INTRODUCTION

Module 2

IAEA

International Atomic Energy Agency

Presentation

- Session 2.1:

  Basic concepts and terminology
- Session 2.2:

  Implications of physical ageing and non-physical ageing on NPP safety

Note: This Workshop is focused on management of physical ageing

IAEA

Basic concepts and terminology

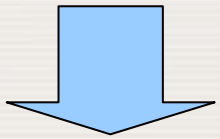
Session 2.1

IAEA
International Atomic Energy Agency

Two kinds of ageing

When NPPs age two kinds of changes occur:

- *physical degradation*, i.e. gradual deterioration in the physical characteristics
- *obsolescence*, i.e. becoming out of date in comparison with current standards and technology



Physical ageing:

processes leading to physical degradation

Non-physical ageing:

processes leading to obsolescence

IAEA

Note: In this Workshop, ageing and ageing management relates to physical ageing.

Ageing

General process in which characteristics of a system, structure, or component (SSC) gradually **change with time or use**

this process may proceed by a single ageing mechanism or by a combination of several ageing mechanisms

Ageing mechanism

Specific process that gradually changes characteristics of an SSC **with time or use**

Examples: curing, wear, fatigue, creep, erosion, corrosion, embrittlement

Ageing Effects

Net changes in characteristics of an SSC that occur with time or use and are due to ageing mechanisms

- ***Ageing degradation***: ageing effects that could impair the ability of an SSC to function within acceptance criteria

Examples:

- ***positive effects*** *- increase in concrete strength from curing; reduced vibration from wear-in of rotating machinery*
- ***negative effects*** *- reduction in diameter from wear of a rotating shaft, loss in material strength from fatigue or thermal ageing, and loss of dielectric strength or cracking of insulation*

IAEA

Ageing management

Engineering, operations and maintenance actions to control within acceptable limits ageing degradation and wearout of SSCs

Examples:

- *engineering actions - design, qualification, and failure analysis*
- *operations actions - carrying out operational procedures within specified limits, surveillance, and performing environmental measurements*

Life management

Integration of ageing management and economic planning to:

- *optimize the operation, maintenance and service life of SSCs;*
- *maintain an acceptable level of performance and safety; and*
- *maximize return on investment over the service life of the plant*

Service conditions

Actual physical states or influences during the service life of an SSC (i.e. environmental, loading, power and signal conditions), including:

- *operating conditions*
- *accident and post-accident conditions resulting from design basis events for the NPP*

Examples: temperature, pressure, radiation, humidity, chemical parameters, electrical parameters, vibration

Stressor

Agent or stimulus that stems from pre-service and service conditions and can produce immediate or ageing/gradual degradation of an SSC

Examples: heat, radiation dose and dose rate, steam, chemicals, mechanical cycling, and electrical cycling

Stressor (Cont'd)

Service life

- actual period from initial operation to retirement of an SSC

Design life

- period during which an SSC is expected to function within acceptance criteria

Stressor (Cont'd)

Condition indicator

- characteristic that can be observed, measured or trended to infer or directly indicate the **current and future ability** of an SSC to function within acceptance criteria

Functional indicator

- characteristic that can be measured or observed to provide a direct indication of the **current ability** of an SSC to function within acceptance criteria

Stressor (Cont'd)

Condition monitoring

- observation, measurement or trending of condition or functional indicators with respect to some independent parameter (usually time or cycles) to indicate the **current and future ability** of an SSC to function within acceptance criteria

Testing

- observation or measurement of condition or functional indicators under controlled conditions to verify that the **current performance** of an SSC conforms to acceptance criteria

IAEA

Failure

Inability or interruption of ability of an SSC to function within acceptance criteria

Maintenance

Aggregate of direct and supporting actions that detect, preclude, or mitigate degradation of a functioning SSC, or restore to an acceptable level the design functions of a failed SSC

- Preventive maintenance – maintenance actions to **control degradation** and failures of an SSC to an acceptable level
- Corrective maintenance – maintenance actions that **restore**, by repair, overhaul or replacement, the capability of a **failed SSC** to function within acceptance criteria

IAEA

Three types of preventive maintenance

- Periodic
  performed at predetermined intervals of calendar time, operating time or number of cycles
- Planned
  refurbishment or replacement that is scheduled and performed prior to expected unacceptable degradation of an SSC
- Predictive or condition directed
  initiated on the basis of condition monitoring

Reliability Centred Maintenance

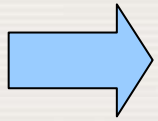
Systematic method
for developing and optimizing preventive maintenance programmes

- by evaluating and prioritizing preventive maintenance actions **according to their effectiveness in reducing the probability of system failure**
- their economic viability also taken into account

Equipment Qualification (EQ)

Generation and maintenance of evidence to ensure that the equipment will operate on demand to meet system performance requirements.

EQ takes into account significant ageing mechanisms that cause equipment degradation during its installed life



Well implemented EQ programs provide an effective strategy for managing ageing of the components covered by the program.

IAEA

Implications of physical ageing and non-physical ageing on NPP safety

Session 2.2

IAEA
International Atomic Energy Agency

Safety aspects of non-physical ageing

Continued operation of older NPPs may pose an undue risk due to their obsolescence in safety standards and technology

Examples:

Inadequate level of plant safety due to

- lack of containment
- lack of diversity, separation, and redundancy
- lack of equipment qualification

Increased failure rates and system unavailability

- lack of advanced materials
- lack of spare parts and manufacturer's support
- lack of software support

IAEA

Safety aspects of non-physical ageing (cont'd)

- Safety levels of older NPPs should be acceptable in terms of current knowledge and safety thinking
- All NPPs should be subjected to a systematic safety reassessment throughout their service life
- Periodic safety review (PSR) is an effective and widely used regulatory instrument designed for dealing with the slow changes resulting from non-physical ageing

IAEA

Safety aspects of physical ageing

- Physical/material ageing of SSCs reduces safety margins provided in the NPP design
- NPP safety could be impaired if
  - reductions in safety margins are not detected, and
  - corrective action is not taken

  before loss of functional capability occurs.

Safety margin:
the integrity and functional capability of both passive and active SSCs in excess of their normal operating requirements.

IAEA

Safety aspects of physical ageing (cont'd)

Physical ageing is a safety concern primarily at system level, as failures of individual components can be usually tolerated.

May increase probability of common cause failures, e.g. simultaneous degradation of physical barriers and redundant components.

This could result in the impairment of one or more levels of protection provided by the defence-in-depth concept.

Examples of significant ageing degradation

- Widespread damage of Alloy 600 components, e.g. SG tubes and RPV head penetrations caused by SCC
- Zircaloy pressure tube rupture caused by hydride blistering
- Failures of primary pumps motors due to degradation of high voltage insulation of stator windings caused by electrical stress
- Failures of electrical cable insulation caused by thermal embrittlement

IAEA

Conclusion

- Ageing in NPPs must be managed effectively to ensure the availability of required safety functions throughout the plant service life, taking into account changes which occur with time and use.
- This Workshop deals with physical ageing of SSCs important to safety.
- It is designed to help you to implement systematic ageing management programmes in nuclear power plants.