Overview of the NEK Commercial Grade Dedication Process with Regard to Industry Lessons Learned

Juraj Milobar, Vedran Nikl
ENCONET d.o.o.
Zelinska ulica 3, 10000 Zagreb, Croatia
juraj.milobar@guest.nek.si, vedran.nikl@guest.nek.si

Roman Medvešek
Nuklearna elektrarna Krško
Vrbina 12, 8270 Krško, Slovenia
roman.medvesek@nek.si

ABSTRACT

Commercial-grade dedication is a methodology used to support operation and maintenance of nuclear power plants by providing means for NPPs and other licensees to maintain and extend their supply chains, thereby making them more robust. The concept was first introduced in the late 1980s through EPRI NP-5652 as an alternative way of accepting items from suppliers who abandoned their nuclear QA programs due to nuclear industry's transition from large equipment purchases, supporting fleet building to smaller purchases of spare and replacement items supporting operation and maintenance. The idea was immediately endorsed by the NRC via Generic Letter 89-02. Since then, the methodology evolved significantly and is currently used in an increasing number of applications that support operations and maintenance as well as new nuclear construction.

The exit of original equipment manufacturers/suppliers caused licensees (NPPs) to implement their own CGD procedures and/or procure basic (safety related) equipment from licensed 3rd party suppliers. In any case, the growing need for CGD prompted The European Commission's science and knowledge service Joint Research Centre to issue a technical report "Lessons Learned from Events related to Commercial Grade Dedication" containing summaries of CGD related events across the industry related to counterfeit, fraudulent or suspect items, inadequacies in CGD procedures (document traceability, testing and inspection, critical characteristic selection…) as well as issues not necessarily related directly to CGD (design, configuration, maintenance…) but still part of the procurement process.

The goal of this paper is to analyse the industry experience laid out in the report and make a comparison with NEK standard CGD practices. Additionally, events deemed applicable/relatable to NEK will be presented as short case studies, with emphasis on how a given issue would be handled in accordance with NEK procedures.

Keywords: *Commercial Grade Dedication, Nuclear Procurement, Counterfeit, Fraudulent And Suspect Items*

1 INTRODUCTION

The rapid pace of technological advancements often leads to the shortening of product lifecycles and ultimately, product obsolescence. This is of particular relevance to the nuclear power industry, where the operational lifetime of NPPs can span multiple decades and the desire for innovation and advancement is often curtailed by the preference for procuring equipment originally supplied during plant build or subsequent plant modifications, thereby prioritizing consistency, reliability and compliance with strict safety standards.

When, for whatever reason, suppliers cease operations or discontinue their nuclear quality assurance programs, the power plants are compelled to find alternative sources and methods of procurement.

One such method, offering NPPs a way of procuring commercial grade items and using them to perform safety related functions, is commercial grade item dedication.

2 BASIC PREMISES OF CGID

As defined in 10CFR21 [1], a commercial grade item is "a structure, system or component, or part thereof that affects its safety function, that was not designed and manufactured as the basic component" and, additionally, "commercial grade items do not include items where the design and manufacturing process 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)".

To better understand the regulatory definitions, one needs to take a quick look into the process of CGID and how it differs from procuring items as basic components from suppliers adhering to a nuclear QA program compliant with 10CFR50, Appendix B [2]. The key differences between these two scenarios are contrasted on Figure 1.

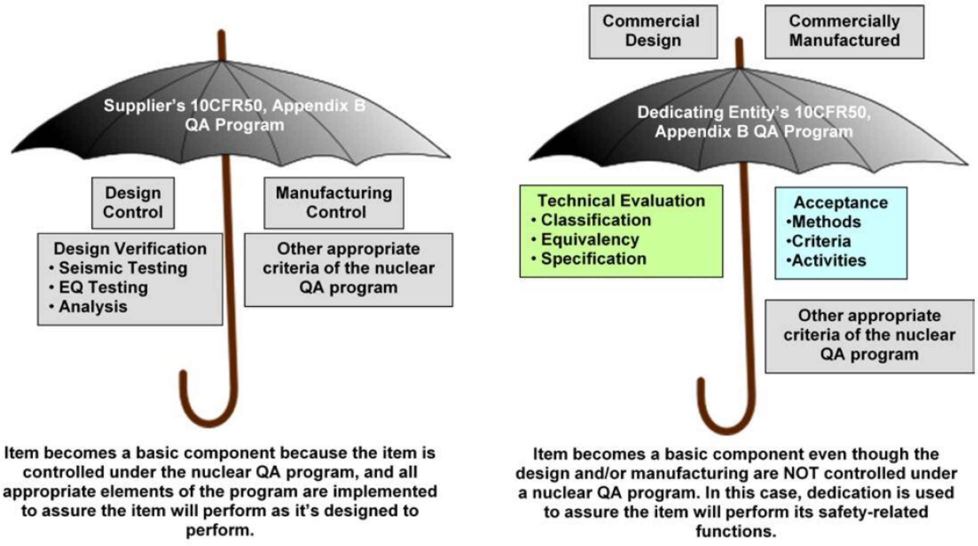

Figure 1: Basic component under 10CFR50, Appendix B (left), vs. CGID (right) [3]

When speaking of procuring products nuclear grade, this means procuring items that have been designed, produced, tested and inspected specifically for use in nuclear facilities. This means that each of these steps is stringently controlled under a nuclear quality assurance (NQA) program to assure the final product is able to perform its nuclear safety function(s).

Commercial grade products, although often compliant to some non-nuclear industry standard, are usually not manufactured with nuclear-specific requirements in mind. Therefore, to be considered for use in a safety related function, these products have to be subjected to a suitability evaluation process. This process is what is known in the industry as commercial grade item dedication (often referred to as simply - dedication).

As shown by Figures 1 and 2, there are two processes that are key to performing a dedication of a commercial grade item: technical evaluation and a subsequent acceptance process. These two processes, if completed successfully, should provide reasonable assurance that the dedicated CGI is equal in quality to an item that would have been manufactured and controlled entirely under a NQA program. Figure 2 illustrates a generic CGID process.

The first step in any technical evaluation is to identify the item being procured. Additionally, during this first step, one has to make sure that the item being procured is a like-for-like replacement of the original item. If this would not be the case, an equivalency evaluation would be required in order to ensure that the proposed alternative item is suitable.

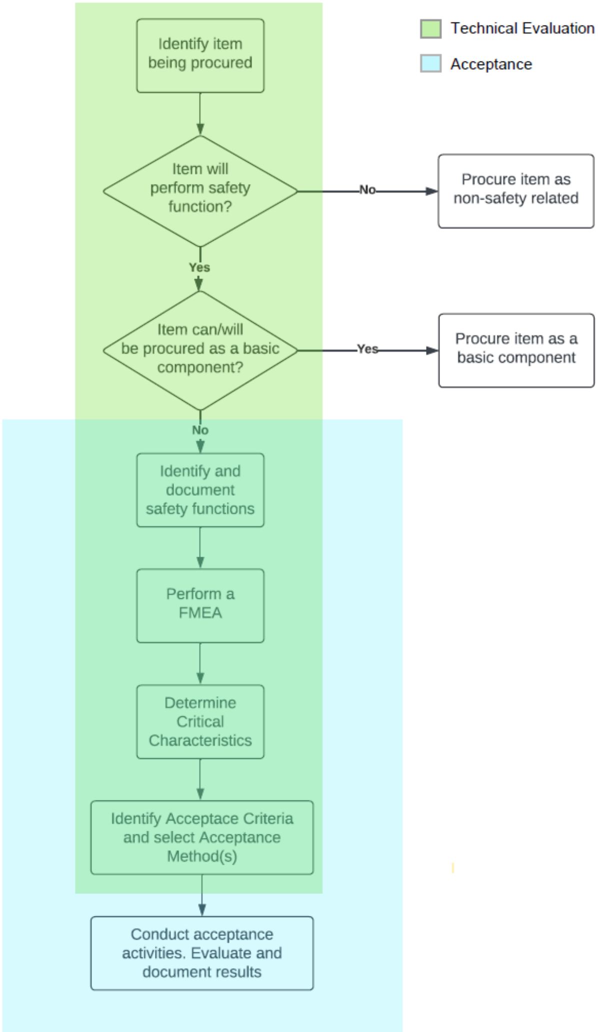

Figure 2: Generic CGID process

Once item suitability is confirmed, a safety classification of the item (if not already determined) must be established. If the item is classified as non-safety related, it is procured as such, and the technical evaluation process is complete. If, however, the item performs any safety-related function it must be procured either as a basic component or as a commercial grade item. If the option of a commercial grade item is chosen, the process continues as follows:

- All required safety functions of the item must be identified and documented
- A failure modes and effects analysis (FMEA) is to be performed to determine all the probable ways the item could fail and how this would impact plant system safety

- Critical characteristics must be identified in such a way that the process of verifying these characteristics will provide reasonable assurance that the item, once dedicated and installed, will be able to perform its safety function(s), i.e., each safety function identified must be supported by adequate critical characteristics.
- Once the critical characteristics are chosen, acceptance criteria are to be determined based on both design requirements and manufacturers published data.
- Finally, in order to conduct verification of the selected critical characteristics, an acceptance method, or a combination of acceptance methods, must be selected. EPRI guidelines [3] define four acceptance methods. These methods, along with their intended uses and limitations are listed in Table 1. These acceptance methods are consistent with 10CFR50, Appendix B, Criterion VII "Control of Purchased Material, Equipment and Services".

Acceptance activities have to be evaluated and well documented to provide traceability of the process as a whole.

Table 1: Acceptance methods

EPRI CGID Method	Intended use
Method 1: Special Tests and Inspections	Commodity items, simple in design, procured frequently and in relatively large quantities. Any sampling plans used need to be properly justified and documented.
Method 2: Commercial Grade Survey	Assemblies, complex in design, manufactured under well documented commercial QA programs. Results of the survey are valid for up to 3 years. Compliance to the survey must be certified by the manufacturer on every procurement subsequent to the survey.
Method 3: Source Verification	Infrequent purchases of items whose critical characteristics can only be verified during the manufacturing process.
Method 4: Supplier/Item Performance Record	Based on documented performance history of an item or a supplier. Use of this method is restricted as per NRC Generic Letter 89-02 so that it can't be used on its own. It is often used to support selection of sampling plans for Method 1.

The elements comprising the dedication process are only part of the overall process of ensuring the quality of plant equipment, shown on Figure 3. With this in mind, it is important to understand that design suitability has to be established prior to initiating a procurement process. CGID is therefore not a substitute for design, it cannot be used to change the design of an item, nor can it improve the items performance or make it more reliable.

Figure 3: Elements ensuring the overall quality of plant equipment [3]

3 CGID AT NPP KRSKO

There are two ways a CGI can be procured for safety-related application(s) at NPP Krško (in further text – NEK): 1) the CGI is dedicated by a supplier and delivered to NEK as a basic component and 2) the CGI is dedicated by NEK. The general steps in these two procurement scenarios are depicted in Figure 4. This section of the article will focus mostly on the NEK in-house dedication.

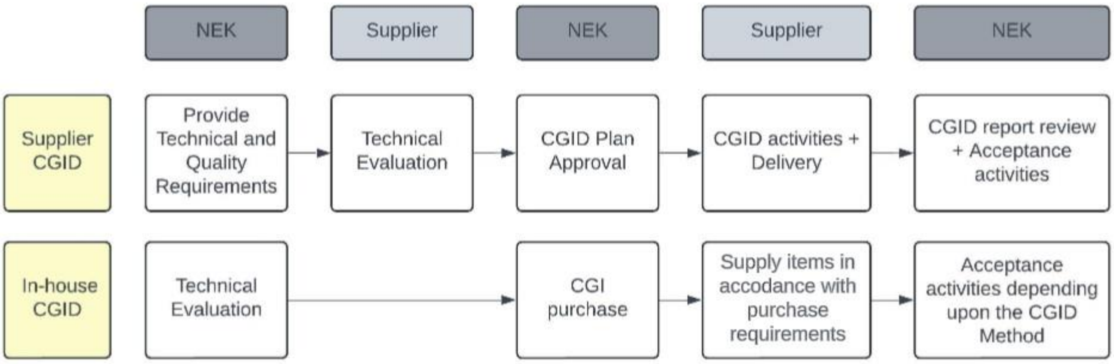

Figure 4: CGI procurement scenarios for SR usage in NEK

3.1 CGID at NEK

3.1.1 Policy

In-house CGD has been implemented at NEK since 1995. The process is governed by NEK ED-10 Program for the Procurement and Dedication of Commercial Grade Items and NEK procedure ESP-2.207 Commercial Grade Item Dedication, which have to be in compliance with regulative demands set by 10CFR50, Appendix B and 10CFR21 – Reporting of Defects and Noncompliance. The core CGID procedure ESP-2.207 is based on EPRI guidelines relevant to the specific topics of CGID procurement scenarios (technical evaluation, sampling, seismic requirements, surveys, audits…). The basic premises of the NEK CGD methodology are described in detail in Appendix V to the IAEA-TECDOC-2034 Suitability Evaluation of Commercial Grade Product for Use in Nuclear Power Plant Safety Systems [4] and can be summarized as follows:

- The definition and criteria for commercial grade items from 10CFR21 are respected.
- CGIs are procured instead of basic components under the following circumstances:

1. The item cannot be furnished to NEK as a basic component produced and controlled entirely under a nuclear quality assurance program in full compliance with 10CFR50, Appendix B
2. The original supplier/manufacturer can no longer furnish the item (the item is deemed obsolete) and a suitable replacement is only available commercial grade
3. Delegating the dedication process to another competent entity is not economically sound

- The technical evaluation follows the general idea and guidance laid out in EPRI 3002002982 Plant Engineering: Guideline for the Acceptance of Commercial-Grade Items in Nuclear Safety-Related Applications, as was described previously in Section 1 of this article. The detailed steps of performing a credible technical evaluation are described in Section 5 of the Guideline [3].
- Available test equipment and manpower are taken into consideration.
- The in-house CGID process at needs to comply with 10CFR50 Appendix B (Criterion III, IV and VII) and NEK Quality Assurance Program

Additionally, the scope of items that can be considered as CGID candidates at NEK has been limited at NEKs discretion and excludes:

- Items designated as ASME class
- Items that are subject to the NEK EQ program
- Digital equipment to be used in replacing original design analog equipment

Finally, for commercial grade items with seismic requirements, seismic qualification can be obtained in two ways:

1) Providing and documenting an engineering evaluation that provides reasonable assurance that previous seismic qualification is maintained or
2) Obtain a new seismic qualification by delegating the seismic testing to a third-party

Although all of the EPRI CGID Methods can be employed at NEK (with limitations on Methods II and IV), the bulk of dedications is performed using Method I: Special Tests and Inspections. In order to provide some insight in the process in question, a flowchart depicting a generic NEK Method 1 CGID process is shown on Figure 5.

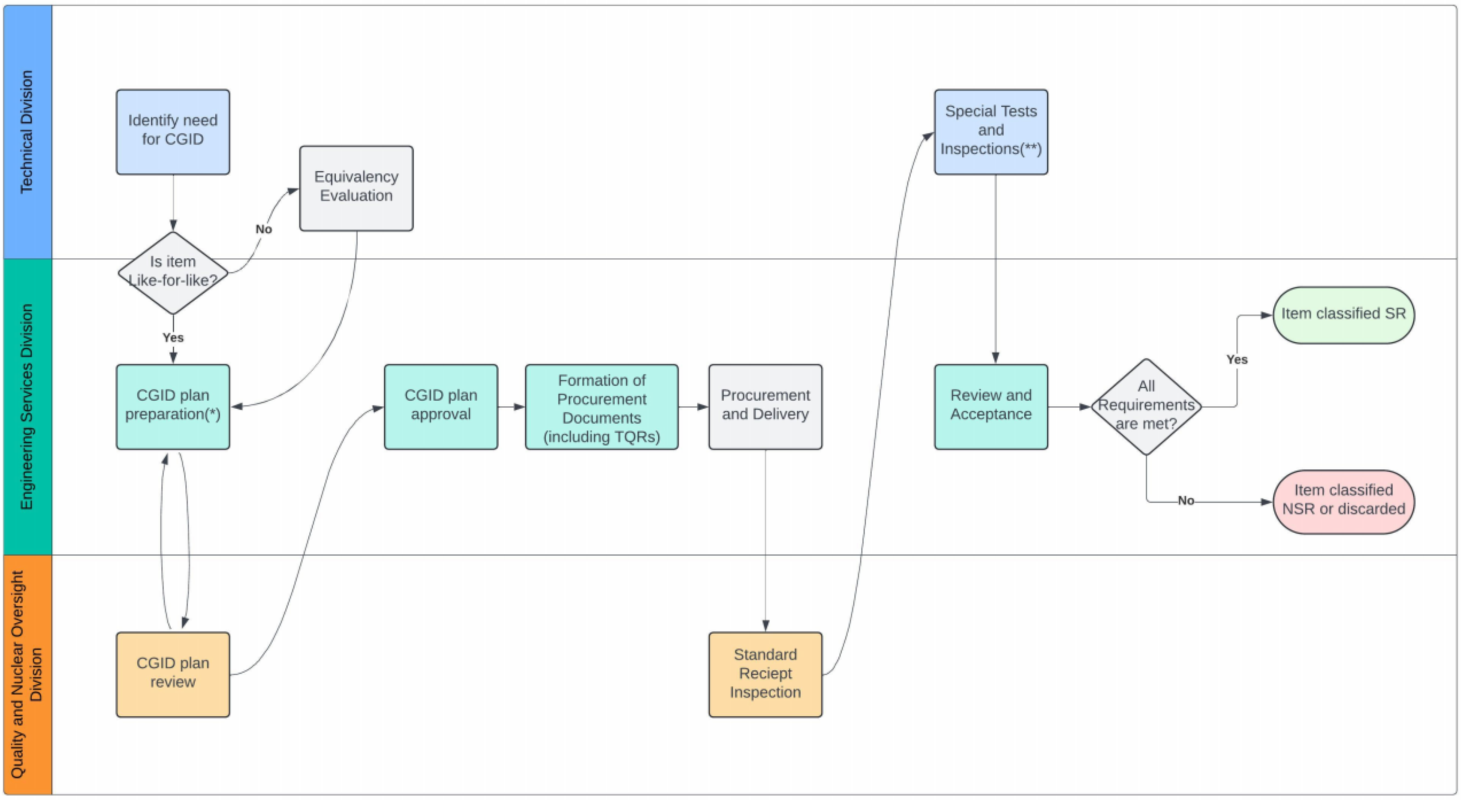

Figure 5 A generic NEK Method 1 CGID Process

3.1.2 Results

A comprehensive search of NEKs E-Business Suite (EBS) was conducted for items dedicated by NEK and those dedicated items currently installed at NEK. The scope of this search includes all dedication work requests completed at NEK from 2012 to 2023.

During this timeframe, 534 dedication requests were completed, resulting in the dedication of over 60 thousand individual items consigning 361 different part numbers. Cumulative number of individual items dedicated in NEK is shown on Figure 6.

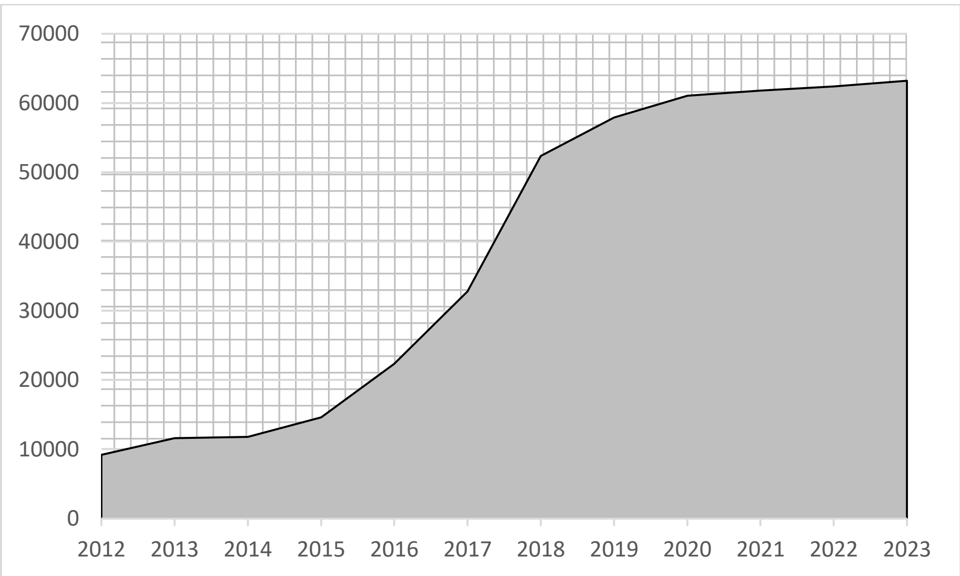

Figure 6: Cumulative number of individual items dedicated in NEK

Items in NEK are divided into components and their spare parts. The bulk of the CGIs dedicated are commodity electrical items (fuses, relays, indicating lights…) and items used as spare parts in electric machinery, such as ball bearings used in electric motors and lugs used in connecting safety related electrical equipment. The quantities of frequently dedicated CGIs are shown in Table 2 and Figure 7.

Table 2: Quantities of frequently dedicated CGI

Item	**Number of items dedicated since 2012**
COMPONENTS:	
Fuses	2686
Indicating lights	1270
Relays	1218
Switches	595
Contactors	192
Circuit breakers	65
SPARE PARTS:	
Lugs, splices	52053
Bearings	1762
Contacts	932
Fuse block	235
Overload heater	207
Capacitor	165

Note that the relative volumes shown on Figure 7 exclude dedicated lugs and splices, both because of the high quantity and the items simplicity.

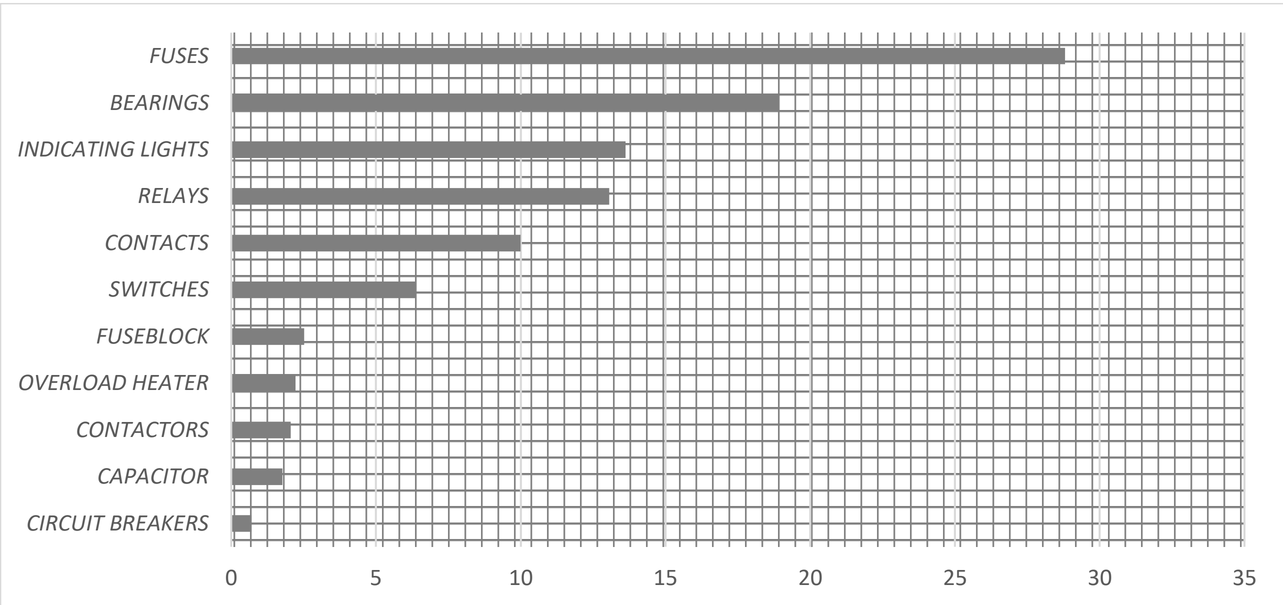

Figure 7: Relative volumes of frequently dedicated CGIs

The vast majority of dedicated items dedicated at NEK consists of recurring procurements of items with well-established plant usage history. Items like fuses and bearings are procured periodically in large quantities for plant maintenance. These items are procured from industry leaders so that a high degree of quality and reliability can be assumed and later confirmed through the dedication process. Some plant-specific items, like switches, contacts and indicating lights comprising control board modules, are procured and dedicated as needed for preventive maintenance or fault correction, because replacing them with other equivalent items would be highly unpractical. Various low voltage switchgear devices like relays, contactors and circuit-breakers are also often dedicated at NEK because it is economically preferable to procurement from other dedicating entities.

3.1.3 CORRECTIVE ACTION

Being a dedicating entity, NEK is required to report any non-conformance related to CGIs it dedicated (as per its 10CFR21 obligation). With this in mind, once dedicated for safety related use, all items are assigned an internal NEK serial number in order to track any potential non-conformance. Until today, there have been no reportable incidents with dedicated commercial grade equipment, which is a testament to both the quality of NEKs CGD and maintenance policies, and the quality of procured commercial grade items.

3.2 SUPPLIER CGID

When an item is to be dedicated and furnished to NEK by a supplier, NEK will communicate all the relevant technical and quality requirements (resulting from plant design documents). This ensures the supplier has enough information to be able to prepare a CGID plan that will provide reasonable assurance that the CGI in question will be able to perform its safety function(s). The suppliers CGID plan is reviewed and approved by NEK before CGD activities are started by the supplier. Once the suppliers CGID report is reviewed and the items are delivered, NEK examines the items and releases them for use.

The sequence of events described above is an ideal version of procuring dedicated CGIs from approved suppliers. The reality of the process is such that this kind of user-supplier interaction is not always probable. Bigger suppliers often dedicate CGIs according to their own evaluations, and their inputs for item qualification (including seismic and environmental) are broad enough to envelop site-specific requirements of individual plants. Such dedication plans and the resulting reports are often considered proprietary/know-how information by the suppliers and are rarely distributed to the purchaser. In these cases, the supplier compares the purchasers' requirements to their dedication/qualification reports and certifies compliance via purchase documents, such as a certificate of conformance/certificate of qualification.

When procurement of complex new items is required, either as a replacement of obsolete items or as part of a plant modification, third party suppliers/qualifiers are often the best option, both because of their expertise and because they often present a favourable economic option.

4 LESSONS LEARNED

As is the case with all aspects of the nuclear industry, the lessons learned from every participant in the CGD process provide valuable input into identifying parts of the process where room for improvement exists. A technical report "Lessons Learned from Events Related to Commercial Grade Dedication" [5], recently published by the European Commission's science and knowledge service Joint Research Centre, is a compilation of generic letters, information notices and licensee reports that are in any way related to CGD. An analysis of the report was conducted via the NEK Corrective Action Program, and the results of this analysis are discussed in the following section. To go into the intricacies of each event, report, notice or guideline (in further text - entries) from the JRC report would far exceed the envisioned scope of this article. Two events, in which the issues were directly caused by inadequacies in the dedicating entities' CGID programs were chosen for more detailed discussion.

4.1 LESSONS LEARNED SUMMARY

Each entry in the original report has been assigned a cause and their applicability to NEK evaluated. The number of instances for each cause is shown in Table 3. In total, there were eleven instances where inadequacies in the CGD process were a contributing factor, and additional five related to CFSI. Other events, caused mostly by procurement and organizational issues, will not be a subject of further interest to this article.

Table 3: Number of instances for each cause appearing in the JRC report

CAUSE	NUMBER OF INSTANCES
CGID Inadequacies	11
CFSI	5
Procurement, not related to CGID	5
N/A or Deemed obsolete	5
HOF	2
Modification/Design deficiencies	2
Equipment qualification	2
Configuration control	1

The inadequacies in the CGID process recognized in the report entries, as well as their frequency in the report, are summarized in Table 4.

The most frequent problem identified in the analysis is the dedication of commercial grade items according to inadequate technical evaluations that overlook items critical characteristics. As discussed in Section 2, the technical evaluation process is a key factor in the CGD process. Special care must be taken to ensure that all safety functions of the item being dedicated are sufficiently supported by verifiable critical characteristics. Not having the resources to verify some characteristic or not having enough experience and training to recognize critical characteristics of complex items isn't a valid reason to exclude them from the technical evaluation. The required items can, in both cases, still be dedicated for use by a third-party dedicating entity.

Although NEK has never had any issues with dedicated CGIs that could be traced to unverified critical characteristics, certain areas for improvement have been identified regarding inadequate documentation of engineering decisions during the CGD process. This problem is mentioned in the NRC Information Notice IN-2011-01 "Commercial Grade Dedication Issues Identified During NRC Inspections" and has also been recently brought up by the NEK Quality and Nuclear Oversight Division. A collective effort is already underway to provide NEK engineers, involved in CGID, with a more detail oriented CGID form, in order to ensure that all engineering decisions are well documented and present a logical and auditable dedication documentation package.

Another important issue identified, was presuming that item qualification is maintained in spite of item design changes. The NRC has identified examples where the items original qualification, achieved through testing and analysis was improperly applied, as similarity between the originally tested and the currently supplied components was not properly established. This is of particular concern for CGIs, as changes made by commercial equipment manufacturers could impact the component's qualification and go undetected.

As mentioned in Section 3.1.1, seismic qualification of CGIs being dedicated can be maintained at NEK, if there is reasonable assurance that the item hasn't undergone design changes that would affect its original seismic qualification. This is usually established in two concurrent ways: 1) direct confirmation by equipment manufacturer/supplier that the item was not changed in any way that would affect the form, fit and function, and 2) by constructing a dedication plan in such a way that the verification process of the selected critical characteristics establishes reasonable assurance that the item has indeed remained unchanged.

Table 4: Inadequacies in the CGID process as concluded from the JRC report

CGID INADEQUACIES	NUMBER OF INSTANCES
Overlooked critical characteristic	4
Unreported/overlooked manufacturer design change	2
Inadequate environmental/seismic qualification	2
Can not be identified from the report	2
Inadequate engineering decision documentation	1
Inadequate knowledge of the CGID process	1
Inadequate use of sampling	1
Item not a candidate for CGID	1

Although not directly related to CGD, it is important to mention that a lot of entries in the JRC report are related to CFSI. The entries in the JRC report, related to this growing phenomenon, range from possible misrepresentation of substandard parts to confirmed and prosecuted criminal falsification of CGID related certificates in the early 2010s. Implementing a well-structured CGID program can provide an additional barrier to introducing CFSI into the plant structures, systems and components.

4.2 EVENT DISCUSSION

The two events discussed in the following two sections have been chosen because they closely relate to recent NEK CGID experiences.

4.2.1 LER 440-2016-003-00: LOSS OF SAFETY RELATED ELECTRICAL BUS RESULTS IN A LOSS OF SHUTDOWN COOLING [7]

On February 11, 2016, with the Perry Nuclear Power Plant in mode 4, an indicated loss of power to the division 1 4kV bus, occurred. An invalid undervoltage signal tripped the bus supply breaker, and the bus loads shed, as expected. The invalid undervoltage signal resulted in a loss of shutdown cooling. The division 1 diesel generator started and loaded the bus. Subsequently the division 1 DG was manually shutdown due to cooling water not being available (the ESW pump couldn't start because of the undervoltage condition). This de-energized all division 1 equipment, including the train supplying shutdown cooling at the time. Shutdown cooling was re-established 42 minutes later from division 2.

Troubleshooting showed that the apparent cause for the loss of the division 1 bus was a manufacturing defect in a fuse used in the A phase bus potential transformer. The fuse, which supplies the undervoltage and degraded voltage circuitry, was found to exhibit intermittent continuity. The failure of the fuse caused an invalid undervoltage signal, shedding the bus. The failure analysis showed that the fuse internals were not soldered correctly during the manufacturing process and this was not detected by the suppliers' dedication process.

This event was chosen because the dedication of fuses can best demonstrate what is meant by the "reasonable assurance" part of the CGID methodology.

A lot consisting of 30 fuses, similar to the ones used at Perry NPP, was recently dedicated at NEK using Method 1 – Special tests and inspections. The fuses were procured and dedicated for the preventive maintenance of safety related 400V switchgear control fuses. The interesting thing about dedicating fuses using this method is that in order to confirm the fuse is capable of performing its safety function, it has to be destroyed in the process. This is why a dedication plan must be formed in such a way that it provides certain assurances by correlating destructive and non-destructive tests.

The safety function of a fuse is generic. It must be able to carry the design load current without interruption and provide fault isolation in case of an overload condition to prevent degradation of the safety related circuitry or isolate non-safety related and safety-related circuits. Based on the safety function and a FMEA, five critical characteristics were chosen for verification: fuse resistance, dimensions, current carrying capacity (110% rated current) and current clearing time (both at 135% and 200% of rated current). Given that the current clearing tests are destructive, the following reasoning was deemed adequate to provide reasonable assurance that the remaining fuses (not submitted to destructive tests) will be properly dedicated.

First, the fuse resistances of the entire lot are to be measured and recorded in order to establish homogeneity of the lot. Any fuse(s) with high discrepancies are to be considered flawed if not proven otherwise. The highest deviation from the lot average was 2%. A review of industry practice showed that manufacturers usually impose broad tolerances for fuse element resistances, ranging from 10 to 50% and a review of available dedication plans from the industry showed a tendency to use a 10% tolerance. The lot was, therefore, declared uniform.

Following this, a sampling plan for further testing was established by respecting the guidelines of the relevant UL 248-1 and 248-9 standards. Five fuses were subjected to further testing, but special care was taken that this testing represents the entire fuse lot, i.e., two fuses were chosen from the higher end of the lot resistance values, two from the lower end and one with the exact lot average resistance. This type of selective sampling was used in order to provide the desired high correlation between the destructive tests (current clearing time) and non-destructive tests (resistance measurement and current carrying capacity). All tests provided results within the acceptance criteria and the 25 remaining fuses were declared adequate for safety related use. This, however, doesn't mean that 100% assurance is given that an event similar to the one in Perry Nuclear Power Plant will never happen. The process simply yields a high degree of assurance that these fuses will perform their safety function. It should also be mentioned that, in recent years, three batches of fuses have failed this type of dedication at NEK. These instances affirm the validity of the process, despite their unfavourable outcomes.

4.2.2 LER 482-2019-002-00: EMERGENCY DIESEL GENERATOR INOPERABLE DUE TO TEMPERATURE CONTROL VALVE FAILURE [8]

During performance of an emergency diesel generator (EDG) monthly operability run at Wolf Creek Generating Station, the EDG was pronounced inoperable due to high intercooler water temperature. Subsequently, condition B of Technical Specification Limiting Condition for Operation (TS LCO) 3.8.1.1. “AC Sources – Operating” was entered. At the time of the event, the unit was at 100% power.

Investigations revealed that the cause of the event was the failure of thermostatic power pills in the intercooler heat exchanger temperature control valve. The failed power pills caused valve failure in the bypass position, reducing cooling flow through the intercooler heat exchanger, thereby causing the high intercooler water temperature.

The most likely cause of the power pills premature failure is accelerated aging induced by the tests undertaken during on-site dedication and shelf-life testing. The tests submitted the rubber diaphragms to additional thermal cycling which led to increased degradation. The in-house dedication, presumably conducted by utilizing Method 1 – Special tests and inspections, was an industry outlier, given that these components are usually procured as basic components.

This event highlights that not every commercial grade item can be a candidate for CGID via Method 1 because testing or even just inspecting some items can lead to significant degradation, making these items liabilities to plant safety.

One such lesson learned at NEK is the dedication of ball bearings. These are dedicated frequently and in relatively high quantities as described previously in Section 3. The first CGID plans for these bearings involved, among other things, opening them and checking their dimensions and configurations. It was almost immediately understood that this is a wrong way of performing a CGID for ball bearings. The act of opening a bearing exposes it to contaminants such as dust, dirt and moisture. These contaminants can enter the bearing and cause increased wear, corrosion and potential bearing failure. Additionally, the precise lubrication applied during the manufacturing can be compromised, leading to inadequate lubrication during operation, endangering the bearings' function and diminishing its operational life. Because of this, it was concluded that the bearings are more suited to Method 2 of CGID – Supplier Survey.

On the basis of the critical characteristics identified by a technical evaluation, the NEK Quality Assurance Department performed a survey of the manufacturers' facilities. The goal of this survey was to acquire reasonable assurance that the manufacturers' commercial grade quality assurance program puts adequate measures in place to assure that the critical characteristics of the bearings are well controlled. The positive results of this survey, combined with the manufacturer issuing certification that the surveyed processes are still in place each time the bearings are procured, give reasonable assurance that the bearings will perform their safety function adequately. This approach in Method 2 utilization is in accordance with NRC Generic Letters 89-02 and 91-05.

The current survey will remain valid for three years, during which its findings can be utilized. However, there is a probability that NEK will not be granted permission to conduct a follow-up survey after the three-year period, in which case a combination of Method 1 and Method 4 shall be employed, with required special tests and inspections being outsourced to a third-party.

5 CONCLUSION

This paper gives an overview of the CGID process and the results of CGID implementation at NEK. The main challenge any NPP faces with introducing CGIs into their safety-related structures, systems and components is that these items might not have been designed with nuclear-specific requirements in mind, which can introduce risks if not properly evaluated. A review of lessons learned from the JRC Report [3] and dedication in NEK shows that a properly implemented dedication process can mitigate the risks by ensuring items can reliably preform their safety-related function. Although certain areas are viewed as problematic across the industry, the CGID methodology is shown to be an important asset in dealing with ageing management of NPPs.

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