Ensuring NQA-1 Compliance with Nuclear Next Gen Technologies Performing a Safety Function Associated with Autonomy or Remote Systems-14549a

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ABSTRACT

First-of-a-kind and cutting edge Next Gen technologies deployed in a nuclear environment may initially appear to fall outside the ability to be qualified in accordance with ASME NQA-1 for a nuclear safety function. However, NQA-1 compliance is possible especially if baked into the early stages of the technology development process. This is particularly applicable as part of the increasingly prevalent application of autonomous processes, advanced manipulation, man-machine interfaces, exoskeletons and other advanced and unique ability options.

INTRODUCTION

This paper provides a simplified overview regarding the ability to comply with NQA-1 when working in technologically new areas such as autonomy, exoskeletons, advanced manipulation, man-machine interface, etc. These areas align with the papers presented in session 51 but the core NQA-1 methodology is applicable in other areas and to other technologies. This paper is intended for introductory purposes not those familiar with NQA-1.

ASME NQA-1 AND COMMERCIAL GRADE DEDICATION

Nuclear facility activities and their associated technologies in the US are required to be performed in accordance with nuclear quality assurance criteria specified in ASME-NQA-1-XXXX where XXXX identifies the version. While the most current version is NQA-1-2015 many facilities QA programs are currently based on NQA-1-2008 with its 2009 addenda. The most common reason is tied to contractual requirements or the commitments made at the time of an NRC license submittal. NQA-1, as it is commonly referred is considered the most rigid QA criteria in the world for the nuclear industry. NQA-1 can be cross-walked to ISO 9000 but DOE and the NRC regulate to NQA-1.

Typically final products or individual components from which prototype technologies are constructed are procured from vendors who produce the product or raw materials in accordance with their own NQA-1 program.

However, due to lack of demand and the added costs NQA-1 compliance requires, there are increasingly fewer vendors and suppliers providing off the shelf items and/or materials that have been produced in compliance with NQA-1. When an item is not available from an NQA-1 compliant vendor, the NQA-1 standard provides a process to acquire and qualify an item as though it were under a NQA-1 program. This process is known as Commercial Grade Dedication, or CGD, and provides an alternative to using NQA-1 qualified suppliers by allowing the acquisition of non-NQA-1 "industrial" components and through a detailed engineering assessment dedicate (qualify) them for use in safety class or safety significant applications. Your individual organization's QA department will be able to assist with the identification of NQA-1 suppliers and your Procurement department should know how to source items as NQA-1 or in a manner that supports the commercial grade dedication process. They need to be involved and part of the process. Otherwise, performance of CGD is primarily an engineering function.

As one delves into the requirements of NQA-1 it becomes apparent that allowances are provided for utilization of goods supplied by a vendor lacking an NQA-1 compliant QA/QC program. Specifically, one should focus on NQA-1 sub part 2.14, Commercial Grade Dedication. CGD provides a vetting process that allows for the utilization of items as though they originated in an NQA-1 program. Essentially, it ensures an equivalency as if the procured item had been generated under the auspices of a formal NQA-1 program. While this process is applied for repair and maintenance items such as pumps, motors, valves, etc., it may also be applied to research projects, one-off items, novel technologies regardless if a finished unit or their individual pieces.

As mentioned, NQA-1 is commonly applied in nuclear facilities for routine industrial components such as valves, breaker boxes, pumps, motors, relays, etc. What we are focusing on in this session is confirming that Safety Significant novel technologies, especially those at a developmental and research stage are adequately assessed such that they may be considered NQA-1 compliant for trial or deployment within DOE facilities. Safety significant, safety class are defined terms that spell out where an engineering assessment needs to be performed to identify critical characteristics that include potential failure modes such that were they to occur during routine operations or an anomalous situations would have a safety significant impact.

Before continuing, let's take a mini-primer on NQA-1.

The requirements of NQA-1 I apply to activities that could affect the quality of nuclear material applications, structures, systems, and components of nuclear facilities.

Examples of nuclear facilities are facilities for power generation, spent fuel storage, waste management, fuel reprocessing, nuclear material processing, fuel fabrication, and other related facilities. Essentially any facility or operation that holds an NRC license. Examples of these activities include siting, designing, procuring, fabricating, constructing, handling, shipping, receiving, storing, cleaning, erecting, installing, inspecting, testing, operating, maintaining, repairing, refueling, modifying, and decommissioning. The application of NQA-1 or portions thereof, is typically invoked by written contracts, policies, procedures, specifications, regulations, NRC license or other appropriate documents.

Within NQA-1 there are several defined terms that we should familiarize ourselves with as they directly apply to our discussion.

critical characteristics: any property or attribute of an item, process, or service that is distinct, desirable, and measurable.

commercial grade item: a structure, system, component, or part thereof, that affects its safety function, that was not designed and manufactured in accordance with the requirements of this Standard.

failure mode and effects analysis: An evaluation of an item's credible failure mechanisms and their effect on system and/or component functions.

safety basis: the documented safety analysis and hazard controls that provide reasonable assurance that a DOE nuclear facility can be operated safely in a manner that adequately protects workers, the public, and the environment.

APPLICATION TO YOUR PROJECT

As may be gleaned from the material we've covered, quality control at nuclear facilities is governed by NQA-1. In turn, NQA-1 contains additional requirements applicable to novel technologies and non-standard equipment providing a venue to demonstrate compliance that permits their use. These characteristics are identified through a front end engineering safety basis assessment that identifies critical characteristics of the technology and/or its impact on a process or system of the facility.

It must be emphasized that the NQA-1 process must be incorporated early into the project life cycle preferably at the planning stage. Doing so will influence

the means of material procurement, possibly require third party testing of the materials of construction and/or functioning parameters or environmental influences to individual component and/or the final assembly. It will also eliminate the headache and expense of trying to demonstrate NQA-1 compliance after the fact. To be fair, NQA-1 compliance at the front end of project planning may influence the project schedule and will add a degree of cost due to the required increased surveillance but, these are minimal compared to attempting to do so at a late stage.

A facility procuring an item that support or provide a nuclear safety function has two options to procure the item. The item should be either procured in accordance with the requirements of NQA-1 or be commercial grade dedicated (CGD). When CGD is required, dedication requirements should be included in applicable procurement and technical documents as necessary to support the planned dedication efforts. It is critical that the performance of CGD be performed by engineering or equivalent within the organization experienced and knowledgeable in the application of CGD.

METHODOLOGY

Fundamental to the CGD effort is the development of a dedication plan and identification of critical characteristics that when verified will provide reasonable assurance that the technology will perform its intended safety function as part of its routine functioning. The dedication plan should be developed by engineering with input from QA regarding how selected critical characteristics should be verified and the safety basis determined. It is important to note that CGD relies on the determination of, and the confirmation of, critical characteristics to provide reasonable assurance that the item will perform its intended safety function. The identified critical characteristics established as part of CGD are those that are important to design, material, or performance characteristics of a commercial grade item that, once verified, will provide reasonable assurance the item will perform its intended safety function. If a characteristic is important to the group needing the item but that characteristic is not critical to providing reasonable assurance that the item or service will perform its intended safety function, then the characteristic should not be designated a critical characteristic.

Before developing the dedication plan, and selection of the critical characteristics, the need for determining that CGD is required:

- A safety basis assessment
- A determination that the item performs a safety function; and

- Confirmation that the item meets the applicable definitions.

Generically, the CGD assessment may be visualized as:

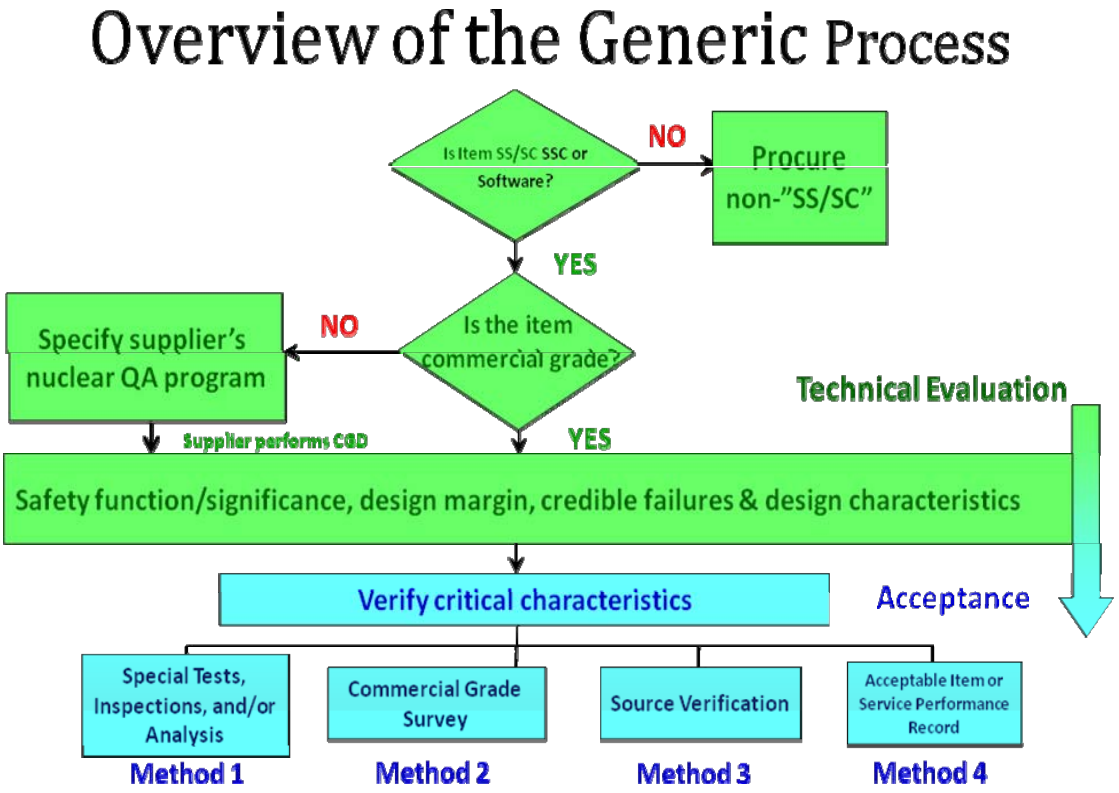

Figure 1 - Overview of A Generic CGD Process

A typical CGD process then includes the following:

- A technical evaluation identifying the critical characteristics;
- Selecting one or more acceptance methods as show is Figure 1 above and criteria for acceptance, for each critical characteristic and
- After acceptance criteria and acceptance methods have been established, through the approved dedication plan, the dedicator uses the plan to evaluate the item or service to be dedicated.

Table 1 - Example Critical Characteristics

Physical Characteristics	Performance Characteristics
Balance Capacitance Conductivity Continuity Density/Specific Gravity Dielectric strength Dimensions (to within manufacturer's tolerance) Elasticity Fatigue resistance Flammability Flashpoint General Configuration of Shape Material hardness Polarity Purity Resilience Resistance Surface Finish Surface hardness Tensile Strength Torque Viscosity Weight	Accuracy Current Rating Cycle Time Flow rate Horsepower Input/output voltage Interrupting current Leakage Load rating Open/closure time Operating range Pickup & Drop-out voltage Power rating Pressure Drop Pressure Rating Pressure Test Rotational Direction Set point stability (no drift) Speed Voltage rating

Table 2 - Example Critical Characteristics By Item

Commercial Grade Item	Critical Characteristics
Limit Switch	Configuration, dimensions, materials (metallic and nonmetallic), markings, operability, voltage rating, current rating
Integrated Circuit	Configuration, gain, input/output impedance, frequency responses, operability
Transistor	Markings, gain, input/output impedance, current rating, voltage rating, operability
Bolting (Nuts, Bolts, Studs, Etc.)	Configuration, dimensions, pitch, material, tensile strength, hardness, plating

Table 3 - Example Failure Modes

Example Failure Modes
Corrosion
Short Circuit
Vibration
Metal Fatigue

The objective is to provide a reasonable assurance that a dedicated item will perform its intended safety function and is the item specified in the procurement documents. Reasonable assurance is established by engineering judgment. That is, a process, defined in a dedication plan, of reasoning that leads from a stated premise to a logical conclusion. This process should be supported by sufficient documentation to permit verification by a qualified individual.

The word “reasonable” connotes a level of confidence which is justifiable but not absolute. In the context of an item, “reasonable assurance” of measureable performance should be based on facts, actions, or observations (objective evidence). While these bases are objective and measureable, the inference of adequacy drawn from them – the decision that “reasonable assurance” has been attained – is inherently subjective and the judgment of reasonability may vary between different observers. These judgments are commonly referred to as “engineering judgment” and should always be documented. In many instances they will be subject to review and audit.

Applying expertise in the subject matter associated with the item is critical. Procurement personnel may not have this expertise for all items being dedicated. Procurement personnel may need to rely on personnel in the design organization or outside sources for the requisite expertise. Experience has demonstrated that the procurement and engineering staff need to work hand-in-hand to reach sound decisions on applying the CGD process for safety applications. When in-house expertise is not available or as experienced as desired, many organizations turn to third party dedicators for support.

There are many representative examples of dedication plans that may be found online or within your organizations procedures. EPRI and DOE have issued documents that contain guidance and templates. DOE is in the process of developing a standardized guidance document for complex wide deployment. Overall, the dedication plan documents the logic and methodology applied to identify a critical characteristic and the subsequent testing and evaluation to substantiate its compliance to provide assurance of NQA-1 equivalency.

CONCLUSION

It should now be apparent that new technologies and one-off projects can be made NQA-1 compliant especially in safety significant situations. Advance planning and early coordination between engineering, QA, and procurement is recommended to facilitate the process and minimize late stage frustrations and technology deployment impacts. Should your organization not be equipped or experienced with NQA-1 sourcing or commercial grade dedication there are third party dedicators that offer this service to industry. Lastly, document, document, document. The need for thorough document cannot be emphasized enough.