



A Qualitative Approach of the Regulation for the Life Extension of Brazilian Nuclear Power Plants

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1. Introduction

On the report of the International Atomic Energy Agency (IAEA, 2021), Nuclear Power Plants (NPPs) are highly safe and protected installations, however, they are susceptible to accidents like any other one, that is why, despite the regulation of a NPP and ensuring safety is a national responsibility, IAEA assists Member States in fulfilling this responsibility, by establishing international safety standards and examining the application of those standards to all types of nuclear installations throughout their total life cycle.

According to Saldanha (2003), in December 2014, from the 438 nuclear power plants in operation, around 80% had been in service for more than 20 years and, to deal with the issue of the end of the life cycle of their NPPs, many countries have chosen for making use of the Long-Term Operation (LTO).

Gregor and Chockie (2006) already justified this option based on its advantages, such as the fact that the extension of the life cycle of 104 plants operated in the US is financially equivalent to the construction of 52 new plants, among other advantages.

As Saldanha (2003) explains, most European States and Japan use Periodic Safety Reviews (PSRs) to obtain authorization for an LTO, but the United States of America practices the License Renew Application (LRA) concept.

According to Gregor and Chockie (2006), the nuclear industry and the US Nuclear Regulatory Commission (USNRC) developed license renewal requirements based on the strategy of distinguishing between active and passive systems, structures, and components (SSCs), and this distinction has culminated in two important sets of requirements, which are: the Maintenance Rule, 10 CFR 50.65 (USCFR, 2017), that manages the aging of active SSCs, and the License Renewal Rule, 10 CFR Part 54 (USCFR, 2016), responsible for managing the degradation of "passive" SSCs. This process has been adopted by IAEA itself as the model for ensuring safe Life Extension operations.

The request for the extension of the Brazilian nuclear power plant life cycle, Angra 1, has already been carried out, and there are two technical documents, developed by the Brazilian National Nuclear Energy Commission (CNEN), NT-CGRC-007/18, (CNEN-2018a), and NT-CGRC-008/18, (CNEN-2018b), which are in force in Brazil, being used, together, as guidelines for the LTO process that is in progress. Technical Note NT-CCGRC-07/18, (CNEN, 2018a), establishes technical and administrative requirements for operational organizations to demonstrate that a NPP can operate in LTO while maintaining safety functions within the Current Licensing Base (CLB).

Technical Note NT-CCGRC-08/18, (CNEN, 2018b), provides regulatory requirements for operational organizations in developing the implementation and improvement of Aging Management (AM) to maintain the safety functions of the SSCs within the Current Licensing Base (CLB).

Technical Note NT-CCGRC-07/18, (CNEN, 2018a), explains, on its second page, that the regulatory assessment of the Aging Management Review and Long-Term Operation will be made considering the document developed by the USNRC, called USNRC-NUREG-1800, (USNRC, 2010b), "Standard Revision Plan for Revision of License Renewal Applications for Nuclear Power Plants", and that the use of Technical Note NT-CCGRC-07/18, (CNEN, 2018a) must be done considering Technical Note NT-

CGRC-008/2018, (CNEN, 2018b).

But do the necessary requirements described in those two Technical Notes for the Life Extension of the Brazilian NPP correspond, in fact, to the requirements of the North American LTO process, adopted by the IAEA as a model to ensure safe Life Extension operations of nuclear power plants?

To verify whether the requirements of the two Technical Notes are in accordance with the standards developed by the USNRC, a critical study of these two Brazilian documents was carried out through a qualitative analysis, examining the points that could be modified and/or improved in the Technical Notes.

2. Methodology

Two checklists were prepared by the author of this work, one on Life Extension, to assess Technical Note NT-CGRC-007/18, (CNEN, 2018a), and another on Aging Management, to examine the Technical Note NT-CGRC-008/18, (CNEN, 2018b). These checklists had, respectively, the License Renewal Rule, 10 CFR Part 54, (USCFR, 2016), and the Maintenance Rule, 10 CFR 50.65, (USCFR, 2017), as the basis for their developments.

The two checklists are entirely made up of dichotomous Yes/No questions, however, as during data collection it was noticed that certain topics addressed by some questions were not mentioned by the Technical Notes, the answer "Data Not Found" was also accepted, as well as the answer "Partially Yes", when it was verified that the Technical Notes dealt with the subjects of some questions, but with a different criterion from what was expected.

The checklist for evaluating Technical Note NT-CGRC-007/18, (CNEN, 2018a), has 18 questions, and the checklist for reviewing Technical Note NT-CGRC-008/18, (CNEN, 2018b), contains 32 questions.

The percentage of questions with "yes" answers from each checklist could demonstrate how close to the totality of the Life Extension process requirements, developed by the USNRC, is the current life extension process of the Brazilian NPP, Angra 1.

Each question on the checklists is worth 1 point, including those with sub-themes (with equal percentages summing a total of 1 point for the question) ones. Thus, through simple calculations, the score of each type of answer ("Yes", "No", "Partially Yes" and "Data Not Found") of the sub-themes of the questions with topic subdivisions was determined.

The checklists were also assigned percentages, each worth 100%. Thus, proportionally, 100% of the checklist with 18 questions is 18 points, and 100% of the checklist with 32 questions is 32 points. Based on this, also by simple calculations, the percentages of the requirements that are not included in the Technical Notes, and those that are included and need to be attended, were determined; as well as the percentages of those requirements that need to be partially attended, and those that do not need to be attended by the licensee to obtain the license for the Extension of the Life Cycle of the Brazilian NPP, through the answers "Data Not Found", "Yes", "Partially Yes" and "No", in due order.

3. Results and Discussion

From the 18 questions that were asked to assess whether Technical Note NT-CGRC-007/18, (CNEN, 2018a), was in accordance with the License Renewal Rule, 10 CFR Part 54, USCFR (2016), all answers were "Yes", except the answers to the question 11 and to a sub-item of question 14, which were not found in the Technical Note and, therefore, received the answer "Data Not Found".

Question 11 seeks to know whether NT-CGRC-007/18, (CNEN, 2018a), requires a more sophisticated asset management tool from the licensee, which considers the useful life, cycle, and main capital investments for the plant.

Question 14 asks whether NT-CGRC-007/18, (CNEN, 2018a), requires the licensee that the application development process involves the following actions: Identification and evaluation of exemptions containing Time-Limited Aging Analysis (TLAA). Although the Technical Note deals with the subject of TLAA, it does not talk about "exemptions" as far as that subject is concerned.

The Table I shows the quantitative data about the responses, which supported the qualitative analysis of Technical Note NT-CGRC-007/18, (CNEN, 2018a):

Table I: Data from Technical Note NT-CGRC-007/18, (CNEN, 2018a)

Response type	Quantity in unit	%
yes	16,86	93,67
partially yes	0,00	0,00
no	0,00	0,00
data not found	1,14	6,33
total	18,00	100,00

From the 32 questions that were asked to assess whether Technical Note NT-CGRC-008/18, (CNEN, 2018b), was in accordance with the Maintenance Rule, 10 CFR 50.65, (USCFR, 2017), all questions received the answer " Yes", with the exception of the answers to questions 26 and 30, which were "Partially Yes," and the answers to questions 6 and 31, which were not found and then received "Data Not Found".

Questions that were not fully answered asked:

- (a) If NT-CGRC-008/18, (CNEN, 2018b), required the licensee to take corrective action and a new and more specific performance criterion (setting goals), if a system could not meet its performance criteria for a period not exceeding 24 months, to demonstrate that the corrective action was effective; and
- (b) If NT-CGRC-008/18, (CNEN, 2018b), required the licensee to have biannual monitoring activities and system trends, to try to identify precursors or incipient failures that could have occurred in other plants and have implications (...).

The answer to the question mentioned in item (a) above was yes, however, NT-CGRC-008/18, (CNEN, 2018b) does not talk about a period not exceeding 24 months.

The answer to the question referred to in item (b) above was also yes, however, NT-CGRC-008/18, (CNEN, 2018b) does not require the activities to be biannual, but rather that they occur once per cycle.

The questions which data of the subjects were not found investigated whether NT-CGRC-008/18, (CNEN, 2018b), required the licensee to manage old inaccessible equipment and whether NT-CGRC-008/18, (CNEN, 2018b), required the licensee to quantify the risk "online" to support the continued operation of the plant.

The Table II shows the quantitative data about the responses, which supported the qualitative analysis of Technical Note NT-CGRC-008/18, (CNEN, 2018b):

Table II: Data from Technical Note NT-CGRC-008/18, (CNEN, 2018b)

Response type	Quantity in unit	%
yes	28,00	87,50
partially yes	2,00	6,25
no	0,00	0,00
data not found	2,00	6,25
total	32,00	100,00

4. Conclusions

Technical Note NT-CGRC-007/18, (CNEN, 2018a), met 93.67% of the guidelines described in the License Renewal Rule, 10 CFR Part 54, USCFR, 2016), as necessary for the process of License Renewal is of acceptable quality, and Technical Note NT-CGRC-008/18, (CNEN, 2018b), met 87.50% of the guidelines described in the Maintenance Rule, 10 CFR 50.65 (USCFR, 2017), as necessary for the Aging Management process of an NPP has acceptable quality.

The percentage of safety list requirements that have not been met does not make the Brazilian NPP Life Extension Process safety level low, because it can be justified by the differences in reality that exist between a Brazilian NPP

and a North American one, and their consequent differences in demand. So that, it is concluded that the two Technical Notes demonstrated to have standards of requirements for the Extension of the Life Cycle of the Brazilian NPP, Angra 1, which not only comply with the standards developed by the USNRC, indicated by the IAEA, but which also guarantee a process that provides high levels of nuclear safety.

It can be said that the quality of the Brazilian process of Life Extension for nuclear power plants is comparable to the quality of international processes accepted as benchmarks of reliable processes by the IAEA, however, for the Brazilian process to become even more complete and rigorous, it is suggested that:

1) the process described by Technical Note NT-CGRC-007/18, (CNEN, 2018a), addresses the identification and evaluation of exemptions containing TLAA and requires a more sophisticated asset management tool from the licensee, considering the useful life, cycle, and major capital investments for the plant, such as life cycle management (LCM); and that

2) the process described by Technical Note NT-CGRC-008/18, (CNEN, 2018b), requires the licensee to manage old inaccessible equipment; specify that corrective action and new, more specific performance criteria are required if the system cannot meet its performance criteria for a period not exceeding 24 months; impose that in the process there are biannual monitoring activities and system trends, in order to try to identify precursors or incipient failures that may have occurred in other plants and may have implications; and establish the need to include data on the requirement to quantify the risk online to support the continued operation of the plant.

References

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[8] USCFR, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants”, USCFR. The Maintenance Rule, Title 10, Part 50.65 (10 CFR 54.65), 2017.