Health and Safety Executive (UK)</td>
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<tr>
<td>I&amp;C</td>
<td>Instrumentation and control</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<tr>
<td>IEE</td>
<td>Item equivalency evaluation</td>
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<tr>
<td>INPO</td>
<td>Institute of Nuclear Power Operators</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>JIT</td>
<td>Just in time</td>
</tr>
<tr>
<td>KTA</td>
<td>Kerntechnischer Ausschuß (German Nuclear Safety Standards Commission)</td>
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<tr>
<td>LOCA</td>
<td>Loss of coolant accident</td>
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<tr>
<td>LTO</td>
<td>Long term operation</td>
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<td>MRP</td>
<td>Materials requirements planning</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>MS</td>
<td>Management system</td>
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<tr>
<td>M&amp;TE</td>
<td>Measure and test equipment</td>
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<tr>
<td>NEA</td>
<td>Nuclear Energy Agency</td>
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<tr>
<td>NEI</td>
<td>Nuclear Energy Institute</td>
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<tr>
<td>NFC</td>
<td>Near field communication</td>
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<tr>
<td>NII</td>
<td>Nuclear Installations Inspectorate (United Kingdom)</td>
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<tr>
<td>NISA</td>
<td>Nuclear and Industrial Safety Agency (Japan)</td>
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<tr>
<td>Nke</td>
<td>Normenausschuss Kerntechnik (German Nuclear Standards Committee)</td>
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<tr>
<td>NPP</td>
<td>Nuclear power plant</td>
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<tr>
<td>NSR</td>
<td>Non-safety-related</td>
</tr>
<tr>
<td>NSSS</td>
<td>Nuclear special safety systems</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OEM</td>
<td>Original equipment manufacturer</td>
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<tr>
<td>OPEX</td>
<td>Operating experience</td>
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<tr>
<td>OPG</td>
<td>Ontario Power Generation</td>
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<tr>
<td>PE</td>
<td>Procurement engineering</td>
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<tr>
<td>PIP</td>
<td>Periodic inspection programme</td>
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<tr>
<td>PM</td>
<td>Preventative maintenance</td>
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<tr>
<td>PO</td>
<td>Purchase order</td>
</tr>
<tr>
<td>PRI</td>
<td>Performance Review Institute</td>
</tr>
<tr>
<td>PSAR</td>
<td>Preliminary safety analysis report</td>
</tr>
<tr>
<td>PSR</td>
<td>Periodic safety review</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>RE</td>
<td>Reverse engineering</td>
</tr>
<tr>
<td>RFI</td>
<td>Request for interest</td>
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<tr>
<td>RFID</td>
<td>Radio frequency identification</td>
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<tr>
<td>ROP</td>
<td>Reorder point</td>
</tr>
<tr>
<td>RSK</td>
<td>Reaktor-Sicherheitskommission (German reactor safety commission)</td>
</tr>
<tr>
<td>SME</td>
<td>Subject matter expert</td>
</tr>
<tr>
<td>SR</td>
<td>Safety-related</td>
</tr>
<tr>
<td>SSC</td>
<td>Systems, structures, or components</td>
</tr>
<tr>
<td>UPC</td>
<td>Universal product code</td>
</tr>
<tr>
<td>UTC</td>
<td>Universal tracking code</td>
</tr>
<tr>
<td>USNRC</td>
<td>United States Nuclear Regulatory Commission</td>
</tr>
<tr>
<td>WANO</td>
<td>World Association of Nuclear Operators</td>
</tr>
</tbody>
</table>
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Vienna, 25 to 27 March, 2014

Technical Meeting

Vienna, 8 to 10 September, 2014

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Assignments

- **ALL**: Full document read through and comments;
- **ALL**: Is there any work in place on obsolescence at your operating organization (e.g. programme document, success stories, etc.?) (to be used in 5.3);
- **ALL**: Need more examples of national standards, and OPEX related to:
  - National standards related to procurement (Table 2);
  - Service and/or equipment supplier metrics (Table 8 and Table 9);
  - Computer security standards (Table 15);
  - Counterfeit items (incidents) (Table 18);
  - Counterfeit item databases (Table 20);
- **ALL**: anyone have a copy or can get of INPO report NX-1037?
- **ALL**: can you provide some standard PO clauses that you use all the time for purchasing within your company for APPENDIX V (ask your procurement group for what standard clauses they have developed)?
- **ALL**: anyone have a standard receipt inspection checklist they can share for APPENDIX VI (ask your warehouse group)?
- Choi/Cai/Ahmed/Jana/Franck/Pat: Country reports (Appendix II)
- Ahmed: 3.3.2: Supplier Identification: add in supply planning information
- Pat: Section 8 & 5.1 (PE function);
- Franck: 3.3.3(audits)
- Pat/John: 5.10 Construction to Ops transition (John has done first draft);
- John: 5.3 Obsolescence (John has done first draft);
- John: Look at incorporating much of services chapter into procurement model chapter: DONE
- **ALL**: get lessons learned from aerospace/automotive, logistics (retail)- John has started (see APPENDIX III)