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Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems

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Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems

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General Comment

Docket ID NRC20180076

I am submitting two comments:

Comment 1 - In TR-102323 R1 listed electrostatic discharge (ESD) testing as optional for safety-related equipment and was based in part on the conclusion that ESD is not a credible common mode failure vulnerability. DG-1333 now endorses ESD testing is on how the RG will be applied for use of equipment qualified to an earlier version of the RG. The basis for this change is not explained in DG-1333. ORNL/LTR-2015/254, Task 4 EMI/RFI Issues Potentially Impacting EMC of I&C Systems, (ML17199A005), makes a thought argument that ESD may actually be a common cause failure vulnerability:

Additionally, it should be recognized that the regulatory guidance on EMC applies to all safety-related I&C systems and components, which are not all implemented in redundant divisions. Therefore, the additional protection provided by redundancy with safety systems should not be the prevailing consideration in assessing potential threats. It is feasible for failure of a safety-related component to lead to immediate safety relevant effects.

A cursory search of the Licensee Event Report database found a small number of events over the past three decades that are attributed to ESD. As an example, a plant trip occurred at the Donald C. Cook Nuclear Generating Station on March 11, 1997, as a result of ESD. Specifically, the controller for a feedwater regulating valve failed when a reactor operator touched it to switch it to manual for mandated surveillance. Consequently, the valve close, leading to a trip based on steam generator low level coincident with a steam flow/feed flow mismatch. Thus, it is seen that ESD can result in safety significant failures.

This argument does not make the case that digital systems are vulnerable to common cause failures from ESD, only that components may be. The ESD testing requirement should be removed from DG-1333.

Comment 2 - DG-1333 does not address now equipment to be used in the future (e.g., an approved digital I&C platform) that was qualified to Regulatory Guide (RG) 1.180, revision 1, will be treated in any NRC regulatory review. The past practice has been to require the licensees to provide an assessment of the changes to the standard between the one used and the one currently endorsed. This practice creates an expensive churn of paper that rarely results in any equipment of plant design change. In the case of DG-1333, NRC has already been given the assessment performed for them by Oak Ridge National Laboratory in ORNL-SPR-2016-108, Task 5Technical Basis for EMC Regulatory Guidance Update (ML16112A369). DG-1333 should be revised to clearly say that equipment qualified to RG 1.180, Revision 1, is considerable acceptable.

Attachments

Pages from EPRI TR-102323 R1, Guidelines for EMI Testing of Power Plant Equipment

Pages from EPRI TR-102323 R2, Guidelines for EMI Testing of Power Plant Equipment load is much less than a long power distribution line. In addition to being lower energy, the rise times of the pulses are much faster. A typical single pulse will have a rise time less than 5 nanoseconds and a pulse width of less than 50 nanoseconds. The amplitudes may be much higher than a surge, but these are quickly damped out due to the losses in the lines. Arcing during the switching will generally cause a burst of these pulses rather than just a single impulse. Unsuppressed relays or coils are the greatest cause of electrical fast transients and transients can be generated even on 5 volt logic lines where the inductive load is the self inductance of the line. These transients may have a DC reference on the line in which they are generated and the ends of the line will cause reflections that will look like ringing. These transients will readily couple to other lines where the DC bias will be eliminated and the line resonances will result in a damped ringing effect.

2.4.2 ***Coupling Mechanisms.*** Coupling of a fast transient or burst of transients will most generally be caused by electric field coupling (relative capacitance) if the fast transient is defined as a voltage spike, or by magnetic field coupling (relative loop area) if the fast transient is defined as a current spike. Shared, common ground (signal return) paths may also be a factor in that this will increase the relative loop area for coupling.

2.4.3 ***Maximum Expected Level.*** The expected level of the fast transient can be up to ± 3 kV at the source point for either power lines or for data and control lines.

2.5 *Electrostatic Discharges (ESD)*

> **NOTE: ESD is not considered a common mode failure mechanism for safety related digital systems. It is recognized as a failure mechanism for digital components, and is included in these recommendations as a prudent test to be performed in laboratory conditions on individual components.**

2.5.1 ***Sources.*** Electrostatic discharge is the sudden transfer of charge between two bodies at differing electrostatic potential. The electrostatic potential may be created by an induced charge on a conductor or by bound charge on an insulator (normally created by triboelectric effects). The bound charge may be caused by casual rubbing between clothing, with the better insulating materials retaining the bound charge and more conductive materials leaking the charge. The induced charge is caused by bringing a bound charge close to a conductor. The sudden transfer of charge may be a result of a spark between two bodies. In the case of the induced charge, the spark may be between the inducing bound charge and a third body. Some discussions also differentiate between a human discharge and a non-human discharge, called a furniture discharge, to the equipment. The actual EMI phenomenon remains the same.

2.5.2 ***Coupling Mechanisms.*** The electrostatic discharge may be directly to the equipment under test or to nearby equipment or structures; the nearby discharges are more commonly called indirect discharges. The discharge voltage may be as high as 15 kV. The sudden transfer of charge may result in peak currents of over ten amperes, but of very short time duration (less than 50 nanoseconds). An ESD event will produce electric field variations and magnetic field variations. The electric field variations will not penetrate conductive surfaces while the magnetic fields will penetrate all but ferrous materials. The magnetic field variations will readily cause EMI to be induced in conductor loops inside the equipment or cables near the discharge point.

The initiation of an ESD is most likely to be caused by the man - machine interface for non-moving equipment such as digital control systems. Most likely points of contact will be keyboards, video terminals, or connectors. This makes the ESD event very localized and does not represent a common mode failure for a safety system.

An estimate can be made to determine how far apart components must be in order to conclude that they would not likely respond to the same ESD event. This can be accomplished by examining the test distances for the indirect ESD discharge. IEC 801-2 (see Figures 5 and 6) places the distance for test at 0.1 meter. A 1-meter separation without any intervening shields can be considered a safe separation distance since the far field[11] radiated electric field emissions will have fallen off by a factor of ten and any near field levels will have fallen off by a factor of 100 or 1000. An intervening conductive shield will reduce this critical distance even further.

2.5.3 ***Maximum Expected Level.*** The maximum expected level of an ESD is highly dependent on factors that affect the breakdown of air by the electrostatic potential and by the dissipation of charge through air ionization processes. The breakdown in air will be directly proportional to atmospheric pressure and inversely proportional to absolute temperature, and is also affected by humidity. The breakdown of air at sea level will be about 40% higher than the breakdown at 3000 meters elevation. Electrostatic charge will dissipate much more rapidly in a humid environment than a dry environment and a decrease in relative humidity from 50% to 10% can be expected to double the ESD level. A conservative level for expected ESD can be taken from the maximum levels given in IEC 801-2, Tables 1a and 1b: 8 kV for direct contact discharge ESD and 15 kV for air discharge ESD. The polarity of the ESD may be either positive or negative.

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[11] For a 1 nanosecond rise time ESD, the high frequency content can be defined as $1/(T_r \pi)$, or 318 MHz and the far field will be defined as wavelength divided by 2π, or approximately 5 cm. in air.

3.4 *Fast transient and impulse tests*

3.4.1 *Specification For EMI Simulation (Reference: IEC-801-4)*

Wave shape:	5 ns rise time, with minimum 50 ns width at 50% peak, double exponential shape
Amplitude:	Bulk current: ±60 amperes peak into 50 ohm load Voltage: ± 3 Kilovolts into 50 ohm load
Repetition:	Burst will consist of individual transients generated at a rate of 2.5 to 5 kHz. Bursts will be repeated at a rate of 3 to 4 Hz.

3.4.2 ***Special Test Considerations.*** Simulation signal will be injected according to the selected standard.

3.4.3 ***Verification of Test Environment.*** EMI simulation will be verified according to the requirements of the selected standard.

3.4.4 *Applicable Standards*

MIL-Std-462C Test CS06, RS02, Part I using above defined limits and special test considerations.

MIL-Std-462D Test CS-115, using above defined limits and special test considerations.

IEC 801-4, using above defined limits and special test considerations.

3.5 *Electrostatic Discharge (ESD)*

NOTE: **ESD is not considered a common mode failure mechanism for safety related systems (see also Section 2.5 above.) The utility should provide justification if test(s) other than (e.g. existing vendor tests) the test specified below are performed.**

3.5.1 *Specification for EMI Simulation*

Pulse Wave Shape:	Specified as current output from a 150 pF storage capacitor through a 330 ohm discharge resistance into a specific load defined in each referenced standard
Pulse Rise Time:	Equal to or less than 1 nanosecond

Electrostatic Discharge

Optional
Optional
Optional

Applicability

- Optional for safety-related equipment
- Optional for equipment important to power production
- Optional for non-safety-related equipment

Testing Standards and Qualifications Alternatives

- IEC 61000-4-2 Level 4 (see Notes)
- Perform testing according to 61000-4-2 to the parameters defined below

Purpose

This test verifies the ability of equipment to withstand electrostatic discharge, which may occur from personnel coming into contact at human-machine interface points of equipment during normal operation.

Pulse Amplitude

± 15 kV air discharge
± 8 kV contact discharge

Pulse Wave Shape

Specified as current output from a 150 pF storage capacitor through a 330-ohm discharge resistance into a specific load defined in each referenced standard

Pulse Rise Time

≤ 1 ns

Pulse Decay Time

Approximately 30 ns at 50% amplitude

Repetition

Apply a minimum of 10 simulations for each polarity at each test point while the system is operating

Notes

Because electrostatic discharge (ESD) is not considered a common-mode failure mechanism for safety-related systems, this is specified as an optional test. Test points should be selected on the basis of accessibility during normal operation. Components such as panel displays, keyboards, and controls may be touched during operation and should therefore be tested extensively. All human-machine interface points electrically isolated from ground should be tested. Side or rear panels not exposed during normal operation need not be tested directly. Cables entering the rear or sides should be tested at the entry point. The highest probability of interference will be at points where wire bundles or loops are close to the point of discharge. ESD tests should be performed when the relative humidity is 30–60%.