Reviews of the aging management programmes for the licensing of the service life extension (mechanical elements)

Previously, we described the requirements of nuclear safety and the licensing of the service life extension. We showed that we need to do two important things in the first period of the nuclear safety licensing of the service life extension:

1. Expanding or redoing (taking into consideration the extended lifetime) the ageing analysis, which limited the lifetime of the nuclear facility to 30 years (this is called Time Limited Aging Analysis – TLAA);

2. Reviewing the currently used aging management, considering the up-to-date technological requirements, and determination of the necessary modifications.

In this article, the review of aging management is described in detail. Dut to limited space, the topic will be discussed in several, sequential articles. In this paper, we focus on the general aspects and mainly on the mechanical systems (structures and components). In the later articles, we will discuss the review of the aging management of facilities, buildings and the electrical and control equipment.

Before we start, we should think about the meaning of aging and aging management. These terms are not unknown for the reader. They can be described with the help of examples from our life, so a detailed ‘scientific‘ explanation is unnecessary. The life-cycle of every natural being - even our own life - goes from an initial condition (birth) to the final condition (death) through decaying processes. In the case of the human body, first there are only minor changes (hair loss, or the hair turns white), but if our blood pressure increases, or we start to feel our back and knees, we notice that we are aging. The doctors advise us to change our habits, to live a healthy life or to take medication. If these are effective and successfull, we can live a normal life despite the years. However, nothing can stop our aging. All these actions are called aging management!

The same can be applied to the machines constructed by man, be they simple or as complicated as a nuclear power plant. The life of these things starts with the design and construction and lasts until they break or until they are removed from operation. Between these two states, the condition of these structures deteriorates over time, because of the operation or the environmental effects. Therefore, these machines are aging, too. We can intervene in this process, which is shown in Figure 1. With the help of the figure we can explain the licensed lifetime of the different mechanical systems of a nuclear power plant.

The lifetime of a machine is limited by the minimal mechanical condition that is necessary to handle several expected malfunctions. This is the minimal level of the mechanical system for it to function, below this level it can't. If a machine is below this level, the machine is considered "dead", even if physically it is not broken. An everyday example: consider a car without a windscreen, the brakes and the lights work every other day and the engine has an extremely high level of fuel consuption. Theoretically, in a closed area, where no one else can be endangered, we could use this car on our own responsibility. It is evident that this car cannot participate in traffic, although it is functioning, but in this condition it wouldn't get a licence.

Thus, there is a minimum technological level for every single mechanical system element for the element to function. For sustaining this desired condition there are several options:

(1) Throw out the smaller, commutable elements and replace them with new ones. This can be done at anytime, so these components don't affect the service life of a nuclear facility (most of the electrical and control equipment belongs to this category).

(2) We can upgrade some devices; if necessary we can enhance them with large-scale reconstruction (pipes, fittings, etc.).

(3) There are long-term passive system elements, which can be replaced involving high investment. In this case, there is no other option than the mitigation of decay, or lowering of the standards. These truly affect the lifetime of a power plant and include, for example, the containment building, the reactor and the steam generator.

In our last article, we presented the size of the service life extension programme and its licence. It is enough to review the current aging management in the field of passive system elements with long lifetime, because these elements are affecting the lifetime of the nuclear power plant, and with these elements testing the conformance of functionality is not possible, while the possibility of direct intervention (reconstruction) is small. This is the third category, as described above. The aging management of the active system elements (which can be tested, serviced, replaced and upgraded) is treated through monitoring the efficiency of the upkeep with the help of the new regulation manuals.

If we take a closer look, passive system elements are those elements that function without moving parts and the changing of their shape or properties. Thus a system element with the function of sustaining pressure, for example is considered passive.

The number of system elements for the service time extension of all units is in the order of magnitude of a hundred thousand. After the already mentioned filtering, almost 35,000 mechanical, 6,500 items of electrical and control equipment, and 2,000 other element will be designated to the chosen category. Because of these numbers, the aging management and its review should be accompanied by other rationalizations.

Because of their importance, the elements of the main water loop are treated separately. The high amount of other system elements must be grouped to simplify our work. Using the experience and procedures of the NRC and the nuclear power plants of the USA, we can make groups from elements that have the same safety category of aging (the material, medium and usage); therefore, the aging management should be the same. The number of these aging management groups (commodity groups, according to USA-terminology) is approximately 150, and this amount can be handled easily.

It has to be proven by an extensive review that the aging management programmes of the most important groups are eligible to meet the requirements of operating the nuclear power plant, despite the aging. Essentially, we need to prove that the aging management programmes match the modern standards and that we are able to notice the effects of the aging and take care of them. These are all requirements for extending the service life from 30 to 50 years.

Since all the requirements of the service life extension are based on USA standards, the reviewing of the aging management programmes should be based on USA standards, too. We reviewed our programmes with the guidance of the NUREG-1801 document (GALL-report: “General Ageing Lessons Learned“). Ten considerations were involved.

According to the requirements, the aging management programme is appropriate if we have a positive answer for all these issues:

1. The identification of aging effects:

The determination of the possible decaying effects of the reviewed mechanical system elements according to our own and international experiences. During the analysis, all the inner and outer environmental effects and effects caused by operational activities should be considered.

2. Aging reducing and preventing arrangements:

We must check if there are any arrangements, that are able to prevent and reduce the aging effects caused by decay processes.

3. Parameters to be checked:

The determination of the parameters of the aging management programme, which hold information about the aging effects.

4. Detection of aging effects:

The determination of the decaying symptoms during our analysis, which must be detected and prevented to avoid the malfunction of the device or the corruption of its reliability. The method for detecting the aging effects is regulated by the operational, technological safety manuals, reports and tests, so primarily we are reviewing these manuals meanwhile, the necessary modifications are determined.

5. Monitoring and Trend Watching:

Determination of the method for monitoring and trend watching. Comparison of the data acquisition of the parameters for the monitoring with the expectations of the third consideration. The imperfection of our data acquisition must be determined.

6. Rating criteria:

Determination of the criteria that regulate the condition of the system elements (based on the ASME BPVC standard).

7. Determination of corrective arrangements:

Checking if the corrective arrangements are regulated in the aging management analysis.

8. Feedback process:

The feedback of information gathered from the inquiry into anomalies and from the checking of the device's condition in the aging management programme.

9. Effectivity of the administrative monitoring:

The relevant NSR standards require that an aging management programme be maintained throughout the entire service life. For the proper operation of the system, the possibility of administrative monitoring must be guaranteed, which lasts from the desing of the aging management programme to the feedback of results. During our review we aimed to ascertain whether in our aging management programmes those administrative monitoring possibilities are present, and whether the information for the aging management organization is available.

10. Operating experiences:

The incorparation of operating experiences is essential for the safe and economic operation of the nuclear power plant. We analysed whether PNPP gathers, evaluates and methodizes the experiences from other power plants about decaying processes.

Before writing about the experiences of the review, we must emphasize the fact that in the PNPP there is aging management activity from the beginning. For example: technological safety reviews, material inspection, and planned preventiv and corrective maintenance. These are all run by separate procedures. It is evident that the aging management programmes comprise these reviews, checks and maintenances activities. During our review we had to investigate whether our activities overall fulfil the ten-criteria requirements. If they do, the current activities should be continued. If not, we should determine the deficiencies and make a proposal concerning modification of our programme.

According to the reviews, the following general considerations should be taken into account:

The aging management of devices belonging to the ABOS 1 classification is adequate, but in these devices‘ programme the regulations of the ASME BPVC must be used.

In the case of the system elements belonging to the ABOS 2 classification, the aging management processes and activities are generally well documented; therefore their review was carried out. In the case of ABOS 3 and 4 class system elements, the activities were not documented at all and in some cases even operational experiences were not available (for example, corrosion coefficients of the pump case).

Aging management of ABOS 1 class devices with accentuated functions are adequate. In the case of devices that don’t belong the ABOS 1, 2, 3 or other safety class, several deficienties were found. So the functions of all aging processes should not be considered known; for example, there is need for a programme which treats the microbiological corrosion of the heat exchangers belonging to the 2nd safety class.

The prevention activities of the fitting maintenance should be renewed. We know the decaying parameters, except in the case of some special constructions. The detection of some aging effects is not guaranteed; for example, the corrosion of fitting houses or some thermal effects. In the case of monitoring and trend watching, the methods for gathering and processing results concerning unique malfunctions do not include investigations regarding the recording of the malfunctions‘ trends. In several cases the acceptance criteria and the number of limit cycles are missing. With some aging effects there are no previously determined corrective arrangements. The processing of operational experiences about aging and service time is insufficient and the feedback is not proper.

All these flaws can be eliminated with technological arrangements. However, the main consequence is that effective, productive aging management – which is a condition of service life extension – needs the united work and effort of all the power plant's workers, because the elements of the aging management of the Paks Nuclear Power Plant are realized by proper maintenance, material inspection and technological reviews. These all guarantee the programme's professional conformance and this was reviewed with the help of the ten considerations outlined above. All aging management programmes constitute a uniform system from a technological-scientific point of view, but the coherent activities are carried out by the organization's different divisions. A very important issue is that cooperative work should be realized during the aging management and the results of data acquisition be shared between the organization responsible for the aging management, the maintenance personnel, material inspectors and other professionals involved in gathering data about the aging. This is the biggest challenge, and if we are able to solve this all technological problems will be easy.

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