

EVALUATION OF SOME AGING EFFECTS ON THE RESEARCH REACTOR IEA-R1

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ABSTRACT

The research reactor IEA-R1 was initially designed and constructed based on using materials and components meeting American standards and industrial practices at the time of its construction (1956-1957). In this paper, a brief description of the procedures for the evaluation of the aging effects on the research reactor IEA-R1 is presented considering the improvement in the technologies from the time of construction to present, and the upgrade for increasing the reactor power and its life extension.

INTRODUCTION

The research reactor IEA-R1 was designed and constructed based on using materials and components meeting the American standards and industrial practices of the time of its construction (1956-1957). From that time to present, the reactor has experienced operating conditions that may cause degradation of most of the materials. Some components have degraded so much that replacement or upgrading was required.

Considering the upgrade of the reactor for increase its power level (from 2 MW to 5 MW), an evaluation of the aging effects is being developed. The main aspects of that evaluation are related to:

- i. safety philosophy and design basis;
- ii. degradation of materials and components;
- iii. external events (e.g., earthquakes);
- iv. procedures of maintenance and inspection;
- v. documentation and quality assurance.

In this paper, a general description of the provisions under implementation to cover aspects above cited is presented.

SAFETY PHILOSOPHY AND DESIGN BASIS

In this area, the applicability of the safety and industrial standards used in the design, construction, operation, maintenance, and inspection of the reactor, from the time of its construction to present, is reviewed. Some discrepancies were noticed from the evolution and the new requirements of the applicable codes and standards. As

examples to mitigate the observed discrepancies and to comply with the new situation we have:

- i. inclusion of new safety systems and features such as the spray emergency core cooling system;
- ii. inclusion of additional requirements in the technical specifications regarding testing and acceptance of the materials for new components;
- iii. devices to prevent loss of coolant may be included (e. g., beam-holes covers);
- iv. inclusion of a vibration detection system for rotating machinery (e. g., for the centrifugal pumps of the main coolant system);
- v. conduction of a consistent safety analysis according the more recent practices and standards.

DEGRADATION OF MATERIALS AND COMPONENTS

The operating conditions and the reactor environment are the main causes of the different types of aging in the materials, depending also on the materials themselves, leading to degradation of the components.

In the reactors, the metallic materials aging may occur when irradiated metallic parts become embrittled; chromium alloy steels decompose; fatigue life may be exhausted so that cracks may be formed and propagate; corrosion attacks result in material loss or in stress corrosion cracking. Synthetics and elastomers become inelastic, swell, shrink or crack; electric contacts may be oxidized; or isolation may lose their high electric resistance. Concrete structures may suffer cracking,

corrosion of the reinforcement, creep, and changes in the mechanical properties.

The main materials aging factors, which are parameters that characterize the service conditions of the components, may be:

- i. alternating stress and strains leading to fatigue effects that may result in crack formation, crack propagation, and failure;
- ii. temperature resulting in thermal aging if it is high enough or in thermal fatigue;
- iii. radiation causing radiation damage pronounced mostly by hardening and embrittlement in metallic materials;
- iv. corroding agents causing corrosion in different ways and by different mechanisms: corrosion attacks in unprotected surfaces, galvanic or crevice corrosion, pitting, and intergranular corrosion;
- v. relative motions of fluids causing erosion and relative motions of solids resulting in fretting or wear.

The evaluation of radiation effects is based on the value of the fast neutrons fluence. For the research reactor IEA-R1 the value of the fast neutrons fluence, from the operational records, is 100 to 1000 times smaller than the value that is the threshold that may cause damage in metallic materials of the core and of the core support structures.

Concerning fatigue, the reactor components do not have significant cyclic loads that cause significant cyclic stresses and strains. Thus, no fatigue damage can be expected in those components.

To evaluate the aging effects due to corrosion, an inspection plan must be provided. The visual inspection of all components and items is planned as well nondestructive tests of some components and piping systems.

Due to severe degradation some components were repaired or replaced (e.g., centrifugal pumps of the main coolant system; secondary piping system).

EXTERNAL EVENTS

More recent standards and regulations than those used in the IEA-R1 design require that external events will be considered as loads in the design basis of the structures, components and systems. Among other external events, it was concluded that the seismic loads must be considered in the structural design of the reactor structures, systems and components.

In the search of applicable codes for existing research reactors, it was found the standard [1] developed by the American Department of Energy (DOE) to consider external events, such as earthquakes, in the evaluation of structures of existing nuclear installations or in the design of new ones.

According to [1], the seismic loads are defined from zones of seismic risk maps (probabilistic approach) and the structural design follows deterministic current practices, using the obtained seismic loads. For the site of the research reactor IEA-R1 (Cidade Universitária, São Paulo,

SP), according to [2], the applicable seismic zone is 0 (zero). From [1] and [3], the corresponding seismic loads may be considered negligible and may not be included in the structural design.

PROCEDURES OF MAINTENANCE AND INSPECTION

The procedures of maintenance and inspection are closely related to the requirements of the applicable codes and standards for inspection and to the components and systems more susceptible to aging effects.

As cited in section "Degradation of Materials and Components", an inspection plan must be implemented, covering the main aspects of the procedures of maintenance and inspection. In addition, a vibration detection system for rotating machinery was implemented.

The operation staff also conducts periodical inspections and maintenance and stores files of occurrences during the reactor operation.

DOCUMENTATION AND QUALITY ASSURANCE

Different from the past, programs for quality assurance and documentation are required for nuclear organizations and installations nowadays. For the research reactor IEA-R1 it was implemented a program for documentation control related to the new reports, drawings and specifications, etc. It is also planned a program to recover and store the old technical documents.

CONCLUSIONS

All main aspects concerning the aging effects on the research reactor IEA-R1 were evaluated. Several provisions resulting from that evaluation were or have been implemented, or are planned. Thus, it is expected that IEA-R1 will satisfy all the applicable requirements for a safe operation now and in the future.

REFERENCES

- [1] DOE, **Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities**, DOE-STD-1020-94, US Department of Energy, Washington, D.C., USA, 1994
- [2] IPT, **Caracterização sísmica do local do reator IEA-R1**, relatório a ser emitido, 1996
- [3] **Uniform Building Code, Earthquake Regulations**, International Conference of Building Officials, Whittier, CA, USA, 1988