AGEING MANAGEMENT IN GERMAN NUCLEAR POWER PLANTS

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Abstract

In Germany, the term 'ageing management' comprises several aspects. A demand for a special ageing monitoring programme is not explicitly contained in the regulations. However, from the Atomic Energy Act and its regulations results the operator's obligation to perform extensive measures to maintain the quality of the plant and the operating personnel working in the plant. From this point of view, comprehensive ageing management in German nuclear power plants has taken place right from the start under the generic term of quality assurance.

1. Introduction

All technical buildings or constructions have only a limited lifetime. Some have lasted for a very long time, like the pyramides in Egypt, others are very short-lived, like personal computers.

Therefore, all aspects have carefully to be considered which may occur during the lifetime of a nuclear power plant. Among those are aspects like conceptional modification as well as changes in safety philosophy. We can have ageing problems with regard to materials, concrete and systems. Some parts have to be replaced after many years of operation. In some cases, spare parts can no more be delivered in the original condition, that is why it is very important that the implementation of newly designed spare parts has no repercussion on other systems. This is, for example, a main point in the field of electrical equipment and instrumentation.

Another aspect to be considered is the transfer of plant-specific knowhow of retiring personnel to younger or new colleagues. With a planned lifetime of the German nuclear power plants of more than 40 years, the operating personnel will completely be exchanged. The same applies to documentation which must be available until the end of the plant's lifetime and which must consistently include all essential modifications.

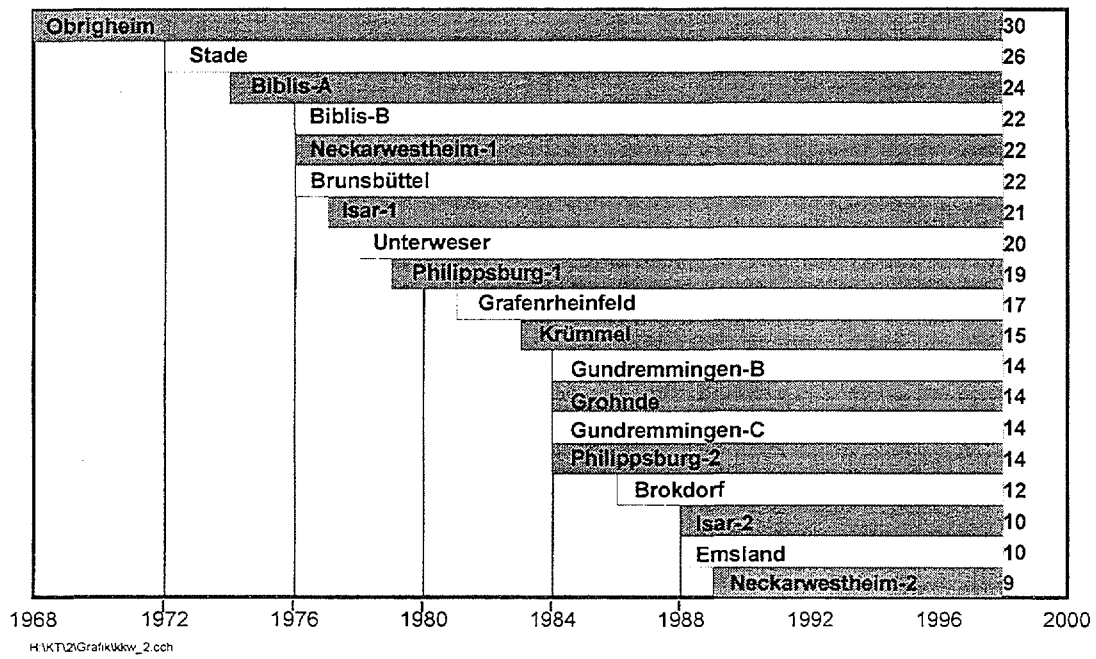
In the field of plant security, there are completely different types of ageing. Because the possibilities of terrorists have developed with time, we have to continuously develop and implement countermeasures.

2. Status of the German Nuclear Power Plants

In 1998, nineteen nuclear power plants have been in operation. Six NPPs are boiling water reactors (BWR), the other thirteen are of the pressurized water reactor type (PWR). The total power amounted to 22,194 MWe in 1997, i. e., on average more than 1,150 MWe per unit.The oldest nuclear power plant still in operation is Obrigheim with a lifetime of 30 years.

The German nuclear power plants have a licence without time limit. Therefore the issue of ageing is very important to the supervisory authorities, as they cannot assess this issue in the frame of licence renewal similar to the procedure in other countries.

TABLE 1: LIFETIME OF THE GERMAN NUCLEAR POWER PLANTS (1998)



3. Conceptional, Technological Ageing

In addition to material ageing, ageing of a plant due to the permanently changing state-of-the-art of science and technology as well as of the development in safety philosophy plays an important role. This aspect of ageing has been taken into account by the upgrading of existing and the installation of new safety systems as well as the introduction of accident management measures. In this regard, recommendations of the German Reactor Safety Commission (RSK) are of high significance. Major incentives for this further development of nuclear safety are derived from research programs financed by the Federal Government.

Because of the permanent increase in expertise from operational experiences, experience feedback and research in the field of reactor safety and the new safety-related requirements resulting from this, the high safety standard during the time of operation has been continued for all reactors in the Federal Republic of Germany by permanent backfittings. To cover this practice for the total time of operation of a plant, the Reactor Safety Commission recommended to perform a comprehensive Periodic Safety Review (PSR) for each nuclear power plant and to repeat it periodically in time intervals of approximately ten years. The operators of German nuclear power plants voluntarily committed themselves to perform these safety reviews.

Some measures shall serve as examples which were later implemented in German nuclear power plants.

- Secondary and primary pressure relief
- Filtered pressure relief of the containment shell
- Exchange of the feedwater pipes and main steam pipes of BWRs

At present, there is an example for a sensible adaptation to the state-of-the-art of science and technology in the field of instrumentation and control. For instance, presently a step-wise change of technology from analogous to digital instrumentation and control is taking place in German nuclear power plants. It cannot be derived from operational experience gained up to now that instrumentation

and control require to be modernized. The international trend, however, is unstoppable towards digitalization and software support. Another aspect are the difficulties to guarantee that spare parts are available for the long term.

4. Material Ageing

Material ageing includes time-dependent modifications of the characteristics of components in the fields machine engineering, electrical engineering and instrumentation and control as well as structural engineering. These modifications are caused by external influences, like mechanical, thermal, chemical influences and/or radiation. The connection of external influences with the different loads (e. g. static, dynamic, cyclic) leads to the damaging mechanisms which are typical of ageing.

In the field of **mechanical engineering**, ageing mechanisms are mainly contained in the following types of faults: corrosion, fatigue, wear, and embrittlement.

Within the scope of the requirements on quality assurance in nuclear power plants, different methods are used to inspect and monitor the components or, respectively, their materials with regard to the above-mentioned ageing phenomena. These methods already start prior to commissioning when the documents for the components are pre-checked, and are continued during the monitoring of construction and installation, including sampling of materials. To monitor materials and components during the operational phase,

- continuous controls,
- periodic controls, i. e. recurrent controls, and
- discontinuous controls, i. e. special control programmes

are used. To examine material ageing, material testing methods are used, which are classified in destroying and non-destroying testing methods. The testing methods in nuclear power plants are:

- ultrasonic test
- radiographic testing by means of X-ray or γ-radiation,
- surface crack test by means of magnetic particle inspection test or dye penetrant test ,
- eddy-current test,
- visual testing by eye, endoscope or videoscope,
- special testing methods (potential probe, sound emission).

Depending on the use of a component and its material, there are different requirements on monitoring for single components and systems. The radiation-induced embrittlement of the reactor pressure vessel is a deciding criterion for the lifetime, since an exchange of the reactor pressure vessel is not possible. Therefore, the directives with regard to the monitoring of the radiation-induced embrittlement of the reactor pressure vessel have been determined in a special standard of the Nuclear Standards Committee (KTA). In addition to reactor pressure vessel monitoring programmes, further programmes are directly linked with ageing phenomena. Among those are e. g.:

- On-line fatigue monitoring
- On-line diagnostic systems to recognize vibration, body sound and leakages.

They have in particular been used from the point of view of lifetime monitoring, prolonging of lifetime, the determination of remaining lifetime, within the scope of fatigue calculations or for the implementation of maintenance strategies (e. g. preventive maintenance). The mentioned measures follow the principle of creating by appropriate measures (e. g. material testings or on-line monitoring)

a data base for a status analysis, of which conclusions can be drawn, e. g. with regard to repair plannings, plant operation and possible exchanges of material and/or components.

In the field of **electrical engineering as well as instrumentation and control**, quantitative knowledge on the influence of decisive loads, like, for instance, temperature load by environmental conditions or self-heating, radiological influences, vibrations, electrical fields, wear, humidity, pressure, chemical changes etc., is required to determine ageing processes and pursue their trends. By directives given in the German regulations, ageing aspects with regard to material choice, design, construction, testing and monitoring during operation as well as maintenance are taken into account.

For instrumentation and control installations, which differ considerably with regard to operational and incident-caused environmental conditions, testing methods were installed in the past with the help of which the required incident-resistance has already been proved individually within the scope of the suitability test for the total time of use (stress parameters). With the draft standard KTA 3706 "Recurrent Proof of Coolant Loss Breakdown Resistance of Electrical-engineering and Instrumentation-and-control Components of the Safety System", the joint effects of the stress parameters shall be investigated and existing uncertainties with regard to their assessment shall be removed.

In the case of ageing aspects in the field of **building structures**, those components of a nuclear power plant are in the fore which have to take the operational and the accidental loads and which have to guarantee the integrity of the buildings relevant to nuclear safety. These are mainly prestressed concrete parts, steel constructions and linking parts, like anchorings, passages or hermetic sealings. The structural requirements in German nuclear power plants were determined in a great number of rules and guidelines as well as in DIN-standards.

In addition to the setting (setting cracks) occurring at all buildings, these components are also monitored with regard to the known ageing mechanisms under the point of view of ageing of the single materials:

- concrete (damages caused by weather influences, chemical reactions with components in groundwater or air, damages by carbonatization, shrinkage due to the high dead weight or, respectively, load, damages by vegetation),
- steel components, like reinforced steel or liner (corrosion damages, embrittlement by radioactive radiation),
- synthetic materials, e. g. as coatings, gap material (damaging by heating, light, chemicals, mechanical use).

The monitoring of nuclear power plant buildings is mainly performed by visual inspections. Additionally, instrumentational methods are used, like, for instance, setting measurements or potential measurements to detect corroded reinforcements.

5. Other Aspects of Ageing

Other aspects of ageing concern in particular the **physical ageing** of the nuclear power plant personnel and the **loss of know-how** through fluctuation of the personnel. In Germany, the reactor personnel counts as occupationally exposed personnel and are medically surveyed. The legal regulations regarding medical surveillance are laid down in the Radiation Protection Ordinance.

Fluctuation of the personnel is negligible within the general working life. In particular, the fluctuation due to age has to be taken into account. Therefore, it is important to secure the transfer of know-how inside the plant and in the training centres, among others in university installations, with the objective to maintain expert knowledge as well as a certain number of nuclear engineers. In all fields, in

particular, however, in shift operation and maintenance, the experience of the individual plays an important role, the transfer of experience to other employees being of particular significance. According to the "Guideline Concerning the Proof of Expertise of Nuclear Power Plant Personnel", training/education leaders are designated within the scope of plant organization who are responsible for building up programmes for the mediation and maintenance of shift personnel expertise.

A special role in transferring know-how is simulator training, which has continuously quantitatively and qualitatively improved in Germany since the 70ies. In addition to the mediation of knowledge on plant engineering, safely acting in different situations and operations is particularly trained with the simulator training concept.

The plant **documentation is** kept in the control room of the nuclear power plants, its adjoining rooms, in workshops, office rooms and the archives. If it exists on paper, it is subject to a certain wear. Furthermore, the documentation is updated and continued within the scope of modification procedures. Far-reaching requirements concerning the content and running of the plant documentation are contained in the nuclear standard regulations. In detail, those are aspects like completeness, relevance, protection against fire and other damaging impacts, running of a second documentation and storageability according to the storage periods given.

In order to better fulfill the requirements on documentation, electronic data processing systems are increasingly used for the processing of the data and information arising in connection with the operation of the plant and are integrated in plant management (Integrated Management Systems). The modifications and changes of hardware and software required for this are guaranteed by given quality standards and data updating is carried out according to determined responsibilities.

Summary

In Germany, the term 'ageing management' comprises several aspects. A demand for a special ageing monitoring programme is not explicitly contained in the regulations. However, from the Atomic Energy Act and its regulations results the operator's obligation to perform extensive measures to maintain the quality of the plant and the operating personnel working in the plant. From this point of view, comprehensive ageing management in German nuclear power plants has been taken place right from the start under the generic term of quality assurance.

Ageing of materials or components is controlled by in-plant quality assurance programmes.

With regard to conceptional ageing, a number of safety-relevant improvements have been carried out. Additionally, the safety-related plant status is regularly controlled by Periodic Safety Reviews (PSR). The review of the plant documentation regarding the complete recording of all modifications is performed by the supervisory authority. The technical requirements on the personnel are subjected to stringent controls. Specific problems of plant operation are trained by control room simulators.

Another important aspect for ageing management is the increase of safety by a comprehensive exchange of information about operational experiences in German and foreign plants. On all levels of German nuclear engineering (manufacturers, utilities, experts, supervisory authorities), efficient methods to guarantee the flux of information have been established and are regulated by law.

Part of those methods is the obligation to report safety-relatedly important events, which is regulated in the "Ordinance on Nuclear Safety Officers and the Reporting of Incidents and Other Events" (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung, AtSMV), their central recording and assessment and the forwarding of information being guaranteed by the Incident Registration Centre of the Federal Office for Radiation Protection. Information of particular, generic importance is given to the Gesellschaft für Anlagen- und Reaktorsicherheit as forwarding news on behalf of BMU to all

participants, so that necessary examinations can immediately be arranged for in the nuclear power plants. Incidents in foreign plants are made accessible via the Incident Reporting System (IRS) of OECD and IAEA.

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