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EQ PRACTICES FOR DIFFERENT SERVICE CONDITIONS

Module 3

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Presentation

- Session 3.1: Harsh environment EQ
- Session 3.2: Mild environment EQ
- Session 3.3: Electrical vs. Mechanical EQ
- Session 3.4: Seismic EQ

Harsh environment EQ

Session 3.1

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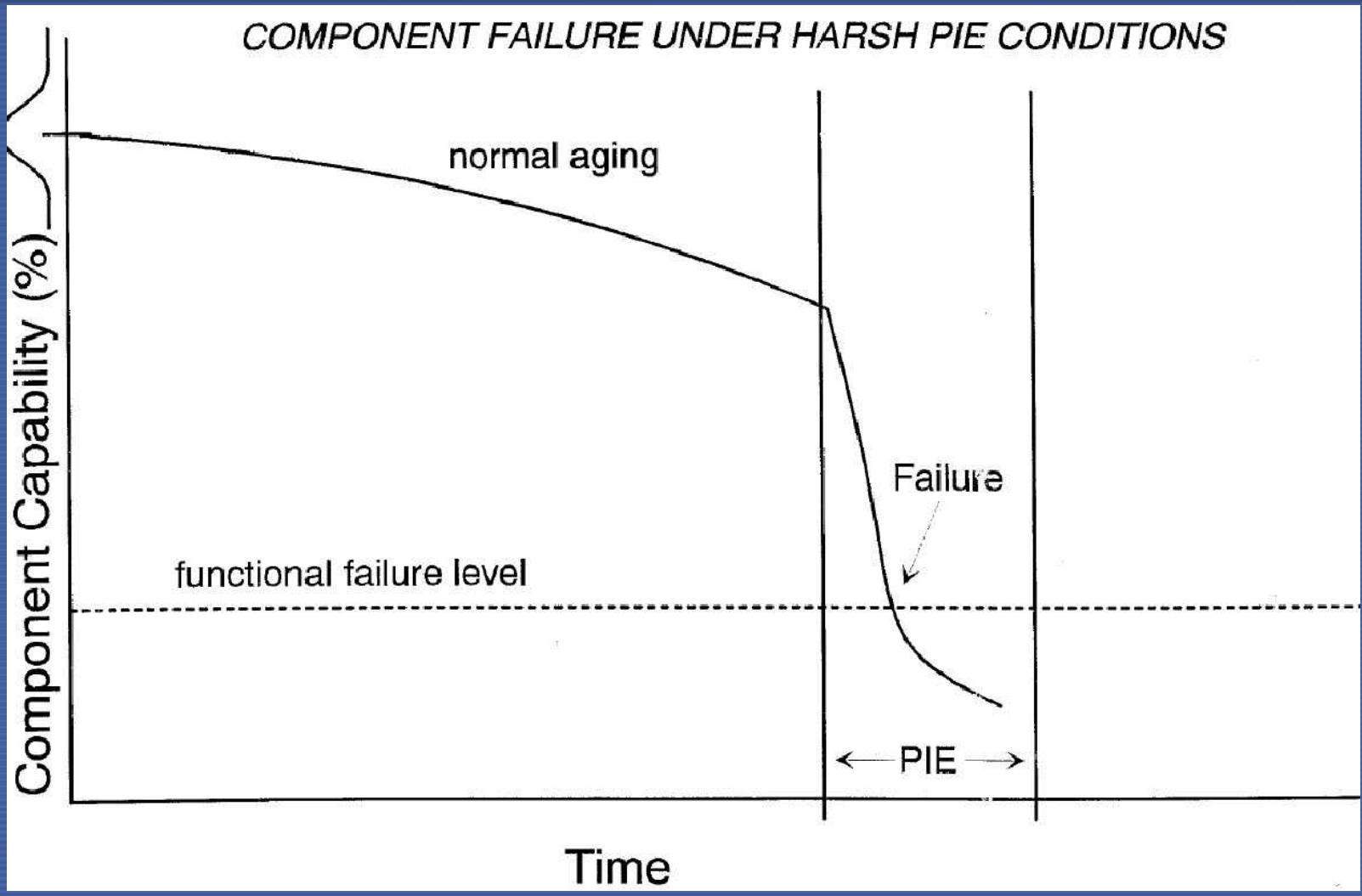
Harsh Environment

Environmental conditions in an NPP location which significantly change as a result of a PIE.

- **During certain PIEs, environmental conditions, operational conditions, or both may be significantly different than those occurring during normal operation and transient conditions.**
- **Significant changes in service conditions create stresses that may result in equipment failures, particularly if the components have experienced in service degradation.**

Harsh environment conceptual figure



Effects caused by harsh environment

High temperature effects:

- Lower dielectric strength
- Lower insulation resistance
- Change semiconductor device characteristics
- Increase electronic circuit failure rates
- Melt certain thermoplastics
- Produce differential expansion
- Lower mechanical strength
- Increase chemical reaction rates (corrosion)

High pressure effects:

- **Crush or damage enclosures**
- **Force external environment into components**
- **Increase heat transfer under saturated steam conditions**

Steam effects:

- **Rapid heat transfer under saturated conditions**
- **Condensate (water) formation on surfaces**
- **Moisture permeation into polymers**
- **Swelling of certain polymers (aged)**

Radiation - degrades properties of organic materials:

- **Decrease elongation and tensile strength**
- **Brittleness in elastomers and rubbers**
- **Produces gases, some corrosive (HCl)**

Radiation - produces semiconductor property changes (transient and permanent):

- **Diodes - increase reverse current**
- **Bipolar - decrease gain, increase leakage current**
- **FET - increase junction and leakage currents**
- **MOS - effects vary, transient**

Caustic chemical spray:

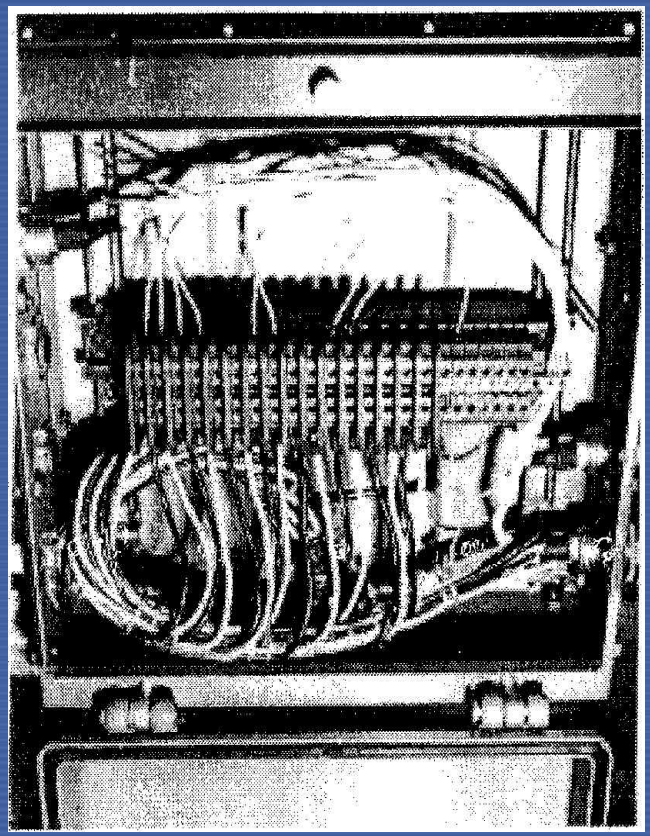
- Accelerates corrosion
- Accelerates hydrolysis
- Increases surface electrical conductivity

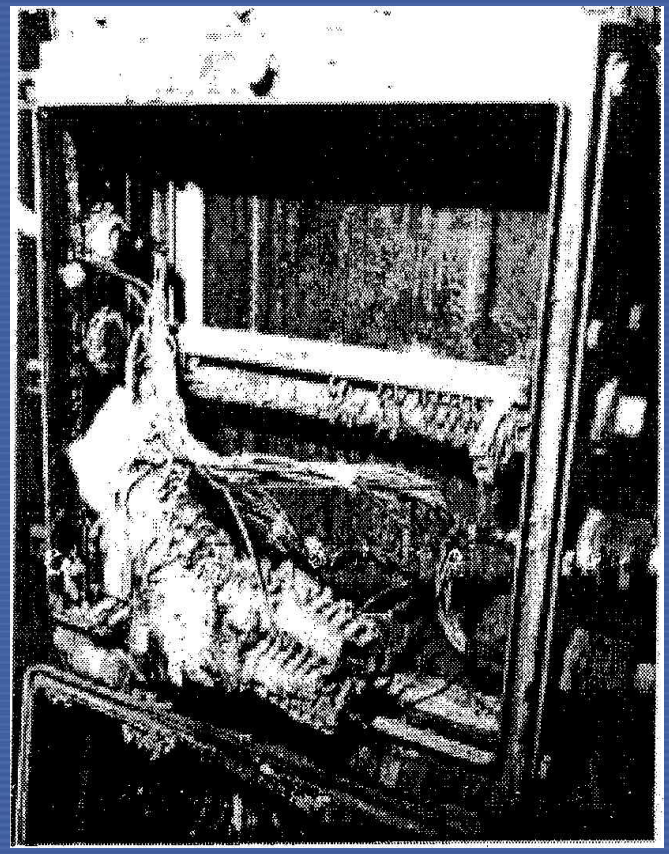
Concurrent conditions (temperature, pressure, steam, radiation):

- Accelerate certain effects
- Produce new effects

Examples of equipment exposed to LOCA Terminal blocks:

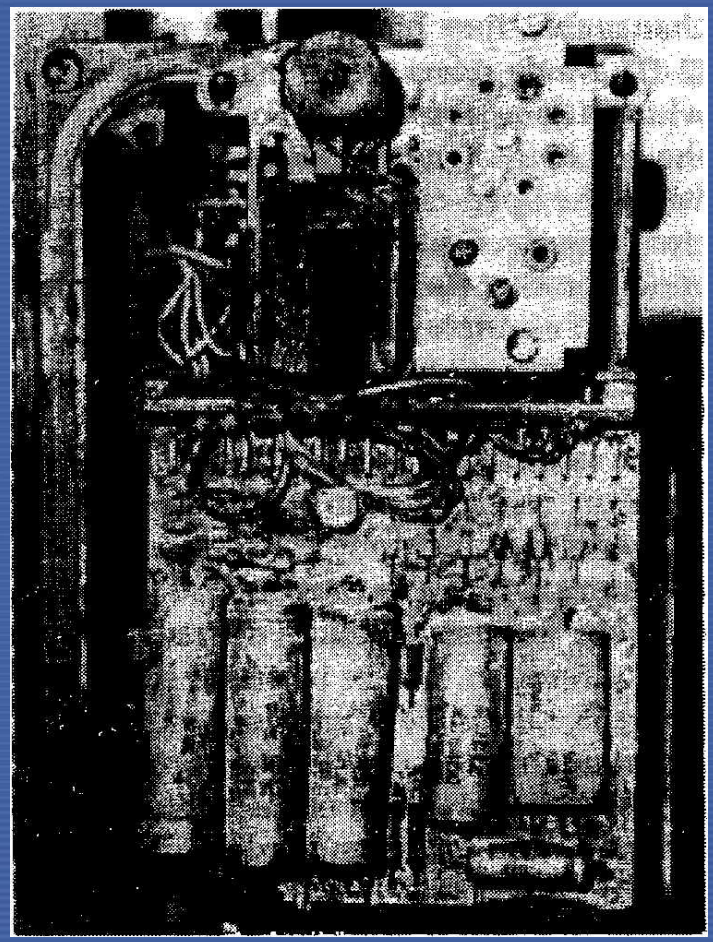
before (left) and after (right) LOCA simulation





Electronic transmitter from TMI-2

Accident stressors such as those that produced this damage to a pressure transmitter at Three Mile Island Unit 2 can cause equipment failures during LOCAs



Harsh environment EQ

- Most Member States require a demonstration of EQ for any safety equipment performing safety functions during harsh environmental conditions.
- This environmental qualification considers any ageing effects that result in degradation that could promote equipment failures during the harsh environment.
- Recognized EQ methods, most often type testing, are used to demonstrate qualification.

Mild environment EQ

Session 3.2

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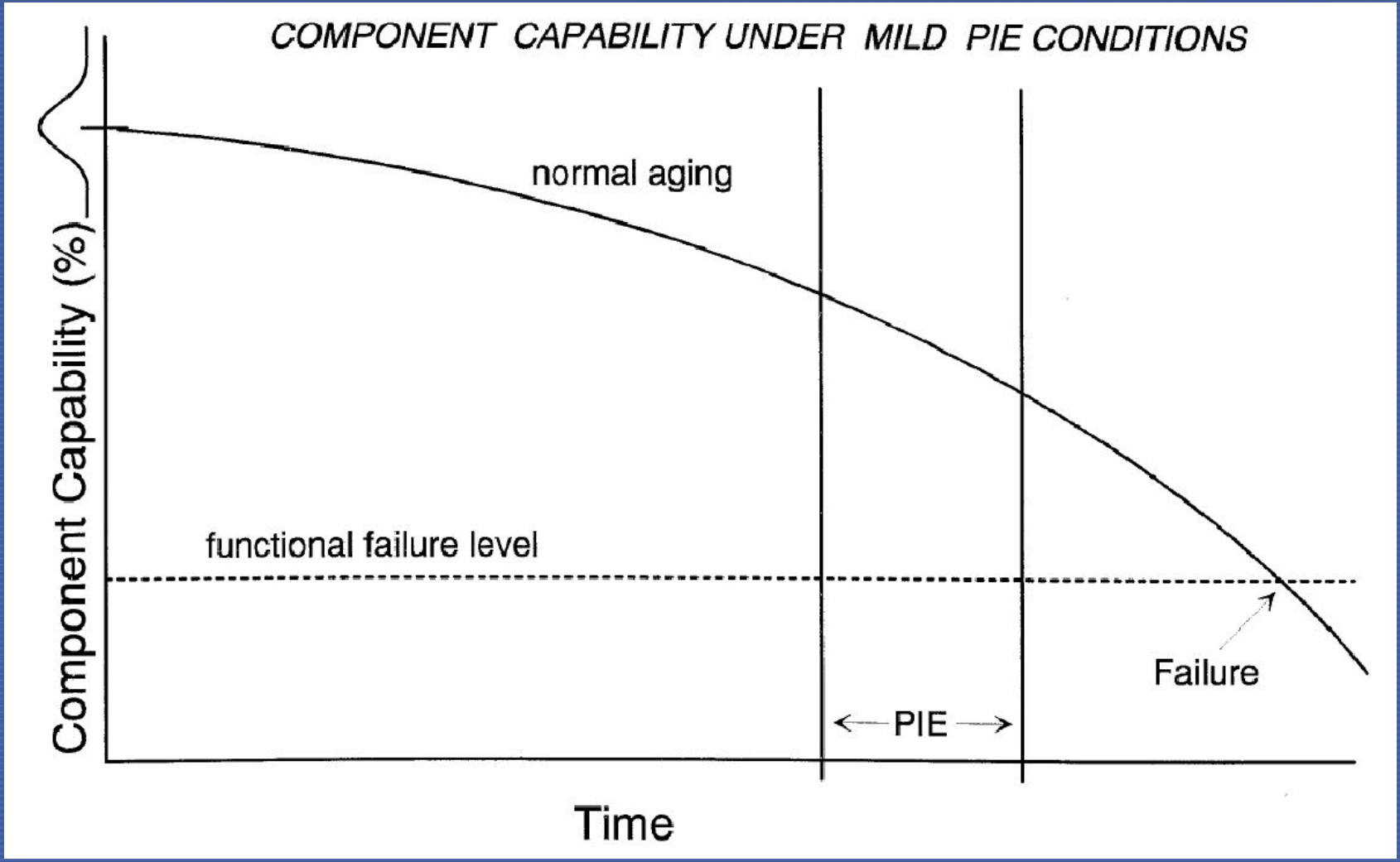
Mild environment

Environmental conditions in an NPP location which do not significantly change as a result of PIEs, except for a seismic event.

- Except for seismic conditions, equipment in a mild environment should not experience significant differences in service conditions (environmental, operational) during PIEs.

Mild Environment Conceptual Figure



General practices used to provide for required functionality of equipment in mild environment

- conservative design practices
- proven equipment designs
- manufacturing production tests
- pre-operational equipment and system tests
- appropriate QA controls during specification, manufacture, installation, testing, operation

General EQ measures for mild environment

- Seismic qualification is required for equipment in mild environment (more info in Session 3.4).
- When PIE operational conditions are significantly different from those occurring during normal operation or surveillance tests, qualification would be required for these more severe conditions.

- Some Member States, e.g. USA do not require formalized environmental qualification programs for mild environment equipment.
- According to NUREG-0588, qualification for mild environment applications is established by the design/purchase specifications containing functional requirements and service conditions under normal and abnormal events combined with well supported maintenance/surveillance programmes.

- Aging can be a common-cause failure mechanism if the population is allowed to reach the wear-out phase.
- "Bathtub" failure rate curve often describes failure rate of a component population.
- In a mild environment objective is to replace the component population when failure rate information indicates the wear-out stage is occurring.

- Some Member States, e.g. France and Germany, require formalized environmental qualification programs for mild environment equipment.
- Seismic and functional qualification is integrated into a structured equipment qualification program that is similar to the program for harsh environment electrical equipment.

Electrical vs. Mechanical EQ

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EQ requirements for electrical and mechanical equipment

- **Electrical equipment is more sensitive than mechanical equipment to accident conditions and related ageing mechanisms.**
- **Electrical equipment EQ required by virtually all Member States**
- **Mechanical equipment EQ required only by some Member States, e.g. France and Germany**

Mechanical equipment characteristics that contribute to its greater environmental tolerance

- —Some types of mechanical equipment (e.g. valves and pumps) are designed and exposed to normal process service conditions that are generally more severe than accident environmental conditions.
- —Normal operation of mechanical equipment, combined with fabrication, preoperational and periodic tests, demonstrates performance under these normal service conditions.
- —Mechanical equipment is principally fabricated of metallic components that are virtually unaffected by LOCA type environmental conditions (e.g. radiation).
- —Mechanical equipment can remain functional after degradation of certain nonmetallic components (e.g. seals, gaskets, packing).

Mechanical codes and standards

- For pressure boundary components, application of codes and standards demonstrates suitability for normal and accident service conditions.
- Codes and standards do not address functionality of active components (e.g. pumps, valves, fans) under normal and accident conditions

Selective environmental qualification programmes may be implemented when:

- operational service conditions during PIEs are significantly different than those during normal operation and functional tests
- failure of non-metallic components of mechanical equipment can prevent the accomplishment of safety functions.

Seismic EQ

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Seismic EQ requirements

- Formalized qualification is generally required to establish equipment performance during seismic events.
- Most Member States require seismic qualification for both electrical and mechanical equipment.
- Seismic qualification generally includes both structural integrity and operability/functional capability.

Qualification by analysis

restricted to:

- structural integrity (cabinets, fixture points, metallic components)
- simple systems (e.g. check valves)

Qualification by testing

- most frequently used seismic EQ method
- possibility to verify functional requirements
- complex specimens can be tested (limited by the size)
- Seismic simulation on vibration/shake tables

Summary

- Service conditions (i.e. either environmental, operational conditions or both) during PIEs may differ significantly from those occurring during normal operation.

- Severity of service conditions and the equipment type determine appropriate qualification practices and methods