

# **Overview of DG-1077**

## **Guidelines for Environmental Qualification of Microprocessor-Based Equipment Important to Safety in Nuclear Power Plants**



**Christina E. Antonescu**  
Engineering Research Applications Branch  
Division of Engineering Technology  
Office of Nuclear Regulatory Research

**Richard T. Wood and Kofi Korsah**  
Oak Ridge National Laboratory

Presented to  
**Advisory Committee on Reactor Safeguards**  
Rockville, Maryland  
February 6, 2003

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# Outline of Presentation

- Overview of DG-1077
- Technical Basis for Environmental Qualification of Microprocessor-Based Equipment
- Summary of DG-1077 Benefits and Value

# DG-1077 Endorses Current Environmental Qualification Standards for Safety-Related Microprocessor-Based Systems

- ❑ The proposed position endorses the guidance in IEEE 323-1983 (reaffirmed in 1996) for the qualification of safety-related microprocessor-based equipment for service in nuclear power plants subject to conditions and clarifications
- ❑ Endorsement of the guidance in IEC 60780 (1998) is introduced
- ❑ DG-1077 applies to new or modified safety-related systems in existing and future nuclear power plants that employ microprocessor-based equipment

## Why is DG-1077 Needed?

- ❑ Responds to NRR User Need Request 2002-017
- ❑ Unique characteristics of microprocessor-based equipment (functional and hardware) should be addressed
- ❑ No existing endorsement of current national or international consensus standards on environmental qualification
- ❑ No comprehensive regulatory guide defining approach to qualification for all environmental conditions (mild as well as harsh)
- ❑ Potential regulatory burden arises from case-by-case treatment of qualification for mild environments

# Resolution of Public Comments

- ❑ Eleven correspondents submitted comments on DG-1077
- ❑ Public comments can be grouped into general categories
  - Need for Guidance
  - Application of location categories
  - Scope of qualification
  - Backfit analysis
- ❑ DG-1077, Rev. 1, reflects resolution of comments

**Technical Basis For  
Qualification Of Safety-Related  
Microprocessor-Based Equipment**

# The Code of Federal Regulations, Title 10, Part 50 Requires Environmental Qualification of Safety-Related Systems

- Structures, systems, and components important to safety must be designed to accommodate the effects of environmental conditions and design control measures such as testing must be used to verify the adequacy of the design
  - Part 50.55a(h), Codes and Standards, Protection Systems
    - ❖ Provides embedded requirement for environmental qualification of all systems important to safety (e.g., Section 5.4 of IEEE 603)
  - Part 50.49, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants
    - ❖ Provides requirement for environmental qualification of electric equipment important to safety that are to be implemented in harsh environments
  - General Design Criteria 1, 2, 4, 13 and 23 in Appendix A
  - Criterion III, XI, and XVII in Appendix B

# Existing Regulatory Guidance on Environmental Qualification Distributed Among Several Resources

- Regulatory Guide 1.89
  - Addresses 10 CFR 50.49 for electrical equipment important to safety
  - Limits scope to harsh environments that are subject to Design Basis Accident (DBA) conditions
  - Endorses IEEE 323
- NUREG-0588
  - Provides NRC Staff position on environmental qualification of safety-related electrical equipment
  - Applies to qualification based on IEEE 323
  - Describes equipment categories that includes mild environment applications (equipment not subject to DBA)
  - States qualification for mild environment should be supported by test or test and analysis

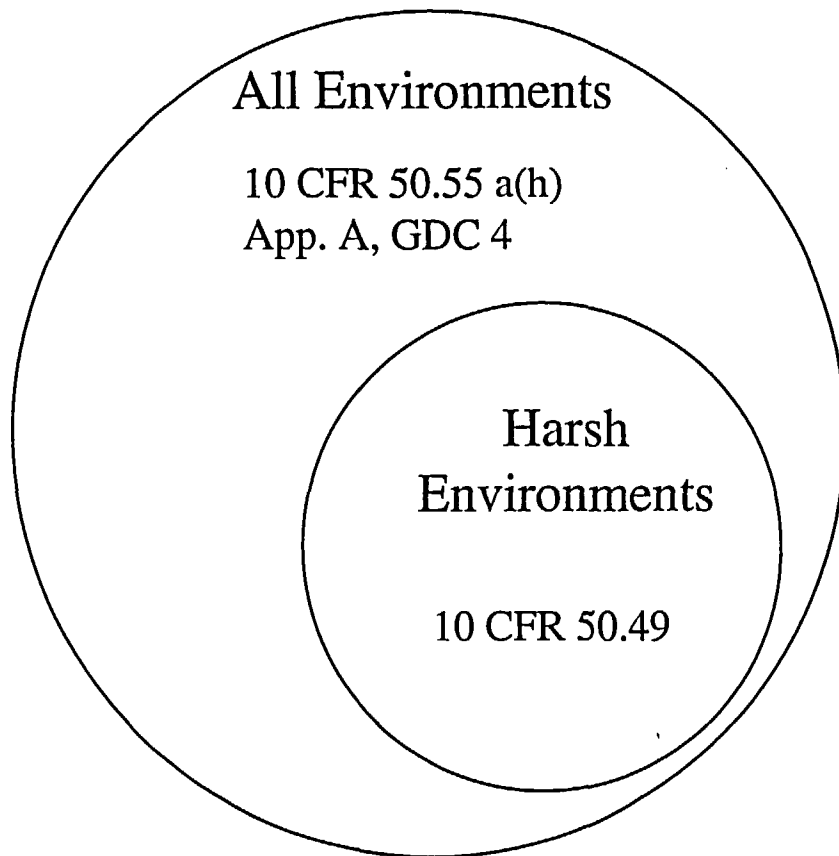


# Existing Regulatory Guidance on Environmental Qualification Distributed Among Several Resources (cont)

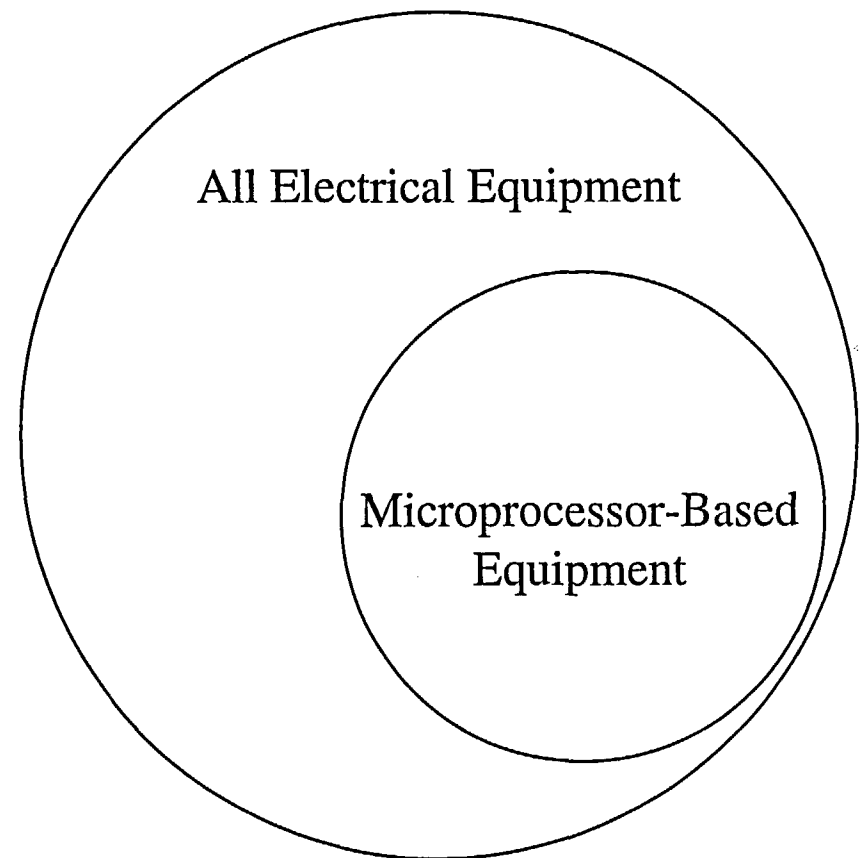
- NUREG-0800, Chapter 7
  - Provides review guidance to NRC Staff on environmental qualification of safety-related instrumentation and controls equipment
  - References design criteria from IEEE 7-4.3.2
  - Specifies qualification for mild environments according to IEEE 323
  - States testing of channel or system “as a whole” is preferred but notes that licensee should confirm conservative design if testing not practical
- DG-1077 is intended to provide a roadmap for existing guidance that is applicable to microprocessor-based equipment

# Environmental Qualification Can Be Viewed According To Two Perspectives

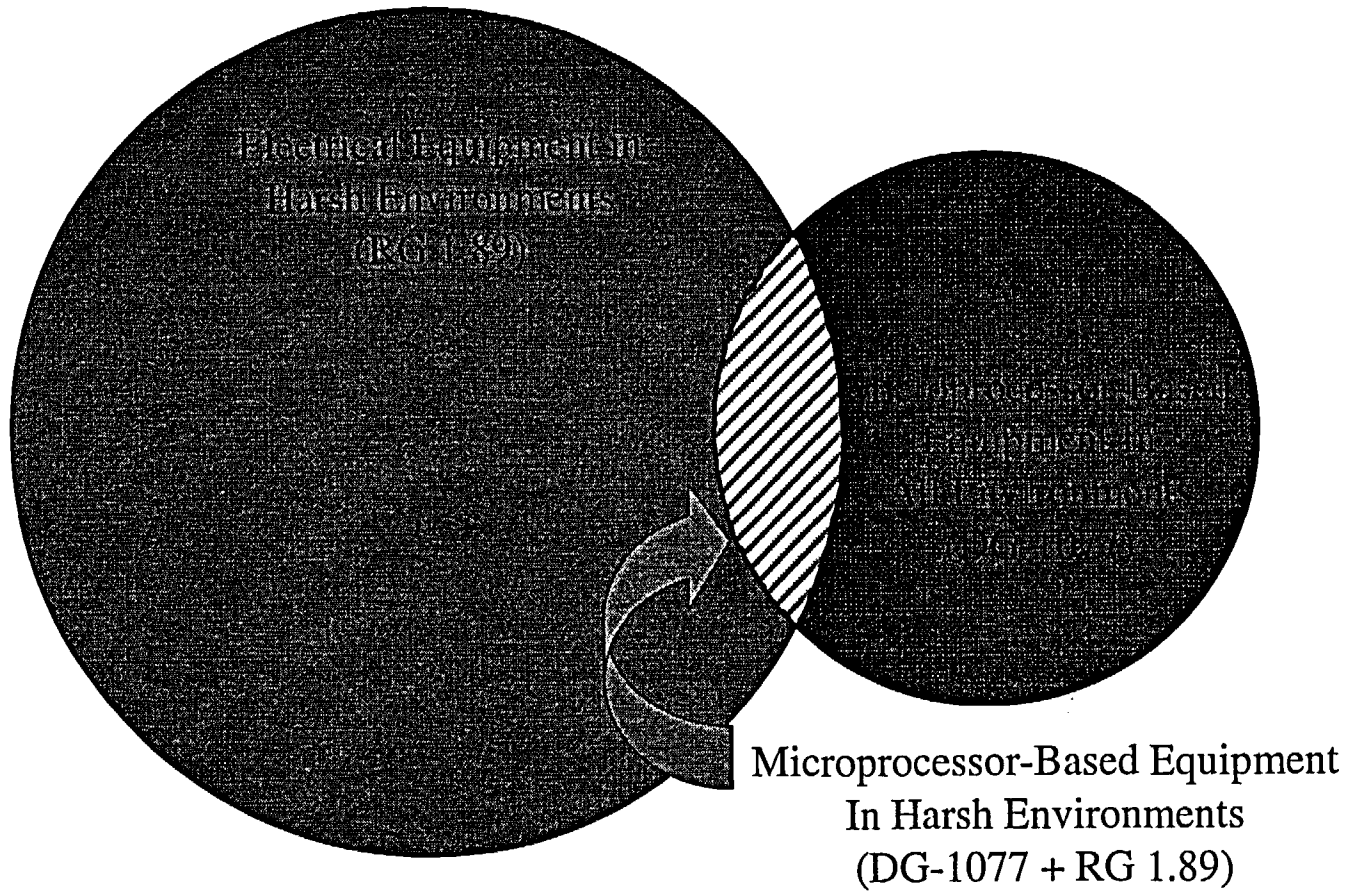
## Plant Environment Viewpoint



## Class 1E Electrical Equipment Viewpoint



# Environmental Qualification Role for DG-1077



# There Are Several Unique Functional and Hardware Characteristics of Microprocessor-Based Equipment

- ❑ High functional density
- ❑ Sequential execution of function
- ❑ Radiation tolerance
- ❑ Increased level of complexity and higher circuit density
- ❑ Higher clock speeds and lower logic voltages

# DG-1077 Endorses Current Environmental Qualification Standards for Safety-Related Microprocessor-Based Systems

- Either IEEE 323-1983 or IEC 60780 are appropriate for satisfying the qualification of safety-related microprocessor-based equipment for service in nuclear power plants subject to conditions and clarifications

## Key Positions in DG-1077

- Environmental qualification of microprocessor-based equipment should address unique characteristics
  - During type testing, equipment should be functioning with operational activities being performed
  - Dynamic response of a distributed system under environmental stress should be considered during qualification testing
- Electromagnetic compatibility testing (i.e., EMI/RFI susceptibility and surge withstand testing) should be included as part of qualification testing:
  - Should be performed as part of the test sequence per IEC 60780, or at an equivalent stage of the test sequence under IEEE 323-1983, if that standard is being applied

# Application of DG-1077 Location Categories

- ❑ Location Categories Are Employed to Streamline the Initial Determination of the Need to Address Aging in Type Testing
- ❑ Category A Locations Correspond to 10 CFR 50.49 Locations
  - Traditional aging factors must be accounted for in qualification
- ❑ Category C Locations Correspond to Areas That Employ Environmental Control
  - Traditional aging factors are not necessary as a step in qualification
- ❑ Category B Locations Correspond to All Other Areas
  - An assessment of the need for addressing traditional aging factors is a necessary step in qualification

## Key Positions in DG-1077 (cont)

- Equipment intended for Category A Locations:
  - Aging must be addressed in type testing (e.g., preconditioning is a necessary part of the test sequence)
  - RG 1.89 guidance for harsh environments is incorporated by reference into DG-1077 (i.e., the exceptions and clarifications specified in RG 1.89 apply)
  - Qualification of microprocessor-based equipment may be in accordance with either IEEE 323-1983 or IEC 60780



## Key Positions in DG-1077 (cont)

- Equipment intended for Category B Locations:
  - Need to address aging in type testing should be based on an assessment of any aging mechanisms that may have significant effects on the expected life of the equipment
  - Documentation of age conditioning or the findings of the assessment of aging mechanisms should be provided
- Equipment intended for Category C Locations:
  - Aging does not need to be addressed in type testing
  - Documentation of age conditioning may be omitted

## Key Positions in DG-1077 (cont)

- Margin should be applied in accordance with the standard being used with the following addition:
  - Temperature margin for conditions other than saturated steam conditions is identified to supplement IEC 60780 guidance on suggested margin factors

# Suggested Considerations for Environmental Compatibility Were Deleted in Response to Public Comments

- Standards and test practices used by IC manufacturers for component stress testing can be identified and listed for each supplier to ensure the use of quality components is maintained
  - Temperature/humidity bias tests (moisture resistance for plastic encapsulated devices)
  - High temperature operating life test (accelerates temperature-related failures)
  - Temperature cycle test (accelerates thermal expansion mismatch)
  - Autoclave test (moisture resistance and resultant galvanic corrosion)
  - Low temperature operating life test (accelerates failures due to MOS device parameter changes)
  - System soft error test (measures actual system soft error performance)

# Suggested Considerations for Environmental Compatibility Were Deleted in Response to Public Comments (cont)

- Multi-tiered protection approaches (based on design/configuration) can be identified to supplement evidence of environmental compatibility
  - Electronic component level
  - Module or circuit board level
  - Cabinet level
  - Room level

# Suggested Considerations for Environmental Compatibility Were Deleted in Response to Public Comments (cont)

- ❑ Any life-limited component of the microprocessor-based system being qualified should be identified and its operational-life should be documented
- ❑ Random failures and degradation in hardware performance (e.g., reduced noise margin) should be addressed using surveillance, on-line diagnostics, maintenance, and/or trending techniques at intervals based on the predicted failure rates. The use of on-line approaches should avoid diagnostic algorithms/procedures that are so complex that their failure could cause more faults than they prevent

# **Summary of DG-1077 Benefits and Value**

# Benefits of DG-1077

- ❑ Explicit guidance on an acceptable method for environmental qualification of safety-related microprocessor-based equipment
- ❑ Endorsement of current national and international qualification standards
- ❑ Specific guidance to address the unique characteristics of microprocessor technology
  - Need to operate the equipment as it is tested by performing full range of functions
  - Need to evaluate dynamic response of distributed system under environmental stress
- ❑ Streamlined approach to the initial determination of whether aging is necessary as part of qualification
  - Designation of plant locations that clearly do not require aging as part of qualification by type test

# Public Comments Contributed to Improved Clarity and Sharpened Focus For Revised Draft Regulatory Guide

- ❑ Comments expressed support for endorsement of current environmental qualification standards (IEEE 323-1983 and IEC 60780)
- ❑ Comments indicated presentation of regulatory position and discussion of technical basis needed improvement
- ❑ Comments indicated some uncertainty about scope and purpose of environmental qualification
- ❑ Some positions in the guide suggesting supplemental information supporting environmental compatibility were misinterpreted as additional requirements



# Final Effective Guide Will Support NRC Mission

- **Contributes to Achieving NRC Goals**
  - Maintaining Safety by providing an approach for verifying that environmental stress will not hinder the performance of safety-related functions by microprocessor-based equipment
  - Reducing Regulatory Burden by minimizing potential regulatory uncertainty and streamlining the determination of necessary qualification steps
  - Improving Regulatory Effectiveness by giving explicit guidance on acceptable practices for environmental qualification that utilize current standards and address the unique characteristics of microprocessor-based equipment