IAEA Nuclear Energy Series

No. NP-T-3.21

Basic Principles

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

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PROCUREMENT ENGINEERING AND SUPPLY CHAIN GUIDELINES IN SUPPORT OF OPERATION AND MAINTENANCE OF NUCLEAR FACILITIES

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA NUCLEAR ENERGY SERIES No. NP-T-3.21

PROCUREMENT ENGINEERING AND SUPPLY CHAIN GUIDELINES IN SUPPORT OF OPERATION AND MAINTENANCE OF NUCLEAR FACILITIES

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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 Article III.A.6 of the IAEA Statute, the 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 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 400 operational nuclear power plants in IAEA Member States, with more than 60 under construction. Operating experience has shown that ineffective control of the procurement process can jeopardize plant safety and has resulted in increased costs to operating organizations. Procurement therefore needs to be 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. the integrity and functional capability in excess of normal operating requirements).

This publication is an update and expansion of IAEA-TECDOC-919, Management of Procurement Activities in a Nuclear Installation, which was published in 1996. Current practices for major procurement functions and special implications for nuclear facilities are documented. This information is intended to help all those involved, directly and indirectly, in ensuring the safe operation of nuclear facilities, 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 publication consists of technical experts from nuclear facilities and from regulatory, plant design, manufacturing, supplier, transport and technical support organizations dealing with procurement.

The work of the contributors to the drafting and review of this publication and that of the authors of IAEA-TECDOC-919 is greatly appreciated. The IAEA officer responsible for this publication was J.H. Moore of the Division of Nuclear Power.

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1. INTRODUCTION

1.1. BACKGROUND

1.1.1. Industry situation

In recent years, nuclear facilities have been impacted by significant procurement related events and concerns. There have been temporary and permanent shutdowns of nuclear power plants due to the installation of counterfeit, fraudulent and suspect items (CFSIs), and issues related to increased reliance on digital equipment and components containing software, on computer security and increased globalization of the nuclear supply chain. Obsolescence and component ageing issues increasingly need to be addressed by nuclear facility procurement organizations. These have led to new actions by facility operators and by regulators.

A significant number of nuclear power plants in some countries are near the end of 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 nuclear power plant equipment in some countries is obsolete [1]. Original suppliers may have gone out of business entirely, consolidated with other companies or made business decisions (typically owing to reduced market demand) not to produce particular items or not to supply them with nuclear grade certifications.

To further complicate the situation, there may be limited information available to support procurement of an exact original component. As industry 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 is not currently manufactured. This can pose a possible safety and economic risk to operations and outage planning owing to safety related equipment not being available when required.

A procurement engineering function has originated in some countries as a result of these concerns. The main functions of procurement engineering are to identify item technical, quality and commercial requirements, and to perform item equivalency evaluations (IEEs) and commercial grade dedication (CGD) in a timely manner.

1.1.2. Safety aspects related to procurement

Accident consequences at a nuclear facility can be severe if the plant does not operate as designed under accident scenarios. An important aspect of safe operation is ensuring that safety related components operate as intended, thereby ensuring that they perform their intended safety function. To facilitate this, operators need to ensure that items procured for safety related systems meet their original design requirements.

The procurement function for nuclear facilities plays a key role in nuclear safety. Beyond ensuring that the required parts are available when needed for operation and maintenance activities, the procurement function helps to ensure that the correct equipment and components are installed in the correct locations in the plant, helping to maintain proper configuration management and safety functions. The procurement organization is typically the interface between the nuclear facility and the 'outside world', and thus is the link 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.

Paragraphs 8.15 and 8.16 of IAEA Safety Standard Series No. SSR-2/2 (Rev. 1), Safety of Nuclear Power Plants: Commissioning and Operation [2], require that:

> "8.15. The operating organization shall establish suitable arrangements to procure, receive, control, store and issue materials (including supplies), spare parts and components.
>
> "8.16. The operating organization shall be responsible for using these arrangements for the procurement of materials (including supplies), spare parts and components and for ensuring that their characteristics are consistent with applicable safety standards and with the plant design."

An IAEA publication, Application of Configuration Management in Nuclear Power Plants, emphasizes the need to maintain plant configuration to support design basis maintenance, stating that [3]:

> “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 a nuclear power plant 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 not functioning as required during design basis accidents or, in some cases, complete equipment failure.

A lack of confidence by a regulator in a plant’s control of purchasing and configuration related processes can lead to costly plant shutdowns. A lack of confidence in a single component, such as a particular relay module or type of cable, can mean replacing a large number of related components in many different locations.

1.1.3. Need for management of procurement activities

In addition to the safety needs identified above, procurement activities are required to be carefully managed to maintain the economic and financial viability of nuclear facilities. Procurement has a direct connection to product costs, in that the costs of materials, spare parts, inventory, staffing and processes required to support procurement all add to facility operating charges. The large number of items procured necessitates a planned, graded approach to procurement activities, with safety related items receiving more attention.

Procurement affects all parts of a nuclear facility’s life. During the initial design, the designers specify materials to be purchased for the facility. These decisions have long term consequences for supply chain participants and for future operation. 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 during each stage can impact on the facility operating costs. During decommissioning, major contracts are placed for decommissioning and site restoration activities, and plant equipment can be disposed of on the open market as surplus.

During each of the above phases, different facility ownership structures may be in place. Each of these owner groups may have different strategic goals with respect to the approaches to be taken for procurement activities and the associated levels of contracted work.

Concerns regarding obsolescence of original equipment increase as nuclear facilities age. This places demands on plant engineering and procurement organizations for equivalent replacement parts. This is in contrast to the desire (as expressed in Section 1.1.2) to maintain nuclear facilities in the exact same configuration as originally designed. Minimizing change virtually eliminates any chance of inadvertently altering the design basis or invalidating assumptions regarding safety related equipment performance or failure modes. Where original equipment manufacturers are unavailable (and sometimes even when they are), such replacement or part substitutions can require complex engineering assessments, reverse engineering or associated design changes in order to ensure the correct requirements are met.

Procurement itself is becoming increasingly complex. There is a changing marketplace in many nuclear power plant 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 materials or to simply 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 the original design and quality requirements. Original vendors themselves have tended to increase their numbers of subsuppliers, making tracking and auditing of parts production more difficult. Where new suppliers have entered, or re-entered, nuclear markets, there can be a learning curve associated with performance to nuclear management system requirements, and thus greater risk of errors, omissions or other non-conformances during this period.

The owners and operators of nuclear facilities 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, integrated systems or skids are purchased. More items tend to be individually purchased (for spare parts) as plants age. If not managed correctly, this can drive inventory levels higher, to unsustainable levels.

As a result of the need for configuration and design control, along with economic viability, nuclear facilities 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, CGD processes, IEEs and procurement engineering functional groups. Such activities are described in this publication.

1.2. OBJECTIVE

This publication provides information regarding good practices for management of procurement and supply chain activities related to the operation and maintenance of nuclear facilities. Typical activities include:

- Needs identification;
- Requirements development;
- Value analysis;
- Supplier research;
- Negotiation;
- Buying activities;
- Establishing acceptance criteria;
- Contract administration;
- Inventory control;
- Transport;
- Receipt;
- Warehousing.

Although targeted at operating nuclear facilities, the principles and processes described are generally applicable to new build nuclear power plant projects and other nuclear facilities. This publication updates IAEA-TECDOC-919, Management of Procurement Activities in a Nuclear Installation [4], which was published in 1996. Guidance provided here, describing good practices, represents expert opinion but does not constitute recommendations made on the basis of a consensus of Member States.

1.3. STRUCTURE

This publication includes information on:

- Managing procurement;
- Typical procurement processes;
- Procurement of services;
- Considerations of special importance and lessons learned;
- Procurement of software and items containing software;
- CFSIs;
- Proactive methods for new nuclear power plants to avoid procurement related issues.

The appendices provide more detail on procurement related data needs, nuclear and non-nuclear experience, demand management calculations and samples of useful templates related to the procurement function. The Annex records the results of a survey of nuclear procurement professionals conducted as part of this publication’s preparation.

1.4. SCOPE

This publication does not specifically describe procurement processes and strategies for new build nuclear power plants, but it does outline considerations that should be taken into account to ensure there is a sustainable market and information available over the lifetime of new nuclear power plants.

This publication is intended for nuclear facility owner operators, designers, engineers and specialists:

(a) To establish, implement and improve procurement practices for nuclear facilities;
(b) To facilitate dialogue between owner operators and regulators when dealing with procurement related issues;
(c) To consider procurement related concerns that can affect routine plant operation when contracting for new facility construction and during the transition from the construction to the operating phases of a facility's lifetime.

More details on procurement and contracting in a nuclear context can be found in the IAEA's on-line nuclear contracting toolkit.[1] The toolkit is targeted at new build or other large nuclear projects.

[1] See http://www.iaea.org/NuclearPower/Infrastructure/NuclearContractingToolkit/index.html

2. MANAGING PROCUREMENT

2.1. INTEGRATED MANAGEMENT SYSTEM REQUIREMENTS

Materials, fuel and services are essential to the operation and maintenance of a nuclear facility, and their proper procurement contributes to safety and reliability. It is fundamental to nuclear power plant safety and for the prevention of accidents that defence 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. Figure 1 shows the standard IAEA model demonstrating how a management system is used to contribute to a healthy safety culture in an organization. Efforts within the management system need to include ensuring that plant materials are of high quality and reliability (see para. 3.32 of IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [6]).

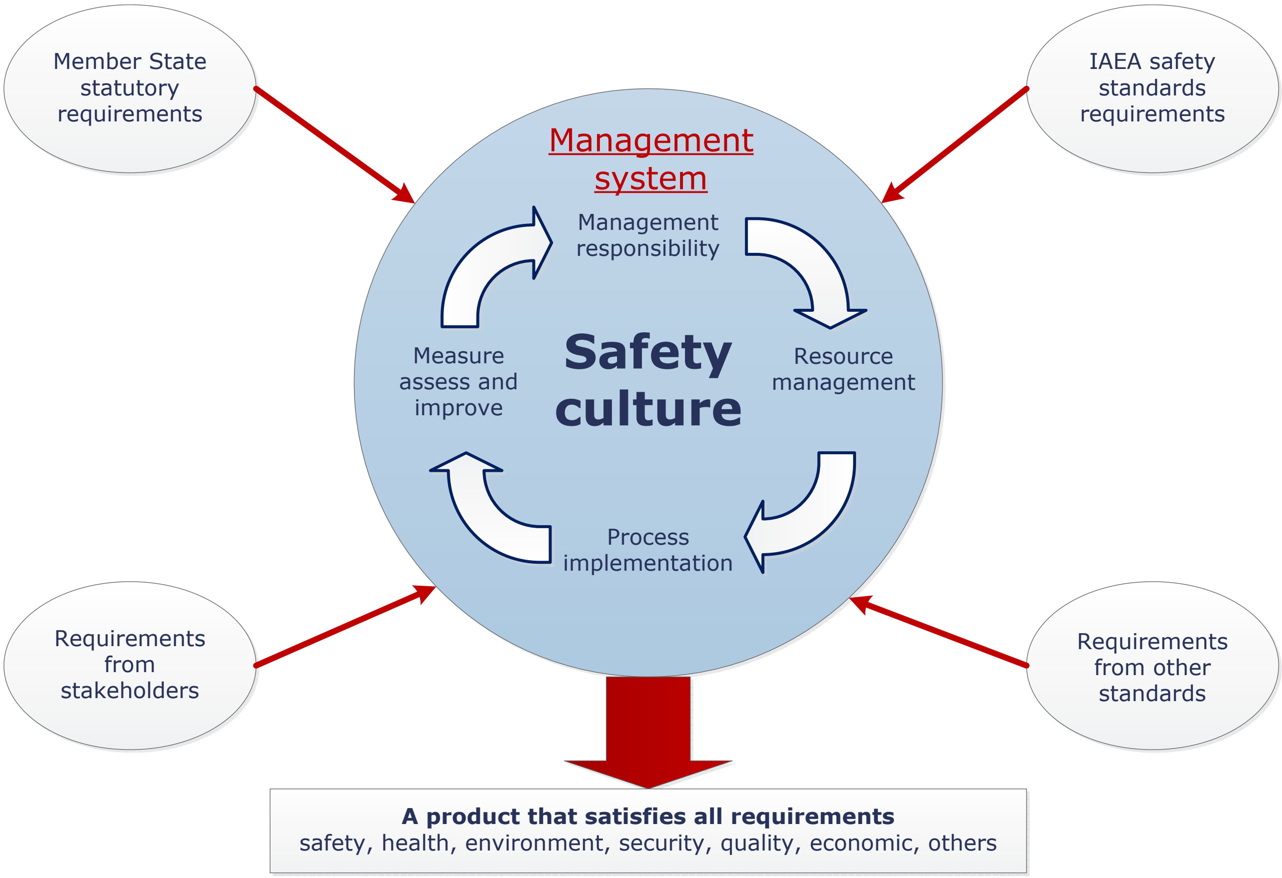


FIG. 1. IAEA safety culture and management system model (reproduced from Ref. [5]).

According to para. 3.3 of SF-1 [6], a key safety fundamental of all nuclear power plants is the fact that:

"The person or organization responsible for any facility or activity that gives rise to radiation risks or for carrying out a programme of actions to reduce radiation exposure has the prime responsibility for safety[5].

"[5] Not having an authorization would not exonerate the person or organization responsible for the facility or activity from the responsibility for safety."

This means that a nuclear power plant 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 manner. 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 (e.g. International Organization for Standardization (ISO) standards), to more recent integrated management system (IMS) approaches such as those described in IAEA Safety Standards Series Nos GSR Part 2 [7], GS-G-3.1 [8] and GS-G-3.5 [9]. The key difference with the IMS approach is that safety is incorporated into the management system. This is included in every aspect of the organization, particularly for procurement specifications and for evaluations of suppliers and supplier requirements.

It should be noted that GSR Part 2 [7] has recently superseded IAEA Safety Standard Series No. GS-R-3.[2] It incorporates a systemic approach to safety, and includes a specific requirement (see Requirement 11 of GSR Part 2 [7]) surrounding the management of the supply chain, which requires organizations to put in place effective arrangements with suppliers to specify, monitor and manage the supply of items, products and services that may influence safety.

Nuclear power plants 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 GSR Part 2 [7], GS-G-3.1 [8] and GS-G-3.5 [9]. GSR Part 2 [7] is the higher level requirements publication, whereas GS-G-3.1 [8] applies more specific guidance for operating facilities and activities, and GS-G-3.5 [9] applies even more specific guidance for nuclear power plants.

Table 1 summarizes key items from these IAEA management system publications related to the procurement and material supply functions, sorted by general topic area. Readers should refer to the corresponding safety standards for a complete description of all management system requirements for a nuclear power plant.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006). This publication has been superseded by GSR Part 2 [7].

TABLE 1. IAEA MANAGEMENT SYSTEM REQUIREMENTS AND GUIDANCE RELATED TO PROCUREMENT

IAEA safety standard	Paragraphs	Requirement/recommendation summary	Comments	Applicable sections of this publication
GSR Part 2 [7] GS-G-3.1 [8]	4.8, 6.1–6.8 6.1–6.84	A management system shall be established, implemented, assessed and continually improved.	Procurement organization at nuclear power plant to take part in these improvement activities.	2.1, 5.9
GS-G-3.5 [9]	2.1, 6.1–6.69	A management system shall be established, implemented, assessed and continually improved. This includes assessment of safety culture, and a corrective action programme.	Procurement organization at nuclear power plant to take part in these improvement activities and actively use the corrective action programme.	2.1, 5.9
GSR Part 2 [7]	3.1(a), 4.28–4.30	Safety shall be paramount within the management system, overriding all other demands.	None.	1.1.2
GSR Part 2 [7]	Req. 12, 5.1	The management system and leadership for safety shall be such as to foster and sustain a strong safety culture.	None.	None
GSR Part 2 [7]	Req. 7, 4.15	The management system shall be developed and applied using a graded approach.	Procurement processes can use a graded approach (e.g. treat safety related different to non-safety-related purchasing).	2.4, 3.2.2, 8.3.4
GS-G-3.1 [8]	2.41–2.44	Grading process: for procurement, the following are identified: – Expectations of suppliers for assessment, evaluation and qualification; – Scope and level of detail of procurement specification; – Need for, and scope of, supplier quality plans; – Extent of inspection, surveillance and audit activities for suppliers; – Scope of documents to be submitted by the supplier and approved by the organization; – Records to be provided or stored and preserved.	None.	2.4, 3.2.2, 8.3.4
GS-G-3.5 [9]	2.41	Type and level of detail in procurement documents can use a graded approach.	Procurement processes can use a graded approach (e.g. treat safety related different to non-safety-related purchasing). See Ref. [10] for examples.	2.4, 3.2.2, 3.4.3, 8.3.4
GSR Part 2 [7]	Req. 8, 4.17–4.20	The management system shall be documented. Documents and records are to be controlled	Processes related to procurement should be explicitly documented and records related to procurement are to be controlled.	2.1, 5.7
GS-G-3.1 [8]	2.37–2.62	Documentation of management system (provides structure of typical management system).	Provides overall typical nuclear power plant management system that procurement processes would be a part of.	2.1

TABLE 1. IAEA MANAGEMENT SYSTEM REQUIREMENTS AND GUIDANCE RELATED TO PROCUREMENT (cont.)

IAEA safety standard	Paragraphs	Requirement/recommendation summary	Comments	Applicable sections of this publication
GS-G-3.1 [8]	5.24–5.28, 5.35–5.49	Documents and records to be controlled via processes.	Procurement management related documents and records to follow a managed process for production, categorization, retrieval, storage and disposal.	5.7
GSR Part 2 [7]	Req. 9, 4.21–4.27	Provision of resources.	Sufficient resources and training should be made available to properly carry out procurement functions.	5.8
GS-G-3.1 [8]	3.5, 4.1, 4.6, 4.8–4.25	Individuals concerned to have capabilities and appropriate resources to discharge their responsibilities effectively, including awareness and other training.	Procurement staff to have sufficient training and resources and be aware of the impacts of their work.	5.8
GS-G-3.1 [8]	5.1–5.17 (especially 5.6)	Processes need to be developed and maintained. Processes should be considered for control of products, purchasing and other management system areas.	Recommended procurement and related processes to be developed.	2.1
GS-G-3.1 [8]	5.18–5.23	Outsourced processes need to be controlled with interfaces to the nuclear power plant’s management system.	Procurement of services needs to be controlled.	4
GSR Part 2 [7]	4.31	Any activities for inspection, testing, verification and validation, their acceptance criteria and responsibilities for carrying out these activities shall be specified. It shall be specified when and at what stages independent inspection, testing, and verification and validation are required to be conducted.	Defining acceptance criteria is an important part of the procurement process.	3.5, 5.9
GSR Part 2 [7]	Req. 11, 4.33–4.36	The organization shall put into place arrangements with vendors, contractors and suppliers for specifying, monitoring and managing the supply to it of items, products and services that maintain safety.	Specific requirement related to management of the supply chain.	2, 3
GSR Part 2 [7]	4.33	The organization shall retain responsibility for safety when contracting out any processes and when receiving any item, product or service in the supply chain.	Oversight processes such as having an informed customer need to be in place.	2.1
GSR Part 2 [7]	4.34	The organization shall have a clear understanding and knowledge of the product or service being supplied. The organization shall itself retain the competence to specify the scope and standard of a required product or service, and subsequently to assess whether the product or service supplied meets the applicable safety requirements.	Informed customer role is one method to achieve this. Too much contracting out can lead to loss of capability in this area.	2.3

TABLE 1. IAEA MANAGEMENT SYSTEM REQUIREMENTS AND GUIDANCE RELATED TO PROCUREMENT (cont.)

IAEA safety standard	Paragraphs	Requirement/recommendation summary	Comments	Applicable sections of this publication
GS-G-3.5 [9]	5.79–5.83	A defined process is needed for using contractors, including confirmation of competency, adequate training and, in some cases, an informed customer oversight function.	None.	4
GSR Part 2 [7]	4.35	The management system shall include arrangements for qualification, selection, evaluation, procurement and oversight of the supply chain.	Supply chain participants, even those external to the operating organization, need to be managed.	3.4–3.7, 3.16, 3.17
GSR Part 2 [7]	4.36	The organization shall make arrangements for ensuring that suppliers of items, products and services important to safety adhere to safety requirements and meet the organization's expectations of safe conduct in their delivery.	Safety requirements are required to be confirmed met for items or services purchased.	3.2, 3.4, 3.5, 3.7
GS-G-3.1 [8]	5.50	Individuals carrying out procurement activities: – Should ensure information provided to suppliers is clear, concise and unambiguous, fully describes products and services necessary, and includes technical and quality requirements; – Should ensure, as a basis for selection, that the supplier is capable of supplying products and services as specified; – Should monitor suppliers to confirm that they continue to perform satisfactorily; – Should ensure that the products and services conform to the requirements of procurement documents and perform as expected; – Should specify the contact individual for all communications on procurement with the supplier; – Should define, where necessary, the interfaces between the organization and suppliers and between different suppliers to ensure that key dates for supply are met.	Defines key procurement organization duties.	3.2–3.7, 3.9, 3.10, 3.16, 3.17
GS-G-3.1 [8]	5.51	Senior management should establish relationships with suppliers so as to promote and facilitate communication, with the aim of improving the effectiveness and efficiency of processes on both sides.	Feedback to suppliers is key to optimizing and improving performance.	3.17.1

TABLE 1. IAEA MANAGEMENT SYSTEM REQUIREMENTS AND GUIDANCE RELATED TO PROCUREMENT (cont.)

IAEA safety standard	Paragraphs	Requirement/recommendation summary	Comments	Applicable sections of this publication
GS-G-3.5 [9]	V.5	Interface arrangements should be agreed in writing between the construction organization, suppliers and other organizational units performing the work, including suppliers with subsuppliers.	Communications are critical to successful procurement. Documented roles and responsibilities assist in work.	3.17.1
GSR Part 2 [7]	6.3	The causes of non-conformances of processes and the causes of safety related events that could give rise to radiation risks shall be evaluated and any consequences shall be managed and shall be mitigated. The corrective actions necessary for eliminating the causes of non-conformances, and for preventing the occurrence of, or mitigating the consequences of, similar safety related events, shall be determined, and corrective actions shall be taken in a timely manner. The status and effectiveness of all corrective actions and preventive actions taken shall be monitored and shall be reported to the management at an appropriate level in the organization.	Non-conformance and corrective action processes are important, and need to extend outside of the organization to all supply chain participants.	3.5.2.3, 3.11.4, 3.12, 3.16, 5.11
GS-G-3.5 [9]	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.	Use of an approved supplier list is seen as a good practice.	3.4.4
GS-G-3.1 [8]	5.29	Types of work for which formal inspection, testing, verification and validation activities are needed should be defined and acceptance criteria and responsibilities for carrying out the work should be stated.	Requires defined processes for acceptance. Inspection and test plans can be produced as part of these processes.	3.5
GS-G-3.5 [9]	5.14–5.22	Provides guidance on inspection and testing, including information to be included in inspection and test plans.	Provides guidance in inspection and test plans preparation.	3.5
GS-G-3.5 [9]	5.24–5.30	Provides guidance on measurement and test equipment (selection, control, calibration, etc.).	Provides guidance on measurement and test equipment. Testing done by vendors should be confirmed to a similar standard.	3.5.2.2, 5.7
GS-G-3.5 [9]	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.	Allows use of commercial products with some controls.	5.1.4

TABLE 1. IAEA MANAGEMENT SYSTEM REQUIREMENTS AND GUIDANCE RELATED TO PROCUREMENT (cont.)

IAEA safety standard	Paragraphs	Requirement/recommendation summary	Comments	Applicable sections of this publication
GS-G-3.5 [9]	5.36	A commercial grade product may need to undergo confirmatory analysis or testing to demonstrate the adequacy of the product to perform its intended function.	Commercial products may need supplementary inspection or testing.	5.1.4
GS-G-3.5 [9]	5.37	When a commercial grade product is proposed for any afety function, a process should be used to determine the product's suitability; this is sometimes referred to as a 'dedication' process in some States.	Commercial grade dedication process required for safety related applications of commercial products.	5.1.4
GS-G-3.5 [9]	5.62–5.64	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.	Spare parts are critical to plant success. Systems need to track parts used to their end locations.	3.12, 5.11
GS-G-3.5 [9]	5.84–5.140	General design information/process steps. Some pertinent ones are: – Structures, systems and components important to safety, including software for instrumentation and control, should be first identified and then classified on the basis of their function and significance to safety; – Procurement activities related to design changes to be via a controlled process with appropriate verification and validation; – Organizations performing qualification testing should have a qualified programme; – Test requirements should be specified, documented and reviewed for validity against acceptance criteria; – Safety related computer programs should be subject to a set of verification and validation tests; – Concessions provided to fabricators from design should be controlled.	Process needed to differentiate part replacements with design changes. Quality list can be a useful tool for classification.	2.4, 3.2, 3.5, 3.16, 5.2, 5.8, 6
GS-G-3.5 [9]	5.141–5.147	Configuration management is critical for safe operation (to maintain conformance with design requirements), especially when changes are made.	Configuration can be lost if part replacements or other procurement activities are not properly controlled within the nuclear power plant or by suppliers.	5.2
GS-G-3.5 [9]	5.148, 5.149	Plant modifications and maintenance need to be controlled.	Control of materials and procurement activities supporting modifications and maintenance supports this (and control of plant configuration).	5.2

TABLE 1. IAEA MANAGEMENT SYSTEM REQUIREMENTS AND GUIDANCE RELATED TO PROCUREMENT (cont.)

IAEA safety standard	Paragraphs	Requirement/recommendation summary	Comments	Applicable sections of this publication
GS-G-3.5 [9]	5.150–5.159	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.	None.	3.11
GS-G-3.5 [9]	5.160–5.162	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.	Item equivalency evaluation or similar process needs to be developed.	3.11.5, 5.1.3
GS-G-3.5 [9]	5.176–5.179	Requirements surrounding configuration control, validation and mitigation of risk for information technology systems.	None.	6
GS-G-3.1 [8]	III.2	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 and document requirements).	None.	3.2
GS-G-3.1 [8]	III.3, III.4	Review, approval and changes to procurement document processes to be defined. Documents to be approved before use and only changed in a controlled manner.	None.	5.7
GS-G-3.1 [8]	III.5–III.11	Suppliers need to 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.	None.	3.4
GS-G-3.1 [8]	III.12–III.16, III.19, III.20	Supplier performance should be evaluated and assessed regularly, and non-conformances addressed.	None.	3.16, 3.17
GS-G-3.1 [8]	III.17	Receipt inspection should be performed promptly. Items should not be released for use until inspections have been completed and documents received and checked.	None.	3.5.2.3, 3.10

Table 2 lists examples of standards and requirements from various countries and international organizations applicable to these areas. The IAEA regularly publishes reports (e.g. Refs [44, 74]) comparing detailed requirements from the IAEA safety standards (e.g. the superseded GS-R-3[3]) with other common systems such as the American Society of Mechanical Engineers (ASME) NQA-1 [72] and ISO 9001:2008 [43]. Differences between GS-R-3 and ISO 9001 existed, because objectives, approaches and perspectives adopted in developing the requirements in each standard were different. GS-R-3 required that health, environmental, security, quality and economic requirements be considered, in conjunction with safety requirements, to help to 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 2. SAMPLE NATIONAL AND INTERNATIONAL STANDARDS RELATED TO NUCLEAR POWER PLANT PROCUREMENT ACTIVITIES

Country/organization	National code or standard related to procurement	Comments
Canada	N286.1-00, Procurement Quality Assurance for Nuclear Power Plants [11]; now part of N286-12, Management System Requirements for Nuclear Facilities [12]	N286.1-00 [11] was a separate procurement related management system requirements publication now incorporated into N286-12 [12]. N286-12 [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.
	Canadian Standards Association CAN3-Z299 Series CAN3-Z299.0-86: Guide for Selecting and Implementing the CAN3-Z299-85 Quality Assurance Program Standards [13] CAN3-Z299.4-85: Quality Assurance Program — Category 4 [14] CAN3-Z299.3-85: Quality Assurance Program — Category 3 [15] CAN3-Z299.2-85: Quality Assurance Program — Category 2 [16] CAN3-Z299.1-85: Quality Assurance Program — Category 1 [17] Note: The above Z299 series is planned to be replaced by a new similarly organized N299 CSA standard series in 2016.	Quality assurance standards originally developed in 1970s as part of Ontario Hydro CANDU related procurement. They were used in developing international ISO 9000 series standards, and were not actively maintained after the 1985 version. 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 programme, 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 inspection and test plans be submitted to the purchaser by the vendor, and have independent inspection and testing.

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006). This publication has been superseded by GSR Part 2 [7].

TABLE 2. SAMPLE NATIONAL AND INTERNATIONAL STANDARDS RELATED TO NUCLEAR POWER PLANT PROCUREMENT ACTIVITIES (cont.)

Country/organization	National code or standard related to procurement	Comments
	REGDOC-3.1.1, Reporting Requirements for Nuclear Power Plants [18]	Defines regulatory reporting requirements for nuclear facilities. Section 15 covers reporting of counterfeit, fraudulent and suspect items. Section 32 covers packaging and transport requirements.
China	HAF601, Design and Manufacture of Civil Nuclear Safety Equipment Installation Supervision and Management Regulations and Non-destructive Testing [19]	HAF601 certification is required for all firms seeking to manufacture, design, install or test safety related equipment at a facility based in China.
	HAF604, Supervision and Management Regulations for Imported Civilian Nuclear Equipment [20]	HAF604 certification is required of firms exporting nuclear safety related equipment and components to China. Covers general rules, registration, regulatory supervision, manufacturing supervision, safety examination and legal responsibilities. Foreign companies are required to have obtained certification from their national standards bodies.
	HAF003, Nuclear Power Plants Quality Assurance Safety Regulations [21]	Nuclear power plant safety regulations for quality assurance in quality assurance programme, organization, design control, procurement control, material control, process control, inspection and test control for non-compliance control, corrective actions, documentation and monitoring. Ensures quality of control for nuclear power plants, nuclear power plant safety related items and services procurement according to guidelines HAD003/03 [22] and HAD003/08 [23], and for fuel assemblies according to HAD003/10 [24].
	HAD003/01, Nuclear Power Plant Quality Assurance Program Development [25]	Nuclear power plant quality assurance programme content.
	HAD003/03, Quality Assurance in Nuclear Power Plant Items and Services Procurement [22]	Nuclear power plant safety regulations for quality assurance in quality assurance programme, organization, design control, procurement control, material control, process control, inspection and test control for non-compliance control, corrective actions, documentation and monitoring.
	HAD003/08, Nuclear Power Plant Items Manufacturing Quality Assurance [23]	Provides quality assurance requirements for nuclear power plant items in manufacturing, including such items as manufacturing unit functions, organization and personnel qualification and training, process standards, process identification, quality planning procedures, work rules, file management, procurement management, material, component identification, inspection and test management, manufacturing equipment management, handling, storage and transport, corrective action items and quality assurance records.
	HAD003/10, Fuel Assemblies Procurement, Design and Manufacture Quality Assurance [24]	Provides quality assurance requirements for nuclear power plant fuel assembly procurement, design and manufacture.

TABLE 2. SAMPLE NATIONAL AND INTERNATIONAL STANDARDS RELATED TO NUCLEAR POWER PLANT PROCUREMENT ACTIVITIES (cont.)

Country/organization	National code or standard related to procurement	Comments
Finland	YVL A.3, Management System for a Nuclear Facility [26]	Defines overall management system requirements for a nuclear facility, including control of products and purchasing. Defines requirements concerning suppliers' management system and quality plans, general requirements concerning project management and safety culture. Purchasing requirements include those related to supplier oversight. Replaces YVL 1.4 [27].
	YVL A.5, Construction and Commissioning of a Nuclear Facility [28]	Requirements concerning project management, safety culture in construction phase, management of supply chains and management of non-conformances. Section 3.4 contains requirements for management of suppliers and the supply chain during construction. Section 5.2 covers regulatory oversight during manufacturing. Replaces YVL A.2 [29].
	YVL E series guides	Provide some detailed safety requirements and 'how to' guidance for selection, qualification, procurement, commissioning and other topics related to specific equipment, such as: nuclear fuel (YVL E.2 [30]), pressure vessels (YVL E.3 [31]), electrical and instrumentation and control devices (YVL E.7 [32]), valves (YVL E.8 [33]), pumps (YVL E.9 [34]), emergency power supplies (YVL E.10 [35]) and hoisting equipment (YVL E.11 [36]).
France	AFCEN RCC-E, Design and Conception Rules for Electrical Equipments of Nuclear Islands [37]	Section A3300 has requirements surrounding procurement related documents (specifications). Section A3710 has requirements surrounding monitoring files covering manufacturing processes. Other sections provide guidance (e.g. selection of suppliers, sampling methods and inspections) for specific components.
	AFCEN, Probationary Phase Rule RPP No. 1 Nuclear Management System, (within RCC-M) [38]	Quality assurance system utilized for French nuclear power plants and referenced in some other countries. Subsection 434 (RPP-1/434) covers purchasing.
Hungary	Nuclear Safety Code Vol. 2 [39]	Appendix to Government Decree 118/2011. Based on GS-R-3*, GS-G-3.1 [8] and GS-G-3.5 [9].
India	AERB/NPP/SC/QA (Rev. 1), AERB Safety Code Quality Assurance in Nuclear Power Plants [40]	Section 3.2.1.3 covers procurement specifically and requires that procured items and services meet established requirements and perform as specified, supplier evaluation based on defined criteria, development of requirements necessary to ensure quality, and evidence that purchased items and services meet requirements before use, for reporting deviations from procurement requirements in procurement documents and for processes for non-conformance control and corrective actions.

TABLE 2. SAMPLE NATIONAL AND INTERNATIONAL STANDARDS RELATED TO NUCLEAR POWER PLANT PROCUREMENT ACTIVITIES (cont.)

Country/organization	National code or standard related to procurement	Comments
	AERB/SG/QA-2, Quality Assurance in the Procurement of Items and Services for Nuclear Power Plants [41]	Provides requirements and recommendations related to implementation and administration of procurement activities in all phases of a nuclear power plant'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.
	AERB/SG/QA-3, Quality Assurance in the Manufacture of Items for Nuclear Power Plants [42]	Provides recommendations on how to fulfil code requirements related to manufacture of items important to safety at nuclear power plants. Sections included for management, performance, verification and corrective functions. Appendices provide examples of quality assurance levels, quality assurance plans, transport controls (including packaging) and design concessions, among others.
International Organization for Standards (ISO)	ISO 9001:2008, Quality Management Systems: Requirements [43]	See Ref. [44] for comparison to GS-R-3*.
	ISO 9004:2009, Managing for the Sustained Success of an Organization — A Quality Management Approach [45]	Provides guidance to organizations supporting achievement of sustained success by a quality management approach. Provides wider focus on quality management than ISO 9001:2008 [43], addressing needs and expectations of all relevant interested parties.
	ISO 10845 series on construction procurement Part 1: Processes, Methods and Procedures [46] Part 2: Formatting and Compilation of Procurement Documentation [47] Part 3: Standard Conditions of Tender [48] Part 4: Standard Conditions for the Calling for Expressions of Interest [49] Part 5: Participation of Targeted Enterprises in Contracts [50] Part 6: Participation of Targeted Partners in Joint Ventures in Contracts [51] Part 7: Participation of Local Enterprises and Labour [52] Part 8: Participation of Targeted Labour in Contracts [53]	Helps organizations to establish a procurement system that is fair, equitable, transparent, competitive and cost effective. These standards are designed to help public, private and international organizations and their main contractors to align their procurement systems with international best practice.
	ISO 14001:2004, Environmental Management Systems — Requirements with Guidance for Use [54]	Specifies requirements for an environmental management system for organizations. Often adopted by utilities and for a requirement for suppliers within the nuclear supply chain.
	ISO/AWI 19443 (draft) Quality management systems — Specific requirements for the application of ISO 9001 and IAEA GS-R requirements by organizations in the Supply Chain of the Nuclear Energy sector 19443	Draft standard by ISO TC85 building on work by Nuclear Quality Standards Association (see below) to produce a common quality standard based on GS-R-3*, ISO 9001:2008 [43] and ASME NQA-1-2008 [56] (and addenda 2009 [57]).

TABLE 2. SAMPLE NATIONAL AND INTERNATIONAL STANDARDS RELATED TO NUCLEAR POWER PLANT PROCUREMENT ACTIVITIES (cont.)

Country/organization	National code or standard related to procurement	Comments
Nuclear Quality Standards Association	NSQ-100, Nuclear Safety and Quality Management System Requirements [55]	Industry led initiative open to major nuclear utilities, nuclear engineers and manufacturers designed to produce a common quality standard based on GS-R-3*, ISO 9001:2008 [43] and ASME NQA-1-2008 [56] (and addenda 2009 [57]). Document layout is similar to ISO 9001:2008 [43]. Correspondence matrices to various quality assurance standards are also published [58–60]. An initiative being undertaken by ISO to convert this to an ISO standard (draft ISO 19443).
Russian Federation	OPB-88/97 NP-001-97 (PNAE G-01 011-97), General Regulations on Ensuring Safety of Nuclear Power Plants [61]	Requires safety classes of nuclear power plant elements be designated by design (four classes defined), and quality assurance requirements assigned to safety classes 1, 2 and 3 be specified in regulatory documents.
	NP-082-07, Nuclear Safety Rules for Reactor Installations of Nuclear Power Plants [62]	Requires, among other things, that quality assurance programmes to be developed for all stages of nuclear power plant life, that safety important components be subjected to inspections and tests during manufacturing to verify design characteristics and that designs contain lists of structures, systems and components whose performance and characteristics are to be verified.
	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 [63]	None.
	NP-061-05, Safety Rules for Storage and Transportation of Nuclear Fuel at Nuclear Facilities [64]	Establishes technical and organizational requirements for nuclear fuel storage and transport systems at nuclear power plants, including separate storage on nuclear power plant sites, off-site facilities, nuclear research installations, and onshore and floating nuclear fuel storage facilities.
South Africa	RD-0034, Quality and Safety Management Requirements for Nuclear Installations [65]	Details regulatory requirements for quality and safety management system requirements for licensees, including procurement requirements, utilizing ISO 9001:2008 [43] as a basis.

TABLE 2. SAMPLE NATIONAL AND INTERNATIONAL STANDARDS RELATED TO NUCLEAR POWER PLANT PROCUREMENT ACTIVITIES (cont.)

Country/organization	National code or standard related to procurement	Comments
United Kingdom	NS-TAST-GD-077 Rev. 3, Supply Chain Management for the Procurement of Nuclear Safety Related Items or Services [66]	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 United Kingdom. Covers requirements on purchasers, supplier selection, procurement documents, quality plans, contract variations, competence, deviations and technical queries, records, inspection and surveillance activities, non-conforming counterfeit and suspect items and management system certification.
	NS-TAST-GD-049 Rev. 4, Licensee Core and Intelligent Customer Capabilities [67]	Helps regulatory inspectors to assess suitability of approaches a licensee may take for in-house expertise to maintain control and oversight of nuclear safety at all times, and for use and oversight of contractors whose work has potential to impact nuclear safety.
	BS 8903:2010, Principles and Framework for Procuring Sustainably [68]	Provides a framework to help management with sustainable and economic development. Covers implementation of sustainable procurement processes across all supply chains, and putting correct measures into place to test sustainability.
	BS OHSAS 18001:2007, Occupational Health and Safety Management Systems [69]	Defines requirements for an occupational health and safety management system. Currently going through the process of becoming ISO 45001.
USA	10 CFR 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants [70]	Regulation requiring control of procurement of safety related items. Includes specific requirements surrounding procurement document control, control of purchased items and services, inspection and test control, control of measuring and test equipment, handling storage and shipping, non-conformances and corrective action, among others.
	10 CFR 21, Reporting of Defects and Noncompliance [71]	Section 21.31 'procurement documents' specifically indicates that Part 21 reporting of defect requirements applies to procurement participants. This includes such things as maintaining records, providing access to the Nuclear Regulatory Commission and reporting defects to the Nuclear Regulatory Commission, among others.
	ASME NQA-1:2012, Quality Assurance Requirements for Nuclear Facility Applications [72]	Quality assurance system utilized for US nuclear power plants and referenced in some other countries. See Ref. [73] for a comparison between GS-R-3* and NQA-1-2008 [56].
	ANSI N45.2.2, Packing, Shipping, Receiving, Storage, and Handling [74]	Original standard used for nuclear power plant transport and storage issues. Now replaced/ incorporated into NQA-1-2012 [72].

TABLE 2. SAMPLE NATIONAL AND INTERNATIONAL STANDARDS RELATED TO NUCLEAR POWER PLANT PROCUREMENT ACTIVITIES (cont.)

Country/organization	National code or standard related to procurement	Comments
	ANSI N45.2.13, Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants [75]	Original quality assurance standard used for nuclear power plant procurement. Now replaced/incorporated into NQA-1-2012 [72]. Remains referenced in many nuclear power plant licences.
	EPRI 1007937, Analysis and Comparison of ANSI/ISO/ASQ Q9001:2000 with 10 CFR 50, Appendix B [76]	Analyses quality requirements in ANSI/ISO/ASQ Q9001-2000 [77] compared with those of 10 CFR 50, appendix B [70], 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 standards.
	EPRI 1008258, An Overview of Other Industry Experience with the ISO 9000 Quality Management System [78]	Presents results of Electric Power Research Institute studies in support of determining how the US nuclear industry can more broadly employ suppliers certified to ISO 9000. Identified operating experience 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. Concludes 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 quality assurance programme, but rather the implementation of the chosen programme.
	NEI 06-14A, Quality Assurance Program Description [79]	Provides a template for applicants to implement applicable requirements of a quality assurance programme meeting 10 CFR 50, appendix B [70] and 10 CFR 52 [80]

* INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006). This publication has been superseded by GSR Part 2 [7].

2.2. SUPPLY CHAIN MANAGEMENT

Supply chain management encompasses the planning and management of all activities involved in sourcing, procurement, conversion and logistics management (according to the Council of Supply Chain Management Professionals). It also includes coordination and collaboration with channel partners, who 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, supply chain management 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. It involves changing relationships and corresponding processes with external suppliers and within the operating organization itself.

Typical nuclear supply chain tiers are shown in Fig. 2. New build projects are typically concerned with how tier 1 technology vendors set up and manage their supply chains, while operating plants typically deal directly with tier 3 and below for spare parts associated with operation 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.

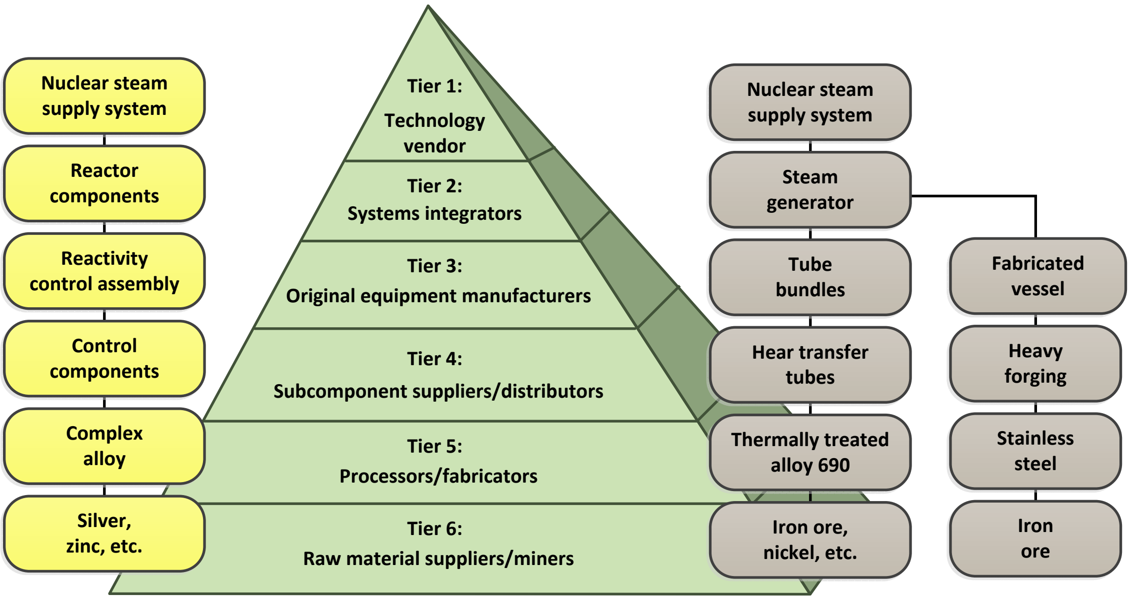


FIG. 2. Typical nuclear supply chain tiers (adapted from Ref. [81] with permission).

An example of a supply chain management activity for an operating facility is the analysis of commodities purchased and the preparation of a strategic positioning action plan for each of them. The Scottish Government, for example, uses an adaptation of a portfolio matrix developed by Kraljic [82] for its public procurement activities. This methodology categorizes commodity types into routine, bottleneck, leverage and strategic categories (see Fig. 3), and suggests typical actions to take to manage the relationships with suppliers in each category (see Table 3). An assessment tool [85] is available to assist in this evaluation approach. Nuclear power plants 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 on a cross-functional basis, should be a key supply chain activity.

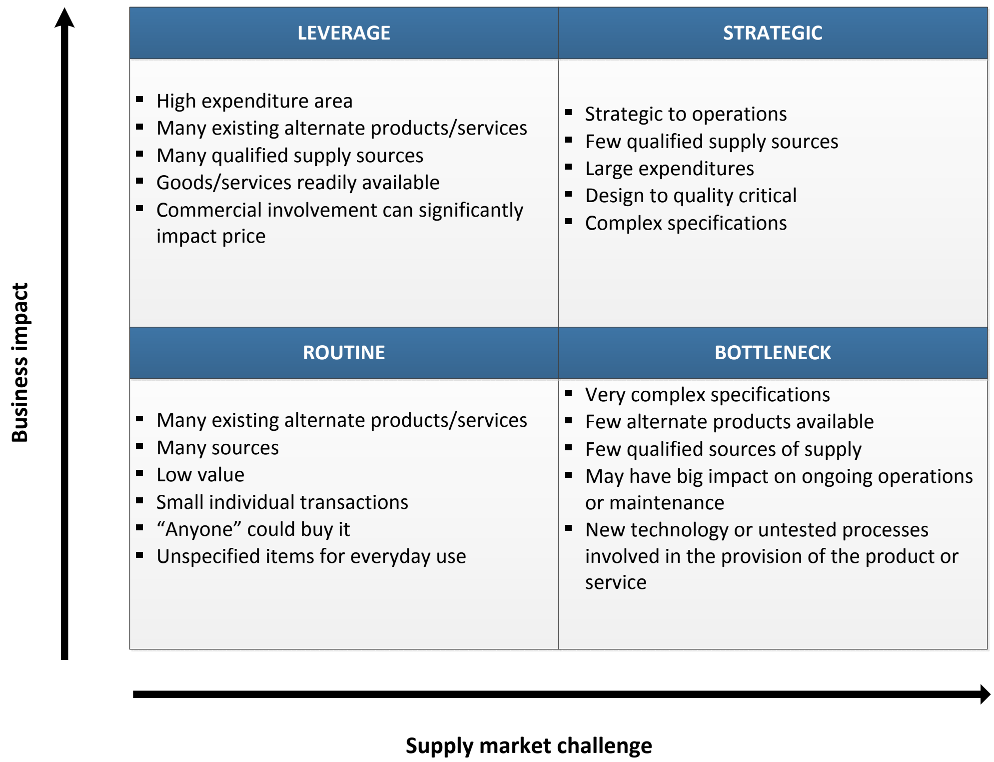


FIG. 3. Strategic commodity positioning (adapted from Ref. [83] with permission).

TABLE 3. TYPICAL SUPPLY CHAIN MANAGEMENT ACTION PLAN FOR VARIOUS COMMODITY TYPES

Commodity position	Examples of commodity	Typical sources	Recommended approach	Typical action plan
Routine	Office supplies, desktop computers, laptop computers, etc.	Local suppliers	Should take up minimal time and effort Minimize management attention and investment (use lower level buyers to manage) Consider e-procurement	Mid-term contracts Utilize supplier's own specifications Offer supplier incentives to substitute Reduce inventory; supplier managed inventory Relationship owned by budget holder/end user Simple performance measurement process with focus on reliability Monitor internal time spent resolving problems
Bottleneck	Complex specification products (e.g. electronic parts, outside services)	Global suppliers, often new suppliers with new technology	Should ultimately be transitioned into another commodity position Ensure supply of critical items	Long term contracts Ensure supplier is motivated to provide quality service Investigate developing new suppliers or alternative products 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
Leverage	Commodities (gravel, soil, courier services, oil, etc.) with multiple suppliers	Multiple suppliers, mostly local	Leverage relationships are built solely around price Cut cost using innovation and competition	Short term contracts/blanket orders Focus on price Ensure suppliers are aware that they are competing 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 suppliers that reduce total costs Manage transport costs separately

TABLE 3. TYPICAL SUPPLY CHAIN MANAGEMENT ACTION PLAN FOR VARIOUS COMMODITY TYPES (cont.)

Commodity position	Examples of commodity	Typical sources	Recommended approach	Typical action plan
Strategic	Most direct commodities (strategic items, high value components)	Established global suppliers	Strategic relationships have to be partnerships with mutual benefits Actively manage the relationship (take prompt action on slipping performance, involve top level management)	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 and service Consider on-site representation Contingency planning and risk analysis

Source: Adapted from Refs [82, 84].

2.3. INFORMED CUSTOMER ROLE

Nuclear facility owners and regulators often use the concept of the 'informed customer' (sometimes referred to as an 'intelligent customer', 'knowledgeable customer' or 'smart buyer') when developing their management system for dealing with service or major equipment suppliers. GSR Part 2 [7] and IAEA Safety Standards Series No. GSG-4, Use of External Experts by the Regulatory Body [86], define informed customer capability as the "capability of the organization to have a clear understanding and knowledge of the product or service to be 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 or process steps can be less well defined.

Some characteristics of an informed customer include (adapted from GSG-4 [86]):

(a) A full understanding of the need for an external expert's services and the context in which work is performed;
(b) Knowledge of what is required and how the work will be used;
(c) Knowledge of proper specification of objectives, scope and requirements of the work so that the product will meet needs;
(d) Knowledge of reasonable time frames for delivery of the work consistent with proper quality;
(e) Knowledge and provision of site specific information that could be useful to the external expert;
(f) An understanding of expected work outcomes;
(g) An ability not to 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;
(h) An ability to oversee the work in accordance with the owner's procedures and management system and to perform technical reviews of the work when necessary;
(i) An ability to ensure regular interaction with suppliers and facilitate interaction with other parties relevant to the task if necessary.

Some operating organizations have developed dedicated staff and training for their informed customer staff. Such personnel can develop efficient processes and points of contact with supplier staff in order to better manage the relationships. Some individuals can be more suitable to the oversight role than others. For example, being a good designer does not necessary mean that the individual can effectively manage design oversight functions.

The Office for Nuclear Regulation, in the United Kingdom, has produced a guidance document on assessment of the intelligent customer role which documents a number of useful principles related to the use of contractors, including [67]:

“.......

4. The licensee should maintain an ‘intelligent customer’ capability for all work carried out on its behalf by contractors that may impact upon nuclear safety;
5. The licensee 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;
6. The licensee 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;
7. The licensee should ensure that contractors’ work is carried out to the required level of safety and quality in practice.”

2.4. SAFETY RELATED VERSUS NON-SAFETY-RELATED PROCUREMENT

Processes for purchasing items can be graded between safety related and non-safety-related. This risk based approach drives quality requirements, acceptance criteria and methods, and the extent and rigour of verification activities during the procurement process. For example, an Electric Power Research Institute (EPRI) report states that a typical US plant would have 80% non-safety-related components [87], 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 (see paras 2.41–2.44 of GS-G-3.1 [8]):

— Safety significance and risk;
— Supplier expectations;
— The scope and level of detail of procurement specifications provided;
— The need for, and scope of, supplier quality plans;
— The extent of supplier inspection, surveillance and audit activities;
— The scope of documents and records provided by suppliers;
— The need for document storage or preservation.

Processes for non-safety-related equipment can depend on factors such as the economic or production impacts of the equipment and the item complexity. Processes for significant non-safety-related equipment can end up being similar to those of safety related equipment.

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

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

The development of a Q-list and thus of graded procurement processes requires a method for systematically evaluating and classifying items. IAEA Safety Standards Series No. SSG-30, Safety Classification of Structures, Systems and Components in Nuclear Power Plants [88], establishes one approach to safety class categorization. It classifies structures, systems and components (SSCs) into three safety related classes according to the severity of consequences of their failures and a ‘non-categorized’ class of non-safety-related items. IAEA-TECDOC-1740 [10] provides further details on the grading of requirements related to procurement.

Another key list established by many operating organizations is a list of all digital or electronic equipment that, if compromised, could result in a safety or security event with the potential to lead to unacceptable radiological consequences. This list is often referred to as a ‘critical cyber asset’ or ‘critical digital asset’ inventory, and is normally classified as security protected. IAEA Nuclear Security Series No. 17, Computer Security at Nuclear Facilities [89], describes how this fits into an organization’s computer security plan. Equipment on this list is required to have increased computer security measures put in place to protect against malicious compromise. These measures require implementation at various stages of the procurement process, and include methods to protect security sensitive information. Computer security personnel should thus be consulted as part of procurement processes as to whether procured equipment is identified within the critical digital asset inventory.

2.5. FAIRNESS AND ETHICS IN THE PROCUREMENT PROCESS

Procurement of major projects, large capital equipment or even smaller goods and services can be subject to unethical behaviour. Factors such as politics, cultural norms and economic development can influence individual behaviours. Such behaviours can include:

- Use of facilitation payments;
- Bribery;
- Gift giving;
- Preferential awarding of contracts;
- Existence of undeclared conflicts of interest;
- Intentional overlooking of quality defects;
- Overlooking absence or forgery of documentation;
- Money laundering;
- Nepotism;
- Extortion;
- Trading in influence;
- Reducing the apparent value of a purchase to avoid any requirements regarding competition, approvals or reporting (e.g. by subdividing and awarding projects or contracts as multiple consecutive contracts to the same supplier);
- Treating workers (including those of subsuppliers) poorly through unfair labour practices or via unsafe industrial safety standards.

A foreign bribery report was published recently by the Organisation for Economic Co-operation and Development (OECD) [90]. The report indicates that bribes were offered or given most frequently to employees of public enterprises to obtain public procurement contracts, and almost half of the cases involved bribery of public officials from countries with high (22%) or very high (21%) levels of human development [90].

Nuclear projects can be impacted by unethical behaviour in terms of safety, security, economics and reputation. Vendors may not wish to participate in environments where unethical behaviour is common. Project managers and senior management should be aware of the potential for such activities, put policies in place to address them and take other steps as necessary to avoid them.

The IAEA has published information on establishing a code of ethics for nuclear operating organizations [91]. It recognizes the fact that the only way to do business as a nuclear industry operating organization is with high ethical standards in all respects, and that not tolerating bribery and corruption — at any level or in any area of the organization — is particularly important [91]. Appendix B of Ref. [91] provides links to codes of ethics for some nuclear industry organizations.

ISO 10845-1:2010 [46], on construction procurement, identifies that basic procurement system requirements should include the attributes of being fair, equitable, transparent, competitive and cost effective. They may also include promotion of other secondary objectives such as promotion of local enterprises, poverty alleviation, job creation, economic development, skills development and environmental standards.

The OECD provides a number of tools as part of its CleanGovBiz initiative that support governments combating corruption and help them to engage with civil society and the private sector to promote real change towards integrity. One of these, produced in cooperation with the United Nations Office on Drugs and Crime and the World Bank, is an anticorruption and ethics compliance handbook for business [92]. Another is specific guidelines for the behaviour of multinational enterprises [93]. Non-governmental organizations, such as Transparency International, can also provide valuable information and reports about specific regions or industries.

In 2011, the National Institute of Governmental Purchasing, in the United States of America, and the Chartered Institute for Purchasing and Supply, in the United Kingdom, formed a partnership to establish an international presence for a standard set of principles and practices for public procurement. Twenty global standards of practice were produced, including one on ethical procurement [94]. This practice indicates that ethical procurement "prohibits breach of the public's trust by discouraging a public employee from attempting to realize personal gain through conduct inconsistent with the proper discharge of the employee's duties" (*footnotes omitted*) [94]. It indicates that procurement organizations should have an adopted code of ethics (a sample supplier code of conduct adopted by the United Nations is available [95]) and require employees to uphold the code and seek commitment to it by all those with whom they engage. The practice further defines a number of elements that are part of ethical procurement. These include:

— Methods to avoid conflicts of interest;
— Ensuring business dealings with suppliers are fair and transparent (open e-procurement platforms can assist);
— Ensuring corruption is reported and not tolerated;
— Ensuring clear policies are in place and followed for accepting business gifts;
— Ensuring ethical practices are defined and embedded in other policies, procedures and practices which overlap procurement;
— Ensuring compliance.

Suppliers with known unethical practices should be excluded from nuclear facility approved supplier lists. As will be described in Section 7, whistle-blower protection and anonymous reporting channels can be a key tool in the fight against counterfeit and fraudulent items or, in fact, against any unethical behaviour.

Reference [96] states that project managers should be eternally vigilant for unethical activities and must resist, to the point of resignation, pressures to behave unfairly. To do so, managers should follow four rules [96]:

> "Rule 1: Assure staff that you are not going to preside over a corrupt organization and that you take it personally.
> Rule 2: Avoid temptation. Ensure that every order needs two signatures so that corrupt behaviour also requires collusion.
> Rule 3: Investigate every rumour diligently and make it known that you are doing so.
> Rule 4: Make it very clear to staff that the taking of bribes means instant dismissal."

Once contracts are awarded, purchasers can be subject to accusations of using unfair tendering practices and be subject to expensive litigation. A good practice utilized in some countries is the appointment of a 'fairness monitor' organization to assist owners in ensuring that procurement processes involving bidding and selection are conducted in a fair and transparent manner [97]. Such a monitor would advise the purchaser on:

— Appropriate wording of request for proposal documents;
— Communications and consultations;
— Adequacy of notification of changes;
— Confidentiality and security of submissions and evaluations;
— Qualifications of evaluation teams;
— Process compliance;
— Objectivity and diligence;
— Proper use of evaluation tools;
— Conflicts of interest.

The monitor would oversee the evaluation process by attending meetings with bidders, monitoring communications, providing advice on procurement documents with a view to ensuring fair treatment and issuing a final report confirming the fairness of the process.

2.6. SUSTAINABLE PROCUREMENT

Sustainable procurement (sometimes called ‘green’ procurement) can be defined as a process whereby organizations meet their needs for goods, services, works and utilities in a manner that achieves value for money on a whole life basis in terms of generating benefits not only to the organization but also to society and the economy while minimizing the damage to the environment. Sustainable procurement saves costs and resources by reducing or eliminating waste by:

— Questioning the need to buy;
— Reducing quantities;
— Saving energy and water;
— Combating climate change;
— Promoting fair trade;
— Promoting reuse and recycling;
— Minimizing packaging
— Optimizing transport efficiencies.

Governmental bodies, corporations and nuclear facility operating organizations often incorporate sustainable development policies as part of their governance to address environmental, economic and social sustainability and to minimize risk.

There can be confusion and differences in opinion on how to implement sustainable requirements given the overall requirements to achieve best value. Organizations should, however, set out a policy on how they intend to implement sustainable procurement at an operational level. The policies should also be reflected in organizational procurement procedures and practices, including in supplier prequalifications, evaluations, contractual agreements, standard terms and conditions, and methods to monitor contract performance.

BS 8903:2010, Principles and Framework for Procuring Sustainably [68], is an example standard for procuring sustainably. The European Commission has also published a guide on environmental public procurement [98], and the World Bank’s International Finance Corporation (IFC) has produced a set of environmental and social performance standards that defines IFC client responsibilities for managing their environmental and social risks [99]. The Construction Industry Institute (CII) has published a number of resources on construction sustainability, including Ref. [100], which lists various construction phase sustainability actions that can be taken by owners and contractors (including those related to material and services procurement), a screening tool for ranking sustainability actions and sustainability related metrics.

2.7. PROCUREMENT STRATEGIES

Operating organizations can benefit from the creation of formal procurement strategies and procurement planning activities. Procurement strategies examine the ‘what’, ‘how’, ‘where’ and ‘why’ of purchasing items and services. They can be prepared for single purchases, groups of requirements or for entire organizations. Corporate procurement strategies are increasingly impacted by, and affect, overall company business strategies.

The Chartered Institute of Purchasing and Supply, in the United Kingdom, defines supply chain strategy as encompassing three specific areas:

(1) Procurement and supply management strategy;
(2) Operations strategy;
(3) Distribution and dissemination strategy.

The procurement and supply management strategy is designed to manage an organization's overall external resources, maximize value and minimize risk. It includes identifying business needs, establishing a governance structure, objectives, key policies, processes, technology support for procurement and performance metrics. Operations strategies cover activities such as inventory management, plant and equipment management, and collaborations. Distribution and dissemination strategy covers such items as customer or supplier relationship management, service levels, delivery methods and disposal. There are also other aspects of a company's overall strategy, which includes such items as finance, human resources, marketing, R&D and technical strategies.

Preparing a corporate procurement strategy often follows the steps of understanding the current status of procurement operations, identifying what is important to the procurement organization as well as to the overall company, defining what success looks like, developing measurable targets that define success, and implementing and measuring the resultant strategy. A vision and mission for the procurement organization and written policy principles are often valuable outcomes of this process.

Procurement policies for an organization are high level documents designed to enable uniform and efficient procurement practices within the organization in alignment with its strategy. They typically includes guidance with respect to organizational roles and responsibilities, source selection and treatment of suppliers, ethics and codes of conduct, professional and personnel development related to the procurement function, corporate oversight, and secondary procurement objectives (e.g. use of targeted enterprises or labour, and sustainable procurement).

As a part of policy and strategy development, procurement organizations need to decide what commercial relationships are to be put in place on an ongoing basis. These relationships need to be regularly reviewed and may need to change over the life of a nuclear facility. Procurement issues such as those relating to equipment obsolescence, spare part stocking and human resources are different for new facilities from those at, or approaching, their refurbishment or decommissioning stages. Corporate mergers, acquisitions or divestitures can also affect the extent to which purchasing functions can be optimally centralized or performed locally at an individual facility.

2.8. RISK MANAGEMENT

Risk management is a continuous and iterative process that includes updating procurement or project related risk documents and their associated risk management plans. It emphasizes the communication of risks and actions taken to mitigate them. Risks can include key technical, schedule and cost risks associated with the procurement of goods or services.

ISO 31000:2009 [101], Risk Management, provides principles, a framework and a process for managing risk. The associated IEC 31010:2009 [102] is a supporting standard for ISO 31000:2009 [101] and provides guidance on selection and application of systematic techniques for risk assessment.

Organizations associated with procurement and major projects should have defined risk management structures that specify the chain of authority, communication structure and management framework with which risk management and the decision processes will occur. For risk management to be effective, it should be an integral part of an organization's management system (e.g. standards, procedures, directives, policies and other management documentation).

Some examples of risks associated with nuclear procurement or contracts can include the following:

(a) Identification of need:
- Understatement of need;
- Overstatement of need;
- Insufficient funding to address need;
- Impractical target dates;
- Probity failure (failure to run a fair procurement process);
- Misinterpretation of user needs;
- Political or company environment (e.g. direction changes from senior management or government);
- Likely media interest.

(b) Establishing requirements:
- Narrow definition or commercial specification (e.g. specific product or brand name identified and not a general requirement);
- Definition of inappropriate product or service;
- Biased specification;
- Specification of 'special order' technical or quality requirements that require suppliers to perform actions outside of their normal production processes;
- First of a kind purchases, new items, customized items or items that have not been produced for a long period of time;
- Inadequate specification or statement of work (for services), including inadequate specification of inspection, test or acceptance criteria and methods, computer security measures, packaging, marking, shipping and storage requirements;
- Detrimental environmental or societal impacts not addressed (impacting on company reputation).

(c) Procurement scenarios:
- Failure to identify potential sources;
- Selecting inappropriate method;
- Supplier collusion;
- Strength of company relative to market.

(d) Bidding, evaluation and placement of purchase order:
- Terms and conditions unacceptable to service providers;
- Providing inadequate information (later interpretation issues or disputes due to unclear or conflicting documentation, requirements or contracts);
- Failure to address service provider enquiries adequately;
- Actual or perceived favouritism in providing information;
- Actual or perceived breach of confidentiality;
- Insufficient number of responses;
- No response from known quality service providers;
- Failure to follow effective evaluation procedures;
- Breaches of security (e.g. unauthorized access to, or disclosure of, sensitive commercial or security related information);
- Offers fail to meet needs;
- Failure to identify a clear winner;
- Decision made on subjective grounds;
- Selecting an inappropriate service provider;
- Selecting an inappropriate product;
- Not matching expectations of buyer and service provider;
- Deadlock on details of agreement;
- Failure to secure mandatory conditions;
- Unfair or onerous requirements on the service provider in contract conditions;
- Failure to reflect the terms offered and agreed in contract;
- Inadvertently creating a contract without proper approvals, or for an inappropriate product.

(e) Contract management and execution:
- — Variations in price and foreign currency exchange;
- — Unwillingness of service provider to accept the contract;
- — Inadequately administering the contract;
- — Coordination issues (e.g. handoff delays, poor communication, language or cultural issues);
- — An absence of efficient dispute resolution process causing delays in contract activities;
- — Production or schedule pressures resulting in short cuts;
- — Issues with implementation of supplier quality management system or quality assurance programme (especially for new or re-established programmes);
- — Commencement of work by the service provider before contract is exchanged or letter of acceptance issued;
- — Unauthorized or unexpected increase in scope of work;
- — Loss of intellectual property;
- — Failure to meet liabilities of third parties (e.g. royalties or third party property insurance);
- — Loss of, or damage to, goods in transit;
- — Fraud or other unethical behaviour (including supply of counterfeit or fraudulent items);
- — Malicious cyber compromise of electronic equipment at the vendor location, during storage or in transit;
- — Inadequate security during production, including a lack of a secure computer development environment, contractor qualifications and on-site security inspections;
- — Disclosure of sensitive information or technology by vendors or subvendors;
- — Key personnel not available (i.e. retirement, left company, company reassignment to different work);
- — Labour or product availability (staff or material not available when needed, including inability to fill larger orders than normal, wrong product shipped or the impact of possible labour disputes);
- — Significant change in supplier operations (including supplier going out of business or being purchased or merged with another entity);
- — Technological failures (product or project does not work, failure of the design);
- — Supplier not familiar with specified design codes (especially for international purchasing);
- — Supplier inexperienced with CGD requirements;
- — Unusual or even normal (i.e. within expected normal ranges for the site) weather conditions, resulting in work being pushed into an unplanned (worse weather) season;
- — Unanticipated field conditions;
- — Contractor or supplier performance;
- — Productivity;
- — Subcontractor performance;
- — Damage, theft or tampering during transport (including hijacking, piracy or cyber-attacks) or storage;
- — Industrial or radiological safety issues (i.e. procedural non-compliances, events or near misses);
- — Improper waste disposal (environmental impacts, items entering counterfeit or fraudulent supply chain, and reputation impacts).

(f) Evaluating the procurement process:
- — Failure to evaluate procurement and management processes;
- — Failure to identify problems and lessons learned and to implement corrective actions (both internal and external to the organization).

A key deliverable of any risk management process is a documented risk management plan (RMP). The RMP includes risk identification and analysis, and informs all stakeholders about how and by whom the identified risks will be managed (accepted, avoided, mitigated, enhanced or transferred), what residual risk remains following mitigation actions and what monitoring will be done. A good practice is for RMPs (often called risk registers) to be prepared for all projects, initiatives and major organizational units. These should be reviewed at regular intervals or at major milestones, and can be combined or summarized as required at a facility or corporate level.

Once risks are identified, the likelihood and consequences of each risk should be defined and an overall risk rating determined. Figure 4 shows a typical risk ranking chart, which provides a colour rating (red, amber, yellow or green) for each identified risk. In the chart for likelihoods, 'almost certain' means the risk is expected to occur in most circumstances, 'likely' means it would probably occur in most circumstances, 'possible' means it could

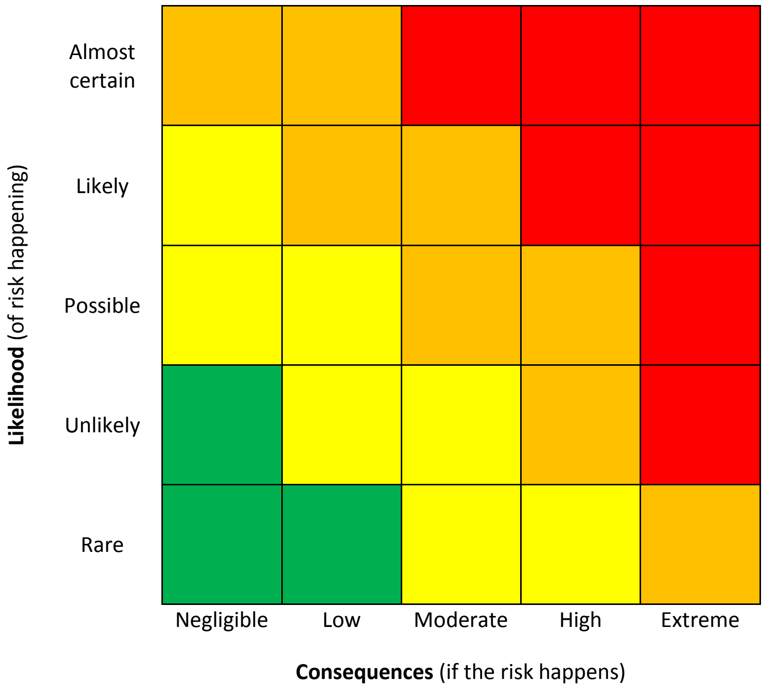


FIG. 4. Overall risk ranking chart.

occur at some time, 'unlikely' means it is not expected to occur and 'rare' means it may occur only in exceptional circumstances. For consequences, 'extreme' means it has significant impact on the achievement of goals/objectives, 'high' or 'moderate' imply high or moderate impacts, 'low' implies impact only on a limited aspect of an activity and 'negligible' implies that the consequences are dealt with by routine operations.

The associated risk register is then prepared (see Table 4), which shows the risk impact, potential actions that can be taken to mitigate the risk, the postmitigative remaining risk and any remaining possible controls.

Risk registers can be used as part of project or procurement funding steps or as part of regular organizational reviews. 'Consequence' in some risk registers is sometimes divided into 'best case', 'most likely' and 'worst case' scenarios for cost or schedule impacts, with each impact being associated with a quantitative value (monetary value for cost impacts, and time (e.g. days or weeks) for schedule impacts). Similarly, 'probability' in some risk registers may be defined as a number based on either judgement or risk simulation methods (e.g. the Monte Carlo simulation). Table 5 shows how this might appear for risks associated with an example project.

As new risks are identified, they should be added to the risk register. Unidentified risks might originally be unanticipated because the probability of the event is so small that its occurrence is virtually unimaginable. Alternatively, an unidentified risk might be one that falls into an unanticipated or uncontrolled risk event category ('force majeure' risks).

EPRI has published a guide for supplier quality management in the context of new nuclear power plant construction [103]. Its aim is to promote quality risk mitigation during procurement of materials, equipment and services intended for use in safety applications. The report identifies potential supplier quality related issues as [103]:

— Supplier experience;
— Change in supplier production operations;
— Cultural, language and communication challenges;
— Technical or quality requirements on standard products;
— First of a kind engineering;
— Time since last production of an item;
— Schedule pressures;
— Limited experience with CGD.

TABLE 4. EXAMPLE PROCUREMENT RISK REGISTER

Risk	Impact	How risky is this if left uncontrolled?			Does procurement plan mitigate risk?	What level of risk remains if mitigated?			Are additional controls needed?
What would stop procurement objectives being met?	What would be the result of this risk?	Likelihood	Consequence	Risk rating (uncontrolled)	What is in place to reduce the risk?	Likelihood	Consequence	Risk rating (controlled)	What else could be done to reduce this risk?
Example: Suppliers do not understand the business need.	Proposals fail to address requirements, no proposals meet need.	Possible	High	A	Make sure description of goods/services is comprehensive Double check the final draft with the business owner Set appropriate weightings	Rare	Moderate	Y	Test description of goods/services with someone not involved in drafting Provide supplier briefings before issuing tender

Risk rating = use colour + letter

G	Y	A	R
green	yellow	amber	red

TABLE 5. EXAMPLE PORTION OF RISK ASSESSMENT MATRIX ASSOCIATED WITH A PROJECT

ID	Threat	Cost impact (US $)			Schedule impact (weeks)			Probability (%)
		Best case	Most likely	Worst case	Best case	Most likely	Worst case	
T1	Labour unavailability due to competing projects	1 000	2 000	4 000	4	8	16	10–25
T2	Construction subcontractor bids come in slightly higher than estimate	0	5 000	20 000	0	0	0	75–90
T3	Material prices rise higher than budgeted	500	1 500	3 000	0	0	0	26–74
T4	Stakeholder objections delay building permit	1 000	2 500	4 000	4	10	16	<10

ID	Opportunities	Cost impact (US $)			Schedule impact (weeks)			Probability (%)
		Best case	Most likely	Worst case	Best case	Most likely	Worst case	
O1	Shorten the construction schedule by adding shifts	3 500	2 000	750	16	10	4	75–90
O2	Obtain material discounts using prompt payment provisions in procurement contracts	3 000	1 500	0	0	0	0	26–74

In the report, EPRI further identifies that management of risks associated with supplier quality issues requires the following [103]:

(a) Effective implementation by purchasers and suppliers of key elements of their nuclear quality assurance programmes (including such items as establishing a nuclear safety culture, corrective action programmes, using performance based audits, addressing CGD programmes within audits, involving technical staff in auditing and internal audit programmes).
(b) Adoption of recommended good practices by project owners, lead engineer–procure–construct firms, purchasers and suppliers to prevent supplier quality issues from occurring. These can include the use of owner procurement risk assessments, effective order entry processes, and efficient and effective purchaser/supplier communication.
(c) Analysing procurement events for risk, putting into place prevention or mitigation plans for those with unacceptable risk (similar to the risk register process described earlier in this section) and incorporating supplier risk into the supplier sourcing and selection process.

Purchasers, if they address the above risks, should see the benefits of reduced rework and labour hours, reduced impact on shop floor operations and delays, reduced overtime and expediting costs, fewer damage claims for missed deliveries and sustained profit margins [103].

CII has looked at project risk assessment from an international perspective. It has developed the International Project Risk Assessment (IPRA) tool [104], which identifies and describes issues that are the critical elements related to international capital projects and allows project teams to focus on risk factors of potential concern. IPRA analysis is focused on issues that are unique to ventures in an international jurisdiction, such as commercial risks, country risks (i.e. taxes, political, cultural and legal), facility specific issues (i.e. sourcing and supply, workforce availability, permitting) and production/operation risks (i.e. language, local workforce and logistics). Such a tool would be useful in identifying procurement and other risks for new nuclear power plants or other major international nuclear projects. CII has also published a guide to using probabilistic risk management in design and construction projects [105] that discusses the use of risk registers at increasing levels of sophistication (identification of risks, deterministic analysis and probabilistic analysis) and interpretation of results. Another CII guide [106] discusses a two party risk assessment and allocation model that is designed to identify, assess and allocate risk before project execution so that risk management efforts during project performance are minimized.

3. PROCUREMENT PROCESS

A typical procurement process is shown schematically in Fig. 5. It is a combination of the model identified in appendix III of GS-G-3.1 [8] (see Fig. 6) and those adopted by many utilities such as the EPRI process model defined in Ref. [107], the Nuclear Energy Institute (NEI) process described in Ref. [108], or process maps defined by CII [109]. The process, guided by an overall corporate procurement strategy, consists of the four major activities of specifying what is needed, sourcing it, using it and taking corrective action as required.

FIG. 5. Nuclear procurement model.

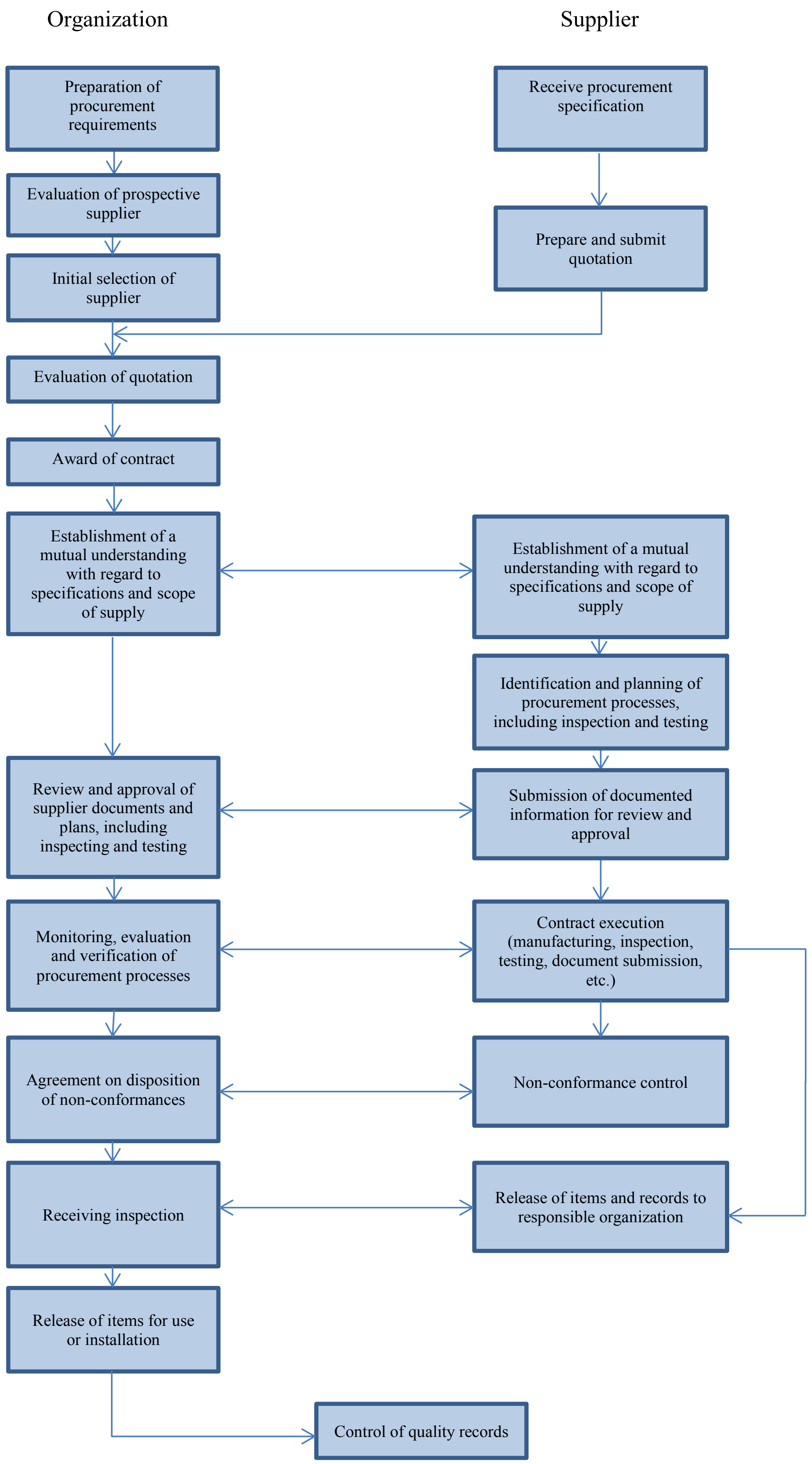


FIG. 6. Procurement process (reproduced from GS-G-3.1 [8]).

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. The information needed is what is required, where that item will be used and for what purpose. The 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 (i.e. individual, supervisor or budget holder) may be required before the purchasing organization can act upon an identified need.

Requests for specific items needed for a nuclear power plant can come from a variety of sources, including:

— 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, on-line or planned outage maintenance;
— Strategic spare parts identified to be purchased for major components or to address single point vulnerabilities (e.g. spare transformers, diesel generators and entire valve assemblies);
— Automatic replenishment of warehouse or stores stock (typically automatically generated via a low stock condition).

Service demand can come from any function within the operating organization (e.g. engineering, maintenance, operations, custodial, administration and finance). Demand can be both long term and short term (once only, or to support a particular time period or a particular activity, such as an outage).

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:

(a) Project overview:
   — Problem statement;
   — Project description;
   — Project goals;
   — Project scope (and exclusions);
   — Critical success factors;
   — Assumptions;
   — Constraints.
(b) Project authority and milestones:
   — Funding authority;
   — Project oversight authority;
   — Major project milestones.
(c) Project organization:
   — Project structure;
   — Roles and responsibilities;
   — Facilities and resources;
   — 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 need 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.

Organizations can often achieve project or other savings if advanced techniques are employed to challenge the scope of work or execution methodology. These can include such techniques as value engineering, design to cost or simply having a senior team review the planned scope at a challenge meeting.

Value engineering consists of a process of information gathering (to determine what functions or performance characteristics are important), alternative generation (to determine various alternative ways of meeting requirements), evaluation and presentation of the best alternative to the client for a final selection [110].

Design to cost is a top down approach that takes final cost needed as an input variable and develops individual project component costs as outputs. Such an approach is designed to foster innovation, new designs, process improvements and efficiency [111]. Even when the final cost of an item is not specifically fixed, the technique can be used to help to identify where total item costs are derived and search for innovative methods to reduce them. An example of the application of design to cost by the Enel group in Slovakia is given in Fig. 7.

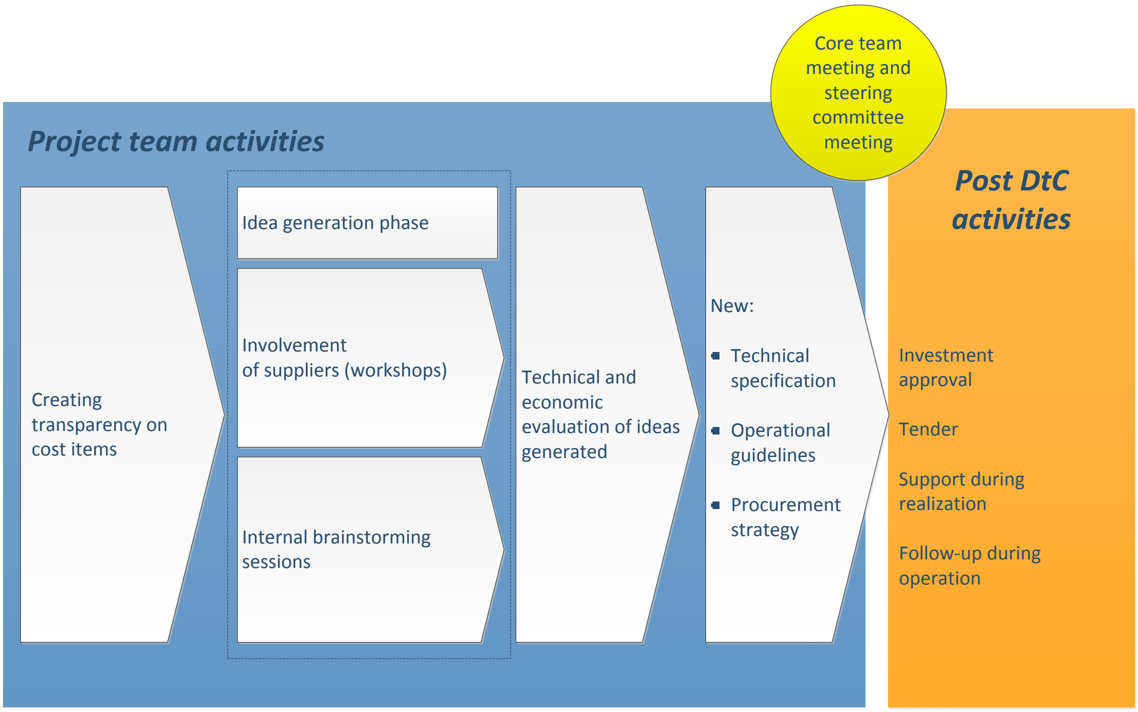


FIG. 7. Design to cost methodology employed at Slovenské elektrárne (reproduced with permission courtesy of Slovenské elektrárne, an Enel group company).

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 analysed can include:

— Specific material requests entered by staff;
— Minimum reorder points 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 on-site or at 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;
- Alternative options available for the item (item already in stock, item readily available from other sources or substitute item with a less hazardous item if possible).

Materials can be broadly divided into engineered materials (e.g. tanks, heat exchangers, motors, pumps and valves), bulk materials (e.g. pipes, fittings, wiring, cables and gravel) and prefabricated materials (e.g. assemblies of items fabricated off-site).

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 and safety stock levels is important for efficient operation, as excessive numbers of transactions can slow down purchasing of other important items. Appendix IV shows some examples of such calculations. Analysis for bulk material can be more complex, as exact quantities required are never actually known until a job is completed, and purchasing may need to be arranged prior to full design completion. Reference [112] provides further details on materials management planning.

Long lead materials associated with plant modifications, including major work and other approved or potential scope for planned outages, are often given special attention. Long lead material often has to be identified by a particular pre-outage milestone. Specially identified staff in the supply chain organization can initiate and chair a series of meetings between assessing, planning, engineering and procurement engineering personnel well before the planned activity to identify item demand, areas of procurement that are not progressing, any barriers and actions to resolve these issues and the individuals responsible.

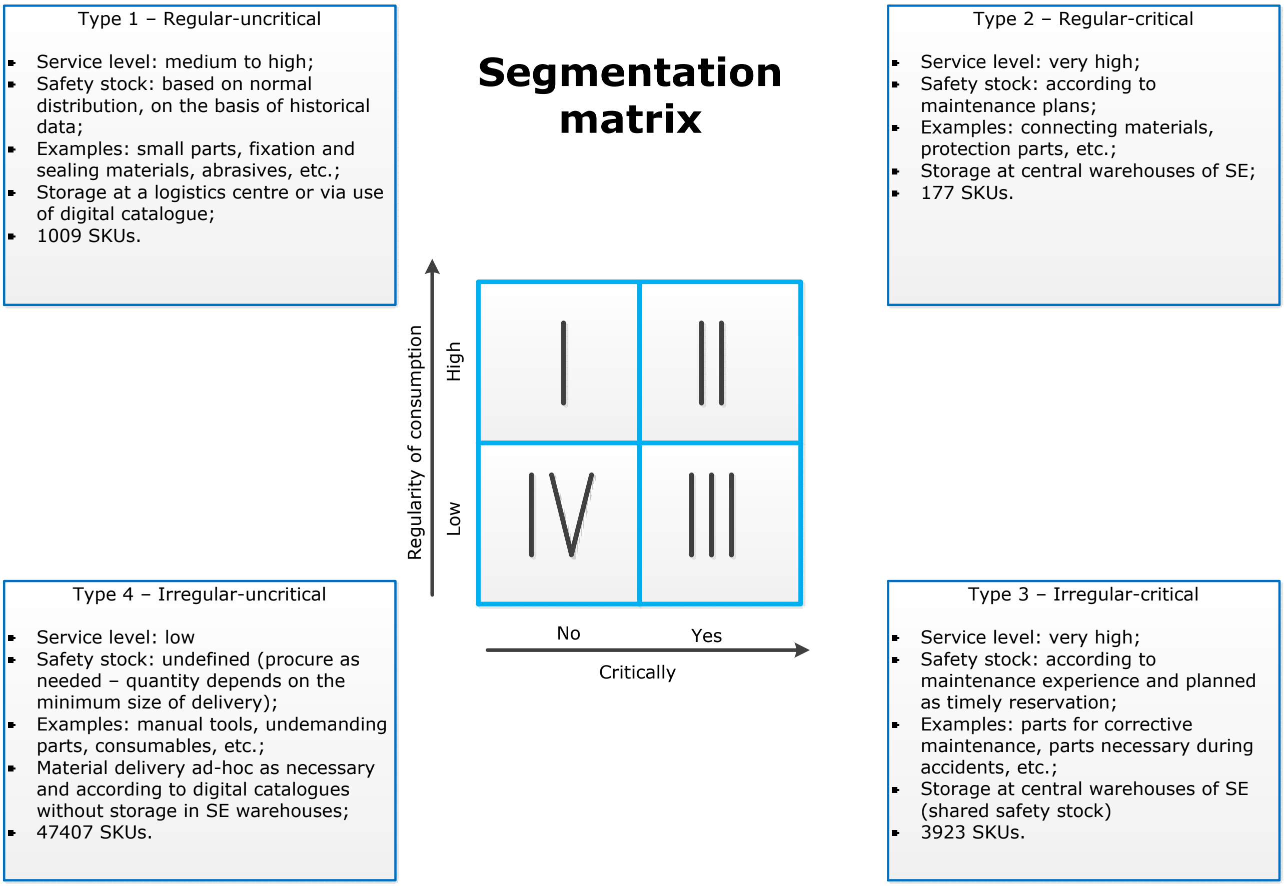
Similar to the strategic commodity positioning matrix described in Section 2.2 (see Fig. 3), the inventory can be segmented into categories according to the regularity of use or consumption and criticality or business impact. This can allow for graded levels of service, inventory levels and safety stocks, and an overall optimization of inventory. An example of this process performed at Slovenské elektrárne, an Enel group company, is shown in Fig. 8.

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 [113] whereby contingency parts are analysed and only purchased (after a challenge process) if they have a greater than 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 (e.g. a potential of ten contingency parts might result in an actual order of only two or three items). When reviewing past work order material usage, work planners should consider both materials issued and those returned when not used. Issued material by itself may not accurately reflect in-plant material usage.

3.2. ESTABLISHING REQUIREMENTS

According to Requirement 11 of GSR Part 2 [7]: “The organization shall put in place arrangements with vendors, contractors and suppliers for specifying, monitoring and managing the supply to it of items, products and services that may influence safety.” Specifying the requirements for such items is a key role of procurement documents.

Technical and quality requirements provide the ability to define which 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



Note: SE — Slovenské elektrárne; SKU — stock-keeping unit (catalogue item).

FIG. 8. Inventory segmentation leading to different service levels, safety stock and storage locations (reproduced with permission courtesy of Slovenské elektrárne, an Enel group company).

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 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 do not (i.e. critical design characteristics). Any revised technical and quality requirements should still assure that these properties of importance are imparted on the item.

Requestors need to identify which 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:

(a) Requestor may not be fully aware of how to provide a detailed technical description of the item (i.e. applicable codes, code effective dates, standards and available options).
(b) Requestor may not be aware of identical or acceptable substitutes already in an operating organization's warehouse or already successfully purchased.
(c) Requestor may not be fully aware of other end uses for the item at the facility that may impact on required stock levels or quality requirements (e.g. for an item used in both safety related and non-safety-related applications).

(d) Requester may not be able to access the list of critical digital assets that identifies equipment that may result in potential unacceptable radiological consequences if maliciously compromised by a cyber-attack (e.g. list that identifies required additional computer security measures).
(e) Requestor may be attempting to purchase a specific item for which there is no supplier in the marketplace with an acceptable quality assurance programme.
(f) Requestor may be attempting to purchase an item that is on an industry list of items with known quality issues (sometimes called a restricted equipment list).
(g) Requestor may not be aware of costs or implications associated with the purchase of a hazardous substance (industrial safety or environmental impacts of a chemical or other substance).
(h) Requestor may not be fully aware of preferred supplier arrangements, blanket purchase orders, contracts or master agreements established with certain vendors or purchasing groups.
(i) Requestor may not be fully aware of stocking and inventory level management strategies, impacts on warehousing and arrangements with certain vendors for just in time or expedited delivery times.
(j) Requestor might be attempting to purchase spare parts for which a strategic decision has been made on economic grounds to replace the item if it fails rather than to attempt repair.

A process should thus be in place to ensure requirements to purchase an item are adequate. Owing to volumes of work involved and its specialized nature, many utilities establish separate organizations dedicated to such activities (see Section 5.1), and often prepare templates and standard contract terms to assist users in the preparation of complete and adequate requirements documents.

When ordering an identical replacement part from the original supplier, establishment of requirements can be straightforward. However, if alternative 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 item’s form, fit or functional design (e.g. colour of coating or expandability features);
— 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 [114]. Operating organizations often develop standard procurement templates and clauses to address many of these items in a consistent manner:

(a) Part numbers, model numbers and mark numbers.
(b) Noun description of items with modifiers sufficient to distinguish item from other similar items (e.g. 1 kΩ ± 5%, 5 W, axial lead or wire wound resistor versus resistor). Catalogue descriptions may be used.
(c) Plant specific or supplier drawings and revision level.
(d) Codes and standards to be applied, including revision level and applicable sections whenever possible:
  — Codes or standards may be able to be specified by reference where the implications are clear and well known to both parties (e.g. by indicating applicable safety classification or quality group of the item).
  — Care needs to be taken to only specify applicable technical criteria in procurement documents (to avoid confusing the supplier with inapplicable or contradictory requirements).
  — References should not be made to unique nuclear standards when procuring a commercial grade item (CGI) for safety related applications, because the commercial supplier will not be familiar with, or qualified to, such standards. In these cases, applicable requirement clauses derived from a nuclear standard such as

those for labelling, handling, packaging or shipping (e.g. NQA-1 [72]) may, however, be specified to ensure suppliers are aware of nuclear specific needs.

- Qualification parameters to maintain compliance with a qualification report or environmental or seismic conditions, or to address electromagnetic compatibility issues.
- Industrial safety, chemical, environmental protection, sustainability or 'green' purchasing requirements.
- Plant specific conditions.
- Material specifications (including the requirement to provide analysis results demonstrating the product meets specifications for all chemical parameters and also any material conditioning requirements).
- Computer security requirements (see Section 6).
- Enterprise computer system requirements (see Sections 5.10 and 8.2, and Appendix I).
- Painting or coating requirements.
- Transport limitations.
- Packaging requirements (see Section 3.8).
- Storage requirements to prevent degradation (see Section 3.11.1).
- Storage maintenance requirements (see Section 3.11.2).
- Shelf life requirements (see Section 3.11.3).

The extent of the technical description is driven by the procurement conditions, the role of the supplier in equipment design, the item complexity, the item's role in performing safety functions (i.e. safety related classification, as described in Section 2.4), the manufacturing processes used in item production, and the 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 and bulk material) can benefit from having standard technical requirements prepared in advance. EPRI has prepared sample procurement requirements for bulk chemicals [115].

Organizations should ensure: that compliance with occupational safety and health requirements is identified, evaluated and incorporated into purchasing requirements; that national laws and regulations and the organization's own occupational safety and health requirements are identified prior to the procurement of goods and services; and that arrangements are made to achieve conformance to the requirements prior to their use [116]. These organization safety and health requirements, or at least the equivalent, should be applied to contractors and their workers.

3.2.2. Quality requirements

Quality requirements are programmes and activities needed to ensure properties or attributes imparted to an item. If procuring an identical replacement item from the original supplier with an approved quality management system, 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 requirements in greater detail, such as detailed dimensions, materials of construction, and special testing and inspection requirements. 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:

(a) Management system programme requirements. Care needs to be taken to only specify applicable quality assurance criteria in procurement documents (to avoid confusing the supplier with inapplicable or contradictory requirements).
(b) Applicable inspection, examination, sampling and test requirements.
(c) Specific qualification requirements for personnel.
(d) Documentation submission and review requirements.
(e) Other applicable requirements such as the purchaser's right of access to the manufacturing facility, processes for non-conformance reporting (including necessary approvals), identification and availability of spare parts, shelf life clauses and other related data required for ordering.

Appendix V provides sample purchase order clauses that can help to address many of these items.

Utilities and suppliers typically grade quality requirements based on the safety related importance of an item (see Section 2.4). Table 6 shows a simple three level grading system utilized by AREVA NP as an example. IAEA-TECDOC-1740 [10] further discusses the grading of requirements.

TABLE 6. AREVA NP QUALITY REQUIREMENTS BASED ON COMPONENT OR SERVICE IMPORTANCE TO SAFETY

Quality grading	Component status	Quality assurance requirements
Safety grade	Products and services that are safety related	ISO 9001:2008 [43] complemented by nuclear specific requirements
Standard grade	Products and services that are not safety related but which are important for construction and operation	ISO 9001:2008 [43]
Not classified	Other products and services	No specific requirements

Source: Reference [117].

3.2.3. Commercial requirements

3.2.3.1. Commercial contract strategies

Various contracting strategies are employed for large projects and services. The operating organization can act as a general contractor and hire companies for various roles (e.g. engineering, procurement or construction). Alternatively, an integrated engineer–procure–construct 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 its prime role in ensuring nuclear safety to a contractor. Within these types of approach, different contract models are possible. Figure 9 shows a variety of contract models, together with information on their suitability based on the level of scope definition that is available. For example, fixed price contracts are most suitable for projects where the scope of work has been fully investigated in advance of the contract award, and carry less risk for scope or cost increases, but require more up front work by the contract owner. Service procurement is more fully discussed in Section 4.

In Fig. 9, the reimbursable cost, cost plus, time and materials, and day rate contract types are examples of what are known as reimbursable contracts. In reimbursable contracts, a contractor is paid for actual costs incurred for execution of a scope of work, and a negotiated fee as the contractor’s profit. CII defines five types of reimbursable contract [118]. These are listed in Table 7.

It should be noted that detailed evaluation criteria should vary significantly between fixed price and reimbursable contracts. While lump sum contracting often places significant emphasis on price, reimbursable contracting places significant emphasis on expertise, experience at successfully completing similar projects, availability of key personnel and ability to meet the schedule. For reimbursable contracts, CII indicates that the following criteria should be assigned greater importance [118]:

- Expertise in reimbursable contracting;
- Experience of the assigned project team, especially the capabilities of the proposed project manager and supervisory personnel;
- Assigned personnel’s experience at executing a reimbursable contract;
- Staffing plan for executing the scope of work;
- Demonstrated capability for meeting the schedule;
- Controls systems, particularly for cost and schedule control and forecasting;
- Procurement capability;

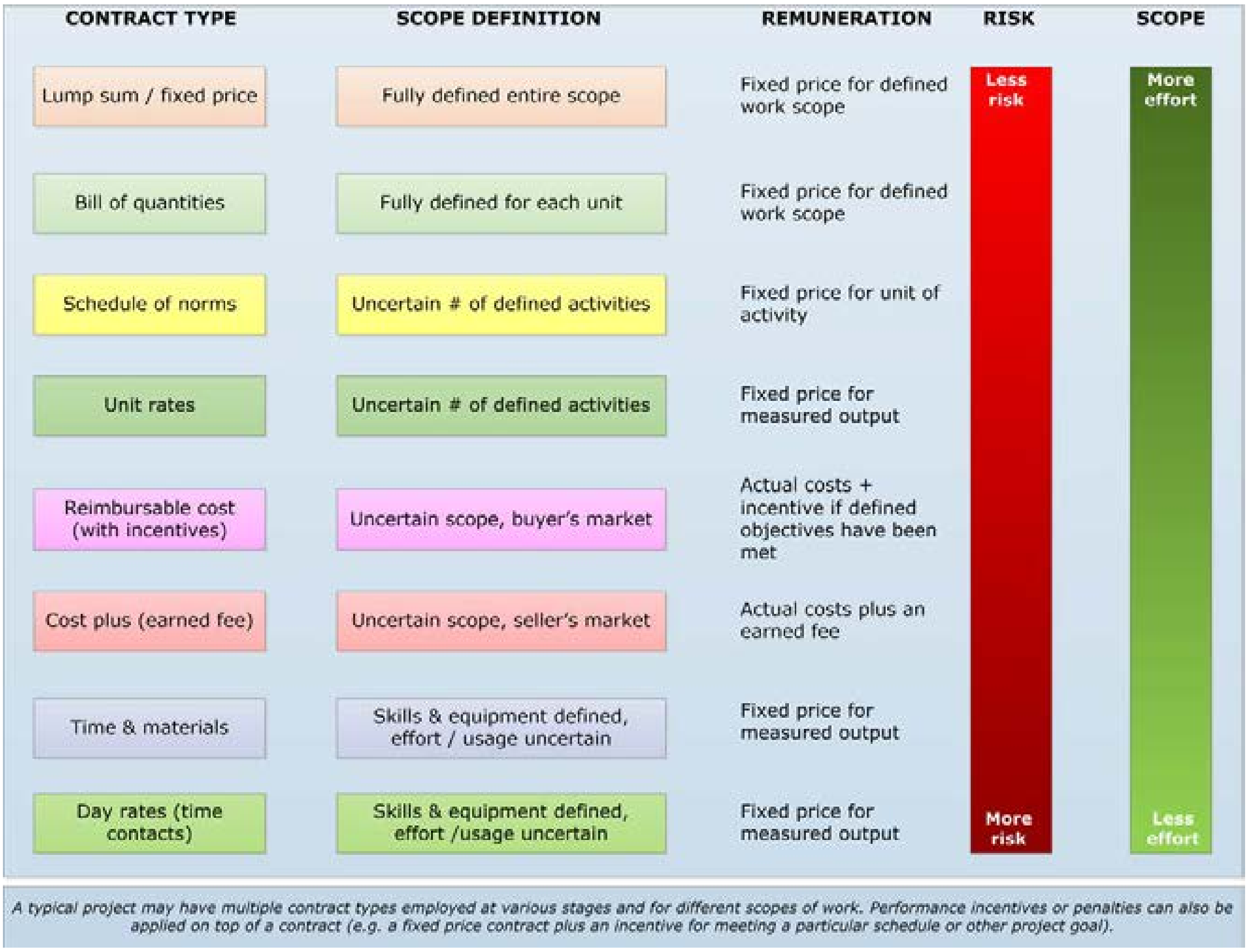


FIG. 9. Contract types versus appropriateness based on scope definition, risk profile and scoping effort required.

— Availability of local resources (i.e. whether the contractor has sufficient local resources to perform this job);
— Compensation structure, including base costs, overheads, salary burdens, fees and incentives.

TABLE 7. REIMBURSABLE CONTRACT TYPES

Type of contract	Provides for
Cost plus percentage fee	A fee paid to the contractor, determined as a percentage of the actual cost of the work
Cost plus incentive fee	An initially negotiated fee to be adjusted later based on a formula calculating the relationship of total allowable costs to total target costs
Cost plus award fee	A fee consisting of a base amount fixed at contract inception and an award amount that the contractor may earn in whole or in part during performance and that is sufficient to provide motivation for excellence
Cost plus fixed fee	A negotiated fee to the contractor that is fixed at contract inception
Cost plus fee with a guaranteed maximum price	Cost reimbursement and a fee with a guaranteed maximum cost to the owner

Source: Reference [118].

A variation on the above contract models that is often used in the oil and gas industry, and which is being employed at Ontario Power Generation's Darlington nuclear power plant refurbishment project, is called an 'engineer–procure–construct partnership'. In such a model, the owner and contractor agree to a contract framework, and then jointly develop budgets and schedules for the execution phase of the project during its definition phase. Execution phase contracts then would include incentives and risk sharing on any cost and schedule overruns. The contractor is, for example, paid a fixed fee for successful contract completion, together with incentives for cost savings below an agreed target price based on an agreed formula (and penalties for coming in above the target price). In this model, the contractor does not profit by additional labour associated with cost and schedule overruns, and receives additional profit for any project savings that can be passed onto the owner. Such a model requires owner and contractor staff to work closely together, often in co-located offices, and thus is not a traditional 'hands-off' engineer–procure–construct type of arrangement.

3.2.3.2. Commercial conditions of importance

Together with technical and quality requirements, purchasers also need to define acceptable commercial requirements related to the item(s) or service(s) 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.

Sole source contracts can be difficult to assess on the basis of price. To ensure a fair price is achieved, potential purchasers need to undertake a process of knowledge acquisition related to the product or service in question. For large contracts, this can mean developing an internal estimate of what the project should cost and any associated risk elements. Such an estimate can be developed using past experience, industry databases of construction costs, third party estimating companies and, perhaps most importantly, by visiting other sites undertaking similar work and speaking directly to the customers at these locations regarding their experiences with the potential supplier. Potential suppliers can be asked to allow these other customers to discuss contract pricing and other potentially sensitive issues during this knowledge acquisition period.

When developing internal project cost estimates, it is important to achieve alignment with decision makers surrounding the quality of the estimate at the particular phase of a project. Figure 10 shows a methodology developed by AACE International. As project definition increases with time, the accuracy of the project estimate increases (i.e. it has less variation).

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

FIG. 10. AACE International cost estimate classification system (reproduced from Ref. [119] with permission).

Some commercial conditions of importance other than price are those related to:

— Incentives and penalties;
— Performance guarantees;
— Insurance to be carried by the supplier;
— Warranties for products delivered (correction of any defects or to address failures);
— Hold-backs;
— Financing requirements;
— Dispute resolution methods;
— Ownership and further use of intellectual property;
— Payment terms;
— Company specific policies surrounding purchasing items from fair trade, sustainable, 'green' or similar suppliers.

Incentives and penalties are a part of many industrial contracts. If they are set up correctly, they can help to 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 products. Incentives can be given for items related to schedule performance, technical performance (e.g. precision of device supplied or efficiency of its operation), cost savings or other parameters.

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. For example, an advance payment bond of such a risk mitigation tool provides the customer with protection in the event that a supplier to whom an advance payment has been made fails to complete work satisfactorily. The bond would usually cover the amount of the advance payment.

Insurance is used as a risk mitigation tool. In the context of the delivery of a good or service, insurance may be held by an owner, a supplier or both (for different insurance aspects). It can be used to provide financial compensation to an owner in the event of failure, bankruptcy or other conditions affecting the supplier that might prevent it from delivering the product. This may include 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 service contracts in addition to the 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.

For nuclear facilities, there is a fundamental difference between markets that provide construction phase insurance and those providing operational phase nuclear property and liability insurance. In addition, insurer appetite for supplying nuclear construction physical damage insurance is high, whereas appetite for delay in startup insurance is much less. Expert advice is recommended.

Warranties are guarantees or promises which provide assurance by one party to another 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. associated with installation, maintenance or design quality). Specifications should include either the takeover 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. six months after product delivery, or some other agreed to time frame). Warranties have both technical and commercial aspects, and are typically evaluated for both aspects.

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, including support in response to potential computer security incidents impacting on operations. Contracts should also include provisions to transfer sufficient knowledge from the design agencies to operating organization staff before deliverables arrive on-site. This can be done in various ways, including special courses for staff or special assignments of staff as ‘trainees’ to work in the contractor’s office under the direction of a supervisor. This latter approach is most effective when the systems are large and complex.

Hold-backs 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. Hold-backs often vary between around 5–10%, and may extend to the end of the warranty period. Financing costs of hold-backs (time value of money) are generally included in quoted prices of fixed price contracts or in the rates of cost plus contracts. The contractor will object to a hold-back if the product sits 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 (see Refs [120, 121] for further information). Acceptable or desirable financing arrangements should be described as part of commercial requirements.

Disputes are regularly encountered in any contracting situation, and efficient processes for resolving them are essential to keep contract activities progressing to the required schedule. Often, the individuals directly administering a contract on both the purchaser and supplier sides can have difficulty agreeing on a satisfactory solution. Contract terms should include an agreed method of resolving such disputes. Standard agreements such as those provided by the International Federation of Consulting Engineers (FIDIC) (see Section 3.2.3.3) often include the establishment of an impartial dispute adjudication board to assist in timely and fair dispute resolution.

Requirements and contracts need to identify who owns the intellectual property at the conclusion of work. This is of great importance to nuclear facilities, which require access to, and the ability to modify, equipment and system designs over an extended period of time. Requirements clauses that allow a facility 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 the 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 drawings or design documents, delivery of goods, completion of work or beneficial occupation, project completion (including documentation), or following satisfaction of 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 the ‘useful’ product being received by the client.

Company specific policies surrounding purchasing items from fair trade, sustainable, ‘green’ or similar suppliers should be documented in purchasing requirements given to suppliers. Any sustainability related requirements would also be evaluated as part of the contractor prequalification process.

3.2.3.3. Standard commercial terms and conditions

To save time and expense, operating organizations often develop a set of standard commercial terms and conditions for use in the procurement process. These can include general contract standards for such items as engineered equipment, engineered equipment spare parts, consulting services, construction services, minor or general services, and the supply of specific products such as chemicals or gases. Commercial conditions of importance would then be developed once for the organization and referred to in subsequent purchases.

Several international organizations have developed standard contract terms for capital construction and other projects that can be useful in nuclear purchasing. These include contract models developed by the FIDIC [122], the NEC [123], the Institution of Chemical Engineers [124], the International Trade Centre [125] and the International Chamber of Commerce [126, 127], among others. FIDIC based contracts are very common for international projects. Many national or local based contract standards also exist.

Common commercial terminologies related to the tasks, costs and risks involved in the 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. Incoterm abbreviations are shown in Fig. 11. The greatest risk to the client is for acceptance of delivery outside of the factory gate (EXW), and the lowest risk is for acceptance on the job site (DDP).

FIG. 11. Incoterms for seller/buyer risks, costs and obligations transfer (reproduced from Ref. [128] with permission).

3.2.4. Administrative controls

Administrative controls for an item to be purchased need to be defined for prospective suppliers, and 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 and 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 and publicity approvals required.
— Format of breaking down of prices and currencies within the tender document (to aid in bid comparison).
— Need for all prospective suppliers to respond to all sections of the enquiry, with any alternatives to requested work (i.e. potential improvements and different ways of working) being separately identified. This will ease comparison between all tenders and bids.
— Formal requirements concerning access of bidders 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).
— For major or long term purchases, one consideration at this stage is the establishment of a fairness monitoring process to assess the fairness and transparency of the procurement process (see Section 2.5).

ISO 10845-3:2011 [48] contains standard conditions of tender. It establishes what a tenderer is required to do in order to submit a compliant tender, makes known the evaluation criteria to tenderers, establishes the manner in which the procuring entity conducts the processes of offer and acceptance, and provides feedback to tenderers on the outcomes of the process. ISO 10845-2:2011 [47] provides a standard format for compiling procurement documentation.

3.3. PROCUREMENT PLANNING

Individual projects or major purchases benefit from a formal planning process. As discussed in Section 3.2, individuals requesting items often have unrealistic expectations regarding the ability of the marketplace or the corporate supply chain organization to source an acceptable item within a specific time frame. A procurement planning step allows a market survey to be completed and allows for communication between all involved stakeholders to ensure expectations regarding timing and other procurement requirements are realistic and that procurement risks are identified and addressed. Such planning also affords the opportunity for the procurement organization to consider consolidation of similar requirements under one contract, or the division of a requirement into several contract packages for economies of scale. Box 1 provides a table of contents from a sample procurement plan.

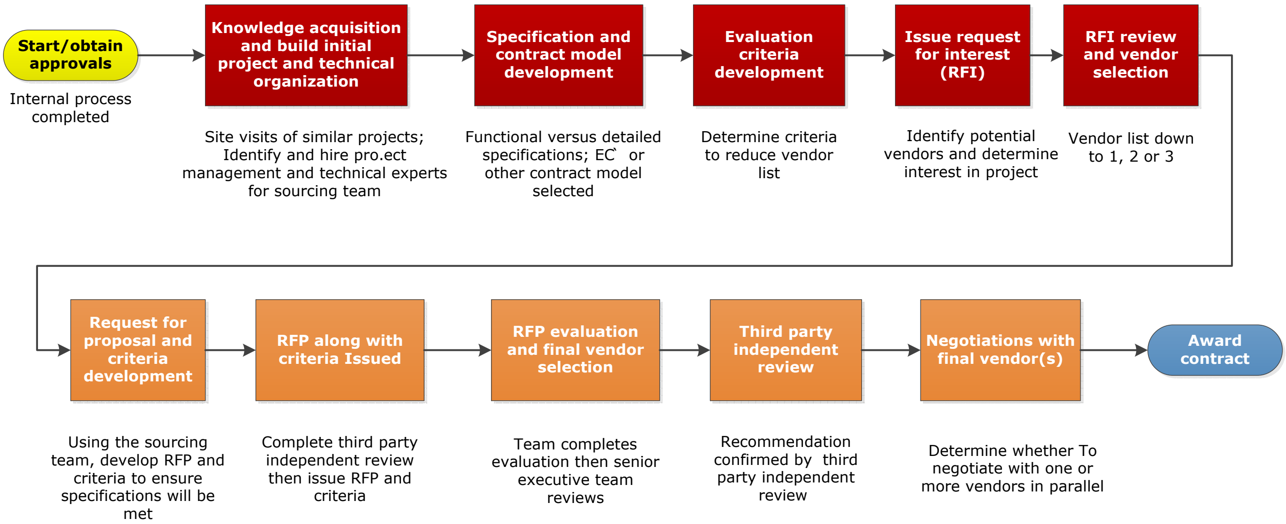
BOX 1. SAMPLE PROCUREMENT PLAN TABLE OF CONTENTS

1. Introduction
   1.1. Purpose
   1.2. Background
   1.3. Objectives
2. Scope of procurement and exclusions
3. Consideration of options
   3.1. Contract options
   3.2. Market research and available suppliers
4. Recommended procurement approach
5. Interfaces and communication
6. Plan (including schedule, assumptions and milestones)
7. Roles, responsibilities and resources
8. Risks and mitigative actions
9. Evaluation process and scorecard
10. Oversight, auditing, and fairness monitoring

In the example given in Box 1, information on the scope of procurement would come from the need identified in Section 3.1 and requirements prepared in Section 3.2. Procurement options, the recommended approach, and a plan for the required activities would be developed by the procurement organization based on its experience with the marketplace (see Section 3.4), with input from other organizations as necessary (notably the individuals who are involved with preparing the technical, quality and commercial requirements). Some organizations formally implement cross-functional sourcing teams for major purchases to ensure that all required inputs are incorporated into the plan. The goal is to ensure organizational alignment on the procurement requirements, supplier approach and the procurement schedule. A typical major contract award process is shown in Fig. 12, with the top line corresponding to the identifying procurement scenarios and suppliers in Section 3.4, and the bottom line containing the defining acceptance criteria and bid evaluation processes in Sections 3.5 and 3.6.

3.4. POTENTIAL PROCUREMENT SCENARIOS AND SUPPLIER SELECTION

Sourcing and qualification for new suppliers in an open market for complex equipment can take 6–12 months, or even longer, to complete. Steps involved typically include a sourcing request for interest (RFI), supplier preselection based on RFI feedback and supplier interest, a prequalification 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). Major contracts may also go through a process of senior executive and/or third party review as shown in Fig. 12.



Note: EPC — engineer–procure–construct; RFP — request for proposal.

FIG. 12. Sample major contract award procurement process/plan.

3.4.1. Procurement scenarios

Supplier identification involves determining which suppliers in the marketplace can meet the procurement requirements defined in the previous step. An important consideration in this phase is the quality assurance 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 the availability of suppliers in the marketplace for that item with acceptable quality assurance programmes. Five basic procurement scenarios exist for nuclear facility items (see Fig. 13).

(1) Scenario A: Item procured under the supplier's management system:
   - (i) Supplier is responsible for assuring quality of item under a management system which includes processes for reporting of defects and non-compliances.
   - (ii) Operating organization is responsible for approving the supplier's management system.
   - (iii) Suppliers do not always consider all parts or items to be safety related. 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 a partial programme (e.g. covering only pressure retaining parts).

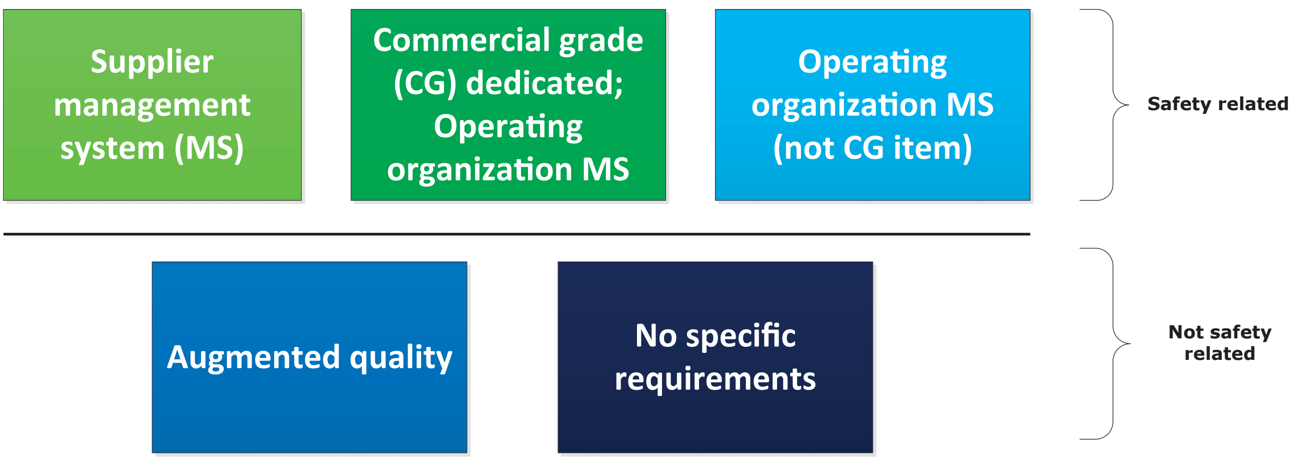


FIG. 13. Potential procurement scenarios.

(iv) To ensure no misunderstanding of supplier responsibilities, operating organizations should consider adding a statement in their procurement documents stating that the operating organization considers all parts of an item procured to be safety related unless otherwise stated, or clearly indicate which parts are considered as safety related under the operating organization's design basis.

(2) Scenario B: Item procured as a CGI for dedication under the operating organization's management system:

(i) If an item is procured as a CGI intended for use in a safety related application, it is the operating organization's responsibility to dedicate the item and assure quality under the operating organization's management system. Guidance is contained in GS-G-3.5 [9] and Ref. [129]. CGD is discussed more thoroughly in Section 5.1.4.

(3) Scenario C: Item procured under the operating organization's management system:

(i) When an item intended for use in a safety related application does not meet the definition of a CGI and a qualified supplier cannot be identified nor is 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.

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

(i) Augmented quality items are non-safety-related 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 which components it considers augmented quality and any requirements specific to such items. An example augmented quality item might be a wire bush tool that has no safety related function; however, owing to foreign material exclusion concerns (potential for filaments of the brush to enter plant systems), it would be purchased as augmented quality.

(5) Scenario E: Item procured with no specific requirements:

(i) These items are non-safety-related and purchased with no specific requirements. They might be ordered solely based on a supplier's catalogue item description.

A review by EPRI in the 1990s indicated that a typical operating nuclear power plant in Canada or the United States of America orders (measured by purchase order line items) approximately 10% of its material as safety related (scenarios A or C), 7% as CGD items (scenario B), 3% as augmented quality (scenario D) and 80% as non-safety-related (scenario E) [87].

3.4.2. Supplier identification considerations

A supplier may have an approved management system; however, buyers need to continue to take care to select only suppliers with the capability to meet procurement requirements specific to the items being procured. Suppliers may not have technical or production capabilities 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 safety related system.

Suppliers often go through a process of prequalification for major contracts designed to filter those who will be asked to submit a tender or bid. A 'request for interest' or 'expression of interest' step is usually performed wherein interested vendors can identify their desire to be part of the bidding process for the identified work. As part of this process, a questionnaire is typically sent to the supplier that poses questions surrounding the supplier's willingness 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 regarding the company's:

— Key personnel;
— Management structure;
— Procedures;
— Industrial safety record;
— Subcontracting strategies;

— Environmental and social performance;
— Willingness to meet ethical standards;
— Anticipation of problem areas;
— Experience with a particular technology or in a particular region;
— Production capability under different conditions.

If too many companies pass the prequalification process (typically, three to six bidders are optimal), then choosing the companies that demonstrate that they most want the work is recommended, as they are most likely to submit competitive bids.

3.4.3. Quality assurance supplier audits

Audits are planned, scheduled and executed at supplier facilities to ensure their management system is effectively implemented and in compliance with all aspects of the procurement requirements [109]. They help to ensure that safety related goods and services are procured from qualified vendors. The extent of audit activities can be graded based on the safety significance of the items being supplied, with examples shown in table 1 and annex VI of IAEA-TECDOC-1740 [10]. Scheduled audits should be supplemented with additional audits when the effectiveness of a quality assurance programme is in doubt unless the supplier is removed from the ASL. Establishment of an audit objective is essential; it may be general (e.g. a requalification audit) or specific (e.g. to identify whether the supplier has addressed a previous audit finding or an observed quality issue).

Effective supplier audits have included consideration of the audit approach, the depth of the audit and the audit team composition, and have included appropriate engineering and technical representatives. Comprehensive multifacility audit teams are found to be effective [130]. Performance based methods (e.g. following a specific product or group of items during its production and auditing supplier processes of interest) have also been shown to be effective in performing these activities, rather than relying on programmatic reviews alone [131]. EPRI has produced a guide [132] for performing such audits (see Fig. 14 for the generic process), as well as some specific information on performing audits of supplier CGD programmes [133]. Manufacturing processes of interest can include:

— Design control (including secure computer development environments);
— Procurement;
— Material control;
— Fabrication processes;
— Testing;
— Inspection;
— Calibration;
— Handling;
— Storage and shipping;
— Documentation;
— Processes for addressing counterfeit and fraudulent items.

In some countries, regulatory bodies perform direct supplier audits in addition to those of the operating organization, while in others the regulator primarily oversees operating organization oversight functions (typically while retaining right of access to nuclear supplier facilities).

Auditing has become more complex owing to the expansion and internationalization of the nuclear supply chain, the increased use of subsuppliers and the ever changing nuclear marketplace. Audits performed individually by operating organizations are time consuming and costly. As more suppliers and countries become involved, both the cost and difficulty of effective auditing have increased. Some groups of nuclear operating organizations have agreed to fund and share the results of common audits, for example, through groups such as the Nuclear Procurement Issues Committee (NUPIC) and CANDU Procurement Audit Committee (CANPAC). NUPIC, for example, allows suppliers that have as few as five customers who are United States Nuclear Regulatory Commission (NRC) licensees or international nuclear plant operators to apply for and be eligible for NUPIC audits. The Nuclear Industry Assessment Committee organization is a supplier based organization that shares audits only with member companies that have a bona fide business relationship with the audited supplier.

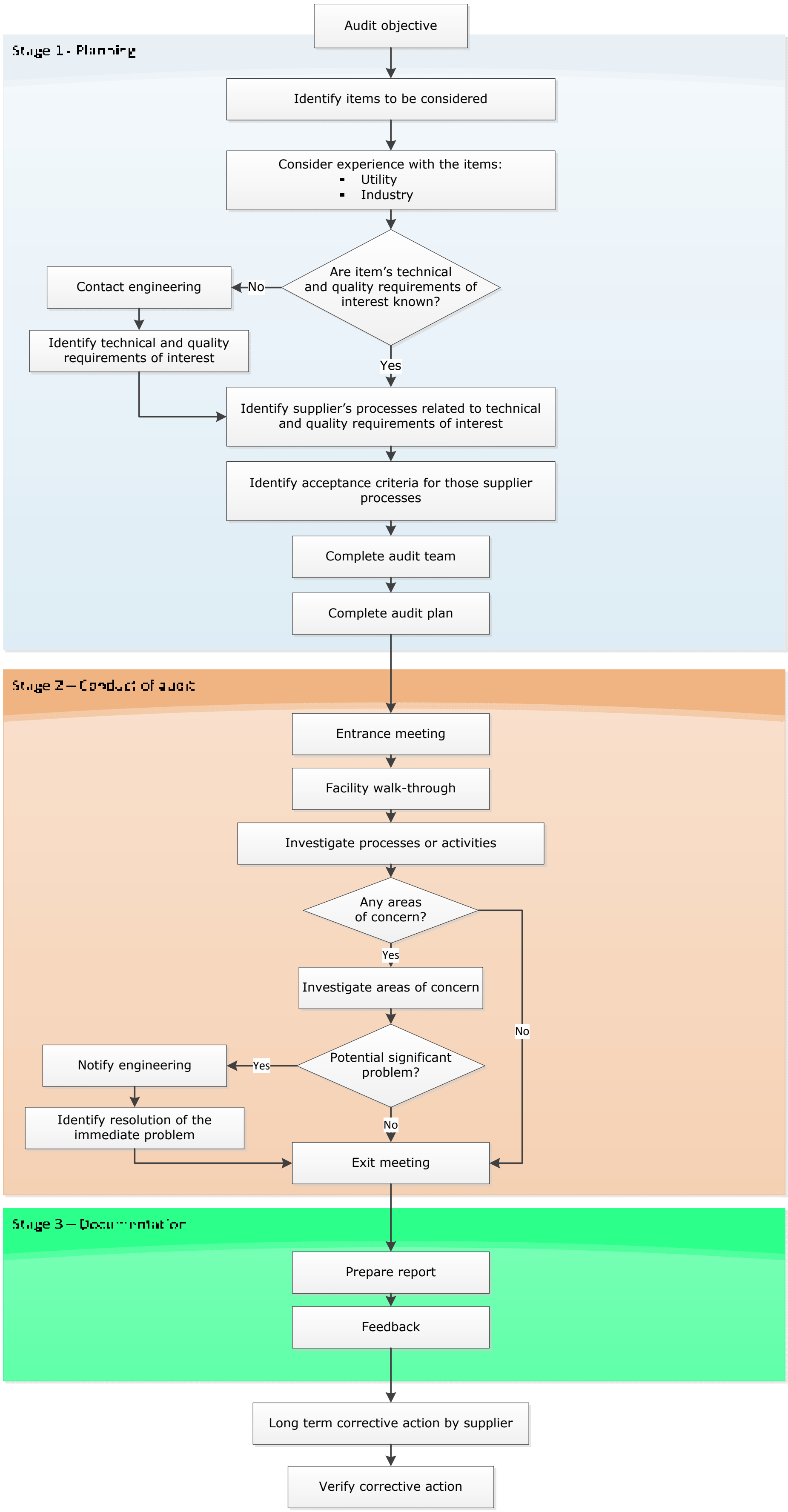


FIG. 14. Performance based supplier audit process (reproduced from Ref. [132] with permission courtesy of Electric Power Research Institute).

Like any other group within a management system, auditing organizations need to seek feedback on their effectiveness, provide their own feedback to their audited suppliers and have corrective action programmes. The NRC provides some operating experience (OPEX) on inadequately performed vendor audits [134]. Examples are given of numerous issues with vendors that had previous successful audits, indicating issues with the effectiveness of audit efforts. Box 2 provides typical attributes of top suppliers as adapted from NUPIC and other sources that can be shared with prospective vendors. The Institute of Nuclear Power Operations (INPO) has also produced a guide covering principles for excellence in nuclear supplier performance [135].

BOX 2. ATTRIBUTES OF TOP SUPPLIERS

Strong quality culture

- Satisfactory implementation of management system;
- Management embraces and leverages audit team input and experience;
- Readiness for audit through detail planning, records retrievability and staff availability.

Management system or quality assurance manual revisions

- Clear description of changes made;
- Highlighted text of changes made.

Order entry review and final certification

- Detailed review of technical and quality requirements;
- Well defined exception process;
- Detailed final review prior to shipment.

Commercial grade dedication

- Well documented CGD process;
- Clear identification of critical characteristics adequately tied to safety function;
- Adequate verification and justification.

Robust internal audit

- Comprehensive system of planned and periodic internal audits;
- Qualified audit participants have no direct responsibility in the areas being audited;
- Checklists and procedures used with documented objective evidence;
- Intrusive;
- Follow-up action taken where needed.

Robust subsupplier audits and surveys

- Effective control and release of procurement documents including changes;
- Effective evaluation, selection and assessment of subsuppliers with clear programme distinction between audit and CG survey;
- Comprehensive and intrusive audits;
- Qualified audit participants have no direct responsibility in the areas audited;
- Checklists and procedures used with documented objective evidence;
- Follow-up action is taken where needed.

Strong corrective action programme

- Low threshold to identify issues and proper significance classification;
- Clear connection between non-conformance and corrective action processes and management system;
- Measures established and implemented to assure conditions adverse to quality are promptly identified and corrected;
- Adequate actions taken to prevent recurrence for any significant conditions adverse to quality;
- Deficiencies identified by customers are adequately assessed and entered into the non-conformance/corrective action programme.

Appendix III provides information on a common National Aerospace and Defense Contractors Accreditation Program (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.

3.4.4. Approved supplier lists

To facilitate ease of potential supplier identification, many operating organizations maintain an ASL of suppliers that have been evaluated and deemed capable of satisfactory performance in the provision of goods and services. These lists can include evaluations of satisfactory supplier management systems, organizational structure and personnel, capabilities, past performance (e.g. quality, cost, schedule and industrial safety) and financial viability, among other factors. ASLs are sometimes referred to as qualified suppliers lists or evaluated supplier lists.

Management system processes should be in place to originate, request, evaluate, qualify and maintain the qualification of suppliers contained within an ASL, as well as to remove suppliers owing to poor quality performance, continued failure to address corrective actions or deficiencies identified during requalification that cannot be corrected.

An ASL would be used, for example, in procurement scenario A of Section 3.4.1, where suppliers would need to have an audited acceptable management system in place and be added to the ASL prior to placement of an order. An ASL typically includes:

— Supplier’s name, address, facility location(s), email address and telephone number;
— Items or scope of supply the supplier is qualified to provide under the approved quality assurance programme scope;
— Certification and accreditation details, including approval methods used (e.g. company audit, third party audit, third party quality assurance certificate, certificate of authorization from a code jurisdiction and security certifications);
— Expiry date of qualification;
— Restrictions on supplier qualifications (e.g. certain scope of services and certain product lines or from a specific facility);
— Approved quality assurance programmes.

When using procurement scenario B of Section 3.4.1 (CGD), 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 3.4.1 (use of the operating organization’s management system to procure the item) is typically used when an item does not meet the definition of a CGI, and is only available from a sole supplier without an approved nuclear management system.

When using procurement scenario D of Section 3.4.1 (augmented quality item), the marketplace usually provides a larger choice of suppliers that can meet established technical and quality procurement requirements. Acceptance criteria are not as stringent because the items are not safety related.

Utilities often also maintain lists of acceptable suppliers for non-safety-related applications, as well as lists of authorized distributors and sales agents associated with qualified suppliers. Additions to such lists are based on commercial, technical, industrial safety or other reasons. Enterprise computer systems can maintain such lists similar to ASLs, with recorded company qualifications identifying what the applicable company can supply. These lists are sometimes referred to as approved vendor lists; however, this term is sometimes used interchangeably with ASL.

3.5. DEFINING ACCEPTANCE CRITERIA AND METHODS

Acceptance criteria and methods are designed to provide evidence that an item, product or service meets its requirements before it is used or otherwise relied upon. A combination of methods is normally relied upon, and may be performed at the fabrication plant or factory or at the nuclear facility following delivery. Factory activities include items generic to the fabricator's management system (typically covered by supplier audits as described in Section 3.4.3) and the specific item to be purchased. Both the supplier and the nuclear facility (customer) are involved. Acceptance criteria are needed for each purchasing requirement to ensure that there is common understanding of the specifics of each requirement and to allow the organization to readily determine that a purchased item meets its requirements (as defined in Section 3.2). The ways in which these criteria are confirmed are called acceptance methods.

3.5.1. Acceptance criteria

3.5.1.1. Criteria establishment

Once an item to be procured is clearly defined, acceptance criteria need to 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 technical 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 that 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 15 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 the item to perform its safety function and, in addition to performance attributes (e.g. fuse ratings, power ratings, dimensions and chemical composition), include such items as seismic qualifications (seismic safety function(s) and any postulated seismic failure mechanisms) and equipment qualifications. These are in contrast to identification attributes (e.g. part number and identification markings) that are not related to an item's safety function but are important in providing some preliminary assurance that a part received is correct. Acceptance of an item should not be solely based on identification attributes.

Factors to be considered in developing acceptance criteria include:

- — Potential consequences of item failure — nuclear safety, security and plant operability should be considered;
- — Historical performance of the supplier in providing items which meet established requirements;
- — Historical performance of the 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 relative to increased assurance provided by verification;
- — Access to supplier facilities;
- — If the item is available stock or if it will be manufactured when the purchase order is received;
- — If the supplier is a manufacturer or third party;
- — Availability of design information;
- — Periodic oversight and reviews being applied;
- — Capability of operating organization staff to conduct post-installation testing;

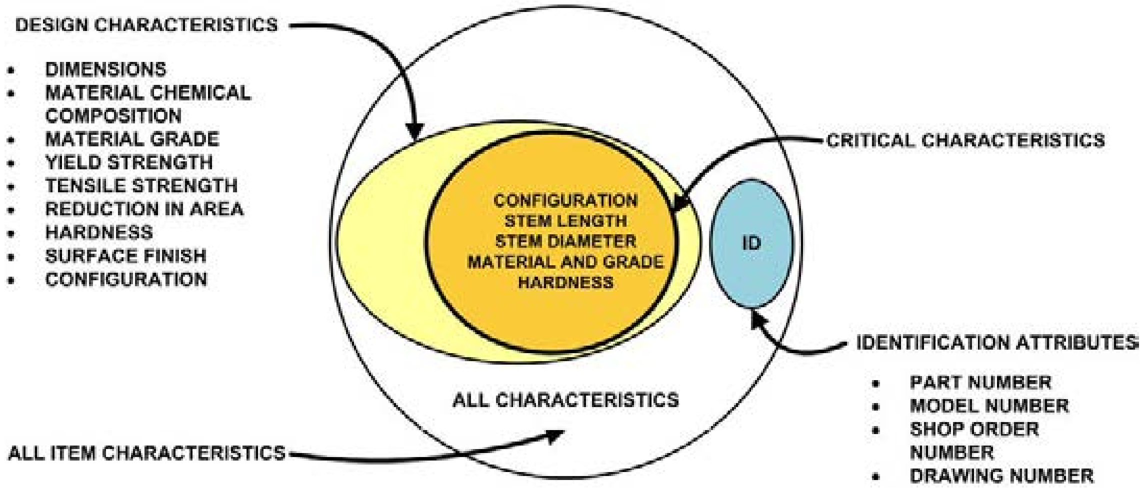


FIG. 15. Critical characteristics for acceptance (reproduced from Ref. [136] with permission courtesy of Electric Power Research Institute).

— Supplier documentation confidence;
— Practicality of performing source verification;
— Operating organization receipt inspection and testing capability.

The NRC identified some attributes of effective product acceptance in Ref. [130]. Its programmes typically include receipt and 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 safety related systems and for all commercial grade (CG) products being evaluated for suitability in safety related 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 management systems, as confirmed by audits, sampling plans are often utilized to perform required inspections and tests. In addition to these receipt and source inspections and tests, effective programmes normally verify traceability to original manufacturers of procured materials, equipment and components in those cases where original manufacturer certifications are elements of the safety related procurement or CGD programme.

3.5.1.2. Inspection and test plans

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 the procurement requirements defined in Section 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 purchasing organization. Acceptance signifies that the agreed inspections and tests confirm that the product will meet the required procurement requirements. Such acceptance should be complete prior to start of manufacturing to ensure that no required checks are missed.

Paragraph 5.19 of GS-G-3.5 [9] describes the typical content of an ITP:

"The following types of information should be included in the inspection and testing plans:

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

(b) A sequential listing of all inspection and testing activities; all products to be inspected and tested should be identified and referenced in the plan.
(c) The procedure, work instruction, specification or standard (or the specific section, if appropriate) that should be followed in respect of each operation, inspection or test.
(d) Reference to the relevant acceptance criteria.
(e) Specification of who is to perform each inspection and test and provision for recording that each inspection and test has been performed satisfactorily.
(f) Specification of hold points beyond which work may not proceed without the recorded approval of designated individuals or organizations.
(g) Specification of witness points where an assigned individual or organization can check activities but where the work need not be stopped if the inspector is not present.
(h) Specification of 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.
(i) The type of record to be prepared for each inspection or test.
(j) The number of products to be inspected or tested when multiple products or repeat operations are involved.
(k) The individuals or organizations that have authority for the final acceptance of the product."

3.5.2. 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 the reviews of supplier documentation, item receipt inspection upon delivery, source inspections (factory inspections and tests) and post-installation site acceptance testing. Testing activities may involve chemical, physical or performance tests and include security related testing.

3.5.2.1. 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 3.4.3). 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 purchasing organization has information indicating that the supplier may have deficiencies in the supplied items.

3.5.2.2. 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. Compromise of electronic equipment is difficult to detect following delivery, so it is recommended that source inspections verify that development and fabrication activities are conducted within secure environments.

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. Sampling plans for selected critical characteristics may be appropriate for mass produced parts (e.g. safety related bolts or cladding tubes). EPRI provides some guidance for sampling associated with CGD activities [137].

All findings and test results should be documented, and all maintenance and test equipment used should be documented as calibrated against national standards.

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, hold and review points

Suppliers follow a process of self-inspection where they verify the quality of their work progressively under the requirements of their own management system, often with the aid of checklists. Witness, hold points and review points are production stages at which the customer (operating organization) may need additional inspection, verification or documentation to ensure that the product meets the 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 the 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 nuclear regulator.

Verification measures vary according to 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 the quality of the completed work and releases the hold. Hold points should be used sparingly because each point 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 the results of a test or inspection prior to the manufacturer proceeding to the next stage of manufacturing.

(b) Factory acceptance testing

Factory acceptance tests (FATs) are performed at the manufacturing facility to ensure that requirements are met. Tests are normally conducted 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 identical to that at the plant, where practical.

It is good practice that individuals who may be 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 to provide any feedback on it prior to its shipment.

FATs are typically a subpart of the product’s ITP and thus follow a pre-approved procedure. The typical content of a FAT procedure includes [138]:

— 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;
— Warnings regarding 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 as per documented requirements.
- — Fabrication and installation are as 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 as per design.
- — Equipment outputs, computations, timing and operator functions behave as per design.
- — Equipment responses to failures (i.e. loss of air or electrical power supply) are as per design.
- — Integrated computer security measures are in place, such as encryption of sensitive information, antivirus software, intrusion detection and required access controls. Vulnerability scanning and active penetration testing may also be conducted.

Following the FAT, 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.

3.5.2.3. 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 the necessary assurances that quality and technical requirements have been met.

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

Standard receipt 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 in which the act of inspection would not adversely affect the 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 (see Fig. 16), hardness testers and equipment for dimension checks, among others. 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 Section 3.5.2.4) 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 promptly segregated from normal stock and quarantined so that they are not utilized by accident in the facility.

3.5.2.4. Post-installation testing/site acceptance testing

Post-installation tests 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 conducted at the facility following installation, often as part of the commissioning process. The tests confirm acceptance criteria that cannot be confirmed at 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 that the integrated (entire) system meets its design requirements, not just to confirm that a particular component, or set of components, from a supplier meets procurement requirements. Commissioning guidance is provided in IAEA Safety Standards Series Nos SSR-2/2 (Rev. 1) [2] and SSG-28 [139], and additional information is provided in Ref. [140].

FIG. 16. X ray fluorescence tool for positive material identification (reproduced courtesy of Olympus-NDT with permission).

Some items that cannot be factory confirmed 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 FATs, SATs are typically a subpart of a product's ITP and thus should follow a pre-approved procedure.

3.6. BIDDING, EVALUATION AND PLACEMENT OF PURCHASE ORDER

3.6.1. Establishing quotations or bids (enquiry methods)

3.6.1.1. Bid invitation specifications or other 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 a slightly different meaning for different organizations), including an invitation to tender, request for proposal and request for quotation invitation to bid.

A bid invitation specification, or other enquiry document, is assembled. It typically includes an invitation transmittal letter, contact information, project, facility and coordination details, and the specific job requirements as 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 and 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 on 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 detailed information on cost rates of personnel by function, additional costs (e.g. travel, training and administrative costs) and mark-ups on direct costs for profits or fees. This would be included in an overall basis of estimate prepared by the contractor (as requested in the bid invitation specification).

ISO 10845-2:2011 [47] establishes a standard format for calls for expressions of interest, for tender and contract documents, and the general principles for compiling procurement documents for supply, services and engineering and construction works contracts, at both main and subcontract levels. ISO 10845-4:2011 [49] specifically sets out standard conditions for the calling for expressions of interest.

3.6.1.2. Methods of obtaining bids

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 observed between the received bids. That is, an attempt is made to level out differences in approaches so that a consistent basis for price comparison can be made.

Open tendering provides transparency to the procurement process, ensures good competition and minimizes the potential for collusion. It does tend, however, to drive decision makers to a lowest cost solution (apparent or submitted) if care is not taken to carefully evaluate all factors (reliability of bidders, quality, lifetime or life cycle costs). Some jurisdictions or treaties require all or some public sector procurement to follow an open process. Examples of these are the European Union directives covering procurement, including Directive 2014/25/EU [141] for the energy and other sectors, and the World Trade Organization agreement on government procurement [142].

Selective or restrictive tendering is a process whereby only specific bidders are invited to submit tenders. Such a process is more common in the private sector than for public procurement, and possesses 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 to maintain contractor economic viability 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 and less attention given to the work), misses the potential for new (more eager or otherwise better) suppliers, makes price comparison more difficult and increases the risk of collusion among routinely successful contractors (they may keep prices high or divide up work among themselves). 'Single source' or 'sole source' requests for quotations are a subset of this process. Such a selective process is becoming more common for nuclear projects in the form of intergovernmental agreements, but does carry these increased risks.

It is important to note that a specification such as a bid invitation specification is needed even for sole source purchases or purchases done via intergovernmental agreements. They allow the purchaser to clearly specify the scope and requirements for the item or service and to create their own estimate for what the work should cost. They also allow the bidder to provide a clearly scoped and accurately costed bid. The purchaser can then compare the received bid against other options (e.g. other purchasing options and the 'do nothing' option) and make an informed decision.

Negotiated tenders or contracts are another variation of 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 the scope definition, this early work may be on a fixed price or time and materials basis. Once detailed design information is available, the contract is negotiated for the remainder of the work 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 a 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, with the selected company being the one that, during the preliminary stage, performed best or provided the best proposals for the subsequent stages.

Operating organizations can establish controls that govern which procurement methods are acceptable based on the cost of the item or service procured. These minimize the overhead costs associated with purchasing of low cost items or services, but ensure fairness, competition and transparency for larger purchases. An example of such a system used by a nuclear operating organization is shown in Table 8.

TABLE 8. SAMPLE PROCUREMENT METHOD REQUIREMENTS FOR AN OPERATING ORGANIZATION

Need	Total estimated value (US $ ’000)	Procurement method
Consulting services	<100	Normally invitational competitive procurement with a minimum of three proponents (when total value increases to US $100 000 or more, the invitational competitive procurement is cancelled and an open competitive procurement initiated) Some sole source procurements allowed with supply chain manager approval
	≥100	Open competitive procurement; sole source procurement not allowed
Non-consulting services	≤20	Direct award
	>20	Normally invitational competitive procurement with a recommended minimum of three proponents Some sole source procurements allowed with appropriate executive level approval (level increases with specific US $ amounts)
Items	≤20	Direct award
	>20	Normally invitational competitive procurement with a recommended minimum of three proponents Some sole source procurements allowed with appropriate executive level approval (level increases with specific US $ amounts)

An important aspect of any bidding process for services is site visits by prospective suppliers. This ensures that suppliers have a clear understanding of the work site and its potential impacts on the project, and that they have an opportunity to ask questions of key individuals within the customer organization. Such a question and answer period should be conducted at the same time for all suppliers so that all suppliers have the same opportunity for questions and access to the answers. In practical terms, however, such common sessions can often yield few questions, and those that are asked may try to expose weaknesses in competitor positions, and thus may be of minimal practical benefit in improving eventual bid quality.

Following the formal site visit, questions or requests for clarifications or exceptions by suppliers should be formally controlled. This ensures that all requests are recorded and reviewed by suitable personnel for their effects on procurement requirements. Exceptions to technical and quality procurement requirements requested by a supplier should be reviewed and approved by the operating organization’s technical organization. Any response to one prospective supplier should be provided to all bidders to aid in bid comparison and to ensure fair treatment.

Individual supplier–customer discussions may be held in private if needed during this period; however, for fairness, answers given to one party should typically be shared with all parties, unless the intellectual property of a particular supplier would be inappropriately disclosed.

3.6.1.3. Establishing master agreements

Master agreements are contracts in which parties agree on terms and conditions that will govern future transactions for a defined period of time. They can be used to procure items or services readily available in the marketplace where opportunities exist to leverage a company’s buying power, or for specific project work. Types of contemplated scope of work and specifications can be included in master agreements. However, the scope of work or specifications, as well as the specific conditions of a particular transaction (e.g. schedule and quantity) are typically agreed upon in a separate transaction document at the time of each purchase. Each transaction document incorporates the terms of the master agreement by reference. A master agreement, which typically applies to the purchase of similar items and services, may be used across multiple business and is re-evaluated periodically.

Where master agreements exist with more than one supplier, a secondary competitive process is typically used, unless the decision has been made to use a direct award or single source process. This involves multiple suppliers competing on job specific parameters (i.e. cost, schedule and technical features) within the terms and conditions laid out in the master agreement. Master agreements established with a single supplier without a primary competitive process typically require an approved single source or sole source justification as part of the agreement set-up. However, awards under such agreements typically do not need further justification unless new items or services are added to the original agreement.

3.6.1.4. Supplier response

Suppliers need to write quality tenders in response to requests in the competitive nuclear sector. The Energy Opportunities Supply Chain Project, in the United Kingdom, has produced a useful guide to writing quality tenders [143]. It includes advice such as taking a project management approach to tender preparation, preparing a compliance matrix to ensure all customer requirements are addressed, using graphics and photographs to communicate information powerfully, making a clear statement as to why the supplier should be selected (i.e. ‘winning themes’), addressing all written questions in a careful manner, and asking for feedback following the process (see Box 3).

BOX 3. ENERGY OPPORTUNITIES SUPPLY CHAIN PROJECT ‘TOP TIPS FOR TENDERING’

Comply with all reasonable requests from the client.
Provide information and answers to questions in full and in formats required.
Submit a compliant bid. If necessary, be clear about any technical and commercial assumptions and/or exclusions. Do not ‘hide’ them and put them in one place.
In the post-bid, negotiation phase, avoid introducing changes not covered in your bid as the bid could rapidly become non-compliant.
Do not assume that the client’s past experience of you is a substitute for answering questions — often the client can only use the information presented.
Always provide examples and evidence to support answers.
Accept that there may be frustrations in working in the environment your client works in.
Seek ways in your bid to illustrate your knowledge and understanding of the client’s working environment.
Look at information provided by your client (e.g. web sites and procurement plans).
Providing unrequested information can be frustrating for the client and may be seen as ‘padding’.
Accept that some requirements flow down from the client’s customer.
Balance selling your company in the tender with detail of what is going to be delivered and how it will be done.
If you have no nuclear experience, counteract this by stressing work you have done in similarly regulated, controlled and hazardous environments and industries. Draw parallels with the nuclear industry.
When invited to present the tender by the client, use this as an opportunity to explain a written answer in more detail. Stick to what is required (as this is what is of real interest) and do not ‘pad’ the presentation out with information not requested.
Answer any Requests for Clarification in full — do not restate what you have already written in your tender. Requests for clarification are made for a reason; the original answer was not adequate.

Source: Part 3 of Ref. [143].

3.6.1.5. Receipt and opening of bids

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 a person in a procurement group who would record details such as date received, prices, durations and alternatives offered; medium value bids might have the opening 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.

3.6.2. Bid evaluation and selection of supplier

Bid evaluation is a key stage of the procurement process. The process should ensure that:

- The purchasing decision is objective;
- The decision making process is fair, transparent and auditable;
- The purchaser can demonstrate best value in the tender process.

The composition and size of the team conducting the bid evaluation will vary based on the complexity of the purchase. Large projects may have large cross-functional teams that bring expertise and stakeholder views from across the entire business, while a single individual within the procurement organization may evaluate simple items. A set of team rules or a team charter are useful tools for large project sourcing teams. Such a charter would define the objectives of the team, its code of conduct, milestones, scope of work and activities, key success criteria, measures and deliverables.

Large projects typically also include a step where members of the bid evaluation team are given a formal background check for any potential issues such as personal or family investments or ties to vendors or related suppliers, past criminal convictions and other conflicts of interest. The specific steps involved will vary by jurisdiction, but will often include a process for criminal background checks and declarations of any potential conflicts of interest by individuals prior to their involvement in bid evaluation activities. An individual should be assigned to vet these declarations.

Bid evaluation can be said to need to adequately weigh the relative importance of functional (technical) requirements, initial 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 with the third [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. Key stakeholders and decision makers should be consulted well in advance, and their input should be taken into account in developing evaluation criteria.

Supplier selection 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 companies, 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 evaluations (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 and capability) after evaluating its technical acceptability.

Even if the potentially successful bidder is practically chosen in advance (e.g. via a single source selection or intergovernmental agreement), there should be an evaluation conducted to confirm that the proposal meets minimum technical, quality and commercial requirements, and that it is superior to a do nothing option or another alternative.

A part of bid evaluation is the determination of whether the bids received are compliant with key aspects of the request for proposal or bid invitation specification. To assist with this, a compliance matrix is often prepared, a sample of which is given in Table 9. Depending on the agreed evaluation criteria and the severity of the non-compliance, non-compliant bids may be excluded from further evaluation. Once the compliance of the bids is generally confirmed, the remainder of the formal bid evaluation can proceed.

TABLE 9. SAMPLE REQUEST FOR PROPOSAL COMPLIANCE MATRIX

Request for proposal		Proposal response			Comments and actions
Section/page/paragraph	Requirement	Volume	Section/page	Paragraph	

A typical bid evaluation process using separate technical and economic evaluation steps is described below in conjunction with a framework adapted from Ref. [145]. 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.

3.6.2.1. 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 covers 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 may 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 and 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 because working level staff tend to move between these competitors as new large contracts are signed. Some contracts impose penalties on contractors for key personnel changes (e.g. changes to a project director) due to any cause.

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 successfully worked together previously are generally 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, and plans for subcontracting).
— The quality of the provided schedule (degree of integration of vendor schedules with operating organization schedules).
— The level and detail of schedules provided, and consistency of dates and milestones within the bid.
— The ability to provide construction and commissioning support (engineering only or turnkey full service).
— Industrial safety programmes (and previous safety record).
— Roles and responsibilities for directing field staff and authorizing design changes.
— 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?).

— The management system (consistent with GSR Part 2 [7], including promotion of a culture for safety and continuous improvement and corrective action processes), and risk management (vendor provides a comprehensive risk mitigation plan and understands and accounts for applicable risks, including those arising from cyber-attacks).
— The supplier's current workload should also be evaluated, as the new work needs to be achievable with some reserve ability to adjust for unforeseen issues.

(d) Warranties

As discussed in Section 3.2.3.2, warranty 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 and conditions for remedies). Economic aspects related to warranties (e.g. expected impact if any on facility costs) would be evaluated separately under the economic evaluation section (Section 3.6.2.2).

The operating organization is generally most protected if warranties start with the placing of applicable items into service (i.e. not upon equipment delivery).

Suppliers typically will not accept financial accountability for force majeure (i.e. extreme weather, political demonstrations and equipment supplier issues) 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 bad weather within normal expected ranges) and by providing a specific list of which items would be considered as payable under force majeure provisions.

(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 national suppliers, and any differences in scope among the service providers. Reference [146] covers developing industrial involvement for a nuclear power plant programme in some detail.

ISO 10845-1:2010 [46] covers using procurement to achieve social and developmental policy objectives, and ISO 10845:2011 parts 5–8 [51–54] cover, respectively, the participation in contracts of targeted enterprises, targeted partners, local enterprises and labour, and targeted labour. The standards provide a framework for writing contractor requirements in such areas into procurement documents and in their evaluation. Strategies can involve granting tender evaluation points for undertaking to address these issues or later in paying a financial incentive as part of the contract if such goals are met.

(f) Alternatives and options

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

3.6.2.2. Economic bid evaluation

Economic bid evaluation combines the results of the technical bid evaluation (see Section 3.6.2.1) 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 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 (i.e. engineering, finance, legal and supply chain) 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, 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 if 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 (i.e. pay, benefits, expenses, profit margin, administration costs and travel costs). 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 of processes for subsuppliers (including their commercial terms and contractual arrangements);
— Dispute resolution provisions.

(b) Economic parameters

In addition to the provided bid price, some economic parameters to be documented and evaluated are the reference date of prices (often the bid date), the provisions for review or increases in price schedules during the life of the agreement, the provisions for project specific prices (e.g. fixed price subprojects), and the 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, a review of reimbursable costs versus overhead rates, overheads and profits on overtime (there should be none, as overhead and profit should be recovered through agreed normal working hours), and payment terms.

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

(c) Financing terms and conditions

Financing cost is an important area to be evaluated. The supplier or the operating organization 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 need to develop joint ventures with construction firms.

Security of financing and insurance provisions are typically areas of evaluation in this part of the economic analysis. Geopolitical issues can influence the ability of even large companies to raise capital on the open market and thus should be a part of risk evaluations.

(d) National participation and 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 (e.g. impact on the gross domestic product of the jurisdiction in question) and any potential impacts (negative or positive) on the operating organization are 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. Inefficient, ineffective or uncooperative supplier project management can substantially increase operating organization costs for oversight, contract management or rework. 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. Past experience with the different suppliers that are bidding should be incorporated into this evaluation.

3.6.2.3. 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 the two envelope process that was described in Section 3.6.1. Attempts should be made to level out any differences in the received bids so that a consistent basis for price comparison can be made. This can be via the three envelope process that was described in Section 3.6.1 or via an internal evaluation of cost implications (including all owner costs) of the different bids.

Owners should consider sharing their evaluation template with suppliers as part of the bidding process to help to ensure that suppliers are aware of the importance that the owner places on the individual elements. Templates can include mandatory (‘go’/‘no-go’ or ‘show stopper’) criteria that can disqualify a bid from further evaluation. A sample portion of a bid evaluation template is shown in Table 10. Numbers in the vendor columns are sample scores on a 0 to 10 scale for the vendor against the respective criteria.

TABLE 10. SAMPLE PORTION OF BID EVALUATION TEMPLATE

Criteria	Weight (%)	Vendor 1	Vendor 2	Vendor 3
Technical: Understanding of scope of work	10	5: Appears supplier cannot provide refuelling support	9: All bid areas responded to, with minor exceptions taken	8: Need for seismic analysis capability not included in bid
Technical: Experience of key personnel	10	7: General manager assigned to project was formerly construction manager of Bredonia[a] nuclear power plant	2: No managers with former experience at Bredonia nuclear power plant	5: Some Bredonia nuclear power plant experience Civil/seismic area appears weak
Technical: Knowledge of Bredonia nuclear power plant design basis	8	9: Original nuclear power plant supplier Has all design information except for minor site implemented modifications	8: Some former Bredonia nuclear power plant engineers on staff Well experienced technical staff on a variety of similar plants	7: Several former Bredonia nuclear power plant engineers on staff
Technical/quality: Performance history with previous projects	10	9: Good performance on previous projects and good external references	6: Some performance issues on previous projects; however, projects completed satisfactorily	4: No track record; new consortia just formed
Commercial: Compliance with terms and conditions	10	10: No requested changes to framework terms and conditions	7: Minor changes to terms and conditions requested (subject to negotiation)	1: Numerous unacceptable changes to terms and conditions requested
Total	100			

Note: Bid evaluation of a nuclear power plan project in the fictitious country of Bredonia.

It is important to appreciate that when evaluating different products or services, different items become more, or less, important. Section 3.2.3.1 identified differences in evaluation criteria that are more important with reimbursable versus fixed price contracts (reimbursable contracts require reimbursable contracting experience and key personnel with experience working in a reimbursable environment). A goal is to reduce or eliminate risks to the purchaser. Table 11 illustrates some of the issues involved.

TABLE 11. IMPORTANT EVALUATION CRITERIA OR STRATEGIES FOR DIFFERENT PURCHASES

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

Source: Chapter 11 of Ref. [144].

Owners should take adequate time to evaluate bids and use a challenge process to ensure bids are 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 of 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.

For projects and services, the experience and quality of a project manager often becomes the deciding factor. Reference [144] 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 by the client.

3.6.3. Negotiation with suppliers

The negotiation process for major equipment or complicated contracts can take substantial time, sometimes months or years, depending on the complexity. Owners typically pick the highest ranked bidder from the evaluation process (see Section 3.6.2) for negotiation, with one or more as backup. Proper negotiation requires technical, financial, legal and commercial staff allocated to the negotiation team, and such people need to have adequate authority to conduct the negotiation. The same people who will be managing a given project are recommended to be heavily involved in the negotiation process, as this creates a better understanding of contract terms and trade-offs during the execution phase. The negotiation process should be run as a stand-alone miniproject, with its own schedule and key milestones. Negotiators should come to the sessions fully prepared with the required time allocated, necessary resources available and ready access to key decision makers. Significant items are typically negotiated first to produce a framework for the overall agreement.

As part of these negotiations, a structured process of negotiating technical and commercial issues is often performed. The purpose is to align the requirements defined within the request for proposal on a line by line basis with the detailed aspects of the supplier's proposal. The result of such a process is typically a co-signed conformance specification, which becomes the agreed supplier scope of work. It is important that any revisions undertaken via this process during negotiations are understood and endorsed by working level staff on both sides, preferably by their formal incorporation into the applicable source documents (e.g. the requirements documents prepared in Section 3.2).

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 are typically of no benefit to either party, as difficulties will most certainly become apparent during subsequent contract execution.

For large contracts, this step typically ends with a review and update of the business case for the applicable purchase, preparation of a contract award recommendation report, and appropriate approvals.

3.6.4. Preparation and placement of purchase order

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 [108].

Verbal 'emergency' purchase orders are normally discouraged, as they may result in procurement requirements not being clearly transmitted to suppliers. If a verbal purchase order is used, the procurement person from the operating organization should read the complete technical and quality requirements to the supplier, with a written confirmation purchase order immediately following. Similarly, issuances of a notice to proceed in advance of a purchase order, such as a letter of intent, are discouraged, as they can reduce the negotiation advantage before the purchase order is signed. However, they may be required to obtain a slot in a supplier's production schedule prior to all purchase order conditions having been agreed to.

Paragraph III.2 of GS-G-3.1 [8] 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:

"— Scope of the work: A full description of the work to be undertaken by a supplier, including interfaces with other work, so that the intent is clearly understood and prospective suppliers can deliver the products or services as specified. [See Section 3.1].
— Technical requirements: The technical requirements for products or services should be specified with reference to technical documents ... [See Section 3.2.1].
— Training requirements: Needs and requirements should be identified and the necessary resources should be provided, for example the need for nuclear facility induction training to enable individuals to work on the site and move around the site unescorted. [See Section 5.8].
— Inspection and testing requirements: When inspection or testing of products is necessary, this should be specified. Acceptance criteria for the requirements should also be specified. [See Section 3.4.4].
— Access to the supplier's facilities: Conditions of access to the supplier's premises to carry out activities such as inspections, audits and surveillance should be defined. These activities may be performed by the organization or by other authorized parties acting on its behalf. [See Sections 3.4.3 and 3.5.2.2].
— Identification of the standards applicable to the management system: The management system standards to be complied with must be clearly defined. ... [See Sections 2.1 and 3.2.2].
— Document requirements: The documents that the supplier is required to submit to the organization for approval or comment should be clearly identified in the procurement documents.
— Record requirements: Requirements on records and on material samples should be made clear to the supplier prior to concluding the contract. This could best be achieved by providing or requiring a record schedule that details all record requirements to be submitted by the supplier. Instructions for the retention

by or transfer of records from the supplier and/or subsidiary suppliers should be specified. These should include the records that are requested by the organization to ensure that the products or services have met or will meet the requirements. Retention periods and responsibilities for the maintenance of records by the supplier should also be specified.
- Timing of submissions: Clear instructions should be given to suppliers regarding the times when the necessary documents and records should be submitted.
- Non-conformance reporting: The supplier should have a clear understanding of the non-conformance control process. It should be made clear which party may sanction which type of non-conformance. [See Section 3.16].
- Subsidiary supplier controls: Unless otherwise specified by the organization, the supplier should be responsible for the control of subsidiary suppliers. Therefore, if a subcontract is placed, the supplier should be requested to secure from the subsidiary supplier all rights of access as a contractual requirement. The supplier should be required to impose management system requirements on the subsidiary supplier consistent with the importance of the subcontracted product. This would include, for example, the responsibility to monitor and evaluate the performance of the subsidiary supplier. [This should also include a process to ensure proper handling of classified information between the supplier and subsuppliers.]"

Paragraph III.2 of GS-G-3.1 [8] covers mainly quality related requirements. Additional agreed commercial and administrative clauses should also be transferred as part of the purchase order. These include clauses associated with:

- Indemnity;
- Warranty;
- Insurance;
- Payment terms;
- Change mechanisms to the purchase order/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;
- Transport charges;
- Delivery requirements;
- Invoicing instructions;
- Patent ownership;
- Work on owner's property;
- Incentives and penalties.

Purchase orders and related documents are increasingly being transmitted directly between purchaser and supplier computers or onto a third party network for processing. This is known as electronic data interchange, and can increase the speed and efficiency of order processing. Electronic funds transfer is a form of electronic data interchange whereby funds (or payments) are electronically exchanged from one party to another.

Both successful and unsuccessful bidders should be notified of contract awards as soon as possible. Unsuccessful bidders should be debriefed regarding the positive aspects of their bids and with suggestions of areas for future improvement. Feedback should be sought from all bidders regarding the overall process.

Some jurisdictions have requirements to observe a 'standstill period', during which purchasers are to refrain from entering into the contract with vendors following notification of a major contract award to all of the (successful and unsuccessful) bidders. Such periods are to allow unsuccessful bidders to be able to identify concerns regarding the outcome of the bidding process, and if necessary to launch court proceedings. Once such a standstill period expires, the ability to launch proceedings becomes limited. If court proceedings are served in jurisdictions having standstill periods, then entering into the contract typically is to be delayed until the legal issues are resolved. Once any required standstill period has elapsed with no challenges from unsuccessful bidders, the purchaser can award the contract. Contract documentation should be collated and finalized to reflect the successful submission and agreed terms and conditions. The documentation needs to be signed in duplicate by the appropriate authority levels in both the purchasing and bidder's organizations, and notice served on any required public contract journals.

3.7. CONTRACT EXECUTION, COMPONENT FABRICATION AND SOURCE SURVEILLANCE

Following purchase order/contract award, activities associated with item production or service provision are completed by the supplier, and the source inspection activities discussed in Section 3.5.2.2 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 the progress of the work and committed to finding equitable solutions to contract disputes.

3.7.1. Kick-off meeting

Prior to the 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 the final signed contract and the scope of the purchase order;
- Roles and responsibilities of contract manager, contract administrator and contractor staff (see Appendix X);
- 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) and near term activities;
- Discussion on readiness to begin work.

Following the meeting, any operating organization provided training (e.g. site specific radiation protection, safety or technical 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. They would ensure that standards stipulated in contractual obligations are maintained, and that technical acceptance of contract deliverables is completed.

The establishment of documented 30/60/90 day plans that cover specific activities and deliverables of the contractor following contract award is a good practice. A list of required activities would be established as part of the final contract negotiations, and helps to ensure that the contract gets off to a good start. Items in such a plan would include such things as appointment of individuals to a project steering committee, establishment of any subteams, initial submission of regular project reports and schedules, submission of certificates of compliance with various regulators and applications for advance payments.

High risk work (nuclear reactor risk, occupational safety risk, radiological safety risk, nuclear security 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.

3.7.2. Monitoring contractor performance

There are a variety of ways to monitor contractor or vendor performance. These include such things as periodic conference calls, status reports, earned value reporting, maintaining a physical work site presence, and quality audits and surveillances. In some cases, for especially large, complex or high value procurements, the buyer may want to send a full time technical representative to be present at the vendor facility. This would have to be negotiated up front as part of the contract requirements. Some specific examples of contractor performance feedback based on this monitoring are discussed in Sections 3.17.1 and 4.4.

Contract administrators and monitors are typically assigned to administer service contracts and for large equipment purchases. A contract management plan is typically prepared and approved by the contract owner (the person in the purchasing organization with the authority for the contract), and details specific activities to be taken. In addition, a contract manager may be delegated some of the functions of the contract owner. Contract administrators and monitors are tasked with ensuring compliance with contractual terms and conditions, and manage changes during contract performance through to contract closeout and termination. Contract monitors observe work activities and equipment used based on risk to verify contract compliance with safety, environmental, quality and commercial requirements. Some specific activities undertaken can include reviews of contractor work sites and field activities, pre-job briefings, job safety analyses, quality and ITPs. They are typically required to keep a log to document all activities, discussions, deficiencies and notifications to stakeholders as required. A table of typical contract owner, administrator, monitor and supply chain organization accountabilities is provided in Appendix X (see Table 28).

The level of effort and intrusiveness required of the owner will be more substantial for reimbursable contracts or for high value or high impact purchases. CII [118] recommends that for reimbursable contracts the owners play a proactive role in monitoring progress and costs by performing the following actions:

- Accessing and understanding the contractor's project controls information to the extent allowed by the contract;
- Clarifying reporting expectations in order to identify issues early, and to forecast cost, schedule and cash flow;
- Monitoring contractor progress and productivity;
- Establishing an auditing function;
- Identifying problems in project performance that are the contractor's responsibility in lump sum contracts (e.g. schedule, cost and quality);
- Supplying more resources and funds to manage and control the contract because the owner is in charge of monitoring and decision making;
- Jointly with the contractor, clarifying and agreeing on detailed reporting expectations, and on controls tools, systems and methods.

3.7.3. 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 than to investigate the problem. Also, by asking questions, the contractor is forced to establish the cause of the problem. The contractor retains the responsibility to both identify the root cause and to find a solution. Any adverse consequences of the solution are also the responsibility of the contractor, and typically their elimination is to 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 become 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 the 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 the operating organization and for the contractor. Experienced staff should thus be employed to make the comments. Comments can be categorized into four basic categories:

— Technical problems or deficiencies that make the work non-compliant with the specification;
— Editorial comments (i.e. poor grammar and cross-referencing errors);
— Requests for clarification;
— 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 comments.

3.8. PACKAGING AND TRANSPORT

Once a manufacturer completes FATs and other final quality checks, items are required to be packaged and shipped to the operating organization. The packaging and transport methods chosen are based on consideration of the method and duration of transport, 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 transport and logistics services would include specifics surrounding cargo marshalling, export preparation, freight forwarding, customs clearances, heavy hauling, ship chartering, multimodal moves, courier services, intermediate storage, insurance during transport, and personnel movement and transport [109].

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 on Incoterms). Care needs to be taken to manage both the risk of 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 transport. Special air, rail, water or road transport may be necessary, depending on the size or weight of the objects involved and the urgency of receipt. Coordination with local transport and police authorities along the 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 the size and weight of goods to be shipped (see sections 3.2.3 and 8 of Ref. [147]).

Special consideration should be given to subcontractors providing heavy lifting or hauling services. Qualifications, experience in similar projects and dealing with special transport permits and licences can all seriously impact successful shipment. Experience has provided examples of large and important items for nuclear facilities being damaged during shipping (e.g. turbine rotors falling off of a barge into the Saint John, New Brunswick, Canada harbour in 2008 [148]).

Labelling during transport should also be considered. Figures 17 and 18 show a variety of labels utilized by Electricité de France (EDF) for transport shipments, pallets, packages, parts and storage locations. It can be advantageous for suppliers to affix labels consistent with the end use nuclear facility’s labelling standards. Transport 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 on-line the physical location of their purchased item while it is in transit. 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 (see IAEA Safety Standard Series Nos SSR-6, Regulations for the Safe Transport of Radioactive Material (2012 Edition) [149], TS-G-1.4, The Management System for the Safe Transport of Radioactive Material [150], and IAEA Nuclear Security Series No. 9, Security in the Transport of Radioactive

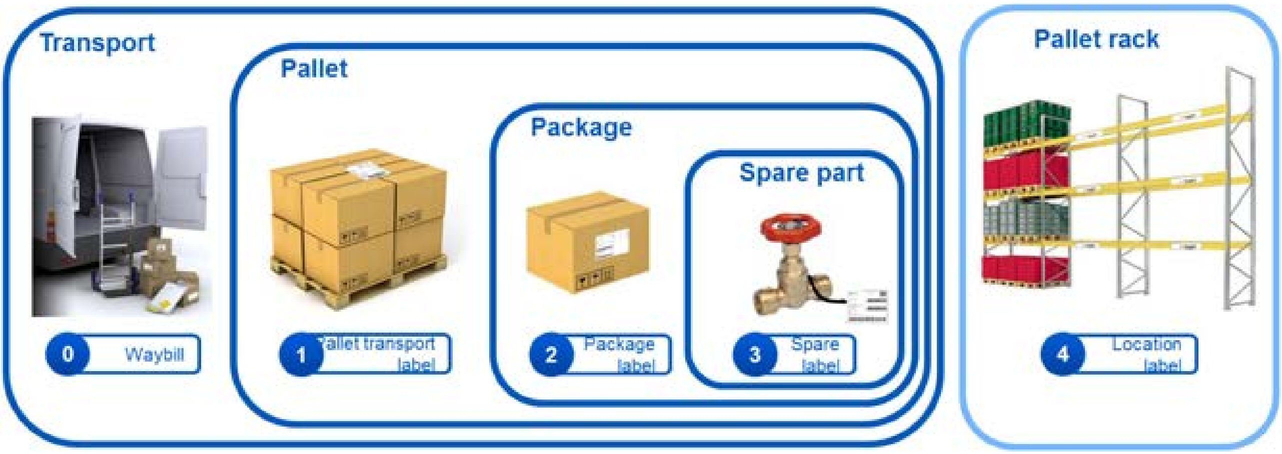


FIG. 17. Electricité de France labelling methodology.

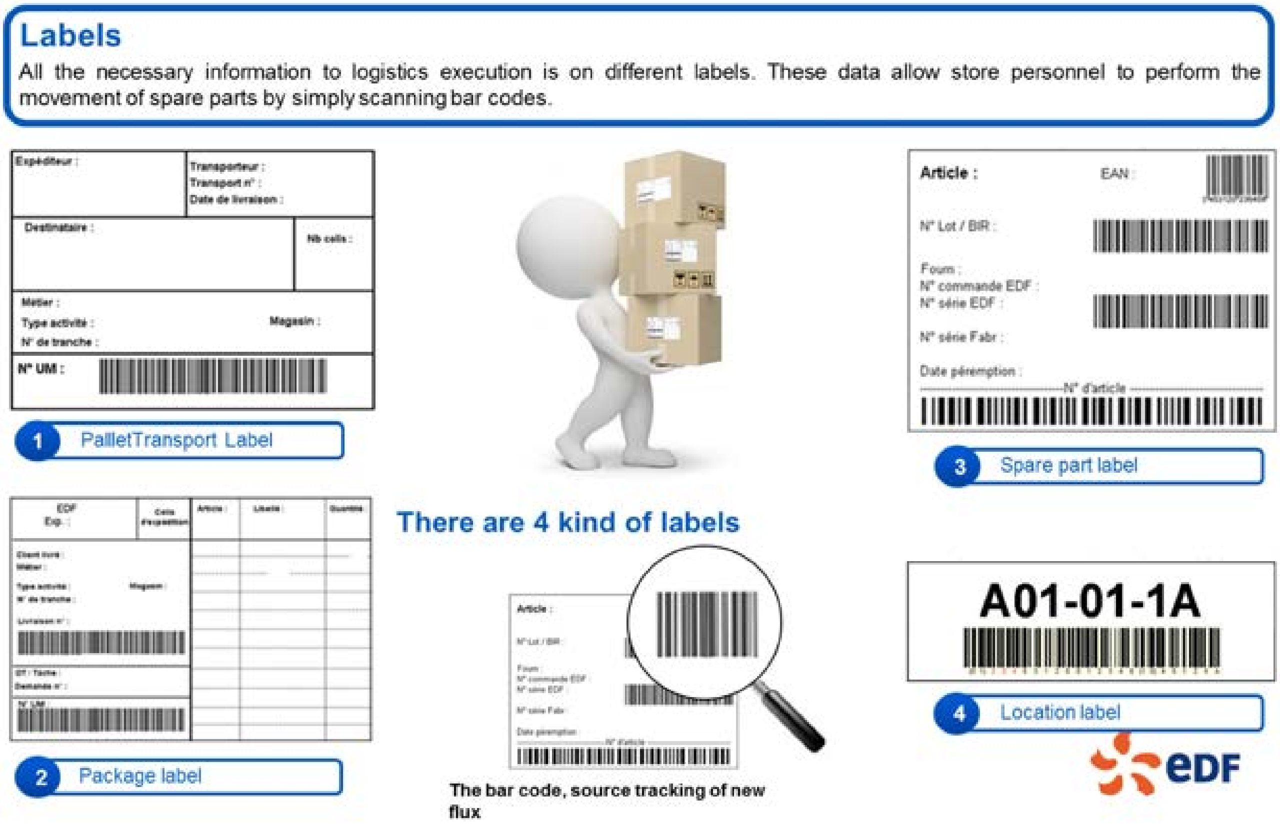


FIG. 18. Electricité de France label examples.

Material [151] for security related details). Other hazardous goods (e.g. chemicals and fuel) will have other specific management system requirements and national regulations.

EPRI has produced a detailed guide on packaging, shipping, storage and handling guidelines for nuclear power plants [152]. The guide contains recommendations for shipping packaging and shipping guidelines for typical nuclear power plant component types that can be used as a basis for internal operating organization practices and standard instructions that can be sent to suppliers.

3.9. 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 [109]. Expediting can consist of simple status reporting, more intrusive methods such as performing shop visits to physically verify item status, or performing forward looking supplier management activities such as reviewing purchase order schedules in detail, comparing schedules against knowledge of supplier and subsupplier capabilities, assessing fabricator shop schedules and monitoring supplier production of interim deliverables. The degree of intrusiveness is dependent upon item criticality, with the 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.

A prerequisite to the expediting function is ensuring that an adequate nuclear safety culture is present within the organization doing the expediting. When done improperly, expediters can encourage suppliers, distributors or testing organizations to ‘cut corners’, to deliver substandard or inadequately tested products, or even can increase the risk of fraudulent activities.

3.10. ACCEPTANCE, INSPECTION AND RECEIPT

Acceptance, inspection and receipt is the process of ensuring, by objective evidence, that the received item or service meets the acceptance criteria (defined in Section 3.5) following the agreed acceptance methods.[4] Services are typically evaluated by the organization receiving the service (e.g. engineering organizations for technical services and maintenance or construction organizations for maintenance or installation contracts), while materials are typically evaluated by the procurement organization’s warehouse staff via the receiving process.

Receiving is the function of receiving and processing incoming materials [108]. Paragraphs 8.30 and 8.31 of IAEA Safety Standards Series No. NS-G-2.6, Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants [153] discuss item receipt. NS-G-2.6 [153] recommends establishment of adequate facilities for receiving materials, and documented processes for controlling the receiving and acceptance process.

All items typically undergo some level of receipt inspection based on their acceptance criteria. As discussed in Section 3.5.2.3, this can include checks for shipping damage or foreign material, checks to verify item identity, confirmation that the correct number of items has been received, checks that the required documentation has been received, and more advanced checks for physical or chemical properties. Non-conforming material should be promptly physically segregated from acceptable material (see Section 3.11.4).

In appendix D of an EPRI report [107], guidance is provided on the establishment and operation of a receiving test and inspection facility:

> “The following should be considered in establishing an area and facilities for testing and inspection:
> 1. Incoming and outgoing materials;
> 2. A QC hold area for non-conforming items;
> 3. An anti-static materials test area;
> 4. Test and inspection equipment storage cabinets and calibration area;
> 5. Large inspection and test equipment not suitable for cabinet storage (floor mounted hardness tester, precision surface plate(s), etc.);

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[4] Some organizations differentiate between inspections performed to confirm correct quantities and types of material have been shipped and to ascertain general material condition with respect to damage, with technical inspections required to confirm all acceptance criteria have been met. This publication does not make that distinction.

6. A test and inspection office area;
7. Separate general test and inspection areas."

Personnel performing receipt inspection should be alert to any indication that the item provided is non-conforming or that certifications provided are fraudulent. Section 7.4 provides a list of signs for receipt inspectors to look for to help in identifying counterfeit or fraudulent items, including:

— Altered or incomplete labelling;
— Obvious attempts at beautification;
— Evidence of hand cut materials;
— Poor fit-up with items from the same manufacturer;
— Documentation discrepancies or illegibility.

Specific training is recommended for warehouse and other facility staff in detection of such items. Counterfeiting is further discussed in Section 7.

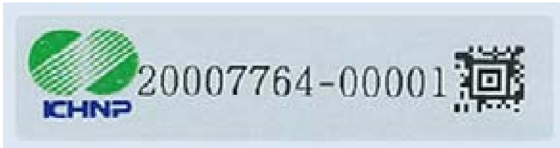
Items failing receipt inspection should have an evaluation to determine whether the deficiency can be resolved. This may involve a technical (engineering) review to determine whether the item can be accepted, reworked, repaired or rejected.

Following receipt, inspection item tagging is typically performed by the receipt inspector. A unique tag or label is affixed to the item (where not applied by the supplier, see Section 3.8) and entered into the operating organization's electronic tracking system. Such labelling can be just alphanumeric (see Fig. 19) or use more modern techniques such as bar coding, laser engraving (see Fig. 20), radiofrequency identification (see Figs 21 and 22), or near field communication. Labelling systems should be designed to facilitate item tracking and traceability back to purchase orders, and ultimately to the source and conditions of fabrication. Radiofrequency identification or near field communication integrated with geographic information system (GIS) and GPS technologies can allow for detailed material tracking throughout a site, providing improved transparency, efficiency and accuracy.

Enterprise systems used for tracking material can facilitate management of item shelf life and identification of specific product location within the nuclear power plant in the event of item recalls or adverse performance trends.

FIG. 19. Sample tags applied at receipt (courtesy of Korea Hydro & Nuclear Power).

FIG. 20. *Laser engraving (courtesy of Korea Hydro & Nuclear Power).*



Size: 6 x 1.5 cm

Adhesive power: >1000gf/25 mm

Excellent heat resistance and cohesion

FIG. 21. *Polyester film radiofrequency identification label with a quick read two dimensional barcode (courtesy of Korea Hydro & Nuclear Power).*

Ceramic RFID tag:

Size : 12 × 7 × 3 mm

Weight : 1.4 g

FIG. 22. *Ceramic radiofrequency identification tag (courtesy of Korea Hydro & Nuclear Power).*

Specialty labelling such as material safety data sheet labels on chemicals would also be confirmed to be in place at this receipt inspection stage (see Fig. 23). If hazardous items are transferred or decanted to a smaller container for field use, field labels need to be applied to the smaller container.

FIG. 23. Sample hazardous chemical labels (reproduced from Ref. [154] with permission courtesy of International Chamber of Commerce, Compliance Center Inc.).

The receipt inspection step typically ends with item placement into a secure warehouse for later installation. However, in some cases, SATs or commissioning of the item may be required to complete the full item acceptance process.

3.11. STORAGE AND WAREHOUSING

This step involves the placement of the item into the operating organization's secure storage and warehousing system until it is 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.

Item traceability from manufacturer, to shipper, to warehouse, to laydown area, to installation in a particular plant location, is important, as are the processes needed to ensure proper handling, transport and storage, and to prevent damage, loss, deterioration or inadvertent use.

Paragraphs 5.151–5.159 of GS-G-3.5 [9] cover numerous aspects of handling and storage, including the need:

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

Paragraphs 8.32–8.40 of NS-G-2.6 [153] cover numerous aspects of storage and issuing spare parts and other material. Beyond those described above, these include the need to have convenient facilities for issuing material, the ability to issue materials on an emergency basis, and ensuring records are kept on to whom and to which destination materials are issued. These and other related topics will be covered in further detail below.

The EPRI guide discussed in Section 3.8 [152] contains detailed storage instructions for typical nuclear power plant component types, which 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 (i.e. less likelihood of damage).

Some lessons learned with respect to packaging for storage reported by EPRI include [152]:

- 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 packaging is often advantageous for warehouse storage.
- Manufacturer's labels should be retained during long term storage.
- Processes for handling outside stored components should be developed (e.g. weatherproof tagging, matching of unique ID numbers to shipping tags which are kept indoors, and review of damage potential of any chemicals used for control of weed growth in outdoor laydown areas).
- Warehouse logistics should be carefully considered (standard pallets, crates and facility for moving long pipe lengths).

The EPRI guide [152] recommends that organizations responsible for storage and warehousing should:

- Consider material incompatibility of carbon steel forklift forks with materials to be carried (e.g. use stainless steel sleeves for lifting stainless steel components);
- Consider carefully the requirements for pipe storage (e.g. indoor versus outdoor, inclined to allow drainage and properly supported);
- Ensure in-storage maintenance is possible;
- Use end caps, plugs or seals (i.e. bags, boxes, tape and cabinets) appropriately to protect against foreign material entry 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 that 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 EPRI guide [152] 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 and chance of losing ID tag);
  - Other factors such as shelf life, in-storage maintenance, the need for frequent handling (for in-storage maintenance) and personnel protection requirements.
- Flammable, hazardous and radioactive substances and incompatible chemicals will require special attention.

3.11.1. Environmental and storage conditions

Items may be damaged by a number of conditions, including:

- Exposure to humidity and moisture (causing corrosion, mould or mildew damage);
- Chemicals;
- Airborne contamination;
- Light/ultraviolet radiation;
- Magnetic fields;
- Static electricity;
- Fires;
- Radiation;
- High or low temperatures.

Physical damage can also be encountered owing to drops, falls or vibrations. Rodents or insects may damage packing materials or the items themselves.

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

3.11.2. 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 to help to maintain their dielectric strength while in storage.

EPRI has produced a report for in-storage maintenance which identifies factors and conditions related to in-storage degradation such as humidity, friction, gravity and loss of electrical capacity [155].

3.11.3. Shelf life

Shelf life is the length of time that a manufacturer will guarantee the usability of a product during warehouse storage. It is the predetermined period between the date of manufacture and the installation [108]. Shelf life can be affected by such parameters as temperature, humidity, pressure, ultraviolet light exposure, ozone levels 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 recommended shelf life. Shelf life information, including expiry dates, and cure or batch dates, should be marked on items or included as separate certification. Shelf life marking should be confirmed as part of the 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 due to humidity, ultraviolet 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 expire within a specified time frame (e.g. within one to two months) to ensure material availability and suitability when needed.

EPRI shelf life guidance (establishing, maintaining and extending shelf life) is given in Ref. [156], which provides a generic shelf life programme for various components such as types of batteries, elastomers, electronic components, reactive liquids and semisolids (e.g. coatings or sealants), resins, plastics and lubricants. An EPRI background study [157] was used in the development of Ref. [156]. A further EPRI report [158] examines specific shelf life issues associated with lubricants, including potential tests that can give confidence that lubricants are acceptable for use following typical supplier recommended shelf lives of two to three years, and recommended storage (preferably inside). Other shelf life data for elastomeric products can be obtained from Refs [159, 160]. French standard RCC-E requires the storage period for electronic components to be preferably less than two years before manufacturing a complete electronic card [37].

In some cases, conservative shelf life guidance provided by vendors can be evaluated and extensions technically justified.

3.11.4. Segregation of non-conforming items

A key warehouse function is to physically separate non-conforming products from products that are acceptable for use in the facility. Non-conforming items can be those that are received as damaged, incomplete, delivered in error or delivered without the 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 needs to be taken to ensure proper storage conditions to prevent material degradation while the non-conformance is being addressed.

3.11.5. Stores inventory management

If not managed, stores inventory can grow to unsustainable levels. Inventory carrying cost is an important consideration because associated activities do not produce any revenue for operating organizations. Inventory carrying costs include the costs of warehousing (e.g. direct costs for space rental, electricity, heating and other utility costs and staff costs) and the opportunity costs of invested funds (e.g. taxes, insurance, shrinkage and obsolescence risk costs).

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. The NEI indicates that an inventory optimization strategy can include the following optimization methods [108]:

— 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 the inventory (i.e. consumable, chemical, repairable and critical);
— Measuring performance;
— Partnering with suppliers;
— Partnering with alliances, interutility and intrautility;
— 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;
— Analysing usage patterns;
— Applying total cost of ownership philosophy;
— Utilizing inventory analysis tools;
— Participating in the design change process early in the process or schedule;
— Encouraging the use of the existing inventory.

Robust information technology (IT) systems are a necessity for proper control of the large amount of data associated with a nuclear facility's inventory. Such systems should incorporate features such as:

— A single source of data entry;
— A 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;

— A recording of material status (e.g. damaged, awaiting inspection, quarantined and issuable);
— Allocation of material to installation work orders;
— Tracking of individual components to storage locations and end locations (for recall purposes);
— Inventory management;
— Material recipients;
— Material substitutions;
— Payment functions.

Various in-house and commercial solutions are available in industry, including enterprise resource planning systems and materials management software. Examples include SAP, ABB Ventyx Asset Suite (PassPort), AREVA VPRM, Intergraph SmartPlant Materials, IBM Maximo and Oracle E-Business Suite.

Numerous methods and technologies are increasingly available to assist in managing inventories. Material tagging systems applied at receipt, and sophisticated tracking systems (e.g. GIS/GPS) discussed in Section 3.10 allow for better and more accurate control of individual items. Unique ID numbers (see Section 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 Section 3.1.3 and Appendix IV) based on known and forecast demands. Finally, supply chain management strategies (see Section 2.2) 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.

3.11.6. Prevention of damage, deterioration or loss of items

The 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 owing to environmental exposure (see Section 3.11.1) or other adverse conditions (e.g. storage batteries being off charge for extended periods can degrade, and the shelf life continues to be reduced). Unattended or unsecured items can be subject to theft or sabotage (including cyber-attacks), which can both delay field work and introduce safety or security 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 (e.g. maintenance staff and contractors) need to be in place. Systems using GIS and GPS technology that was discussed in Section 3.10 can assist.

Operating organizations typically set up a programme for regular warehouse inspections (e.g. on a monthly basis) and for inventory confirmation (typically annually). These can help to detect adverse general workplace conditions, and incorporate detailed inspections of a sample of random items and materials to help to detect improper storage, loss of inventory or other adverse conditions.

Increased security requirements for secure storage areas for equipment identified on the critical digital asset list should be considered to provide protection against malicious compromise. The need for secure, segregated storage for these critical digital assets is due to the absence of security controls in place during transit, storage and installation.

3.11.7. Field storage

Just prior to use, material is typically collected for each work management job (all material for the 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 to 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.

Operating organizations typically set up processes to ensure that minimal packaging and dunnage (i.e. loose material related to shipping that supports or protects cargo) enters the operating island, and that the amount of temporarily stored equipment is minimized. This reduces radioactive waste production and fire hazards. Recoverable packaging and dunnage is preferentially used where cost effective.

3.11.8. Interutility transfer of material

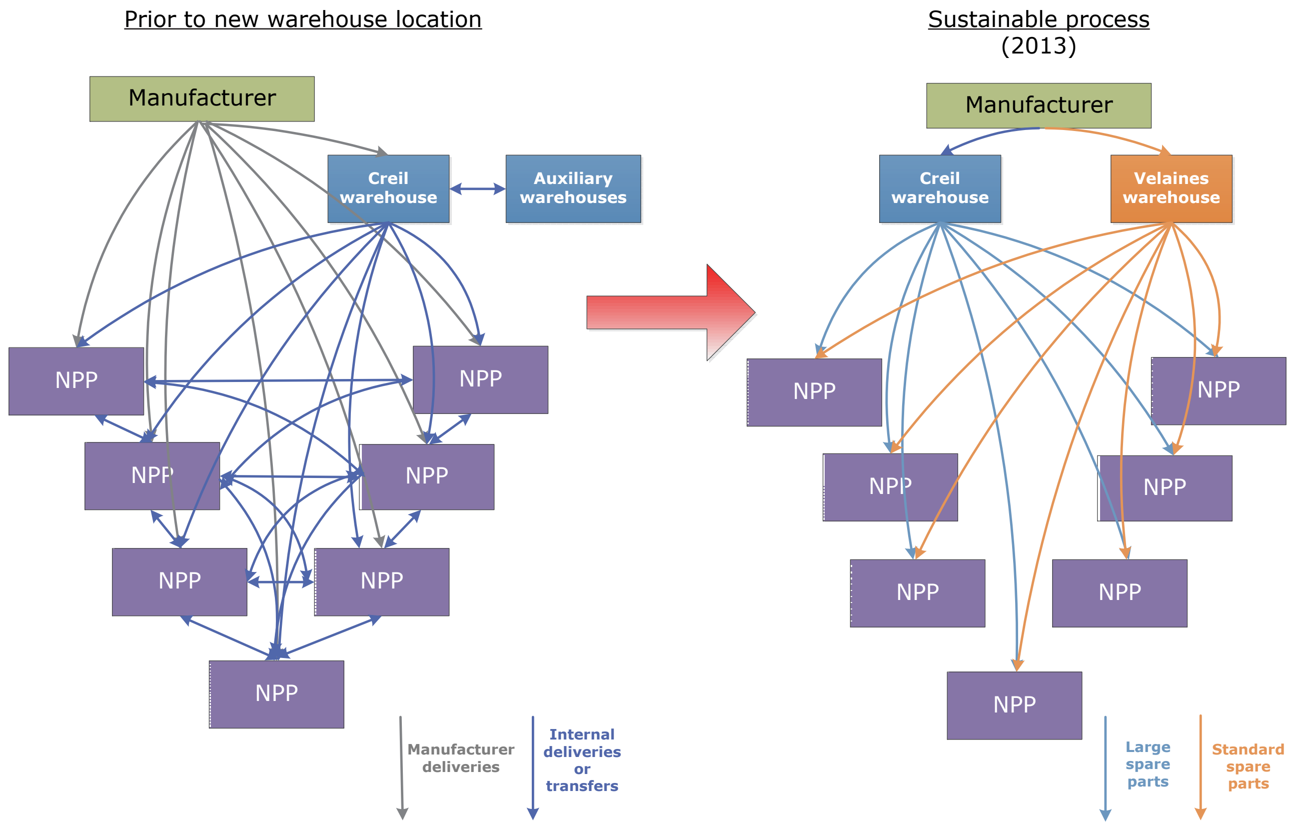
Occasionally, it may be beneficial to transfer material among operating organizations (e.g. nuclear facilities, companies and utilities). An operating organization may have an urgent need for an item, and a willing supplying operating organization may be identified. Shared inventory and cooperative warehousing arrangements are increasingly being developed. EPRI has produced a guide to some of the considerations involved with interutility transfers [161]. The receiver needs to provide itself with assurance that the received item will meet its own requirements. This may involve activities such as reviewing the seller's original procurement specifications, reviewing the seller's audit reports, performing a CGD process after item receipt (if not transferred as safety related), notifying the original supplier of the transaction (to ensure notification of any original supplier identified defects or recalls) and performing appropriate receipt inspection.

3.11.9. Alternative warehousing and supply strategies

Operating warehouses and storing inventory is a bottom line cost for operating organizations. Increasingly alternative warehousing arrangements are becoming more practical. Centralized facilities, just in time (JIT) deliveries, supplier managed inventories and supplier owned inventories all have the ability to decrease facility costs. In some cases, warehouse operation services or warehouses themselves can be contracted out.

Companies with large fleets of nuclear facilities can benefit from having large centralized warehouses that support multiple locations. For example, EDF has used two centralized warehouses (Creil at St Leu d'Esserent and another at Velaines) and a centralized procurement organization since 2013. All suppliers deliver material to one of these two warehouses, which then take orders from and provide deliveries to the nuclear power plant customers (see Fig. 24). Nuclear power plants maintain only local safety and operating stock.

JIT is an operations management philosophy with objectives to reduce waste and to increase productivity. Developed extensively in the automotive industry, JIT inventory systems focus on having 'the right material, at the



Note: Old arrangement on the left; after new warehouse strategy on the right. NPP — nuclear power plant.

FIG. 24. Electricité de France parts warehousing arrangements.

right time, at the right place and in the exact amount', without the safety net of an inventory. Having local suppliers with fast delivery capability is typically necessary to implement a JIT system. The JIT methodology should be considered carefully, and the use of an effective stocking plan is necessary to compensate for the weaknesses of this method [108].

A 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 is managed by the supplier [108]. The inventory includes items a supplier owns and maintains on the premises of the purchaser. This can also be known as consignment inventory [108]. Payment is not made to the supplier until an item is used.

3.12. ITEM INSTALLATION, TESTING AND USE

When items are installed in a facility, a key activity to be performed is to update enterprise tracking systems to record that the specific items have been installed in the facility, and that any items replaced have been removed. This allows tracking of the items in the event of a supplier recall or other discovered adverse condition relating to the items. Processes related to this typically involve the maintenance organization updating (or requesting updating) the enterprise computer system, as part of work task closeout activities, to indicate the item installations and removals for the applicable equipment locations (see Section I.10 for further details).

Depending on the acceptance criteria established for the item in question, there may be post-installation or SAT requirements for the item to be confirmed and documented following installation (see Section 3.5.2.4).

3.13. REPAIR, REFURBISH OR RETURN TO STOCK

Items often need to be placed into the facility inventory following activities that are not typical purchases direct from a material supplier. These include items that have been repaired or refurbished (either at the nuclear facility or by an external repair company), or items that are surplus following construction activities (e.g. surplus material or construction or commissioning spare parts). A key prerequisite for placing such items into the inventory is the availability of material traceability information. This necessitates the establishment of management system processes for maintaining tracking and control of such items throughout their lifetime (either during the construction period or during the repair and refurbishment process), and the transfer of such data along with any construction or repair purchasing information (e.g. specifications and purchase order information) into the operating organization's enterprise IT systems.

Items being placed into stock following these activities should follow a defined process similar to incoming receipt inspections. Such items 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, subcomponents partly removed or (if long periods of time have elapsed) the item may have aged.

Items placed into a warehouse should thus be screened to ensure the following information is provided [108]:

— Work order or modification number;
— Quantity returned;
— Stock number/catalogue identification number;
— Unique ID number (e.g. serial number, uniquely tracked commodity (UTC) number);
— Indication if item was installed or used, removed from service, repaired or cannibalized;
— Reason for return;
— Statement of acceptability and 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 to be repairable, an evaluation as to whether a repair should proceed should be carried out by considering parts availability, cost of repair (internally or externally) and a comparison to purchasing a new item.

3.14. DISPOSAL OF UNUSED MATERIAL

Utilities should have processes in place to identify potential unneeded spare parts in the inventory due to modifications (obsolete material), as well as material identified as excess stock, damaged or with a 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 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.

3.15. 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 prior to final payment and provides an opportunity to accurately assess contractor performance based on the criteria on which they were chosen. This performance information should be shared with the contractors so that they can improve their processes. They may be given both positive and negative feedback. It is also the opportunity for the contractors to provide positive and negative feedback on how the owner administered the contracts so that the owner can also improve. Further details on supplier feedback are discussed in Section 3.17.

3.16. NON-CONFORMANCE CONTROL

A key element in the procurement process is the formal means of identifying, tracking assessing and initiating corrective actions as a result of non-conformances.

Non-conformances are normally documented whenever an acceptance criterion or supplier management system requirement is detected as not being fulfilled. Non-conformances can be defined as the supply of products or services that do not meet technical or quality requirements specified in procurement documentation. They may be identified upon receipt or during installation, commissioning or use. Non-conformances are normally identified by operating organization staff, but occasionally the supplier may identify a non-conformance via a product recall notice. Section 5.9 discusses some lessons learned with respect to product recalls.

Non-conformance reporting processes are invoked to correct the immediate non-conforming condition in a timely and systematic manner, to determine the causes of the non-conformance to prevent reoccurrence in other circumstances, to evaluate the extent of the condition (i.e. review the possibility that the conformance exists elsewhere) and to initiate any 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 subsuppliers. Subsupplier processes need to connect in a timely manner with top level supplier processes and those of the operating organization. To achieve this, operating organization non-conformance processes and databases are recommended to incorporate the ability to track specific non-conformances against specific manufacturers or suppliers.

3.17. SUPPLIER MANAGEMENT

3.17.1. Supplier feedback

Supplier evaluation involves objective analysis of existing suppliers by evaluating past performance. Suppliers are typically evaluated based on their technical quality, delivery, service, cost and management capabilities [108]. 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 to be more balanced. Metrics can be in the categories of safety (both nuclear and industrial), 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 on measured and perceived performance.

Some possible metrics for material suppliers are described in Table 12. Service supplier metrics are discussed in Section 4.4. Such metrics and associated supplier scorecards should be available to staff performing bid evaluations as an input to the evaluation process. Suppliers with good records for performance would thus be rewarded and be more likely to receive new contracts.

TABLE 12. MATERIAL SUPPLIER POTENTIAL METRICS

Metric category	Definition	Comment
Delivery performance	Percentage of shipments received early, on time or late	None
Overages/shortages	Percentage of shipments received with too many or too few items	None
Damaged items	Percentage of items received with damage due to poor packaging or handling	None
Receipt inspection metrics	Percentage of items accepted for use, rejected, discarded or used as is	None
Documentation issues	Percentage of items received with incomplete or erroneous documentation	None
Problems identified during purchase order formulation and implementation	Issues documented during purchase order formulation and implementation	Evaluate as number or as percentage of purchase orders placed
Parts/material problems identified during installation or operation as a result of supplier error or quality issue	Number of parts/material problems identified during installation or operation as a result of supplier error or quality issue	Evaluate as number or as percentage of purchase orders placed

3.17.2. Supplier claims

Suppliers can make claims for additional costs related to the supply of goods or services, 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 because 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 to 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 of inadequate factual support (as much as two thirds according to one estimate [144]). However, there is often 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

4.1. BACKGROUND AND DRIVERS

Nuclear facilities have a need for a variety of services. These can include contracts for plant maintenance, construction, inspections, cleaning, transport, or 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 carrying out all maintenance for a facility). Procurement of services has taken on additional importance for many operating organizations. Many operators have business drivers to outsource certain aspects of facility operation, whether it is for construction, maintenance work, technical support or other functions. Drivers may be financial (cost savings), the need for specific expertise, the need for flexibility in staffing, the need to address temporary work increases, or the need to complete work that is not core to the operation of a nuclear facility. This trend has been increasing in some countries, and is more likely to be the case for newcomer or developing nuclear States without large national nuclear workforces. Facilities built under engineer–procure–construct or build–own–operate models tend to operate with higher levels of non-owner service contracts.

4.2. RESPONSIBILITY FOR SAFETY AND MANAGEMENT SYSTEMS

As discussed in Section 2.1, 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 (see para. 3.6 of the Fundamental Safety Principles [6]). This can be more difficult for service suppliers for a number of reasons:

(a) Individuals outside of the owner’s company are not under direct managerial oversight and control of owner supervision (e.g. they cannot control resource decisions, it is more difficult to provide fast direction).
(b) Outside companies may work in non-nuclear industries, they may not be fully aware of nuclear requirements and they may not be as fully engaged with or trained in human performance tools or in nuclear safety culture.
(c) Key activities related to quality (i.e. inspections and tests) may be unseen or not witnessed by the owner (making errors, omissions and fraud less likely to be detected).
(d) Levels of training and qualification may be lower in outside workforces.
(e) Outside workforces may be more transient, leading to lower levels of experience at the facility in question and unexpected changes in personnel (an experienced person can suddenly be replaced by an inexperienced person).
(f) Owner oversight of outside workforces can be difficult or resource intensive if many suppliers and supporting management systems are present (e.g. auditing and oversight costs rise).
(g) Excessive owner outsourcing can reduce skill levels within owner organizations to manage external suppliers (e.g. no informed customer or smart buyer capability developed).
(h) Owner oversight costs and resources applied to outside workforce oversight increase costs to owners and reduce the benefits of outsourcing, thus tending to be discouraged by owner management.
(i) Economic pressures may be present to deliver services to lower quality levels or with higher risks to owners (e.g. using less experienced personnel, minimized redundancy in skill sets, and less emphasis on corrective action resolution and reporting of defects).
(j) Economic disputes can delay responses to important activities.
(k) Contractual arrangements can contribute to making accountability for overall quality difficult to determine (e.g. contracting engineering for a project separate from construction and separate from material supply).

GSG-4 [86] covers the 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, that they are technically competent, that they have a management system, that they maintain confidentiality and that they support the regulator’s safety culture.

4.3. SERVICE PROCUREMENT PROCESSES

Procuring services follows the same general approach as documented in Section 3. The purchaser first needs to prepare a specification for the work that is analogous to the purchasing requirements described in Section 3.2. Bidders then prepare formal bids, the operating organization evaluates the 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 owner, with assistance from assigned contract administrators or monitors. Where contract administrators and monitors are assigned, it is usually beneficial to involve them as early as possible in the procurement process to allow their knowledge and experience to be applied to the service purchasing requirements documents. An overview of typical roles is given in Appendix X.

Services can be provided by a supplier with an accredited nuclear management system or they may require a CGD process where they might potentially adversely affect the function of safety related equipment. Section 11 of Ref. [136] contains information on the CGD of services. Services that might require CGD include:

- — Repair services;
- — Testing services;
- — Fabrication, machining, cleaning and manufacturing services;
- — Consulting services;
- — Engineering and technical services;
- — Calibration services;
- — Computer software services.

Services can be dedicated if the critical characteristics identified in the technical evaluation can be verified during the acceptance process. Additional information on technical support for nuclear operations is contained in Ref. [162].

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

Suppliers can be turnkey, full service or general purpose suppliers, and thus be able to carry out a wide variety of tasks. Alternatively, they can be contracted for only 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 that company strategy remains consistent and that sufficient internal expertise is maintained. Some possible strategies for engaging service suppliers are listed below, and 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 is always kept within the operating organization (i.e. in-house).
- — The supplier is used only for overflow work.
- — The supplier is used only for balance of plant or non-safety-related work.
- — The supplier is used only for specialty work.
- — Multiple suppliers are used, depending on the work or specialty.

Newcomer States typically rely on their nuclear facility supplier for most engineering design and installation support, especially in the early stages of a facility's life. However, it is normally necessary, owing to the different business drivers and possible motivations of the operating organization and supplier, to develop a 'utility engineer' oversight role to ensure:

- — The supplier understands the peculiarities of the specific nuclear facility;
- — Correct problem definition where problems and solutions may not be clear;
- — Value for money is obtained for a particular project;
- — The nuclear facility is not adversely affected by installed modifications;

— Nuclear safety implications for the facility are understood and addressed;
— Nuclear facility personnel understand the implications of installed modifications.

The 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 and modification packages) and performing contract and project management on behalf of the operating organization. Several operating organizations have found this to be a unique skill set which needs development and aptitude that can be different from 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, to coach and to 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 and specific scope of technical work);
— Expected volume and amount of work;
— Process for individual subprojects (how the scope is defined, financial arrangements such as the need to rebid on subprojects with a fixed price and use of draw down contracts);
— Availability and 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 and software);
— Owner support to be provided (e.g. training, licensing support and administrative support);
— Accountabilities with respect to the reporting of defects and corrective action programmes (including interfaces between service providers and owner programmes);
— Commercial and financial expectations;
— A requirement for suppliers 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 to 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, 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.

After specification development, bid evaluation, negotiation for services and contract execution follow the processes described earlier in Sections 3.6 and 3.7.

4.4. SERVICE SUPPLIER FEEDBACK

As discussed in Section 3.17.1, good and regular communication that includes formal reporting or scorecard processes is useful for suppliers and operating organizations in long term business relationships. This is especially important for services because 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 13. 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. Sample sets of reports generated from metrics similar to those used at an operating organization are shown in Figs 25 and 26.

TABLE 13. SAMPLE SERVICE SUPPLIER SCORECARD METRICS

Metric category	Metric topic
Safety	Industrial safety performance (lost time accident rates, injuries per person-hour, housekeeping); see Appendix IX Work site housekeeping Nuclear safety performance (no attributable events) Environmental performance (no attributable events) Quality of training Radiation safety (e.g. personnel contamination events, collective exposure and radiation work planning compliance)
Quality	Customer and contract manager satisfaction Final quality of product or service (deliverables provided at various phases such as preliminary engineering, detailed design, installation, commissioning and closeout) Technical accuracy Configuration management (maintaining plant design basis documents and enterprise systems up to date) Clarity and editorial accuracy Rework metrics (e.g. documents and products returned for revision or rework, construction or maintenance trades rework instances) Non-conformances observed Procedural compliance, including maintaining internal procedures up to date Warranty claims Unplanned field change rates Records maintained accurately and submitted as required Use of trained, qualified personnel
Cost	Cost control and budget Project cost growth rates Billing and invoicing accuracy No non-justified claims or additional charges Value added by supplier (e.g. cost savings identified or better solutions) Care of items or material supplied by owner (no loss or damage)
Schedule/work control	Schedule adherence Milestone performance Earned value performance Timely reporting of schedule deviations Document turnaround time Document and project closeouts completed within acceptable time frame

TABLE 13. SAMPLE SERVICE SUPPLIER SCORECARD METRICS (cont.)

Metric category	Metric topic
Project management	Responsiveness (when faced with critical situations), flexibility and cooperation Independence and interface management (e.g. communications and reporting timeliness, clarity, accuracy and performing independent work) Project predictability Leadership behaviours (e.g. supervisory oversight, accountability and engagement) Corrective action and audit programme implementation Documentation of lessons learned

Engineering Services Division - Design Agencies Project Performance Report				Feb-10
Key Performance Indicator	Month			
	Units	Actual	Target	Status
Score Card Compliance				
Project Score Card Compliance from Projects	#	37	37	✓✓
Design Agency Performance	Quality Performance	Schedule Performance	Cost Performance	Overall
	Score	Score	Score	Score
Agency - 1 - Station - A	86	85	90	87
Agency - 1 - Station - B	75	81	76	78
Agency - 1 - Overall	80	83	83	82
Agency - 2 - Station - A	65	80	78	75
Agency - 2 - Station - B	88	84	93	89
Agency - 2 - Overall	76	82	85	82
Other Agencies - Station - A	82	94	96	87
Other Agencies - Station - B	68	75	74	72
Other Agencies - Station - C	57	66	63	60
Other Agencies - Overall	69	78	78	73

Legend:
80-100% score
70 to < 80% score
60 to < 70% score
< 60% score

FIG. 25. Sample design service provider comparison scorecard.

Certification of individuals should also be considered. The Slovakian operating organization Slovenské elektrárne, an Enel group company, is developing a programme to monitor performance, safety culture, skills and certificates for individuals that are not under its direct management. A pilot programme has been launched for maintenance services, with evaluation of individuals being performed after each plant outage. After scoring positively and recurrently in each area, Enel issues the individual with a ‘nuclear skill passport’. In the future, Enel would encourage suppliers to use those individuals for contracted work.

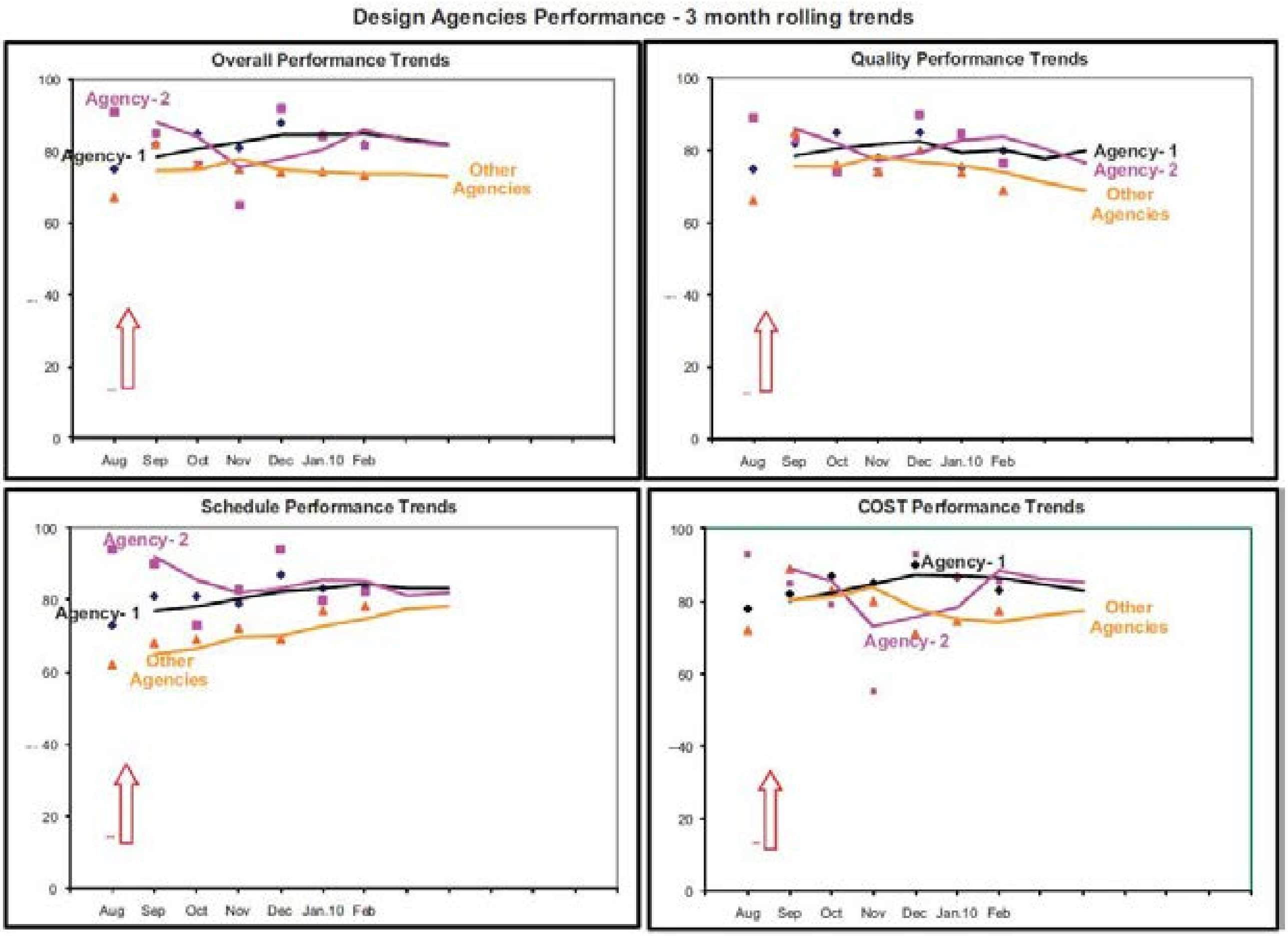


FIG. 26. Sample service provider performance trend reports.

4.5. SERVICE LESSONS LEARNED

As discussed in Section 2.3, a key lesson learned related to services is the need for an informed 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 to 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 safety related activities. Individuals performing the informed customer role need knowledge of the activities that they are overseeing, and so opportunities need to 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.

A report by the Royal Academy of Engineering identifies some recommendations related to services [163]. These include the need to incorporate lessons learned from similar projects, to maintain a risk register reviewed at senior levels, to 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 some examples of potential failures in the performance of different types of service related to CGD that can affect safety related equipment functions (see Table 14) [136]. If a service procured can impact a safety related function, the report recommends that critical characteristics for the service be identified which, once selected, provide reasonable assurance that the service provided meets the specified requirements [136]. Acceptance criteria would then be selected to ensure the criteria are met. Some specific issues or guidance identified for CG services are:

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

CGD is discussed more fully in Section 5.1.4.

TABLE 14. POTENTIAL FAILURES IN SERVICE PERFORMANCE

Type of service	Potential failures
Testing	Improperly calibrated test equipment Technician inadequacies in performing the test Improper test specimen preparation Improper calculation of test results
Fabrication, machining, cleaning and unique manufacturing processes	Failure to meet dimensional requirements Material contamination Foreign material — failure of or lack of foreign material exclusion controls
Engineering or technical services (including training)	Incorrect calculations Failure to confirm initial assumptions Errors conveyed during training
Calibration	Improperly calibrated test equipment Improper standards

Source: Adapted from table 11-1 of Ref. [136].

5. CONSIDERATIONS AND LESSONS LEARNED

5.1. PROCUREMENT ENGINEERING FUNCTION

The procurement process requires technical information as an input to ensure that procured items will perform their intended design functions. Owing to the potential complexity of translating such technical information (e.g. design specifications, codes and standards) into procurement instructions for suppliers (particularly with regard to changes in the supplier marketplace with passage of time), many operators have created a procurement engineering group or function.

The procurement engineering 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 for managing suppliers), and often serves as a bridge between those functions. In some organizations, the procurement engineering function resides with the design group, while in others, it resides within the procurement and 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 a request for quotation or a request for proposal documentation sent to equipment suppliers.

For illustration, Fig. 27 provides the high level responsibilities of the design engineering, procurement engineering and purchasing functions. It should be noted that there are some areas of overlap; not shown is feedback from purchasing to procurement engineering to design engineering surrounding areas of possible process improvements (e.g. ways to minimize costs or improve efficiency).

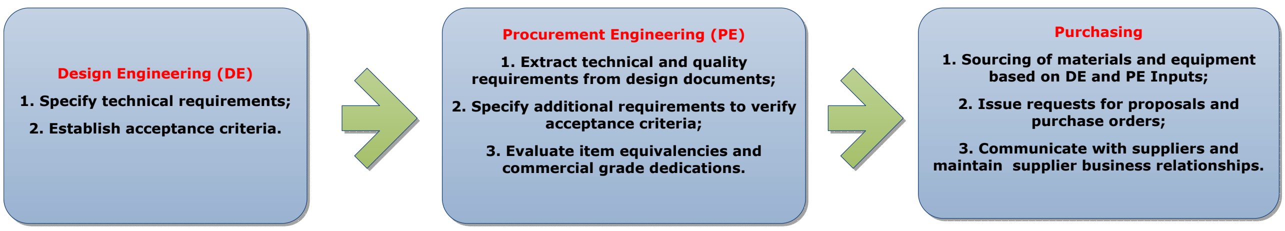


FIG. 27. Responsibilities of design, procurement engineering and purchasing.

Major activities within procurement engineering are thus to:

— Establish procurement technical and quality requirements (see Sections 3.2 and 5.1.1);
— Establish acceptance criteria (see Sections 3.5.1 and 5.1.2);
— Evaluate item equivalency (see Section 5.1.3);
— Perform or manage CGDs (see 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 the establishment of technical and quality requirements for items. As a requestor may not have full knowledge of all procurement process requirements and data needs, procurement engineering staff are trained especially to clearly and correctly articulate such requirements. This function also generally includes the screening of setting up new catalogue IDs for items to be purchased, and linking them to the item’s requirements. As part of this process, end use analysis of items is performed to determine whether the item needs to be purchased as safety related or not; and whether it is a critical digital asset or not. To aid in improving the efficiency of the screening process, operating organizations can establish a procurement engineering exemption list of items that are not plant equipment (e.g. kitchen, office or hygiene supplies, transport equipment, and certain tools or test equipment) and automatically exempt them from procurement engineering review.

5.1.2. Establishing acceptance criteria and methods

Following the establishment of requirements and supplier selection, acceptance criteria for the item, as well as the methods by which they will be confirmed, need to be defined and documented. As described in Section 3.5, acceptance criteria and methods are designed to ensure that purchasing requirements have been met before the product is used. Procurement engineering 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 nuclear facilities age, greater difficulty is typically experienced in obtaining identical spare parts. Marketplace changes can cause original equipment manufacturers to go out of business. They may decide to discontinue products or to replace products with improved models, or they may decide to discontinue their nuclear management system or quality assurance programme. With nuclear power 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 alternatives.

Nuclear facilities need methodologies and staff to locate replacement items and to 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 a facility, including both safety related and non-safety-related 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 procurement engineering staff are often assigned this role.

Paragraph 4.1 of IAEA Safety Standards Series No. NS-G-2.3, Modifications to Nuclear Power Plants [164], indicates that a plant modification "does not include the replacement of a component by an equivalent component in recognized maintenance activities." That is, item replacement processes are different to design changes or modifications.

Equivalent components are those that are either identical to the original component or those for which a safety assessment has 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 alternative item replacements are those where some changes may be allowed but where the item still meets the 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 subcomponents in a motor or power supply by an original equipment manufacturer during a rewind or refurbishment, or upgrading 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 to 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 nuclear power plant. The characteristics of design changes and item replacement processes are given in Table 15.

TABLE 15. CHARACTERISTICS OF DESIGN CHANGES AND PART REPLACEMENT PROCESSES

Process	Characteristics
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 as impact on interfaces is 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 alternative or subtier supplier)

Reference [3] on configuration management recommends organizations “Use an effective, documented process for evaluating replacements to confirm that the component is equivalent, through procurement engineering methodologies such as 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 15.

IEEs allow for replacement of parts with equivalents. New items are evaluated against, and need to be found equivalent to, the original items in terms of form, fit and function (performance characteristics). Form, fit and function are identifiable and measurable attributes of a replacement item that provide assurance that the item will perform its design function and is equivalent in its 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 provides a documented methodology for replacement items, including both like for like replacements and IEEs (see Fig. 28) [114]. The assessment model confirms the safety classification of an item by looking at all its end uses in a nuclear power plant. It examines differences between the old and replacement items, documents such differences and, if deemed equivalent, develops requirements for the replacement item. Of particular importance is the analysis of failure modes and the effects of the replacement item (e.g. impacts of failures due to corrosion, shorts, open circuits, vibration and fatigue), and if the item responds in an identical way to the original. This completed assessment is used to determine whether equivalent replacement or design change or 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 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) [114]. 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 [114]. 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-safety-related items or systems. This depends on factors such as risk significance, importance to plant reliability, item cost, maintenance and installation cost, and potential affects on personnel safety and plant security.

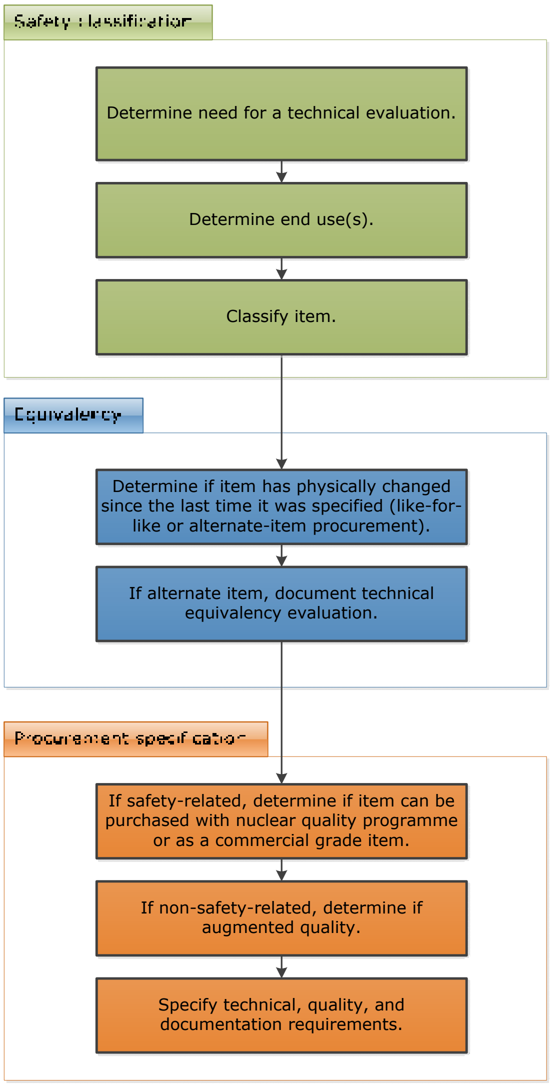


FIG. 28. Sample assessment process for evaluation of replacement items for nuclear power plant equipment (adapted from Ref. [114] with permission courtesy of Electric Power Research Institute).

5.1.4. 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 assurance programme meet technical and quality requirements for safety related end uses in a nuclear facility.

CGIs are typically safety related items that were not designed and manufactured as safety related (see 10 CFR 50 [70] for a typical definition). They do not include items where design and manufacturing processes require in-process inspections and verifications to ensure that defects or failures to comply are identified and corrected (i.e. one or more critical characteristics of the item cannot be verified).

For nuclear facilities other than nuclear power plants, a simpler definition for a CGI can be an item that exhibits all the following criteria:

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

The CGD process has been needed in many countries owing to a reduction in nuclear power plant construction, which has caused many suppliers to not maintain their nuclear management systems or quality assurance programmes. Parts may no longer be available, or even if they are available, they do not have the required nuclear quality assurance programme documentation. Therefore, there is no supplier assurance that component design is controlled, and it is possible that substandard items will be manufactured owing to a 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 that they are acceptable in safety related applications.

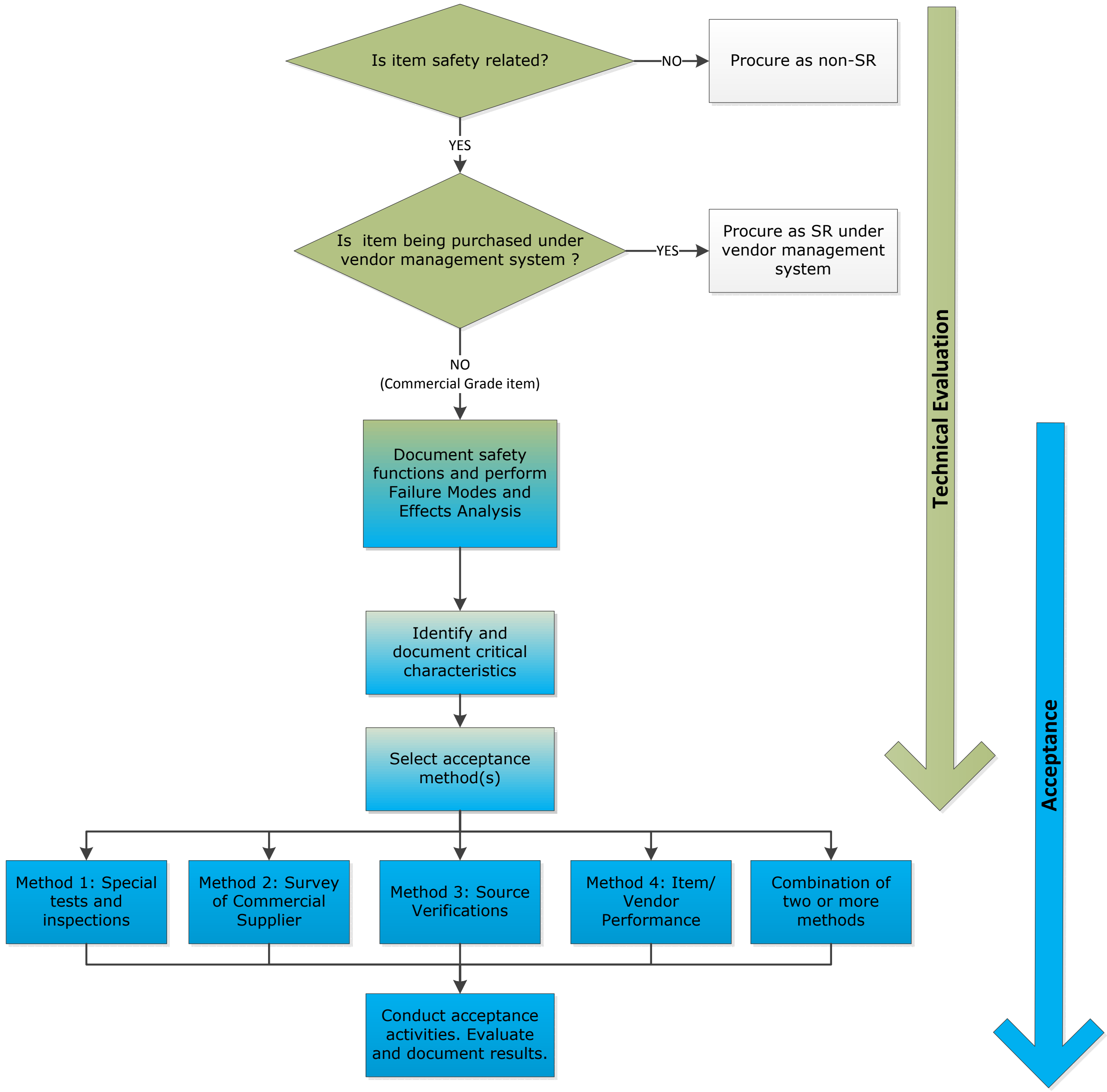
Paragraphs 5.35–5.37 of GS-G-3.5 [9] cover the CGD process and state that:

> "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. 29. 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, and 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 (based on Ref. [136]):

(a) Identifying safety functions of the item. This means identifying end use applications, determining the safety function of the item in the end use applications and clearly documenting these in a technical evaluation.
(b) Performing a failure modes and effects analysis (FMEA) to postulate credible failure modes of the item in its operating environment, and the effects of these on the safety functions. The FMEA should be performed only by individuals with appropriate technical qualifications, experience and training.
(c) Producing a list of appropriate critical characteristics of the item to be dedicated that, once verified, will provide reasonable assurance that the item being dedicated is capable of performing its intended safety functions. Identification of critical characteristics involves four basic steps. First, the characteristics necessary to preclude failure of the item to perform its safety functions are determined. Second, a set of critical characteristics to be verified is identified. Third, the set of critical characteristics identified is reviewed to ensure that they are adequate to provide reasonable assurance that the item being dedicated will be able to perform each intended safety function. If it is not, additional critical characteristics are identified. Finally, the critical characteristics selected are clearly documented in the technical evaluation along with the basis for their selection. When the dedicating entity does not know the end use applications for the item and does



Note: SR — safety related.

FIG. 29. Representative process for commercial grade dedication (adapted from fig. 4-1 of Ref. [136] with permission courtesy of Electric Power Research Institute).

not establish specific boundaries for the dedication, all of the original design requirements and allowable tolerances are critical characteristics that are to be verified. The evaluation should be explicitly bounded by identifying the suitable end uses of the item along with applicable safety functions and any limiting conditions.

(d) Defining and implementing an appropriate method of acceptance to confirm such critical characteristics. Figure 29 shows four such methods: special tests and inspections, CG supplier survey, source verification and acceptable supplier and item performance records. Characteristics of each method and their uses are shown in Table 16.

TABLE 16. COMMERCIAL GRADE DEDICATION ACCEPTANCE METHODS AND SUITABILITY

Acceptance method	Specific operating organization activities	Specific supplier activities	Most suitable for
Method 1: Special tests and inspections	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	Furnish technical design information to enable operating organization to verify critical characteristics	Items furnished from multiple suppliers Items relatively simple in nature Items on which post-installation tests can be conducted to verify critical characteristics
Method 2: Commercial grade supplier survey	Conduct survey of CG programme Require supplier to invoke controls necessary to verify critical characteristics Accept item based on supplier certificate of conformance verified by CG survey	Implement controls necessary to verify critical characteristics Provide operating organization with a certificate of conformance (as requested)	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
Method 3: Source verification	Conduct source verification Accept item based on documented source verification results	Implement item specific design, fabrication, assembly, manufacturing, testing or inspection controls substantiated by the source verification for a particular CG item Allow operating organization access to facilities to conduct source verification	A single item or shipment of items purchased on an infrequent or expedited basis
Method 4: Acceptable supplier/item performance	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	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	Items where results of historical performance can be compiled utilizing: Monitored item performance Industry product tests National codes and standards (not specific to the nuclear industry) Other industry databases (military, aerospace, etc.)

Source: Adapted from table 2-4 of Ref. [129].
Note: CG — commerical grade.

Digital technology and nuclear services can undergo the CGD process. Guidelines for CGD of digital technology are covered in Section 6.3. Services can be dedicated if the critical characteristics identified in the technical evaluation of the service can be verified during the acceptance process. In a service context, these are controls, which, once selected to be verified, provide reasonable assurance that the service provided meets specified requirements. Verification of these controls will provide reasonable assurance that the safety function of plant equipment affected by the service will not be adversely affected. An example of this is provided in Table 17.

TABLE 17. EXAMPLE OF CONTROLS AND ACCEPTANCE CRITERIA FOR CALIBRATION SERVICES

Critical controls	Acceptance criteria
Adequacy of measurement standards	Standards have accuracy, stability, range and resolution required for item being calibrated
Calibration procedures	Adequate documented instructions exist for performance of accurate calibration
Qualification of personnel	Personnel have adequate skills, training and experience to ensure accurate and repeatable calibration
Environmental controls	Calibration environment is controlled to the extent necessary to ensure continued measurement with required accuracy on standards and measuring equipment
Calibration status	M&TE and standards are uniquely identified and labelled to indicate calibration status
Calibration traceability	Calibration standards and reference materials are traceable to national, international or intrinsic standards where available
Storage and handling	M&TE and standards are handled, stored and transported to avoid deterioration or damage, which could affect the calibration of the equipment
Out of tolerance notification	Notification process when supplier's M&TE and standards are found to be out of tolerance to an extent that customer's calibration results may be invalid

Source: Adapted from table 11-3 of Ref. [136].
Note: M&TE — measurement and test equipment.

EPRI and other organizations have produced numerous guidance documents covering the CGD process. Key references are provided in Table 18. Of special note is the difference between a vendor audit as described in Section 3.4.3 and a CG survey. A CG survey focuses on supplier controls related to specific critical characteristics identified in a dedication technical evaluation, while a vendor audit examines all aspects of the vendor's management system (typically ISO 9000 for commercial suppliers).

TABLE 18. GUIDANCE DOCUMENTS AND OPERATING EXPERIENCE RELATED TO COMMERCIAL GRADE DEDICATION

Country	Organization	Document	Comment
India	AERB	AERB/SG/QA-3, Quality Assurance in the Procurement of Items and Services for Nuclear Power Plants [42]	Section 10 covers CG stock items. Allows items 'with a proven record' to be used providing that 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.

TABLE 18. GUIDANCE DOCUMENTS AND OPERATING EXPERIENCE RELATED TO COMMERCIAL GRADE DEDICATION (cont.)

Country	Organization	Document	Comment
USA	EPRI	3002002982, Guideline for the Acceptance of Commercial-grade Items in Nuclear Safety-related Applications, Revision 1 to EPRI NP-5652 and TR-102260 [136]	Expands upon generic process and guidance included in NP-5652 [129] and TR-102260 [165] to provide a detailed process that includes both operating plant and supplier perspectives. Includes examples of dedication technical evaluation forms and other tools that may be used to help, establish an effective process.
USA	EPRI	1016157, Information for Use in Conducting Audits of Supplier Commercial Grade Item Dedication Programs [133]	Summarizes key elements of utility and supplier CGD programmes and points out potential differences between licensee and nuclear supplier implementation. Contains a set of generic forms that could be used to document CGD evaluations.
USA	EPRI	NP-5652, Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications (NCIG-07) [129] Note: Superseded by report 3002002982 [136]	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.
USA	EPRI	TR-102260, Supplemental Guidance for the Application of EPRI Report NP-5652 on the Utilization of Commercial Grade Items [165] Note: Superseded by report 3002002982 [136]	Provides supplemental implementation guidance to NP-5652 [129] 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.).
USA	EPRI	NP-6629, Guidelines for the Procurement and Receipt of Items for Nuclear Power Plants (NCIG-15) [107]	Defines purchasing a CGI, using a utility quality assurance programme as a possible procurement scenario. Points to NP-5652 [129] (see above) for detailed requirements.
USA	EPRI	TR-112579, Critical Characteristics for Acceptance of Seismically Sensitive Items (CCASSI) [166]	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 [75] and EPRI reports 3002002289 [167], NP-5652 [129] and TR-102260 [165].
USA	EPRI	1003105, Dedicating Commercial-grade Items Procured from ISO 9000 Suppliers [168]	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.

TABLE 18. GUIDANCE DOCUMENTS AND OPERATING EXPERIENCE RELATED TO COMMERCIAL GRADE DEDICATION (cont.)

Country	Organization	Document	Comment
USA	EPRI	TR-017218-R1, Guide for Sampling in the Commercial-grade Item Acceptance Process [137] Note: Combined with 43004 in the November 2013 version of 43004	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.
USA	NRC	Inspection Procedure 38703, Commercial Grade Dedication [169]	Regulator inspection procedure use to determine whether a failure of an SR item was a result of a deficient CGD process, or verify a licensee's CGD process meets requirements.
USA	NRC	Inspection Procedure 43004, Inspection of Commercial Grade Dedication Programs [170]	Regulator inspection procedure to verify a dedicator's CGD programme satisfies requirements.
USA	NRC	Information Notice No. 83-79, Apparently Improper Use of Commercial Grade Components in Safety-related Systems [171]	Heat exchanger outlet valve at D.C. Cook unit 2 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.
USA	NRC	Information Notice No. 87-66, Inappropriate Application of Commercial-grade Components [172]	Identifies problems resulting from inappropriate application of CGIs within class 1E electrical panels (differences in quality and qualified life expectancy (10 years versus 2 years) between a particular manufacturer's nuclear and CG relays).
USA	NRC	Information Notice No. 88-95, Inadequate Procurement Requirements Imposed by Licensees on Vendors [173]	Supplier QA programme does not address procurement and QA controls of ASME code exempt load bearing parts. In another case, cracks were discovered in spare safety valve guide and bearing assemblies in storage that were inappropriately procured as CG.
USA	NRC	Information Notice No. 92-51, Misapplication and Inadequate Testing of Molded-case Circuit Breakers [174]	Documents several issues with MCCB testing. One of these was that a supplier indicated instantaneous trip set points of CG MCCBs with non-adjustable magnetic trips that 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 CG MCCBs with non-adjustable magnetic trips supplied to nuclear utilities fall within the appropriate design band. Highlights the need and importance of determining critical characteristics and testing for them.

TABLE 18. GUIDANCE DOCUMENTS AND OPERATING EXPERIENCE RELATED TO COMMERCIAL GRADE DEDICATION (cont.)

Country	Organization	Document	Comment
USA	NRC	Information Notice No. 96-40 (with supplement 1), Deficiencies in Material Dedication and Procurement Practices and in Audits of Vendors [175]	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 purchase orders. Highlights the need for attention to detail in CGD processes.
USA	NRC	Information Notice No. 2011-01, Commercial-grade Dedication Issues Identified During NRC Inspections [176]	Summarizes NRC staff findings in area of CGD over a 2 year 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.
USA	NRC	Information Notice No. 2014-11, Recent Issues Related to the Qualification and Commercial Grade Dedication of Safety-related Components [177]	Informs addressees of issues identified during NRC vendor inspections with qualification and CG dedication of SR replacement components. Five examples of vendor qualification and CGD issues are described. In these examples, the vendors were unable to provide reasonable assurance that the supplied equipment would operate on demand and would meet its performance requirements for the designed life of the components and under the full range of operating conditions, up to and including design basis accident conditions.
USA	DOE	Guidance for Commercial Grade Dedication [178]	Consolidation of best CGD practices from both DOE Environmental Management Complex and commercial nuclear industry.
USA	OFR (NARA)	10 CFR 21, Reporting of Defects and Noncompliance [71]	Section 21.7 indicates that suppliers of CGIs are exempt from the provisions of this part to the extent that they supply CGIs.

Note: AERB — Atomic Energy Regulatory Board; ASME — American Society of Mechanical Engineers; CG — commercial grade; CGD — commercial grade dedication; CGI — commercial grade item; DOE — United States Department of Energy; EPRI — Electric Power Research Institute; MCCB — moulded case circuit breaker; NARA — National Archives and Records Administration; NDT — non-destructive testing; NRC — United States Nuclear Regulatory Commission; OFR — Office of the Federal Register; QA — quality assurance; QMS — quality management system; SR — safety related.

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 procurement engineering function supports the 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 alternative item, requiring an evaluation by engineering as to its equivalency to the original item (typically called an IEE) and the documentation of technical and quality requirements for the alternative item. Similarly, a supplier may no longer have a specified nuclear quality assurance programme, requiring commercial dedication processes to be applied to the item (see Section 5.1.4) or an alternative 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 procurement engineering 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

Requirement 10 of SSR-2/2 (Rev. 1) [2] is related to control of plant configuration. These requirements emphasize the need to maintain plant configuration documentation in strict accordance with the actual physical configuration. Reference [179] presents a basic approach to configuration management and describes how many plants have worked to improve their configuration management processes.

INPO has produced a process description [180] related to the configuration control process that links to materials and services processes [108]. 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 publication (e.g. defining requirements, ensuring items meet acceptance criteria, tracking items to specific nuclear power plant end use locations, maintaining proper records and ensuring no counterfeit items enter the plant) all support maintaining this plant configuration. Where configuration is inadvertently lost, plants can be shut down or can require extensive efforts to re-establish adequate configuration.

Modern enterprise computer systems can help to automatically perform many process actions for maintaining configuration management. 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;
- Calculations;
- Drawings;
- Bills of material;
- Spare parts;
- Vendor information;
- System descriptions;
- Maintenance and operating procedures.

Changes only have to be entered once into the computer when changes are made, as linked information is automatically updated. Special consideration will be needed to address security concerns (e.g. ensuring only approved individuals have access to configuration details for security related equipment).

Owing to the complex data requirements surrounding plant configuration (see Appendix I), it is essential to ensure such data are 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 modification 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 the numbers of suppliers, optimizing reorder points and addressing longer term spare parts issues) can be more difficult and be given less attention owing to time or other pressures. As discussed in Section 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 and a lack of spare parts).

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:

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

5.3. OBSOLESCENCE AND MODERNIZATION

IAEA Safety Standards Series No. NS-G-2.12, Ageing Management for Nuclear Power Plants [181], 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, increased susceptibility to cyber-attacks and reduced capability for long term operation.

INPO defines obsolete equipment as “an item in plant service that is no longer manufactured or is otherwise difficult to procure and qualify” [182]. This is in contrast to the lesser concern of obsolescence caused by a plant, in which, for example, a nuclear power plant does not need a part any more, owing to a modification or modernization project.

Longer operating lifetimes are planned or envisaged as nuclear facilities age and undergo life extensions. Nuclear facilities thus increasingly 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.

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);
— Long term repair and rebuild programmes, including cannibalization of parts from inoperable spares;
— Subsidizing companies (to maintain production capacity and support for key items);
— Funding a special manufacturing run (possibly in conjunction with other operating organizations);
— Finding alternative vendors (developing item equivalency or low cost modifications that allow other manufacturers’ products to be used);
— Ensuring contracts are given to companies with key capabilities (support smaller companies with regular purchasing, potentially even buying such companies if they fall into financial difficulties);
— Pooling inventories with similar facilities;

— Periodic computer security monitoring and assessments for obsolete digital equipment;
— Protection via technology transfer contract provisions (see Section 8.3.3);
— Reverse engineering (see Section 5.3.2);
— Modernization programmes (see Section 5.3.3).

Instrumentation and control (I&C) components are of special concern. Demand for nuclear I&C components and the range of safety related components are relatively small and qualification costs are 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 components, resulting in a diminished inventory of analogue equipment. Obsolescence is not as serious an issue for nuclear power plant 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 nuclear facilities 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 nuclear facilities. A possible programmatic approach to address obsolescence on a facility wide basis is described in Section 5.3.1. I&C obsolescence is discussed in some detail in IAEA-TECDOC-1402 [183].

EPRI has identified a number of initiatives under way in the United States of America to address obsolescence [184], and include:

— Pooled inventory management (PIM);
— RapidPartSmart (RAPID);
— An obsolete items replacement database (OIRD);
— A proactive obsolescence management system (POMS);
— POMS preventive maintenance (PM) forecasting.

PIM 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 perform 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 and targets a number of obsolescence issues [185].

RAPID is a database established by a number of operating organizations to pool their on-hand nuclear plant inventories and, when necessary, make them available to ‘participants in need’.

OIRD is a database developed in 2000 by the Nuclear Utility Obsolescence Group (NUOG) and Scientech. It was designed to be integrated with the inventory databases in RAPID. Initial utility data entered in OIRD were the contents of the EPRI obsolete item database and consisted of IEE 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 whether the model number is still supported. Information provided by vendors is used to populate and update POMS and is 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 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 ten obsolescence issues [186].

Obsolescence issues can be identified by almost any part of an operating organization, including the procurement organization, operations, maintenance, design, plant engineering, and planning. The procurement organization has a key role in assisting to address obsolescence issues. Staff can:

— Flag obsolete items in enterprise data systems and prompt action when the 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;
— Identify near term obsolescence issues based on projected usage data.

NUOG, which is coordinated through INPO, has produced a programme guide to address nuclear utility obsolescence [186]. The guide provides information on programme organization methodologies, information exchange and monitoring. Metrics are associated with such items as the numbers of obsolescence problems solved versus unsolved, systems reviewed versus not reviewed, average closure times for identified issues, and lag times.

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 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 (BOMs), producing a list of targeted catalogue ID numbers 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 alternative components would be collected. This would then provide 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 alternative components via station modification or parts substitution processes. Failing this, engineering resources would consider reverse engineering options with manufacturers (see Section 5.3.2) or more significant modification programmes (see Section 5.3.3). Consideration should be made for adding incremental resources required by other support organizations (e.g. purchasing and vendor audits) into the obsolescence team to maximize its effectiveness.

5.3.2. Reverse engineering

EPRI defines reverse engineering as the “process of developing technical information sufficient to duplicate an item by physically examining, measuring, or testing existing items; reviewing technical data; or performing engineering analysis” [187]. It may be used:

— To address an obsolescence situation;
— To achieve cost savings by purchasing from an alternative supplier;
— To address issues with lapses in the quality assurance programme from an original supplier;
— To resolve lead time concerns;
— To improve item performance.

Although the intent of reverse engineering is to obtain an essential item that is identical to the original, based upon the nature of a reverse engineered item, both the design and manufacture of the new item will inherently change. Therefore, 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 to be 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. original equipment manufacturer drawings are not to be sent to a reverse engineering vendor; however, pertinent data can often be transcribed).

EPRI has produced a guide to reverse engineering for nuclear power plants [187]. Reverse engineering 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 are then collected. These can include:

- — Component and item drawings;
- — System drawings;
- — Vendor specifications;
- — Vendor procedures;
- — Vendor manual information;
- — Station procedures;
- — Original procurement specifications.

The original item is then inspected and measured, and pertinent data are 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 reverse engineering, interfacing item data or actual interfacing parts may need to be supplied to the vendor. Any history or OPEX related to the item should be forwarded to the vendor to help the vendor address any previous concerns.

The next step in the reverse engineering 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 manufacture. It is often beneficial to produce a prototype for evaluation prior to full production.

Once it has been determined to proceed with the reverse engineering item, engineering approval for the replacement item is required, typically via an IEE (see Section 5.1.3).

5.3.3. Modernization programmes

In some cases, operating organizations have embarked on modernization programmes in part to address obsolescence concerns. These can include parts substitutions or major modifications. Digital upgrades, for example, can often replace a large number of separate analogue components with a single digital multifunction 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. IAEA publications on digital upgrades include Refs [188, 189]. Digital equipment is however susceptible to cyber-attacks, which necessitates implementation of computer security measures. IAEA Nuclear Security Series No. 17, Computer Security at Nuclear Facilities [89], can assist with identification of computer security measures for digital equipment.

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 (direct current) and dynamic (alternating current) components of output from existing process sensors to gain ageing related information about I&C sensors. New sensors can be installed to help to monitor installed equipment [190].

Design changes may be costly but may be the most cost effective method to address certain obsolescence issues. Proposals should have solid economic justifications, and uncertainties present with new technologies should be analysed for potential risks.

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 [191, 192]. 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 on nuclear power plant outage and 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, security or economically important spare parts such as those that might address single point vulnerabilities.

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 to ensure critical equipment and major purchases are repaired or purchased and received in a timely manner. The actual procurement steps are not any different to 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 the expectations of internal organizations and the vendor (i.e. providing clear and accurate requirements), ensure the vendor has internalized these expectations (i.e. the people actually performing the work understand the expectations as opposed to simply being sales representatives), 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 [192].

INPO has published guidance for owner oversight of new plant component fabrication which is applicable to both new plant construction and replacement and repair activities [193]. 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. Reference [193] also 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 I&C components) and component oversight attributes (typical types of component 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 contingency spares are purchased or stocked. These demands can come from specific maintenance work being assessed, programmes to reduce instances where work is dropped owing to a 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 facility. 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 is ever used in maintenance.

Poor planning can contribute to inventory growth. When the 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 [113]. 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. The time required to deal with any individual request can increase (owing 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 will not need to wait for follow-up item purchases. Finally, the operating organization can see the cost of carrying an inventory increase as levels of materials stored increase.

Operating organizations should have processes in place to manage inventory levels in a sustainable manner. This will contribute to nuclear power plant efficiency and economic operation. These processes can include demand side initiatives (i.e. challenge or screen addition of newly stocked items; see Section I.3), methods to pool or share inventories (sharing costs with other organizations), methods to have suppliers hold inventories (e.g. supplier held inventory with just in time delivery methods as needed), reviews of usage patterns to review stock levels, and measures to surplus or sell unneeded inventory excesses. Inventory segmentation according to criticality and regularity of use categories as described in Section 3.1.3 can assist.

5.6. INTERNATIONALIZATION OF THE SUPPLY CHAIN

The nuclear supply chain for reactor construction was traditionally relatively nationally based. It has, however, undergone a trend towards longer term consolidation, with a smaller number of internationally recognized reactor models in the marketplace. As nuclear power has expanded into new markets, the 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 (WNA) performed a review of the nuclear supply chain outlook up to the year 2030 [81] and reported, for example, that the number of ASME N-stamp holders as of 2009 is greater outside of the traditional ASME markets of Canada and the United States of America, than within (69 in Canada and the United States of America, 74 in Asia and the European Union) [81].

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 to deliver high quality, reliable and cost competitive components.

However, this internationalization of the supply chain does present several challenges. Increasing numbers of foreign or offshore suppliers can increase the complexity and expense of auditing, source inspection, shipping (i.e. longer distances, need for multiple freight modes, customs clearance complexity) and material tracking activities. Risks associated with CFSIs (see Section 7), intellectual property theft, communications (i.e. language and culture), responsiveness (i.e. longer delivery and response times, potential for accidents and loss), macroeconomics (i.e. exchange rates) and geopolitics can increase.

International suppliers still have significant regulatory and technical constraints when supplying components for the nuclear island. The Fundamental Safety Principles [6] provides the framework for safety regulation with the principles incorporated into national licensing procedures. Different regulatory regimes have nevertheless evolved across the world, and inevitably there are inconsistencies in the way safety and security is approached among States and even within States. Such variations can introduce additional compliance costs for global supply chains which can then hamper the development of an open international trading system. Governments, working through IAEA structures and other intergovernmental organizations, such as the Nuclear Suppliers Group (NSG), and partnerships at global and regional levels can assist in bringing about a consistent regulatory regime that would further open the nuclear reactor and equipment supply market [194].

The above issues are echoed by CII in its International Project Risk Assessment guide, which indicates that [104]:

> "...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."

CII has also published a global procurement eGuide [109] and an international project readiness guide [195], and which help to address global procurement and supply chain issues, including:

- Emerging issues such as entering new markets;
- Workforce issues;
- Projects of growing size and complexity;
- Strategic supplier relationships;
- Emerging markets (global sourcing);
- Materials, manufacturing and fabrication quality;
- Environment and sustainability.

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 [196].

Localization desires by States for nuclear equipment supply run somewhat counter to the increasing globalization of the nuclear supply chain. The WNA suggests an approach whereby there is close collaboration on procurement procedures to be followed between the main nuclear power plant supplier, the relevant national economic development agency and the operating organization [196]. 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 prequalify and compete. Complementary measures are necessary by the economic development agency to promote capacity upgrading among local companies and to help them to achieve the necessary quality certifications.

States embarking on new build or major refurbishment programmes have thus found it useful to establish cooperative supply chain associations that support local industries in understanding and navigating the nuclear supply chain process. This can include assistance in entering the market for new build, maintenance and decommissioning, growing capability and competitiveness, and driving innovation in manufacturing processes and products.

5.7. PROCUREMENT RECORDS CONTROL AND STORAGE

As discussed in Section 2.1, records need to be kept for procurement related activities. Proper retention and storage policies, procedures and facilities need to be in place to ensure required records are available over the life of the facility. Systems need to be in place to ensure records availability following natural or human made disasters. Records allow demonstration to regulators and other stakeholders that quality processes have been followed for procurement related activities, and will assist with later facility operation and maintenance. Without these very important records, the operating organization has no basis for continued plant operation. Some procurement related records include:

(a) Equipment, material order or contract numbers.
(b) Design documents.
(c) Manufacturing drawings.
(d) Procurement specifications.
(e) Quality plans (for each process, from raw material production to final product quality inspection and test records).
(f) Raw material and purchased part quality records:
- Material quality certificates;
- Chemical composition certificates;
- Material property tests;
- Non-destructive testing (NDT) records;
- FAT records;
- Repair and material substitution records;
- Other inspection records.

(g) Fabrication records:
- Weld procedures;
- Weld electrodes used;
- Personnel qualification;
- Supplier materials approvals (including furnace number and batch number);
- Welding material batch;
- NDT inspection results;
- Destructive test records.

(h) Manufacturing process test reports and records:
- Heat treatment;
- NDT;

— Pressure tests;
— Seal tests;
— Electrical performance tests;
— Instrument calibration;
— Equipment functional tests;
— Stability tests;
— Cleanliness inspections;
— Final dimension checks.

Procurement document approval and change procedures should be defined. Documents should be able to be validated as being in accordance with the provisions of the product's quality assurance programme, quality inspection standards and procedures, personnel qualification requirements, inspection requirements, and measurement and test equipment calibration requirements. Paragraphs 5.35–5.49, II.1–II.27 and the annexes of GS-G-3.1 [8] provide details on recommended guidance.

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 and UTCs).

5.8. HUMAN RESOURCES AND TRAINING

Training is a key aspect of nuclear facility operation, and individuals are required to have received appropriate education and training, and have acquired suitable skills, knowledge and experience to ensure their competence (see para. 4.23 of GSR Part 2 [7]). The IAEA has published a number of publications related to nuclear power plant training, including IAEA Safety Standard Series No. NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants [197], and advocates that operating organizations adopt a systematic approach to training as described in Ref. [198].

Individuals involved in procurement require training that is specific to their job duties. The NEI has identified some specific training areas required [108]. These include contract administration, contract management, purchasing, procurement engineering, inspection, parts planning, expediting, material receipt, warehousing, inventory analysis and investment recovery. Other key areas for training include computer security and auditing.

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

As will be discussed in Section 6, specialized training within the procurement and contracts organizations is necessary for computer and digital system purchases to address computer technical and security related issues.

Individuals involved in inspection and auditing activities are key to procurement quality. Within a given jurisdiction, multiple nuclear power plant designs may be present, and with global supply chains, several different national standards may be employed for manufacturing or testing. Inspectors need to 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;
— Identifying and addressing CFSIs.

5.9. RECALL OF MATERIAL BY SUPPLIERS

Recalls are requests to return to a supplier a batch or an entire production run of a product, usually owing to the discovery of safety issues or a product defect. For nuclear facilities, the main issue of concern is how to quickly identify where in the facility 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 manual record 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 turnkey or engineer–procure–construct projects, there may be few operating organization purchasing activities under way during construction. Thus, the turnover period from construction to commissioning and operation may be when the operating organization purchasing function begins. Prior to this phase, the operating organization will need to establish its 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 facility vendor prior to this phase can help expedite the performance of these steps.

A careful review of data required to support future procurement is recommended as part of system and area turnovers for new projects (see section 4.2 of Ref. [199]). Appendix I describes specific data needs for procurement, such as a master equipment list (MEL), BOMs and spare parts lists, which have substantial linkages to plant design configuration data. For new facilities, 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 facility vendor or the operating organization may be responsible for inputting 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 inputting process should thus begin well before the expected time of turnover, preferably as a formal part of the plant's design process. Responsibilities for such activities should be included as part of new build or major project contracts, as will be discussed later in Section 8.2.

At the time of turnover, it should be confirmed that the facility 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, operation and maintenance activities post-turnover.

Material ordered as part of facility construction as spares or remaining surplus material will need to be transferred to the operating organization and placed in its secure warehouse. A methodology for this should be developed in advance, which may be somewhat like the interutility transfer process described in Section 3.12.8. The process will need to ensure that the construction organization maintains item traceability back to its approved suppliers during the construction phase and transfers all related procurement data (e.g. specifications and purchase orders) to the operating organization.

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

Following plant turnover, both procurement volumes and their character 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 facility 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. Paragraphs 6.1–6.8 of GSR Part 2 [7] requires that nuclear facilities should have processes in place for monitoring, self-assessment, independent assessment, management system review, lessons learned and methods to address non-conformances via corrective and preventive actions.

The above requirements are also discussed in paras 6.1–6.69 of GS-G-3.5 [9], which describe the typical attributes of a good system:

— Regular management oversight reviews;
— Self-assessments by senior management, 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
— Reviews of non-conformances, with corrective and preventive actions.

A difficulty with the procurement function at nuclear facilities is that many critical functions are dependent upon individuals and organizations outside of the facility or its owner's organization. Owners need to establish processes to monitor and assess performance of these external entities (as well as of their 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, and each operating organization needs to develop a system to do so that is adapted to its own particular circumstances.

The audit function as described in Section 3.4.3 is one input into this process. Auditing can provide assurance that vendors and suppliers are following prescribed processes and agreed management system steps as part of the process of supplying components or services.

The NEI has developed a number of process diagnostic indicators [108] for assessing materials and services processes. Some of these include:

(a) Demand counts (e.g. numbers of requests);
(b) Differences in request lead time (e.g. need date minus identification date);
(c) Demand quality (e.g. completeness of requests);
(d) New stock code generation rates;
(e) Demand filled by an item already in inventory versus demand needed to be met by an external purchase;
(f) Critical spares availability;
(g) On-time parts availability;
(h) Procurement engineering workloads;
(i) Supplier performance;
(j) Completion of in-storage maintenance activities;
(k) Percentage of items returned to stores;
(l) Total material expeditures;
(m) Total inventory values;
(n) Stock outs.

Paragraph 5.63 of GS-G-3.5 [9] 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 the effectiveness of identifying and meeting required material demands (see Fig. 30) based on part availability versus need. A similar model is available for contingency parts. Nuclear facilities are encouraged to develop ways to measure the outcomes of each quadrant as a method of trending the effectiveness of identifying and meeting parts needs. Special programmes such as obsolescence management (see Section 5.3) should develop their own metrics.

Several non-nuclear-specific organizations have prepared benchmarking indicators of supply chain and procurement performance. For example, the American Productivity and Quality Center publishes a benchmarking measures list [200] for procurement that includes measures of cost effectiveness (e.g. costs to process an order per amount of revenue or value of purchase), process efficiency (e.g. number of staff required to process an order per value of purchase, and transaction amount per purchase order), cycle time (e.g. average supplier lead time on purchased materials) and staff productivity. Results of benchmarking can be compared across similar companies within a given industry.

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 that in-service component failures or other non-conformances are tied to supplier identifying information when such information is entered into an operating organization'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 upon which organization or company the corrective actions should be focused. One may be aware that a facility is having issues with 'valves', but not knowledgeable as to whether one has a generic issue with multiple suppliers, maintenance practices or with a particular valve supplier.

Such data and trends focused on individual suppliers can be effective tools when reviewing actual performance and plant 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 particularly useful for regular service providers (see Section 4).

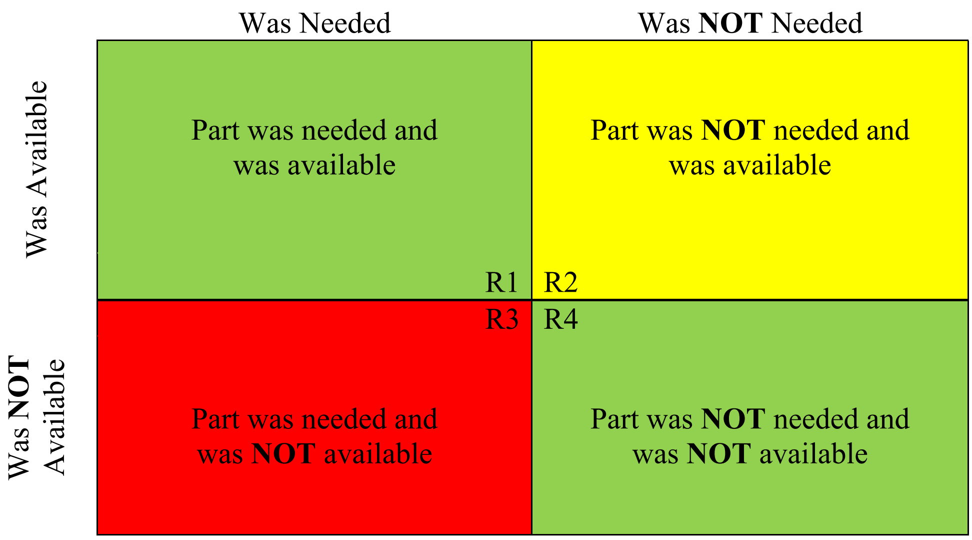


FIG. 30. Model for measuring effectiveness of identifying and meeting required material demands (modified from Ref. [113] with permission courtesy of Electric Power Research Institute).

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 relate to the confidentiality, integrity and availability of required data within plant computer systems.

In the context of nuclear safety, both software that is integral to plant SSCs and software used in the design and analysis of safety related SSCs is of concern. In a nuclear security context, software and items identified in critical digital and cyber asset inventories are of primary concern, because these items may lead to potential consequences if they are maliciously compromised.

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. In addition, procurement of I&C devices without embedded software is becoming increasingly difficult, as many manufacturers stop production of older analogue devices. Devices may have software and firmware used for actual control functions or for less intrusive diagnostic functions.

Hardware components can be tested using conventional methods (e.g. factory testing, inspection and testing, construction check and tests, and commissioning). Software, however, is tested by conformance to defined performance criteria, which requires careful analysis and assessment to provide reasonable assurance that items will perform intended functions.

Paragraph 2.1 of IAEA Safety Standards Series No. NS-G-1.1, Software for Computer Based Systems Important to Safety in Nuclear Power Plants [201], 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."

This indicates the clear need for proper transmission of software requirements to the supplier during the procurement phase.

Another challenge with equipment with software is that verification of physical attributes is very difficult and, in some cases, is not possible. For example, access to source codes may not be available, 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, a strong emphasis on the testing of software under all representative conditions and on the 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 nuclear facility operations. Software qualification processes are defined in various standards and guides such as Refs [202–208]. Software qualification typically involves two discrete steps:

(a) Software categorization and classification based on system and equipment operation (this step corresponds to the IAEA software safety classification described in NS-G-1.1 [201]):
    — To identify software or firmware in equipment;
    — To establish software function: safety related, control, monitoring and annunciation;
    — To assess impact of software failure.
(b) Software qualification commensurate with the risk based categorization (item (a) above). This includes (this step corresponds to the IAEA software safety verification and validation steps described in NS-G-1.1 [201] and Ref. [209]):
    — Configuration scope;
    — Required documentation;
    — Testing protocols and acceptance criteria;
    — Version and revisions.

Owing to their relatively short product lifetimes and relatively regular software revision and patch cycles, a good practice for purchasers of items containing software is to request a full set of items necessary to describe the software being purchased, the source code, and hardware and software as necessary to compile and load the software onto the applicable field hardware. Intellectual property issues may require that some of this information be held in escrow or in an otherwise secure manner to allow the nuclear facility to utilize the software in the event that the supplier goes out of business or ends the product's life. Such items may include:

(i) Computer system design requirements and description.
(ii) Software design description.
(iii) Software load media specification (record) (contains source code and instructions on how to build the design basis software, including instructions for installing on the target hardware).
(iv) Software configuration specification (contains key configuration inputs e.g. software load media, root directory structure, major files and executables, and other critical attributes).
(v) Software maintenance plan (indicates the location where design basis software is kept and whether there are cybersecurity impacts) and describes:
    — The category of software and process required to make changes and perform modifications;
    — The development environment including compilers and programmers;
    — The maintenance environment and equipment;
    — The recovery plan and procedure.
(vi) Test reports.
(vii) Software release notes.

6.3. COMMERCIAL GRADE DEDICATION OF DIGITAL TECHNOLOGY

Upgrades to nuclear I&C equipment are increasingly required at older nuclear facilities. Original designs typically used analogue technology, while preferred replacement equipment often applies digital technology owing 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, conduct vendor assessments and employ other methods to confirm that the commercial item has adequate quality and will perform the 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 a nuclear facility. Items such as failure or startup modes for new digital equipment can be completely different to those of their analogue equivalents. For example, on restoration of power following an interruption, an analogue controller might return to its previous control set point, while a digital controller may reset to a (usually different) predefined factory set point. 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 with specialized training often need to be utilized, and work closely with procurement staff to address such subtle or unexpected differences and to achieve successful replacements.

EPRI has produced a guide for CGD of digital equipment in safety related applications which refers to other EPRI CGD documents and provides additional guidance and examples for digital equipment [210]. A supplementary report provides additional guidance for high integrity applications [211]. EPRI has also published information related to lessons learned with qualification of CG digital devices, which identified electromagnetic testing as an area that required particular focus, often with the need to add additional filters to commercially procured equipment [212]. Other reference material includes various EPRI reports [213–216] and an NRC publication [217].

Design and analysis software that is not resident or embedded (installed as part of) in plant SSCs can also be subject to a CGD process where there is potential to impact a safety function. This can include software for finite element analysis, piping analysis, seismic analysis, thermal and flow analysis, nuclear physics, electrical system analysis and accident analysis, among others. Suppliers of such products often do not maintain a nuclear quality assurance programme, and software program results could contain conceptual, arithmetic or interface errors that can affect nuclear safety. EPRI has also produced a guide to the CGD process for such software [167].

Computer security testing such as vulnerability scanning and penetration testing should be considered when performing CGD to ensure that compromised equipment is not installed. If CGD equipment is found to be more susceptible to compromise, compensatory measures should be considered for implementation.

6.4. COMPUTER SECURITY

Protecting computer systems and the information they contain from unauthorized access, sabotage or malicious use is called computer security or cybersecurity. IAEA Nuclear Security Series No. 17 [89] details some of the special considerations with respect to computer security.

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 the memory. In addition, many plant computer systems are now linked to digital networks that extend across the plant, performing safety, security, accident mitigation monitoring, and emergency preparedness functions. These linkages now often extend outside of the nuclear facility.

In the IT industry, the attack surface of a system is considered to be 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 [218].

Publications of the IAEA Safety Standards Series and the IAEA Nuclear Security Series point to the need for computer security. Table 19 lists some applicable IAEA publication paragraphs.

TABLE 19. IAEA COMPUTER SECURITY RELATED CLAUSES

IAEA publication	Paragraph
IAEA Safety Standards Series No. NS-G-1.1, Software for Computer Based Systems Important to Safety in Nuclear Power Plants [201]	3.15. 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.
Nuclear Security Series No. 13, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5) [219]	4.10. 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.
IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), Safety of Nuclear Power Plants: Design [220]	Requirement 39: Prevention of unauthorized access to, or interference with, items important to safety. Unauthorized access to, or interference with, items important to safety, including computer hardware and software, shall be prevented.

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

Computer security standards have been produced as 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 20. 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 and external threat management).

TABLE 20. SELECTED COMPUTER SAFETY AND SECURITY DOCUMENTS AND STANDARDS

Country/ organization	Standard	Comments
Canada (CSA)	CSA N286.7-99 (R2012), Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants [221]	Specifies requirements for quality assurance programmes applicable to design, development, maintenance, modification and use of analytical, scientific and design computer programs used in nuclear power plant applications. Such computer programs are used to perform or support: (i) Design and analysis of SR equipment and SSCs as identified by the owner; (ii) Deterministic and probabilistic safety analyses and reliability studies; (iii) Reactor physics and fuel management calculations; (iv) Transfer of data between computer programs or pre or postprocessing calculations associated with (i)–(iii).

TABLE 20. SELECTED COMPUTER SAFETY AND SECURITY DOCUMENTS AND STANDARDS (cont.)

Country/ organization	Standard	Comments
Canada (CSA)	CSA N290.7-14, Cyber Security for Nuclear Power Plants and Small Reactor Facilities [222]	Addresses cybersecurity at nuclear power plants and small reactor facilities for the following computer systems and components: (i) Systems important to nuclear safety; (ii) Nuclear security; (iii) Emergency preparedness; (iv) Production reliability; (v) Safeguards; (vi) Auxiliary assets or systems which, if compromised, exploited, or failed, could adversely impact (i)–(v) Pertains to securing essential computer systems and components against cyber-attacks resulting in loss of availability, degradation or loss of ability to perform their intended function, compromise of integrity and loss of confidentiality of their information.
IEC	ISO/IEC 15408-1:2009, Information Technology — Security Techniques — Evaluation Criteria for IT Security [223]	To be used as a basis for evaluation of security properties of information technology products.
IEC	IEC 62645:2014, Nuclear Power Plants — Instrumentation and Control Systems — Requirements for Security Programmes for Computer-based Systems [224]	Addresses requirements for computer security programs and system development processes to prevent or minimize the impact of attacks against I&C computer based systems.
ISA	ANSI/ISA-62443-1-1(99.01.01)-2007, Security for Industrial Automation and Control Systems Part 1: Terminology, Concepts, and Models [225]	Describes basic concepts and models related to computer security. Formerly designated as ANSI/ISA-99.00.01-2007.
ISA	ANSI/ISA-62443-2-1 (99.02.01)-2009, Security for Industrial Automation and Control Systems: Establishing an Industrial Automation and Control Systems Security Program [226]	Describes elements contained in a computer security management system for use in industrial automation and control systems environment and provides guidance on how to meet requirements described for each element. Formerly designated as ANSI/ISA-99.02.01-2009.
ISA	ANSI/ISA-62443-3-3 (99.03.03)-2013, Security for Industrial Automation and Control Systems Part 3-3: System Security Requirements and Security Levels [227]	Defines detailed technical requirements for IACS security. Formerly designated as ISA-99.03.03.
ISA	Numerous standards under ISA/IEC-62443 series in four groups (general, policy and procedures, system integrator, and component provider) [228]	Series of standards, technical reports and related information that define procedures for implementing electronically secure IACSs. Formerly the ISA-99 series of standards.
ISO	ISO/IEC 27001:2013, Information Technology — Security Techniques — Information Security Management Systems — Requirements [229]	Specifies generic requirements for establishing, implementing, maintaining and continually improving an information security management system.
ISO	ISO/IEC 27002:2013, Information Technology — Security Techniques — Code of Practice for Information Security Controls [230]	Guidelines for organizational information security standards and information security management practices including selection, implementation and management of controls taking into consideration an organization's information security risk environments.

TABLE 20. SELECTED COMPUTER SAFETY AND SECURITY DOCUMENTS AND STANDARDS (cont.)

Country/ organization	Standard	Comments
Republic of Korea (KINS)	KINS/GT-N09-DR, Cyber Security of Digital Instrumentation and Control Systems in Nuclear Facilities [231]	One of nine draft regulatory guides based on a ten year R&D project, Development of the Safety Regulation Technology for Digital I&C Systems, which incorporate lessons learned from licensing experiences related to digital upgrades in operating nuclear power plants and newly constructed plants. Presents the regulatory position on cybersecurity of digital I&C systems in nuclear facilities. Covers safety related and non-safety-related digital I&C systems and M&TE.
NERC	Critical infrastructure protection (CIP) standards (NERC 1300) CIP-002-3 through to CIP-009-3 [232] CIP-002-3 – Critical Cyber Asset Identification CIP-003-3 – Security Management Controls CIP-004-3 – Personnel and Training CIP-005-3a – Electronic Security Perimeters CIP-006-3a – Physical Security of Critical Cyber Assets CIP-007-3a – Systems Security Management CIP-008-3 – Incident Reporting and Response Planning CIP-009-3 – Recovery Plans for Critical Cyber Assets	Used to secure bulk electric systems.
USA (IEEE)	IEEE 7-4.3.2-2010, Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations [233]	Subclause 5.9 emphasizes the developer–utility partnership throughout the software life cycle to ensure control of access. Subclause 5.17 provides information on the use and dedication of commercial digital equipment.
USA (NEI)	NEI 08-09, Cyber Security Plan for Nuclear Power Reactors (Rev. 6) [234]	Document to assist licensees in constructing and implementing their cybersecurity plan licence submittal as required by 10 CFR 73.54 [235]. Covers network analysis and establishing and implementing the programme and provides a draft template for a cybersecurity plan. A section is devoted to system and services acquisition and procurement.
USA (NEI)	NEI 10-09 Rev. 0, Addressing Cyber Security Controls for Nuclear Power Reactors, Section 11 [236]	Provides assistance in implementing aspects of NEI 08-09 [234]. Note this document is not formally endorsed as of 2016 by the NRC.
USA (NRC)	10 CFR 73.54, Protection of Digital Computer and Communications Systems and Networks [235]	Requires licensees to submit a cybersecurity 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.
USA (NRC)	RG 5.71, Cyber Security Programs for Nuclear Facilities [237]	Provides an approach that NRC 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 [238]. Includes general requirements, and elements of, and how to, maintain a cybersecurity plan.

Note: CSA — Canada Standards Association; I&C — instrumentation and control; IACS — industrial automation and control system; IEC — International Electrotechnical Commission; IEEE — Institute of Electrical and Electronics Engineers; ISA — International Society of Automation; ISO — International Organization for Standards; KINS — Korea Institute of Nuclear Safety; M&TE — measurement and test equipment; NEI — Nuclear Energy Institute; NERC — North American Electric Reliability Corporation; NRC — United States Nuclear Regulatory Commission; SR — safety related; SSC — structures, systems and components.

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 to be effective in ensuring correct and complete information is provided to vendors. Table 21 identifies typical topic areas for standard clauses that could be developed at nuclear power plants to address computer security related procurement. Some specific language is available in Refs [239, 240].

TABLE 21. TYPICAL TOPICS FOR COMPUTER SECURITY RELATED STANDARD PROCUREMENT CLAUSES

Standard clause topic	Explanation
Access ports	Ensure 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).
Malicious software prevention	Antivirus or malware detection software should not impact real time process control software used in a nuclear power plant (owing to the need for deterministic behaviour of the software). Vendors should apply verification and validation activities to any incorporated antivirus or malware features to the same level as the software and systems being protected.
Security management	Vendors should conduct 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.
Systems as access points	Ensure systems requiring access to the external environment (i.e. beyond a nuclear facility’s electronic security perimeter) have technical controls in place to control access. Examples might include unidirectional communications, having access denied by default, user identification and password control via authenticated workstations, continual logging of access, intrusion detection systems, banner messages containing warnings regarding such things as software usage (may be used by authorized users and for 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).
Physical access requirements	Describe graded requirements for physical protection of systems when not to be installed in an already secure area (e.g. to be installed outside a nuclear power plant’s protected area).
Account management	Ensure controls for enforcement of access authentication and accountability of user activity, minimizing risk of unauthorized system access, ensure access permissions are consistent with the ‘need to know’ concept, generate logs to provide audit trails of individual user access activity, do not include generic administrator or shared accounts, ensure regular password changes.

EPRI has been developing a methodology for procuring digital I&C systems, which are classified as critical assets, with necessary computer security controls [241]. Steps are shown in Table 22, and it should be noted that a substantial number of these steps need to be taken prior to finalizing the purchase of such an asset. Specific examples of use of the methodology have been published for single loop controllers [242], feed pump turbine speed control [243] and digital feedwater control [244]. An EPRI report has also been published for the power delivery and utilization (non-generation) sector [245].

TABLE 22. ELECTRIC POWER RESEARCH INSTITUTE COMPUTER SECURITY METHODOLOGY STEPS

Methodology step	Sub-step
Procurement and cybersecurity programme	Know organization and facility cybersecurity strategy Incorporate cybersecurity into existing processes Identify roles and responsibilities
Specification development	Determine type of purchase Determine use case, data flow and access points Determine security controls required for use case Establish owner/operator and supplier responsibilities Develop system and component specification based on security controls determined to be supplier's responsibility
Development of general cybersecurity specifications	Confirm use case and data flow Map to required security controls Identify potential conflicts Identify negotiable or optional security controls or configurations Identify possible design modifications Identify unused alternative features, functions and configurations Identify product or development environment certifications Describe supplier's secure development environment Consider additional supply chain considerations Supply field engineering services
Evaluation and incorporation with procurement procedures	Evaluate responses and determine gaps Identify potential conflicts Identify compensating controls Analyse risks and cost/benefit Apply cybersecurity when selecting supplier Perform oversight of cybersecurity requirements Receive component or system Maintain configuration control

Source: See Ref. [241].

Within this EPRI methodology, the procurement engineering specialist in 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 computer security strategy;
- — Ability to work with computer security experts, I&C engineers and other subject matter experts to evaluate and analyse supplier responses and procurement options.

7. COUNTERFEIT AND FRAUDULENT ITEMS

7.1. BACKGROUND

Counterfeit and fraudulent items are a growing concern worldwide and are of increasing concern for nuclear facilities. They can pose immediate and potential threats to the safety of workers, to facility performance, to the public and to the environment, and can negatively impact on facility performance and costs. Therefore, each organization's senior management should be knowledgeable and actively participate in and support CFSI processes.

These concerns extend beyond the equipment or component levels to the raw materials used in facility construction, and to the chemicals and other substances used in a facility. Even when equipment is bought from an original equipment manufacturer, there is a possibility that the materials or certain components used by the manufacturer may be counterfeit or fraudulent. Supply chain and procurement processes have a role in detecting and preventing the entry of such counterfeit and fraudulent items, or indeed any non-conforming substandard item, into nuclear facilities.

There are many contributors to the growing number of counterfeit and fraudulent items entering the marketplace. Nuclear facilities and their suppliers should be aware of the issues, and should implement measures to detect and prevent the introduction and use of counterfeit and fraudulent items, including raw materials and components (see Ref. [246] for further details on this subject).

7.2. TERMINOLOGY

Items can be classified according to the categories shown in Fig. 31 and Table 23. Genuine items can include those produced by legitimate manufacturers but which do not meet requirements (i.e. can be substandard or non-conforming). Non-conformances can emerge at any stage of the supply chain, including during design, manufacturing, storage and transport.

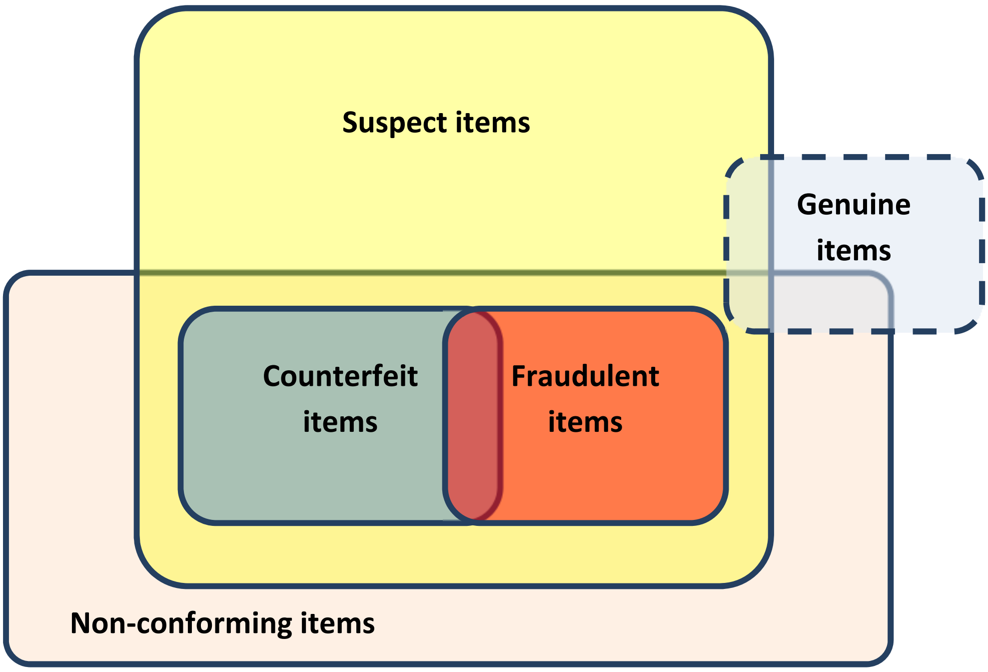


FIG. 31. CFSI classification.

TABLE 23. TERMINOLOGY ASSOCIATED WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS

Item term	Definition
Genuine	Items that are produced and certified without intent to deceive.
Non-conforming (substandard)	Items that do not meet intended requirements or function, and may be provided by legitimate suppliers without intent to deceive.
Suspect	Items where there is an indication or suspicion that they may not be genuine.
Fraudulent	Items that are intentionally misrepresented with intent to deceive, including items provided with incorrect identification, falsified or inaccurate certification. 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.
Counterfeit	Items that are intentionally manufactured, refurbished or altered to imitate original products without authorization in order to pass themselves off as genuine.

It should be noted that in some countries, there is an increasing tendency to deal with counterfeit and fraudulent items separately from non-conforming or substandard items. For example, EPRI when revising a technical report removed ‘substandard items’ from the title, leaving just counterfeit and fraudulent items [247]. The thinking is that the knowing or unknowing deception associated with counterfeit and fraudulent items is especially problematic and an increasing concern for operating organizations, while substandard items are different in nature and can be dealt with by normal operating organization non-conformance processes. This publication uses the term counterfeit, fraudulent and suspect items (CFSIs).

7.3. EXPERIENCE WITHIN NUCLEAR AND GENERAL INDUSTRIES

CFSIs of concern to nuclear facilities are those that look nearly identical to original items, but which contain substandard, 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 functional capability when needed. Infiltration of CFSIs into industry can also lead to a loss of legitimate firms from the marketplace. Generally, counterfeiters target 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 (e.g. plates, pipes, fasteners and valves) are the most counterfeited items, followed by electrical devices such as circuit breakers and then rotating equipment [248]. Photographs of documented counterfeited articles are shown in Figs 32–36.

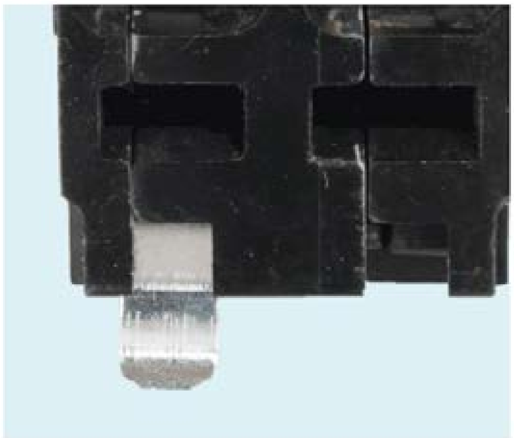
The United States Department of Commerce reports that there was a 140% increase in counterfeit incidents among suppliers of industrial parts to the United States Department of Defense from 2006 to 2009 [252]. The value of counterfeit goods seized by the Royal Canadian Mounted Police in Canada increased by 500% in less than ten years, according to 2012 intellectual property crime statistics [253]. Governments in many jurisdictions have been active in the area, with one example being an anticounterfeiting trade agreement negotiated between Australia, Canada, the European Union, Japan, the Republic of Korea, Mexico, Morocco, New Zealand, Singapore, Switzerland and the United States of America [254]. EPRI has documented cases of recent counterfeiting in the nuclear and other industries, some of which have resulted in deaths [247]. Although large increases in confirmed counterfeit instances have not been seen in the commercial nuclear power industry, general industry and nuclear power industries 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 (on early detection and what to look for) for supply chain and other personnel on the subject of counterfeit items.

Counterfeiting Characteristics - QO Circuit Breakers

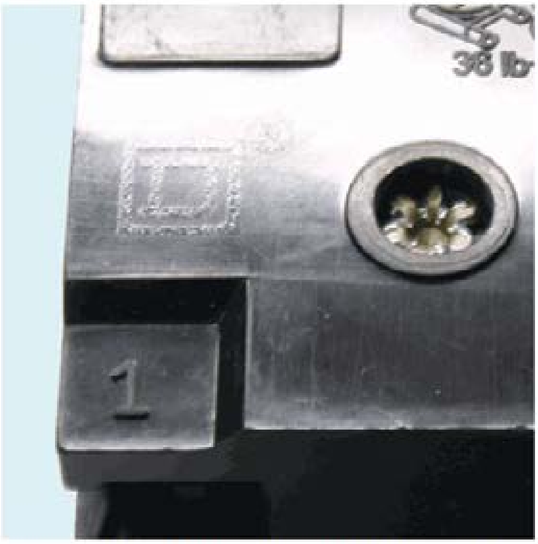
Characteristics are for QO & QOB 1-pole, 2-pole & 3-pole breakers under 80 amps and QO tandem breakers.

Note: Lack of the following characteristics does not guarantee authenticity of the breaker. To avoid counterfeits, only buy Square D products from an authorized Square D distributor or retailer.
Click here to find an **Authorized US Retailer**.Click here to find an **Authorized US Distributor**

Some counterfeit labels do not indicate country of origin.



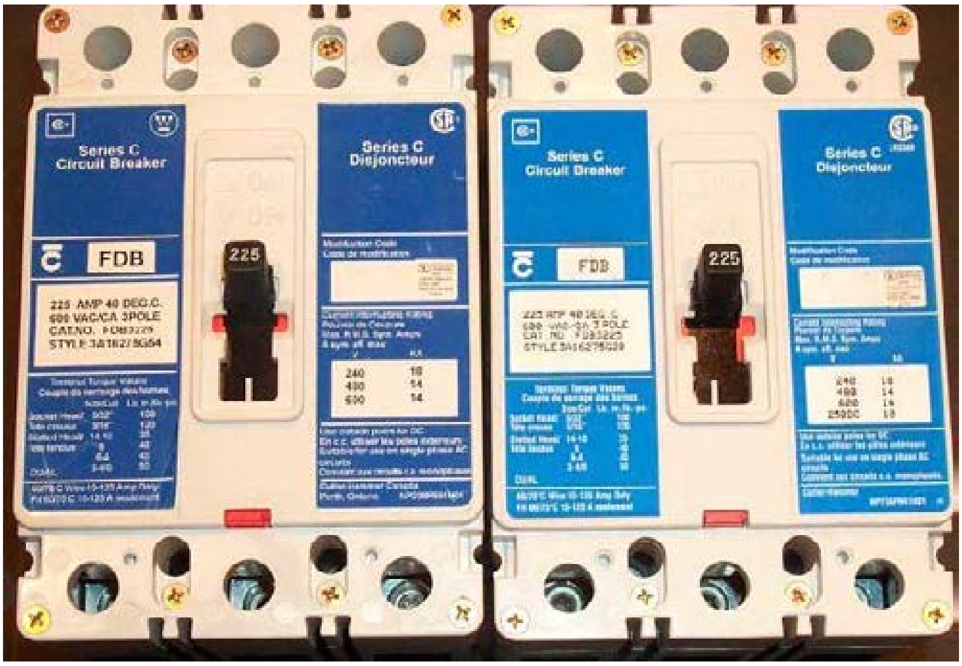
Many counterfeit breakers have a bright silver rail clip.



Some counterfeit breakers have printed logos or logos that appear to be etched. Some counterfeit breakers may be missing the logo.

Ampere ratings molded into the handles of new (post 1999) breakers indicate the product is counterfeit

FIG. 32. Square D QO counterfeit breaker characteristics (courtesy of Schneider Electric).



Counterfeit Legitimate

FIG. 33. Counterfeit (left) and legitimate breaker (right) supplied to a hospital in Montreal (reproduced from Ref. [249] with permission courtesy of CSA Group Inc.).

Note: Clamp marks and different rivet sizes are evident in the figure.

FIG. 34. Flanges received as 'new' at the Savannah River Site (reproduced from Ref. [250] with permission).

FIG. 35. Suspected counterfeit capacitors intercepted due to awareness training (reproduced from Ref. [251] courtesy of Electric Power Research Institute).

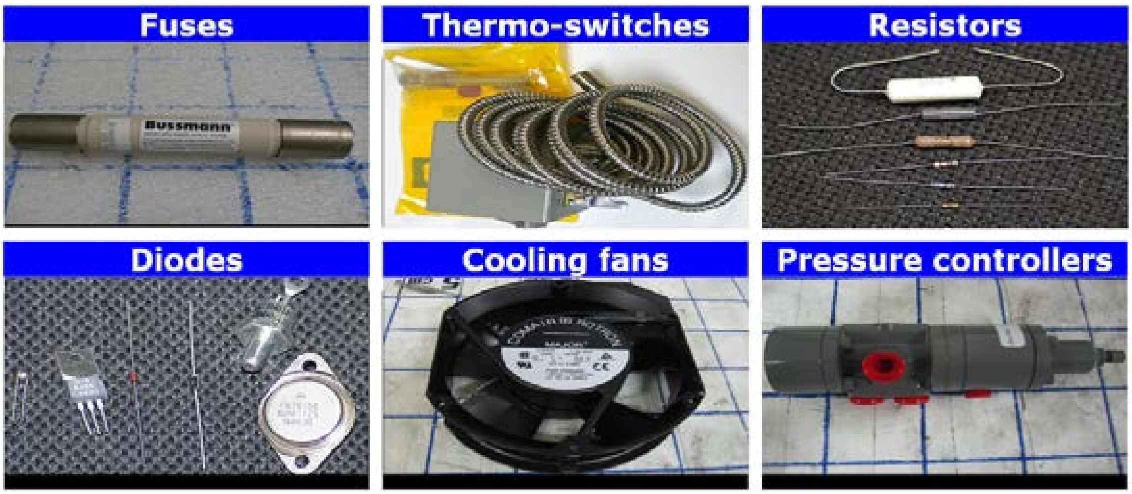


FIG. 36. Example commercial grade items supplied with falsified quality certificates (courtesy of the Korea Institute of Nuclear Safety).

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 80–90% 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 is not disposed of properly and some parts that are simply phoney and do not work at all [255]. Nuclear and defence industries 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. Recyclers 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 [255].

Electronic 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 to 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 counterfeit items are shown in Fig. 37.

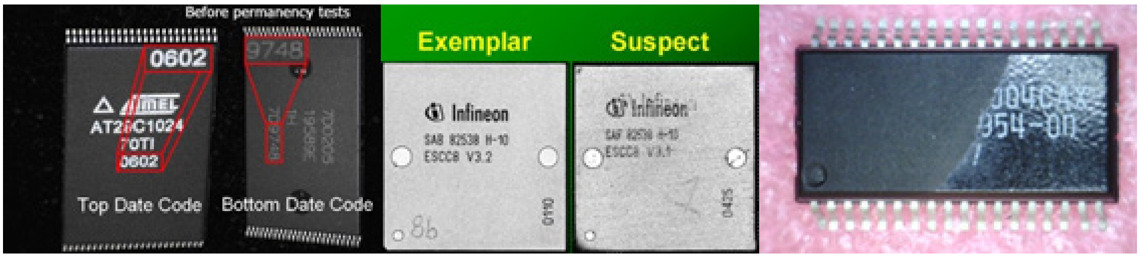


FIG. 37. Electronic counterfeit examples (left: date code changes; centre: tampering detected via acoustic microscope; right: blacktopping detected by heated solvent test) (reproduced courtesy of SMT Corp.).

In 2011, the OECD Nuclear Energy Agency issued a report on nuclear power plant OPEX with regard to CFSIs [252]. Table 24 documents a number of these and other issues that have become public in the nuclear industry (those related specifically to the CGD process in Table 18 are not repeated). Table 25 lists additional CFSI incidents reported and lessons learned from Ref. [246]. It should be noted that reporting mechanisms for such issues have not been evenly nor well developed in general throughout the industry, and not all national regulators have specific requirements in place to address CFSI reporting, especially for those that were detected prior to installation.

Text cont. on p. 154

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY

Country/ organization	Publication	Issue	Lessons learned
Canada	REGDOC-3.1.1, Reporting Requirements for Nuclear Power Plants [18]	Licensee shall report on the discovery of CFSIs during the course of licensed activities.	All discoveries to be reported to regulator (not just those installed in-plant).
	Presentation at an IAEA Technical Meeting [256]	Five counterfeit Burr Brown operational amplifiers installed in two reactors in shutdown and regulating systems in 2008. Discovered by licensee and resolved when one amplifier failed calibration. Regulatory reporting was delayed (regulator discovered through a whistle-blower).	Expectations regarding reporting CFSIs should be clear for licensees.
		Receipt inspection identified a Baumer gauge as suspect when part number on gauge did not match purchase order, packing slip and gauge markings not consistent with Baumer gauges, and faceplate had poor printing. Conclusion was that the gauge had been modified from imperial to metric units by unknown persons.	OEMs should be involved with part modifications. Importance of careful inspection of received items.
Finland	YVL A.3, Management System for a Nuclear Facility [26]	Item 640 requires the licensee to have in place procedures to reliably prevent purchasing of counterfeit and fraudulent products.	New regulation added in 2014.
IAEA	IAEA-TECDOC-1169, Managing Suspect and Counterfeit Items in the Nuclear Industry [246]	Provides examples of known CFSIs for specific types of component 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.	See Table 24.
OECD/NEA	NEA/CNRA/R(2011)4, Nuclear Regulator's Role in Assessing the Licensee's Oversight of Vendor and Other Contracted Services [257]	Booklet aimed at all types of contracted service; however, prevention of CFSIs and other substandard items is part of this overarching topic.	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.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
OECD/NEA	NEA/CNRA/R(2011)9, Operating Experience Report: Counterfeit, Suspect and Fraudulent Items [252]	Provides country by country OPEX on CFSIs and processes in place in OECD members. Some specific cases are described in country sections of this table.	Specific recommendations from the report include the implementation of a CFSI prevention programme, standard language and specific event reporting criteria for CFSIs, dedicating staff to address control and detection of CFSIs, increased training, sharing of OPEX, including standard procurement language related to CFSIs, implementing CFSI disposal policies, using anti-counterfeiting technologies, and developing best practices.
OECD/NEA	NEA/CNRA/R(2012)7, Regulatory Oversight of Non-conforming, Counterfeit, Fraudulent and Suspect Items (NCFSI) [258]	Provides insights that should be useful to regulators and others in the nuclear safety community for addressing the issue of CFSIs within the nuclear industry's supply chain.	Each supply chain 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 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 are 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, the 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 non-conforming CFSIs on their current regulations and revise them if necessary, and also to consider methods for inspecting non-conforming CFSI controls.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
Republic of Korea (KHNP)	Managing the Supply Chain: Challenges and Overcoming in Korean Nuclear Industry [259]	In November 2012, KHNP confirmed some suppliers had supplied items by falsifying foreign dedication entities' quality certificates for CGIs, such as fuses, relays and diodes. Comprehensive inspections expanded to all Q-class QVD items supplied to KHNP over the past ten years for nuclear power plants in the Republic of Korea while investigating certificates for CGD. Permission given for restart in January 2013. In May 2013, falsification of EQ certificates of control cables supplied to Shin-Kori units 1, 2, 3 and 4 and Shin-Wolsong units 1 and 2 was uncovered. The SR function in severe environments such as LOCA and fire, was called into question. KHNP immediately shut down affected nuclear power plants to replace related parts. Regulator investigation was expanded to all nuclear power plant EQ certificates (SR items purchased within last six years in 23 operating units and 8 units under construction were investigated). Components with falsified certificates were replaced or retested. Untraceable certificates were treated the same as falsified ones. NSSC permitted restart of the plants in January 2014. Six nuclear engineers and equipment suppliers were given prison sentences.	Do not be overconfident and complacent if experiencing excellent nuclear power plant performance for a long time period. Be transparent and open in quality and procurement activities (it is easy for the nuclear industry to be closed owing to its nature). Encourage anonymous reporting (counterfeits and scandals were revealed by anonymous tip-offs).
United Kingdom	NS-TAST-GD-077, Revision 3, Supply Chain Management Arrangements for the Procurement of Nuclear Safety Related Items or Services [66]	Requires purchasers to have processes in place and support of suppliers to investigate examples of non-conforming suspected fraudulent items.	Example of national regulations related to CFSIs.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
USA (CII)	RS 264-1, Product Integrity Concerns in Low-cost Sourcing Countries: Counterfeiting in the Construction Industry [248]	The consensus of 187 industry and government leaders from eight countries interviewed was that the magnitude of counterfeiting problems has grown from “big” to “very big”.	CII identified the following lessons: — Maintain integrity of supply chain; — Adopt a zero tolerance policy; — Train and educate procurement, quality management, and field personnel on counterfeit goods dangers; — Train and educate customs officials and other law enforcement agency personnel; — Establish more stringent supply chain activities; — Use effective positive materials identification processes; — Put more emphasis on documenting the quality and integrity of the sourcing of raw materials and commodity items.
USA (EPRI)	3002002276, Plant Support Engineering: Counterfeit and Fraudulent Items [247]	In 2008, counterfeit integrated circuits and electrolytic capacitors were discovered at Millstone nuclear power plant. The integrated circuits were discovered when a portal monitor could not be calibrated, and the capacitors were discovered through dimensional checks and subsequent investigation. In 2009, a nuclear power plant instrument manufacturer was questioned on the validity of several phototransistor optocouplers used in timers for several nuclear power plant customers. The date code on the device was after OEM had stopped production of the item. In 2013, capacitors purchased through an OEM supplier recommended broker identified with no date code were found to be counterfeit.	Electronic counterfeiting is becoming an issue.
USA (NUMARC)	NUMARC 90-13, Nuclear Procurement Program Improvements [260]	Recommended to put more emphasis on technical verification product quality than relying on supplier documentation	Recommendations: — Increase engineering involvement; — Increase awareness of CFSIs; — Share information via industry OPEX forums; — Procure items from OEMs or authorized distributors whenever possible; — Ensure product performance via traceability to the OEM or through testing and inspection, when procurement from the OEM or authorized distributor is not possible; — Establish acceptance criteria for items at start of procurement process.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
USA (NRC)	NEA/CNRA/R(2011)9, Operating Experience Report: Counterfeits, Suspect and Fraudulent Items [252]	In October 2008, ABB capacitors were identified during CGD activities. The capacitors were procured from a commercial distributor. No actual failures or damage occurred.	Importance of attention to CFSI issues during CGD activities.
	Information Notice No. 83-01, Ray Miller, Inc. [261] and Bulletin No. 83-07, Apparently Fraudulent Products sold by Ray Miller [262] (including supplements)	Unauthorized substitutions or modifications were made to a variety of materials (e.g. welded pipes substituted for seamless pipes, standard grades of stainless steel substituted for low carbon or in some cases the reverse, foreign made products substituted for domestic made products).	Existence of companies and individuals willing to use counterfeit items.
	Bulletin No. 87-02, Fastener Testing to Determine Conformance with Applicable Material Specifications [263] (with supplements)	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 their actual bolt content. Bulletin requested nuclear power plants to review their receipt inspection requirements and internal controls for fasteners and independently determine, through testing, whether fasteners (studs, bolts, cap screws and nuts) in stores facilities meet required mechanical and chemical specification requirements.	Counterfeiting of fasteners had reached sufficient state that country wide review of situation was warranted.
	Bulletin No. 88-05, Nonconforming Materials Supplied by Piping Supplies, Inc. at Folsom, New Jersey Manufacturing Company at Williamstown, New Jersey [264] (with supplements)	Non-conforming material supplied by Piping Supplies Inc. at Foslum, New Jersey and West New Jersey manufacturing company and Williamstown. A number of test reports were apparently used to certify CG, foreign steel meets ASME requirements by using a domestic forging company's letterhead. Bulletin required nuclear power plants to submit information regarding materials supplied by two 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 replace such material.	Documents incidences of forgeries of test reports.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Bulletin No. 88-10, Nonconforming Molded-case Circuit Breakers [265] (with supplement 1)	Non-conforming moulded case CBs. Related to Information Notice No. 88-46 [266]. Bulletin requested nuclear power plants to take actions to provide reasonable assurance that moulded case CBs, including CBs used with motor controllers, purchased for SR applications without verifiable traceability to the CB manufacturer perform their safety functions. Untraceable CBs were required to be tested or replaced (see specific details in bulletin).	Issues with refurbished moulded case CBs had reached sufficient states 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 other refurbished CBs.
	NEA/CNRA/R(2011)9, Operating Experience Report: Counterfeits, Suspect and Fraudulent Items [252]	In October 2009, CGD activities associated with a batch of Cooper Busmann fuses were identified. The affected fuses contained an underlying defect consisting of a missing internal fuse link.	Importance of CGD activities.
	(See also Ref. [241])	In October 2006, DeKalb Y-Globe Valve, ¾ NPS Class 1500 were discovered in nuclear power plant warehouse. The valve, reportedly made of stainless steel, exhibited extensive rust blooms and magnetic properties. It was in fact constructed of carbon steel. No additional counterfeits were detected.	Importance of personnel training in detection of counterfeit items.
	Generic Letter 89-02, Actions to Improve the Detection of Counterfeit and Fraudulently Marked Products [130]	Actions to improve detection of counterfeit and fraudulently marked products. Focused on effectiveness of CGD programmes. Shared NRC perspectives on ways to address concerns with dedication and counterfeit products.	Identified three 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.
	Generic Letter 89-09, ASME Section III Component Replacements [267]	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 nuclear power plants.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Generic Letter 91-05, Licensee Commercial-grade Procurement and Dedication Programs [268]	Licensee CG procurement and dedication programmes. Identifies a number of failures in CGD programmes found during 13 inspections. In a number of cases, nuclear power plants 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. The Generic Letter was intended to further clarify information provided in Generic Letter 89-02 [130].	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 the importance of CGD programmes.
	Information Notice No. 83-07, Nonconformities with Materials Supplied by Tube Line Corporation [269] and Bulletin No. 83-06, Nonconforming Materials Supplied by Tube Line Corporation Facilities at Long Island City, New York; Houston, Texas; and Carol Stream, Illinois [270]	Non-conformities with materials supplied by Tube Line Corporation items found and identified to have been shipped from an unapproved nuclear source, not having had proper heat treatment and not meeting ASME code requirements for NDE. Subsupplier had purchased material foreign stock from material suppliers without an appropriate QA programme and not performed the required heat treatment.	Subsupplier performance is important to nuclear quality.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 84-52, Inadequate Material Procurement Controls on the Part of Licensees and Vendors [271] (with 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 or incomplete survey and audit records; — Breakdown of procurement controls with respect to requirements of 10 CFR 21 [71], appendix B to 10 CFR 50 [70] and the ASME code. Licensee deficiencies included: — Inadequate specification of code requirements on purchase orders 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 programmes; — Failure to perform adequate internal audits of the procurement process; — Inadequate training of personnel who procure nuclear materials under requirements of 10 CFR 21 [71], appendix B to 10 CFR 50 [70] and the ASME code; — Insufficient management attention to procurement activities.	Attention on behalf of suppliers and purchasers is important.
	Information Notice No. 88-19, Questionable Certification of Class 1E Components [272]	Questionable certification of class 1E components supplied to Wolf Creek nuclear power plant. Supplier records did not support statement on certificate of compliance that all purchase order requirements had been met.	Importance of review of supplier documentation provided with purchase order.
	Information Notice No. 88-46, Licensee Report of Defective Refurbished Circuit Breakers [266]	Licensee report of defective refurbished CBs. Surplus or refurbished electrical equipment, such as CBs or CB parts, was supplied to nuclear power plants but was portrayed as new. Examples provided of some physical identifying differences noted (e.g. photocopied labels, rough and worn appearance).	Importance of receipt inspection programmes to catch potential CFSIs.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 88-48, Licensee Report of Defective Refurbished Valves [273] (including supplement 1)	Report of defective refurbished 2 inch valves (leaking steam at bonnet and packing) at Diablo Canyon nuclear power plant. Valves were purchased from a local supplier. OEM reviewed and indicated valves were likely counterfeit and not refurbished.	Need knowledge of suppliers and source of supply.
	Information Notice No. 88-97, Potentially Substandard Valve Replacement Parts [274] (including supplement 1)	Potentially substandard valve replacement parts. Valve internals at Palisades nuclear power plant 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 nuclear power plant 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. The nuclear power plant and supplier both failed to adequately verify that the parts would perform their function.	Substandard items can enter nuclear power plant stores. Suppliers need good control over subsupplier activities.
	Information Notice No. 89-03, Potential Electrical Equipment Problems [275]	Possible electrical equipment problems. Inspection findings showed counterfeit, substandard or questionable electrical equipment or components had been used in nuclear power plants. Several electrical suppliers identified as refurbishing and selling defective equipment components to nuclear and non-nuclear industries.	CFSI issue is not confined to the nuclear industry. Licensees were asked to review procurement procedures and practices, especially in areas such as purchase orders, material requirements, vendor qualifications and receipt inspections, to ensure quality control and compliance.
	Information Notice No. 89-39, List of Parties Excluded from Federal Procurement or Non-procurement Programs [276]	List of parties excluded from US federal procurement or non-procurement programmes. 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, fraudulent or counterfeit parts being used in the nuclear industry.	Importance of having an up to date database of acceptable and unacceptable suppliers.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 89-45, Metalclad Low-voltage Power Circuit Breakers Refurbished with Sub-standard Parts [277]	Metalclad, low voltage power CBs refurbished with substandard parts. Discovery of defects in metalclad, low voltage power CBs at Quad Cities nuclear power plant including missing, non-standard and substandard parts, and improper assembly and misadjustment. Deficiencies were discovered when breakers were shipped to the OEM facility for overhaul, and some devices had failed in-service or during testing. Items were purchased as CG, had been taken from a non-OEM supplier from supposedly 'new' stock and had been maintained in the meantime by Quad Cities staff. It was not determined who was responsible for CB condition at Quad Cities or why the conditions remained undetected during maintenance activities. Other nuclear power plants found to have defective equipment from this supplier.	Importance of proper control around CG material and knowledge of suppliers.
	Information Notice No. 89-56, Questionable Certification of Material Supplies to the Defense Department by Nuclear Suppliers [278] (with supplements)	Questionable certification of material supplied to Department of Defense by nuclear suppliers. Corporate officers for PVN and ALLOY were indicted and later pleaded guilty for their roles in selling CG steel as military grade steel which was used to build and repair United States Navy submarines and surface ships. Suppliers had provided steel to some nuclear power plants, and audits revealed issues with these suppliers.	Existence of companies and individuals willing to counterfeit documents.
	Information Notice No. 89-59, Suppliers of Potentially Misrepresented Fasteners [279]	Suppliers of potentially misrepresented fasteners. Provided addressees and names of suppliers and/or manufacturers of suspected counterfeit fasteners that were identified in NRC Bulletin No. 87-02 [263].	See Bulletin No. 87-02 [263] above.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 89-70, Possible Indications of Misrepresented Vendor Products [280]	Increased number of instances of misrepresented vendor products being supplied to the nuclear industry. General indications may be found early in procurement processes, beginning with price quotes and scheduled delivery time. Some things found present when misrepresented products were identified include: — Vendor name: Several instances of counterfeit and fraud involved vendors who were not authorized distributors for products supplied. — Price: Quoting prices significantly lower than those of competition. — Delivery schedule: Shorter delivery time than that of competition. — 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, had been substandard. At receipt, inspection labels in wrong location or appearing different, or if tags are attached with screws rather than rivets is a potential indicator of a CFSI. Measurement and testing during receipt inspection is also important.	Provides example of areas of interest in reviewing quotations and performing receipt inspection for possible CFSIs.
	Information Notice No. 90-46, Criminal Prosecution of Wrongdoing Committed by Suppliers of Molded-case Circuit Breakers and Related Components [281]	Criminal prosecution and conviction of wrongdoing by suppliers of moulded case CBs 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 CBs and switches, some of which were sold to nuclear power plants.	Existence of companies and individuals willing to counterfeit product.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 90-57, Substandard, Refurbished Potter & Brumfield Relays Represented as new [282]	Substandard refurbished Potter and Brumfield relays represented as new. Company had modified and/or refurbished 22 rotary, non-latching MDR type Potter & Brumfield relays and supplied them to Harris nuclear power plant and the United States Department of Defense for use on submarines. The company president had directed employees to make relays appear new and affix counterfeit labels. The president was fined US $7500 and ordered to make restitution to the US Government of US $350 000. The company had to pay US $30 000 (US $10 000 for each count) and restitution of US $2 501 000, less amount paid by the president.	Existence of companies and individuals willing to counterfeit product.
	Information Notice No. 90-60, Availability of Failure Data in the Government-Industry Data Exchange Program [283]	Availability of failure data in the GIDEP. The NRC provided information relative to availability of data on engineering, metrology, material problems (failure experience), and reliability and maintainability through the GIDEP.	Databases prepared on a national, industry or international basis related to CFSIs are useful.
	Information Notice No. 1991-09, Counterfeiting of Crane Valves [284]	Counterfeiting of Crane valves. Valves purchased for a chemical plant near Houston, Texas, were found to be counterfeited (manufactured in Taiwan, China 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.	Items can go through two or more distributors before reaching an end user facility. Nuclear power plants could buy a CGI 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 for 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.
	Information Notice No. 92-22, Criminal Prosecution and Conviction of Wrongdoing by a Commercial Grade Valve Supplier [285]	Criminal prosecution and conviction of wrongdoing by a CGI valve supplier. President of company who supplied counterfeit valves under Information Notice No. 88-48 [273] (see above) pleaded guilty on charges that the company sold counterfeit valves ultimately installed at Diablo Canyon and Vogtle nuclear power plants and a United States Marine Corps military base in Quantico, Virginia. The individual was sentenced to three years imprisonment and the company was ordered to pay restitution of US $213 825.03 to NRC licensees.	Need knowledge of suppliers and source of supply. Existence of companies and individuals willing to counterfeit products.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 92-56, Counterfeit Vales in Commercial Grade Supply System [286]	Counterfeit valves in commercial grade supply system. Supplier purchased approximately 7500 nameplate labels from a label manufacturer, which were imprinted with several valve manufacturer names (including Crane, Pacific, Walworth, Powell and Lunkenheimer). Company confirmed to have supplied two counterfeit CGI valves to Indian Point 2.	Existence of companies and individuals willing to counterfeit products.
	Information Notice No. 92-68, Potentially Substandard Slip-on, Welding Neck, and Blind Flanges [287]	Potentially substandard slip-on, welding neck and blind flanges. Numerous reports of flanges supplied to US 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 tonnes of flanges to the United States of America. Instances of flanges at two US nuclear power plants 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 receipt inspection stage).	It is possible for a nuclear power plant to install potentially substandard or defective equipment or material if it does not adequately verify that products can be traced to original manufacturers.
	Information Notice No. 93-43, Use of Inappropriate Lubrication Oils in Safety-related Applications [288]	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 and incorrect type of oil was used in SR equipment (18 of 33 samples taken). The nuclear power plant had not sampled the oil when it was delivered to verify that it had received the oil ordered.	Importance of receipt inspection activities to confirm critical characteristics, including chemical composition.
	Information Notice No. 93-73, Criminal Prosecution of Nuclear Suppliers for Wrongdoing [289]	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 was found to have been sold in unsatisfactory condition, or to contain substandard parts, manufacturing processes or workmanship.	Existence of companies and individuals willing to counterfeit products.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 95-12, Potentially Non-conforming Fasteners Supplied by A&G Engineering II, Inc. [290]	Potentially non-conforming fasteners supplied by A&G Engineering II, Inc. The 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&G was not adequate to support the material certifications issued.	Importance of supply chain audits to validate record management practices of suppliers.
	Information Notice No. 2007-19, Fire Protection Equipment Recalls and Counterfeit Notices [291]	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.	Importance of receipt inspection activities.
	Information Notice No. 2008-04, Counterfeit Parts Supplied to Nuclear Power Plants [292] (see also Ref. [252])	Counterfeit parts were supplied to nuclear power plants. Documents cases of supplying counterfeits parts to nuclear power plants (e.g. Ladish stop check valves at hatch installed in a non-SR system during maintenance activities on a similar valve in the vicinity of installed counterfeit) (see also Ref. [247]); possibly counterfeit Square D CBs removed from warehouse at Catawba (see also Ref. [247]).	Identified three 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;
	Information Notice No. 2012-22, Counterfeit, Fraudulent, Suspect Item (CFSI) Training Offerings [293]	CFSI training offerings. Provides a list of available training.	Emphasized regulator interest in training for detection of counterfeit items.
	Information Notice No. 2013-02, Issues Potentially Affecting Nuclear Facility Fire Safety [294] (see also Ref. [247])	Issues potentially affecting nuclear facility fire safety. Counterfeit single jacketed fire hoses, fire extinguishers, fire pipe hangers and sprinklers discovered in non-nuclear applications in US industries. Information Notice issued to warn US nuclear industry reissues. Eight items in total were discussed and none was reported discovered within US nuclear facilities, although two potential matches were investigated.	Emphasizes existence of counterfeit items in industry, the potential for nuclear safety impacts and the importance of information sharing.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	Information Notice No. 2013-15, Wilful Misconduct/Record Falsification and Nuclear Safety Culture [295]	Documents several incidences of records falsification at and related to US nuclear power plants, including a case of an owner/president of a supplier directing an employee to switch a broken display on a Peach Bottom nuclear power plant steam leak detector monitor with a working display unit from Brunswick nuclear power plant. 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.
	Summary of Event and Plant Conditions (as of May 16, 2013) [296]	San Onofre units 2 and 3 shut down due to steam generator leaks. Southern California Edison replaced unit 2 SGs in January 2010 and unit 3 SGs in January 2011. Each replacement steam generator experienced severe leakage during its first cycle of operation. Plant was eventually decided to be permanently shut down owing to cost of replacement.	Identifies risk of substandard major components being installed, even when provided by experienced vendors.
	Part 21 (non-conformance) Report 1997-06-0: Limitorque counterfeit component [297]	Counterfeit component installed in a non-SR Limitorque actuator purchased from a ‘surplus’ market.	Surplus parts market has higher chance of CFSIs.
	Part 21 (non-conformance) Reports 1995-212 and 1996-06-04 Aerofin Cardinal Industrial products capscrews [298, 299]	Inadequate heat treatment resulting in bolt mechanical properties below required minimums (used in SR cooler at Palisades nuclear power plant). Initial bolt problem had been identified by a different customer and the supplier reported the issue to other customers and the NRC. Investigation and testing traced the problem to a heat treating furnace at the manufacturing facility.	Records and regulatory processes for reporting supplier defects are important.
	SECY 89-010, Advance Notice of Proposed Rulemaking — Acceptance of Products Purchased for Use in Nuclear Power Plant Structures, Systems, and Components [300]	Advance notice of proposed rulemaking document requested public comment on whether or how NRC regulations should be revised to provide increased assurance that counterfeit or misrepresented vendor products are not installed in nuclear power plants. It was withdrawn in 1994 (SECY 94-277 [301]), as it was thought issue was adequately covered by 10 CFR 50, appendix B [70].	Indication of importance of CFSI issue to regulatory bodies.

TABLE 24. SAMPLE EXPERIENCES OR REGULATIONS WITH COUNTERFEIT, FRAUDULENT AND SUSPECT ITEMS IN THE NUCLEAR INDUSTRY (cont.)

Country/ organization	Publication	Issue	Lessons learned
	NEA/CNRA/R(2011)9, Operating Experience Report: Counterfeits, Suspect and Fraudulent Items [252]	In June 2010, Walworth Manual Globe Valves, 1-1/2 inch were identified by station receipt inspector after comparisons made to similar valves in the inventory. OEM confirmed the counterfeits.	Importance of receipt inspection process, training and a questioning attitude.

Note: ASME — American Society of Mechanical Engineers; CB — circuit breakers; CFSIs — counterfeit, fraudulent and suspect items; CG — commercial grade; CGD — commercial grade dedication; CGI — commercial grade item; CII — Construction Industry Institute; EPRI — Electric Power Research Institute; EQ — equipment qualification; GIDEP — Government-Industry Data Exchange Program; KHNP — Korea Hydro & Nuclear Power Company; LOCA — loss of coolant accident; NDE — non-destructive examination; NRC — United States Nuclear Regulatory Commission; NSSC — Nuclear Safety and Security Commission; NUMARC — Nuclear Utility Management and Resources Council; OECD/NEA — OECD Nuclear Energy Agency; OEM — original equipment manufacturer; OPEX — operating experience; QA — quality assurance; QVD — quality verification document; SR — safety related.

TABLE 25. CFSI LESSONS LEARNED FROM IAEA-TECDOC-1169 [246]

Type of item	Issue	Lessons learned
Fasteners	CFSI 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 the potential that they could be reused in applications where genuine high strength bolts were required. Stainless steel bolts were handstamped to indicate they met a different standard.	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.
Circuit breakers	Refurbished moulded case electric CBs continue to be widely counterfeited and misrepresented as new. Moulded case CBs should not be taken apart and serviced or refurbished except by the original manufacturer or qualified supplier.	Refurbished moulded case CBs should not be accepted without original manufacturer or qualified supplier certification.
Metal struts and fittings	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.	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.
Steels	Procured during construction: — Steels were ordered to a specific standard but were supplied to another standard, for financial gain. — Suspicion aroused when material test reports were checked. — Solution: Additional Charpy impact tests were performed, absorbed energy met the original acceptance criteria, and the steels manufactured to the other standard were accepted.	Receipt inspection should be performed thoroughly to detect suspect items. Suppliers should be monitored and controlled more strictly.
Pump shafts	Used for spare parts of fire protection pumps, procured during operation: — Suspicion identified when the run out check of the pump shafts was performed at the receiving inspection. — Solution: Engineering decision made to discard the shafts and purchase new ones.	Receipt inspection should be performed thoroughly to detect suspect items. 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, transport or manufacturing.

TABLE 25. CFSI LESSONS LEARNED FROM IAEA-TECDOC-1169 [246] (cont.)

Type of item	Issue	Lessons learned
Throttle valves and 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 were damaged by cavitation as a result of sudden throttling during the commissioning test. — Solution: To avoid cavitation and to optimize the efficiency; the 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.	Anticavitation design should be considered in the throttle line. Experience and design changes were incorporated into the 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 a 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.	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; detailed 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 feedwater 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 feedwater system. — Solution: Eddy current testing and engineering evaluation were performed to assess the effect of loose parts on the steam generator; the disc bolt was replaced with a thicker one; weak parts of the valve were reinforced.	Similar valves supplied by the 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 buildup 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 a design change to allow frequent checks of differential pressure.	Filtering material should be replaced periodically taking into account any unforeseen ageing effect caused by use in a differential pressure environment, regardless of manufacturer instruction. Differential pressure of filter should be checked frequently.

TABLE 25. CFSI LESSONS LEARNED FROM IAEA-TECDOC-1169 [246] (cont.)

Type of item	Issue	Lessons learned
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: A design change from thread type to sleeve type was made, damaged thread of guide stud was discarded and stud hole thread was bored.	Experience and design change was incorporated into the next plant design.
Reactor coolant pump seal housing bolts	Procured during construction and installed: — During annual outage, suspicion was 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; NDE and engineering evaluation on rusted bolts performed and a leakage check was performed after bolting.	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.	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.	Receipt inspection should be performed thoroughly to check full bolt engagement in nuts on assemblies.

TABLE 25. CFSI LESSONS LEARNED FROM IAEA-TECDOC-1169 [246] (cont.)

Type of item	Issue	Lessons learned
Electrical and instrumentation and control cables — fire retardancy	Procured during construction: — Supplied from warehouse of a nuclear power plant 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 owing 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).	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.
Transformers	Procured during construction: — Stored for a long time in conditions (variable temperatures and humidities) that were not strictly controlled; possible insulation/paper degradation occurred. — Installed in unit. — Suspicion aroused when several transformers failed during commissioning (short circuits, fires). — Solution: New transformers ordered (insulation: moulded resin) and stored on-site in suitable conditions, to enable immediate replacement of failed transformers in future.	Evaluation/inspection of item status should be carried out prior to installation, to assess effect of storage conditions on item. Spare parts and components inventory should take into account necessity to replace any installed suspect items when they fail.
Electronic cards in logic loops	Procured during construction and installed: — Suspicion aroused when spurious trip signals were generated in some pins on the card, when the card failed (situation generated a reactor trip during commissioning tests). Manufacturer confirmed failure as being generic in nature following a request by the nuclear power plant to carry out an investigation. — Solution: Modification implemented in loops which used such pins and which had an impact on other similar logic; balance of cards was kept unchanged.	Approach to disposition of suspect items should be related to importance of the item for safety or for plant availability. Any suspicions should be identified at an early stage, during commissioning tests, if possible (schedule special tests for CFSIs). Ask for information and clarification from the supplier together with an investigation on any faults identified in order to simplify engineering evaluation.

TABLE 25. CFSI LESSONS LEARNED FROM IAEA-TECDOC-1169 [246] (cont.)

Type of item	Issue	Lessons learned
Liquid relief valves	Used in degasser condenser, operating in tandem with the pressurizer, procured for construction, in accordance with the standard design, and installed. — Suspicion aroused through feedback that suggested that other nuclear power plants of the same design replaced these valves with new ones, with better dampening features. — Suspicion confirmed during a transient, when the unit was shut down and valves operated, but did not close properly (they 'chattered'), generating heavy water losses. — Solution: Repair of valves (for short term); order of new valves similar to those utilized by other nuclear power plant's with installation to occur during annual outage.	Database of CFSIs should be permanently monitored to take into account operating experience of other nuclear power plants. Replacement of such items should be considered as an important part of annual outage work. Replacement of suspect items could be implemented with cooperation of other nuclear power plants interested in such work.
Identification and markings	The following are examples of CFSIs that were discovered as a result of improper markings: — Metal flanges stamped as forgings when other markings on face of flange indicated that parts were cold rolled. — Metal flanges as part of fabricated assemblies without any required markings on the flanges, such as manufacturer, material type, specification or dimension. — 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. — Metal piping and pipefittings requested from national manufacturers received from foreign manufacturers. — 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.	Detailed visual inspections of items are a key way to discover CFSIs.

Note: CB — circuit breakers; CFSIs — counterfeit, fraudulent and suspect items; NDE — non-destructive examination.

7.4. TOOLS TO ADDRESS COUNTERFEIT AND FRAUDULENT ITEMS

Some tools to counteract counterfeiting are described in some detail in this section and include:

(a) Engineering involvement in procurement and product acceptance;
(b) Detailed knowledge of suppliers, including reducing use of independent distributors and parts brokers and effective supplier audits;
(c) Questions regarding counterfeit and fraudulent item identification methods and programmes within supplier audit checklists;
(d) Identification of 'at-risk' procurement;
(e) Clear and complete procurement requirements;
(f) Procurement clauses and standard contract language addressing counterfeit and fraudulent items;
(g) Bid evaluation processes accounting for counterfeit and fraudulent item concerns;
(h) Zero tolerance policies for vendor counterfeiting;
(i) Safeguarding of protection of intellectual property;
(j) Use of difficult to counterfeit, positive identification tools;
(k) Sensitive scrap and disposal policies;
(l) Design rules and practices that emphasize diversity of supply;
(m) Thorough receipt inspections;
(n) Contractual arrangements for independent testing;
(o) Training programmes on recognizing counterfeit parts;
(p) Procedures for addressing suspected counterfeit and fraudulent item incidents, which include engagement of original equipment manufacturers;
(q) Industry databases of incident data;
(r) Human performance tools;
(s) Participation in industry peer groups;
(t) Mandatory reporting to regulators of discovered items;
(u) Whistle-blower protection and rewards.

EPRI has developed a risk mitigation document [247] and self-assessment checklist [302] to provide utilities with a means to assess existing anticounterfeiting measures and a tool to identify opportunities to improve anticounterfeiting measures in existing processes and programmes. The checklist can be shared with all supply chain tiers to raise awareness of the counterfeiting issue and communicate effective means to minimize risk.

7.4.1. Engineering involvement in procurement and product acceptance processes

Inadequate engineering involvement is a common weakness in procurement programmes, particularly for CGI procurement. Involvement of engineering staff would normally include:

— Development of procurement requirements;
— Determination of critical characteristics of selected products that are to be verified during product acceptance;
— Determination of specific testing applicable to selected products;
— Evaluation of test results.

7.4.2. Detailed knowledge of suppliers

Knowledge of a supplier's operations and practices is key to gaining confidence in its ability to avoid counterfeit and fraudulent item issues. Such knowledge is obtained via a process of assessments and audits, regular communication (including requesting of counterfeit and fraudulent item data from suppliers), and by experience with the supplier over a period of time. Minimizing the number of suppliers that a nuclear facility deals with can make such efforts more practical, as does reducing the use of independent distributors and parts brokers. Using only original manufacturer approved distributors wherever practical is recommended, as is verifying supplier provided data such as address, ISO certification and authorized distributor status.

Changes in supplier ownership or financial position should trigger a reassessment as to whether such changes require increased scrutiny for a time period until confidence can be re-established.

Qualification of authorized distributors and agents through evaluation or audits and limiting purchases to these proven and experienced vendors will aid in preventing CFSIs. Determination of 'authorized' status should only be pursued through the original equipment manufacturer or original component manufacturer.

Regular communication with suppliers is recommended. For example, EPRI recommends periodically transmitting a letter or brief survey to suppliers to determine whether they are aware of CFSIs and are taking precautions to avoid them, and to request feedback if a CFSI incident impacts products that have been purchased (see also Sections 3.4.3 and 7.4.3 for information on supplier audits) [247].

7.4.3. Questions regarding counterfeit and fraudulent item identification methods and programmes within supplier audit checklists

Suppliers regularly undergo assessments and audits related to their management systems and quality assurance programmes. Good practice is to include an assessment of their documented measures and practices related to CFSI identification, and notification methods and programmes within the scope of these assessments and audits. Some specific supplier evaluation questions are included in Ref. [247].

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.

7.4.4. Identification of 'at-risk' procurement

Staff within procurement organizations should have the necessary training and experience, and process controls should be in place to assist in recognizing at-risk procurement scenarios. These scenarios include:

(a) Procurement of components that are known to have counterfeits in industry;
(b) Procurement of items that have long been considered unavailable on the open market;
(c) Use of new suppliers, equipment brokers, independent distributors or Internet exclusive suppliers;
(d) Not buying from authorized distributors;
(e) Expedited schedules;
(f) Highly discounted pricing;
(g) Supplier refusals to offer a traceable source, or refusals to provide or be accountable for certification.

Location of sourcing can also be a trigger for a potential at-risk procurement scenario, with some sourcing jurisdictions having greater numbers of reported issues than others.

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, as described in Section 7.4.3. SAE International, for example, has produced standard SAE ARP6178 [303] on performing risk assessments of electronic distributors related to counterfeit and fraudulent items. Such procurement scenarios can trigger additional inspections and oversight actions as necessary.

7.4.5. Clear and complete procurement requirements

Clear procurement requirements are important to both receipt of the required product and for avoiding counterfeit and fraudulent items. Descriptions should include important characteristics of the item as opposed to just model numbers. The following are desired:

— Contractual requirements pertaining to disposal of rejected and surplus items (see Section 7.4.11);
— Provision of counterfeit or fraudulent items (see Section 7.4.6);
— Communication of actions that will be taken if counterfeit or fraudulent items are provided (see Section 7.4.8);
— Provision of product certifications;
— Use of escrow payments when appropriate, and with clear, detailed descriptions of the item;
— Applicable standards;
— Acceptance criteria.

7.4.6. Procurement clauses and standard contract language addressing counterfeit and fraudulent items

Standard procurement clauses related to counterfeit and fraudulent items applied to all orders can raise the profile of the issue with suppliers. An example of an acceptable clause is given in Section V.22. EPRI has proposed the following standard procurement clause in Ref. [247] (other examples from the aerospace industry and the United States Department of Energy are included in the same report):

> "Seller is hereby notified that the delivery of suspect/counterfeit items is of special concern to (Utility Name). If any items specified in this Order are described using a part or model number, a product description, and/or industry standard referenced in the Order, Seller shall assure that the items supplied by Seller meet all requirements of the latest version of the applicable manufacturer data sheet, description, and/or industry standard unless otherwise specified. If the Seller is not the manufacturer of the goods, the Seller shall make reasonable efforts to assure that the items supplied under this Order are made by the original manufacturer and meet the applicable manufacturer data sheet or industry standard. Should Seller desire to supply an alternate item 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 alternate items to Purchaser.
>
> "If suspect/counterfeit items are furnished under this Order or are found in any of the goods delivered hereunder, such items will be dispositioned by (Utility Name) and/or the original manufacturer, and may be returned to the Seller in accordance with the warranty provisions applicable to the Order. The Seller shall promptly replace such suspect/counterfeit items with items meeting the requirements of the Order. In the event that the Seller knowingly supplied suspect/counterfeit items, the Seller shall be liable for reasonable costs incurred by the Purchaser for the removal, replacement, and reinstallation of said goods in accordance with the warranty provisions applicable to the Order."

Some operating organizations also explicitly require supplier management systems to specifically address counterfeit and fraudulent items, adding a procurement clause such as [304]:

> "To mitigate the CFI risk, (operating organization name) requires our approved suppliers to recognize this risk by introducing into their quality assurance program a documented process to prevent, detect and disposition suspect CFI's."

7.4.7. Bid evaluation processes accounting for counterfeit and fraudulent item concerns

Policies that require selection of lowest cost bids can contribute to more at-risk procurement scenarios and CFSI incidents. Bid evaluation criteria are recommended that address the type of supplier (i.e. Internet, broker, authorized distributor and original manufacturer), level of experience with the supplier, willingness of the supplier to certify that the items are genuine and supplier historical performance.

7.4.8. 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, 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. For example, Underwriters Laboratories (UL) has established a team dedicated to counterfeiting issues that work towards developing 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 to identify counterfeit products, providing real time support for customs and law enforcement officials, and producing detailed enforcement manuals and reference materials [305].

7.4.9. Safeguarding of protection of intellectual property

Intellectual property received from suppliers and original equipment manufacturers for the purpose of nuclear facility operation (e.g. drawings, manuals, specifications and capability curves) 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 it also helps to prevent this information from falling into the hands of counterfeiters.

7.4.10. Use of more difficult to counterfeit, positive identification tools

The National Electrical Manufacturers Association has produced a publication [306] listing certain anticounterfeiting and authentication technologies that can be used in industry. These technologies include:

(a) A variety of security inks and coatings:
- Intaglio inks, which provide a distinctive feel such as 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;
- Photochromatic inks.

(b) Difficult to mimic elements such as:
- Security printing (e.g. microtext, nanotext and guilloche);
- Security papers (e.g. designed for tamper resistance or containing security threads, fibres and other embedded features);
- Optical technologies (e.g. holograms and films).

(c) Chemical and molecular tag and nanotechnologies.

(d) Electronic tracking and tracing systems (e.g. bar codes), which can track an item through the supply chain.

Existing inventories can be backfitted with such markings where not already applied.

7.4.11. Sensitive scrap and disposal policies

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

7.4.12. Human performance tools

Standard nuclear industry human performance tools can be utilized to help in the detection of counterfeit and fraudulent items [307, 308]. Pre-job briefings for receipt inspectors, warehouse staff and maintenance staff, for example, can cover counterfeit and fraudulent item detection. Encouraging a questioning attitude or stopping when unsure can facilitate individuals stopping jobs when they are concerned whether an item to be installed is genuine or not. Procedure use and adherence can encourage staff to fully complete any checklists, processes or other activities designed to assist in counterfeit and fraudulent item detection or prevention. Other human performance tools can be utilized or adapted to assist.

7.4.13. Design rules and practices that emphasize diversity of supply

Although not implemented specifically to address counterfeit and fraudulent item issues, nuclear defence in depth design practices have been in place for many years and emphasize the diversity of suppliers when designing critical systems. For example, suppliers of equipment for a primary reactor shutdown system would not be considered to supply equipment related to a secondary shutdown system. Such practices could be extended into the broader supply chain, with single distributors or service suppliers, where practical, not being considered for all critical supply functions.

It should be acknowledged that such practices can provide nuclear facilities with some protection from the impacts of a single counterfeit and fraudulent item related incident, but do not lessen the need for strong responses to such detected incidents.

7.4.14. Thorough receipt inspections

As discussed in Section 3.6.2.3, receipt inspectors should be aware of things to look for in detecting potential counterfeit and fraudulent items. Table 26 provides some specific details.

TABLE 26. SIGNS THAT AN ITEM IS POTENTIALLY A COUNTERFEIT AND FRAUDULENT ITEM

Category	Signs
General	Nameplates, labels or tags altered, photocopied, silkscreened, painted over, not secured well, or showing incomplete data or missing data (preprinted labels will normally show typed entries). Obvious attempts at beautification made, such as excess painting or wire brushing, hand painting (touch-up), stainless steel painted and non-ferrous metals (e.g. copper, brass and bronze) appearing clean and bright, indicating recent polishing. 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). Hand tool marks on fasteners or other assembly parts (upset metal exists on screw or bolt head) or dissimilar parts evident (e.g. seven of eight bolts of the same material and one of a different material). Assembled items fit poorly. Configuration not consistent with other items from supplier or varies from supplier literature or drawing. Inconsistency between vendor name on item and shipping container. Nameplates attached with inconsistent fasteners, such as screws instead of rivets or rivets and screws. Nameplates attached in a different location to normal. Nameplates appearing old or worn, with paint on them or looking newer than component. Metallic items pitted or corroded. Nameplates missing manufacturer standard markings, stamps or logos and with irregular stamping or inconsistent type style. Different appearance of items in same shipment. Properly identified items (e.g. struts and fittings) mixed with unmarked items (e.g. no manufacturer name, logo, part numbers or load capacity). Unusual boxing and packaging of item; packaging inconsistent with supplier's normal packaging or documentation requirements. Dimensions of item inconsistent with specification requested on purchase order and those provided by supplier at time of shipment. Evidence of previous bolt head scoring on backs of flanges or evidence that area has been ground. Loose or missing fasteners. Evidence of marring, tool impressions, traces of Prussian blue or lapping compound or other evidence of previous attempts at fit-up. Heat discoloration evident. Dissimilar materials carelessly in contact. Item cleanliness poor. Price of item offered unusually low. Supplier is not a factory authorized supplier.

TABLE 26. SIGNS THAT AN ITEM IS POTENTIALLY A COUNTERFEIT AND FRAUDULENT ITEM (cont.)

Category	Signs
Documents	Use of correction fluid or correction tape evident; type style, size or pitch change evident. Document not signed, initialled when required, excessively faded or unclear (indicating multiple, sequential copying) or missing data. Name of document approver or title cannot be determined, or typed approval name does not match signature. Technical data inconsistent with code or standard requirements (e.g. no impact test results provided when impact testing required, physical test data indicate no heat treatment and heat treatment required, chemical analysis indicates one material and physical tests indicate another). Certification or test results identical between items when normal variations should be expected. Unusual disclaimers or denials of responsibility for the accuracy of test results. Document traceability not clear; documentation should be traceable to items procured. Documentation not delivered as required on purchase order or in an unusual format. Documents photocopied when originals would be expected. Corrections not properly lined out, initialled and dated. Text on page ends abruptly and number of pages conflicts with transmittal. Required watermarks missing. Inconsistent configuration between product and product literature or between other items from same supplier. Lines on forms bent, broken or interrupted, indicating data have been deleted or exchanged (physically cut and pasted). Data on a single line are located at different heights. Item or component matches description of one that is on a Member State list of CFSIs.
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 (e.g. brush marks to repair spray paint). Inconsistent shades on painted surfaces.
Tags	Tags attached with different method (e.g. screws instead of rivets) or in different location to normal. 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.
Handwheels	Handwheel appears older than valve. Handwheel looks sandblasted or newer than valve. Different types of handwheel on valves of same manufacturer.
Nuts and bolts	Nuts and bolts have a used appearance (wrench marks on flats). Improper bolt and nut material (e.g. bronze nut on stainless steel 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 and stem. Evidence of previous bolt head scoring on backs of flanges or evidence that area has been ground to remove such marks. On a stainless steel valve, an unusually shiny finish indicates bead blasting; an unusually dull finish indicates sand blasting; finish on a new valve is in between.

TABLE 26. SIGNS THAT AN ITEM IS POTENTIALLY A COUNTERFEIT AND FRAUDULENT ITEM (cont.)

Category	Signs
Manufacturer's logo	Missing altogether. 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 or 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. Poor fit between assembled parts. Improper materials (e.g. bronze nut on a stainless steel or stainless steel valve shows characteristics of carbon steel such as rust blooms and magnetism). 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 is 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, and poor legibility). Circuit breaker 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 is no longer manufactured or is old. Different short circuit rating. Breaker comes in cheap, generic type packaging (e.g. bulk packaged in plastic bags, brown paper bags or cardboard boxes with handwritten labels) instead of manufacturer's original boxes. Data on carton or label have been altered or are inconsistent. Moulded case circuit breakers may be labelled with the refurbisher's name rather than the label of a known manufacturer. Labels do not indicate the country of origin. Logos are printed on, appear to be etched or are missing. 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 (refurbishers often coat them with clear plastic to produce a high gloss that gives the casual observer the impression that it is new; the plastic case of new moulded case circuit breakers often has a dull appearance). Rating stamp is in wrong place. Third party markings on item. Terminal lugs on both ends. Terminal hardware wrong size or type or mismatched. Cover screw seals are missing, rough or poorly resealed.

TABLE 26. SIGNS THAT AN ITEM IS POTENTIALLY A COUNTERFEIT AND FRAUDULENT ITEM (cont.)

Category	Signs
Electrical devices	Connections show evidence of previous attachment (metal upset or marring, or screwdriver marks). Electrical leads are of different lengths or are not as long as stated in vendor product catalogue. Connections show arcing or discoloration. Item appears to have signs of paint or smoke. Metal colour inconsistencies. Plastic parts of different colours. Pitted, worn or damaged contacts and lugs. Contact surfaces that do not mate properly. Broken, sloppy or damaged solder terminations. Different screw types or items on terminals. Missing terminals. Rough metal edges. Lubrication appears to be old. Fasteners loose, missing or show metal upset. Moulded 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 are 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 are missing and screws are used in place of where rivets are normally used; or rivets look to be reused. Moulded case circuit breakers shiny or appear painted with lacquer. Past due date calibration stickers (internal and external). Motor control centre breakers not easily opened or closed with compartment door closed. Exposed buswork with compartment doors open. Fuse labels missing or weathered. Electrical approval markings missing on devices. Bases show evidence of wear.
Relays	Painted relay base grommets (normally clean). Terminal strips fastened with eyelets. Painted rivets fastening terminal strips to relay housings. Termination screws in brown paper bags (should be in clear, heat sealed plastic bags). Repainted inner bell surface of relays. Missing or inconsistent date codes, inspection stamps and test stamps. Incorrect shaft relay cover clearance, shaft play and lack of bearing lubricant. Tops of rotor shafts painted a colour other than black. Non-uniform numbers stamped on contact decks, indicating decks made up from various relays. Incorrect coils installed (i.e. 125 V direct current relay with 200 V direct current coil).
Capacitors	Polished surfaces scratched or dented. Termination lugs scarred. Buildup of debris and dirt in termination guards. Plain packaging (no manufacturer bar codes).
Electronic components	Electrolytic capacitors are not marked with a date code. Electrolytic capacitors have different dimensions. Fairchild phototransistor optocouplers are small in size, packaged incorrectly and the date code indicates that the suspect device was manufactured after the genuine device has been discontinued by the OEM. Integrated circuit board chip altered to make chips appear newer than they are.

TABLE 26. SIGNS THAT AN ITEM IS POTENTIALLY A COUNTERFEIT AND FRAUDULENT ITEM (cont.)

Category	Signs
Rotating machinery and valve internal parts	Signs of 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 surfaces. 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 handmade parts. Painted stainless steel, freshly painted parts or 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 that look newer than the component. Missing manufacturer standard markings and logos. Traces of Prussian blue. Markings not legible. Evidence of restamping. 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 government specifications or standards.
Fire protection equipment	Counterfeit fire extinguisher handles may be made from improper materials or are an improper colour (e.g. products from OEMs have aluminium handles that are silver in colour, while counterfeits have black or red plastic handles). Bottom of counterfeit fire extinguishers may have a different configuration or design features, for example: — Thicker, rolled or curved bottoms instead of authentic straight, flush bottoms; — Authentic cylinders have a date code stamped on the cylinder bottom; — Counterfeit fire extinguishers have lighter weight material construction; — Authentic cylinders are of a one piece design and do not show external welds (on counterfeits, welding quality may be poor and may be welded in multiple or different locations, particularly around the base); — Pressure gauges look different or may be the wrong colour, and may be improperly assembled or may not function; — When counterfeit cylinders are turned upside down, the cylinder contents drop to the top. There may be multiple issues with labels on counterfeit fire extinguishers. Label background may not be exactly the same colour or shade as an authentic label. Counterfeit labels may be screen printed and commonly have the same identical serial numbers on different cylinders. The easiest method to find these counterfeits is to check serial numbers. If more than one cylinder has the same serial number, it can be assumed that all of those cylinders are counterfeit. Improper certification marks (e.g. Underwriters Laboratories label information). Misspelled words and/or incorrect text fonts type on the labels or instructions. Authentic labels have anticounterfeiting features such as circles, letters or symbols cut into them; counterfeit labels will have those features printed on the labels instead of cut into the labels. Logos or manufacturer symbols may be incorrect on the counterfeit cylinders (e.g. slightly different colours used or sizes or shapes of logos may be somewhat different).

TABLE 26. SIGNS THAT AN ITEM IS POTENTIALLY A COUNTERFEIT AND FRAUDULENT ITEM (cont.)

Category	Signs
Lifting devices	Lifting devices visibly altered (e.g. overstamping or striking through original information and adding new markings). Used appearance of items (strings appear worn or hook has indications of previous use). No documentation or incomplete documentation. Polyester lifting slings without red core yarns visible or otherwise contrary to the information received with the slings.

Source: Adapted from Refs [107, 246, 309, 310].
Note: OEM — original equipment manufacturer.

For at-risk procurement scenarios (see Section 7.4.4), enhanced inspection (including destructive) may be appropriate. This can include such activities as requesting inspection and testing criteria from the original equipment component or original equipment manufacturer, using photographs of authentic items to aid authentication when performing receipt inspection (e.g. by verifying that manufacturer and certification organization markings are correct), consulting available industry data on known counterfeits when performing receipt inspection and for electronics, and consider implementing the guidance given in Refs [311, 312].

7.4.15. Contractual arrangements for independent testing

Typically, equipment manufacturers supply equipment with test certifications for such items as environmental or seismic qualification. Following the certification falsification scandals in the Republic of Korea in 2012, the Korean regulator mandated that testing and certifying of parts and items could only be done by institutes that the regulator designated. These changes were an attempt to reduce the potential for corruptive relations between manufacturers and test organizations [313].

7.4.16. Training programmes on recognizing counterfeit parts

Training is typically required in the recognition of counterfeit and fraudulent items. Training raises awareness levels and increases significantly the possibility of detection of counterfeit and fraudulent items. Vigilant inspections at the source (factory), at the warehouse (receipt inspection) and pre-installation (by the installers) are key barriers to counterfeit and fraudulent items. 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 counterfeit and fraudulent item detection, and EPRI has produced a computer based course for this purpose [314].

7.4.17. Procedures for addressing suspected counterfeit and fraudulent item incidents, including engagement of original equipment manufacturers

Processes need to be set up in advance for addressing suspected CFSI incidents. This is to ensure that staff members are 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 original equipment manufacturer, 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 items;
- — Adding the incident to facility corrective action programmes;

— Notifing the appropriate internal organizations;
— Gathering information;
— Considering the reporting to industry databases;
— Contacting original equipment manufacturer or supplier for information about related incidents or any ongoing investigations;
— Carefully deciding whether the item supplier should be notified of the specific incident (they may tip off counterfeiter who may destroy evidence) and whether the item should be returned;
— Inspecting, testing, reviewing or taking other actions as required to determine whether the item is genuine or non-conforming;
— Notifing regulators and other appropriate agencies as required;
— Notifing national customs and law enforcement agencies as required;
— Physically disposing of suspect items.

7.4.18. Participation in industry peer groups

The use of industry peer groups is a method to help share knowledge and experiences related to CFSIs on a regional basis. Some groups in operation include the EPRI Joint Utility Task Group on procurement engineering and NUPIC. Voluntary reporting of incidents to a centralized database managed by the peer group and further sharing with the international community is recommended (see Section 7.4.20).

7.4.19. Mandatory reporting to regulators of discovered items

Many jurisdictions increasingly are requiring mandatory reporting of discovered counterfeit and fraudulent 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 counterfeit and fraudulent items.

An example of such a requirement is in the United States of America, where contractors subject to the Cost Accounting Standards under Section 26 of the Office of Federal Procurement Policy Act (41 US Code Section 422) and who 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 counterfeit and fraudulent item incidents to the IAEA through the incident reporting system (IRS) [315]. Reporting code 5.7.6 is available within the IRS for this purpose.

7.4.20. Industry databases of incident data

Incident data related to counterfeit and fraudulent items have been recorded by a number of organizations, both inside and outside of the nuclear industry. A regular review of, and contribution to, such databases can lower the risks associated with inadvertent purchases of counterfeit and fraudulent items. Some sources of information are shown in Table 27.

TABLE 27. SOURCES OF INFORMATION RELATED TO COUNTERFEIT AND FRAUDULENT ITEMS

Organization	Topic covered	Comment
Canadian Standards Association	General	Ability to submit incident reports on possible counterfeit marks
Electric Power Research Institute	General	Suspect counterfeit and fraudulent item data database being developed To be available to and input by EPRI members
Electronics Systems Community Anti-Counterfeiting Forum	Electronics	Source of best practices and a database of counterfeit items
ERAI	Electronics	Provides ability to report and search for electronic counterfeit items
Factory Mutual	General	Statement on counterfeiting and news and product alerts (including notifications of known items bearing counterfeit Factory Mutual certifications)
Government-Industry Data Exchange Program	General	For Canadian or US organizations which directly or indirectly provide products or services to the Canadian or US Governments Maintains database with ability of members to submit data for exchange of technical information (including recounterfeit items) with other GIDEP participants
National Electrical Manufacturers Association	Electrical	News postings on counterfeit items plus other resources
National Intellectual Property Rights Coordination Center	General	US Government's clearing house for investigations into counterfeiting and piracy
Underwriters Laboratories	General	Anticounterfeiting programme information
United States Consumer Product Safety Commission	General	General US consumer site reporting product recalls including counterfeit items

7.4.21. Whistle-blower protection and rewards

Identification of fraudulent or counterfeit activities can be difficult for some individuals where their company cultural environment does not support such activities. Those who report wrongdoings may be subject to retaliation, such as intimidation, harassment, dismissal or violence by their fellow colleagues or superiors. In some countries, whistle-blowing is even associated with treachery or spying. Some jurisdictions have enacted anonymous reporting channels, specific whistle-blower protection legislation, and monetary rewards for reporting of counterfeit, fraudulent or unethical activities within their nuclear industries. For example, the Republic of Korea has recently instituted a leniency programme that includes financial rewards for nuclear whistle-blowers to the amount of 1 billion won (approximately US $1 million) [316]. The OECD has provided a useful guidance document on establishing whistle-blower protection and encouraging reporting [317].

8. PROACTIVE METHODS FOR NEW FACILITIES TO AVOID PROCUREMENT ISSUES DURING OPERATION AND MAINTENANCE

8.1. BACKGROUND

Given the requirements to control safety related and security related procurement over time for a nuclear facility, there are lessons learned to effectively enable procurement to support facility maintenance:

(a) Additional procurement processes are needed to support safety related procurement. However, operating organizations typically have limited resources and capabilities to meet all identified needs. Q-lists allow procurement groups to focus only on items used for safety related end uses, and thus make best use of available resources.
(b) Augmented procurement processes are necessary to handle critical digital assets and associated security measures.
(c) Changes in the marketplace will occur (e.g. companies dropping quality assurance programmes). Procurement organizations can utilize Q-lists and critical digital asset lists to focus on those changes for only those suppliers.
(d) Processes to identify critical equipment for facilities (e.g. INPO's AP-913 equipment reliability process [318]) may result in treating some materials used for critical end uses that are neither safety nor security related (e.g. production or economically significant material) the same way as safety or security related material.
(e) When implementing a nuclear programme or at new nuclear facilities, it is recommended to incorporate items (a)–(d) and build into supplier contracts the provision of procurement related data requirements (see Section 8.2 and Appendix I).
(f) 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 because the original supplier will typically support activities related to maintenance, parts availability and auditing of subsuppliers.

8.1.1. 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 in the 1970s and 1980s). This invoked the need for expensive and invasive configuration management restoration and design basis reconstitution programmes. Much of this effort was spent re-establishing the following:

— Clear design bases for nuclear power plant systems and components (e.g. technical specifications and BOMs);
— MELs categorized by equipment criticality to safety or economics in order to provide a priority system for maintenance and procurement;
— Equipment BOMs to allow components and piece part maintenance in a targeted effective and efficient manner;
— PM strategies and programmes for safety related equipment and equipment critical to operation where failure would cause safety or economic risks to the nuclear power plant.

8.1.2. Approach for new nuclear power plants

For new nuclear power plants, it is critical to undertake these activities as part of the design engineering phase and ensure that the following procurement related data are available to the eventual operating organization:

— Specifications for engineering flow diagrams, operational flowsheets and equipment tags;
— Design BOMs with clear manufacturer, model and part numbers and descriptions;

— Equipment BOMs and critical spare parts lists for equipment;
— Single failure analyses to minimize single points of vulnerability for economic or production reasons;
— Computer security risk assessments at both the facility and system levels;
— PM strategies to maintain critical spares for safety related 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 and Appendix I for further details).

8.1.3. Need for effective contract strategies and incentives

The UK Royal Academy of Engineering reviewed lessons learned for new nuclear construction [163]. It emphasized the need to ensure that contract strategies reflect the risk being carried by each party. Such contracts need to define clearly the scope and responsibilities of contractors and, most importantly, that the work needs to be placed with quality contractors. The report stated that competitive tendering works well for procurement of many goods and services, but it is not a panacea. For more complex and technically challenging tasks that require a range of special skills, an arrangement is required which provides incentives for specialist contractors to collaborate and innovate for the duration of the project.

8.2. ITEMS TO BE INCLUDED IN NEW NUCLEAR POWER PLANT CONTRACT REQUIREMENTS RELATED TO OPERATIONS AND MAINTENANCE DATA NEEDS

Procurement documentation for safety related and other critical components and structures needs to be available and to be stored physically and electronically for a facility's lifetime. It is vital for these components to remain as close as possible to the original specifications to ensure that incidents impacting on safety or production do not occur. A 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 nuclear power plants, other nuclear facilities or major projects such as refurbishments provide an opportunity to readily obtain required information that can be used throughout a facility's life. The operating organization at the time of contract negotiation has greater leverage over the vendor, and thus is in a better position to demand that such information be provided as part of the project 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 or later facility operation.

There is a distinct value proposition for future operating organizations to fix requirements for their operating phase enterprise data systems prior to new build contracts being finalized, and to include requirements for facility suppliers, major refurbishment contractors, and commissioning organizations (as part of their contractual requirements) to populate initial data and utilize such systems. Use of the same systems by all staff on a given project is preferred. This will prevent development of interim solutions that are later replaced by operating phase systems, minimize duplication of time and effort needed to implement duplicate systems, 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.

Typical documentation or data to be included at handover of the plant by the facility vendor include:

— Equipment lists;
— Bills of material;
— Spare parts lists;
— Quality list (whether item is safety related or not);
— Vendor manuals;
— Criticality codes (item critical to safety or production or not, e.g. see Ref. [318]);
— Equipment and material specifications;
— Material traceability requirements (e.g. uniquely tracked commodities);
— 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 material quantities);
- Maintenance manuals;
- List of subsuppliers for components and contact details;
- Operation manuals;
- Plant system classification and configuration information (e.g. system lists and coding systems used);
- Lead time of equipment and materials;
- Subsupplier quality control plans;
- Process and instrumentation diagrams for systems;
- Instrument calibration settings (including applicable design calculations, set points, tolerances and as-left values);
- Electrical models, drawings and relay settings (including applicable design calculations, 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.

Appendix I provides details regarding the specifics of some of the data and some related example enterprise database screens. It is important that this information, to the greatest extent possible, be collected and transmitted in a database electronic type format, and not strictly as individual document files and records (e.g. use database fields as opposed to paper, PDF or other similar formats). This allows enterprise systems to be more easily set up and populated with useful data. Where documents are provided (e.g. drawings, operations manuals, design descriptions and calculations), editable source versions of such documents (e.g. in Word, OpenDocument, AutoCAD or other editable formats) should be required to be provided as part of contracts to allow for future revisions by operating organization staff. Agreements related to intellectual property rights should be negotiated to ensure that the operating organization can utilize and revise such documents as necessary.

Of particular importance for procurement is the grading of items into safety related 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 focusing on such lists, operating organizations can prioritize their efforts on the most important items and any vendor issues related to such items (e.g. financial viability, quality assurance programme, maintenance and obsolescence issues).

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 arrangements 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 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.

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 nuclear power plant is around 60 years, and therefore components need to be available over that extended period of time. However, the bulk of component purchases for a nuclear power plant is 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 lives. 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 in a region helps to ensure that suppliers have a secure demand for their components, lowers the average cost of implementing 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 technology transfer agreements.

8.3.2. Contract arrangements

Technology owners are experts in the fields of their technology and usually own the intellectual property related to plant design. Traditional contract models for nuclear power plant construction require a transfer of data and other intellectual property related to procurement (see Section 8.2) to the eventual operating organization 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 or operator if not negotiated up front.

An equity partnership model where technology owners build–own–operate, and possibly transfer, a nuclear facility can help alleviate some of these concerns. Such models mean that the technology provider shares risk with the facility owner, and thus typically has fewer issues with sharing intellectual property if it makes plant operation more efficient. Technology providers 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. Reference [319] discusses alternative contracting and ownership approaches for new nuclear power plants and some of the advantages and disadvantages.

8.3.3. Technology transfer agreements

Technology transfer agreements within supply contracts are designed to ensure that should a manufacturer decide to close down a facility or no longer produce an item, the operating organization would be able to re-engineer or manufacture the component locally. This allows for the intellectual property related to manufacturing the item to be transferred to the operating organization. The operating organization would then contract a different organization to produce the item.

Such agreements for the transfer of intellectual property are particularly important for safety related 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.

These provisions should not be confused with localization provisions within contracts, which are often also referred to as technology transfer agreements. Such provisions are designed to develop national capability to produce or use a particular technology.

8.3.4. Supply chain of technology providers

When evaluating facility suppliers, potential owners need to look at the financial health of suppliers and subsuppliers, as well as the current technology supply market. First of a kind technology carries 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 subsupplier liquidity to ensure that component delivery in the immediate to short term is not jeopardized. If subsuppliers 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 the criticality of the components provided. Subsupplier management and databases, non-conformance reports, lessons learned reports and documentation control can be prioritized to ensure that they are receiving the attention deserved. Industry databases that monitor financial positions of subsuppliers (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 facilities do have very specific requirements, but off the shelf items 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 uses of nuclear energy, other organizations are also active in supporting 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 WNA 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 the standardization of nuclear reactor designs. This can only be achieved by the 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 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.

The 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 Working Group 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 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 towards facilitating the increased application of the off the shelf approach discussed in Section 8.3.5.

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 focuses on key legal, regulatory and procurement aspects of nuclear new builds 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 Section 3.4.3, sharing quality assurance audit findings is useful and necessary in the current global nuclear supply market. New owner operators are encouraged to join and participate in industry common auditing organizations such as Nadcap or CANPAC, and actively report adverse findings with their suppliers to such organizations. Efforts to standardize quality assurance programmes should also be encouraged.

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 inventories for a single operating unit or a 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 United States of America is the STARS Alliance, which includes the Callaway, Diablo Canyon, Palo Verde and Wolf Creek nuclear power plants [320]. The cooperating organizations all operate large, Westinghouse designed, relatively new pressurized water reactors (PWRs) in NRC region IV.

Technology vendors or technology specific organizations (e.g. CANDU Owner's Group, Boiling Water Reactor (BWR) Owner's Group and PWR Owner's Group) can often assist in these arrangements.

8.4.4. Nuclear Suppliers Group

NSG is a group of nuclear supplier States that seeks to contribute to non-proliferation of nuclear weapons through implementation of two sets of guidelines for nuclear exports and nuclear related exports, copies of which are included in Refs [321, 322]. NSG guidelines are implemented by each participating government in accordance with its national laws and practices.

NSG guidelines also contain the so called 'non-proliferation principle', adopted in 1994, whereby a supplier, notwithstanding other provisions in the NSG guidelines, authorizes a transfer only when satisfied that the transfer would not contribute to the proliferation of nuclear weapons. The principle seeks to cover the rare, but important, cases where adherence to the non-proliferation treaty or to a nuclear weapon free zone treaty may not, in itself, be a guarantee that a State will consistently share the objectives of the treaty or that it will remain in compliance with treaty obligations.

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 a nuclear facility.

Documentation needs to support the procurement process are large. These typically include a full list of components installed in the facility, their criticality to plant safety or economic operation, and their supporting BOMs, 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 facility operation should be anticipated at the contractual stage for new nuclear facilities, and included in formal documentation to be turned over to the facility operator by the nuclear facility vendor.

In some jurisdictions, a dedicated organization has been found to be useful to execute procurement engineering related activities. Such activities are specialized in nature, and a dedicated organization can be more efficient and produce higher quality products 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 of a 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 being used in the nuclear industry. Operating organizations need to be aware and to put processes in place to request declaration of any software or digital equipment included within vendor products, qualify and control such software, and to address computer security issues within procurement requirements.

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

Unplanned changes in nuclear facilities 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. Operating organizations need to continuously anticipate and manage such changes to ensure that quality parts and services are available on an ongoing basis to support the safe and economic operation of nuclear facilities.

Appendix I

PROCUREMENT RELATED DATA NEEDS

I.1. BACKGROUND

As discussed in Section 5.10, nuclear power plants have large data needs associated with procurement and supply chain processes. Although many of the data were generated via paper systems for older nuclear power plants, most utilities have, or are moving to, systems whereby most or all of such data are 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 facility staff where accurate, current data can be obtained relating to plant equipment, materials, approved design configurations and work tasks. This appendix describes some of the data needs for supporting typical procurement functions.

I.2. EQUIPMENT LISTS

The 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, BOMs, spare parts, work orders, calibration settings, calibration records and maintenance call-ups, among other things. 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) and pump motor 1. Indications as to whether the equipment is safety related, seismically or environmentally qualified, or a critical item is also often provided in the MEL and linked to the equipment location.

The relationship between equipment tags, catalogue IDs/stock codes (see Section I.3) and BOMs (see Section I.4) is shown in Fig. 38.

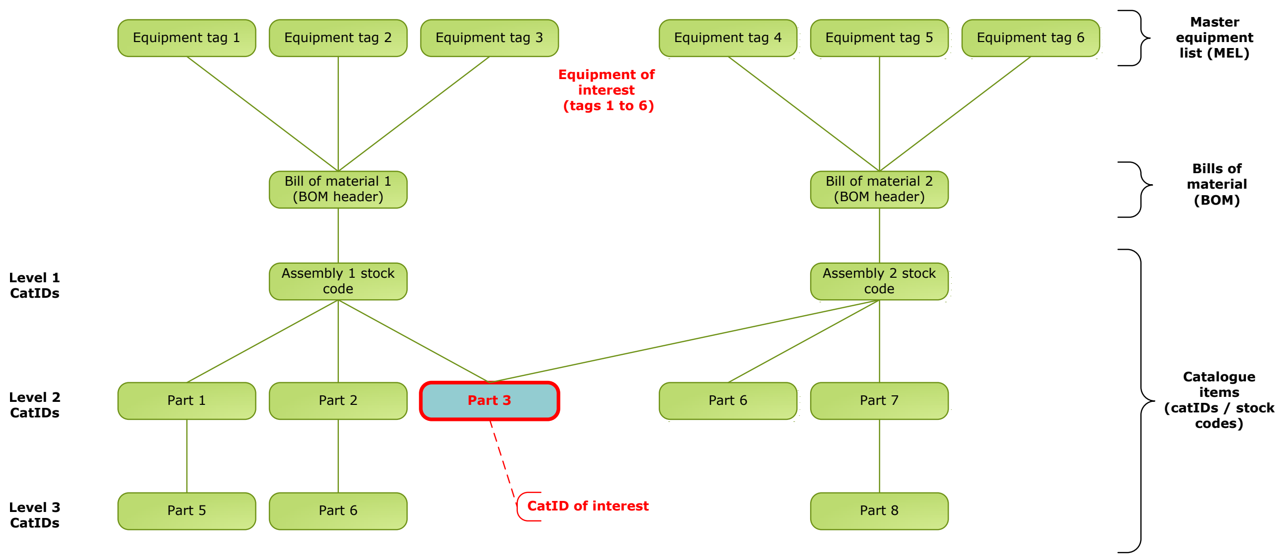


FIG. 38. Relationships between equipment tags, bills of material and stock codes.

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. ‘Part 3’ is used in each assembly).

Figure 39 shows an example enterprise MEL application for the Dukovany nuclear power plant 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).

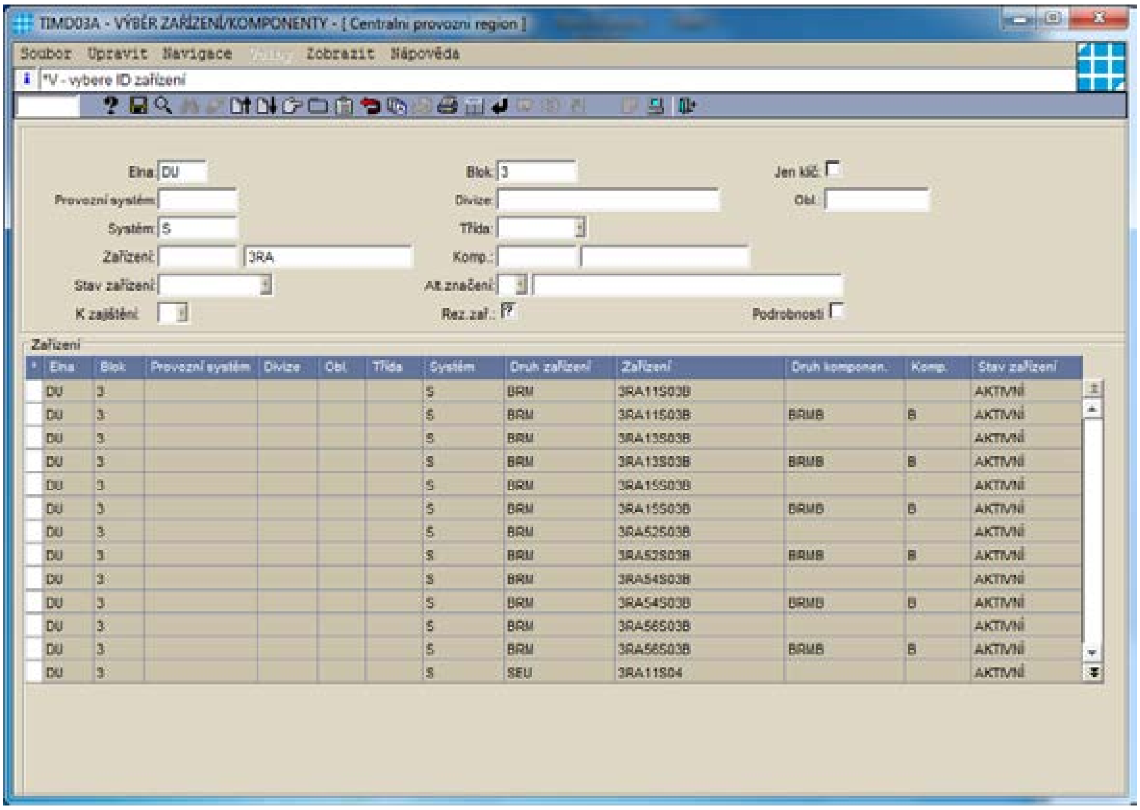


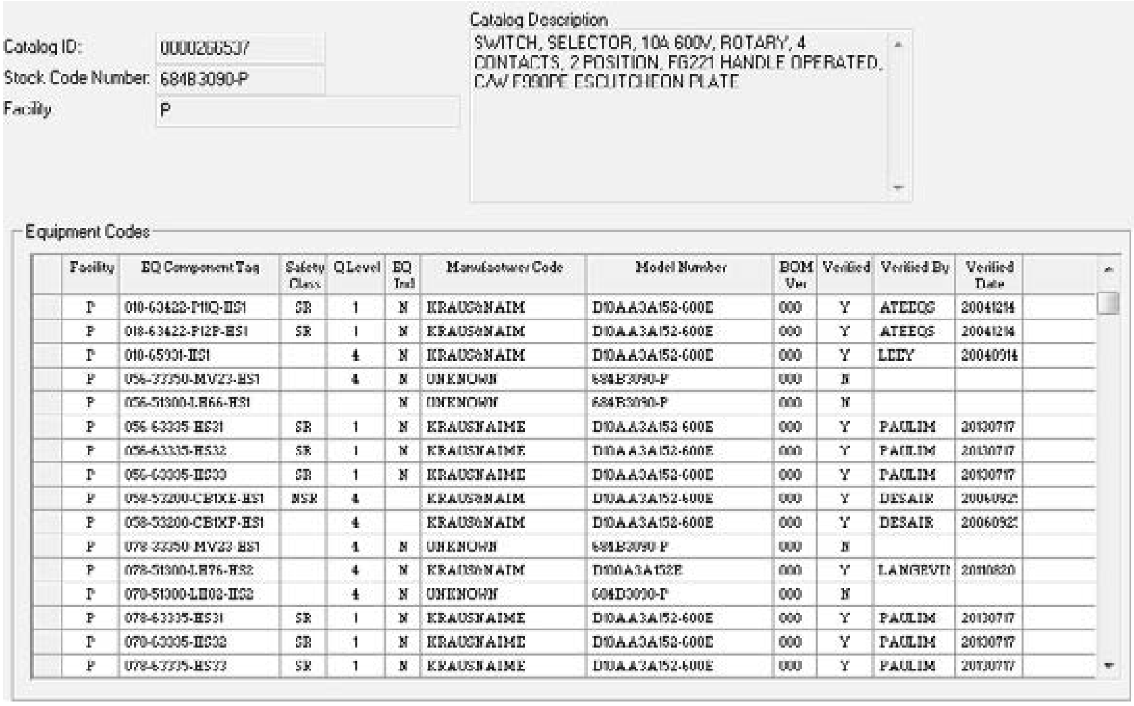
FIG. 39. Sample master equipment list selection screen (courtesy of CEZ Group).

I.3. CATALOGUE ID AND 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. valve, motor, electronic device, reel of cable or spare part) or simply a convenient way to represent an assembly of items that might be bought separately (see Fig. 38). CAT IDs are linked to a description of the item’s technical and quality requirements (see Section 3.3). CAT IDs may be used in multiple locations and on multiple systems in a nuclear power plant.

Unique numbers for CAT IDs are produced and controlled by operating organizations because vendors or suppliers may utilize duplicate numbers, or they may perform substitutions of components or make other changes within their internal numbering 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 40 shows a CAT ID description for a handswitch and related equipment that use the CAT ID number (i.e. where the item is installed) at an Ontario Power Generation (Canada) nuclear power plant. Note that the same catalogue item has both safety related and non-safety-related applications, and the stock code number indicated is a cross-reference to a legacy numbering system used prior to the introduction of CAT ID numbers. Figure 41 shows a CAT ID description for a globe valve used at an EDF (France) nuclear power plant.



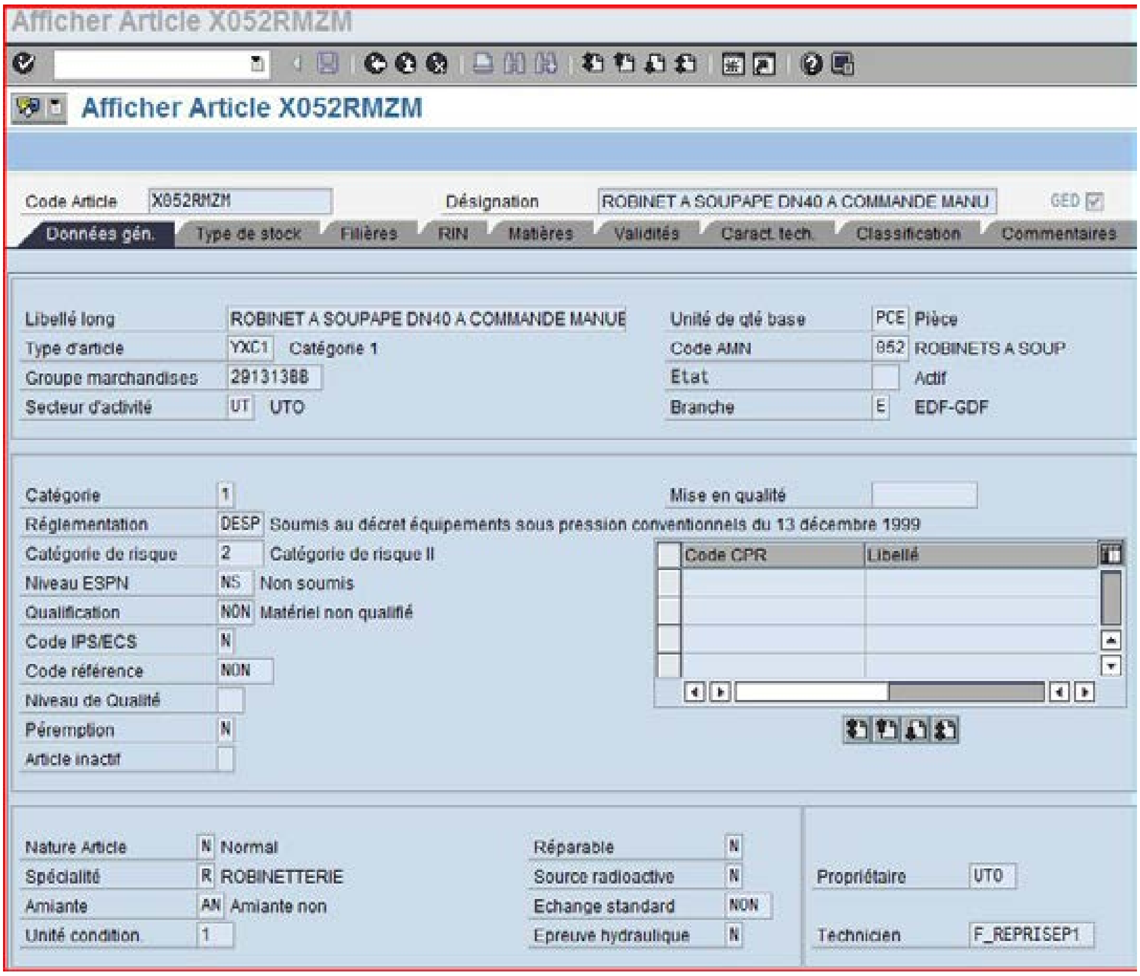
Catalog ID: 000026653?
Stock Code Number: 684B3090-P
Facility: P

Catalog Description
SWITCH, SELECTOR, 10A 600V, ROTARY, 4 CONTACTS, 2 POSITION, FG221 HANDLE OPERATED, C/W F990PE ESCUTCHEON PLATE

Equipment Codes

Facility	EQ Component Tag	Safety Class	Q Level	EQ Trnd	Manufacturer Code	Model Number	BOM Ver	Verified	Verified By	Verified Date
P	010-63422-P10Q-HS1	SR	1	N	KRAUS&NAIM	D10AA3A152-600E	000	Y	ATEEQS	20041214
P	010-63422-P12P-HS1	SR	1	N	KRAUS&NAIM	D10AA3A152-600E	000	Y	ATEEQS	20041214
P	010-65901-HS1		4	N	KRAUS&NAIM	D10AA3A152-600E	000	Y	LEEY	20040914
P	056-33350-MV23-HS1		4	N	UNKNOWN	684B3090-P	000	N		
P	056-51300-LH66-HS1			N	UNKNOWN	684B3090-P	000	N		
P	056-63335-HS31	SR	1	N	KRAUSNAIME	D10AA3A152-600E	000	Y	PAULIM	20130717
P	056-63335-HS32	SR	1	N	KRAUSNAIME	D10AA3A152-600E	000	Y	PAULIM	20130717
P	056-63335-HS33	SR	1	N	KRAUSNAIME	D10AA3A152-600E	000	Y	PAULIM	20130717
P	058-53200-CB1XE-HS1	NSR	4		KRAUS&NAIM	D10AA3A152-600E	000	Y	DESAIR	2006092?
P	058-53200-CB1XF-HS1		4		KRAUS&NAIM	D10AA3A152-600E	000	Y	DESAIR	2006092?
P	078-33350-MV23-HS1		4	N	UNKNOWN	684B3090-P	000	N		
P	078-51300-LH76-HS2		4	N	KRAUS&NAIM	D10OA3A152E	000	Y	LANGEVI?	20110820
P	078-51300-LH82-HS2		4	N	UNKNOWN	684B3090-P	000	N		
P	078-63335-HS31	SR	1	N	KRAUSNAIME	D10AA3A152-600E	000	Y	PAULIM	20130717
P	078-63335-HS32	SR	1	N	KRAUSNAIME	D10AA3A152-600E	000	Y	PAULIM	20130717
P	078-63335-HS33	SR	1	N	KRAUSNAIME	D10AA3A152-600E	000	Y	PAULIM	20130717

FIG. 40. Catalogue description for a handswitch and related equipment that use the catalogue number (courtesy of Ontario Power Generation).



Afficher Article X052RMZM

Afficher Article X052RMZM

Code Article: X052RMZM
Désignation: ROBINET A SOUPAPE DN40 A COMMANDE MANU
GED

Données gén. | Type de stock | Filières | RIN | Matières | Validités | Caract. tech. | Classification | Commentaires

Libellé long: ROBINET A SOUPAPE DN40 A COMMANDE MANUE
Type d'article: YXC1 Catégorie 1
Groupe marchandises: 29131388
Secteur d'activité: UT UTO
Unité de qté base: PCE Pièce
Code AMN: 052 ROBINETS A SOUP
Etat: Actif
Branche: E EDF-GDF

Catégorie: 1
Réglementation: DESP Soumis au décret équipements sous pression conventionnels du 13 décembre 1999
Catégorie de risque: 2 Catégorie de risque II
Niveau ESPN: NS Non soumis
Qualification: NON Matériel non qualifié
Code IPS/ECS: N
Code référence: NON
Niveau de Qualité:
Péremption: N
Article inactif:
Mise en qualité:
Code CPR | Libellé

Nature Article: N Normal
Spécialité: R ROBINETTERIE
Amiante: AN Amiante non
Unité condition.: 1
Réparable: N
Source radioactive: N
Echange standard: NON
Epreuve hydraulique: N
Propriétaire: UTO
Technicien: F_REPRISEP1

FIG. 41. Catalogue information for a French nuclear power plant's globe valve ('robinet à soupape'; courtesy of Electricité de France).

I.4. BILLS OF MATERIAL

A BOM is a list containing the quantity and description of all materials required to construct a component [108]. In this context, a BOM is an equipment BOM (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 and construction spares). E-BOMs are typically hierarchical in nature with the top level representing the entire component (e.g. a valve assembly), lower tiers representing major subcomponents (e.g. a valve actuator or the valve itself), and even lower tiers detailing individual parts that make up the item separately (e.g. valve body, stem and gasket material; see Fig. 38 for a typical hierarchy). 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 thus a description of an equipment hierarchy and can be applicable to multiple locations and equipment tags within a facility. In addition, multiple BOMs may be acceptable for use in a given equipment location (e.g. two acceptable but different valves may be acceptable in a given location). Plant enterprise systems should keep track of which approved BOM is installed at a given location.

Figure 42 shows a typical BOM header within a nuclear power plant’s enterprise system (a 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 from Fig. 42 is shown in Fig. 43. A similar application at Dukovany nuclear power plant is shown in Fig. 44.

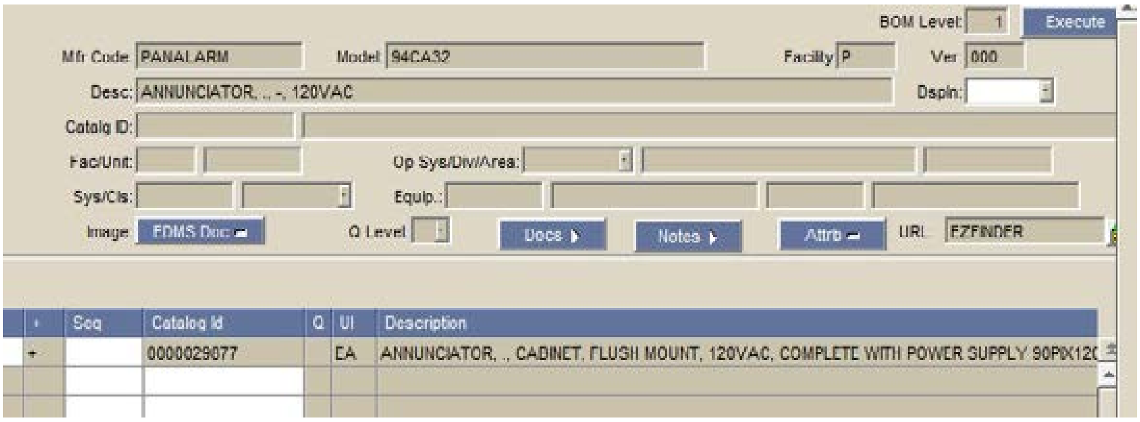


FIG. 42. Top level (‘level 1’) BOM for an annunciator (courtesy of Ontario Power Generation).

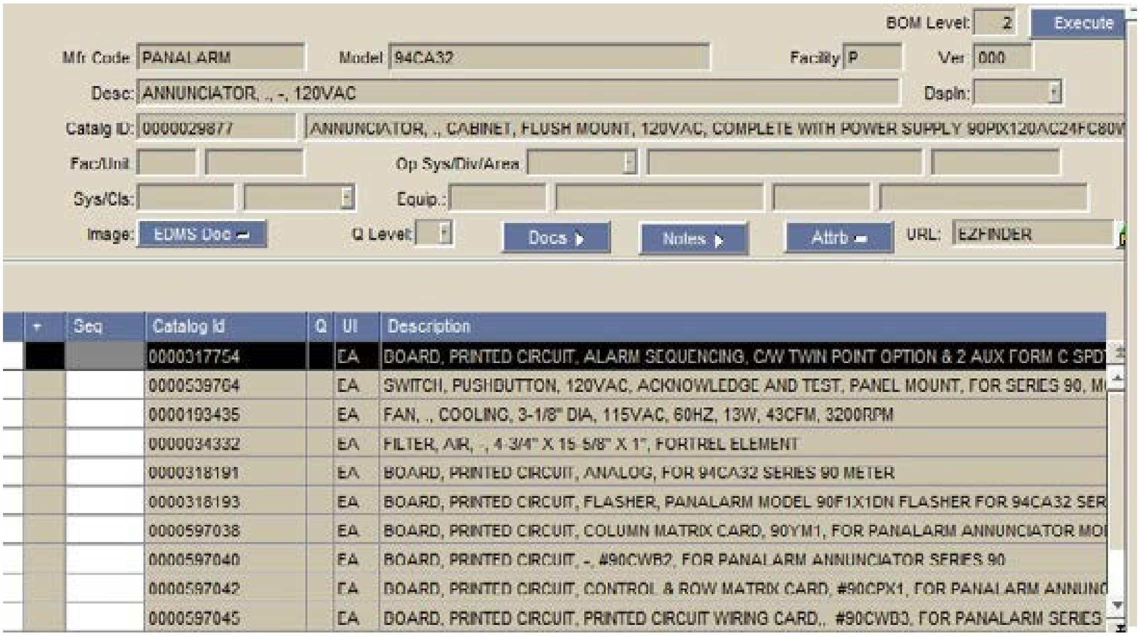


FIG. 43. Lower level (‘level 2’) BOM for annunciator spare parts (courtesy of Ontario Power Generation).

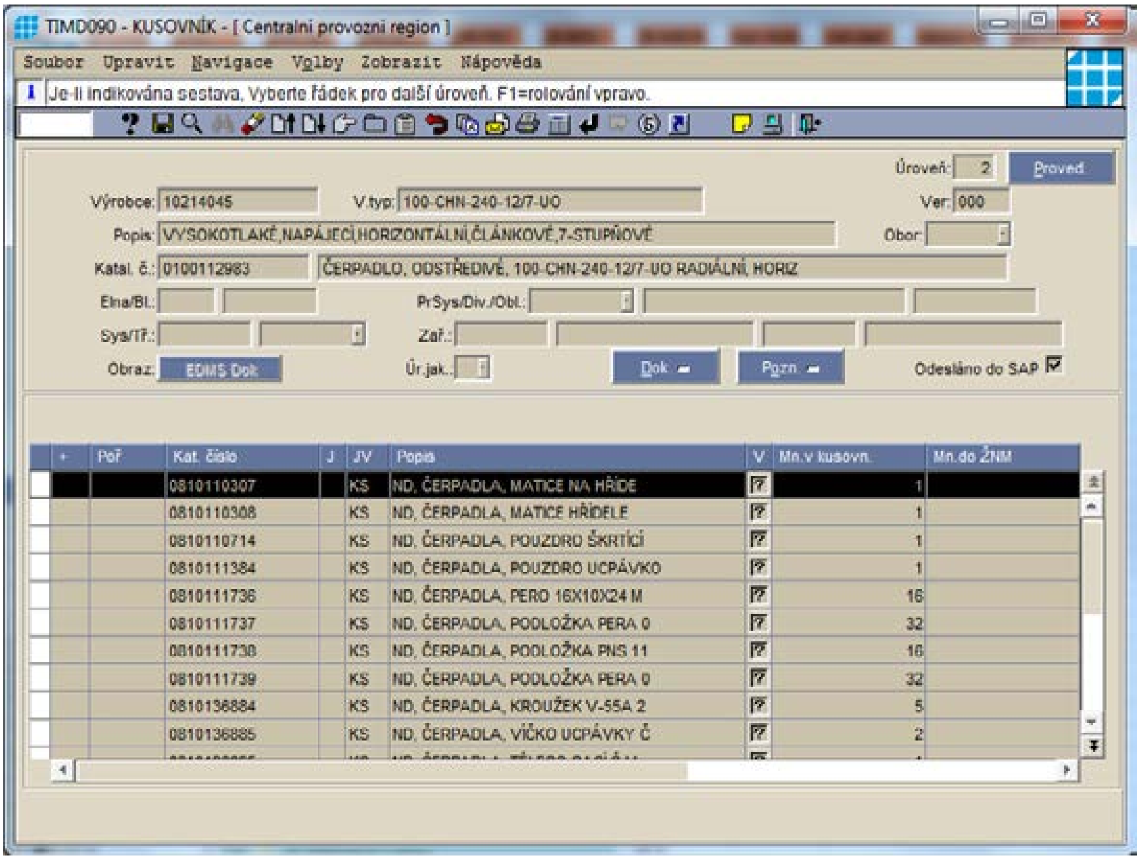


FIG. 44. Dukovany nuclear power plant level 2 bill of materials for a high pressure seven step horizontal pump showing its subcomponents (courtesy of CEZ Group).

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 by considering manufacturer recommendations, maintenance feedback, 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 for a given component.

I.6. QUALITY LIST

As described in Section 2.4, a Q-list describes whether equipment in a nuclear power plant is safety related or not. It is frequently derived from an equipment tag database field in the MEL (i.e. a Yes/No flag for being safety related or not).

Figures 45 and 46 illustrate how this information can be coded in an enterprise application. The safety class field of Fig. 45 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. 46 (‘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).

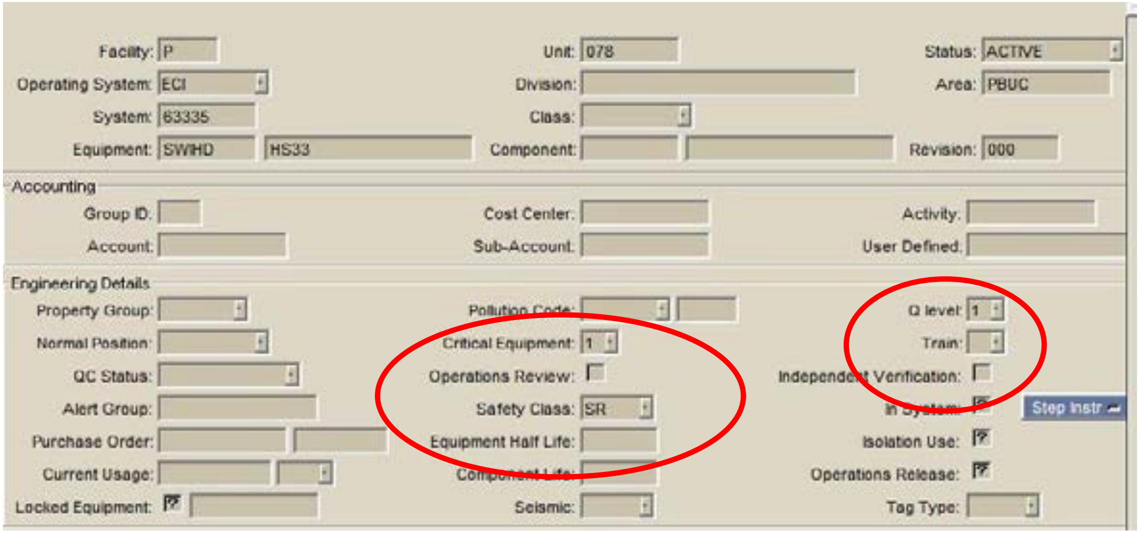


FIG. 45. Sample quality list information with safety class = safety related (SR) and quality level (Q-level) = 1 together with critical equipment code = 1 (courtesy of Ontario Power Generation).

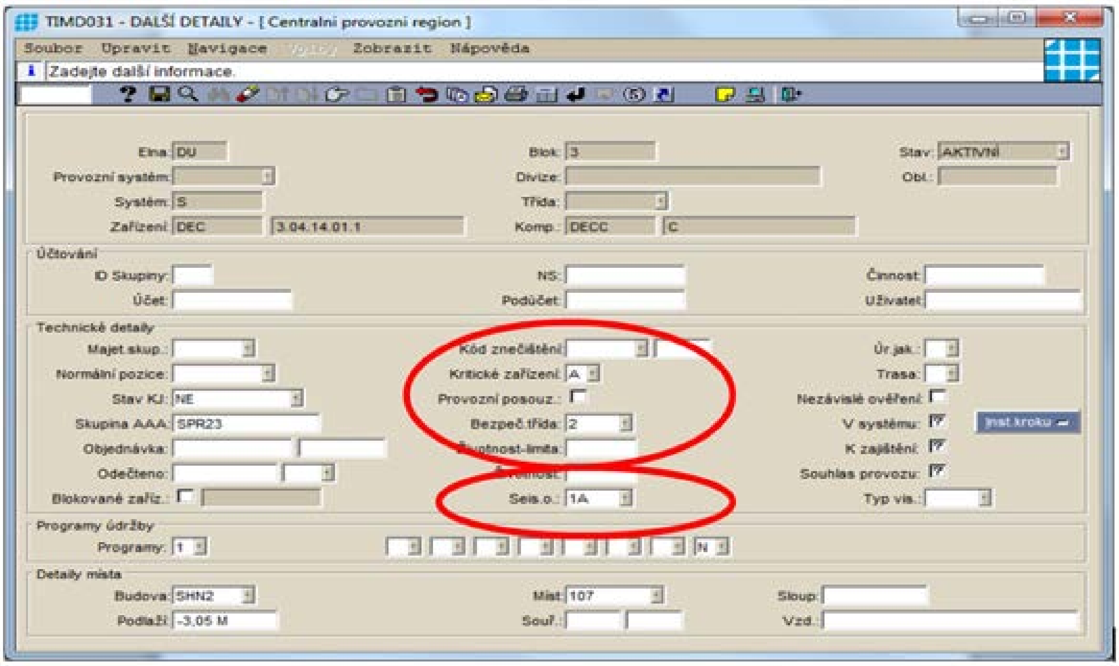


FIG. 46. Equipment data panel for Dukovany nuclear power plant showing seismic class data, criticality level (based on risk classification) and safety level (according to legislation) (courtesy of CEZ Group).

I.7. VENDOR MANUALS

Vendor or maintenance manuals are instructions provided by suppliers on 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. Figures 47–49 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.

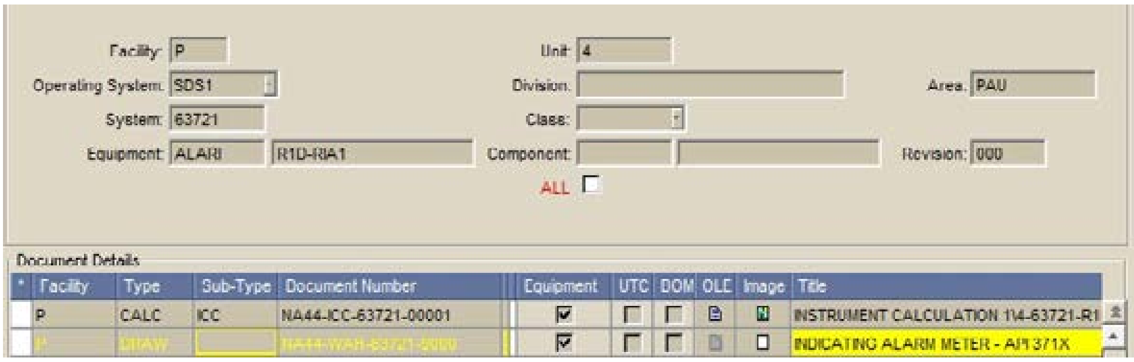


FIG. 47. Vendor manual document number (in yellow text) linked to an equipment tag 4-63721-R1D-RIA1 (courtesy of Ontario Power Generation).

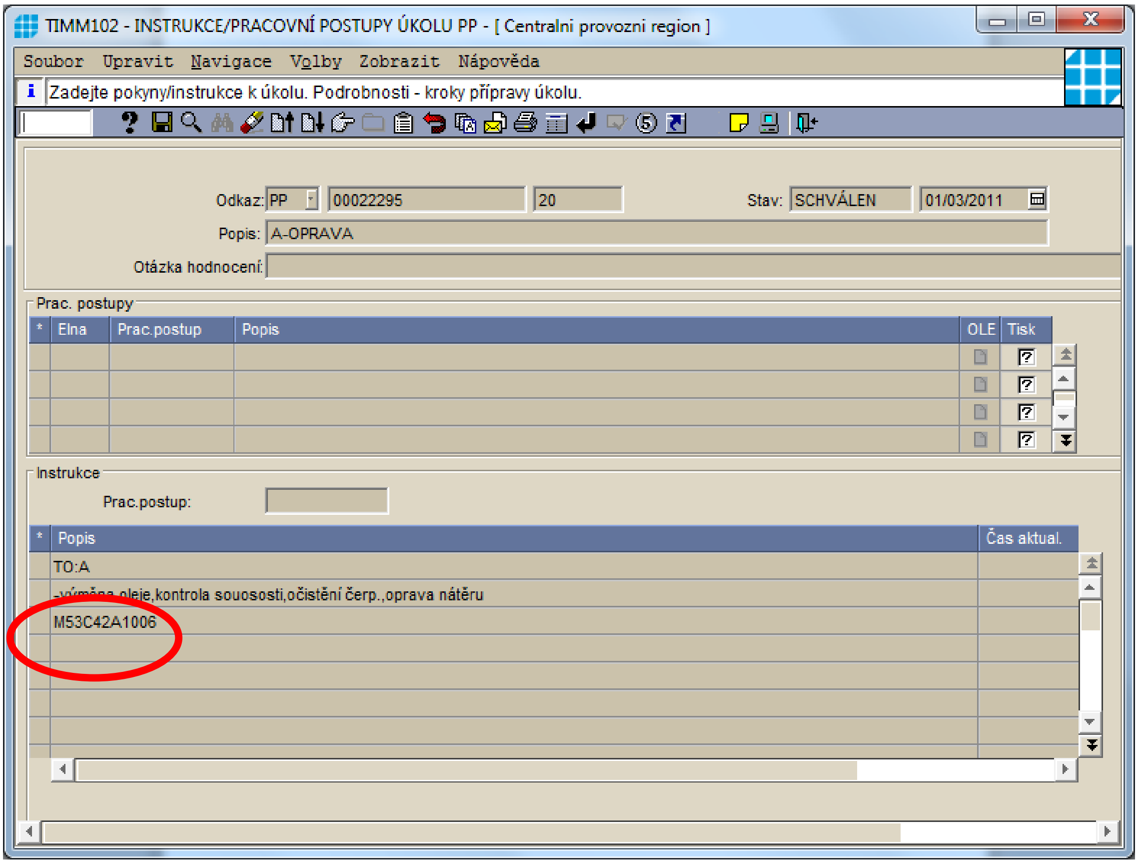


FIG. 48. Reference to maintenance manual in Dukovany nuclear power plant enterprise system (courtesy of CEZ Group).

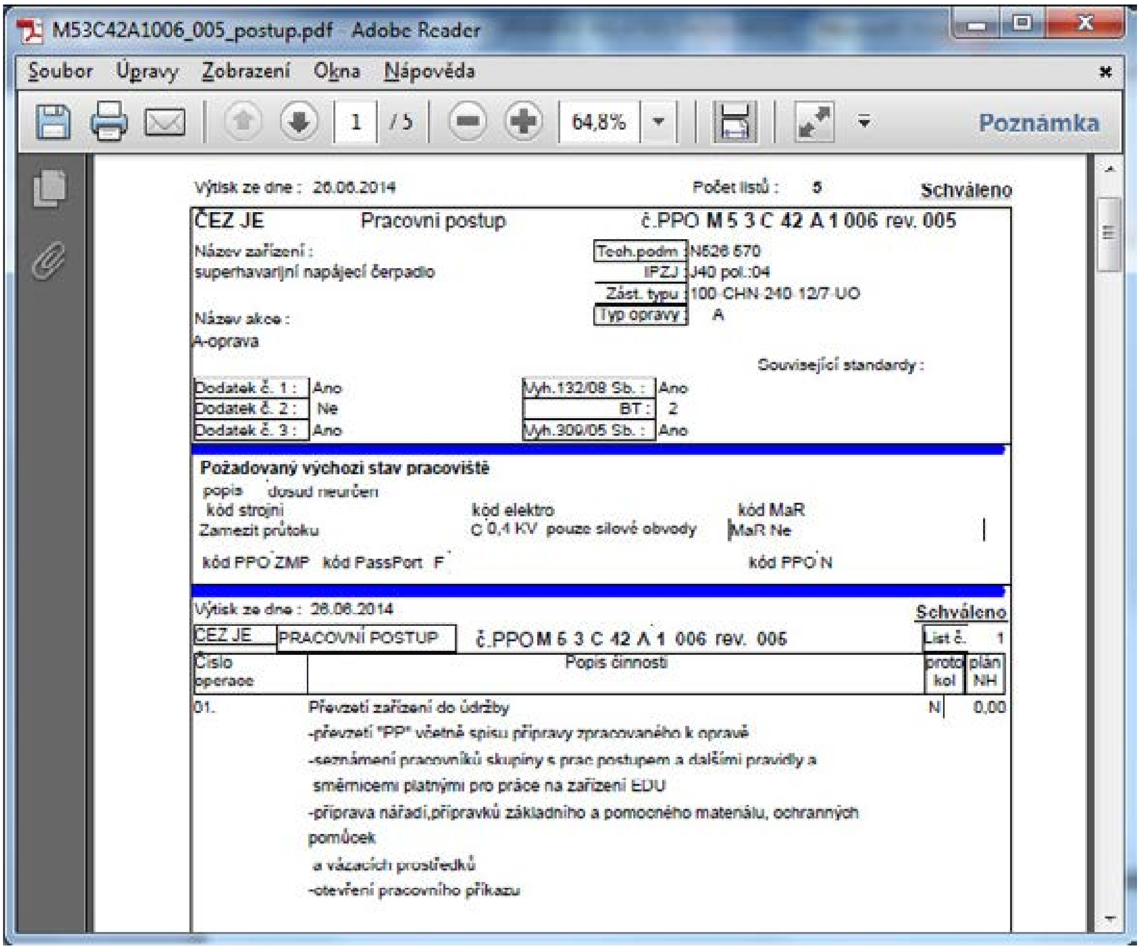


FIG. 49. Maintenance manual referred to in Fig. 48 (courtesy of CEZ Group).

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 [318]. Plants often define such a 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 [318] defines one such methodology and divides equipment into categories of highly critical, low critical, non-critical and run to maintenance. An EPRI report [323] provides some examples of how criticality coding has been implemented at some nuclear power plants. Enterprise systems would include such criticality coding into the information stored against each equipment item.

Figures 45 and 46 in Section I.6 show 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 engineering 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 50 and 51 show 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 towards the former type of system as it allows details to be more readily accessible by facility staff.

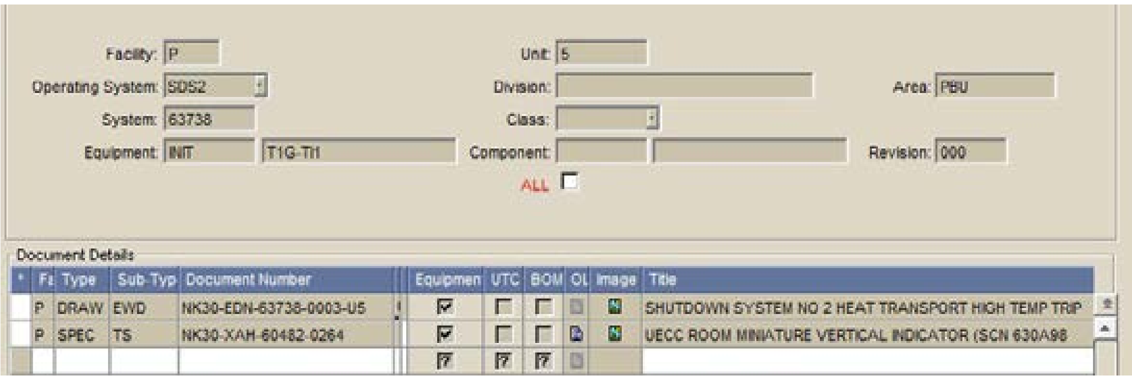


FIG. 50. *Equipment specification linked to equipment tag sample (courtesy of Ontario Power Generation).*

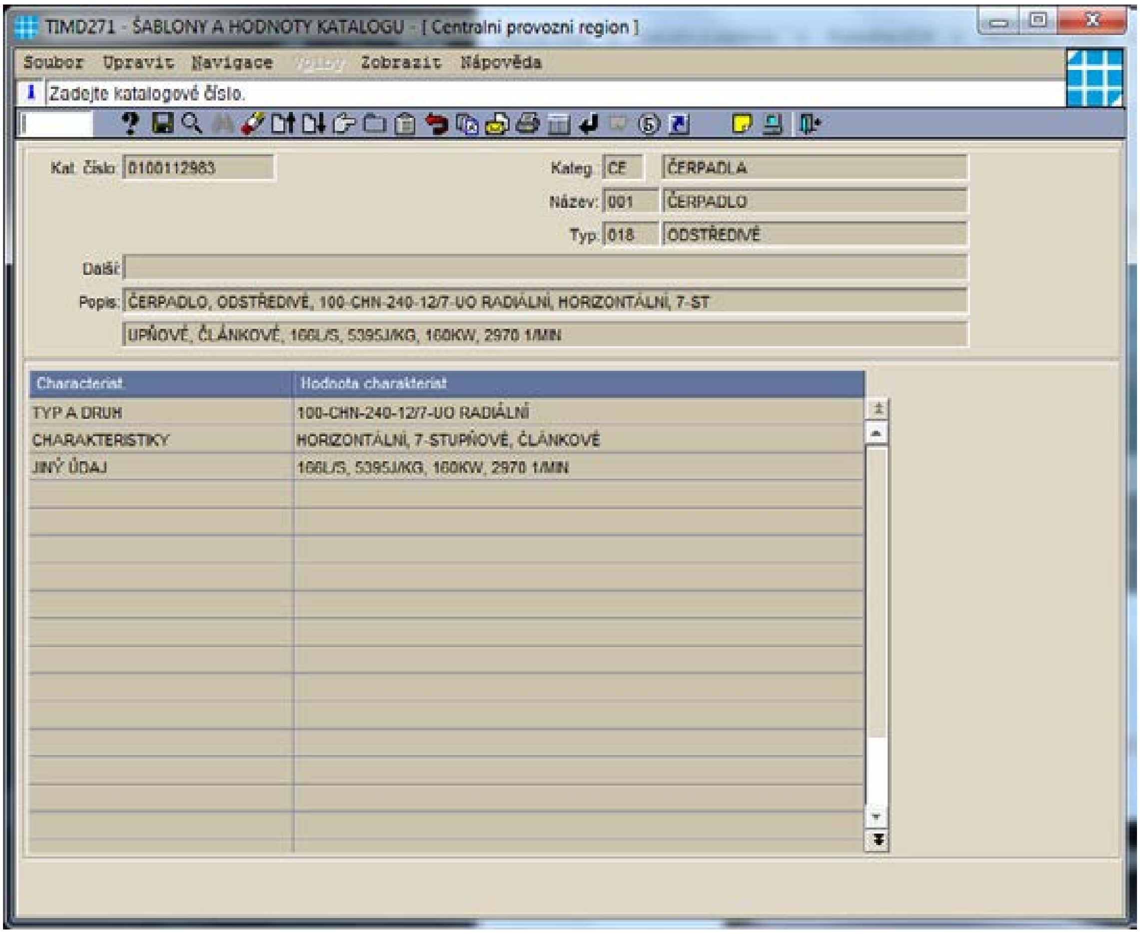


FIG. 51. *Equipment specification reference stored in an enterprise system (courtesy of CEZ Group).*

I.10. MATERIAL TRACEABILITY CONTROLS

As described in Section 3.12, nuclear facilities 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-conforming or deficient. Stock codes or catalogue IDs 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 therefore often assign a unique number to items that is applied by the plant upon receipt. Such numbers are often called UTCs, which stands 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 plant.

Figure 52 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. the UTC number is linked to the equipment tag). Figure 53 illustrates a return ticket showing a UTC coded item being returned to stock.

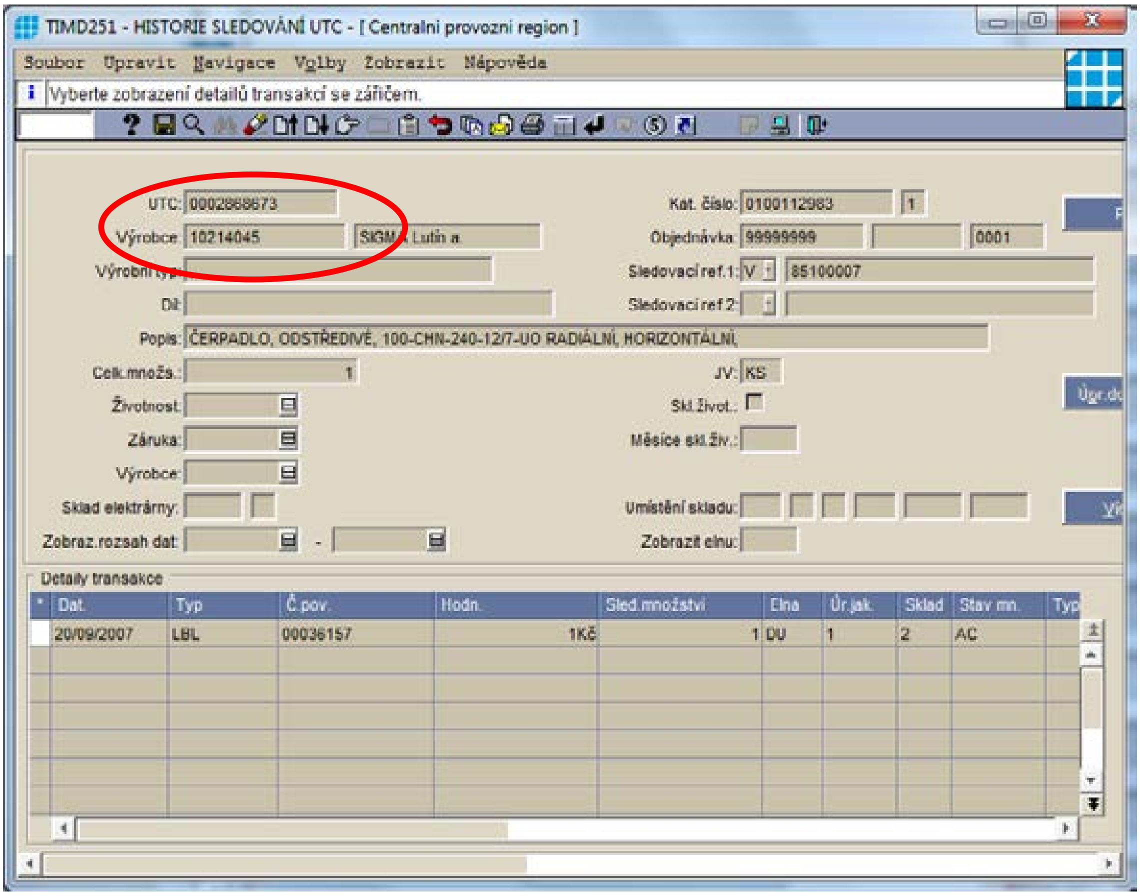


FIG. 52. Uniquely tracked commodity panel in enterprise system (courtesy of CEZ Group).

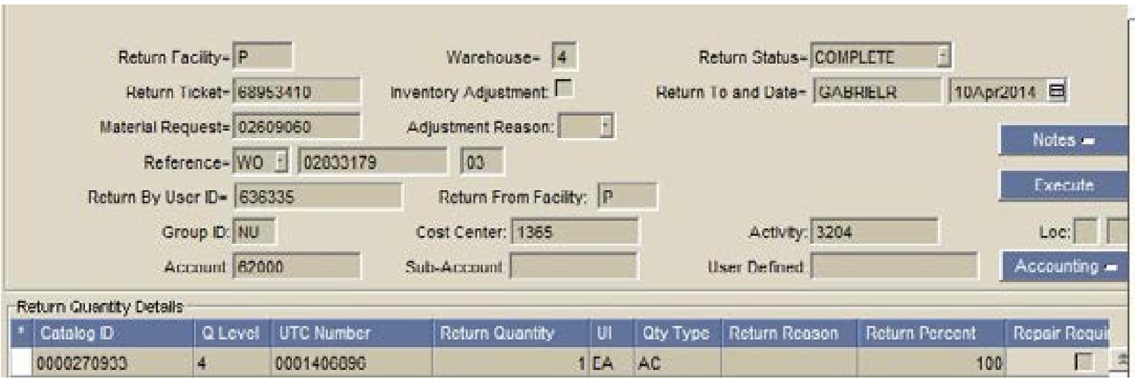


FIG. 53. Uniquely tracked commodity of equipment linked to a specific material return request (courtesy of Ontario Power Generation).

I.11. WAREHOUSE CONTROLS

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

Figure 54 shows an example list of predefined warehouse storage conditions for a nuclear power plant (letters H–Z represent different conditions such as temperature controlled warehouse, moisture control, fire protection required, nuclear safety requirements and whether the item is a chemical). Figure 55 indicates stock availability levels for a component (potentially divided into a number of locations or on order), and Fig. 56 shows a specific warehouse location for an item.

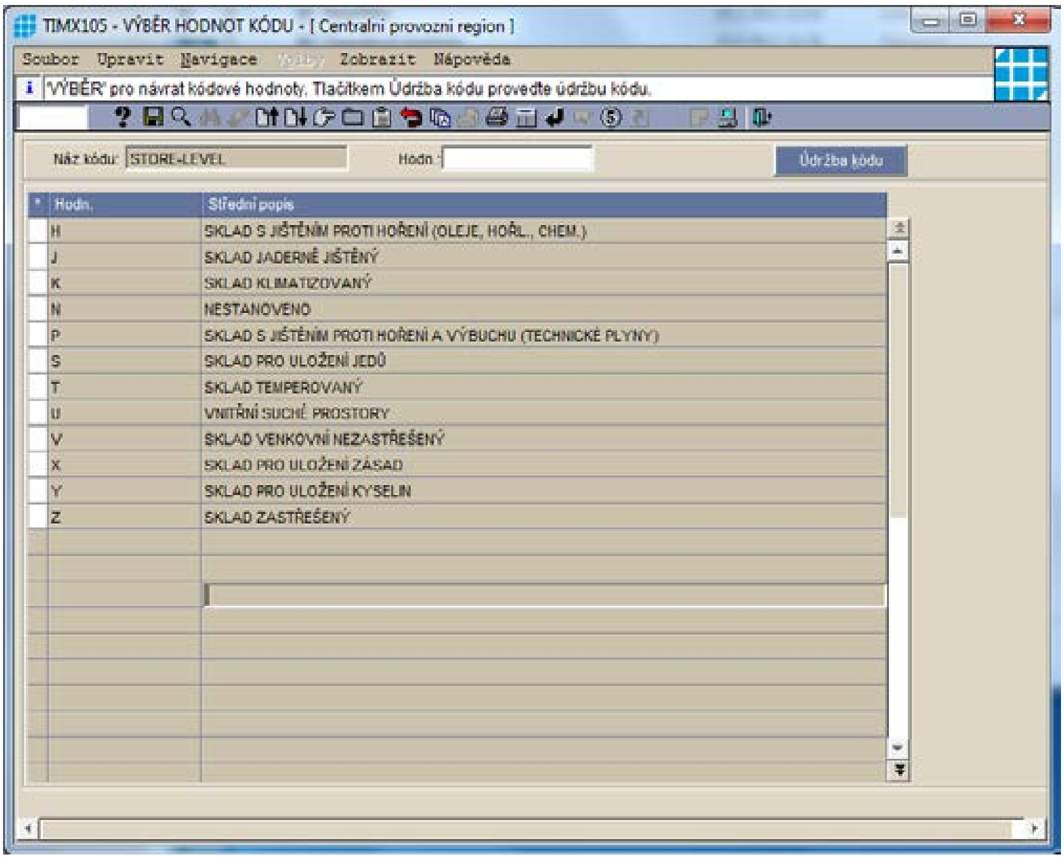


FIG. 54. Dukovany nuclear power plant warehouse storage conditions (courtesy of CEZ Group).

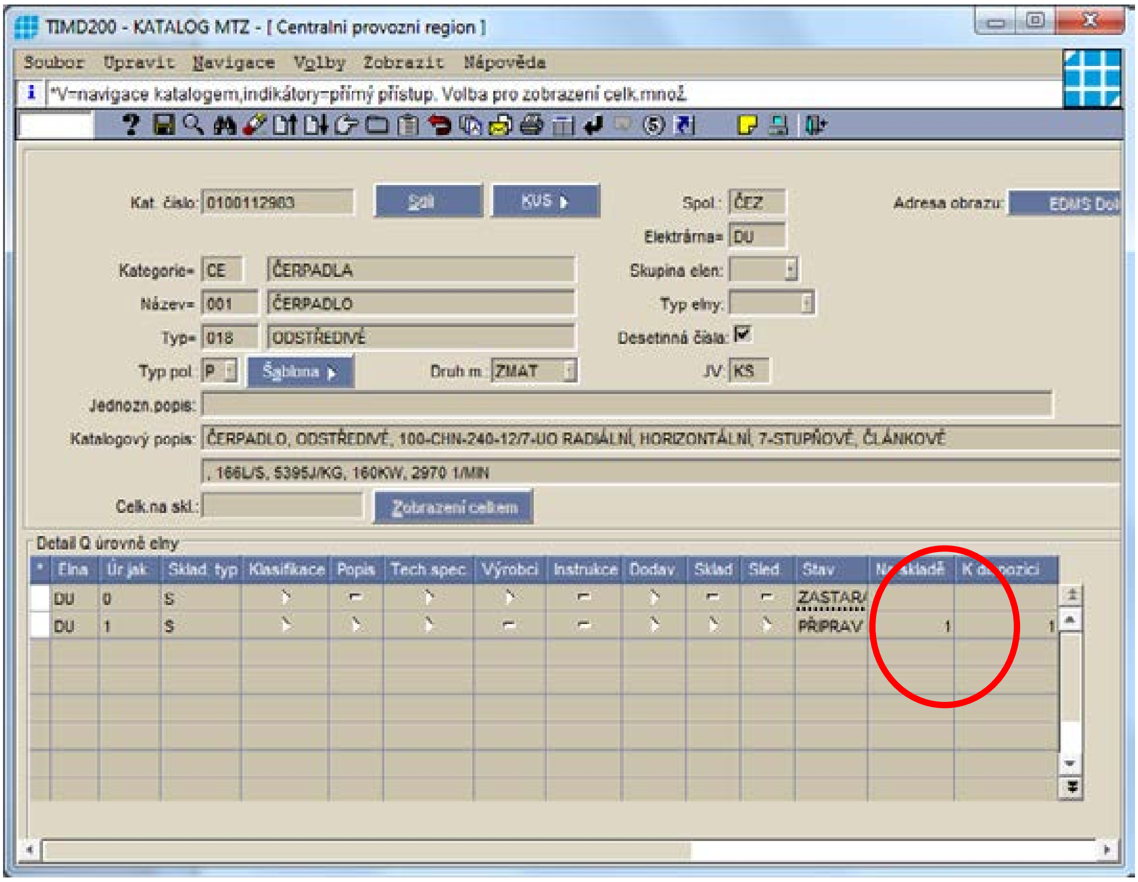


FIG. 55. Dukovany nuclear power plant available stock for high pressure seven step horizontal pump (reproduced courtesy of CEZ Group).

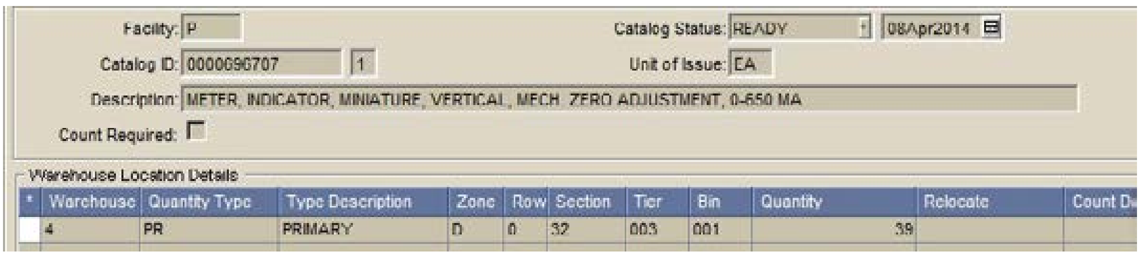


FIG. 56. Warehouse location sample (courtesy of Ontario Power Generation).

Figure 57 provides details regarding reordering of an item. Also shown are the item automatic reorder point (two items on hand), the 'target maximum' (amount targeted to always have on hand), and normal lead times related to an order (35 days internally to place the order, 229 days awaiting receipt from the vendor and 2 days to put the item into the warehouse).

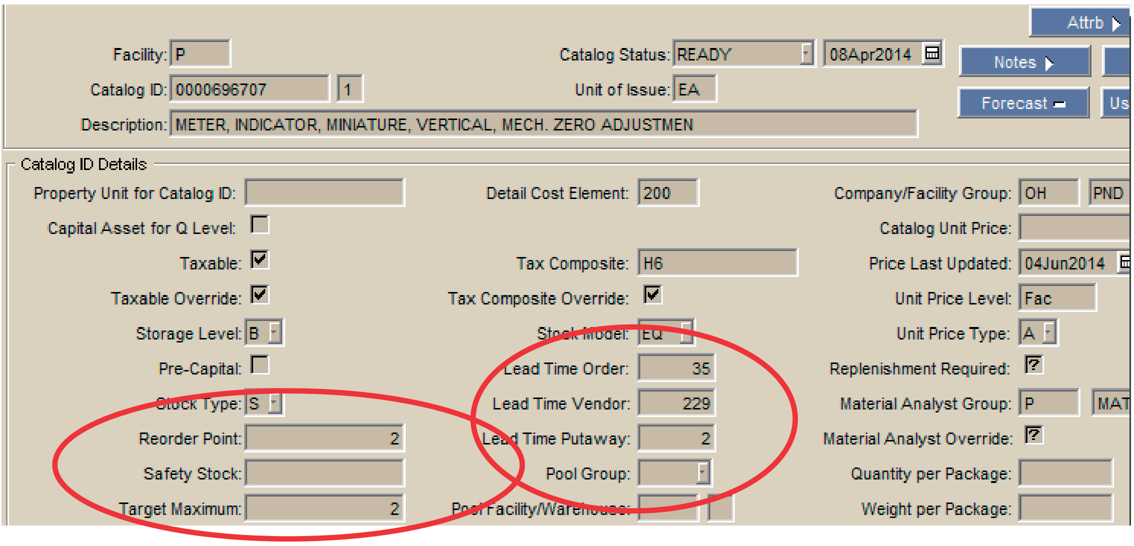


FIG. 57. Reorder point example (reproduced courtesy of Ontario Power Generation).

I.12. MAINTENANCE STRATEGIES

Maintenance strategies are published guidance at nuclear power plants 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 the replacement cost of a component when compared to a typical repair cost. An example might be that 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. The 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 [108]. 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 a nuclear facility wishes to do business with for cost or item criticality reasons and is therefore needed by individuals placing orders for the facility.

I.14. VENDOR MATERIAL AND TEST RECORDS

Nuclear facilities 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 plant staff. Enterprise systems typically provide the capability for such records to be electronically scanned and stored upon receipt for the life of the facility.

Figure 58 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.

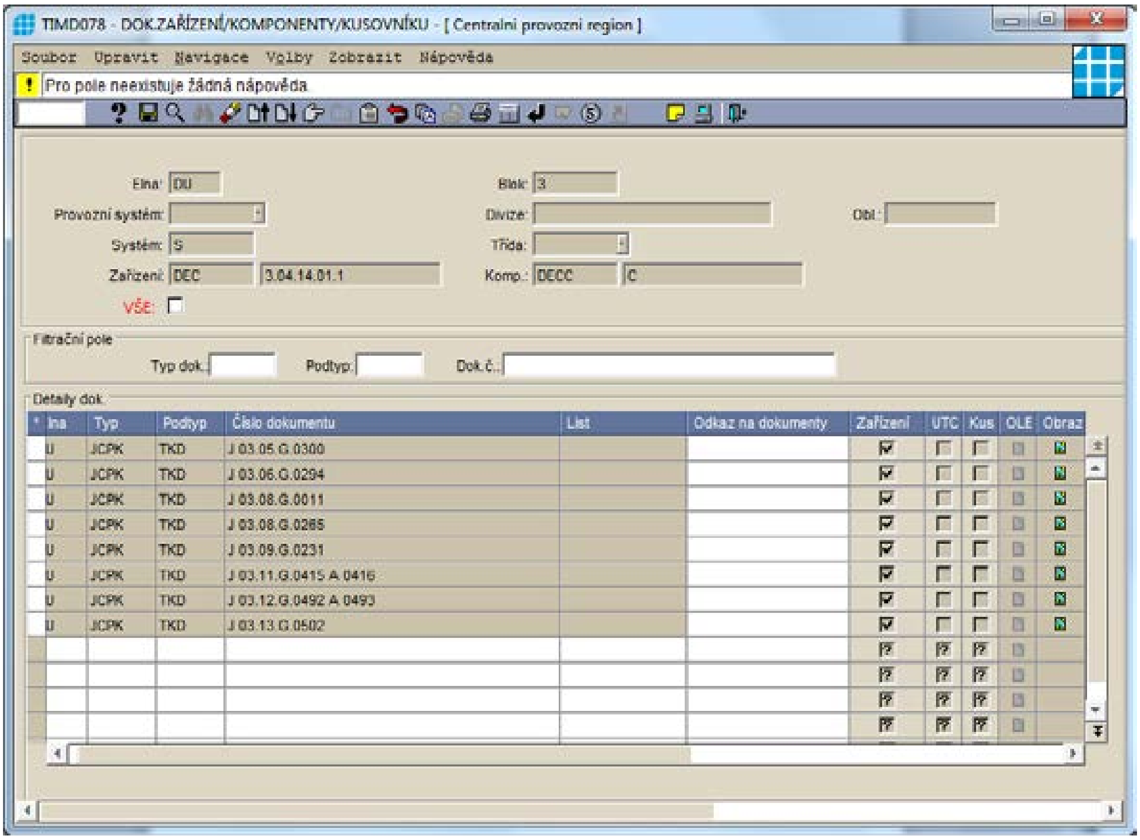


FIG. 58. Documents related to an equipment tag/location (courtesy of CEZ Group).

Appendix II

PROCUREMENT RELATED NUCLEAR EXPERIENCE (OPERATING EXPERIENCE)

Appendix II describes procurement related experience provided by individuals in selected Member States. The Annex to this publication can also be referred to for additional information obtained from an IAEA survey of nuclear procurement professionals.

II.1. CANADA

Canada has 19 operating nuclear power plants at 4 sites, with 3 operating organizations (Ontario Power Generation, Bruce Power and New Brunswick Power). All stations are pressurized heavy water reactors of CANDU design, and went into service between 1971 and 1993. Some units have undergone major mid-life refurbishments. Sections II.1.1–II.1.4 describe typical procurement issues that have impacted the installed fleet and still continue to do so.

II.1.1. Quality assurance vendor programme decline and implications

II.1.1.1. Declining quality assurance programmes decrease efficiency

From the time that the nuclear power plants were built to the time that they came into operation, overall demand for components and parts declined. Numerous vendors responded by not maintaining their vendor quality assurance programmes, since it was not beneficial for them to do so. As a result, a number of changes have occurred.

The decline of vendor quality assurance programmes inherently decreases efficiency and increases risks as operating organizations shift from reliance of vendors avoiding mistakes (via quality assurance programmes) to one of catching mistakes (via CGD). It can be said that most manufacturers are good but do less quality assurance or the least quality assurance they can document.

II.1.1.2. Commercial grade dedication is expensive

There is a greater reliance on CGD. As operating organizations attempted to implement and improve the procurement engineering 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 tended to be costly, and there were limited choices for third party dedicators in Canada in comparison to the United States of America.

II.1.1.3. Difficult to manage and large backlog of necessary audits for vendor quality assurance programmes

When the procurement engineering function was first implemented, there was a drive to rely more on vendor quality assurance programmes (as opposed to source surveillance). As a result and with increasing rigour, those vendors identified as having reliable vendor quality assurance 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, safety related 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 to ensure that timely audits were conducted.

II.1.1.4. Obsolescence continues to be an issue

As the fleet aged, changes in the marketplace occurred (i.e. component design changes were made by vendors and manufacturers went out of business) and obsolescence became a larger issue. Operating organizations had to rely on their engineering organizations to disposition obsolescence on a case by case basis. Electronic parts, in particular, predominated these issues.

II.1.1.5. Decreased and optimized number of vendors on the approved supplier list

Over time, operating organizations reduced their number of vendors that required vendor quality assurance programmes (or the vendors ceased to maintain them) to a more optimized level. This allowed greater focus, enabling more effective and timely audits.

II.1.1.6. Utilities have reduced costly source surveillance

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

Although audits continue to be effective, it has been noted that it is not always possible to carry out true performance based audits owing to low volumes of nuclear work being performed by some vendors. In these cases, operating organizations may opt for source inspections to be carried out on specific orders so that true performance based experience may be witnessed.

II.1.2. Other items

II.1.2.1. Receipt inspection is good

It appears that receipt inspection has been, and continues to be, performed well by operating organizations. With the implementation of procurement engineering, receipt inspection rigour was increased, particularly in terms of documenting receipt inspection activities (both in planning and execution).

II.1.2.2. Trust vendors for non-safety-related items

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

II.1.2.3. Equivalency versus design change

As change occurs (e.g. obsolescence), the need to perform a design change versus an item equivalency will arise. 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.

II.1.2.4. New concerns in counterfeiting

Counterfeit items is a topic gaining more interest by regulators. Counterfeit items do not appear to be a major issue yet, but supply chains have become increasingly global and more complex, and regulators are proactively focusing on this. Recent regulatory changes have required counterfeit item reporting to the regulator. Experience has shown that it can take some time (3–6 months or longer) to conclude that an item is truly counterfeit and longer to determine the source of the counterfeit. 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 procurement engineering function in the 1990s, in response to regulatory pressures to improve procurement rigour, it became apparent that the necessary constructs to execute the procurement engineering 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 lists, BOMs for sustaining maintenance, and associated warehouse and procurement information. These datasets are interrelated and necessary for procurement engineering to identify end uses of the items that are procured. This is a necessary first step in determining whether items are safety related, and an input to which, if any, quality and technical requirements are required. Reconstituting these datasets via configuration management restoration projects was a costly yet necessary first step in ensuring procurement (among other things) could be done effectively. This subject is 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, for example, changing maintenance strategies resulting in changing warehouse stock needs, a backlogged supply chain due to new processes (e.g. implementation of the procurement engineering function), obsolescence and unqualified vendors.

In response to limited stock availability, maintenance organizations would attempt to proactively 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 the 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. procurement engineering staff, designers, buyers, expediters, warehouse staff and work packages assessors) that are needed to perform all the activities required to identify and obtain items from suppliers for use in the plant.

II.2. SLOVENIA

The nuclear power plant Krško (a single 727 MW PWR unit, jointly and equally owned by the electric power utilities of Slovenia and Croatia), after 30 years of commercial operation, with a potential 30 years of life ahead, faces a challenging procurement arena. Vendors and suppliers leaving the nuclear arena, or their consolidation by acquisitions and mergers, reduces the supply sources and competition. Being a single unit operating in accordance with US regulations, codes and standards (nuclear steam supply system supplier origin), Krško faces the challenges of a small volume and narrow market targeted procurement process.

The vintage of installed components (late 1970s and early 1980s) makes them non-standard, potentially obsolete products that require special purchase orders with long lead times and high costs. In case of obsolescence, additional time and costs are involved for engineering (identification of identical or alternative replacement, equivalency evaluations, and design reviews) and qualification efforts.

Through industry exchange of information and experience (e.g. WANO, INPO, IAEA, NUPIC and EPRI), an increasing occurrence of CFSIs is being reported.

The above present some of the procurement challenges for Krško, and in accordance with plant policy, a conservative and proactive approach has been applied. Original equipment manufacturers are the preferred source of supply. Nuclear power plant Krško staff participate in numerous relevant industry activities and utility joint efforts, ranging from specialized education and training, to joint working groups, task forces and memberships, for example, INPO, EPRI, NUPIC, RAPID and POMS. The plant intranet portal contains a living document (open for update) on the topic of CFSIs and spare parts with very specific data and examples to support receiving inspection and procurement engineering activities. Constant investments into plant modernization and component replacements reduce the plant vulnerability to obsolescence. The number of installed obsolete items is approximately 40% lower in comparison with contemporary plants.

II.3. REPUBLIC OF KOREA

The Republic of Korea has had recent experience with CFSIs. In October 2012, CFSI cases were identified in a nuclear power plant in the Republic of Korea, and a full scope investigation of CGD quality documentation was initiated. A number of forged equipment qualification reports were identified in Shin-Kori units 1 and 2 and Shin Wolsung units 1 and 2. In May 2013, the Nuclear Safety and Security Commission ordered immediate shutdown of the affected operating units, and it was decided that an investigation would be expanded to all nuclear power plants in the Republic of Korea (all domestic and foreign equipment qualification test reports for recently purchased safety related items for operating and under construction plants).

The investigations systematically identified applicable test reports, visited or contacted the testing organizations and, where testing was identified as 'falsified' or 'not verifiable', ensured the items were replaced or had a safety evaluation conducted on them. As of December 2013, some 247 examples of forged quality verification documents (QVDs) and 30 forged equipment qualification reports were uncovered for the operating fleet, and 408 'unidentified' QVD cases and 7 equipment qualification cases were treated the same as the forged cases. More cases were discovered for new or under construction nuclear power plants [324]. Typical items supplied with false QVDs included shafts, support studs, hexagonal nuts, bolts, drain pipe, air filters, pulleys and sleeves.

Some countermeasures initiated included improvements in the procurement, contract and quality assurance systems (organization, supervision and IT improvements), tightening disqualification of counterfeiting suppliers (1–10 years), improvements in test result processing and verification (validating hardcopy versus electronic data, registration within IT systems), strengthening manufacturing and receipt inspection processes for CFSIs, registration of domestic CGD specialized organizations, and encouragement of anonymous reporting via an ombudsman system and financial incentives.

II.4. UNITED KINGDOM

II.4.1. Regulation

Procurement of nuclear facilities in the United Kingdom is subject to nuclear site licence conditions issued by the Government through the Office for Nuclear Regulation (ONR). Each nuclear facility in the United Kingdom must have a nuclear site licence and must comply with the 36 general conditions that are set out in the Licence Condition Handbook (October 2014) [325].

In addition, the ONR has published a technical assessment guide [66] for the procurement of nuclear safety related items or services; a guide [67] on intelligent customers and a guide [326] on records management also apply to the procurement phase, and ONR interventions look across all three of these documents.

Procurement governance arrangements need to be developed (including a policy, manual, procedures and template documents) and approved within the utility company. The ONR monitors the arrangements via interventions and deems the arrangements to be 'adequate'.

Some procurement contracts become lifetime records for nuclear safety related systems and need to be retained while the plant is in place. A formal record retention schedule needs to be created and managed by the procurement organization. The utility company may elect to set hold points during the various procurement stages and, importantly, obtain approval for the contract and its content from all technical stakeholders (with particular emphasis on the engineering, project management and design authority quality functions before contract award). For contracts with high nuclear safety significance, the ONR may enforce additional hold points before and/or after contract award.

There is a general requirement that the utility puts in place adequate arrangements to ensure that suitably qualified and experienced personnel are employed to implement adequate management arrangements and to act as an intelligent customer. This includes being able to demonstrate that any contractor or supplier is suitable, capable and experienced, and has the necessary processes and procedures to deliver the scope of work that they are being contracted to provide.

II.4.2. Current nuclear procurement activities in the United Kingdom (October 2014)

There are three main categories of nuclear power plants in the United Kingdom, reflecting the different life cycle stages: new build, existing operational plants and post-operational plants (i.e. those in decommissioning). Each category attracts different procurement strategies to address the challenges and different issues faced.

II.4.2.1. New build

Table 28 summarizes the approaches being taken in respect of realizing new nuclear power stations in the United Kingdom.

TABLE 28. THREE NEW NUCLEAR POWER STATIONS IN THE UNITED KINGDOM

Utility name	NNB GenCo	Horizon Nuclear Power	Nugen
Shareholders	Electricité de France (lead) China General Nuclear and China National Nuclear Corporation AREVA Others	Hitachi GE	Toshiba GDF Suez
Nuclear technology	AREVA EPR	Hitachi boiling water reactor	Westinghouse AP1000
Turbine provider	Alstom	GE	Toshiba
Site locations	Hinckley Point Sizewell	Wylfa Oldbury	Moorhouse
Procurement strategy	150+ contracts with scope ranging from major turnkey systems (e.g. turbine group) or single original equipment manufacturer (e.g. pumps)	Hitachi GE will procure equipment from original equipment manufacturers and integrate	Westinghouse will assemble modules for delivery to site and procure equipment from original equipment manufacturers and integrate
Service contracts	All developers will place contracts for: — Major civil works — Mechanical piping/equipment installation — Electrical cabling — Technical services consultancy		
Site development	All developers will place separate contracts for site enabling works and off-site developments such as access roads and worker accommodation		

II.4.2.2. Existing fleet in operation

In the United Kingdom, two companies run operational nuclear power stations:

- Magnox Limited, which is owned by the Government, has two operational power stations at Wylfa and Oldbury. EU procurement regulations apply.
- EDF Energy owns and operates 14 advanced gas cooled reactor nuclear plants across seven sites at Torness, Hunterston, Heysham (1 and 2), Hinkley Point, Dungeness, Hartlepool, and one PWR plant at Sizewell.

The procurement challenge is to source spares for the ageing fleet, provide support during major outages and to procure engineering technical services to support life extension.

II.4.2.3. Existing post-operational fleet

The UK Government is responsible for all decommissioning of existing facilities through the Nuclear Decommissioning Agency; therefore, all procurement follows EU directives.

A joint venture between Fluor and Cavendish is responsible for Magnox decommissioning, which, in turn, appoints contracts and places equipment contracts centred on defuelling, cleaning, safe storage and demolition.

II.4.3. Procurement strategies

Typically in the United Kingdom, standard forms of contract used are based on FIDIC [122], NEC3 [123] and Institution of Chemical Engineers [124] contracts. However, other customized forms of contract are also used.

There is a tendency in the United Kingdom to adopt collaborative approaches between employers and contractors where the work scope is complex or where the contract term spans several years. This allows for a target cost or incentivized payment mechanism. It also allows for framework contracts to be established, with key performance indicators to be included, with safety and security as paramount.

Other features of procurement in the United Kingdom with regard to nuclear power plants include:

- Competitive tendering is widely used.
- Many companies form joint venture arrangements to bid for large nuclear contracts.
- Overall, utilities are not able to pass on the full liabilities associated with nuclear equipment or services to the supply chain.

II.4.4. Other applicable information

Other information applicable to nuclear procurement in the United Kingdom includes the WANO/INPO document on principles for excellence in nuclear supplier performance [135] and GSR Part 2 [7], GS-G-3.1 [8] and GS-G-3.5 [9].

II.5. UNITED STATES OF AMERICA

There are currently five units under construction at three sites in the United States of America. Twenty-four companies currently operate 63 commercial nuclear plant sites, with a total of 102 units. Some of these units have undergone major upgrades, such as steam generator replacements and reactor vessel head replacements.

Commercial generating stations in the United States of America are of BWR and PWR designs. These plants started commercial operation between 1969 and 1996. Sections II.5.1–II.5.5 describe typical procurement issues that have and continue to affect the installed fleet.

II.5.1. Decline in number of suppliers that implement nuclear quality assurance programmes

US regulations require that entities licensed to operate commercial nuclear facilities manage activities associated with basic components (safety related equipment) in accordance with the quality assurance programme requirements included in appendix B to 10 CFR 50 [70]. In turn, licensees impose these quality assurance programme requirements as part of contractual terms and conditions that apply to the purchase of safety related equipment and replacement items.

As major procurement activities to support construction of the current US fleet came to a close in the late 1980s, the number of suppliers in the United States of America that implement a quality assurance programme meeting the requirements of appendix B to 10 CFR 50 [70] has decreased. The inability to procure spare and replacement items from suppliers with a nuclear quality assurance programme led to the development of a CGI dedication methodology.

Under a nuclear quality assurance programme, suppliers establish adequate confidence that the items they provide as safety related meet design requirements. Items that are not supplied as being safety related are referred to as CGIs. CGD methodology is used by nuclear plant licensees or other dedicating entities with a nuclear quality assurance programme to obtain reasonable assurance that the item being dedicated is capable of performing its intended safety functions.

II.5.2. Use of commercial grade dedication for increasingly complex devices and applications

Reliance on CGD as a means of accepting spare and replacement items for use has increased substantially over the past three decades. Once used as a last resort by nuclear plant licensees to accept relatively simple spare and replacement items, CGD is now used by licensees and suppliers to accept a wide range of items, and is used by some suppliers as a primary means of delivering safety related items to the marketplace.

Use of dedication by suppliers and for increasingly complex items has resulted in development of updated guidance on dedication [136], as well as guidance on how to dedicate complex equipment such as digital equipment [210, 215].

II.5.3. Digital equipment and cybersecurity

Analogue equipment is increasingly difficult to find as it is replaced with digital technology. New requirements that apply to procurement of digital equipment impact replacement of older equipment with digital elements. It can be difficult or impossible to successfully apply new requirements to older digital equipment. Several US regulations apply to digital equipment, such as the NRC regulatory guide [237] and 10 CFR 73.54 [235].

II.5.4. Obsolescence

Obsolescence is a continuing challenge. Some equipment is essentially obsolete by the time a new plant is commissioned, and the amount of obsolete equipment increases over time. Almost every plant in the US fleet has implemented programmatic controls to address obsolescence. Approximately 20% of plant equipment is currently classified as obsolete in that it is no longer supported by the original equipment manufacturer.

The basic model implemented is outlined in an EPRI report [186]. The model includes the identification, prioritization and resolution of obsolescence issues.

One of the biggest challenges in identifying which equipment and parts are obsolete is the quality and completeness of data in plant information systems. Identifying obsolete equipment involves contacting the original equipment manufacturer to determine whether it still supports the equipment. In some cases, plant information systems do not include the original equipment manufacturer make and model number information for equipment (other forms of ID, such as plant unique equipment ID numbers or part numbers assigned by the architect–engineer or nuclear steam system supplier are used). Recovering original equipment manufacturer make and model number information can be challenging and time consuming.

II.5.5. Counterfeiting and fraud

The US industry implemented measures in the 1980s to prevent counterfeit and fraudulent items from being introduced into nuclear power plants. These measures are outlined in Refs [107, 130] (see also Ref. [246]). Although these measures have served the industry well, the commercial nuclear industry in the United States of America recognized the threat presented by the global increase in counterfeiting. The industry has undertaken voluntary initiatives to address the threat caused by counterfeit and fraudulent items. In July 2014, EPRI published a report [247] that discussed measures which can be taken to prevent and detect counterfeit and fraudulent items as well as measures that can be taken to control items suspected of being counterfeit or fraudulent.

Appendix III

NON-NUCLEAR INDUSTRY EXPERIENCE

III.1. AUDITING AND SUPPLIER QUALITY PROCESSES

The nuclear industry is not the only industry that has safety and quality as shared goals. The aerospace, defence, transport and medical device industries are notable examples that have developed auditing processes which can provide potential lessons to be learned for the nuclear industry.

For example, like nuclear power plants, 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 assurance programmes and sharing of auditing results beneficial.

Within the aerospace industry, 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, to accredit suppliers and to define operational programme requirements. All major aerospace companies (e.g. Boeing, Airbus, Bombardier and Embraer) participate, and approximately 5000 supplier audits are performed each year. Non-conformances are responded to in a similar way as one might expect in the nuclear industry, 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 [327]. 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 (see Fig. 59) is the step whereby an industry wide task group has the opportunity to review audit results. Task force members have 14 days to approve the audit for accreditation

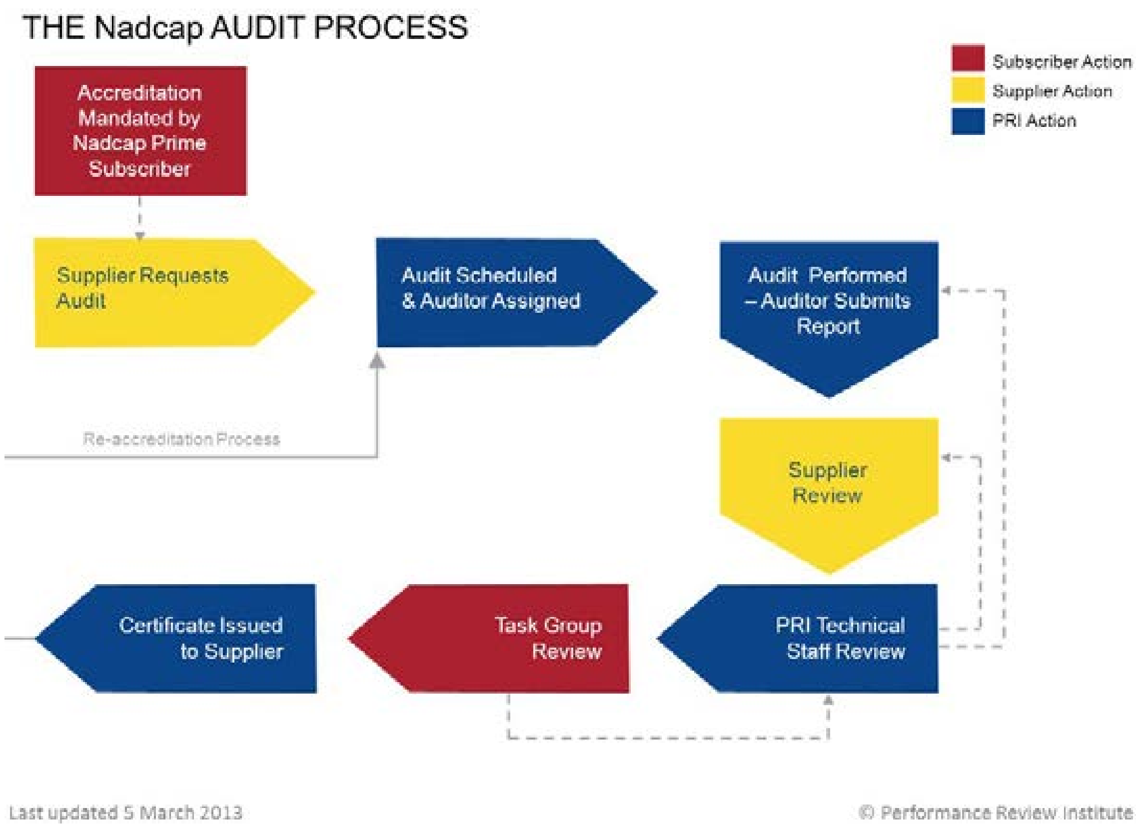


FIG. 59. Nadcap audit process for aerospace suppliers (reproduced from Ref. [328] courtesy of Performance Review Institute).

or to raise additional questions. In case of questions, the responsibility passes back to the PRI staff engineer for resolution with the supplier. For the vast majority of the time, however, the task group supports accreditation and PRI sends out a certificate to the supplier because of the work put in by the supplier and staff engineer.

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 [329] is a common quality management standard for aviation, space and defence 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 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 transport, PRI is developing an accreditation programme based on the aerospace industry's Nadcap programme. Like Nadcap, the programme is intended to 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 transport and power generation accreditation.

Within the medical devices industry, PRI similarly administers the MedAccred industry managed supply chain oversight programme, which reduces the risk to patient safety by addressing many of the challenges posed by today's global, multitier supply chain. Regulatory requirements addressed include US Food and Drug Administration (FDA) requirements, the ISO 13485 medical devices quality management system [330] and the European Medical Device Directive [331]. In the United States of America, purchasing controls is one of the top cited FDA inspection observations for the medical device quality system, and such violations have been included as an element of several enforcement actions (e.g. warning letters and consent decrees) [332].

CII has published a report [333] that compares supplier quality practices in healthcare, aerospace and shipbuilding industries. It reports that the healthcare industry primarily deploys quality processes during the planning and supplier selection processes, aerospace companies perform quality surveillance at supplier facilities during the fabrication (execution) and release from shop stages, while the shipbuilding industry follows a product life cycle management process that rejects packages during execution, release from shop, received at site and mechanical completion stages. The report recommends development of supplier partnerships, sharing comparative data between partners and suppliers to enhance productivity, managing the product life cycle, involving fewer, higher quality, more dependable suppliers, and creating a common IT platform to allow for secure sharing of relevant project information. It also recommends using non-conformance processes as teaching opportunities for those involved.

III.2. COUNTERFEIT AND FRAUDULENT ITEMS

As was discussed in Section 7, the issue of counterfeit and fraudulent items affects many industries in addition to the nuclear industry. EPRI has documented recent incidents in other industries [247], including cases of counterfeit lifting slings (non-nuclear power plant), pump skid lifting lugs (petrochemical industry), fraudulently certified pipe (Chinese manufactured pipe for the Datong power station that was fraudulently certified in the United States of America), contaminated radioactive steel shipped to Germany from India, fraudulent ISO 9001 certifications for valves at a United States Department of Energy facility, fraudulent welding certifications, fraudulent titanium tubing for a defence helicopter and various fraudulent electrical parts. These all point to the need for information sharing within and outside of the nuclear industry to combat this issue.

III.3. ELECTRONICS INDUSTRY

In 2001, the National Electronics Manufacturing Initiative organized a team of industry leaders to investigate and define the issues surrounding BOMs [334]. BOM errors were found to typically fall within three categories: completeness, consistency and correctness, with up to 80% of all BOMs being found to have some issues. A goal was to address such issues involving the exchange of information between business partners, who were increasing becoming more diverse. The team developed a set of Product Data eXchange specifications that were designed to create ‘perfect BOMs’. In addition, a set of supply chain and BOM standards were produced [335–337]. The specifications utilize an extensible mark-up language encoding scheme to enable supply chain partners to exchange product content, changes and subsequent manufacturing information in a common language.

These efforts point towards the importance of BOM integrity and configuration to general industry and towards potential future initiatives that might be possible within the nuclear industry to transfer BOM data between nuclear power plant vendors, suppliers and operating organizations.

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 (ROPs), reorder quantities (ROQs) and safety stock levels is important for efficient operation. This appendix provides some examples of calculations that can be performed.

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

$$\text{ROP} = (\text{daily usage} \times \text{lead time (in days)}) + \text{safety stock} \quad (1)$$

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

The appropriate economic order quantity (EOQ) is a well known inventory concept and can be calculated by the following formula [338]:

$$\text{EOQ} = \sqrt{\frac{2DS}{HC}} \quad (2)$$

where

D is the annual product demand in quantity per unit time, which is also known as a rate;
S is the product order cost, which is the cost of making an order and is independent of EOQ;
C is the unit cost;

and H is the 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 can be 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 the 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:

$$\text{ROQ} = \text{SL} \times \text{UR} \quad (3)$$

where

ROQ is the reorder quantity (based on shelf life and usage);
SL is the shelf life in years;

and UR is the 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 PURCHASE ORDER PARAGRAPHS

EPRI has defined a number of standard clauses related to procurement of items and delivery of substandard and counterfeit items (see appendix A of Ref. [107]). These have been adapted below for an international audience and updated for Appendix V. 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. Appendix V does not provide sample procurement language that is specific to computer security related procurement (see Refs [239, 240] for sample language that is applicable to that area).

V.1. MANAGEMENT SYSTEM

The items/services shall be provided in accordance with [the Supplier's/Manufacturer's management system], which has been approved by [the Buyer's quality organization] at the following location: [place] ________.

The Supplier shall maintain and implement this management system in accordance with [the applicable standard] and allow access to the 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, its Authorized Representative and/or an Authorized Inspection Agency and/or an Authorized Inspector and/or an Authorized Nuclear Inspector as identified in the appropriate regulations shall have rights of free access to the Supplier's and any subtier supplier's facilities and records for inspection or audit by the Buyer, designated representatives 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 manufacturing, regulatory, technical and quality assurance programme requirements as identified in the Purchase Order.

V.3. CORRECTIVE ACTION PROGRAMME

The supplier should be aware that a corrective action programme must be maintained and demonstrated in order to do business with the Buyer as a requirement of being on the Approved Supplier Listing (ASL).

V.4. ADDITIONAL MANAGEMENT SYSTEM REQUIREMENTS

Additional management system requirements: [to be added].

V.5. NATIONAL NON-CONFORMANCE REPORTING REQUIREMENTS

It is the responsibility of the Supplier's senior management to immediately notify the Buyer in writing when a known or suspected defect or non-conformance is discovered that affects, or may affect, a product that has already been delivered to the Buyer. The notification shall be on the company's letterhead and include the identification and endorsement of senior quality management. The company must submit such notification by email to: [enter address].

The notification shall include the following details as a minimum:

(a) A clear description of the defect or non-conformance.
(b) An assessment of the impact of the defect or non-conformance to the product form, fit or function. The potential impact on safety should also be addressed, if known.
(c) An identification of the Buyer catalogue identification numbers(s) that are affected including Buyer purchase order and line item numbers, ship date, quantity, manufacturer product identification/traceability (i.e. serial number, lot number, batch number and manufacturing date).
(d) Immediate short term actions to be taken to remedy the situation by the Buyer (addressing the availability of replacement item(s) and delivery time lines).
(e) Long term corrective action plan to address the root cause for the defect or non-conformance, including completion/implementation commitments.

The supplier shall extend the above reporting requirements to subtier suppliers.

The requirements of [national non-conformance reporting requirements, where applicable, e.g. 10 CFR 21] apply to this Purchase Order. If you (the Supplier), or one of your subsuppliers, identify 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 Buyer as this address:

[Manager, Nuclear Quality, Purchasing Organization name, address and telephone number]

V.6. COMMERCIAL GRADE AND NON-SAFETY-RELATED ITEMS

All items, and parts thereof, supplied to this Purchase Order are considered to be safety related items when shipped by the Supplier unless otherwise stated by the Supplier. When an 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 with access to such documentation upon request.

Parts of safety related items that 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: [Add 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: [Add Purchasing Organization name and address].

V.7. 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 and functional properties) as those originally qualified as per [add applicable specifications, codes or standards originally used].

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

V.8. 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 or 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: [add 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.9. 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.10. 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.11. PRESSURE BOUNDARY CODE REQUIREMENTS

[Add applicable pressure boundary code] items shall meet: Code Edition: [add number].

Material for items governed by the rules of [add 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 [add 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.12. QUALITY SYSTEM CERTIFICATES

[Applicable pressure boundary code] material procurement for material manufacturers or material suppliers with [applicable] quality system certificates:

(a) Material shall be supplied in accordance with [add applicable pressure boundary code] under an approved management system by a material manufacturer or material supplier having an [add applicable certification].

(b) The material manufacturer shall include its Certificate Number and expiry date on the Certified Material Test Record (CMTR) or Certificate of Compliance as required by [add applicable pressure boundary code].

V.13. PROCEDURE/CERTIFICATION APPROVAL

Suppliers performing work on-site who plan to use their own procedures shall submit the procedures to the designated representative listed below for review and approval: [add name and telephone number]

Suppliers 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.

Contractors shall provide the following personnel certifications prior to the start of work: [add certifications]

V.14. 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 [add number] days of advance notice for the purpose of establishing hold points and [add number] hours of 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: [add contact and telephone number].

V.15. WITNESS/HOLD POINTS

The following witness/hold points apply: [add information]

V.16. 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.17. DOCUMENTATION

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

Documents shall be legible and must be located inside the product packaging. If the size of the documents does not allow for inclusion within the product packaging, the documents must be placed in a separate package and sent at the same time, to the same location as the product. Non-conforming packages will be returned at the Supplier's expense.

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

[add Purchasing Organization's name and address]

(a) Statements:
- (i) Statement of identification as commercial grade item;
- (ii) Statement of conformance with Supplier's management system;
- (iii) Quality assurance programme/management system;
- (iv) Statement of approved change, non-conformance or waiver;
- (v) Statement of code (pressure boundary) reconciliation (if required);
- (vi) Shelf life;
- (vii) Statement of:________________.

(b) Certifications:
- (i) Certificate of conformance with Purchase Order requirements;
- (ii) Certificate of conformance with IEEE-344 (seismic);

(iii) Certificate of conformance with IEEE-323 (equipment qualification);
(iv) Certificate of equivalency with items originally supplied;
— Make;
— Model;
— Serial No.;
— Original specification:________________________;
(v) Certificate of conformance to time–current curve.

(c) Test records:
(i) Non-destructive examinations:
— Ultrasonic;
— Eddy current;
— Radiographic;
— Hardness;
— Magnetic particle;
— Liquid penetrant;
— Other.
(ii) Material properties:
— Impact (Charpy v-notch, drop weight) at [add temperature];
— Dielectric strength;
— Flattening;
— Welding;
— Bend;
— Flame (IEEE-383);
— Proof load (fasteners);
— Insulation resistance;
— Other.
(iii) Design/fabrication:
— Pneumatic pressure;
— Performance/functional;
— Hydrostatic pressure;
— Calibration;
— Leakage;
— Equipment qualification;
— Electrical continuity;
— Other.

(d) Reports:
(i) Heat treatment;
(ii) Failure analysis;
(iii) Certified material tests:
— Physical (may include test records);
— Chemical;
(iv) Pressure boundary supplemental tests;
(v) Pressure boundary code data;
(vi) Cable specification data;
(vii) Other.

(e) Design documentation:
(i) Drawings:
— As-built;
— Bill of material;
— Assembly;
— Other;

(ii) Manuals and instructions:
- Operations and maintenance;
- Handling and installation;
- Long term storage;
- Recommended spare parts;
- Other.

(f) Inspection or test plans:
(i) Special inspection plan;
(ii) Verification plan;
(iii) Other.

(g) Other.

V.18. CERTIFICATE OF CONFORMANCE

A certificate of conformance is required. Failure to provide one with complete and accurate information will result in the shipment being put on hold.

V.18.1. Certificate of conformance applicable to a manufacturer

The Supplier shall provide a similar statement on the packing slip or on a separate cover document with the following certification and information:

Conformance statement: "The equipment/item/material listed herein has been inspected by the company and is in conformance with the contract requirements and approved for shipment".

(1) Buyer Purchase Order number and Purchase Order line item number.
(2) Buyer CAT ID number.
(3) Printed name, title and signature of an authorized representative of the company's quality assurance authority.

V.18.2. Certificate of conformance applicable to a distributor or manufacturer acting as a distributor

When the Company is a Distributor or a Manufacturer acting as a Distributor for product supplied from stock, there are two options:

(a) A manufacturer's certificate of conformance exactly as per requirements noted in Section V.18.1 and a copy of the manufacturer's quality assurance programme certificate. The manufacturer and exact facility location must be on the Distributor's supplier list on file with the Buyer.
(b) A certificate of conformance from the Distributor exactly as per the requirements noted in Section V.18.1, with the following additions: identify on the certificate of conformance who manufactured the product and the management system implemented by the manufacturer. The manufacturer and exact facility location must be on the Distributor's supplier list on file with the Buyer.

The certificate of conformance shall satisfy the following criteria:

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

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

V.19. HANDLING, PACKAGING AND SHIPPING

Handling, packaging and shipping of the item supplied under this Purchase Order shall be in accordance with [add company or national standard such as ASME NQA-1a-2009, Part II, Subpart 2.2].

The 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.

Note: The following requirements shall apply to handling and packaging of all stainless steel materials and items:

(1) Nylon or stainless steel fork protectors and slings must be used when transporting or hoisting stainless steel materials to avoid risk of carbon steel contamination.
(2) Materials used for tying stainless steel materials shall be of stainless steel, nylon or other approved materials that will not cause contamination. Carbon steel wires or straps shall not be used.
(3) Marking materials shall have a halogen content no higher than 500 ppm. Exposure to salts or other halides shall be avoided.

[Add additional shipping requirements]

V.20. 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 orders.

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:

(a) Individual items:
    — Code stamp;
    — Grade;
    — Heat number or code;
    — Rating;
    — Manufacturer name or code;
    — Material specification;
    — Item serial No.;
    — Material description or composition;
    — Size;
    — Length or dimensions;
    — Hydrostatic test pressure;
    — Schedule;
    — Calibration due date;
    — Measurement and test equipment identification;

— Testing laboratory label/stamp (e.g. UL, CSA, DIN, etc.);
— Purchase Order item No;
— Other:___________________________________.

(b) Cable reel rim or tag:
— Contract or Purchase Order;
— Purchase Order item No.;
— Reel No.;
— Cable length;
— Conductor size.

Identification markings and tagging shall be clear, unambiguous and indelible, and shall be applied in a manner not affecting the function of the item.

[Consider specifying advanced methods of identification such as barcodes or RFD].

V.21. SHELF LIFE

The Supplier shall not ship any item that has less than [add time] remaining shelf life at the time of shipment. The Supplier shall provide shelf life data by one of the following methods:

— Expiry date;
— 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 the shelf life may be determined by the Buyer.

V.22. SUBSTANDARD COUNTERFEIT AND FRAUDULENT ITEMS

The Supplier is hereby notified that the delivery of substandard, counterfeit or fraudulent 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, the Seller shall be responsible for assuring 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 Supplier 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 and meet the applicable manufacturer data sheet or industry standard. Should the Supplier decide to supply a replacement part that may not meet the requirements of this paragraph, the Supplier shall notify the Buyer of any exceptions and receive the Buyer's written approval prior to shipment of the replacement parts to the buyer. 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 [add Buyer's name] and/or the original equipment manufacturer and may be returned to the Supplier. The Supplier shall promptly replace such suspect/counterfeit parts with parts acceptable to [add Buyer's name], and the Supplier shall be liable for all costs, including but not limited to [add Buyer's name] internal and external costs, relating to the removal and replacement of such parts. To mitigate the CFSI risk, the Buyer requires approved suppliers to recognize this risk by introducing into their quality assurance programme or management system a documented process to prevent, detect and disposition suspect CFSIs.

V.23. NEW ITEMS

All item(s) provided in this Purchase Order shall be supplied in 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 from new, unused parts.

Appendix VI

SAMPLE RECEIPT INSPECTION CHECKLIST

Appendix VI provides a sample generic receipt inspection checklist based on Refs [107, 339], which 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 as described earlier in Table 26, in Section 7.4.14. The wording may be modified to meet requirements and policies specific to each operating organization.

Receipt No.:	CAT ID No.:	Date:
P.O. /		Dated:
Item description: (Category, name, type)		
Qty/unit received:		Storage level:
UTC No.:		
Shelf life item:	No	Yes [enter date]
In-storage maintenance required:	No	Yes
Special handling needed:	No	Yes
Contact personnel (operating organization contacts)		
For special tests or inspection:		ext.
For documentation acceptance:		ext.
For item acceptance:		ext.
Other:		ext.

Checklist	N/A	REJECT	ACCEPT
1. Initial appearance			
Corrosion/exposure fire exposure evident (weathered, road salt, contaminants) Tie down failure/rough handling (damaged container, shifted load) Physical damage (broken, deformed, cracked parts) Physical count Check for foreign material Items are as identified on purchase order Packaging acceptable for storage			

Checklist	N/A	REJECT	ACCEPT
2. Identification and marking (as applicable)			
Shipping container/package Material specification Lot or batch No. Heat No. or code Serial No. Purchase order No. Other Individual items Purchase order 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 purchase order Purchase order item No. Reel No. Cable length Conductor size Measurement and test equipment ID No. Calibration due date Serial No. Part No. Hydrostatic test pressure Schedule Testing lab (e.g. UL, CSA, DIN, etc.) label/stamp Other			
3. Mechanical inspection			
Visual inspection Protective coverings Coatings or preservatives Workmanship Weld preparation (undamaged and in accordance with applicable drawings and specs) Desiccant installed Inert gas blanket intact Lubricants acceptable Other Measurements Dimensions, nominal per purchase order Dimensions, special Material constituents nominal per purchase order Material hardness nominal per purchase order Material hardness Physical properties Thread pitch nominal per purchase order Other Number of items checked: [Insert number]			

Checklist	N/A	REJECT	ACCEPT
4. 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 purchase order
  Dimensions, special
  Electrical resistance, nominal per purchase order
  Electrical resistance, special
  Electrical continuity
  Physical properties
  Other
Number of items checked: [Insert number]			

5. Documentation			

Documentation meets purchase order requirements and is traceable to item and purchase order
Statements
  Statement of identification as commercial grade item
  Statement of conformance with suppliers management system
  Quality assurance programme/management system
  Statement of approved change, non-conformance or waiver
  Statement of code (pressure boundary) reconciliation (if required)
  Shelf life (expiry date: [Insert date])
  Statement of: [Insert type]
Certifications
  Certificate of conformance (C of C) with purchase order requirements
  C of C with IEEE-344 (seismic)
  C of C with IEEE-323 (equipment qualification)
  Certificate of equivalency with items originally supplied
    Make: [Insert make]
    Model: [Insert model]
    Serial No.: [Insert number]
    Original specification: [Insert details]
  C of C to time–current curve			

Checklist	N/A	REJECT	ACCEPT
6. 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 [insert temp.] 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 Other			
7. 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			
8. 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			

Checklist	N/A	REJECT	ACCEPT
9. Inspection or test plans			
Special inspection plan Verification plan Other			

Counterfeit or fraudulent item checklists completed	YES:	NO:
Engineering review required	YES:	NO:
Other		
List calibrated instruments used during inspection (ID No., Type, Calib. Exp. Date)		
Remarks		
Checklist summary		
Hold/reject tag issued	YES:	NO:
Reason		

Tag No.:	Date issued:	Date removed:
Item accepted:	Inspected by:	
Name:	Title:	Date:

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. SCOPE

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

1.1 Scope of vendor proposal

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

2. REFERENCES

Lists developmental or performance references. Identifies each reference by its document title and document number if applicable. If there are no references, ‘None’ is stated.

3. 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. GENERAL

Provides applicable requirements for materials or services being purchased. 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), site familiarization requirements, and qualification and training requirements. Supplementary specification data sheets may be referenced.

5. 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 (specific 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 system 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 while manufacturing. If an optional engineering specification data sheet is used, any items in the above list that are not dealt with in the data sheet need to be covered in additional text in this section.

6. TESTS AND TEST REQUIREMENTS

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 systems, 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, production tests, including clause(s) for foreign material exclusion, test and non-destructive examination documentation requirements, and commissioning and integration requirements. Note that materials or equipment that were actually tested (factory acceptance tested 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. PRODUCT FORM AND IDENTIFICATION

Identifies applicable form and/or identification requirements to be imposed on supplied material. Factory acceptance tested material, if shipped to site with the agreement of the operating organization, should be individually identified to differentiate from new, unused parts. If there are no form and/or identification requirements, state "None".

8. SPECIAL PACKAGING AND SHIPPING, HANDLING AND STORAGE

Defines applicable requirements for packaging and marking (identification) for shipping, shipping and handling requirements (including any shelf life or maintenance requirements applicable to storage), foreign material axclusion methods, and related documentation. Note that factory acceptance tested material, if shipped to site with the operating organization agreement, needs to be individually identified to differentiate from new, unused parts. Foreign material exclusion methods should include the requirement to make any foreign material exclusion covers easily visible and to provide a listing of foreign material exclusion covers to assist in complete removal of all covers. Requirements should include clauses for the vendor to provide a detailed vendor BOM 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 purchase order includes many components. The vendor BOMs 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. MATERIAL SAFETY DATA SHEET

Specifies submittal requirements for all applicable material safety data sheets. If there are material safety data sheet requirements, state 'Yes'; if they are not required, state 'No'.

10. 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 FAT material is shipped to site, appropriate documentation needs to be enclosed with the shipment to make clear that the shipment includes FAT material.

Appendix VIII

SAMPLE NUCLEAR PURCHASE SPECIFICATION

The following is a sample generic purchase specification related to management system activities developed in the 1990s as part of the development of IAEA-TECDOC-919 [4]. It can serve 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 requirements

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:
   (a) Enforcement regulation of 00000 Atomic Energy Act, Article 000;
   (b) Management system requirements described in technical specification.

1.2. Upon contract award, the contractor shall submit to the buyer the following documents (three copies) for the buyer's review, within four months after award.
   When the contractor needs to change or revise the documents, the contractor shall submit to the buyer revised documents for the buyer's review, and incorporate the buyer's comments, if any:
   (a) Management system programme manual and procedures;
   (b) 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 contractors are performing quality related activities, the buyer has a right to request a stop to work for appropriate corrective actions as necessary. When the contractor receives a stop work request from the buyer, the contractor 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 are to be filed, indexed and collected in accordance with procedures approved by the buyer. Control measures for quality assurance 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 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 the contractor's responsibilities, and whose position level shall be equal to or above any other department manager.

2.0. Quality assurance audit, surveillance and inspection requirements

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

2.2. The buyer or representative shall be allowed free access to the contractor's or subcontractor's facilities, work site, quality records, among other things, for the buyer's audit, surveillance and inspection. The contractor shall provide the buyer with help (e.g. office and telephone) without any extra charge.

2.3. The contractor's procedures, including the 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 quality assurance programme implementation capability and status. Audit, surveillance and inspection by the buyer or by the buyer's 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 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 the contractor's own expense.

2.6. In the event that the contractor cannot afford to perform tests on the contractor's own facilities, the contractor 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 reinspection without any extra charge.

2.8. The contractor shall submit to the buyer the result of the corrective action or a plan in the event that corrective action cannot be taken immediately, within 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. <u>Site inspection and test</u>

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 a 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, among other things, required for the equipment, instruments, system and circuits during preventive maintenance and the startup 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. <u>Notification of significant deficiencies</u>

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

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

(b) Conditions adverse to quality against a preliminary safety analysis report, as significant deficiencies for final design admitted for construction;

(c) Significant deficiencies in structure, system, and/or construction that require comprehensive evaluation, design change and repair.

Appendix IX

SAMPLE SUPPLIER SAFETY PERFORMANCE ASSESSMENT[5]

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

(a) Which senior person in the company responsible for safety has been involved in the contract?
(b) Was the contractor's local safety statement provided to all employees?
(c) What safety surveillance of the contract by the contractor's company safety organization was carried out during the contract period? Did the contractor's company receive any copies of reports generated?
(d) How many people on average were employed by the contractor on-site?
(e) What was the contractor's accident frequency rate during the contract period, for example, the number of lost time accidents divided by the person-hours worked?
(f) How many minor (i.e. no lost time) accidents occurred during the contract?
(g) Did any major injuries or fatal accidents occur to contractor personnel during the contract period? If so, how many and how did the contractor respond?
(h) How does the contractor's safety performance compare with the industry average and industry best performers?
(i) Did the contractor carry out any specific safety training of personnel other than site orientation training?
(j) Were safety topics observed to be incorporated into regular pre-job briefings and meeting introductions?
(k) Was the safety performance of contractors and that of internal operating organization staff observed to be to the same high standards?
(l) Were any safety publications issued by the contractor to personnel?
(m) Were contractor vehicles, tools and plant in good, well maintained condition throughout the contract?
(n) How well did the contractor comply with assessment of substances harmful to health requirements?
    (i) Was information received on all hazardous materials that the contractor brought onto the site?
    (ii) Were copies received of assessments of effects of potentially hazardous substances and necessary precautions?
    (iii) Did the contractor comply with assessments and any additional requirements required to ensure the safety of the contractor and other personnel?

[5] Based on annex 17 of Ref. [4].

Appendix X

SAMPLE CONTRACT ADMINISTRATION ACCOUNTABILITIES

Appendix X provides a sample accountability matrix (see Table 29) for contract owners, administrators, monitors, supply chain personnel and others associated with administrating a typical service contract at a nuclear facility. It includes activities related to contract planning, contract prequalification, procurement, post-award activities, contract execution and contract closeout. Two models of contract field execution are shown, the first whereby the owner/operating organization retains full control over the work site, and a second ‘owner only’ model, where a construction island separate from the normal owner workspace is established and that is under the direct control of the constructor. The choice of which model is preferred can depend on the cost effectiveness and the ease of setting up the separate construction island, the risks involved (safety, production, environmental or commercial) with less oversight in an owner only model, any operational restrictions that such an arrangement might impose, and national labour legislation.

TABLE 29. SAMPLE CONTRACT ADMINISTRATION ACCOUNTABILITIES

Stage	Applicable section of this publication	Process step	Requirements	Contract owner	Contract administrator	Contract monitor	Supply chain	Others
Contract planning	3.2. Establishing requirements and 3.5. Acceptance criteria	Prepare statement of work	Clearly define extent of work and identify required resources	A			I	
		Identify safety, environmental and quality requirements	Conduct a review of the work to be done to identify all foreseeable significant safety, environmental and quality requirements	A				C Safety, environmental, technical resources and others as required
		Establish contract requirements	Determine roles under national safety legislation and finalize contract requirements	A	C		C	C Legal and other stakeholders as required
		Prepare contract requirements document	Prepare contract requirements document for review and approval, and develop a purchasing strategy	A			A	R Technical resources and others as required
Contractor prequalification	3.4. Supplier identification	Provide contractor with prequalification package	Forward copy of contractor questionnaire, along with cover letter and ‘information for contractors’, to contractor	A			R	
		Evaluate contractor’s prequalification submission	Potential contractor’s health and safety programme and safety ratings shall be evaluated before the contractor is eligible to submit a quotation or proposal on a contract					A Supplier safety compliance department

TABLE 29. SAMPLE CONTRACT ADMINISTRATION ACCOUNTABILITIES (cont.)

Stage	Applicable section of this publication	Process step	Requirements	Contract owner	Contract administrator	Contract monitor	Supply chain	Others
Procurement	3.6. Bidding, evaluation and placement of purchase orders	Issue an invitation to contract	Prepare and issue a request for quotation or request for proposal to a list of qualified and approved proponents	CR	C		A	C Legal and other stakeholders as required
		Evaluate proposals/ quotations	Evaluate submissions and recommend the best value submission(s)	A	C		A	C Legal, technical resources and other stakeholders (as required, e.g. cross-functional sourcing team)
		Select a contractor	Award the contract and issue a purchase order	CR	C		A	C Legal
Post-award	3.7.1. Kick-off meeting	Conduct job site and orientation meeting(s)	Job site meeting(s) provide an opportunity to meet personnel and review the terms and conditions	I	A	I	I	
		Conduct a mark-up meeting	Where union agreements require, schedule a mark-up meeting to discuss work distribution among the various trades		A			C Human resources
		Verify qualifications and provide site specific training	Determine whether competency requirements and qualifications have been met and define the plans for any required site specific training	C	A			
		Review and approve readiness to start work	Review and approve all permits, training, etc., required to begin work	S	A		I	

TABLE 29. SAMPLE CONTRACT ADMINISTRATION ACCOUNTABILITIES (cont.)

Stage	Applicable section of this publication	Process step	Requirements	Contract owner	Contract administrator	Contract monitor	Supply chain	Others
Contract execution	3.7.2. Monitoring contractor performance	Administer the contract	Ensure compliance with contractual terms and conditions, and manage changes, during contract performance through to closeout and termination	S	A	I	C	
		Monitor and verify the contractor's activity	Monitor work activities to verify contract compliance	I	C	A	C	
	3.7.3. Providing direction and feedback	Report on performance	Document administrative actions and all data required to support the project's business activities and performance assessment	V	A	V	V	
Contract execution: owner only	3.7.2. Monitoring contractor performance	Administer the contract (owner only)	Administer and record job progress; monitor the work for correction of deficiencies by the contractor	S	A		C	
		Monitor and verify the contractor's activity (owner only)	Monitor work activities to verify contract compliance		A			
	3.7.3. Providing contractor direction and feedback	Report on performance (owner only)	Document administrative actions and all data required to support the project's business activities and performance assessment	C	A	C	C	
Contract closeout	3.7.3. Providing contractor direction and feedback	Evaluate and report on performance	Complete final contract closeout report for the contractor's performance	S	A	C	C	
	3.15. Contract closeout	Verify contract completion	Verify that technical and commercial contract conditions have been fulfilled	S	A	C	C	
		Close out the contract	Ensure that all work has been completed successfully and that all deficiencies and administrative matters have been resolved	S	A	C	C	

Note: A — accountable for the activity; C — consult as required; CR — is to concur with the activity; I — is to be informed; R — responsible; S — is to approve; V — is to review.

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Annex

SURVEY OF MEMBER STATE PROCUREMENT PRACTICES

A–1. INTRODUCTION

This Annex documents the results of a survey sent by the IAEA to a general audience of worldwide nuclear professionals prior to a September 2014 technical meeting on procurement engineering and supply chain issues. The survey was designed to seek information on current procurement practices and trends within the nuclear power industry. It was distributed to all subscribers to the IAEA Nuclear Engineering electronic newsletter, and informally to other known industry contacts via the IAEA procurement consultancy team that worked on this publication, and via other IAEA staff members. Some 53 responses were received, 20 of which provided information regarding what location the survey applied to as shown in Fig. A–1.

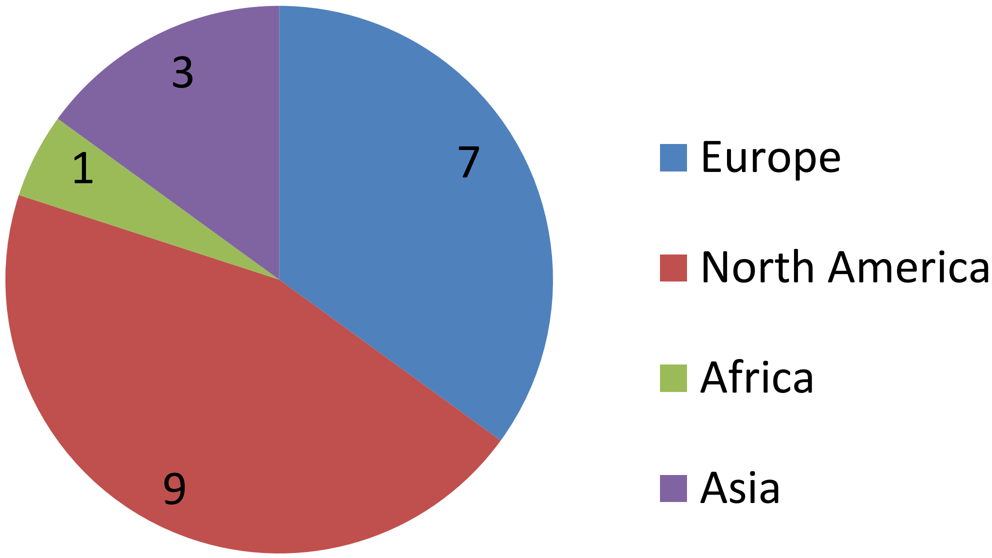
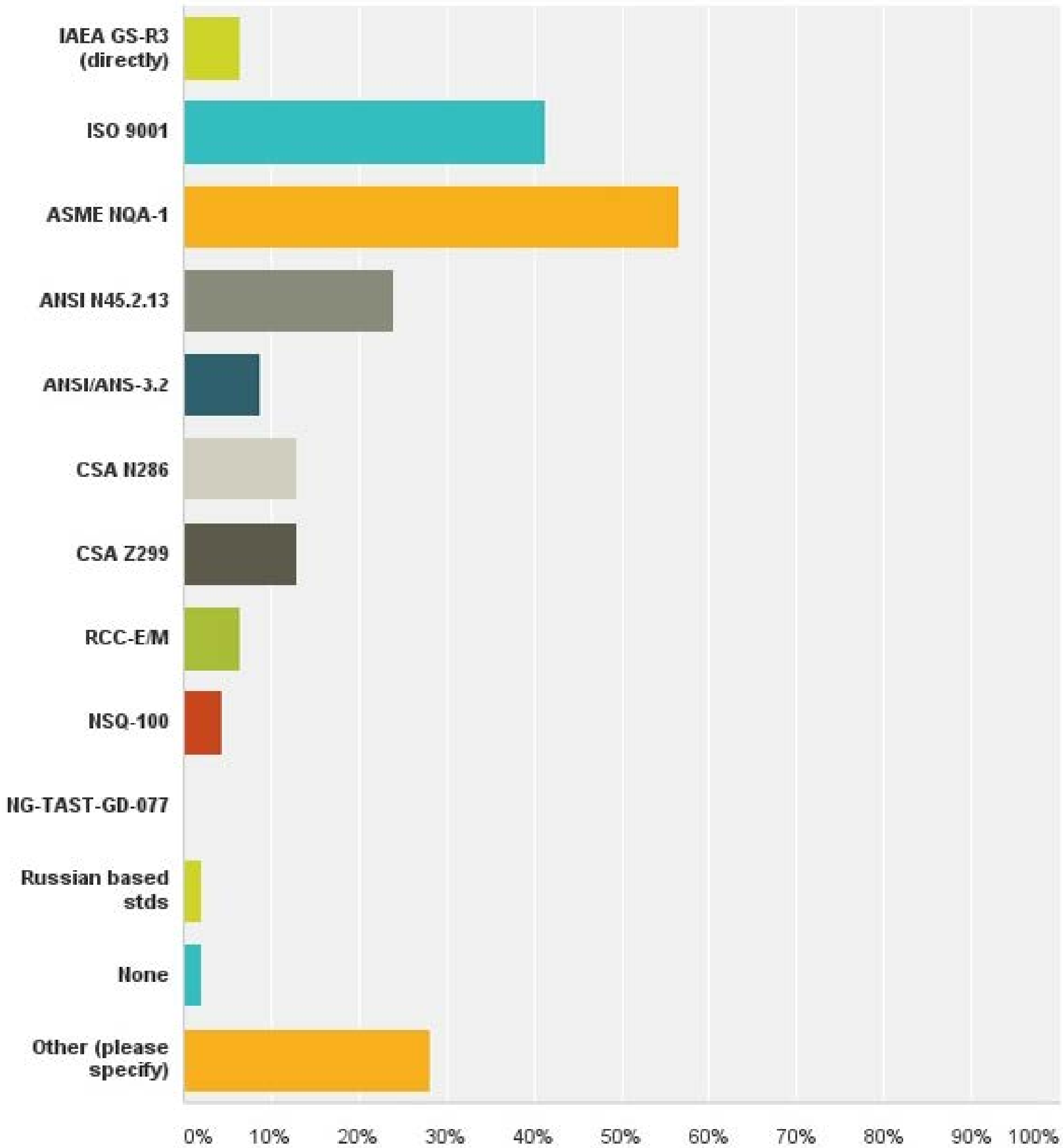


FIG. A–1. Survey responses by region.

Over half of the 17 respondents who provided their job function (53%) were in a procurement related role at an operating nuclear facility, with the next largest answer (29%) being in an engineering role. Responses were also received from regulators, suppliers and non-nuclear procurement professionals (6%). Details regarding the specific questions asked and the responses received are given in the following sections.

A–2. MANAGEMENT SYSTEMS

A question was asked as to what management system standards are applied that are relevant to safety related procurement at the respondents’ plant(s). The largest response was for ASME NQA-1, with the second largest being ISO 9001. Responses are shown in Fig. A–2.



Note: Based on 46 responses; stds — standards.

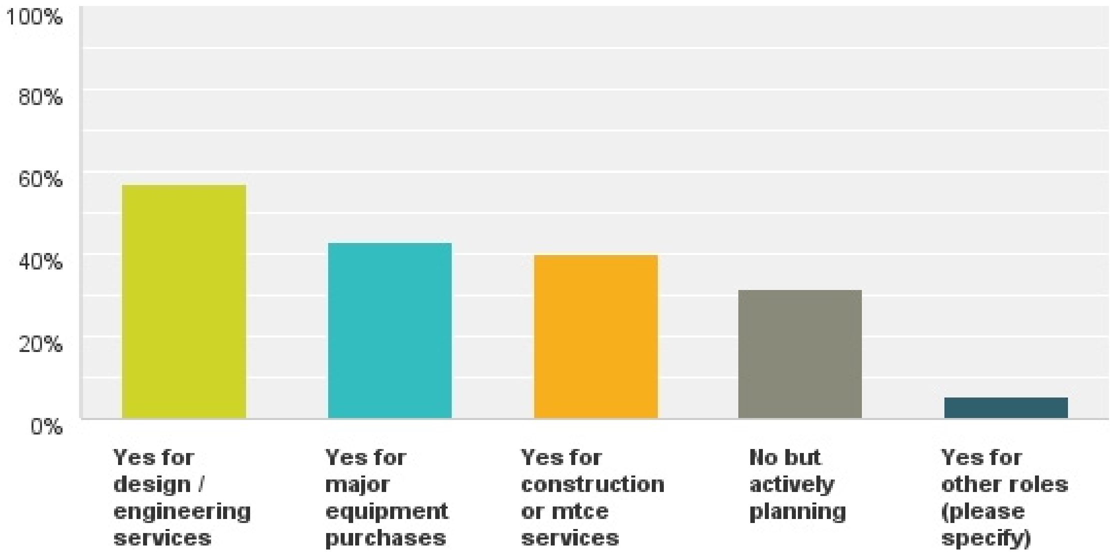
FIG. A–2. Management systems used.

A–3. INFORMED CUSTOMER ROLE

A question was asked as to whether a formal informed customer function has been set up at facilities to oversee contracted activities. Most facilities (57%) reported that such a function has been set up for design activities, with lesser amounts for major equipment purchases (43%) or construction or maintenance services work (40%). Many organizations (31%) were actively planning establishing such a role. Full results are shown in Fig. A–3.

A–4. SHARING OF AUDIT FINDINGS

Questions were asked as to whether procurement or supply chain audit summaries or findings were gathered from and/or shared with other companies or organizations. Over half of respondents (58%) indicated that such information was gathered, while a slightly larger amount (65%) indicated that they shared such data. Written comments indicated that sharing was done via the Nuclear Procurement Issues Committee, the CANDU



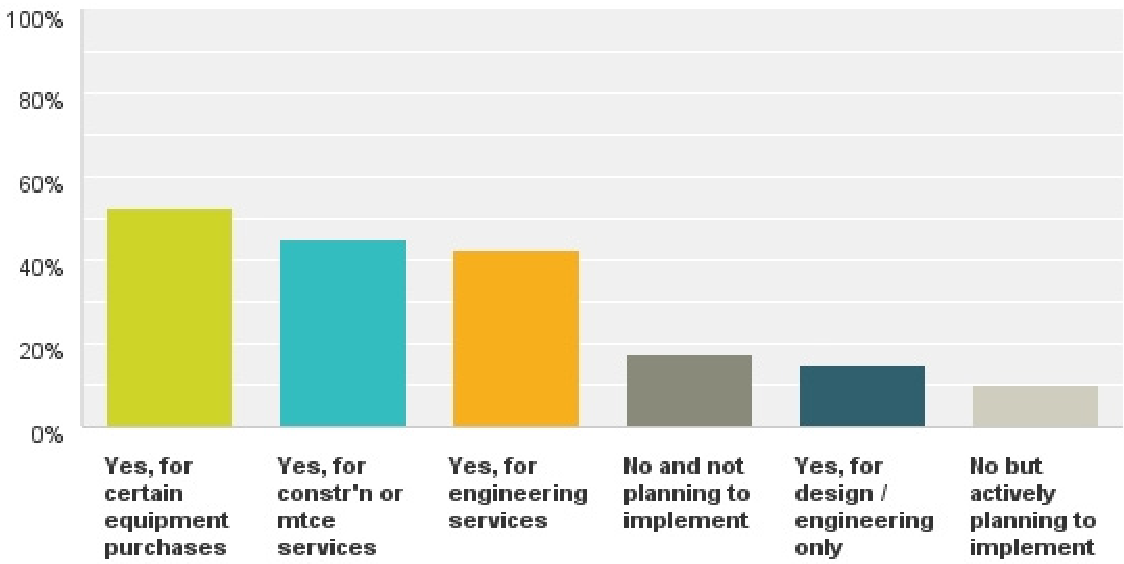
Note: Based on 35 responses; mtce — maintenance.

FIG. A–3. Knowledgeable customer role usage.

Procurement Audit Committee, the Nuclear Industry Assessment Committee, the Institute of Nuclear Power Operators, the World Association of Nuclear Operators and some company specific or country specific methods (e.g. Finland).

A–5. PREFERRED SUPPLIER RELATIONSHIPS

A question was asked as to whether organizations had preferred supplier agreements in place with specific companies. Of the 40 respondents, over half (53%) indicated that they did have agreements for equipment purchases, as did substantial numbers for construction or maintenance services (45%) and engineering services (43%). Only 17% of respondents reported that they were not planning to implement such arrangements. Full results are shown in Fig. A–4.

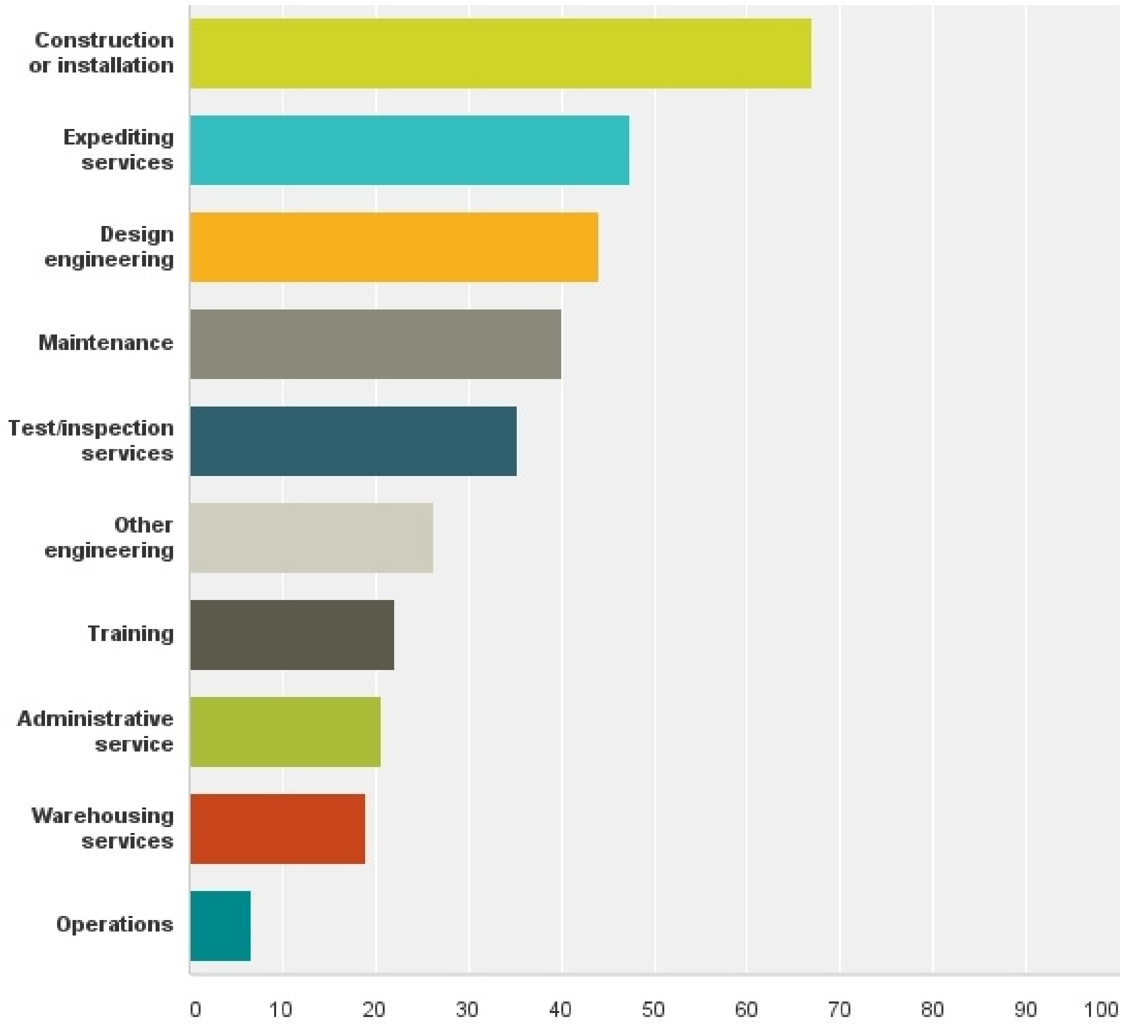


Note: Based on 35 responses; constr'n — construction; mtce — maintenance.

FIG. A–4. Preferred supplier arrangements.

A–6. CONTRACTING OUT

A question was asked as to the level of contracting out of work at the respondents' facilities. Out of the 27 responses received, construction or installation services contracting was highest (67%), followed by expediting (47%), design engineering (44%), maintenance (40%) and others. Full results are shown in Fig. A–5.



Note: Based on 27 responses.

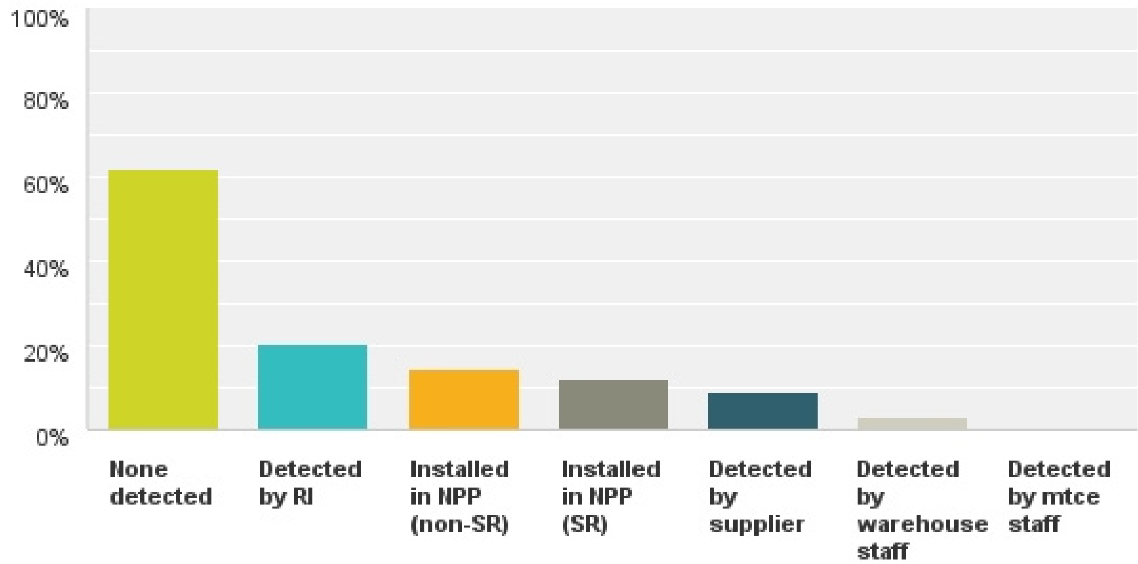
FIG. A–5. Contracting out of work.

A follow-up question was asked as to whether individuals thought that these levels would change over the next three years. Most of the 18 respondents (67%) felt that the levels would stay about the same, 28% felt that they would increase, while the remaining 5% felt that they would decrease.

A specific question was asked about subcontracting for expediting services. About half (52%) of the 25 respondents indicated that this was done, 44% indicated that it was not done, and one person did not know.

A–7. COUNTERFEIT AND FRAUDULENT ITEMS

A question was asked as to whether, in the past five years, individuals were aware of any incidences of counterfeit or fraudulent items related to their nuclear facility. Most of the 34 respondents (62%) indicated that none had been detected, while some were aware of certain items being detected by nuclear power plant receipt inspectors (21%), the supplier or distributor (9%), or warehouse staff (3%). Some instances of items being installed in the plant were reported, with 15% indicating items being installed in non-safety-related applications, with 12% indicating items being installed in safety related applications. Full results are shown in Fig. A–6.



Note: Based on 34 responses; mtce — maintenance; NPP — nuclear power plant; RI — receipt inspector; SR — safety related.

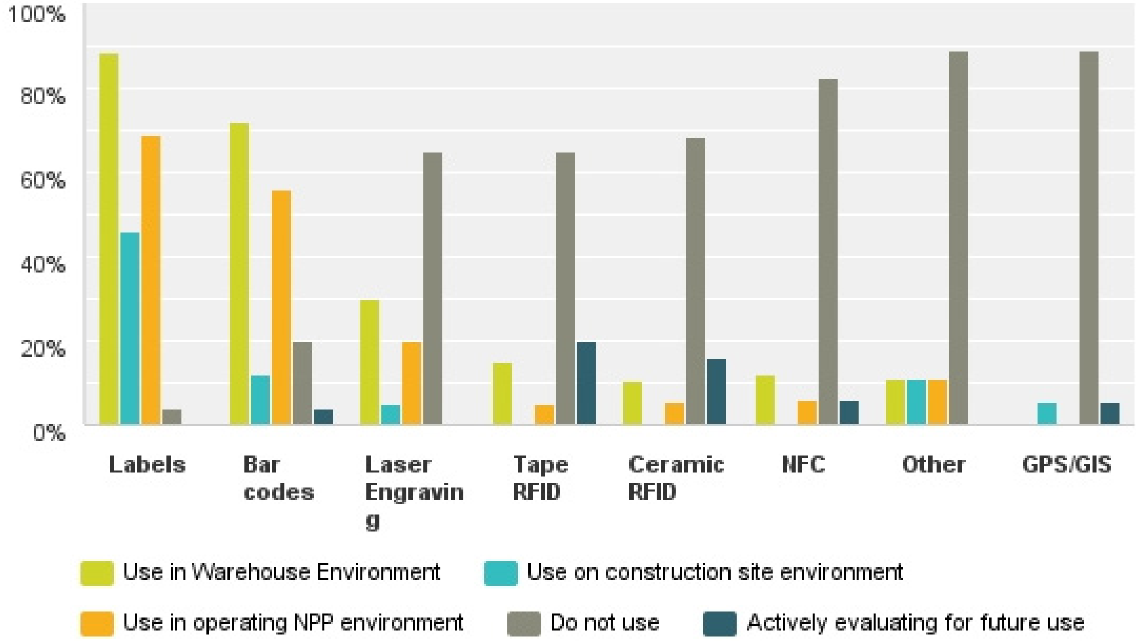
FIG. A–6. Counterfeit and fraudulent items.

A follow-up question was asked as to whether individuals were aware of any incidences of substandard items being installed in the plant. These would be significant events that required item replacement or disposition to continue plant operation. Approximately one quarter of respondents (8 out of 34 responses) indicated that they were aware of such events.

A–8. MATERIAL TRACKING TECHNOLOGY

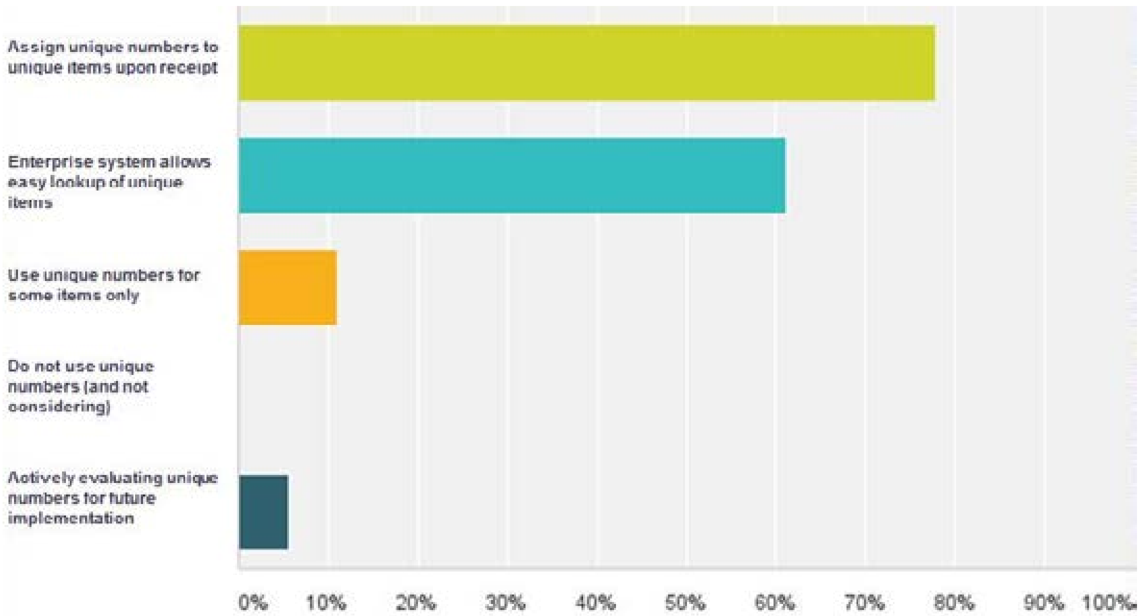
A question was asked regarding the use of various advanced methods of inventory tracking and control technologies at respondents’ sites. Simple tagging with labels and bar codes remain the most popular methods, with other technologies being evaluated for future use. There appears to be much potential within the industry for increased use of such technologies. Results are shown in Fig. A–7.

A question was asked surrounding the use of methods to actively track unique items (via the use of unique numbers or other methods) to end locations (e.g. specific plant equipment locations). Of the 22 respondents, most individuals (73%) indicated that unique item numbers were assigned to items upon receipt, and many individuals (55%) indicated that their enterprise computer systems allow for easy look-up of such numbers. Some individuals (9%) indicated that they use such systems only for certain items. Full results are shown in Fig. A–8. Written comments indicated some confusion around the concept for some individuals (i.e. between stock code/catalogue item numbers versus unique item numbers), and so the survey results may be overstated in this area.



Note: Based on 26 responses; GIS — geographic information system; GPS — Global Positioning System; NFC — near field communication; NPP — nuclear power plant; RFID — radiofrequency identification.

FIG. A–7. Usage of advanced material tracking technology.



Note: Based on 22 responses.

FIG. A–8. Unique item tracking usage.

A–9. WAREHOUSE INVENTORY GROWTH AND SPACE SHARING

A question regarding the management of stores inventory growth was asked. Over half (56%) of the 25 respondents indicated that they have taken active measures to manage stores inventory growth, with 40% stating they have not done so and 4% not knowing. Written comments indicated that this issue was of concern, with some methods employed being stock segmentation, purging of obsolete catalogue item numbers, meetings with operations staff and creation of inventory management groups.

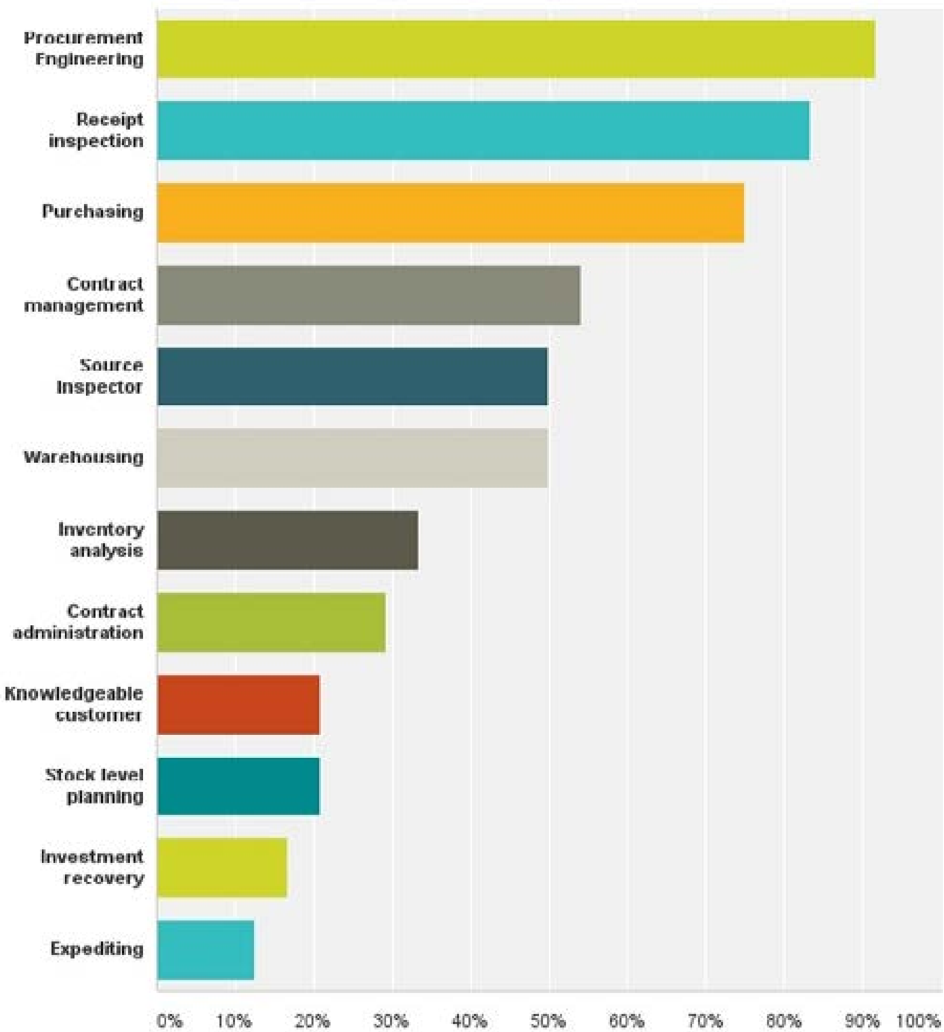
A question was asked on the use of shared warehousing space or shared inventory with other facilities outside of one's own particular company. Of the 26 respondents, a large majority (81%) indicated that this is not done, with only 4 respondents (15%) indicating that this is practised (one person did not know). Possible cost savings thus appear to be available to operating organizations in this area.

A–10. CRITICAL PROCUREMENT

A question was asked as to whether companies take any special action or form special teams for high risk or critical equipment procurement. A large majority (80%) of the 25 respondents indicated that this was done (three individuals (12%) said that it was not done and two (8%) did not know).

A–11. TRAINING AND QUALIFICATION

A question was asked regarding the extent of formal training and qualification programmes for procurement related roles. The procurement engineering function was the most commonly cited role that had a formal programme, followed by receipt inspection, purchasing, contract managers and others. Full results are shown in Fig. A–9.



Note: Based on 24 responses.

FIG. A–9. Procurement related training and qualifications.

A–12. PERFORMANCE IMPROVEMENT, TRACKING AND ASSESSMENT

Questions were asked as to whether companies had in place formal processes for supplier performance and assessment, or for evaluation of the performance of procurement or of material management organizations. Supplier performance assessment tracking was in place in 78% of organizations (18 of 23 responses), and internal material management organization assessment methods were in place at 75% (18 of 24 responses) of the companies surveyed.

A–13. ENTERPRISE COMPUTER SYSTEMS

Individuals were asked as to whether they had enterprise wide computer systems in place for managing procurement functions. Out of the 25 respondents, 56% (14) indicated that they had a commercially developed software system in place and 32% (8) indicated that they had an in-house developed system in place. Written comments indicated that commercial software packages included ABB Ventyx (Passport), SAP, IBM Maximo and Oracle.

A–14. LESSONS LEARNED

A free format question was asked about possible lessons learned regarding the procurement function that should be passed on to newcomer States. Some of the responses received are given below:

- Know what you want to do for procurement before the beginning of plant construction.
- Implement codes and standards of regulatory guides.
- Develop performance indicators for procurement activities.
- Perform self-assessments to assess the progress of assigned jobs.
- Review internal procurement procedures periodically.
- Increase utility/operating organization involvement in the early stages of nuclear power plant development.
- Join or create an industry organization for sharing experience, benchmarking and cost savings.
- Strengthen management systems related to the procurement function.
- Adopt an integrated approach to supply chain management.
- Know your suppliers.
- Consolidate suppliers if possible.
- Finalize equipment design and inspection and test programmes before manufacturing.
- Ensure subcontractors have a good understanding of special nuclear requirements — International Organization of Standards (ISO) certification is not enough for nuclear specific features.
- Focus on manufacturing quality management systems, welding procedures, manufacturing processes, heat treatment and forming.
- Allow for adequate time for new manufacturing construction methods and for inspections by authorities.
- Create detailed technical specifications and technical and quality requirements in order to obtain all data, documentation and records needed for nuclear power plant operation — update specifications as equipment is procured.
- Maintain proper traceability to installed locations.
- Encourage standardization.
- Be aware of counterfeit and fraudulent items.
- Perform strategic sourcing.
- Ensure there are qualified and experienced procurement engineers involved to set requirements for safety related materials and services — these will help to ensure vendors are qualified and supply to requirements.
- Suppliers who profess to having an active quality assurance programme do not always effectively implement their programmes.
- An experienced nuclear quality assurance manager is essential; managers with only ISO 9001 or other commercial experience are typically ineffective at implementing nuclear quality assurance programmes.

— A high degree of supplier oversight is needed — this should increase for more critical items, components and services.
— Even if a supplier may be qualified or approved to supply certain parts, they still need to be managed (oversight) and reviewed (receipt inspection).
— Address globalization of supply chain issues.
— Set a proper procurement strategy considering long term dependency by suppliers for critical items and services (by addressing future maintenance and service needs, and ensuring supplier qualification and development in non-competitive areas).
— Perform thorough auditing and surveillance at critical points during manufacturing to ensure suppliers are performing as intended.

A second free format question was asked regarding the greatest worries of the procurement function. The major worries cited included:

— Increases in counterfeit and fraudulent items driven by lowest price bidding systems;
— Plants located in remote areas having difficulties obtaining parts during emergencies or during unit outages;
— Long lead times for original equipment manufacturer and supplier items;
— Obsolescence issues;
— Suppliers outside of the country not agreeing to follow local regulatory requirements;
— Multinational suppliers not knowing specific requirements for different countries;
— Knowledge transfer;
— A lack of projects resulting in loss of competencies by traditional suppliers;
— Supply chains becoming more complex and diversified because of globalization, with new players not necessarily possessing nuclear experience.

ABBREVIATIONS

ASL	approved supplier list
ASME	American Society of Mechanical Engineers
BOM	bill of material
BWR	boiling water reactor
CANDU	Canadian deuterium uranium
CANPAC	CANDU Procurement Audit Committee
CAT ID	catalogue identification
CFR	Code of Federal Regulations
CFSIs	counterfeit, fraudulent and suspect items
CG	commercial grade
CGD	commercial grade dedication
CGI	commercial grade item
CII	Construction Industry Institute
CORDEL WG	Cooperation in Reactor Design Evaluation and Licensing Working Group
CSA	Canadian Standards Association
E-BOM	equipment bill of material
EDF	Electricité de France
EPRI	Electric Power Research Institute
EOQ	economic order quantity
FAT	factory acceptance test
FIDIC	International Federation of Consulting Engineers
GIS	geographic information system
ID	identification
IEE	item equivalency evaluation
INPO	Institute of Nuclear Power Operations
IRS	incident reporting system
ISO	International Organization for Standardization
IT	information technology
ITP	inspection and test plan
I&C	instrumentation and control
JIT	just in time
MEL	master equipment list
Nadcap	National Aerospace and Defense Contractors Accreditation Program
NDE	non-destructive examination
NDT	non-destructive testing
NEI	Nuclear Energy Institute
NRC	United States Nuclear Regulatory Commission
NSG	Nuclear Suppliers Group
NUOG	Nuclear Utility Obsolescence Group
NUPIC	Nuclear Procurement Issues Committee
OECD	Organisation for Economic Co-operation and Development
OIRD	obsolete items replacement database
OLM	on-line monitoring
ONR	Office for Nuclear Regulation
OPEX	operating experience
PIM	pooled inventory management
PM	preventive maintenance
POMS	proactive obsolescence management system
PRI	Performance Review Institute
PWR	pressurized water reactor

Q-list	quality list
QVD	quality verification document
RAPID	RapidPartSmart
SAT	site acceptance test
SSCs	structures, systems and components
UL	Underwriters Laboratories
UTC	uniquely tracked commodity
WANO	World Association of Nuclear Operators
WNA	World Nuclear Association

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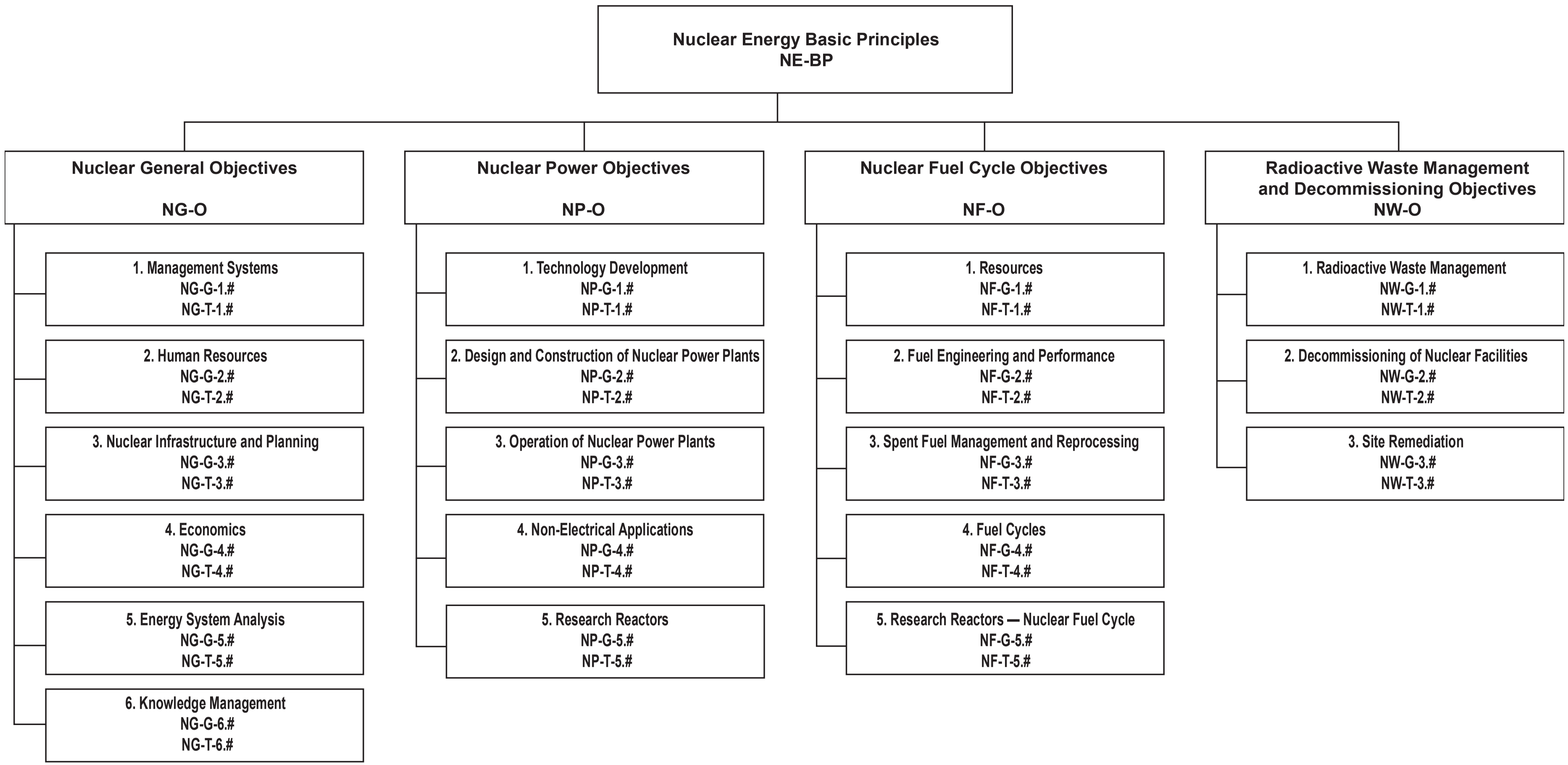

Key

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