

Lifetime management for mechanical systems, structures and components in nuclear power plants

E. Roos*, K.-H. Herter, X. Schuler

Materials Testing Institute (MPA), University of Stuttgart, Pfaffenwaldring 32, D-70569 Stuttgart, Germany

Received 2 March 2006; received in revised form 29 June 2006; accepted 3 July 2006

Abstract

Guidelines, codes and standards contain regulations and requirements with respect to the quality of mechanical systems, structures and components (SSC) of nuclear power plants. These concern safe operation during the total lifetime (lifetime management), safety against ageing phenomena (ageing management) as well as proof of integrity (e.g. break exclusion or avoidance of fracture). Within this field the ageing management is a key element. Depending on the safety-relevance of the SSC under observation including preventive maintenance various tasks are required in particular to clarify the mechanisms which contribute system-specifically to the damage of the components and systems and to define their controlling parameters which have to be monitored and checked. Appropriate continuous or discontinuous measures are to be considered in this connection. The approach to ensure a high standard of quality in operation and the management of the technical and organisational aspects are demonstrated and explained.

© 2006 Published by Elsevier Ltd.

Keywords: Lifetime management; Ageing management; Proof of integrity; Damage mechanisms; Basis safety concept; In-service monitoring; Technological ageing; Material-related (physical) ageing; Deming-process

1. Introduction

In most countries it has been stipulated that the licensing of nuclear power plants and their subsequent operation is based mainly on proof of the plant safety (e.g. strength analysis for operational conditions, postulated accidents, etc.). In Germany the atomic energy act [1] requires that “*every necessary precaution has been taken in the light of existing scientific knowledge and technology to prevent damage resulting from construction and operation of the installation*”. This has been realised in guidelines and in the nuclear standards [2–4] with their indications and requirements for plant safety. According to these documents it has to be ensured that:

- safety with respect to the quality of the systems, structures and components (SSC) is provided by the design, the material and the manufacture;

- the quality of the SSC has to be guaranteed and documented throughout the lifetime (extensive quality assurance during design, manufacture, and operation);
- the operational parameters (damage mechanisms) relevant for the integrity of the SSC are monitored and
- operational experience is recorded continuously and safety-related information is evaluated.

Therefore, the guidelines and standards contain all the requirements for a safe operation throughout the lifetime (lifetime management), for the control of ageing phenomena (ageing management) as well as for proof of integrity (e.g. with the aim to demonstrate break exclusion) for mechanical SSC, Fig. 1.

In Germany the discussions on ageing of mechanical SSC to be included in a structured ageing management process for nuclear power plants started at the beginning of the 1990s [5,6], Fig. 2.

*Corresponding author. Tel.: +49 711 685 2604; fax: +49 711 685 3144.
E-mail address: eberhard.roos@mpa.uni-stuttgart.de (E. Roos).

2. Definitions and methodology

2.1. Lifetime management and classification of the components

Lifetime management, Fig. 1, stands for the integration of ageing management and economic planning for SCC in order to

- optimise the operation, the maintenance and the lifetime of the plants,
- maintain an accepted level of safety and performance,
- maximise return on investment over the lifetime of the plant.

Various engineering measures are required depending on the safety relevance of the SSC or for reasons of preventive

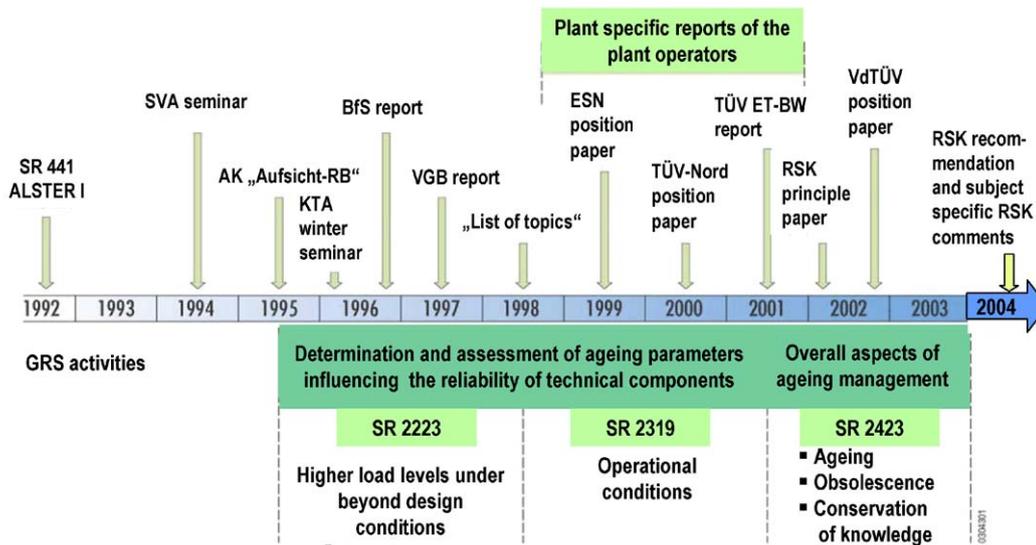


Fig. 1. Correlation between lifetime management, ageing management and proof of integrity for mechanical systems, structures and components.

maintenance [7–10]. Consequently, the SSC have to be divided into three groups, Fig. 3.

The first step within the scope of lifetime management of mechanical components is to select and arrange the SSC and to assign these to group 1, 2 or 3. The classification is according to the requirements of the nuclear codes and standards (RSK-guidelines, KTA) and if necessary according to plant-specific and safety-related factors. The plant operator is responsible for the classification and an expert has to check it on the basis of the current codes, standards and the state-of-the-art.

- *Group 1:* Failure of the SSC shall be excluded to avoid subsequent damage, e.g. reactor pressure vessel (RPV) and main coolant lines (MCL). The required quality shall be guaranteed for subsequent operation. The causes of possible in-service damage mechanisms shall be monitored and controlled (proof of integrity) [11]. Implementing this “proactive approach” prevents damage.
- *Group 2:* For redundant SSC the failure of a single part is allowable from a safety relevant point of view. However, common mode failure shall be excluded. The present quality shall be maintained for subsequent operation. The consequences of possible in-service damage mechanisms shall be monitored (preventive maintenance, time- or condition-oriented).
- *Group 3:* There are no defined standards for the quality of the SSC concerning subsequent operation (failure-oriented maintenance).



SR ... - Research projects sponsored by Government
 BFS - Federal office for radiation protection; GRS - Gesellschaft für Anlagen- und Reaktorsicherheit mbH, a scientific-technical expert and research organisation; KTA - Nuclear safety standards commission; RSK - Reactor safety commission; SVA – Swiss association for atomic energy; TÜV - Technical supervisory association; VGB – German federation of the owners of large boilers
 Source: GRS (2003) Cologne

Fig. 2. Relevant ageing management activities in Germany—an overview [6].

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات