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Commercial grade dedication challenges for Brazilian nuclear industry

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ABSTRACT

According to NRC, the commercial-grade dedication is a process by which a commercial-grade item (CGI) is designated for use as a basic component. This acceptance process is undertaken to provide reasonable assurance that a CGI to be used as a basic component will perform its intended safety function and, in this respect, is deemed equivalent to an item designed and manufactured under a quality assurance program. This assurance is achieved by identifying the critical characteristics of the item and verifying their acceptability by inspections, tests, or analyses by the purchaser or third-party dedicating entity. In Brazil there are two Nuclear Power Plants in operation, one is American design (Angra 1), other is German design (Angra 2) and one is under construction that is German design (Angra 3). The nuclear safety items are imported and many of them are obsolete and besides the process of purchasing imported items is very complicated. If the nuclear industry in Brazil adopt the Commercial-grade dedication it will improve the internal market and facilitate the process of purchasing items. The Brazilian Quality Assurance Standard (Cnen NN 1.16) shows the 18 Basic requirements of 10 CFR 50 App B, so the Brazilian Industry can be qualified according to this Brazilian standard. The critical characteristics identification and the testing process is an engineering responsibility that Brazilian engineer can perform. This work shows the challenge of commercial-grade dedication in Brazil and discuss the importance of this process to the operation of the nuclear power plants in Brazil, including the long-term operation and others Brazilian nuclear projects..

Keywords: **Nuclear industry, commercial-grade, quality assurance.**

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1. INTRODUCTION

Dedication is an acceptance process used in the nuclear segment, which allows that an item manufactured as a commercial grade, that is manufactured for industrial application can be applied to systems that perform safety nuclear power plants, replacing those that were originally manufactured under rigid requirements.

The Dedication Process aims to provide a guarantee that, through evaluation and Acceptance methods, a commercial grade item can be used as a component correspondent of nuclear grade, certifying that the commercial item will perform the same intended safety function and, consequently, the application is considered appropriate.

The objective of this work is to present to demonstrate that the Dedication Process is possible in Brazil, from the technical point, considering that the nuclear power plant has difficulty of replacing items when suppliers decide to stop its Quality Assurance Programs and nuclear qualification processes in accordance with Nuclear Standards.

Therefore, the process is indicated to enable the replacement of equipment that have a safety function in nuclear installations and that for some reason have been discontinued or lost their qualification and their acquisition was not possible.

In this work are detailed the phases for use of commercial grade items in important applications to nuclear safety, through the Dedication Process, which involves: - Technical Assessment and Acceptance Methods.

Angra 1 started the License Renewal and Long-term Operation project. Many items in Angra 1 are obsolete or manufacturers no longer have the quality Assurance program for the provision of safety-related items. So the dedication process is very important to ensure that Angra 1 will operate until 2044 or more

2. HISTORICAL OF DEDICATION

In Brazil, the Regulatory Authority that authorizes, licenses, regulates and supervises activities in the nuclear segment is the National Commission of Nuclear Energy (Cnen). Therefore, in Brazil,

Cnen is the responsible for approving the requirements for the design, construction and operation of Nuclear Installations, defining the requirements for the systems, equipment and parts of Nuclear Plants.

Although Brazil does not own Nuclear Plant projects, the country currently has two plants in operation, which were acquired from international manufacturers. The Angra 1 Plant was acquired from the American company Westinghouse and the Angra 2 Plant of the German company Siemens-KWU, through contracts and agreements entered into with the Brazilian Government and the countries of origin. Since the nuclear power plants in Brazil have different origins, the Brazilian Regulatory Agency (Cnen) has chosen to use and require Eletronuclear Termonuclear S/A, responsible for the operation of both nuclear power generation units in Brazil, to comply with the requirements of manufacturing, operation and licensing, based on the same ones described in the countries of origin of the projectors.

In this sense, the Dedication Process can be currently used in Brazil, and has the approval of Cnen, since it has already been approved by the Nuclear Regulatory Commission -NRC, which is the American Regulatory Body of activities in the nuclear segment, and be widely used in the USA.

The Dedication Process was initially adopted by American nuclear power plants, especially because of the lack of suppliers of nuclear grade products. Following the Three Mile Island (TMI) crash in 1979 and an end to a cycle of intensive construction of new nuclear power plants in the US, there was a drop in investment in this sector. By having many equipment manufacturers either leave the market or abandon product lines that were designed and manufactured.

US nuclear power plant operators have suffered damages caused by the lack of qualified products on the market. The US government, through the Nuclear Regulatory Commission (NRC) published the 10CFR21, and together with an important American Research Body, called the Electric Power Reseach Institute (Epri), formed a study group with plant and market participants to publish a Guide for Use of Commercial Items in Applications Related to Nuclear Safety.

3. DEDICATION PROCESS

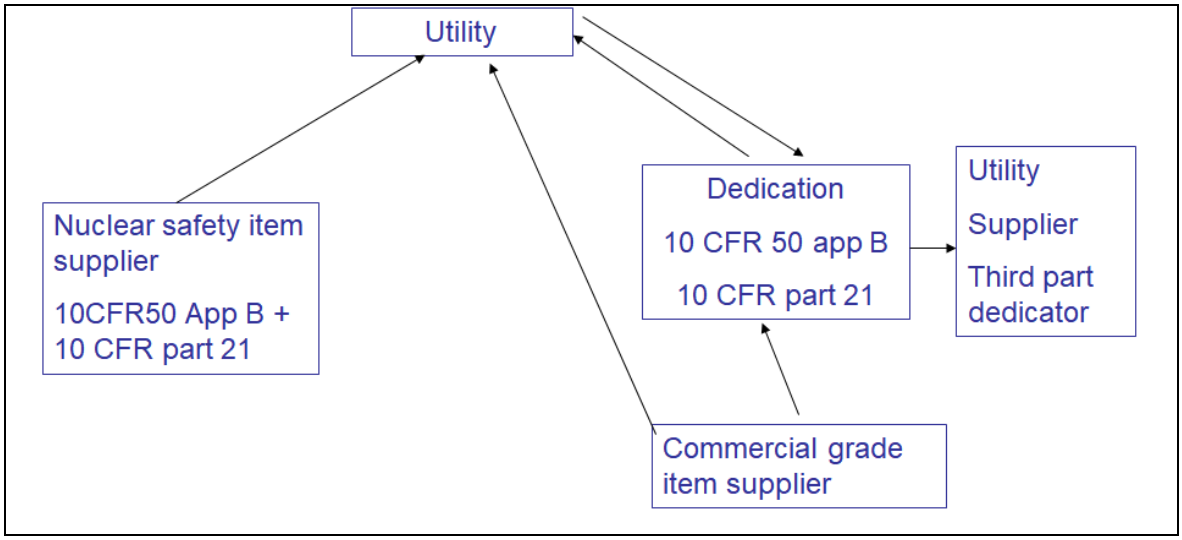
Some typical examples of commercial grade items that may be objects of Dedication Process and later used in the nuclear segment are presented in the following table.

Table 1: *Nuclear Items that can be commercial grade items dedicated.*

-Screws -Bearings -Anchoring Screws -Control switches -Counter-pins -Filters -Fuses - Integrated Circuits	-End switches - Grease and Lubricating oils -Engines -Pump diaphragms -Mechanical seals -Pressure switches -Réles - Resistors	-Capacitors -Solenoids - Temperature switches -Terminal Blocks -Connectors -Transistors -Transmitters - Internal Valves - O rings - Gaskets - Others.

The dedication can be done by the utility, by the supplier our by a third part dedicator, and it must be done according the Figure 1:

Figure 1: *The dedication process*.



In Brazil the Quality Assurance Standard is Cnen NN 1.16, and it is similar to 10CFR50 appendix B, so for the Brazilian utilities, suppliers or third part dedicators the QAP must be based on Cnen NN 1.16.

Commercial grade items can be applied to nuclear-grade systems, equipment, and components once their equivalence and similarity to the quality of a nuclear-rated item have been proven to be

called dedicated items. For example, many manufacturers of commercial items have excellent Quality Assurance Programs to satisfactorily control their products, having documentation controls that ensure the conformity of their items, demonstrating performance and reliability.

The use of commercial grade items in applications related to nuclear safety involves two distinct processes:

(1) Technical Evaluations for preliminary analysis of the conditions of the Dedication Process, where the specifications of the original product and the candidate for the Dedication Process are verified and the critical characteristics are determined and which possible methods of acceptance can be used.

(2) The Acceptance methods, which act as a tool for validation of the Dedication Process and ensure the dedicated item reasonable guarantee that will meet the requirements as specified.

The technical evaluations should preliminarily verify that the specifications of the item to be dedicated may meet the requirements for the qualified nuclear item and are considered the first step of the Dedication Process. If a manufacturer can supply the item identical to the original item, which has already been manufactured in accordance with the nuclear qualification requirements, although its Nuclear Quality Assurance Program has been replaced, the technical evaluation can be simplified.

Approval to start the process may be based on the manufacturer's reliability and performance, which will be analyzed and evaluated in detail using the Acceptance Methods. Identifying the model and the item descriptor helps to approve and justify the beginning of the Dedication Process when it is verified that it is the same model of the originally accepted item.

If a manufacturer can only offer a similar alternative item, the preliminary Technical Assessment must be conducted to approve the possible equivalence, preventing the Dedication Process from requiring time and costs for a commercial item that can already be previously rejected.

The Acceptance Methods for the commercial grade item must provide reasonable assurance that the item received is in accordance with the specification. Acceptance methods consist of measures that ensure that the commercial item will fulfill the same functions as the one that was once supplied in accordance with strict criteria. The selection of the correct acceptance method will vary based on many factors.

For the use of a commercial grade item in nuclear safety applications actions must be taken to ensure that the item is appropriate to the application required. The technical evaluation combined with the acceptance methods must prove that the item is in accordance with the requirements.

The dedication method is the sum of two important elements: technical evaluation and acceptance criteria.

Before selecting the acceptance method for a particular item, the following fundamentals must be adopted:

• Determine the safety function of the item;

• Confirm that the item can be dedicated;

• Identify critical characteristics.

3.1. Determining the Item security function

The first step is to conduct a study to determine whether the item is classified a safety related because of its function. This assessment should consider whether all components within the equipment are classified as safety-related. It is possible that many components installed inside a nuclear equipment do not need to have the same requirement.

Most nuclear installations have their systems, equipment and components classified or not as to the relationship of importance in safety, this information is usually maintained in databases and documents. Updating this documentation and databases should ensure that modifications or changes to the original design reflect the actual situation of the configuration, considered as the latest version of piping diagrams, electrical diagrams and instrumentation, Equipment Diagrams.

For each component it is necessary to check drawings with assembly and maintenance details, bill of materials and spare lists, it is expected that each item receives its ranking in relation to the importance of its function. The safety function is determined by analysis of engineering based on a logical methodology of criteria, where it evaluates:

• What is the safety function of the main equipment where the component is installed?

It is necessary to evaluate the formal classification received by the main equipment and the consequence of a possible failure in normal operation or in an abnormal situation. It is necessary to

check whether the component function is active or passive. Active components are those that change status in the process, such as examples of valves that allow passage or not of fluids and breakers that open or close electrical circuits. Unlike the active components the passive components do not change the status in the process, such as pipes, vases, brackets, but can also play an important role in safety. It should be evaluated whether the equipment requires seismic classification to withstand abnormal vibration situations caused by earthquakes or any possible other sources of vibration, as well as whether the equipment requires special rating to withstand Sudden environmental changes, such as increased radiation, pressure, humidity, temperature and others.

• What is the function of the item?

It is important to know the function of the item in normal condition or accident, this information goes beyond the assembly drawings, specifications provided by the manufacturers comprising an analysis of the function of the item and its contribution in the equipment and system to which belongs.

• What are the known ways of failing the item in service?

Considerations should be made associated with failures, as well as evaluation of the environmental condition in normal operation, possible occurrences of seismic events, ageing, degradation due to radiation, temperature, corrosion and others.

Is there any possible known failure in the item that precludes the security response desired by the equipment?

This is the most important criterion to evaluate, to determine the critical function of the item. It is possible to occur item failures that do not preclude the expected response of the equipment, thus allowing it to satisfactorily perform the intended safety function. As an example, we can cite a fuse holder, which may fail to generate an electrical circuit, but take the system to a safe, deenergized condition.

The engineering analyses must be performed by professionals with the deep knowledge of the functions of the system, equipment and component where the item will be installed.

It is necessary to confirm that the commercial item to be dedicated has the ability to also meet the requirements required for items that were originally manufactured with nuclear safety rating.

The dedication process cannot allow low-quality items or even counterfeit items to be installed in equipment that requires safety rating, compromising your response in an adverse situation.

Therefore, it is necessary for the item to be dedicated to present minimum requirements for initial approval of the dedication process. As an example, it should be required that the manufacturer and its supplier have a quality assurance program, which guarantees their items a degree of reliability. Another example would be the analysis of the knowledge that the manufacturer holds about the item, as for how long it already manufactures the item. In order to eliminate the risks of acquiring a counterfeit item, you must carry out the acquisition process only from distributors authorized by the manufacturer.

The third step of a generic process of dedication is the verification of the critical characteristics of the item to be devoted. Critical characteristics are identifiable and measurable attributes or variables of the item to be devoted, which must be analyzed through measurements, CGS, analysis of test reports, for the purpose of verifying whether the item to be dedicated is in According to the specifications.

Based on performance and the particularity of each item, specific features can be designated as critical to ensure that the item to be dedicated is in accordance with the specified and will work correctly in your application.

(i) Types of critical characteristics

The critical characteristics can be chosen according to the specificities of the item to be devoted, for example, dimensional and functional characteristics that can be observed, measured and verified. Therefore, critical characteristics are identifiable and measurable attributes or variables of the item, which must be analyzed through measurements, CGS, analysis of test reports, with the purpose of verifying whether the item to be dedicated is in According to the specifications.

(ii) Selection of Critical features

The selection of critical characteristics should consider the importance of the attribute or measurable variable with respect to the execution of the desired and main function of the item. A typical list of example descriptions of items and potential critical characteristics are presented in Tables 1, 2 and 3 but are not necessarily limited to these.

Table 2: *Example of critical characteristics.*

Product identification	Colors code	Prints and typings	Casing type
	Dial Type (Scale, graduation)	- identification plates	- model and serial number
Physical characteristics	- Ohmica	- Elasticity	-Pureity
	- Capacitance	- Fadigue	- Viscosity
	- Color	- Indutance	- weight
	- Size	- Material	
	- hardness	- Permeability	
	- Concentratio	- Polarty	
Performance features	-accuracy	-Time stability	- Stability
	- Gain	- repeatability	- Calibration
	- Range	- Range-input and output	- resistance to flame propagation
	- Potency	- nominal pressure	
	- nominal voltage	- Velocity	

Table 3: *Example of item commercial grade versus critical characteristics.*

Item Grade Commercial	critical characteristics
Bearing	dimension, type, nominal load, material, model
Nut/bolt assemblies	dimension, type, material, hardness, purity
Sealing rings	dimension, material, elasticity, purity
Terminal blocks	dimension, configuration, nominal voltage, nominal current, material, type, model, fixation
Connection terminals	-dimension, material, nominal voltage, color, rididity
Relay	configuration, nominal voltage, nominal current, response

	time, contact material, number of cycles
Fuse	setting, nominal current, response time, interrupt current, dimension
Resistor	type, material, dimension, precision, tolerance, power dissipation, resistance value
Belts	dimension, material, rupture voltage, resistance to fatigue, nominal load
Spiral joints	configuration, dimension, model, number of turns, material, density
Pressure switches	configuration, dimension, material, voltage and nominal current, response time, precision, range
Lubricating oils and greases	color, viscosity, density, chemical composition
Motor-speed	power, insulation class, materials, bearing types, weight
Solenoid valve	configuration, size, nominal pressure, opening and closing time, nominal current and voltage
Key end-of-course	configuration, dimension, material, voltage and nominal current
Integrated circuits	configuration, gain, input/output impedance, frequency response
Transistors	configuration, gain, input/output impedance, frequency response

Commercial Grade Items for dedication that require seismic and environmental qualification require specific analyzes of critical characteristics. In some cases, it is important to apply special tests for behavior analysis and operation under adverse conditions. The critical characteristics must be selected considering the worst environmental conditions where the item can be installed, thus all possible conditions are met.

4. METHODS FOR DEDICATION

4.1. Method 1 – Special Tests, Inspections or Analyses

Tests and inspections may be conducted during or after receipt of the item in the Dedication Process in order to verify the critical characteristics. Special tests may also be added to the process after the item is installed, such as its response under normal operating conditions in the actual environment. Confirmation of the item model is considered a critical feature and should be observed.

Method 1 should be used when the dedicator prefers to perform critical feature checks during or after receipt. The dedicator can use this method when information exists on the item's data and they are measurable, the conditions for testing and verifications must be provided.

Method 1 is most appropriate when:

1- The Item is provided by various manufacturers;

2- The Item is relatively simple;

3- Only the critical characteristics check can be performed after installation.

Reference data for critical characteristics should be available in documents such as drawings, specifications, instruction manuals, bill of materials, catalogs ... Interfaces with manufacturers may be required to obtain data. When it is not possible to obtain sufficient information of the critical characteristics due to property rights, other methods must be considered.

In summary, method 1 is important in allowing the tracer to select and verify critical traits by performing tests. Method 1 is recommended when there is technical knowledge about the item, performing tests are feasible, feasible and suitable for checking the critical characteristics. Method 1 may be used in combination with other methods of acceptance.

Critical features can be verified through testing and inspection during receipt or after installation. A record plan, such as a checklist, should be created. The plan should include:

1. Tests and Inspections to be performed;

2. Methodology of the tests and description of the technique to be used;

3. Acceptance criterion previously defined in the Technical Evaluation, specific for each critical characteristic to be evaluated;

4. Documentation to register the tests and inspections to constitute the objective evidences of the process.

The tests and inspections should consider and define by statistical model the number of samples to be analyzed, based on the quantity of items to be dedicated.

4.2. Method 2 – Commercial grade survey of supplier (CGS)

Commercial grade survey of supplier is the means by which the dedicator can verify that the manufacturer has a quality control equivalent to that required for manufacturers of items with nuclear qualification.

Method 2 can be used when the manufacturer accepts and allows to receive evaluation of its manufacturing process through CGS by the dedicator or outsourced by the contractor. The CGS is based on the verification of the Quality Assurance Program through implemented controls and procedures, good practices, training and standardization.

In the specific case of Brazil, Cnen published the quality assurance requirements through document Cnen 1.16. It is up to the developer, using method 2, to compare, evaluate, and certify that the quality program of the manufacturer of the commercial item meets the requirements of Cnen document 1.16.

CGS can be used for items considered simple or complex. Method 2 is most appropriate in the following situations:

1. There are few manufacturers and options for replacing the item.

2. The detailed technical information of the item is not available.

3. There is more than one nuclear facility interested and needing the item. CGS costs can be shared and the Manufacturer shows more interest in increasing its market.

4. The dedicator can not perform tests and inspections that easily prove the critical characteristics.

Significant technical and quality information can be obtained from the manufacturer regarding the item during the CGS. This information may also be used to facilitate the application of other methods.

Basic criteria should be conducted during the CGS, the dedicator must confirm that the critical characteristics of the commercial grade item are controlled through activities of the quality assurance program and are properly documented. CGS criteria vary by item and depend on the number of critical characteristics.

The results of the CGS should be documented in accordance with an CGS Plan that should include:

1. Description of the items included object of the CGS;
2. Definition of Critical Characteristics;
3. Verification of the Controls that involve the CCs;
4. Verification activities carried out with their respective results;
5. Conclusion and opinion on the result of approval or not of the dedicated item.

Non-conformities or deficiencies identified during CGS may be corrected by the manufacturer for modifications or additions to the quality assurance program or the option to apply the other methods of acceptance may still enable the process of dedication.

Once the manufacturer's Quality Controls have been found to be appropriate the builder may include in its specifications information that the manufacturer must maintain its program as a delivery requirement, and during the receiving process, Certificates of Conformity may still be required.

The dedicator must observe how often the information obtained in the CGS needs to be updated based on performance, complexity, standards, frequency of acquisition.

4.3. Method 3 - Source Verification

Method 3 is based on the unique tracking of certain phases in the manufacturing process of the dedicated item. For use of method 3 it is desirable for the manufacturer to maintain a Quality Assurance Program similar or equivalent to that of the nuclear segment. However, it is not

mandatory since the dedicator assumes responsibility for following each phase considered important in the manufacturing process.

This method requires item-by-item follow-up to be dedicated, method 3 may involve activities described in methods 1 and 2, such as testing and verifying the control in the manufacturing process, being based exclusively on the phased monitoring of the manufacturing process. Method 3 involves the verification of critical characteristics by following and obligatorily witnessing certain phases in the manufacturing process.

The basic purpose of method 3 is to ensure that the manufacturer satisfactorily controls the critical characteristics of the item.

The main activity of the dedicator in this method is to witness the phases in the manufacturing process. The scope of follow-up may include non-destructive testing, response and performance testing, final inspections, and may include the manufacturer's unique activities related to the dedication process such as project control, calibration, material control, training and others.

The results of using Method 3 should be properly documented to compose the process of acceptance and dedication of the item. The documentation should include:

1. Description of Item or items accompanied, check the possibility of specific registration in the item through printing or typing;
2. Description of the critical characteristics considered;
3. Specific controls implemented;
4. Methods of measurement and verification carried out and in which phases;
5. Final evaluation of acceptance or non-acceptance of the item.

Deficiencies identified during phases in the process of monitoring the Method and may be corrected by additional controls of the manufacturer or by inclusion of other acceptance methods.

4.4. Method 4 – Acceptable Supplier/Item performance record

Method 4 consists of the analysis of the manufacturer's reports and documentation, for example, certificates of conformity and test reports. In essence, Method 4 allows the Dedicator to accept the item commercial grade by the proven performance of the manufacturer and the item, through the presentation of documents that prove their historical performance. In general, method 4 should not

be applied as the only method of acceptance, but its combination with the other methods ensures the reasonable reliability process for the completion of the dedication process.

Method 4 is indicated when there are documents and records of the historical performance results of the manufacturer and the item, and can be demonstrated by:

1. Performance monitoring and item performance;
2. Item testing reports;
3. International standards and standards demonstrating their conformity with the specified;
4. Documentation proving compliance with restricted standards, such as military, aerospace, aeronautical applications and others.

Special attention should be made to the use of Method 4, due to the difficulty of relating the performance history with the critical characteristics of the item, and for this reason it may be necessary to add one or more combined methods. However, it is predicted that method 4 is the lowest cost and time, since it consists of the documentation analysis available.

The dedicator can establish the documentation that contains the item records and manufacturer using the following bases and sources of information:

1. Historical performance reports. The performance of an item can be monitored and recorded, usually this information is available in maintenance-related documents, where there are records of faults and defects, due to manufacturing problems, misuse or lack of maintenance. It can also be added important documents regarding the need for periodic tests and maintenance, where the behavior, tendency, performance, response, situation of the item are recorded;
2. Historical supply verification. If a given manufacturer has already provided a dedicated item through methods 1.2 and/or 3, and the dedicator has the knowledge of the performance of this item, method 4 can be used as a new option of dedication, with reduction of cost and time;
3. Test results in special laboratories. The manufacturer may use independent laboratories to check the quality of their items, and once proven their performance and performance, such information may compose method 4.
4. Reports and results of audits carried out by certifiers or group of consumers may compose method 4;
5. Certificates of conformity or engineering reports describing and proving the equivalence and similarity of the dedicated item with the original qualified item;

6. Compliance certificates for specific standards and restricted supply standards, such as military, aeronautical, aerospace, and others.

The dedicator must, following the same treatment of the other methods, provide documentation that presents the result of the process of dedication, which should include:

1. Information regarding manufacturer and item;
2. Establishment of the specific critical characteristics of the item
3. Results of analysis of performance records and item performance;
4. Comparison Bases to accept or reject performance results;
5. Final evaluation of acceptance or not of the item.

If the performance record of the item demonstrates reasonable assurance that the related requirements as critical characteristics have been met, the commercial grade item can be regarded as a dedicated item for application in systems, equipment or Components that require nuclear qualification.

The composition documentation for method 4 should be periodically revalidated, as the manufacturer's and item's situation can be changed.

4.5. Combination of two or more methods

The methods of acceptance can be applied in combination, assisting an effective verification of the critical characteristics and production of evidence that ensure and guarantee the process of dedication to its validation. In fact, some of the different activities described as examples in this work regarding the four methods can be performed jointly or simultaneously because they are correlated, for example during an CGS (Method 2) it is possible that it is carried out the monitoring of the specific part of the product manufacturing (Method 3) and still be asked to the manufacturer item performance documents as well as test reports (Method 4)..

5. CONCLUSION

The dedication process is technically feasible to assist nuclear installations in the acquisition, replacement or maintenance of their systems, equipment and components that are classified as important to safety. The implementation of actions, measures and activities that involve technical and engineering knowledge enable and assure the items dedicated reasonable guarantees in their use.

In Brazil is possible to dedicate item because there are manufacturers and laboratories that presents quality assurance programs and the national nuclear industry has professionals with technical competence capable of identifying the critical characteristics of the components to be dedicated, as well as selecting the methods for dedication.

Angra 1 will operate until 2044, 20 years in addition to the initial operating licence. Many items are obsolete or manufacturers no longer have the quality Assurance program for the provision of safety-related items. So, the dedication process is very important to ensure that Angra 1 will operate until 2044 or more.

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