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BASIC CONCEPTS AND PROCESS FOR EQ

Module 2



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Presentation

- Session 2.1:
Basic concepts and terminology
- Session 2.2:
EQ methods
- Session 2.3:
EQ process

Basic EQ concepts, standards and terminology

Session 2.1



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What is EQ?

EQUIPMENT QUALIFICATION

The generation and maintenance of evidence to assure that the equipment will operate in demand, to meet the system performance requirements.

Why to qualify?

- **EQ is one of the defence-in-depth methods for protection against the release of radioactive materials**
- **EQ is a design tool for preventing failures of equipment due to hazardous service conditions, e.g. high temperature, humidity and radiation fields due to LOCA, or high vibration due to earthquake.**

What equipment should be qualified?

- **Equipment that is required for operation of systems important to safety during a design basis event (e.g. LOCA), or equipment whose failure could cause failure of the system to perform its safety function.**
- **Equipment that is required for**
 - **reactor shutdown**
 - **reactor cooling/removal of residual heat**
 - **minimizing potential release of radioactive materials**

Examples: sensors (p,T, neutron), cables, connectors, penetrations, MOVs, motors

Current situation

- Current situation regarding implementation of EQ differs greatly depending on the plant vintage and technology.
- On new and some older NPPs, EQ can be considered well established and the current efforts deal mainly with the preservation or maintenance of EQ .
- On some older NPPs, EQ has not been formally established and current efforts deal with upgrading / backfitting EQ.

Basic EQ standards

- International Standards on qualification :
 - IEC 780 for environmental qualification
 - IEC 980 for seismic qualification.
- Other well known EQ standards:
 - IEEE (United States)
 - KTA (Germany)
 - RCCs (France)

IAEA requirements and recommendations on EQ

- The Safety Requirements on Design (NS-R-1) provides basic requirements on Equipment Qualification in the Chapter “Requirements for Plant Design”. (5.45, 5.46)
- The Safety Guide on Periodic Safety Review (NS-G-2.10) provides recommendations to review plant specific EQ programmes as one of 13 technical subjects.

IAEA requirements and recommendations on EQ

Safety Requirements NS-R-1

- 5.45. A qualification procedure shall be adopted to confirm that the items important to safety are capable of meeting, throughout their design operational lives, the demands for performing their functions while being subject to the environmental conditions (of vibration, temperature, pressure, jet impingement, electromagnetic interference, irradiation, humidity or any likely combination thereof) prevailing at the time of need. The environmental conditions to be considered shall include the variations expected in normal operation, anticipated operational occurrences and design basis accidents. In the qualification programme, consideration shall be given to ageing effects caused by various environmental factors (such as vibration, irradiation and extreme temperature) over the expected lifetime of the equipment. Where the equipment is subject to external natural events and is needed to perform a safety function in or following such an event, the qualification programme shall replicate as far as practicable the conditions imposed on the equipment by the natural phenomenon, either by test or by analysis or by a combination of both.
- 5.46. In addition, any unusual environmental conditions that can reasonably be anticipated and could arise from specific operational states, such as in periodic testing of the containment leak rate, shall be included in the qualification programme. To the extent possible, equipment (such as certain instrumentation) that must operate in a severe accident should be shown, with reasonable confidence, to be capable of achieving the design intent.

IAEA requirements and recommendations on EQ

Safety Guide on PSR (NS-G-2.10) (1)

Objective

4.17. The objective of the review is to determine whether equipment important to safety is qualified to perform its designated safety function throughout its installed service life.

Description

4.18. Plant equipment important to safety should be properly qualified to ensure its capability to perform its safety functions under postulated service conditions, including those arising from external events and accidents (such as loss of coolant accidents, high energy line breaks and seismic or other vibration conditions) in a manner consistent with the safety classification [4, 6–8]. A qualification procedure should be used to confirm that the equipment is capable of meeting, throughout its service life, the requirements for performing safety functions while subject to the environmental conditions (vibration, temperature, pressure, jet impingement, irradiation, corrosive atmosphere and humidity) prevailing at the time of need, with account taken of the ageing degradation of the equipment that occurs during service. conduits).

IAEA requirements and recommendations on EQ

Safety Guide on PSR (NS-G-2.10) (2)

4.19. Qualification of plant equipment important to safety should be achieved through a process that includes generating, documenting and maintaining evidence that equipment can perform its safety functions during its installed service life. This should be an ongoing process, from the plant design to the end of service life, and plant ageing, modifications, repairs and refurbishment, equipment failures and replacements, and abnormal operating conditions should be taken into account. Although many parties (such as plant designers, equipment manufacturers and consultants) are involved in the equipment qualification process, the operating organization has the ultimate responsibility for the development and implementation of a plant specific equipment qualification programme that includes generating and maintaining the documentation demonstrating qualification.

4.20. The review of equipment qualification should determine (a) whether assurance of the required equipment performance capability was initially provided and (b) whether equipment performance has been preserved by ongoing application of measures such as scheduled maintenance, testing and calibration and has been clearly documented. It should be noted that a review relating to (a) above may not be necessary if a previous review has concluded that adequate initial equipment qualification was established; and a review relating to (b) above should provide assurance that equipment qualification will be satisfactorily preserved in future. A plant walkdown of installed equipment should be performed to identify for qualified equipment any differences from the qualified configuration (abnormal conditions such as missing or loose bolts and covers, exposed wiring or damaged flexible conduits).

SAFETY FUNCTION

Specific purpose (of an equipment) that has to be accomplished for safety.

- **The safety function of an equipment is generally established in terms of its required behaviour (active or passive) and its duration.**
- **The equipment safety function is a basic input in the EQ program.**

POSTULATED INITIATING EVENTS (PIEs)

- Events that lead to anticipated operational occurrences or accident conditions
- PIEs include events expected to occur occasionally (e.g. loss of off-site power) and others not expected but theoretically possible, e.g. large LOCA or HELB

SERVICE CONDITIONS

- **Environmental, loading, power and signal conditions expected during normal operation and PIEs.**
Subdivided into:
 - *Environmental conditions*, e.g. ambient temperature (normal, abnormal, accident), ambient pressure, humidity/steam, chemical spray (during accident), submergence, seismic (vibration)
 - *Operational conditions*, e.g. self-heating, cycling, electrical loading, mechanical loading, process fluid conditions, electromagnetic interference (EMI)
- **Service conditions provide the input data for the EQ process.**

AGEING

- Potential common cause failure mechanism that has to be evaluated in EQ
- Particularly significant during those PIEs when service conditions differ substantially from normal operation or periodic testing
- EQ normally considers ageing effects by simulating them by accelerated tests.

QUALIFIED LIFE

- Qualified life is the period of time for which satisfactory performance can be demonstrated for a specific set of service conditions.
- Before the end of its qualified life, equipment has to be replaced, life limiting materials replaced, or a new longer qualified life established.
- Some Member States rely on ‘ongoing qualification’ (e.g. inspection, maintenance, testing) to maintain equipment in a qualified state.

QUALIFICATION MARGIN

- **Qualification margin is the difference between specified service conditions and the more severe conditions used when qualification is established**
- **Margin accounts for normal variations in equipment production, measurement inaccuracies, errors in defining service conditions and satisfactory performance, etc.**

RELIABILITY DATA

- Current qualification practices do not make use of statistical or reliability data.
- EQ relies generally on testing of representative samples of the equipment (normally limited in size), conservative assumptions, margins and QA controls to provide assurance that the equipment safety function will be met.
- Reliability data, now starting to be available from the operating NPPs, can provide a basis to establish qualification for PIE service conditions similar to those normally occurring.

DOCUMENTATION

- Documented evidence of qualification is generated during the EQ process.
- Qualification documentation must be maintained during NPP service life in a well organized, understandable and auditable form.
- EQ documentation relevant to establishing qualification for a specific equipment is usually kept in an EQ file.

QUALITY ASSURANCE

- **QA during the EQ program ensures validity of results obtained for a specific equipment.**
- **Further QA steps ensure that installed equipment matches that which was qualified and is suitably applied, installed, maintained and periodically tested.**
- **EQ uncertainty can result from defective QA implementation, e.g.**
 - Testing laboratory's instruments not properly calibrated.
 - Equipment design changes made by the Manufacturer without considering qualification significance.
 - Formulation of a material changed by the supplier without notifying the equipment manufacturer.
 - An equipment installer fails to properly install environmental seals.

TRAINING

- Being a highly specialized field of activity, related to plant safety, specific training of participating personnel is a basic need in the development of EQ programs.
- EQ knowledge and skills are achieved through a combination of technical education, specialized training, and on the job training.
- Related QA systems should specify training profiles for different EQ related positions.

EQ methods

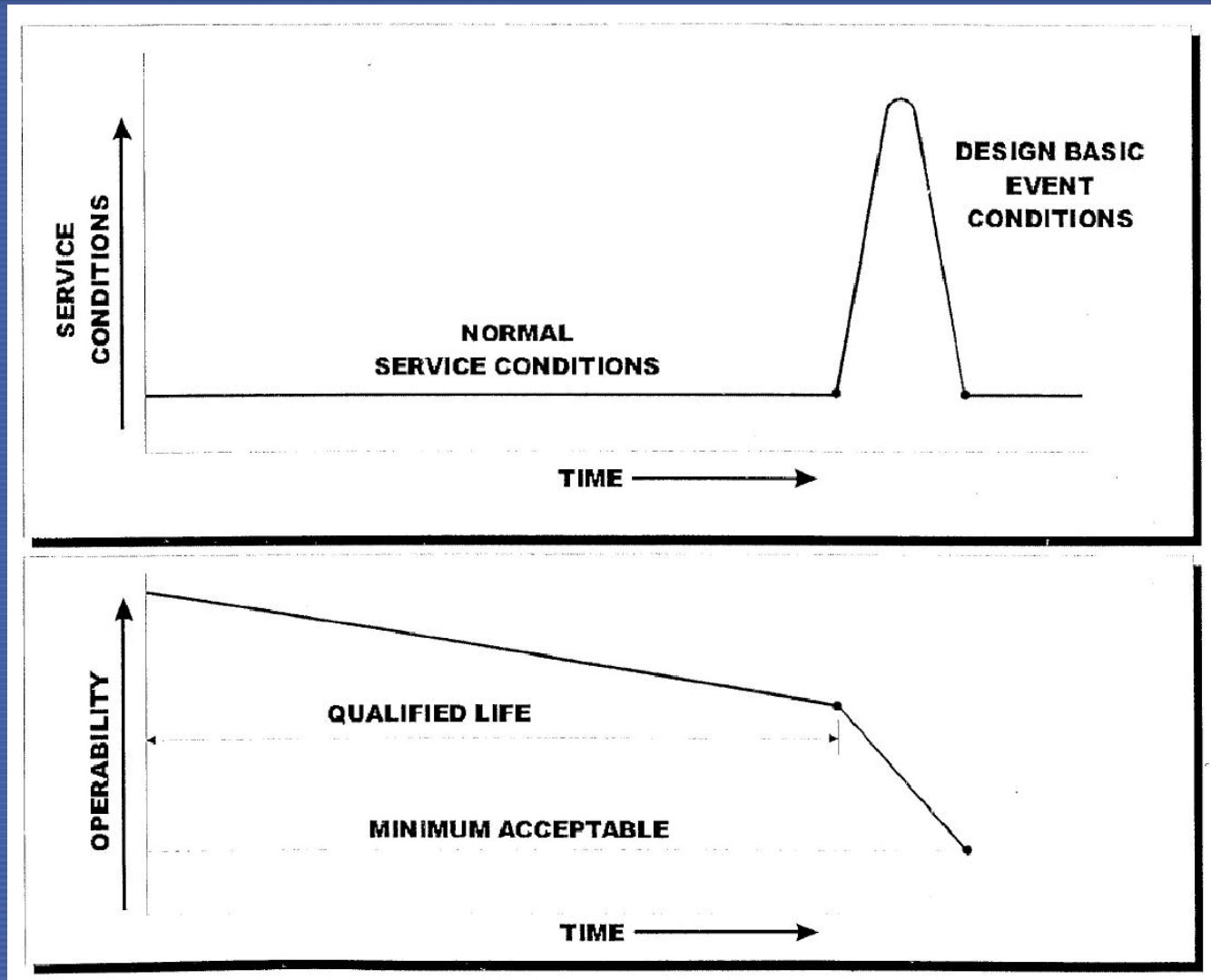
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Figure illustrating the intent of qualification



Recognized EQ methods

- **Type testing**
- **Analysis**
- **Operating experience**
- **Combination of the above**
- **Ongoing qualification**

Type testing

- Most often used method
- Provides straightforward results
- A representative sample of equipment is subjected to specific testing
- Performed for different aims:
 - To qualify a specific equipment
 - To qualify a family of equipment
 - For specific service condition (plant specific or envelope requirements)

Analysis

- A quantitative analysis of a mathematical model of the equipment is performed
- Mostly used for seismic qualification (in simple equipment)
- Difficult to apply for environmental qualification

Operating experience

- **Qualification is accomplished by the use of consistent information on successful operation of same equipment in equal or more severe service conditions**
- **Normally not acceptable as the only means to establish EQ**
- **In practice, only useful as a complement to another qualification method**
- **Used in seismic EQ**

Ongoing qualification

- Activities performed subsequent to initial EQ, e.g. condition monitoring, preventive maintenance and analysis of operating experience, to extend qualification for an additional period of time.
- Qualification is extended based on testing of leading samples of equipment (e.g. cable deposits).

EQ process

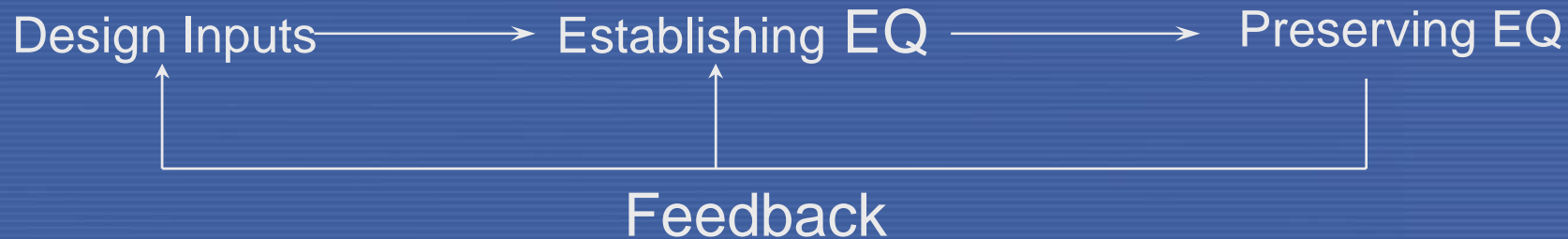
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Equipment Qualification (EQ) Process



Design Inputs

- identify PIEs
- specify service conditions
- determine required safety functions
- develop list of equipment, including functions and mission time

Establishing EQ

- define EQ requirements and criteria
- select qualification method
- establish qualification
- define installation and maintenance requirements
- document qualification results

Preserving EQ

- installation and maintenance control
- replacement control
- modification control
- service condition monitoring
- analysis of degradation and failures
- analysis of experience feedback
- personnel training
- documentation

Upgrading EQ

Upgrading EQ is a special case of establishing EQ that applies to existing equipment in operating plants. Upgrading EQ may also involve establishing or verifying design input information.

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