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AGEING OF RESEARCH REACTORS

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Abstract

Historically, many of Research Institutions were centred on a research reactor facility as main technological asset and major source of neutrons for research. Important achievements were made in time in this research institutions for development of nuclear materials technology and nuclear safety for nuclear energy.

At present, ageing of nuclear research facilities among these research reactors and ageing of staff are considerable factors of reduction of competence in research centres. The safe way of mitigation of this trend deal with ageing management by so called, for power reactors, Plant Life Management and new investments in staff as investments in research, or in future resources of competence. A programmatic approach of ageing of research reactors in correlation with their actual and future utilisation, will be used as a basis for safety evaluation and future spending.

1. 'DESCRIPTIVE' THE PRESENT STATUS OF RESEARCH REACTORS AGEING

Ageing Feedback to research, design, redesign technology of materials and processes operation new limits, new regulations is a continuous process. Continuous Reliable Founding of Research Reactor Operation till Decommissioning is one of safety issue for which nor operating organisation either regulatory authority is directly responsible. The government, in this situation, bear the responsibility for direct financing or to establish legal mechanism to ensure Continuous Reliable Founding of Research. Operating organization and regulatory authority have the role to sustain the request for funds and to support for efficient utilization in the general interest of society for nuclear safety. Dealing with priorities or funds allotment there is only one priority — nuclear safety.

Prevention of ageing of research reactor is usually performed too late when phenomena or indication of ageing occur, this is based on large number of information of old reactors in operation. A programmatic prevention activity of ageing can be developed at any age of the research reactor in operation, starting with a matrix of ageing mechanism ranked on probability to occur the most sensitive elements of systems to ageing, including all active and passive safety systems and those which may drastically limits the availability and life of research reactor. This will result in criteria for ageing assessment and in predictive actions to manage the ageing of facility.

Descriptive approach of ageing of research reactors systems and structures is one of factors limiting systematic approach of issue.

Most of ageing related activities are post-factum descriptive causes of failures, in operating research reactors, are events, sometimes being difficult to split in to natural (ageing) or human errors causes. Without attempting to establish a clarification in the most cases reported, relative to ageing deal with corrosion, stress corrosion without identification of root causes and a unique solution replacement of component by a new one following the initial design to avoid large impact in commissioning and licensing of new part.

Recognised ageing factors and mechanism in the systematic presentation, may be:
- physical ageing phenomena on components and systems;
- evolution of safety standards and criteria;
- evolution of design criteria and ' good engineering practice';
- evolution of technology — new products/ obsolete materials;
- evolution of risk by the authorities and the public;
- need to upgrading and improvement of documents;
- increased demands to reduce waste production.

Physical effects manifest the impact of ageing in research reactors:
- reliable degradation resulting from high failure rates of ageing components;
- obsolesce of equipment resulting in unavailability of replacement or parts and maintenance on serviceable components;
- radiation damage effects causing embrittlement of materials;
- radioactivity buildings resulting in high exposure rates which hamper operation and maintenance;
- loss of integrity of piping, pool, tanks, confinement and structures for corrosion, stress cracking, wear;
- loss of motivation of staff in categories of researcher, operating personnel, maintenance personnel.

Staff ageing itself is one of safety issue affected by the following factors:
- mobility — incentive, motivation, cost training and licensing;
- health — increased health risk with age;
- retirement — increasing the mean age of staff without new employment.

2. CURRENT RESEARCH REACTORS AGEING PROBLEMS

During the lifetime of the reactor aggressive environment and operating conditions caused degradation of some components below their initial specifications.

Continuous decision process concerning safety of facility deal with:
- Reasons for upgrading and refurbishment to cope with ageing effects and meet new safety standards;
- Reasons for shutdown and decommissioning, both ways on the basis of:
  - legal background and procedures;
  - reactor actual and foreseen utilization;
  - financial support for the next 10 years;
  - lessons learned from similar facilities.

Legal background and procedures for research reactors should be completed and reinforced by the regulatory authority in developing countries. Documents on nuclear safety reactors developed by the IAEA starting with Safety Standards, safety guides, safety practice until technical documentation series cover entirely the safety requirements, operation, maintenance, core conversion, ageing, decommissioning, being used as reference for safety evaluation of a facility.

Actual and foreseen reactor utilization may be found in one of the activities as a combination of education, research, technology development and services. Reactors, which sustain programs for future nuclear technology development and are sustained by their Government, are likely to be refurbished and develop programs for ageing mitigation. On the other hand the underused reactors without financial support are exposed to permanent shutdown and decommissioning, still requiring a program for decommissioning and a large amount of money.

There are numerous facilities which belong to the same family of design, age and utilization, but without similar financial resources there is the case judgement on the future of this facility.

Problems which may occur in the operation of one of their facilities may occur to another facility, following the probability rules. Learning from the experience of similar facilities may help to solve some problems before the event happens.

Most of research reactors of one family (one recognized designer/supplier) have many design similarities which appear like technical solutions. Some of these technical solutions were rapidly accepted by other designers without having in mind specific conditions, correlations and technological limitation at that time, producing equipment and systems which are less resistant to ageing. Common causes of ageing of a family of reactors can be found in the original design.

3. AGEING EVALUATION PROGRAM (AEP)

The review of ageing and safety upgrading is generally focused on hardware and component degradation and/or obsolesce. There is also the need to review the loss of safety knowledge that occurs with the loss of staff due to retirements or organizational changes.

The objective of AEP is to determine the life expectancy (residual work life) of a reactor by performing suitable investigation measures, taking into account special design features of the facility post-operation period and operation experience. It should also be determined to what extent modification, refurbishment or replacement measures have to be taken in the near future to guarantee the safe operation of the facility according to the present state-of-the-art of science and technology. The ageing evaluation program is being focused on the systems and components of the reactor.

The plan can be subdivided into several phases. The first phase includes inventory of all structures, systems and safety equipment (further named components in this section), analysis and evaluation of operating documents and results of regular inspections, special unusual occurrences/events, analysis evaluation of comparable events at the nuclear facility, identification, compilation on life limitation effects and ageing effects. The second phase concerns the determination of critical components with respect to susceptibility to malfunctions. The third phase concerns the determination of critical groups of components for comparison with other facilities for damaging mechanisms (radiation, corrosion wear, fatigue) and selection of components for subsequent investigations. The fourth phase concerns the elaboration and execution of inspection program analysis for safety of components and safety evaluation of inspection results.

Ageing Evaluation Program should take into consideration:

- the inherent safety of original design using passive principles and systems which are less susceptible to ageing than those designs based on active countermeasures/action;
- the built-in capacity of the facility to cope with ageing, such as supplementary thickness of the wall for corrosion, larger diameter of pipes for future power increase, extra heat transfer capacity, built-in heat exchanger and cooling tower, electrical power supply to accommodate new electrical equipment and additional requirements of new experiments.
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Due to the evolution of regulations and safety standards old design facilities do not meet all present requirements; this is why they are considered aged. During the preparation of the Ageing Evaluation Program a judgment is necessary to evaluate the significance of non-compliance with the last standard requirements. The result of this judgment should be considered along as the expected remaining life of the reactor in terms of cost benefit.

Another important section of Ageing Evaluation Program concerns life extension of research reactors: this is a nuclear activity which will be performed according to new standards of design, construction, testing and operation based on the review of safety analysis, accompanied by new licensing of modifications and personnel.

The Ageing Evaluation Program is based on several sources of data and information derived from the operation of the reactor, periodic inspection and maintenance, event analysis and reporting, quality assurance relevant audits and inspection in the non-conformance reporting.

Other important sources of information are:
- the studies and works done in nuclear power plants to prevent ageing of safety systems where similarities are reasonably judged;
- the incident reporting system for research reactors (IRSRR) established by IAEA is a very useful tool where event analyses are in connection with ageing consequences.

The last chapter of the Ageing Evaluation Program concerns the actions and measures for ageing mitigation. In this area a major difference from nuclear power plant is noticeable. In a power plant most of non-conformities in equipment and systems are identified during inspection and are replaced by routine procedures. In research reactors the non-conformity is less discovered during inspections but and more likely during normal operation activities when abnormalities occur. The basic safety requirements are the same for power plant and for research reactors even in the inspection area of activities, but the techniques, methods and approach of inspection in these two situations are different due to reduced capability and means in the case of research reactors.

Since a power plant should ensure a high availability many components are exchanged without any indication on unavailability, the research reactors, due to the general lack of financial means, such components are not replaced. Thus these components are used until their life ends, calling randomly for replacement, with negative effects in availability and safety. In such cases only the provisions of fail-safe concept of the initial design operate.

3.1. The present status of relationship between ageing of research reactors and their nuclear safety

The present status of representation of ageing of research reactor is at the level of qualitative description of physical conditions concerning mainly the presentation of different aspects of ageing of various facilities frequently oriented to the availability of the facility to satisfy new technical and experimental requirements.

There is not a systematic approach of relation between the ageing process of the facility and trends in its nuclear safety. The ways in which ageing diminishes effectiveness of defence in depth by mechanisms of barriers ageing, equipment and safety system and which is the gap between initial designed performances of safety system and recent requirements derived from the last ICRP Recommendations lacks a thorough understanding.

The mitigation mechanism of ageing is at the level of description, replacement of equipment, repair of some systems based on the initial design or sometimes using new engineering solutions without sound safety analysis.

3.2. Priority for future work on safety of ageing reactors

Development of safety criteria for evaluation of safety of installations older than 20, 30, 40 years against which the lifetime of the facility may be justified. Lifetime assessment techniques, programs in order to evaluate the probability of an event in the remaining life to permanent shutdown should be developed.

In the 50 years of research reactor operation a large amount of data concerning material behaviour under irradiation was accumulated in comparison with the data available 30 – 40 years ago in the early design of nuclear facility.

Synthesis of these data in an international effort may lead to realistic evaluation of ageing of safety components under specific conditions of operation, to assess the structural integrity and remaining life of such a safety component.

Maintaining an adequate number of skilled and motivated staff for the safe operation of research reactors has been a great concern for operating organization of aged facilities:

a) through international cooperation based on the above-mentioned sources, in the attempt to a systematic approach of research reactors ageing, the Agency may draw some general guidelines;
b) Ageing Evaluation Program issued by each research facility, based on general guidelines, will contribute to the realistic understanding of situation and decision for new expenses (funds) which may be allotted.

3.3. Needs for strengthening international cooperation including recommendations for IAEA future activities

Ageing of nuclear research reactors generally became an issue of concern, but only ageing of safety equipment should be addressed by different approaches to generate models for safety evaluation of few types of worldwide recognized designs for research reactors.

4. CONCLUSIONS

A programmatic approach of ageing of research reactors in correlation with their actual and future utilization, will be used as a basis for safety evaluation and future spending.