Some Problems Regarding PCI Testing Per MIL-STD-188-125

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Abstract—This paper discusses two problems related to the measurement of residuals when doing Pulsed Current Testing (PCI) according to MIL-STD-188-125. The first discusses the superfluous requirement for residual measurements during E1 verification testing. The second discusses the requirement of 10 Amps or less of residual current during acceptance testing, regardless of the intended system's voltage or current rating. A typical measurement of residuals is done on power filters, as these are common Points Of Entry (POE) for a HEMP shielded facility. The standard, however, not only requires that the connected and protected equipment suffer no damage or outage, but that residuals should also be measured. These must be the same as in acceptance. This paper argues that measuring residuals during verification as a pass/fail criteria is unnecessary and misleading. Furthermore, the standard does not identify the voltage or current ratings under which the residual limits are valid and thus it is assumed are valid for all system ratings. This is clearly misleading, misapplied, and costly. Rather than looking at a specific residual current, the standard should set a related criteria for assuring the survival of a system to a HEMP event without incurring unnecessary costs.

I. VERIFICATION TESTING

A. The first PCI test done is acceptance, which consists of pulsing the protection filters to a prescribed waveform, risetime, FWHM, and amplitude. Presumably the idea in the standard is to identify the residuals with the filters installed (along with the SE testing) to ensure the protected area or building is reasonably secured against EMP. After the installation has been declared as passing acceptance, testing for verification can proceed. This is done with power and equipment on and with loads connected and energized. The test is supposed to simulate an actual EMP into the facility. Acceptance testing is done with prescribed resistive loads and no power. Acceptance testing does not account for any type of reactive or non-linear load in the system. It is a simple baseline to see what the filter will do and make note of the residuals. But consider the difference in a verification test. The filters are now fully powered and connected to completely unknown loads. Filter manufacturers, have no idea what source or load impedances the filters are going to see once installed in a system. These loads could be inductive, capacitive, or non-linear. While the people doing the verification testing may know what the loads are, commercially available filters are not typically designed for any specific application. It is simply not practical to design filters around changing loads. It can be shown, both by empirical evidence and analysis that residuals will change depending on the source or load impedance in which a filter is installed. This should not be surprising as any change in the characteristic load or source impedance will affect the filter performance and thus also the PCI performance. If a system has been tested for verification and survived, it should not be failed for exceeding residuals. If the intent of the test is to show that the system would survive, then having a residual's pass/fail criteria for verification is irrelevant and it only adds cost and confusion to an installation by trying to perform at a level that is not necessary.

II. SYSTEM RATINGS

A. In Table B-III of MIL-STD-188-125 the peak current residual for the commercial power line test is < 10 Amps. There is no consideration as to whether one is testing a 100 Amp or a 1200 Amp filter. Nor is there any consideration to the system voltage as some systems may operate at 120/208 VAC, others at 277/480 VAC or even at much higher voltages of 2400/4160 VAC. For the smaller 100 Amp filter, a 10 Amp residual is 10% of the normal operating current, while for a 1200 Amp filter the residual is ~0.8%. The purpose of the residual current value is to ensure that any signals penetrating inside the shielded building do not perturb the electronics operating inside. However, current cannot be forced into a load without a voltage present. Hence, the resulting voltage transient developed across the load should be considered, since it is this voltage transient that can cause damage to equipment. In order to do this, consideration of the system voltage is necessary. Defining current residuals without regard to the voltage system level or filter current rating does not seem to provide a consistent method for determining adequate system protection. A more consistent and practical method would be to measure the voltage residuals at the load and set a percentage tolerance according to the voltage system in use. Current residuals could still be used, but this would require a conversion back to the corresponding voltage developed across the test load and then apply the limits. At the very least, those involved should understand that adhering to residuals without regard to system rating could be misleading and costly.

III. REFERENCES

1. MIL-STD-188-125-1, "High-Altitude Electromagnetic Pulse (HEMP) Protection For Ground-Based C4I Facilities Performing Critical, Time-Urgent Missions, Part 1: Fixed Facilities, 7 April 2005.