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The French safety authority's views on ageing issues in nuclear power plants

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1. Introduction: ageing issues

As every human construction, nuclear power plants are subject to ageing phenomena, which are very similar to those existing in industrial facilities.

First, ageing can affect components through different phenomena, like gradual degradation of mechanical properties due to environmental conditions (thermal ageing, irradiation-induced embrittlement). Ageing can also result from corrosion (stress corrosion, erosion corrosion) or fatigue (mechanical or thermal).

But ageing does not only affect materials. The ageing of organisations also has to be addressed. Thus, operating teams must be renewed regularly. But engineering teams as well in the power plants as in their technical supports are also concerned. In France, most of the power plants were built in the eighties. Many of the engineers hired at that time will retire at about the same time. The management of the age distribution in the teams challenges the durability of skills and know-how.

These skills also rely on subcontractors: their going out of business can impair the ability to repair or replace important components. This phenomenon may happen for electronic components but also for mechanical components.

Thus ageing phenomena in nuclear power plants question their lifetime, which is necessarily finite.

In this paper, we will address the regulatory views on lifetime and ageing issues.

2. Plant lifetime from a regulatory point of view

French regulations on nuclear power plants do not define any lifetime or introduce any lifetime in the licensing process. Of course, a projected lifetime is taken into account for the design of the plant, but it has nothing to do with any regulatory lifetime. From the French point of view, a plant can be operated as long as safety is guaranteed. Such an approach requires periodic checking that the level of safety is adequate.

That is why French regulations give the power to the safety authority to ask for a comprehensive review of the safety of the plant, at any time.

Practically, such a review is required every ten years and is called periodic safety review (PSR).

This PSR aims at checking that safety requirements are still met. It also provides the opportunity to implement improvements in the safety demonstration, for instance to take into account experience feedback.

The contents of the PSR are discussed with the safety authority and must obtain its approval. Soon, the oldest reactors in operation in France will be 30 years old: PSRs will start from 2009 on. This step is very important because ageing phenomena will have to be evaluated in order to decide if the plant may operate for ten more years. In 2001, the French safety authority required from the utility EDF to be presented, for each reactor reaching 30 years of operation, an analysis of the condition of the plan with respect to ageing phenomena and a demonstration that safety conditions are adequate for plant operation to proceed. EDF started to prepare these files which are called "Dossier d'aptitude à la poursuite de l'exploitation" (DAPE – Operation continuation aptitude file). On the basis of these files, at the end of the 30 year-outage of each reactor, the safety authority intends to take a position on the possibility to carry on with operating the reactor.

3. Ageing of components of main primary and secondary systems

The ageing of the components of the main primary system (MPS) and main secondary systems (MSS) will play a major role in the assessment of the possibility to operate the reactors beyond 30 years.

Therefore, to be consistent with the defence in-depth approach, the safety authority requests the utility to take ageing into account at every stage, from design to operation.

At the design stage, materials must be chosen regarding their behaviour in operation. The mechanical properties to be considered must be the properties at the end of plant life, taking into account the relevant ageing phenomena (thermal ageing, irradiation-induced embrittlement). Fatigue must be prevented through design measures (e.g. limitation of stress concentration and reduction of vibration phenomena). Moreover, in-service inspection of each component must be favoured through design measures in order to allow NDE to be performed with acceptable radiological conditions.

In operation, the parameters which have an influence on the ageing phenomena must be monitored (temperature, pressure, chemical elements content). The prevention of fatigue requires dedicated monitoring measures consisting in transient book keeping in order to check that the usage factor stays inferior to 1.

The order of November 10th, 1999 requests the utility to define, for each degradation mode, "ageing surveillance programmes" and to submit these to the safety authority. These programmes must be revised as often as necessary, especially to take into account the experience feedback, and at least every ten years.

In-service inspection (ISI) performed during outages is a key moment to check the state of the components. ISI aims at detecting flaws before they could lead to a leak: indeed, the integrity of the MPS and MSS is essential to the safety of the plant. In this framework, the definition of in-service inspection programmes must be based on a thorough analysis of the degradations that may occur and of the areas where they could appear. When a control is planned, its goal

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(kind, size, orientation, location of the flaw) and its frequency must be defined adequately. Moreover, the NDE method must be adapted to the flaw that is looked for and this must be assessed through a performance demonstration process called “qualification”.

Nonetheless, a programme elaborated through this process is not sufficient. Experience shows that, despite how clever engineers may be, some phenomena cannot be predicted. That is why the safety authority requests the utility to add some sample checks to in-service inspection programmes. Every ten years, the MPS and MSS are submitted to a comprehensive visit, including sample checks, and to a hydraulic test. This test is very meaningful because it allows to test all areas of the circuits. It has proved useful in 1991 when a hydraulic test showed the presence of stress corrosion cracks on a vessel head.

This explains why the safety authority is rather reluctant towards the risk-informed approach, especially when it is used alone.

Good design, good manufacturing and good surveillance during operation are not sufficient. Repair or replacement techniques must be prepared in order to act if a degradation should occur. The French nuclear fleet is made of similar reactors built approximately at the same time: a degradation would likely affect many reactors, leading to a tremendous need for repair or replacement. France experienced this situation in 1991 when stress corrosion cracking was detected on many vessel heads. Since then, the safety authority has required the utility to prepare for different repair or replacement operations in order to be ready if necessary. This implies to prepare for the technical skills but also to check the availability of subcontractors. Some components are said not to be replaceable: the vessel head and the reactor containment. Therefore, the quality of design, manufacturing and operation must be higher than for other components and this quality must be checked in a more exacting way.

4. Conclusion

Design and manufacturing must lead to a reduction of ageing phenomena. But, in many cases, these phenomena cannot be totally prevented. Therefore, in-service inspection programmes must be performed in order to check periodically the condition of the components. These programmes rely on scientific analyses but sample checks also have to be implemented within a defence in-depth approach. The programmes aim at detecting flaws early enough to avoid leaks. Repair and replacement operations must be prepared and performed when necessary.

The oldest French plants will soon be 30 years old. A comprehensive review of the condition of each reactor will be conducted, especially regarding their behaviour towards ageing phenomena. After each review, the safety authority will authorise further operation of the reactor: in this framework, the French safety authority is convinced that international experience feedback is essential and believes it is important to share experience with other countries about the different ageing phenomena.

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