Aging Management Plan for a Typical Research Reactor

Mahsa Ebrahimi [a,c], Mohammad Nazififard [a,b,d], Kune Y. Suh [a,b*]
[a] *Seoul National University, 1 Gwanak-Ro, Gwanak-Gu, Seoul, 151-744, Korea*
[b] *PHILOSOPHIA, 1 Gwanak-Ro, Gwanak-Gu, Seoul, 151-744, Korea*
[c] *IKIU, Qazvin, Iran*
[d] *Shiraz University, Shiraz, Iran*
[*] *Corresponding author: kysuh@snu.ac.kr*

1. Introduction

Development of an aging management plan (AMP) is a crucial contributor to maintaining the reactor safety and controlling the risk of degradation of the concrete reactor building of a nuclear power plant [1, 2].

The design, operation and utilization of a research reactor (RR) fundamentally differ from those of power reactors. The AMP should nonetheless be present on account of radioactive materials and radiation risks involved. This is mainly because the RR is deemed to be used as an experiment itself or to conduct separate experiments during its operation. The AMP aims to determine the requisites for specific structural concrete components of the reactor building that entail regular inspections and maintenance to ensure safe and reliable operation of the plant [3].

The safety of a RR necessitates the provision which is made in its design to facilitate aging management. Aging management of RR's structures is one of the vital factors to safety, to ensure continued adequacy of the safety level, reliable operation of the reactor, and compliance with the operational limits and conditions [4].

Moreover, engineering systems should be qualified to meet the functional requirements for which they were designed with aging and environmental conditions for all situations and at all times taken into account.

This study aims to present an integrated methodology for the application of an AMP for the concrete of the reactor building of a typical RR. For the purpose of safety analysis, geometry and ambient conditions were taken from a 5 MW pool-type, light-water moderated, heterogeneous, solid fuel RR in which the water is also used for cooling and shielding (Fig. 1). The reactor core is immersed in either section of a two-section concrete pool filled with water.

This paper makes available background information regarding the document and the strategy developed to manage potential degradation of the reactor building concrete as well as specific programs and preventive and corrective maintenance activities initiated for RR.

2. Methods and results

Aging is defined as a general process in which characteristics of systems, structures and components (SSCs) gradually change with time or use [6, 7]. RRs typically experience two kinds of time dependent changes:

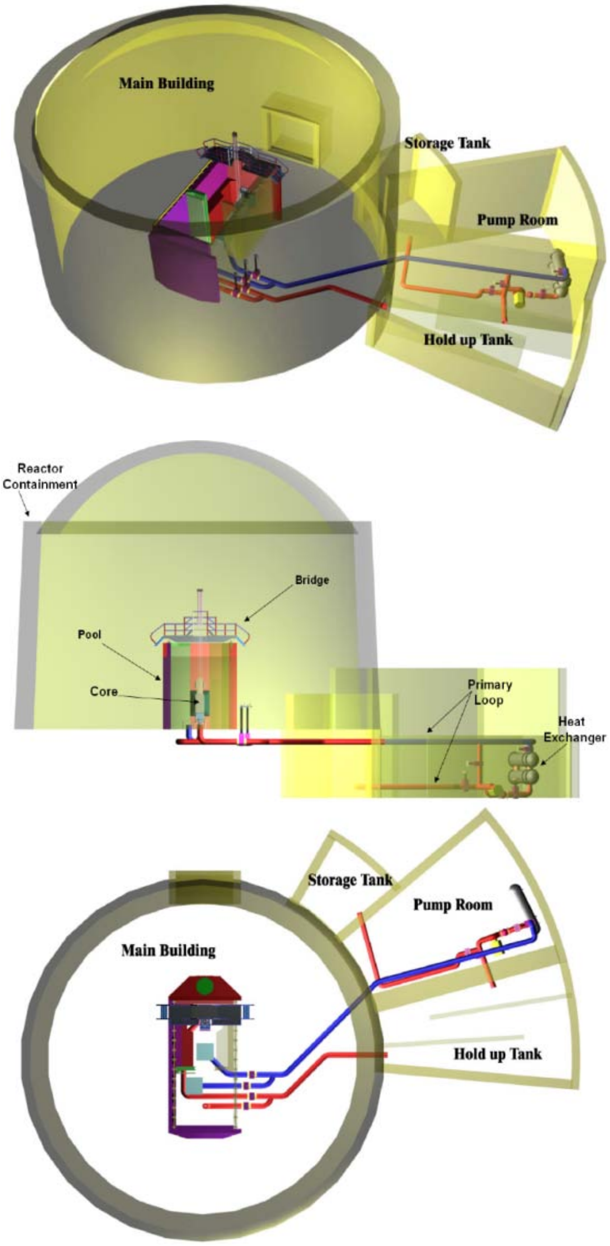

Fig. 1 Schematics of RR building and its utilities [5]

(1) Degradation of SSCs (physical aging), i.e. gradual deterioration in their physical characteristics;

(2) Obsolescence of SSCs (nonphysical aging), i.e. their becoming out of date in comparison to current knowledge, standards and technology [4].

This process ends up degradation of materials subjected to normal service conditions. The AMP is applied to the reactor building structure, but it does not include the internal components of the structure. The environmental conditions include climatic conditions such as humidity, frost and winds as well as site conditions such as salinity, sand, dust or chemical agents. They are all considered in AMP. All the effects of these conditions are considered as corrosion, erosion or undesirable chemical reactions occurring at the equipment exposed to such conditions. The data are mainly gathered and analyzed form in-service inspection programs which are conducted to help make sure that the RR structures have sufficient structural margins to continue to perform in a reliable and safe manner. Routine observation, general visual inspections, leakage rate tests, and destructive and nondestructive examinations are done to identify areas of the RR degradation [2].

First, the structures are sorted in accordance with their safety classes. Then thorough assessment is made of the damaged structure or component including evaluation of (1) cause of deterioration, (2) extent of deterioration, and (3) effect of deterioration on the functional and performance requirements of the structure or component [8].

Our preliminarily results show that the performance of the RR safety-related concrete structures has been compared favorably with the available guidelines [2, 5-11] that have been developed over the years through knowledge acquired in testing laboratories and supplemented by field experience [2]. However, there have been a few isolated incidents of degradation that primarily occurred early in life. Previous studies [6-10] conducted on concrete materials and structures indicate that only limited data are available on the long-term (40 to 80 years) properties of reinforced concrete materials [2, 9, 10]. Reinforced concrete structures almost from the time of construction will start to deteriorate in one form or another due to exposure to the environment (e.g., temperature, moisture, cyclic loadings, etc.) [8]. In order to evaluate the safety of reactor, it is desired to indicate how the structures have changed under the influence of aging factors and environmental stressors. Durability has been included in the design through specifications for maximum water-cement ratios, requirements for entrained air, minimum concrete cover over reinforcement, etc. Service-related degradation, however, can affect the performance of RR concrete structures [2]. In this study the degradation mechanisms are considered in the AMP e.g., temperature, moisture, cyclic loadings, etc. This study, however, shows the rate of deterioration mostly depends on the component's structural design, materials selection, and construction quality, curing and aggressiveness of the environmental exposure [8].

3. Conclusions

The current study has designed and evaluated the AMP for a typical RR. It was found that generally the performance of considered RR concrete structures has been very good in comparison with available guidelines. It is suggested that periodic inspection, maintenance, and repair are the key elements in managing the aging of concrete structures. Additional studies of aging mechanisms in modeling and management of RR aging would be very interesting.

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