Regulatory Approach To and Lessons Learned with Licensing of Service Life Extension at PAKS NPP

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Abstract: Paks Nuclear Power Plant of Hungary decided to extend the original design lifetime of the plant by 20 years, which expires on December 31, 2012 concerning unit 1. The Hungarian Atomic Energy Authority established the legal environments in order to license the extension using an approach similar to that followed in the United States. The regulation specifies the pre-conditions for the extension, defines the scoping and screening process for the passive and long lived systems, structures and components to be involved in the licensing and the respective methods of treatment and also determines how the active components shall be dealt with during the extended lifetime. The regulatory procedure is a two-step process including the oversight of the preparatory programme of the operator for the extension that started 4 years before the expiry of the lifetime and the licensing process itself, which is currently under way for unit 1 after the submittal of the licensee's application at the end of 2011. The first experiences with the regulatory assessment of the application are available yet and presented in this paper.

1. Introduction

The original 30 years design lifetime of the four-unit Paks Nuclear Power Plant expires in 2012, 2014, 2016 and 2017, respectively for the units. The owner of the NPP decided in 2000 to extend the original design lifetime of the units by 20 years. The Hungarian Atomic Energy Authority, as the nuclear safety regulator established the basic legal opportunity in order to being able to license the extension [1]. After summing up the international, primarily the US background and documentation of license renewal of the nuclear power reactors, the legal conditions and stipulations have been compiled into the Hungarian legal instruments. In order to create the legal basis a maintenance rule, the development of formal ageing management programs and supplementation of equipment qualification had to be introduced into the regulation system. All these areas and the detailed rules have been set out in the Nuclear Safety Code [2] and the respective regulatory guidelines. The sections below describes these legal requirements and the licensing process of service life extension, while Section 4 summarizes the first experiences gained during the assessment of the service life extension license application of unit 1.

2. Legal environment for service life extension

The operator of the nuclear power plant shall demonstrate the fulfilment of the safety functions for the safety class systems, structures and components (SSCs) and for those, the failure of which may jeopardize the fulfilment of a safety function. The method of demonstration can be selected by the licensee [3] according to Figure 1 with the stipulations that environmental qualification should be implemented for I&C components operating in harsh environment and ageing management should be used in relation to a scope of components and list of degradation processes identified by the authority in the respective regulatory guideline [4]. Accordingly, the demonstration may be performed by safety analysis, environmental qualification, ageing management or maintenance effectiveness

monitoring, or by the joint, coordinated implementation of these. The expectations of the authority regarding these methods are included in further regulatory guides [4]-[9].

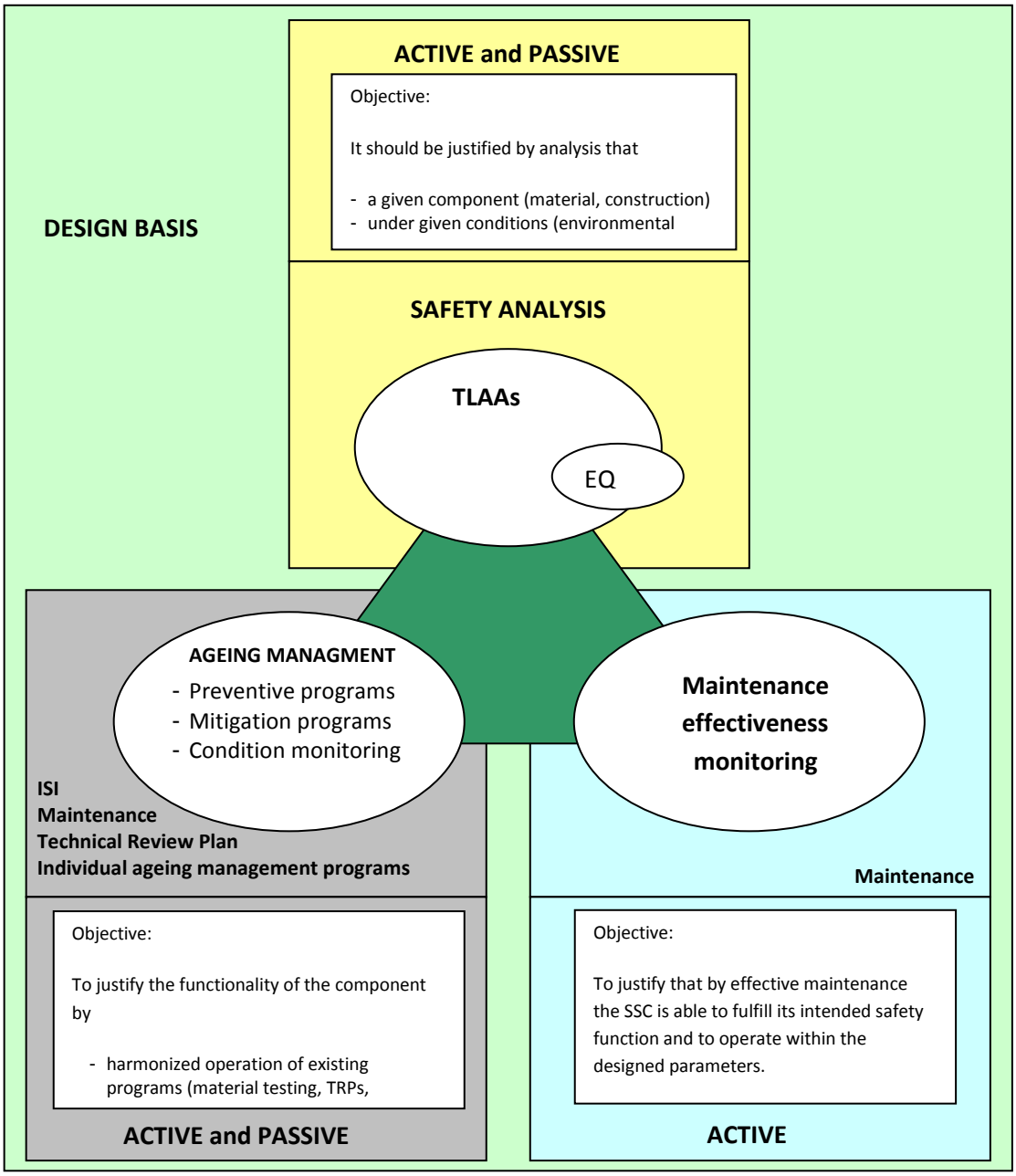

Figure 1: Demonstration of safety of SSCs

The service life extension licensing process shall focus on the passive long-lived SSCs from the scope above. Concerning the passive long-lived components the safe future operability shall be demonstrated by Time Limited Ageing Analysis (TLAA) and appropriate ageing management by maintaining a non-degrading safety margin. The required scoping process can be seen in Figure 2. The list of minimum scope of TLAAs is included in a regulatory guideline [9], which had to be supplemented by the operator based on the operating experience. Table 1 shows the final list (gray background indicates the supplement by the operator). At the same time the due management of active components shall also be demonstrated by the effective ongoing operational plant programs as required above or by other means like repair & replacement.

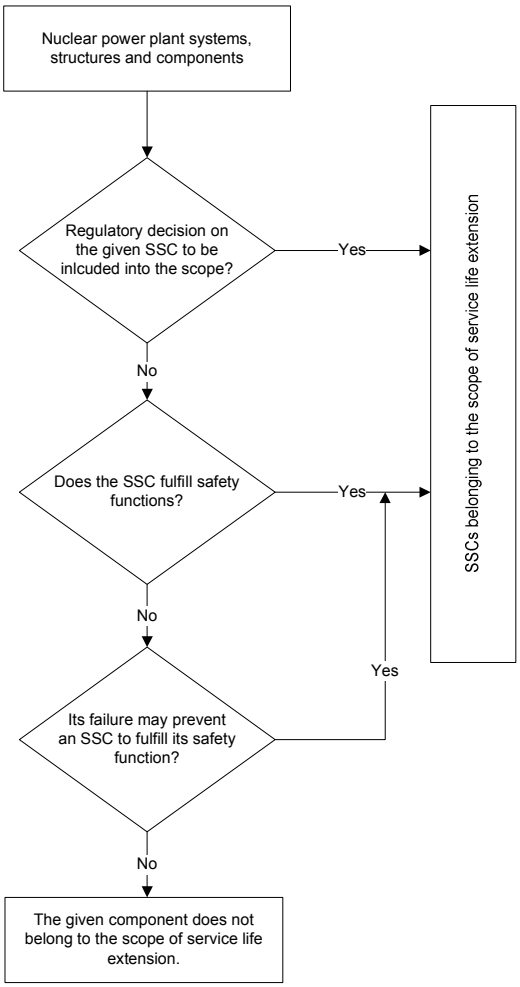

Figure 2: Scoping of SSCs for service life extension

Table 1: Time Limited Ageing Analyses (gray: identified by the operator)

Low cycle fatigue analysis of mechanical components	Thermal embrittlement of 22K casting components
Environmental qualification of electric and I&C components	Fatigue analysis of safety related cranes
PTS analysis of reactor pressure vessels	Fatigue analysis of spent fuel pool cladding
Pressure/temperature limit curves of reactor pressure vessels	Material property change of steam generator tubes
Crack propagation analysis of detected flaws	Material property change of heavy concrete structures
Thermal stratification induced fatigue analysis of pipelines	Strength of important building structures
Cooling down and heating up limits	Increased pressure integrated containment leakage test
Initial conditions of transient operating modes	Corrosion wall thickness allowance
High energy line brake assigned to specific CUF limit	Fatigue analysis of main coolant pump fly wheel
Flow induced vibration fatigue of RPV internals	Building settlement and its consequences
Flow induced vibration fatigue of steam generator tubes	Boron consumption of spent fuel pool frames
Change of material properties RPV internals	Under cladding cracking of heat affected zone of RPV
Fatigue analysis of hermetic penetrations	Material property of ceramic insulation of reactor head
Fatigue analysis of hermetic claddings (welds)	

The service life extension shall not address such problems that should be resolved for maintaining the current operating licence conditions. The Hungarian regulations use the Periodic Safety Review (PSR) with a 10 year period to assess the ageing issues in a wider sense: ageing of SSCs, people, organisation, requirements, procedures etc. The PSR proved to be an effective opportunity for a complex overview of SSCs' technical conditions, their ageing management programs, environmental conditions, changes in the state of the art of science and technology, utilisation of operational experience, etc. Altogether it is applicable to identify the safety issues and provide continuous safety improvement of the plant. On the

other hand the living or updated Final Safety Analysis Report that keeps track of the plant modifications contains the licensing basis, description of the plant and the safety case.

It also follows from the above approach that the gaps of the design basis and all safety issues identified during the operation of the plant shall be resolved within the current licensing basis and, as such, are pre-conditions for the extension of the service life. Regarding Paks NPP such major problems were the missing design basis analyses since the Soviet vendor did not provide all (especially strength) analyses for the units, the qualification of electrical equipment was not complete, just a warranty was available for 30 years which accepted during the original licensing process. Additional pre-conditions have been identified during the PSRs and the environmental licensing process: the Severe Accident Management Guidelines and the respective accident management modifications (passive hydrogen management, external vessel flooding, reinforcement of spent fuel cooling, accident measurement system with electric power supply) shall be implemented and modifications related to prevention of atmospheric release after a primary-to-secondary leak shall be completed before obtaining a license for service life extension.

3. Licensing process

First of all an environmental impact study and a licensing process had to be carried out, which was completed by the environmental authority at end of 2006 and issued the license. The law, then, specified the nuclear safety licensing of service life extension as a two-step process. At the first stage the programme on the preparation for service life extension had to be submitted to the authority, in which the licensee had to demonstrate that all the relevant areas, issues were tackled and the necessary resources to carry out the programme aimed at developing the license application of the plant were in place. After the submittal and assessment of the programme for the 4 units of the plant in 2008 and 2009, the authority issued a resolution [10] about the acceptance of the program, while setting up some additional stipulations [11]. Altogether no such deficiency was found which would rule out the possibility of later approval of the service life extension. During the review the HAEA noted 315 findings based on which corrections had to be initiated and 101 further comments which had to be taken into account in order to improve the preparatory actions. The resolutions specified the following main rules for the remaining preparatory period:

1. Information shall be provided to the authority on the progress of implementation of the program on a regular basis.
2. Progress of introduction of maintenance effectiveness monitoring, ageing management programs and progress in preparation of time limited ageing analysis shall be reported.
3. Specific technical issues shall be dealt with during the preparation: scoping issues with special attention to system boundaries, replacement of secondary piping containing copper, extension of service cycle numbers, identification of susceptibility to and monitoring of thermal stratification, management of primary piping support problems, monitoring of condition of carbon steel collectors not used but remained in the steam generators after refurbishment.

At the second stage the licensing process itself shall be conducted. Since the operation license expires on December 15, 2012 for unit 1 the license application had to be submitted until December 15, 2011. The authority had 1 year to scrutiny the application, request supplementation, and to carry out inspections to reassure that the licensee met all the respective requirements and the service life can safely be extended and decide if the license can be granted.

The regulations require the license application to contain:

- general information about the plant,
- scoping and screening of licensing scope,
- review of ageing management of passive and long lived SSCs,
- modification of the FSAR, TechSpec and other operational documents (accident and emergency procedures, emergency plan),
- demonstration that the service life extension programme has been completed and based on that the plant is safely operable for the extended service life, the necessary technical and administrative conditions and resources are provided.
- outline of the activity aimed at maintaining the due conditions of the SSCs

4. Lessons learned

4.1 Oversight of the service life extension programme

The regular reports of the licensee about the progress in completing the service life extension implementation programme opened the opportunity to regularly obtain a picture on the number of tasks that have been or are still to be completed. Despite the fact that the authority indicated at the beginning of the implementation that it is a very ambitious programme that does not contain place for delay, several tasks have undergone the modification of the deadlines. Some of them have not been crucial, but delays in the introduction of the maintenance rule, performance of equipment qualification, introduction of new material testing programme and completion of strength calculations lead to the consequence that not all the tasks of the programme were accomplished before the submittal of the license application, but still remained for the regulatory assessment phase and will be treated as a supplement of the application. This circumstance indisputable impedes the review of the license application and several missing information shall be requested during the process.

However it is a positive experience and can be offered for other small countries facing at first time with life extension that the preparation and the regulatory assessment of the service life extension programme brought in many results, which helped both the operator and the authority to better get ready for the licensing itself. A routine in the development of such a complex licensing documentation, parallel management of many technical and administrative issues, opportunity to preliminary devote time and resources for the works foreseen for the preparation were all important areas to learn of by the licensee. The authority opinion and requirements concerning the work and the programme presented in this preliminary phase also assisted and conducted the operator much in the development of the licensing documentation.

The regulatory inspections of the implementation of the programme consisted of the review of the regular progress reports, assessment of the fulfilment of the tasks specified in the ruling on the programme and site inspections in such selected areas, where problems had been expected: completion of time limited ageing analyses, maintenance effectiveness monitoring, environmental qualification of electric equipment. Consultations with the operator were also held to obtain more accurate picture about the progress of the implementation of the programme.

One of the most important pre-conditions for service life extension is the integrated assessment of the technical state of safety related SSCs. As a selected area the authority joined the assessment of the safety class 1 mechanical components (practically the pressure boundary components of the primary circuit and the reactor internals) process via a dedicated

inspection process. Based on an informal recommendation by the regulator on the approach the operator developed a methodology to conduct this assessment. The scope consisted of the revision of the lifecycle data of the components, including material testing results, operational and maintenance history, indication lists, ageing management programme, strength analysis, regulatory resolutions and a comprehensive site inspection of the designated parts and locations of the components during the last full outage of unit 1 in 2011. A team of inspectors participated in the inspections by dividing the work according to components; each of them performed 3-4 site inspections after the several preparatory consultations with the operator. The result was very positive in the sense that it drew the attention to some important technical issues that should be addressed for service life extension. Such were the internal material testing of the emergency core cooling nozzle of the reactor pressure vessel, the lower nozzle of the pressurizer and the hardness measurements of the main gate valve housing, which were not part of the normal testing programme, and deficiencies of life cycle documentation of the components, which had not been identified as an issue beforehand by the operator.

In line with the importance of the task the authority launched a dedicated inspection of the project that is being carried out by the operator to review the compliance of the strength analysis of the Safety Class 1-2 components with ASME Section III. In addition, as a preliminary step of the project, the load catalogue of the plant was also reviewed and it was also covered by the inspection. The huge design documentation limited the opportunity of the regulatory assessment, for which the same inspectors were designated to review the documentation of the components. It was clear already at the beginning that the in-depth assessment of only the main components is possible and even for that purpose external contractors had to be involved in the work. The assessment yielded many comments due to inconsistencies of the documentation that reflected the lack of routine of such a huge design work. For example, the contractors performing the design tasks had to obtain ASME expertise before the project; appropriate international experts with due ASME background had to be found to support the approval of the design calculations and improve the reliability of the results, but which also resulted that several versions of the documentation were developed. According to the authority’s approach it was not possible to simply get rid of the original strength calculations results and the critical locations that are susceptible to any stressor had to be dealt with special attention. This work is still in progress, but without positive result of the inspection process it can be an obstacle of granting the service life extension license.

For economic reasons and in order to maintain the consistence of the technical programme elements of the plant, a transition of the material testing programme of the plant from the original Soviet-based approach to the ASME XI method was also a pre-condition. After several submittals and supplements, finally, the eight years material testing cycle of unit 1 could be started according to ASME in 2011.

4.1 Preliminary lessons with the license application

The operator submitted the service life extension license application and its supporting documentation to the HAEA on December 5, 2011. It contains seven main chapters. The whole original documentation contained more than 21000 pages, but with the already requested supplementations the volume has been multiplied. According to the preliminary estimations 25 inspectors of the HAEA will devote at least 750 inspector-days for the work, which is organized in small groups with designated inspectors in charge of specific subchapters. A review plan containing a system of aspects was developed to uniformly document the results of the regulatory assessment. The structure of the document follows the requirements described above. The first lesson was that it is almost impossible to be

overviewed by a single person and that a lot of only indirectly required information had to be requested in addition. However, it was a later declared intention of the licensee to submit only the most important documents and quickly respond to any additional request. This was not agreed beforehand with the authority.

The main goal of the authority is to complete the review of first instance by the middle of the year to reveal all such important deficiencies in the documents which should still be addressed by the licensee in the second half of the year. During the review the grouped comments are immediately forwarded to the operator to provide timely response.

The following general conclusions can be drawn about the areas assessed yet:

- The integrated plant assessment complies with the requirements; however additional justifications had to be requested in relation to some plant programme ensuring the due maintenance of the qualified state of certain components.
- Concerning the ageing management review the general picture is that the AM programme is basically operating and only some less important issue exists. A problem can be that there is no evidence if the feedback function would be effective.
- The time limited ageing analyses seem to be complete; supplements, additional analyses may, though, be necessary. Six items have been temporary terminated requesting some additional information.
- The maintenance effectiveness monitoring system in Paks NPP is operated but its introduction has not been completed yet. There are many tasks that seem to be still open and many questions to be answered. Further regulatory inspections are planned to provide evidence whether the service life can be safely extended from that aspect.

5. Interaction with the stress tests

The post-Fukushima stress tests have been completed in Hungary as required by the European Council and specified by the European Nuclear Safety Regulators Group. The results were confirmed by the international peer review. Safety improvements have been decided by the operator of the plant, which have been supplemented with additional measures by the authority. A task plan shall now be submitted to the authority till June 30, 2012 to schedule the safety improvement tasks. In principal, these modifications are not interconnected with the service life extension, and will be carried out in the frame of the normal business of the NPP.

6. Summary

Due to the historical heritage of nuclear licensing of the Soviet era, Hungary had to develop a unique approach by which the service life extension of its single nuclear power plant can be licensed. Taking account of the missing design basis, deficient equipment qualification and lack of ageing management approach, after a rather huge research work the HAEA initiated the amendment of the legal spectrum from the Atomic Act to the regulatory guides to provide opportunity for the operator to prepare for the life extension. The US license renewal practice was combined with the existing Periodic Safety Review approach and it concluded in a two-stage process the real life test of which is in progress: the licensing of service life extension for unit 1 is under way. It was obvious and now it is underlined by the reality that this pilot extension task deserves a huge amount of work both from the operator and the regulator and may contain many hidden pitfalls. The regulatory assessment of the application till now shows that although there is no such fact which would prevent the authority from granting the service life extension license, several evidences shall still be obtained from the licensee to do so.

[1] Act CXVI of 1996 on Atomic Energy
[2] Government Decree 118/2011 (VII.11) Korm on the nuclear safety requirements for nuclear facilities and the respective regulatory requirements including Volume 1-9 of the Nuclear Safety Code
[3] Regulatory Guideline 4.12: Ageing management during operation of nuclear power plants, Version 2, 2007 March, Hungarian Atomic Energy Authority, Budapest, Hungary
[4] Regulatory Guideline 1.26: Regulatory supervision of ageing management, Version 2, 2007 March, Hungarian Atomic Energy Authority, Budapest, Hungary
[5] Regulatory Guideline 1.27: Regulatory supervision of environmental qualification of equipment and maintenance of their qualified state, Version 2, 2007 March, Hungarian Atomic Energy Authority, Budapest, Hungary
[6] Regulatory Guideline 3.13: Consideration of ageing processes during design, Version 2, 2007 March, Hungarian Atomic Energy Authority, Budapest, Hungary
[7] Regulatory Guideline 3.15: Environmental qualification of equipment during the design of nuclear power plants, Version 2, 2007 March, Hungarian Atomic Energy Authority, Budapest, Hungary
[8] Regulatory Guideline 3.18: Evaluation of brittle-fracture resistance of VVER-440/213 reactor pressure vessel for normal operation, hydrostatic test, pressurized thermal shock (PTS) and unanticipated operating occurrences, Version 2, 2009 October, Hungarian Atomic Energy Authority, Budapest, Hungary
[9] Regulatory Guideline 4.14: Activities to be implemented by the operator to support the license application for operation beyond design lifetime, Version 2, 2009 October, Hungarian Atomic Energy Authority, Budapest, Hungary
[10] HA4918: Regulatory resolution about the termination of the regulatory review of the service life extension programme of Paks NPP, June 18, 2009, Hungarian Atomic Energy Authority, Budapest, Hungary
[11] HA4919: Regulatory resolution about further regulatory requirements determined based on the regulatory review of the service life extension programme of Paks NPP, June 18, 2009, Hungarian Atomic Energy Authority, Budapest, Hungary