Responses to Public Comments Submitted on the Draft Regulatory Guide for Evaluation of Electromagnetic and Radio-Frequency Interference in Safety-Related I&C Systems (DG-1029)

September, 1998

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH
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Comment Guide

A guide is provided to map comments provided on DG-1029 to corresponding topics. First, the general issues discussed in Section B are indexed and linked to the individual comments that relate to each particular issue. Next, the remaining comments are grouped in additional general categories for mapping. Finally, the comment categories for the submissions are identified from each commentor and indexed. Again, please note that the comments are identified by the roman numeral designation corresponding to commentor (see Table below) and by the associated response number given inside pointed brackets (i.e., <#>). The page numbers correspond to the page containing the response associated with a particular comment.

Table Commentors responding to DG-1029

Commentor ID	Company Name	Correspondent
I	Framatome Technologies	P. V. Liddle
II	CHAR Services	R. D. Meininger
III	NA	C. E. Kunkel
IV	Carolina Power & Light	D. B. Alexander
V	PECO Nuclear	G. D. Edwards
VI	TU Electric	C. L. Terry
VII	Nuclear Energy Institute	D. J. Modeen
VIII	Virginia Power	J. P. O'Hanlon
IX	Arizona Public Service	J. M. Levine

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- Commentor IX: <100>

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- Commentor I: <2>, <3>
- Commentor II: <25>

Susceptibility limiting practices
- Commentor II: <18>
- Commentor IX: <101>

Susceptibility test conditions
- Commentor II: <14>, <19>, <21>

Comment Categories for Each Submission

Commentor I (P.V. Liddle, Framatome Technologies)

Commentor II (R.D. Meininger, CHAR Services)

Commentor III (C.E. Kunkel)

Commentor IV (D.B. Alexander, Carolina Power & Light)

Commentor V (G.D. Edwards, PECO Nuclear)

Commentor VI (C.L. Terry, TU Electric)

Commentor VII (D.J. Modeen, Nuclear Energy Institute)

Commentor IX (J.M. Levine, Arizona Public Service)

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A. Introduction

Draft Regulatory Guide DG-1029, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," was issued for public comment as announced in the Federal Register on February 17, 1998. The public comment period was closed on April 10, 1998. DG-1029 describes design, installation, and testing practices acceptable to the U.S. Nuclear Regulatory Commission for addressing the effects of electromagnetic interference, radio-frequency interference, and power surges on safety-related instrumentation and control systems in a nuclear power plant environment. This document presents the responses by U.S. Nuclear Regulatory Commission staff to public comments received on DG-1029. Table 1 identifies the nine sources of public comments and their respective organizations.

Table 1. Commentors responding to DG-1029

Commentor ID	Company Name	Correspondent
I	Framatome Technologies	P. V. Liddle
II	CHAR Services	R. D. Meininger
III	NA	C. E. Kunkel
IV	Carolina Power & Light	D. B. Alexander
V	PECO Nuclear	G. D. Edwards
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In this report, Section **B. General Issues** (p. 3) summarizes the staff response in terms of general issues that are common to many comments. Section **C. Specific Comments** (p. 35) presents the public comments received, arranged by commentor (designated according to the roman numeral ID shown in Table 1), and the detailed staff response to each comment. Finally, Section **D. DG-1029 Change Proposals** provides a listing of proposed revisions to the draft regulatory guide that were developed in response to the public comments..

The reader should be aware that there is a **Comment Guide** (p. vii) that provides a mapping of the comments and associated staff responses to the general issues discussed in Section **B** and to specific issue categories. This guide should help the reader in viewing the staff responses in proper context.

The presentation of the public comments in Section **C** provides the text of each submission with staff responses following specific comments. Each comment is reproduced verbatim from the letters submitted and any comment identifier provided by the commentor is maintained. The only modification to any individual submission arises from rearrangement of the comments, in some cases, to better group comments by type (i.e., general or specific). A number of inserts were placed in the comments by the staff reviewers and are enclosed in <pointed brackets>. These inserts reflect a unique number, assigned across the entire set of responses, to better identify the staff responses to different issues within individual paragraphs of a submission and to support mapping of the responses into common issue categories.

A note to the reader is warranted. This report is not a stand-alone document. A copy of the draft regulatory guide is needed to fully understand both the comments and the staff responses. For example, a comment may cite a page number or figure and provide a comment on the material without specifically repeating the material to which the comment is directed. Such comments are not always intelligible. In such cases, reference to the draft regulatory guide, and possibly the subject standard, usually provides the appropriate context.

B. General Issues

Comparison of DG-1029 and the SER on EPRI TR-102323

The regulatory guidance in DG-1029 is intended to be consistent with the position by U.S. Nuclear Regulatory Commission (NRC) staff set forth in the Safety Evaluation Report (SER), dated April 17, 1996, on the Electric Power Research Institute (EPRI) topical report, EPRI TR-102323. DG-1029 complements the position expressed in the SER by improving the technical basis for evaluating electromagnetic interference (EMI), radio-frequency interference (RFI), and power surges. The positions described in each document endorse EMI/RFI-limiting practices based on IEEE 1050, endorse test criteria and test methods for susceptibility, emissions, and surge withstand capability (SWC) to evaluate safety-related I&C systems, and identify appropriate operating envelopes for susceptibility, emissions, and surge withstand testing. The differences that exist between the regulatory position described in DG-1029 and the staff position expressed in the SER result because of additional insight gained as part of the NRC-sponsored confirmatory research to develop the supporting technical basis for this position. It is intended for the regulatory position described in DG-1029 to provide additional clarity in guidance on the use of test criteria from consensus standards and on the operating envelopes for the nuclear power plant environment. The regulatory position described in DG-1029 will reflect one approved methodology for addressing issues of electromagnetic compatibility (EMC) for safety-related instrumentation and control (I&C) systems when it is finalized. Further clarification is given below on the comparison between DG-1029 and the SER and on the rationale for differences between the two positions.

Applicability — DG-1029 applies to safety-related I&C equipment (digital, analog, and hybrid) for all new installations or modifications to existing equipment while the SER on EPRI TR-102323 addresses only digital safety-related equipment. Thus, DG-1029 addresses the absence of guidance on the means for evaluating the EMC of analog and mixed analog/digital safety-related equipment.

EMI/RFI Limiting Practices — The position in DG-1029 focuses on a consensus standard that is widely available to the general public. DG-1029 endorses IEEE Std 1050-1996 with one exception, while the SER accepts similar guidance in Ch. 6 of EPRI TR-102323. EPRI TR-102323 references IEEE Std 1050-1989 for grounding practices and then references EPRI TR-102400 for more detailed guidance on EMI/RFI limiting practices. NUREG/CR-5941 documents the evaluation of IEEE Std 1050-1989 and recommends four exceptions (three of which were addressed in the 1996 revision of the standard).

Test Criteria — The SER on EPRI TR-102323 addresses test criteria and methods from IEC 801, while DG-1029 does not. The intent of the regulatory position described in DG-1029 is to endorse finalized (i.e., balloted and approved) standards for use in ensuring EMC. IEC 801 still contains draft parts that have not been approved by ballot. With the recent issuance of IEC 61000-4, it is not likely that IEC 801 will ever be finalized. Therefore, IEC 801 was not included for endorsement in DG-1029. IEC

61000-4 has not yet been reviewed so endorsement of that standard series is not within the scope of DG-1029.

Test Methods — DG-1029 offers the option of using complete test suites for EMI/RFI evaluations from either MIL-STD 462D or MIL-STD 462, which are comparable versions from the same family of tests. The SER accepts the EPRI TR-102323 approach that can be interpreted as allowing the user to mix and match tests from the MIL-STDs and IEC 801. The suite of test methods in each MIL-STD were developed to be internally consistent and to provide complementary coverage of EMI/RFI phenomena. For example, applying low and high frequency conducted emissions tests from MIL-STD 462D (CE101 and CE103) as well as low and high frequency conducted susceptibility tests from the same standard (CS101 and CS114) gives acceptable coverage of the conducted continuous wave EMI phenomenon. Such coverage may need to be demonstrated when selecting test methods from different standards.

Test Levels — DG-1029 endorses operating envelopes that are tailored for the specific test methods. In effect, a set of operating envelopes are established for the MIL-STD 461D criteria, while another comparable set are established for the MIL-STD 461C criteria. EPRI TR-102323 gives generic test levels over extended frequency ranges, rather than method-specific test levels framed in suitable units and frequency ranges. As a result, the frequency ranges sometime extend beyond the ranges covered by some of the recommended test methods. Therefore, testing may be required over frequencies for which a particular test method has not been validated or for which the specified test equipment may not be designed to accommodate. The SER accepts this approach provided the user supplies justification that the results are valid over the entire frequency range. An additional distinction arises from the fact that the operating envelopes presented in DG-1029 are supported by a clearly defined technical basis that accounts for military experience, nuclear power plant emissions data, and industrial emissions limits. These operating envelopes also provide some benefits through frequency range exemptions and relaxation factors for test levels.

Documentation — DG-1029 clarifies the level of evidence that is acceptable for EMI/RFI and power surge withstand qualification. Documentation guidance is intended to relieve some uncertainty in the process of establishing an acceptable level of EMC. In any event, quality assurance records are required for safety-related equipment as a criterion in Appendix B of the Code of Federal Regulations (CFR), Title 10, Part 50.

Mechanism for Update — NRC has existing mechanisms to allow the revision of the guidance provided in DG-1029. Although revision 1 of EPRI TR-102323 was published to incorporate technical agreements expressed in the SER, EPRI typically does not revise its reports following publication. In any event, there is no clearly defined mechanism for triggering a revision to EPRI TR-102323. Regulatory guides typically endorse widely available, consensus standards that are governed by a committee of stakeholders from the user domain and are subject to periodic review. While it is proposed that EPRI TR-102323 be adopted as an ISA standard, that action is uncertain given the issuance of IEC 61000-4.

To conclude, the continued use of the SER on EPRI TR-102323 by the nuclear power industry is not precluded by the regulatory position described in DG-1029. However, DG-1029 presents clarification of the staff position on EMC based on an improved technical basis that accounts for updated industrial guidance (e.g., the latest revision of IEEE 1050) and recent technical findings (e.g., more data characterizing the electromagnetic environment at nuclear power plants). It is felt that the guidance in the draft regulatory guide is clear in its approach and will yield results that can be easily defended. In addition, the draft regulatory guidance endorses standards available to the general public that are comprehensive in nature and represent consensus of views from various organizations. While EPRI TR-102323 remains as an approved method for the industry, DG-1029 provides needed guidance for safety-related analog and hybrid equipment while also supplying additional clarity on the means for evaluating digital equipment. Therefore, DG-1029 represents a comprehensive, straightforward approach to establishing evidence that demonstrates the EMC of new or modified safety-related equipment.

Prescriptiveness of DG-1029

It is not the intent of DG-1029 to be prescriptive, but to provide a well-established, systematic approach based on consensus standards for ensuring EMC and the capability to withstand power surges in safety-related I&C equipment within the environment in which it operates. DG-1029 contains only as much technical detail as is needed to describe the design, installation, and testing practices acceptable to the NRC staff for addressing the effects of EMI/RFI and power surges on safety-related I&C equipment. The technical detail in DG-1029 is comparable to the detail in EPRI TR-102323.

Scope of Application for DG-1029 Guidance

Existing Plants vs. New Plants
The regulatory position described in DG-1029 is consistent with the previous staff position expressed in the SER on EPRI TR-102323 in that each applies to both future nuclear power plants and to presently operating nuclear power plants that plan modifications of safety-related equipment. Neither position applies to existing equipment that is not scheduled for modification. Thus, existing installations of safety-related equipment are unaffected by EMC guidance.

Definition of Upgrade
To more clearly define the scope of applicability for DG-1029, the terminology will be changed from "upgrade" to "modification to safety-related equipment." A modification is the introduction of equipment to a safety-related I&C system that differs from the original equipment in terms of technology, fabrication, functional configuration, or performance. For example, a modification might be the replacement of an original analog safety-related I&C system with a new digital safety-related I&C system or a new analog safety-related system of a different design. A modification is not intended to

constitute the interchange of identical electrical parts during the repair or maintenance of a safety-related I&C system.

Testing at Plant Site

There is apparently a misunderstanding of the application of DG-1029. The guidance in DG-1029 does depend heavily on testing, but not testing following equipment installation at a plant. The testing practices are not installation tests but rather are intended to be performed in a test facility or laboratory. The recommended design and installation practices are intended to minimize problems associated with installing safety-related I&C systems in future nuclear power plants and presently operating plants that are planning modifications. To make this usage clear, a statement will be added to DG-1029 identifying these as laboratory, not site, tests.

Additional Site Measurements

The regulatory position in DG-1029 does not require additional site measurements to determine the electrical noise present in the plant environment. The operating envelopes presented in DG-1029 are based on MIL-STD operating envelopes for comparable military facilities and are generally applicable subject to the conditions of the regulatory position. The suitability of the operating envelopes to address the nuclear power plant environment has been confirmed with high confidence by long-term site measurements at several nuclear power units, as well as by the data reported in EPRI TR-102323. However, the volume of data available cannot provide complete assurance that the envelopes bound all possible EMI/RFI events at every nuclear power plant. It is possible that there are significant EMI/RFI emitters at some power plants that were not adequately characterized by site surveys conducted to date. Thus, the intent of the position in Section C.1 of DG-1029 (stating the 8 dB plant emissions margin and identifying the need for an assessment of electromagnetic conditions) is to ensure that the operating envelopes are not indiscriminately applied and that their integrity is maintained. Some effort is necessary on the part of the user of this guidance to demonstrate an understanding of the electromagnetic environment at the point of installation. Through such an assessment, the possibility that safety-related equipment will be installed adjacent to strong EMI/RFI emitters can be reduced and the applicability of the operating envelopes in DG-1029 can be confirmed. Thus, the practical consequence of the position is not necessarily to encourage testing of the EMI/RFI sources in the area where safety-related I&C systems will be installed, but to promote an assessment (or evaluation) of the types of EMI/RFI sources in the area. Of course, testing might be one of the assessment tools. Other ways to assess the EMI/RFI sources can include review of existing EMI/RFI test reports on equipment comparable to that located at the site, vendor materials and manuals, or previous measurements at similar sites; identification of known characteristics (e.g., radios are narrowband sources and arc welders are broadband sources); and application of analytical models. It should be noted that the staff position expressed in the SER on EPRI TR-102323 accepts the use of the envelopes contained in that document without the need for a plant-specific EMI survey if the plant-specific electromagnetic environment is confirmed to be similar to the seven plants that participated in the EPRI survey.

Coverage of Analog and Hybrid
All new or modified safety-related equipment (including analog or hybrid equipment) must adhere to the environmental compatibility criterion (see General Design Criterion 4 in 10 CFR 50, App. A). The guidance presented in DG-1029 provides added clarity regarding means to establish evidence that equipment are compatible with particular environmental service conditions (i.e., electromagnetic and power surge conditions).

The explanation of "hybrid" for I&C equipment is a combination of analog and digital electronics in the equipment, with the mixed-mode equipment providing the same function(s) as totally analog or totally digital equipment.

The application of the same set of testing criteria is appropriate for both analog and digital equipment. While the specifics of the testing procedures (e.g., bandwidths, dwell times, etc.) for analog and digital equipment are likely to be different, they could also be significantly different for two analog systems that are dissimilar in design. The characteristics of a specific equipment design are identified in the equipment specification, which is the basis for defining acceptable performance in the test plan. Therefore, the variability of performance metrics is taken into account in the guidance provided by DG-1029.

Finally, the cost of implementing the regulatory guidance for new analog and hybrid systems, along with digital systems, is expected to be minimal because the guidance is consistent with current established practices presently being applied throughout the commercial power industry. The value of the regulatory guidance is that it offers clear guidance on necessary practices and a systematic approach to meet long-standing requirements from 10 CFR 50.

DG-1029 Position on Other Testing Options

A number of technical standards were reviewed during the course of the development of a technical basis for addressing EMC and the standards endorsed in DG-1029 were found to be applicable for establishing regulatory guidance that would provide a systematic approach to EMC. NUREG/CR-5941 and NUREG/CR-6431 document the technical basis behind the selection of these standards. There are additional standards of interest that are either under development or have been developed since the investigation was completed. The regulatory position described in DG-1029 does not prohibit the use of any other standards, but gives guidance on one method of EMC evaluation that is acceptable to the NRC staff.

The regulatory position in DG-1029 provides a workable guide to achieve a level of EMC through the use of available testing resources. MIL-STD 461 test criteria and IEEE Std C62.41 test criteria are endorsed to form a solid basis for emissions, susceptibility, and power surge withstand testing to evaluate safety-related I&C systems. The recommended test criteria are comprehensive and guidance is provided on their applicability.

The regulatory position in DG-1029 does permit the use of alternate test methods. Tables 1 and 2 in DG-1029 identify optional suites of EMI/RFI test criteria from MIL-STD 461D and MIL-STD 461C, respectively, that are acceptable. While the MIL-STD 461D test criteria represent current practice, the counterpart test criteria in MIL-STD 461C are also acceptable. This flexibility is intended to minimize the burden on the nuclear power industry and avoid overly prescriptive guidance. However, the regulatory position described in DG-1029 does not encourage the mixing and matching of test criteria and methods. It is intended that *either* the MIL-STD 461D *or* MIL-STD 461C test criteria be applied in its entirety, without selective application of individual criteria (i.e., no mixing and matching of the "D" and "C" test criteria). In addition, operating envelopes that are framed in the proper units and frequency ranges are presented for each suite of test criteria. The MIL-STD test suites were developed to be internally consistent and to provide complementary coverage of EMI/RFI phenomena. Such coverage may need to be demonstrated when selecting test criteria or operating envelopes from different standards. Thus, the option of using complete test suites is appropriate while the mix-and-match option could result in confusing and unverifiable test results.

DG-1029 does not contain any guidance on the use of IEC 801 since the intent of the regulatory position is to endorse finalized standards for use in ensuring EMC. IEC 801 still contains draft parts that have not been approved by ballot. With the recent issuance of IEC 61000-4, it is not likely that IEC 801 will ever be finalized. While IEC 61000-4 is presently available and another commercial standard is under development by ANSI, the regulatory guidance in DG-1029 is based on the review of technical standards available during the period in which the technical basis was developed. Even though the IEC standard has been formally issued, copies of it have only been available for review in recent months. IEC 61000-4 has not yet been reviewed so endorsement of that standard series is not within the scope of DG-1029. It has been recommended in NUREG/CR-6431 that NRC follow the development of the commercial standards and review them for their applicability. If appropriate, these standards could be endorsed and included in future regulatory guidance. Finally, it should be noted that the use of IEC 801 by the nuclear power industry is not precluded by the regulatory position described in DG-1029. In fact, the SER on EPRI TR-102323 provides an acceptable method for the evaluation of EMC that includes IEC 801.

Endorsement of MIL-STD 461C

MIL-STD 461D provides the latest revision of the test criteria (which includes improvements based on experience and the latest technical information), thus it is the primary focus of this guidance. However, guidance on the MIL-STD 461C counterparts to the MIL-STD 461D test criteria is also given. The rationale behind the optional specification of the "D" and "C" test criteria is to avoid placing an undue burden on the nuclear industry by limiting the available test resources to those test laboratories with the MIL-STD 462D test capability. Thus, there is no prohibition against using the MIL-STD 461C test criteria to evaluate new equipment.

It is intended that *either* the MIL-STD 461D *or* MIL-STD 461C test criteria be applied in its entirety, without selective application of individual criteria (i.e., no mixing and matching of the "D" and "C" test criteria). The MIL-STD test suites were developed to be internally consistent and to provide complementary coverage of EMI/RFI phenomena.

The operating envelopes for MIL-STD 461D and MIL-STD 461C are comparable, and due consideration is provided for differences between the tests. When evaluated in the context of the test methods being performed, there should be no difference in the applications of the operating envelopes.

Rationale for DG-1029 Operating Envelopes

The technical basis for all of the EMI/RFI operating envelopes in DG-1029 begins with MIL-STD envelopes corresponding to the electromagnetic environment military ground facilities. The electromagnetic conditions in military ground facilities were judged to be comparable to that of nuclear power plants based on general layout and equipment type considerations. Plant emissions data were used to confirm the adequacy of the EMI/RFI operating envelopes. From the MIL-STD starting point, susceptibility envelopes were adjusted to account for the plant emissions data available from the site surveys reported in NUREG/CR-6436 and in EPRI TR-102323. Adjustments to the emissions envelopes considered margin with the susceptibility envelopes and the primary intent of the MIL-STD envelopes (e.g., whether they were specified based on protecting sensitive receivers on military platforms). Finally, when changes to the operating envelopes were motivated by technical considerations, consistency among the envelopes for comparable test criteria from similar suites of test methods (e.g., between MIL-STD 461D and MIL-STD 461C or between the DG-1029 and the SER on EPRI TR-102323) was promoted and commercial emissions limits for industrial environments were factored into the adjustments. These considerations contributed to meeting the goal of establishing comparable assurance that equipment will indeed be compatible with the projected electromagnetic environment.

There are some cases where the operating envelopes in the draft regulatory guide differ with the envelopes addressed by the SER. However, there is a clearly defined technical basis for the envelopes presented in DG-1029 that accounts for military experience, nuclear power plant emissions data, and industrial emissions limits. A recent review of the technical basis for each operating envelope presented in DG-1029 was conducted to account for technical issues posed as part of the public comments on the guide. As a result, the operating envelopes were modified in some cases to reflect an updated rationale. The rationale for each operating envelope presented in DG-1029 is discussed below.

Susceptibility Operating Envelopes

CS101/CS01—Conducted Susceptibility, Low Frequency

Original rationale

Originally, DG-1029 presented one CS101 (conducted susceptibility, power leads, low frequency) envelope for all equipment, with a modified level at 50 kHz. MIL-STD 461D provides two envelopes corresponding to equipment with source voltages at or below 28 V and equipment with source voltages above 28 V. Collapsing the two envelopes into one and adjusting the level at 50 kHz was based on the following considerations. The envelope for equipment with source voltages at or below 28 V (converted to dBμA for comparison based on an assumption of 0.5 Ω impedance) only provided a 4 dBμA margin above the highest measured data reported in EPRI TR-102323. Therefore, this envelope was adjusted. In the absence of any other technical considerations, the envelope was raised to an equivalent level with the envelope for equipment with source voltages above 28 V, creating only one envelope for the phenomenon. This adjustment also made the CS101 envelope consistent in level with the comparable envelope addressed by the SER on EPRI TR-102323. A similar adjustment in level was effected for the CS01 (conducted susceptibility, power leads, low frequency) envelope. Finally, the endpoint for the CS101 envelope at 50 kHz was adjusted to match the comparable level for CS01. These adjustments to the CS101 and CS01 operating envelopes were motivated by the need to provide adequate margin above plant emissions data and supported the goal of establishing comparable levels of assurance among the test criteria.

Updated rationale

CS101 (conducted susceptibility, power leads, low frequency) in MIL-STD 461D provides two envelopes for military ground facilities. These envelopes correspond to equipment with source voltages at or below 28 V and equipment with source voltages above 28 V. The similarity in the military ground facility environment and the nuclear power plant environment supports the use of these envelopes. These envelopes are adopted without change in DG-1029. In addition, notation is included in DG-1029 specifying that the starting frequency for testing of ac powered equipment is the second harmonic (as-is the case in the MIL-STD).

Figure 1 provides a comparative plot of the RG (i.e., DG-1029) envelopes for CS101 and CS01, the baseline MIL-STD envelopes, the corresponding envelope endorsed by the SER on EPRI TR-102323, and the plant emissions data presented in NUREG/CR-6436 and EPRI TR-102323. The RG and MIL-STD envelopes are converted from voltage to current for comparative purposes based on an assumption of 0.5 Ω impedance. It is seen that the RG and SER envelopes are similar in level. The most notable exception is the less restrictive RG envelope for equipment with source voltages at or below 28 V. As can be observed from the plot, this envelope only provides a 4 dBμA margin above the highest measured plant emissions data reported in EPRI TR-102323. However, in the frequency range below 120 Hz, the 4 dB margin is judged to be sufficient for two reasons. First, the starting frequency for testing of ac powered equipment is specified to be the second harmonic so the ac limit does not apply over the frequency range with the 4 dB margin. Second, although the envelope does apply over the frequency range with the 4 dB margin for dc powered equipment, the bounding plant data resulted from ac powered equipment according to EPRI so adequate margin for dc powered equipment is probable.

CS114/CS02—Conducted Susceptibility, High Frequency

Original rationale

The operating envelope for military ground facilities (Army) from CS114 (conducted susceptibility, bulk cable injection, high frequency) in MIL-STD 461D was adjusted to account for conducted emissions levels measured in nuclear power plants. As a minimum, modifications of safety-related equipment must demonstrate that they can withstand the ambient conducted emissions in the plant. In the absence of other technical considerations, the level to which the operating envelope was raised was selected to be consistent with the operating envelope addressed in the SER on EPRI TR-102323. The break frequency at 30 MHz and the level at 400 MHz were maintained because of practical considerations regarding the ability of the test equipment specified in MIL-STD 462D to generate the desired test levels. The envelope from CS02 (conducted susceptibility, power and interconnecting control leads, high frequency) in MIL-STD 461C was also raised to account for conducted emissions levels measured in nuclear power plants. Again, the level to which the operating envelope was raised was selected to be consistent with the operating envelope addressed in the SER on EPRI TR-102323. These adjustments to the CS114 and CS02 operating envelopes were motivated by the need to provide adequate margin above plant emissions data and met the goal of establishing comparable levels of assurance among the test criteria.

Updated rationale

The original rationale for the envelopes is valid. Based on a review of the MIL-STD 461D specifications and rationale [MIL-STD 461D App.], an exemption regarding the application of the test over the upper frequency band is included. The military indicates the CS114 (conducted susceptibility, bulk cable injection, high frequency) test as being optional over 30 MHz to 400 MHz provided that the RS103 (radiated susceptibility, electric field, high frequency) test is also conducted [MIL-STD 461D, pp. 10,14, and A-33]. No such exemption is indicated for CS02 (conducted susceptibility, power and interconnecting control leads, high frequency).

Figure 2 provides a comparative plot of the RG (i.e., DG-1029) envelopes for CS114 and CS02, the baseline MIL-STD envelopes, the corresponding envelope endorsed by the SER on EPRI TR-102323, and the plant emissions data presented in NUREG/CR-6436 and EPRI TR-102323. The RG and MIL-STD envelopes for CS02 are converted from voltage to current for comparative purposes based on an assumption of 50 Ω impedance. The conflict between the MIL-STD emissions envelopes and the plant emissions data is clearly seen. For this reason, the RG envelopes are adjusted from their MIL-STD basis. It is also seen that the RG and SER envelopes are similar in level. The most notable exception is the less restrictive RG envelope CS114 above 30 MHz. This difference accounts for practical considerations regarding the ability of the test equipment specified in MIL-STD 462D to generate the desired test levels.

RS101/RS01—Radiated Susceptibility, Low Frequency

Original rationale

The operating envelope for military ground facilities (Army) with equipment sensitive to magnetic fields from RS101 (radiated susceptibility, magnetic field, low frequency) in MIL-STD 461D was adopted unchanged. The operating envelope for military ground facilities from RS01 (radiated susceptibility, magnetic field, low frequency) in MIL-STD 461C was adjusted to account for radiated emissions levels measured in nuclear power plants. In the absence of other technical considerations, the envelope was adjusted to match the corresponding RS101 operating envelope. The resulting RS101 and RS01 operating envelopes in DG-1029 are also consistent in level with the comparable envelope addressed in the SER on EPRI TR-102323. The adjustment to the RS01 operating envelope was motivated by the need to provide adequate margin above plant emissions data and met the goal of establishing comparable levels of assurance among the test criteria.

Updated rationale

The original rationale for the envelopes is valid. Based on a review of the MIL-STD 461D specifications and rationale [MIL-STD 461D App.], an exemption is included for these tests. The MIL-STD rationale states that this test is specialized with limited applicability and is "intended primarily to ensure that performance of equipment potentially sensitive to low frequency magnetic fields is not degraded." Therefore, an exemption is be allowed to exclude these tests for equipment provided that the design and installation practices identified in IEEE 1050-1996 are followed and that the equipment is not scheduled to be installed in close proximity to sources of low frequency magnetic fields such as cathode ray tubes (CRTs), motors, cable bundles carrying high currents, etc.

Figure 3 provides a comparative plot of the RG (i.e., DG-1029) envelopes for RS101 and RS01, the baseline MIL-STD envelopes, the corresponding envelope endorsed by the SER on EPRI TR-102323, and the plant emissions data presented in NUREG/CR-6436 and EPRI TR-102323. The conflict between the MIL-STD emissions envelopes for RS01 and the plant emissions data is clearly seen. For this reason, that RG envelope is adjusted from its MIL-STD basis. It is also seen that the RG and SER envelopes are identical.

RS103/RS03—Radiated Susceptibility, High Frequency

Original rationale

The operating envelope for military ground facilities from RS103 (radiated susceptibility, electric field, high frequency) in MIL-STD 461D was based on envelopes for Navy and Air Force facilities. The Army ground facility envelope was higher across the frequency range, presumably to account for emissions from specialized transmitters and portable transceivers. Since administrative controls (exclusion zones) are specified in DG-1029 to limit the contribution of such devices, it was considered appropriate to use the lower levels. In addition, the RS103 operating envelope in DG-1029 is consistent with the comparable envelope addressed in the SER on EPRI TR-102323. The operating envelope for military ground facilities (Army) from RS03 (radiated susceptibility, electric field, high frequency) in MIL-STD 461C was adjusted to account for radiated emissions levels measured in nuclear power plants. In the absence of other technical considerations, the RS03 envelope was raised to be consistent with the RS103 operating envelope. These adjustments to the RS103 and RS03 operating envelopes were motivated by the need to provide adequate margin above plant emissions data without being unduly restrictive and met the goal of establishing comparable levels of assurance among the test criteria.

Updated rationale

The original rationale for the envelopes is valid. Based on a review of the MIL-STD 461D specifications and rationale [MIL-STD 461D App.], an exemption for applying the test over the lower frequency band is included. The military indicates the RS103 (radiated susceptibility, electric field, high frequency) test as being optional over 10 kHz to 30 MHz provided that the CS114 (conducted susceptibility, bulk cable injection, high frequency) test is also conducted [MIL-STD 461D, pp. 10, 19, and A-33]. No such exemption is indicated for RS03 (radiated susceptibility, electric field, high frequency).

Figure 4 provides a comparative plot of the RG (i.e., DG-1029) envelopes for RS103 and RS03, the baseline MIL-STD envelopes, the corresponding envelope endorsed by the SER on EPRI TR-102323, and the plant emissions data presented in NUREG/CR-6436 and EPRI TR-102323. The MIL-STD 461D RS103 envelope for Army ground facilities is shown to illustrate difference that can result if administrative controls are not in place. The RG envelope is identical to the MIL-STD envelope for Navy and Air Force facilities. The conflict between the MIL-STD emissions envelopes for RS03 and the plant emissions data is clearly seen. For this reason, that RG envelope is adjusted from its MIL-STD basis. It is also seen that the RG and SER envelopes are identical.

Emissions Operating Envelopes

The equipment emissions operating envelopes described in DG-1029 have a clear technical basis that accounts for military experience, nuclear power plant emissions data, and industrial emissions limits. They are based on the equipment emissions operating envelopes for military ground facilities that are presented in MIL-STD 461D and MIL-STD 461C. The electromagnetic environment in military ground facilities is judged to be comparable to that for nuclear power plants based on general layout and equipment type considerations. A review of the rationale for the MIL-STD operating envelopes indicates that there are some instances where MIL-STD envelopes are primarily intended to protect sensitive receivers, which would not be common in nuclear power plants. In those cases, the Federal Communications Commission (FCC) Part 15 and International Special Committee on Radio Interference (CISPR) limits for industrial class equipment are factored into adjustments of the MIL-STD envelopes.

CE101/CE01—Conducted Emissions, Low Frequency

Original rationale
Since MIL-STD 461D CE101 (conducted emissions, power leads, low frequency) provides no specific guidance on operating envelopes for military ground facilities, which have been identified as having electromagnetic conditions most comparable to nuclear power plants, it was appropriate to adopt the operating envelopes from MIL-STD 461C CE01 (conducted emissions, power leads, low frequency). The technical basis for establishing immunity levels for a particular phenomenon (e.g., conducted EMI/RFI) over a selected frequency range (e.g., 30 Hz to 50 kHz) is not dependent on testing criteria or methods but rather on the environment in which the equipment will be installed. Therefore, the caution against mixing and matching test criteria and methods is not at issue. The high frequency range (> 1.15 kHz) of the CE101 and CE01 envelopes for ac powered equipment was adjusted to promote consistency among the conducted emissions operating envelopes at 10 kHz for CE101 and CE102 (conducted emissions, power leads, high frequency) and at 15 kHz for CE01 and CE03 (conducted emissions, power leads, high frequency). The adjustments to the CE01 operating envelopes and the adoption of the CE01 envelope as the basis for CE101 were motivated by the need to adequately control the growth of plant emissions and met the goal of establishing comparable levels of assurance among the test criteria.

Additional considerations
The original CE01 and CE101 envelopes for ac power leads in DG-1029 do not include the distinction between equipment of differing consumption power levels nor the relaxation based on fundamental current. Therefore, it was possible that certain devices might not be able pass those emissions limit for ac power leads at 60 Hz. Thus, the original operating envelopes for CE101 and CE01 in DG-1029 required adjustment to adopt the distinction offered in the MIL-STDs

Updated rationale
A review of the MIL-STD 461D specifications and rationale [MIL-STD 461D App.] shows that the intent of the MIL-STD 461D CE101 (conducted emissions, power leads, low frequency) envelopes is to limit the "amplitude of harmonic currents conducted on the power distribution system." The envelopes are "based on maintaining the harmonic distortion of the (platform) power distribution system within 5% of the supply voltage with any single harmonic being less than 3%." The MIL-STD rationale also states that total harmonic distortion (THD) that is greater than "5% is above the tolerance of most electronic equipment, induction motors, magnetic devices, and measuring devices." Therefore, the MIL-STD envelopes provide a sound basis for the DG-1029 envelopes.

MIL-STD 461C CE01 (conducted emissions, power leads, low frequency) for military ground facility platforms and MIL-STD 461D CE101 for surface ship platforms each offer a single envelope for application to dc power leads and two separate envelopes for application to ac power leads for 60 Hz equipment. The two ac power lead envelopes correspond to equipment operating at input power ratings greater than 1 kVA and less than or equal to 1 kVA and these envelopes provide the guidance for variations in power consumption. The envelope for ac power leads on equipment operating at less than or equal to 1 kVA ranges from the power line frequency to 10 kHz for CE101 and to 15 kHz for CE01. The envelope for ac power leads on equipment operating at greater than 1 kVA ranges from the first power harmonic to 10 kHz for CE101 and to 15 kHz for CE01. In addition, the MIL-STD envelopes offer a dB relaxation for equipment and subsystems with a fundamental current (i.e., load current at the power frequency) that is greater than 1 ampere. The break frequency for the envelope for ac power leads on equipment operating at less than or equal to 1 kVA is 1.15 kHz. The endpoints in the high frequency range (>1.15 kHz) of the CE101 and CE01 envelopes are adjusted for use in DG-1029 to promote consistency among the conducted emissions operating envelopes at 10 kHz for CE101 and CE102 (conducted emissions, power leads, high frequency) and at 15 kHz for CE01 and CE03 (conducted emissions, power leads, high frequency). The dc power lead emissions envelopes for CE101 and CE01 are adopted unchanged. Also, notation is included in DG-1029 to identify the allowed relaxation of the envelope for equipment and subsystems with a fundamental current that is greater than 1 ampere.

Figure 5 provides a comparative plot of the RG (i.e., DG-1029) envelopes for CE101 and CE01, the baseline MIL-STD envelopes, and the corresponding envelope endorsed by the SER on EPRI TR-102323. The envelopes for ac power leads are less restrictive than the MIL-STD envelopes in the higher frequency band (> 1.15 kHz) because of adjustments to promote consistency between the conducted emissions operating envelopes at 10 kHz for CE101 and CE102 and at 15 kHz for CE01 and CE03. The RG emissions envelope for dc power leads is less restrictive than the corresponding SER emissions envelope. The RG emissions envelopes for ac power leads are somewhat more restrictive than the corresponding SER emissions envelope. Nevertheless, the power quality basis for ac-power-lead emissions envelopes provides an appropriate foundation for the RG envelopes.

Finally, the wording for the exemption for these tests now more clearly reflects the basis for the envelopes and the justification required. The updated exemption states that the envelopes are based on maintaining the harmonic distortion of the power distribution system within 5% total harmonic distortion of the supply voltage with any single harmonic being less than 3%. Therefore, the test can be exempted if it can be demonstrated that the power quality requirements of the new or modified equipment are consistent with the existing power supply and do not impose harmonic distortions on the existing power distribution system that exceed 5% THD or other power quality criteria established with a valid technical basis.

CE102/CE03—Conducted Emissions, High Frequency

Original rationale

The operating envelopes for CE102 (conducted emissions, power leads, high frequency) in MIL-STD 461D were adopted unchanged. The permitted relaxation of the CE102 emissions envelopes based on increasing source voltage was also adopted. Additionally, the operating envelopes for CE03 (conducted emissions, power leads, high frequency) in

MIL-STD 461C were adopted unchanged. Given the technical pedigree for the MIL-STD envelopes, they provide an appropriate, well-founded basis for the DG-1029 envelopes.

Updated rationale

The rationale in MIL-STD 461D Appendix [MIL-STD 461D App., pp. A-24, A-25] states that the levels for the low frequency band of CE102 (conducted emissions, power leads, high frequency) are set to address power quality, which is a common issue with nuclear power plant applications. The levels for the higher frequency band are based on controlling potential radiated EMI that could affect sensitive receivers, which are not normally present in nuclear power plants. Therefore, the levels in the low frequency band of the MIL-STD emissions envelopes for CE102 and narrowband CE03 (conducted emissions, power leads, high frequency) are adopted unchanged while the levels in the higher frequency band are raised for application to nuclear power plants. The CISPR Class A and FCC Part 15 Class A conducted emissions levels are used as the basis for setting the envelope levels presented in DG-1029. Thus, each envelope retains the low frequency slope and level of the corresponding MIL-STD envelope but the upper frequency levels are set to be equivalent to the CISPR limit, which encompasses the FCC limit.

Figure 6 provides a comparative plot of the RG (i.e., DG-1029) envelopes for CE102 and CE03, the baseline MIL-STD envelopes, the corresponding envelope endorsed by the SER on EPRI TR-102323, and the Class A equipment emissions limits for CISPR and FCC Part 15. The RG and MIL-STD envelopes for CE102 are converted from voltage to current for comparative purposes based on the test apparatus impedance established in MIL-STD 462D. The CISPR and FCC limits are converted from voltage to current for comparative purposes based on the test apparatus impedance defined for those test methods. The RG envelopes completely encompass the CISPR and FCC conducted emissions limits. The RG envelopes are slightly more restrictive than the corresponding SER envelope. Nevertheless, the power quality basis for the low frequency component of the emissions envelopes and the industrial emissions limit basis for the high frequency component of those envelopes provide an appropriate foundation for the RG envelopes for CE102 and CE03.

Additional considerations

The CE102 and CE03 electromagnetic emissions envelopes in DG-1029 completely encompass the FCC Part 15 Class A and CISPR Class A emissions limits for high frequency conducted emissions. Therefore, equipment that passed the FCC or CISPR tests would fulfill the DG-1029 guidance in the relevant frequency ranges. However, the user would still need to demonstrate compliance with the emissions envelopes in the frequency ranges not covered by FCC or CISPR.

Finally, the broadband envelope and the requirement to perform broadband measurements for CE03 is deleted. A review of EMI/RFI practices for the military indicates that broadband emissions are controlled to protect specific types of receivers and nuclear power plants do not contain such devices.

RE101/RE01—Radiated Emissions, Low Frequency

Original rationale

The RE101 (radiated emissions, magnetic field, low frequency) operating envelope was based on the Army ground facility envelope in MIL-STD 461D. The RE101 operating envelopes were adjusted because virtually no margin was allowed between the operating envelope for equipment emissions measured at 7 cm and the RS101 (radiated susceptibility, magnetic field, low frequency) operating envelope for radiated susceptibility over the same frequency range. Some margin was deemed necessary to control the potential future growth of radiated magnetic field levels within specific areas of nuclear power plants. In the absence of other technical considerations, the lowered level for the operating envelope for emissions measured 7 cm away from the equipment was selected to be consistent with the operating envelope addressed in the SER on EPRI TR-102323. A comparable shift in field strength was enacted for the operating envelope for emissions measured 50 cm away from the equipment. The operating envelope for military ground facilities from RE01 (radiated emissions, magnetic field, low frequency) in MIL-STD 461C was adjusted to provide greater consistency between the RE101 envelope for emissions measured 7 cm from equipment and the RE01 envelope. The envelopes are consistent with the comparable envelope presented in the April, 1994, version of EPRI TR-102323. These adjustments to the RE101 and RE01 operating envelopes were motivated by the need to adequately control the growth of plant emissions and met the goal of establishing comparable levels of assurance among the test criteria.

Updated rationale

When Oak Ridge National Laboratory (ORNL) developed recommendations for operating envelopes, the researchers had available the April, 1994, version of EPRI TR-102323. However, the September, 1994, version of EPRI TR-102323 was reviewed by NRC staff as the subject of the SER, dated April 17, 1996. Therefore, ORNL used an outdated envelope as the point of comparison for the RE101 (radiated emissions, magnetic field, low frequency) and RE01 (radiated emissions, magnetic field, low frequency) operating envelopes. Thus, the level to which the RE101 and RE01 envelopes in DG-1029 are adjusted is corrected be consistent at the lowest frequency with the operating envelope addressed in the SER on EPRI TR-102323.

Figure 7 provides a comparative plot of the RG (i.e., DG-1029) envelopes for RE101, RE01, and RS101, the baseline MIL-STD envelopes, and the corresponding envelope endorsed by the SER on EPRI TR-102323. It is seen that the RG for emissions measured at a distance of 7 cm from the equipment and SER envelopes are similar in level. The RG envelope for emissions measured at a distance of 50 cm from the equipment provides an alternate envelope for area emissions control.

Finally, the wording in DG-1029 now states that emissions measurements at 50 cm are an alternative to measurements at 7 cm [MIL-STD 461D App., p. A-37]. Therefore, the user has the option of either measurement with the corresponding envelope.

RE102/RE02—Radiated Emissions, High Frequency

Original rationale

The RE102 (radiated emissions, electric field, high frequency) operating envelope was based on the envelope for Army ground applications in MIL-STD 461D. The envelope was extended below 2 MHz to provide complete coverage of the frequency range corresponding to the test method. The basis for the envelope from 10 kHz to 2 MHz is a relationship with CE102 (conducted emissions, power leads, high frequency), which addresses power quality issues [MIL-STD 461D App., p. A-25]. Thus, the emissions envelope is continuous over the frequency range corresponding to the test criteria in DG-1029 and provides consistent coverage compared to RE02 (radiated emissions, electric field, high frequency). Use of the restrictive Army emissions envelope was justified because the site survey data for electric fields, reported in NUREG/CR-6436, closely approach the 8 dB margin band below the RS103 (radiated susceptibility, electric field, high frequency) operating envelope. Therefore, close control of radiated electric field emissions seemed justified. The operating envelopes for RE02 (radiated emissions, electric field, high frequency) in MIL-STD 461C were adopted unchanged. Both the narrowband and broadband envelopes were adopted to correspond to the test method. The adjustment to the RE102 operating envelope was motivated by the need to adequately control the growth of plant emissions and met the goal of establishing comparable levels of assurance among the test criteria.

Updated rationale

The rationale in MIL-STD 461D Appendix [MIL-STD 461D App., p. A-38] states that the primary intent of the RE102 (radiated emissions, electric field, high frequency) test is to protect sensitive receivers. However, the levels for the low frequency band (<2 MHz) were based on the levels from CE102 (conducted emissions, power leads, high frequency), which address power quality [MIL-STD 461D App., p. A-25]. Therefore, the very restrictive levels for the envelopes are raised but the slope of the lowest frequency band (which is related to the CE102 envelope) is maintained. The highest frequency component is adjusted using the CISPR Class A and FCC Part 15 Class A radiated emissions levels as the basis for setting the slope and level for the envelopes above 25 MHz. The emissions envelope component over the remaining frequency band (below 25 MHz) is adjusted in level from its MIL-STD basis to correspond to the industrial emissions basis for the component of the envelope in the high frequency band. Thus, the RE102 emissions envelope presented in DG-1029 retains the low frequency slope of the MIL-STD envelope at levels comparable with those endorsed in the SER but the envelope levels in the upper frequency band are set to encompass the CISPR and FCC limits. Finally, the RE02 (radiated emissions, electric field, high frequency) narrowband envelope presented in DG-1029 adopts the RE102 envelope shape and level based on the same underlying rationale.

Figure 8 provides a comparative plot of the RG (i.e., DG-1029) envelopes for RE102 and RE02, the baseline MIL-STD envelopes, the corresponding envelope endorsed by the SER on EPRI TR-102323, and the Class A equipment emissions limits for CISPR and

FCC Part 15. The RG envelopes completely encompass the CISPR and FCC radiated emissions limits. The RG envelopes are somewhat more restrictive than the corresponding SER envelope in the mid-frequency range and less restrictive in the lower and higher frequency ranges. Nevertheless, the relationship to the power quality criteria for the low frequency component of the emissions envelopes and the industrial emissions limit basis for the high frequency component of those envelopes provide an appropriate foundation for the RG envelopes for RE102 and RE02.

Additional considerations

The RE102 and RE02 electromagnetic emissions envelopes in DG-1029 completely encompass the FCC Part 15 Class A and CISPR Class A emissions limits for high frequency radiated emissions. Therefore, equipment that passed the FCC or CISPR tests would fulfill the DG-1029 guidance in the relevant frequency ranges. However, the user would still need to demonstrate compliance with the emissions envelopes in the frequency ranges not covered by FCC or CISPR.

Finally, the broadband envelope and the requirement to perform broadband measurements for RE02 is deleted. A review of EMI/RFI practices for the military indicates that broadband emissions were controlled to protect specific types of receivers and nuclear power plants do not contain such devices.

To conclude the discussion of the rationale for the operating envelopes presented in DG-1029, the adoption of the draft regulatory guide should not reduce the availability of EMI/RFI-qualified equipment suppliers. The regulatory position offers clear guidance on the acceptable application of consensus standards that are well-established and widely available so it should help the suppliers focus their EMC efforts. While there are some instances where the operating envelopes in the draft regulatory guide differ with the envelopes addressed by the SER, the application of the operating envelopes presented in DG-1029 should not cause an undue burden. In fact, the susceptibility envelopes presented in DG-1029 are, in some cases, less restrictive than those endorsed by the SER. The emissions envelopes presented in DG-1029 are modified based on an updated rationale and are more in line with those endorsed by the SER on EPRI TR-102323. These envelopes fully encompass the FCC Part 15 Class A and CISPR Class A emissions limits for industrial environments. Therefore, some credit can be taken for commercial equipment certification. In addition, since the operating envelopes are tailored to each particular test method in DG-1029, there is no added burden required for justification of the use of those test methods over extended frequency ranges. Finally, these operating envelopes also provide some benefits through frequency range exemptions and relaxation factors for test levels.

Proper Units for Operating Envelopes
The operating envelopes presented in DG-1029 are framed in proper units and frequency ranges for each specific test method. There is a concern that mixing of measurement units could possibly lead to confusion in applying the operating envelopes. Therefore, the operating envelopes in DG-1029 are presented in the measurement units of the test method.

The operating envelopes for CE101 and CE01 (conducted emissions, power leads, low frequency), CE03 (conducted emissions, power leads, high frequency), and CS114 (conducted susceptibility, bulk cable injection, high frequency) are given in terms of current because that unit corresponds to the appropriate measurements for the test method. The operating envelopes for CE102 (conducted emissions, power leads, high frequency), CS101 and CS01 (conducted susceptibility, power leads, low frequency), and CS02 (conducted susceptibility, power and interconnecting control leads, high frequency) are given in terms of voltage because that unit corresponds to the appropriate measurements for the test method. Some examples of the rationale for unit of measurement choices in the MIL-STD guidance are provided below.

The basic issue being addressed in the conducted emissions tests is potential degradation from voltage ripples associated with the allowable distortion of power source voltage waveforms. Since limiting voltage distortion is a major factor in the basis for the CE102 test, the operating envelopes in the MIL-STD 461D and DG-1029 are specified in terms of dBμV. In addition, the test equipment specified in the description of the CE102 test method provides for voltage measurements. The use of a standardized line impedance (i.e., a line impedance stabilization network) over the frequency range of the CE102 test provides for the convenient measurement of the voltage as developed across this impedance. Hence, the voltage measurements are both simple and practical. Note that the CE101 and CE01 operating envelopes are in terms of current because of the difficulty in controlling the power source impedance in test facilities at lower frequencies. This type of control would be necessary to specify the operating envelope in terms of voltage.

It is also appropriate to present the CS101 and CS01 operating envelopes in terms of dB μV and V (rms), respectively, since these tests are used to verify the ability of equipment to withstand voltage ripples on power leads. The units of the CS101 susceptibility operating envelope are consistent with the units of the CE102 operating envelope, and the units of both operating envelopes are indicative of the test methods. The comparable low frequency, conducted susceptibility operating envelope addressed in the SER on EPRI TR-102323 is expressed in terms of V (rms) and dBμA.

Rationale for DG-1029 Surge Levels

The discussion in Section 6, paragraph 2 of DG-1029 is not prescriptive guidance but rather a description of the rationale for the selection of the withstand levels that are presented in the following sections. The endorsement of test methods and withstand levels represents the guidance of the regulatory position. It is not the intent of DG-1029 to classify by decree all locations in a nuclear power plant as belonging to a particular location category with a particular exposure level. Instead, the categories defined in IEEE C62.41-1991 (Reaffirmed in 1995) are identified along with the different exposure level groupings and then the basis for the withstand levels is stated (i.e., *Category B* locations with a *Low to Medium Exposure* level). The basis for the withstand levels was selected because it reasonably bounds projected surge conditions in nuclear power plants with adequate margin. In the same sense, the EMI/RFI operating envelopes reasonably bound the projected electromagnetic conditions in nuclear power plants with adequate margin.

In the context of IEEE Std C62.41-1991, "service entrance" is the point at which power enters a building or structure. Based on this description of "service entrance," it is true that a large number of the circuits in a nuclear power plant would be *Category A*. However, an assumption was made that *Category B* would be a reasonable bounding case for the exposure of most circuits to power surges. Details of the rationale for the Category and Exposure Level selections are provided in NUREG/CR-5941.

Limiting Practices Endorsed in DG-1029

The position in DG-1029 focuses on a consensus standard for EMI/RFI limiting practices that is widely available to the general public. DG-1029 endorses IEEE Std 1050-1996 with one exception, while the SER accepts similar guidance in Ch. 6 of EPRI TR-102323. EPRI TR-102323 references IEEE Std 1050-1989 for grounding practices and then references EPRI TR-102400 for more detailed guidance on EMI/RFI limiting practices. NUREG/CR-5941 documents the evaluation of IEEE Std 1050-1989 and recommends four exceptions (three of which were addressed in the 1996 revision of the standard).

A number of "low tech" methods for solving EMI/RFI concerns are addressed in IEEE Std 1050-1996. These include wire and cable separations, shielding techniques, shielded enclosure integrity, apertures, gasketing, grounding techniques, EMI/RFI filters, and circuit board layouts. Other methods, like EMI/RFI source identification and exclusion zones, are discussed in DG-1029.

Documentation Identified in DG-1029

DG-1029 clarifies the level of evidence that is acceptable for EMI/RFI and power surge withstand qualification. Documentation guidance is intended to relieve some uncertainty in the process of establishing an acceptable level of EMC. Section 7 is not intended to create a new requirement for extensive documentation. The wording in Section 7 has been changed to avoid this inference.

The documentation discussed in Section 7 addresses necessary evidence that safety-related I&C equipment meets its specification requirements and is compatible with the projected electromagnetic environment, that the user adheres to acceptable installation practices, and that administrative controls have been established covering the allowable proximity of portable EMI/RFI sources. Such documented evidence is routinely required as quality assurance records to confirm that a design accommodates the effects of the service conditions to which it will be subjected. This documentation will benefit both future and existing plants.

Cost/Impact of DG-1029

All new or modified safety-related equipment (including analog, digital, or hybrid equipment) must adhere to the environmental compatibility criterion (see General Design Criterion 4 in 10 CFR 50, App. A). This is a long-standing requirement. The guidance presented in DG-1029 provides added clarity regarding means to establish evidence that safety-related equipment are compatible with particular environmental service conditions (i.e., electromagnetic and power surge conditions). The regulatory position described in DG-1029 is consistent with the previous staff position expressed in the SER on EPRI TR-102323 in that each applies to both future nuclear power plants and to presently operating nuclear power plants that plan modifications of safety-related equipment. Neither position applies to existing equipment that is not scheduled for modification. Thus, existing installations of safety-related equipment are unaffected by EMC guidance.

The cost of implementing the regulatory guidance for new analog and hybrid systems, along with digital systems, is expected to be minimal because the guidance is consistent with current established practices presently being applied throughout the commercial power industry. The value of the regulatory guidance is that it offers clear guidance on necessary practices and a systematic approach to meet long-standing requirements from 10 CFR 50. Until recently, NRC provided EMI/RFI and power surge withstand guidance on a case by case basis. In the SER on EPRI TR-102323, the NRC staff found the guidance described in that document, which involved a similar level of testing, to be acceptable as one approach to contributing to EMC. The regulatory position in DG-1029 represents another acceptable method that is similar in approach to the guidance in EPRI TR-102323.

The regulatory positions in the SER and DG-1029 are intended to describe systematic approaches that yield defensible results and alleviate the need for site surveys. The staff position expressed in the SER requires that plants undergoing a new installation or modification of safety-related equipment confirm that their electromagnetic environment is indeed similar to one of the seven plants where site survey data was collected by EPRI. The staff position expressed in DG-1029 requires an assessment of the local electromagnetic environment to identify any unique EMI/RFI emitters. Therefore, application of the operating envelopes endorsed by either position should not require additional measurements in most cases.

While there are some instances where the operating envelopes in the draft regulatory guide differ with the envelopes addressed by the SER, the application of the operating envelopes presented in DG-1029 should not cause an undue burden. In fact, the susceptibility envelopes presented in DG-1029 are, in some cases, less restrictive than those endorsed by the SER. The emissions envelopes presented in DG-1029 will be modified based on an updated rationale and will be more in line with those endorsed by the SER on EPRI TR-102323. These envelopes will fully encompass the FCC Part 15 Class A and CISPR Class A emissions limits for industrial environments. Therefore, some credit can be taken for commercial equipment certification. In addition, since the operating envelopes are tailored to each particular test method in DG-1029, there is no added burden required for justification of the use of those test methods over extended frequency ranges. Finally, the DG-1029 operating envelopes also provide some benefits through frequency range exemptions and relaxation factors for test levels.

Regarding the cost factors identified in public comments, the EMI/RFI and surge withstand testing costs should be equivalent to those incurred under the guidance given in EPRI TR-102323. Also, as a point of clarification, the regulatory position only applies to new or modified safety-related I&C systems. Hence, there is no extension of the regulatory position to nonsafety-related equipment or to existing safety-related equipment. Finally, the costs of assuring equipment designs are being maintained and establishing programmatic controls to ensure necessary EMI/RFI requirements are met should not appreciably differ from the costs that can be reasonably expected from the application of the requirements in 10 CFR 50, App. B. Indeed, design control, test control, and quality assurance records are already necessary elements for the qualification or dedication of any safety-related equipment.

Additional Guidance Suggested by Commentors for DG-1029

Extending Operating Envelopes > 1 GHz

The value of extending the RS103 (radiated susceptibility, electric field, high frequency) envelope to cover up to 10 GHz is recognized. However, the upper frequency for the RS103 test was set at 1 GHz for two reasons. First, the need for guidance on susceptibility levels above 1 GHz in nuclear power plants arose after the operating envelopes were adopted. In fact, there were no measurable emissions observed in the frequency range 1 GHz to 8 GHz during the site survey of nuclear power plants reported in NUREG/CR-6436. Second, the MIL-STD 461D RS103 envelope for military ground facilities is 50 V/m above 1 GHz. This envelope seems unsuitable for nuclear power plant application. Since the completion of the original research on the technical basis for DG-1029, cellular-type communications have become common in this frequency range, and the issue should be revisited. However, before guidance can be included, the technical basis for an acceptable operating envelope must be developed for this frequency range. In the interim, exclusion zones can be established through administrative controls to prohibit the activation of portable transceivers (communication devices) in areas where safety-related I&C systems have been installed. Thus, exclusion zones are a means to address the potential susceptibility issue.

Addressing Signal Line Susceptibility

The recommended MIL-STD 461D and MIL-STD 461C susceptibility test criteria are not generally applicable to signal lines. In addition, the power surge test criteria in IEEE Std C62.41-1991 (Reaffirmed in 1995) are only applicable to power leads. The MIL-STDs do leave open the possibility of specifying test criteria for signal line susceptibility when it is deemed necessary, but offer no guidance on acceptable operating envelopes (these must be determined on a case by case basis). Hence, this lack of guidance left signal line susceptibility as an open issue when applying the recommended MIL-STD test criteria and operating envelopes. EPRI TR-102323 endorses the IEC 801-4 and 801-5 surge test criteria, and they are applicable to both power leads and signal lines. Thus, the SER on EPRI TR-102323 is recognized as representing current guidance for addressing this issue. Since the need to specifically address signal line susceptibility in nuclear power plants is recognized, a separate investigation has been initiated by NRC to develop a technical basis for establishing appropriate signal line susceptibility test criteria and operating envelopes.

Power Quality and Power Systems

DG-1029 does not contain specific guidance on power system design or power quality testing standards. The focus of DG-1029 is on equipment, not power distribution systems. Therefore, the intent of the regulatory position described in DG-1029 is not to address all aspects of power-related design issues in detail but rather to indicate the degree of surge protection and the level of power distortions that are acceptable and to identify test criteria and test methods that are appropriate for validating the efficacy of the means of protection applied in equipment design. The power surge guidance in DG-1029 provides information on surge voltages in low-voltage ac power circuits. With this information, equipment designers and users can evaluate their operating environment to determine the need for surge-protective devices. The implementation of surge protection is a part of the power system design specifications and detailed guidance on the means to establish design requirements is not within the scope of this regulatory position.

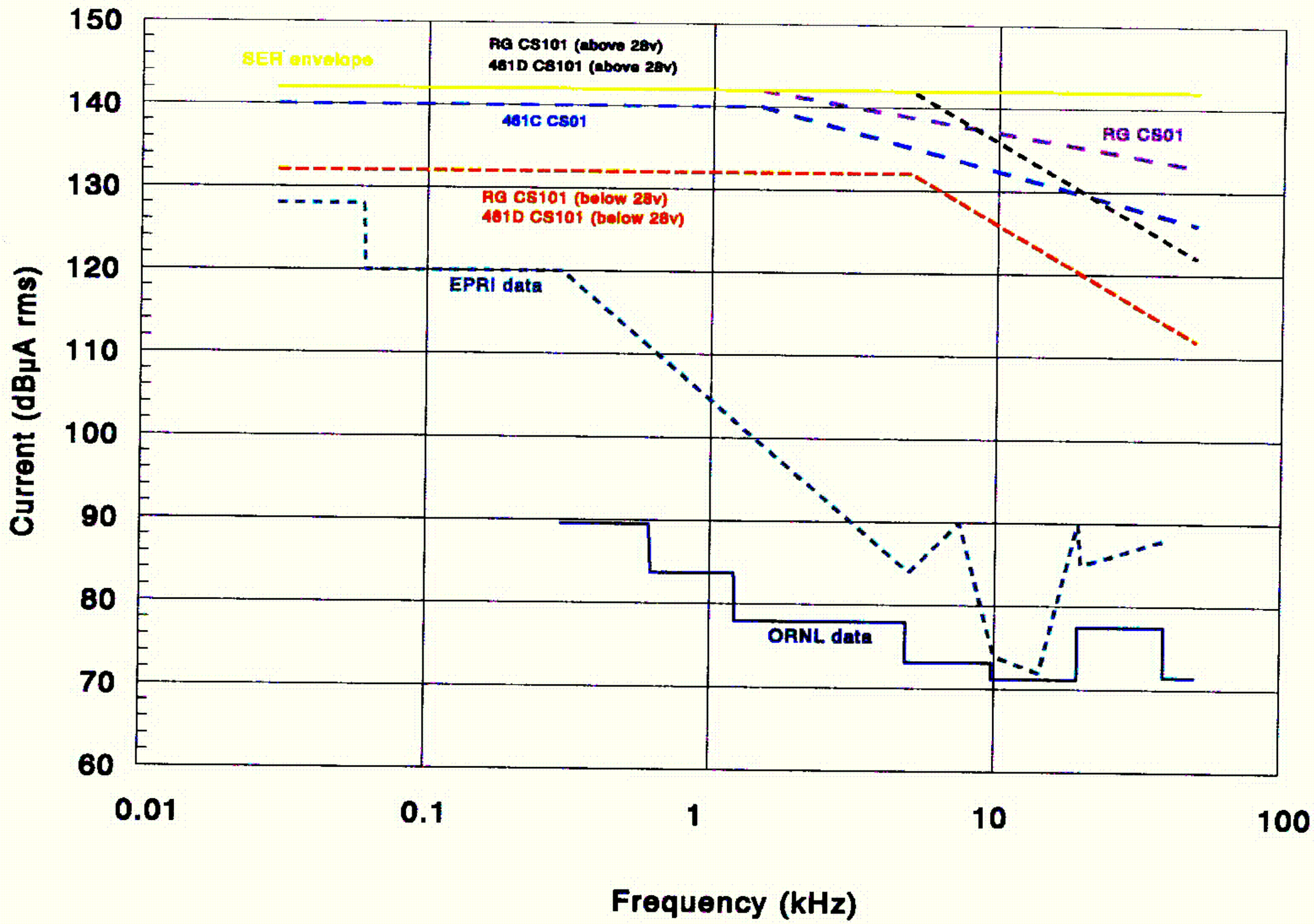

Figure 1 Comparison of low-frequency conducted susceptibility envelopes

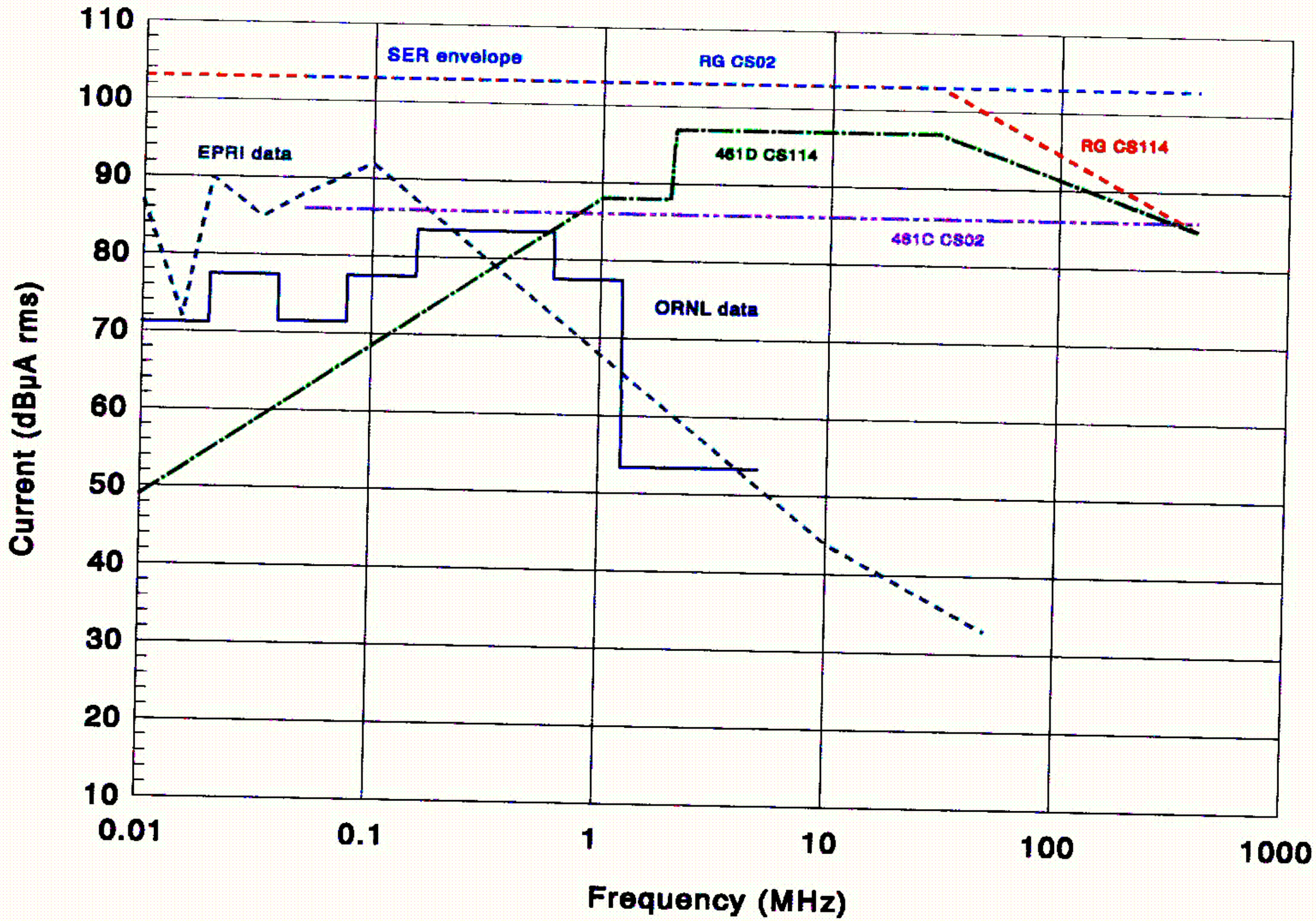

Figure 2 Comparison of high-frequency conducted susceptibility envelopes

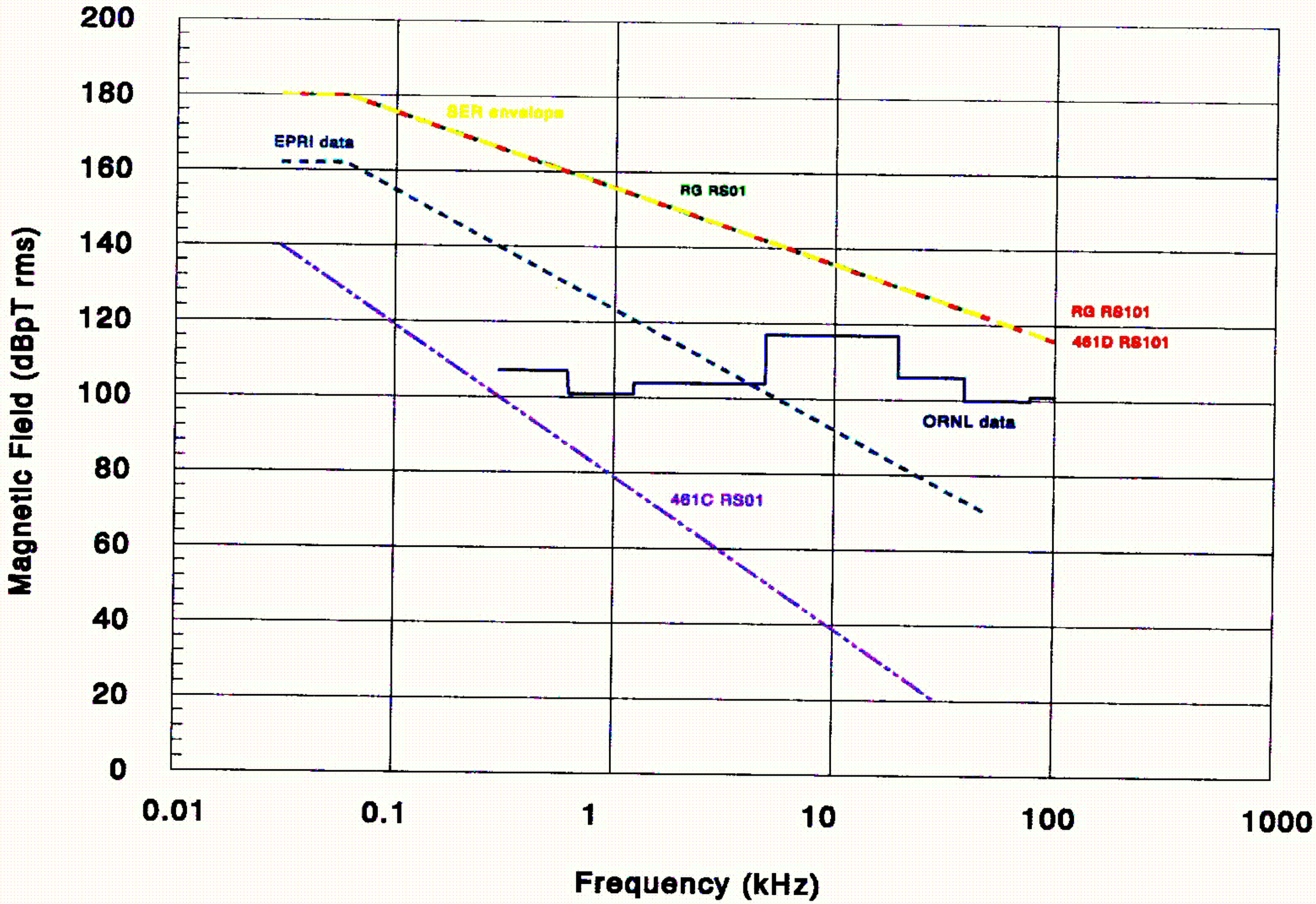

Figure 3 Comparison of low-frequency radiated susceptibility envelopes

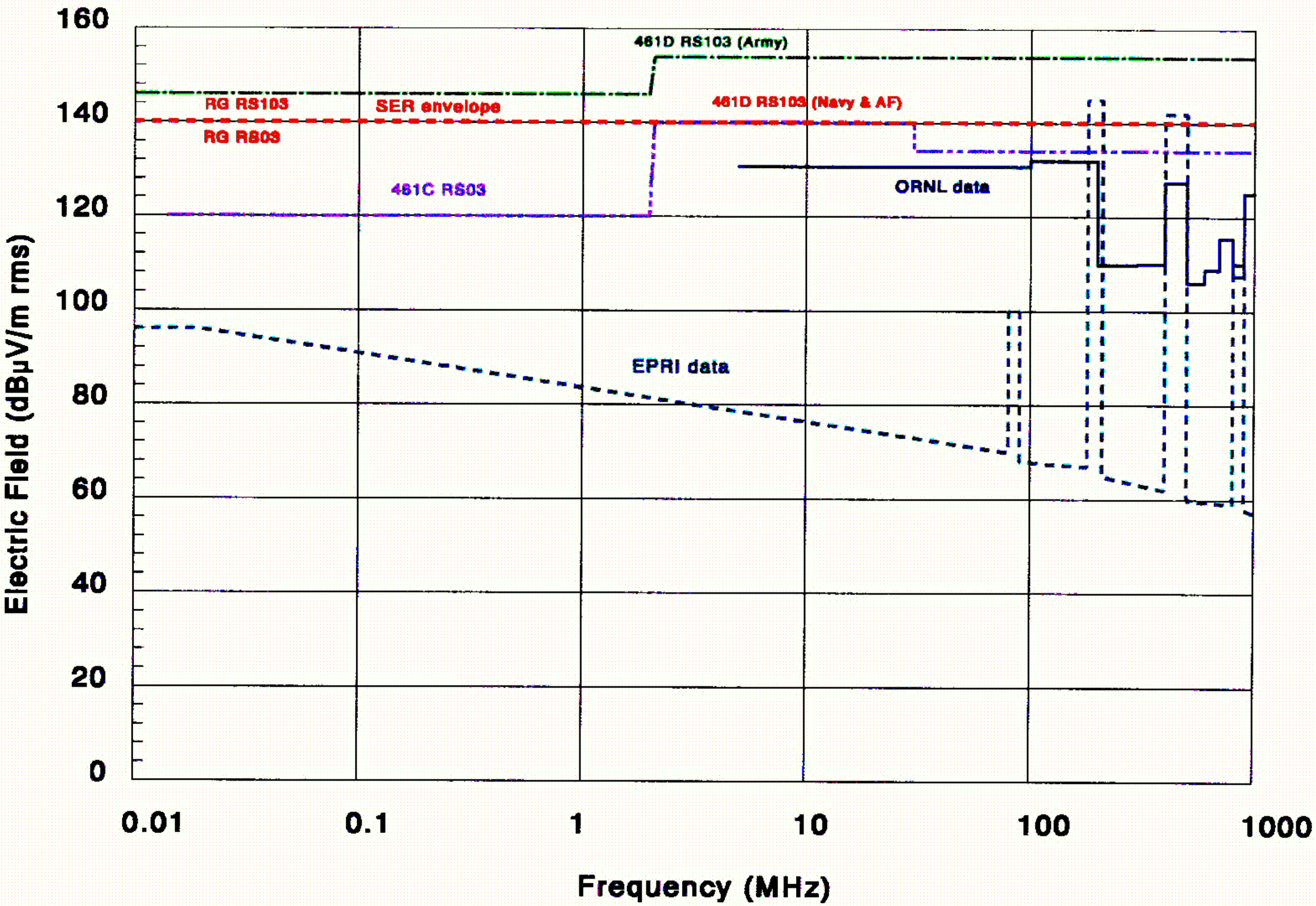

Figure 4 Comparison of high-frequency radiated susceptibility envelopes

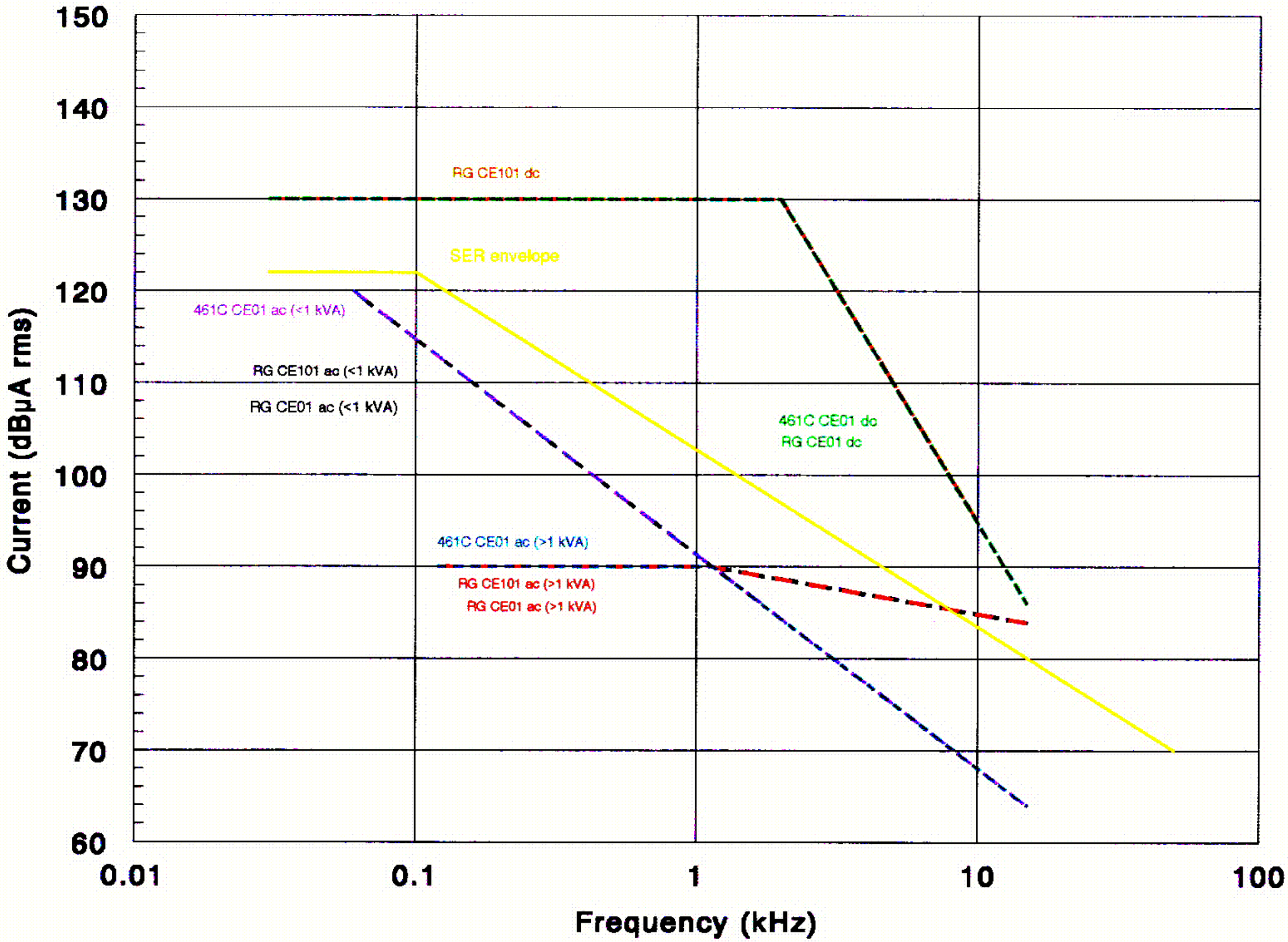

Figure 5 Comparison of low-frequency conducted emissions envelopes

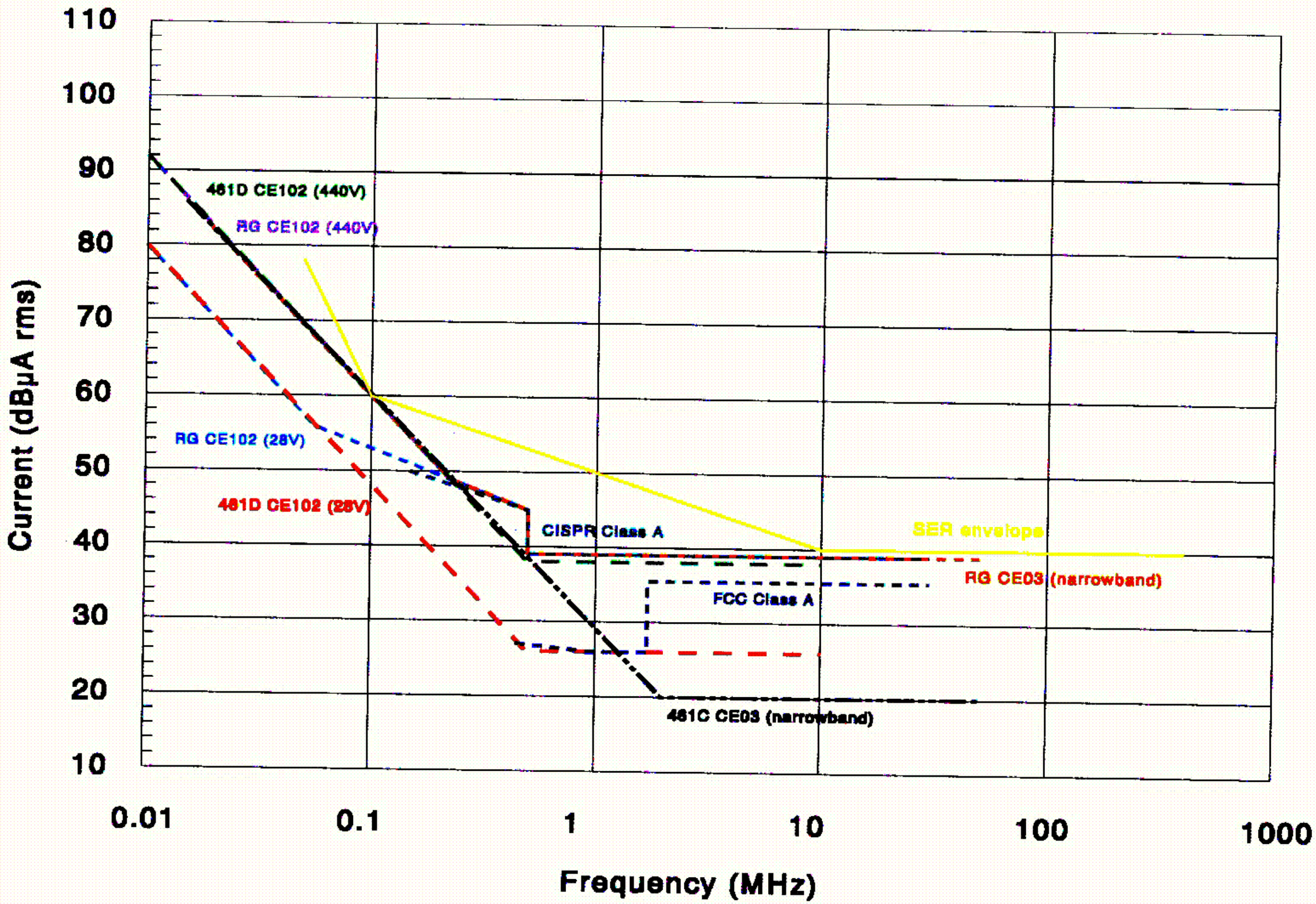

Figure 6 Comparison of high-frequency conducted emissions envelopes

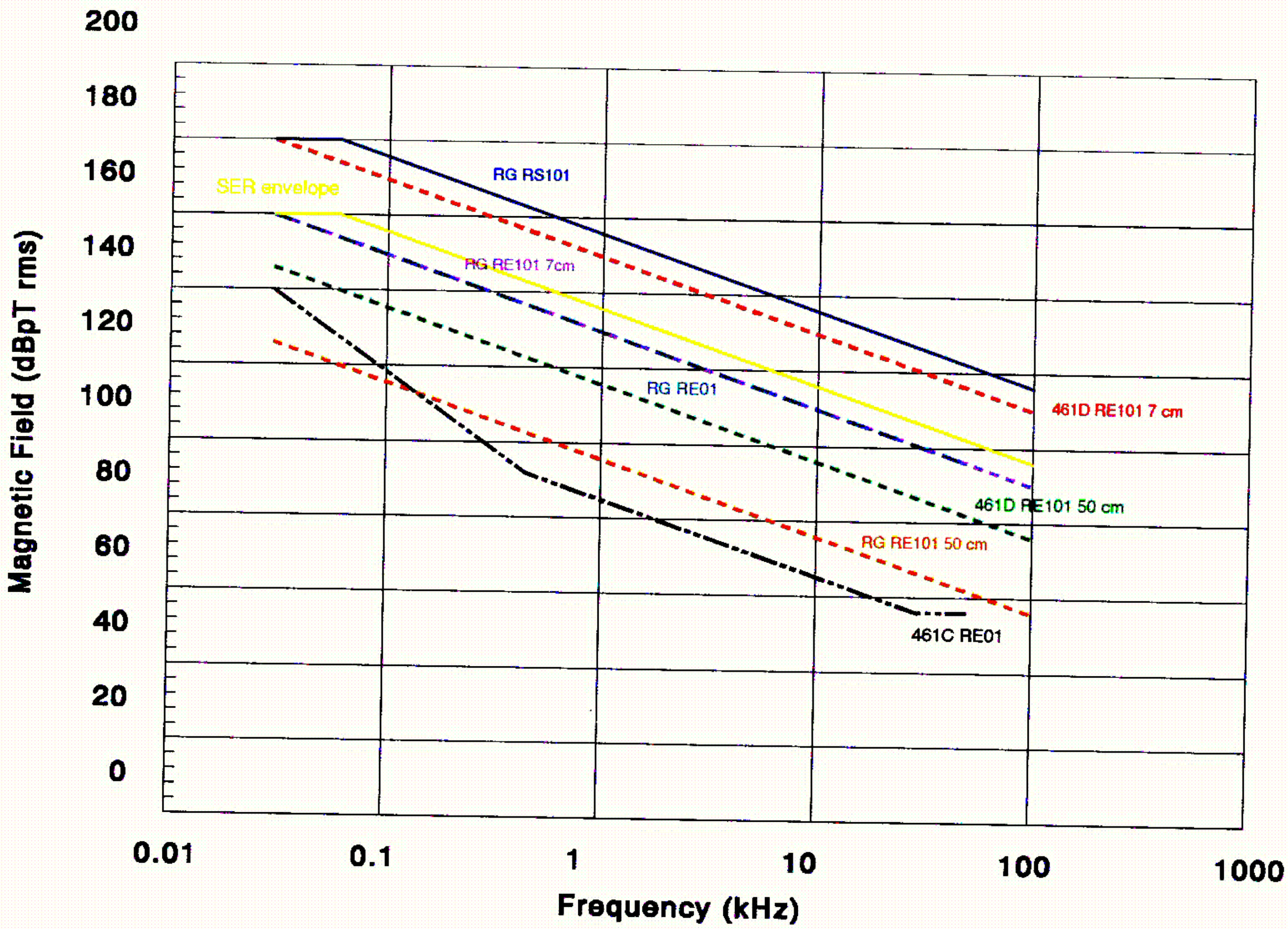

Figure 7 Comparison of low-frequency radiated emissions envelopes

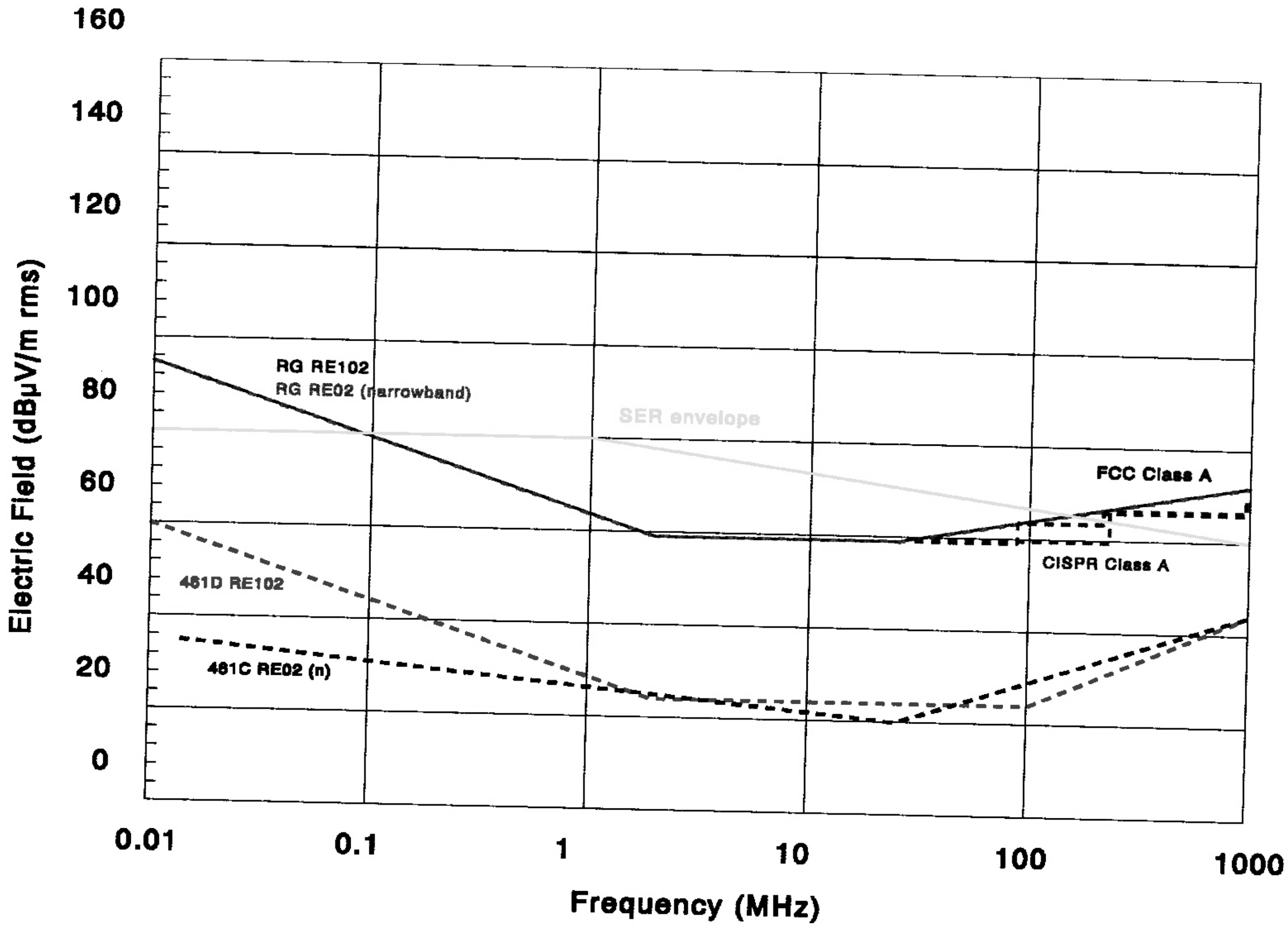

Figure 8 Comparison of high-frequency radiated emissions envelopes

C. Specific Comments

Commentor I

I. B. DISCUSSION

The RG does not cover signal line susceptibility test criteria, but instead mentions IEC 801 and its treatment in the SER for EPRI TR-102323. If signal line susceptibility test criteria were addressed directly, it would add to the usefulness of the RG. <1>

Technical Response

<1> The recommended MIL-STD 461D and MIL-STD 461C susceptibility test criteria are not generally applicable to signal lines. In addition, the power surge test criteria in IEEE Std C62.41-1991 (Reaffirmed in 1995) are only applicable to power leads. The MIL-STDs do leave open the possibility of specifying test criteria for signal line susceptibility when it is deemed necessary, but offer no guidance on acceptable operating envelopes (these must be determined on a case by case basis). Hence, this lack of guidance left signal line susceptibility as an open issue when applying the recommended MIL-STD test criteria and operating envelopes. However, the need to address signal line susceptibility in nuclear power plants is recognized and a separate investigation has been initiated by NRC to develop a technical basis for establishing appropriate signal line susceptibility test criteria and operating envelopes.

I. C. REGULATORY POSITION, Section 6.2, 2nd paragraph, 3rd sentence

The definition of virtual origin does not match the reference standard. It should read: "Virtual origin is the point where a straight line between the 30% and 90% points on the leading edge of the waveform intersects the V=0 line. <2>

Technical Response

<2> The comment is accurate and a change will be made. Since the Combination Wave is being discussed, the corrected definition will read: "The virtual origin is the point where a straight line between the 30% and 90% points on the leading edge of the waveform intersects the V=0 line for the open-circuit voltage and the I=0 line for the short-circuit current."

I. C. REGULATORY POSITION, Section 6.3

It would be helpful to add the following information to this section: The number of pulses in a burst is determined by the pulse frequency. For peaks ≤2 kV, the frequency shall be 5 kHz ±1 kHz. For peaks >2 kV, the frequency shall be 2.5 kHz ±0.5 kHz. <3>

Technical Response

<3> It is agreed that adding the referenced information would be helpful since it is part of the guidance in IEEE Std C62.41-1991 (Reaffirmed in 1995). The addition will be made, along with further clarification that the two values of the repetition rate only reflect limitations in the inherent performance of pulse generators, not characteristics of the environment.

Commentor II

II. C. REGULATORY POSITION, Section 2, 2nd paragraph

This paragraph takes issue with a statement in the IEEE 1050 standard and rather than simply providing clarification, proceeds to add confusion. It is probably fair to state that any person involved in the EMI industry will state that semantics is one of the greatest problems. Many technical terms will have different meanings in different context. To demonstrate this, CHAR Services quotes the following definitions, relating to electromagnetic waves and electric or magnetic fields, from IEEE Std 100, Standard Dictionary of Electrical and Electronic Terms:

radiated radio noise. Radio-noise energy in the form of an electromagnetic field including both the radiation and induction components of the field.

radiation, electromagnetic (antenna). The emission of energy in the form of electromagnetic waves.

field strength (electromagnetic wave). A general term that means the magnitude of the electric field vector, commonly expressed in volts per meter, but that may also mean the magnitude of the magnetic field vector, commonly expressed in amperes (or ampere-turns) per meter. *Note*: At frequencies above 100 megahertz, and particularly above 1000 megahertz, field strength in the far zone is sometimes identified with power flux density P ....

near-field region (1) (antennas). That part of space between the antenna and the far-field region. *Note*: In lossless media, the near-field may be further subdivided into reactive and radiating near-field regions.

reactive field (of an antenna). Electric and magnetic fields surrounding an antenna and resulting in the storage of electromagnetic energy rather than in the radiation of electromagnetic energy.

Section 2 of DG-1029 has presented the case that the E-Field does not fall off with 1/distance-squared, but only with 1/distance, which is true. In reality, the 1050 Standard does not say E-Field, only field. According to the above definitions the 1050 Standard statement in paragraph 4.3.7.4(c) is within the allowable definitions; however, it would probably create less confusion if the term "***field***" were replaced with "***electromagnetive wave energy***" in the 1050 Standard.

The discussion in the DG-1029 paragraph invoking the analysis of "field strength" being attenuated at either $1/r^3$, $1/r^2$ or $1/r$, relates to the analysis of the vector components from the Electric Dipole antenna and Magnetic Loop antenna . Without clarification, this creates confusion because it tends to conflict with the Biot-Savart law for magnetic flux density from a current carrying conductor, where the Magnetic Flux Density equals $\mu I/2\pi r$, stating that the magnetic field is directly proportional to the current and inversely proportional to the distance. Telling someone that the magnetic field falls off inversely with distance cubed from a power conductor for the ninth harmonic on the power system could get them into trouble.

The confusion as to whether the field strength falls off at either $1/r^3$, $1/r^2$, or $1/r$, arises when one fails to bound frequency (wavelength) and dimension of the current carrying conductor — or to describe the antenna. In addition, relating the choice between the electric field falling off at $1/r^3$ or the magnetic field falling off at $1/r^3$ being a function of the source impedance being greater than or less than 377 ohms is only a myth. In reality, the difference in attenuation lies in whether the source is an electric field dipole antenna or a magnetic loop antenna. In the analysis of the electric dipole antenna, the E-field vector has a $1/r^3$ component and in the analysis of the magnetic loop antenna, the H-field vector has a $1/r^3$ component.

As we start to take statements about field strength out of context, it becomes confusing as to whether we are talking about a long straight current carrying conductor or an electric field dipole and we can thus believe that the magnetic flux density falls off with distance squared from the current carrying source. Of course, this is not true. Henry Ott does not make this error nor do the basic physics texts. The MIL-STD 461D does make this error (more explained in discussion on DG-1029, paragraph 4.5) and when TR-102323-R1 was first written, this error was also introduced on page 3-4. <4>

It would be wise to point out that the paragraph 4.3.7.4(c) of the 1050 Standard should be discussing power and leave the rest for an accurate reference book. <5>

Finally, referencing a Standard by date of revision will force the users of this document to be using an outdated document when the applicable standard is later revised again. On the other hand, referencing a standard as a living document allows the user to apply the latest technology available from Standard Working Groups. It would be better to reference Standards as the "latest affirmed version." The IEEE Standard 1050 Subcommittee is currently planning a major rewrite of this standard. If there is fear that the revision of a standard might affect the intent of a REGGUIDE, then it would probably be best to include the requirements in the REGGUIDE and simply give credit to the source. <6>

Technical Responses

<4> As discussed in Section 2 of DG-1029, the statement is true that "field strength" (both electric and magnetic) falls off as the inverse of distance (1/r) in the far field of the electromagnetic radiation source. Indeed, this is acknowledged in the comment. A rationale is offered in the regulatory position as to why the statement is true and can be easily verified. The technical basis for the statement is cited in NUREG/CR-5941 with numerous references [Ott (1976), Johnson and Jasik (1984), Wolff (1966)]. The comment that the IEEE 1050 statement in paragraph 4.3.7.4 , which is the subject of the objection, is within allowable definitions is not valid given that the standard specifies that

it is addressing radiative coupling (a far-field effect) in the section under contention [see page 10 of IEEE 1050-1996].

The intent of the comment seems to be to point out that evidence taken out of context or incompletely presented can create confusion. It was the intent of the discussion in DG-1029 to clarify the context of the objection by presenting the rationale as support. The only likely technical question would be whether "radiative coupling" is really a far-field effect. That issue is easily resolved by referring back to the definition of "radiative coupling" provided in Section 4.2 of IEEE Std 1050-1996 (again, see page 10 of the standard). It states the following: "Radiative coupling refers to circuits located in the *far field* of a source where the source's emissions are seen as a true propagating wave." This definition formed the basis for the exception to the statement in Section 4.3.7.4 [see page 23 of the standard] that maintained that the "field strength" of propagating electromagnetic waves is inversely proportional to the *square* of the distance from the source of radiation. With a clear understanding of whether you are in the near field or far field of the source of radiation, there should be no confusion about attenuation rates ($1/r^3$, $1/r^2$, or $1/r$). Since "radiative coupling" is a far-field effect, the "field strength" falls off as the inverse of distance, not as the *square* of the distance.

Furthermore, there is no conflict between the Biot-Savart law (i.e., the magnetic flux density from a current carrying conductor equals $\mu I/2\pi r$) [Jordan and Balmain (1968)] and the attenuation rates associated with the "field strength." In the context of the comment, the Biot-Savart law is being applied to steady currents, hence there is no inverse-distance (radiation) term. If the Biot-Savart law was extended to cover the case of an alternating (non-steady) current, there would be an inverse-distance term. The traditional method used to derive electric and magnetic "field strengths" is by solving Maxwell's equations for electromagnetics. This derivation will yield "field strengths" comprised of terms related to distance ($1/r^3$, $1/r^2$, or $1/r$) and the source impedance. With terms that vary inversely with distance, it's easy to see that when r is large, some terms become negligible compared with others. There should also be no confusion about the types of source impedance, as indicated by the comment. This appears to simply be a case of semantics. The electric field dipole antenna is a high impedance source, while the magnetic loop antenna and current-carrying wire are typically low impedance sources.

Thus, the exception to Section 4.3.7.4 in IEEE Std 1050-1996 on how "field strength" falls off is appropriate and will be retained.

<5> It is incorrect to state that IEEE 1050, paragraph 4.3.7.4(c) should be discussing power since its scope is more general. IEEE Std 1050-1996 provides guidance concerning I&C equipment grounding in generating stations. As part of that guidance, Section 4.3 of the standard discusses techniques for minimizing electrical noise (EMI/RFI). This noise is more often portrayed in terms of voltages, currents, electric fields, and magnetic fields than in terms of power or power density. In particular, the context of Section 4.3.7.4 is radiated fields (electric and magnetic) and the techniques employed to minimize the coupling of unintentional noise (voltage and current) from the radiated fields into electronic equipment. Hence, it would appear to be inappropriate to point out that the

paragraph 4.3.7.4 (c) of the 1050 Standard should be discussing power, when it includes much more.

<6> The concept of referencing "the latest affirmed version" of a standard is unacceptable because a revision could drastically change the regulatory guidance being endorsed without a review by NRC. It should be noted that IEEE 1050 has recently undergone a revision and that DG-1029 endorses that version (IEEE 1050-1996).

II. C. REGULATORY POSITION, Section 3

Paragraph 1 on page 9 recommends that either the "C" or "D" version of this standard be used in it entirety with no mixing. This recommendation is taken from Section 7 of NUREG/CR-6431. At the same time, NUREG/CR-6431, in Section 8, CONCLUSION, points out that the MIL-STDs "may decrease in availability" and "There are commercial standards under development by the International Electrotechnical Commission (IEC) and ANSI." The MIL-STD's do not cover surge tests. The IEEE C62.41-1991 does. The IEEE C62.41 includes the issue of Fast Transients, but lifts the pulse specifications from IEC 801-4, 1988. Thus, one set of U.S. Standards will not cover all required tests. The current version of the IEC Standards will cover all required susceptibility tests. In addition, there were a number of technical justifications for the major revision of the MIL-STD 461 to the MIL-STD 461D, including adjustments of levels, coupling, and elimination of the Narrowband and Broadband comparison data. <7>

The statement is made that "these criteria cover... transients..." but on the next page Table 1 and Table 2 do not list any standard that covers transients. <8>

This section needs to be revised to provide a workable guide to achieve electromagnetic compatibility through the use of the available testing resources. Certainly, CHAR Services was not able to find a continuous roadmap to perform the desired tests according to acceptable standards. <9>

Technical Responses

<7> MIL-STD 461D provides the latest revision of the test criteria (which includes improvements based on experience and the latest technical information), thus it is the primary focus of this guidance. However, guidance on the MIL-STD 461C counterparts to the MIL-STD 461D test criteria is also given. The rationale behind the optional specification of the "D" and "C" test criteria is to avoid placing an undue burden on the nuclear industry by limiting the available test resources to those test laboratories with the MIL-STD 462D test capability. It is intended that *either* the MIL-STD 461D *or* MIL-STD 461C test criteria be applied in its entirety, without selective application of individual criteria (i.e., no mixing and matching of the "D" and "C" test criteria). The MIL-STD test suites were developed to be internally consistent and to provide complementary coverage of EMI/RFI phenomena. For example, applying low and high frequency conducted emissions tests from MIL-STD 462D (CE101 and CE103) as well as low and high frequency conducted susceptibility tests from the same standard (CS101

and CS114) gives acceptable coverage of the conducted continuous wave EMI phenomenon. Such coverage may need to be demonstrated when selecting test criteria from different standards.

The MIL-STDs do indeed provide methods for surge tests. However, the IEEE Std C62.41-1991 (Reaffirmed 1995) test criteria are endorsed because they provide more complete coverage of the phenomena. The combination of the MIL-STD and IEEE Std C62.41 test criteria form a solid basis for emissions, susceptibility, and power surge withstand test criteria to evaluate safety-related I&C systems.

It is true that dependence by the U.S. military branches on the MIL-STDs is expected to decrease. It is also true that a commercial standard has been recently issued by the IEC and another commercial standard is under development by ANSI. However, the regulatory guidance in DG-1029 is based on the review of technical standards available during the period in which the investigation was performed. Even though the IEC standard has been formally issued, copies of it have only been available for review in the last few months. It has been recommended in NUREG/CR-6431 that NRC follow the development of the commercial standards and review them for their applicability. If appropriate, these standards could be endorsed and included in future regulatory guidance.

<8> The inclusion of "transients" in the statement about the coverage of the MIL-STD EMI/RFI test criteria was an oversight and will be corrected.

<9> The section describing the regulatory position on EMI/RFI testing in DG-1029 already provides a workable guide to achieve EMC through the use of available testing resources. The recommended test criteria are comprehensive and guidance is provided on their applicability (e.g., no mixing and matching of test criteria). Tables 1 and 2 in DG-1029 list the test criteria for each MIL-STD and indicate the electromagnetic phenomena that each test addresses in the descriptions (e.g., CE101 addresses conducted emissions in the low frequency range). To further clarify the use of the test criteria, guidance will be added to the position stating that the MIL-STD 461D test criteria represent current practice but the counterpart test criteria in MIL-STD 461C are also acceptable. This flexibility helps avoid overly prescriptive guidance.

II. C. REGULATORY POSITION, Section 4, 4.1 CE101

The limits set in Figure 4-1 are 32 dBμA more restrictive than the TR-102323-R1 guidelines for the ac leads and 8 dBμA less restrictive for the dc leads. Further, these levels are inconsistent with the guidance in MIL-STD 461D, which really only apply to Army and Navy aircraft and Navy ships and submarines. Further, Figure 4-1 does not give any guidance for variations due to consumption power level. The result is that a device drawing 500 milliamperes ac power (114 dBμA at 60 Hz) could never pass this test. Suggest this paragraph and figure be revised to be more in line with the TR-102323-R1. <10>

Technical Response

<10> The paragraph and Figure describing the CE101 (conducted emissions, power leads, low frequency) test criteria and operating envelopes will be changed to address the technical observation that certain devices could not pass the ac emissions limit at 60 Hz. The distinction between equipment based on power consumption was erroneously omitted. This correction will lessen the difference between the draft regulatory guide envelopes for CE101 and the conducted emissions envelope addressed in the SER on EPRI TR-102323. The considerations that must be taken into account in the revision of the DG-1029 operating envelope are discussed below.

The first issue is the source of the CE101 emissions envelope in DG-1029. Since MIL-STD 461D CE101 provides no guidance on operating envelopes for military ground facilities, which have been identified as having electromagnetic conditions most comparable to nuclear power plants, it was appropriate to adopt the operating envelopes from MIL-STD 461C CE01 (conducted emissions, power leads, low frequency). The technical basis for establishing immunity levels for a particular phenomenon (e.g., conducted EMI/RFI) over a selected frequency range (e.g., 30 Hz to 50 kHz) is not dependent on testing criteria or methods but rather on the environment in which the equipment will be installed. Therefore, the caution against mixing and matching test criteria and methods is not violated.

The second issue is determining appropriate guidance for emissions envelopes suitable to nuclear power plants. A review of the MIL-STD 461D specifications and rationale [MIL-STD 461D App.] shows that the intent of the MIL-STD 461D CE101 envelopes is to limit the "amplitude of harmonic currents conducted on the power distribution system." The envelopes are "based on maintaining the harmonic distortion of the (platform) power distribution system within 5% of the supply voltage with any single harmonic being less than 3%." The MIL-STD rationale also states that total harmonic distortion (THD) that is greater than "5% is above the tolerance of most electronic equipment, induction motors, magnetic devices, and measuring devices." Therefore, the MIL-STD envelopes provide a sound basis for the DG-1029 envelopes.

MIL-STD 461C CE01 for military ground facility platforms offers a single envelope for application to dc power leads and two separate envelopes for application to ac power leads for 60 Hz equipment. The two ac power lead envelopes correspond to equipment operating at input power ratings greater than 1 kVA and less than or equal to 1 kVA and these envelopes provide the guidance for variations in power consumption. The envelope for ac power leads on equipment operating at less than or equal to 1 kVA ranges from the power line frequency to 10 kHz for CE101 and to 15 kHz for CE01. The envelope for ac power leads on equipment operating at greater than 1 kVA ranges from the first power harmonic to 10 kHz for CE101 and to 15 kHz for CE01. The break frequency for the envelope for ac power leads on equipment operating at less than or equal to 1 kVA is 1.15 kHz. The endpoints in the high frequency range (>1.15 kHz) of the CE101 and CE01 envelopes will be adjusted for use in DG-1029 to promote consistency among the conducted emissions operating envelopes at 10 kHz for CE101 and CE102 (conducted emissions, power leads, high frequency) and at 15 kHz for CE01 and CE03 (conducted emissions, power leads, high frequency). The dc power lead emissions envelopes for CE101 and CE01 remain unchanged.

The dc power lead emissions envelopes for CE101 and CE01 remain less restrictive than the emissions envelopes addressed in the SER on EPRI TR-102323. The ac power lead emissions envelopes for CE101 and CE01 exhibit a more complex comparative behavior, but the envelopes remain somewhat more restrictive than the envelopes addressed in the SER on EPRI TR-102323. The power quality basis for the MIL-STD emissions envelopes (5% THD) provides a compelling technical justification to retain the military level for the ac power lead emissions envelopes.

II. C. REGULATORY POSITION, Section 4, 4.2 CE102

The limits in Figure 4.2 are extracted directly from MIL-STD 461D and are specified in terms of dBμV while all of the survey data in TR-102323-R1 and NUREG/CR-6431 was measured in terms of dBμA. If one takes the starting point for the 115V limit at 10 kHz (100 dBμV) and converts this to current on a 50 ohm line, this equates to 66 dBμA and this point is discontinuous (by 21 dBμA) with the ending point from the limit for an ac line in paragraph 4.1. The uncertainty of actual line impedance at the point of measurement applies equally to both current and voltage measurement. However, the difficulty in making a voltage measurement was demonstrated in the site survey data by both EPRI and Oak Ridge. Clearly, voltage measurements are not practical and considerable site emission data exists in terms of current.

Suggest this paragraph be completely revised to give allowance to making measurements in terms of current and to keep the emissions levels consistent with paragraph 4.1 (to be revised) and the TR-102323-R1. <11>

Technical Response

<11> It is unnecessary to change the paragraph in the description of testing for high frequency conducted emissions to give allowances for making measurements in terms of current. The basic concern being addressed in the test is to ensure that equipment performance is not degraded from voltage ripples associated with the allowable distortion of power source voltage waveforms [Javor (1993)]. Since limiting voltage distortion is a major factor in the basis for the CE102 (conducted emissions, power leads, high frequency) test, the operating envelopes in the MIL-STD are specified in terms of dBμV. In addition, the test equipment specified in the description of the CE102 test method provides for voltage measurements. The use of a standardized line impedance (i.e., a line impedance stabilization network) over the frequency range of the CE102 test provides for the convenient measurement of the voltage as developed across this impedance. Hence, the voltage measurements are both simple and practical.

If the intent of the comment involves the fact that the CE102 operating envelopes are in terms of voltage while the site survey data are in terms of current, then it should be reiterated that the operating envelopes are presented in the measurement units of the test method. Thus, it is proper for the CE102 operating envelope to be displayed in terms of dBμV. It should be noted that the site survey data described in NUREG/CR-6436 were collected through the measurement of current levels because it involved a noncontact test methodology. Personnel at the nuclear power plants were reluctant to discuss any methodology that was invasive in nature (i.e., voltage measurements) and the approval process would have been time consuming and uncertain. Furthermore, the site survey data were not the basis for the operating envelopes in DG-1029 but were used to confirm the suitability of the envelopes. The process employed for converting the operating envelopes for comparison with the survey data is discussed in NUREG/CR-6431.

It is also unnecessary to change the CE102 emissions envelope so that the levels are consistent with the CE101 (conducted emissions, power leads, low frequency) envelope. The emissions envelope levels at 10 kHz for CE101 and CE102 in DG-1029 are consistent (see response <10>). In the CE102 test, control of the power source impedance is provided with a line impedance stabilization network (LISN). The impedance of the LISN is a few ohms at low frequencies and increases to approximately 50 ohms at the higher frequencies [see MIL-STD 462D, p. 24, Fig. 7]. The assumption made in the comment of a 50 ohm line impedance at 10 kHz for the conversion of the 115V CE102 operating envelope from voltage to current is not correct. At 10 kHz, the impedance of the LISN is only a few ohms and there is no disparity with the CE101 ac operating envelope. Note that the CE101 operating envelope is in terms of current because of the difficulty in controlling the power source impedance in test facilities at lower frequencies. This type of control would be necessary to specify the operating envelope in terms of voltage.

II. C. REGULATORY POSITION, SECTION 4, 4.3 CS101

This paragraph specifies susceptibility in terms of dBμV while the correlating emissions in paragraph 4.1 are specified in terms of dBμA. TR-102323-R1, in Figure 7-1 specifies the susceptibility test level in terms of dBμA. It turns out that the MIL-STD 461D specifies the actual limit as power output of the test generator and when taking the limiting case of trying to drive voltage into a low impedance filter, the two tests' limits are identical. For consistency and taking credit for lessons learn through NUREG/CR6341 and NUREG/CR-6436 regarding the measurement of EMI, the susceptibility test levels for this paragraph should be presented in terms of dBμA. <12>

Technical Response

<12> It is appropriate to present the CS101 (conducted susceptibility, power leads, low frequency) operating envelope in terms of dBμV since the CS101 test is used to verify the ability of equipment to withstand voltage ripples on power leads. The units of the CS101 susceptibility operating envelope are consistent with the units of the CE102 (conducted emissions, power leads, high frequency) operating envelope, and the units of both operating envelopes are indicative of the test methods. The CE101 (conducted emissions, low frequency) operating envelope is in terms of current because of the

difficulty in controlling the power source impedance in test facilities at lower frequencies. This type of control would be necessary to specify the operating envelope in terms of voltage. The comparable low frequency, conducted susceptibility operating envelope addressed in the SER on EPRI TR-102323 is expressed in terms of V (rms) and dBμA. There is a concern that mixing of measurement units could possibly lead to confusion in applying the operating envelopes. Therefore, the operating envelopes in DG-1029 are presented in the measurement units of the test method.

II. C. REGULATORY POSITION, Section 4, 4.4 CS114

On first appearance, this paragraph closely matches the susceptibility levels of TR-102323-R1 in Figure 7-2. However, this curve also bears no resemblance to the susceptibility limits in MIL-STD 461D, Figure CS114-1. If one selects the limits curve for Army, Ground (Table III of MIL-STD 461D) the required test level at 10 kHz is 49 dBμA, 54 dBμA below the level specified in Figure 4.4 of the DG-1029. The significance of this is that the CS114 has applied some experience in setting the absolute current levels low while the TR-102323-R1 has followed the CS02 guidance, which uses the power output criteria to limit the actual current. Certainly, the absolute requirement in Figure 4.5 for current levels would create a test problem if a high impedance filter were used on the input power. <13>

TR-102323-R1 deals with the issue of unknown impedance by reverting to the power limit of the source established in MIL-STD 461C, CS02, the equivalent of 1 watt of power into a 50 ohm load.

In reality, MIL-STD 462D specifies the test limits for CS114 as the forward power necessary to drive the current into a 50 ohm test fixture, normalized to 1 watt of applied power, similar to CS02.

The suggestion is that this paragraph clearly defines the conditions necessary to meet the susceptibility limits; that is, explain the limiting issue of power. <14>

Technical Responses

<13> The MIL-STD 461D CS114 (conducted susceptibility, bulk cable injection, high frequency) operating envelope was adjusted for the DG-1029 application to account for conducted emissions levels measured in nuclear power plants that were higher than the similar military environments. As a minimum, modifications of safety-related equipment must demonstrate that they can withstand the ambient conducted emissions in the plant. In the absence of other technical considerations, the operating envelope was raised to be consistent with the operating envelope addressed in the SER on EPRI TR-102323. The break frequency at 30 MHz and the endpoint at 400 MHz were maintained because of practical considerations regarding the ability of the test equipment specified in MIL-STD 462D to generate the desired test levels.

<14> Detailed information on the CS114 (conducted susceptibility, bulk cable injection, high frequency) test method is more appropriately left to MIL-STD 462D. The description in Section 4.4 of DG-1029 presents the test criteria for CS114 along with the associated operating envelope. The CS114 test actually involves coupling current levels onto power leads that were derived from voltage ripple levels and are specific to a recommended testing apparatus. Because the testing apparatus is well defined, it is a simple task to convert the current levels into voltage levels, if desired. The MIL-STD 461C CS02 operating envelope is given in terms of voltage. The power input for both test methods is limited simply to avoid overdriving the equipment under test. An explanation of this limitation is provided for both the CS114 and CS02 tests in the descriptions of the test methods in MIL-STD 462D and MIL-STD 462, respectively.

II. C. REGULATORY POSITION, Section 4, 4.5 RE101

This paragraph has good news and bad news. The good news is that it exempts equipment "that is not intended to be installed in areas with other equipment sensitive to magnetic fields." The bad news is that if you have to test for emissions, the emission levels are more restrictive than the TR-102323-Rl guidelines and also carry an error from the MIL-STD 461D standard.

First, dealing only with the 7 cm envelopes, the curve from Figure 4.5 is 30 dBpT more restrictive than the curve from the MIL-STD 461D, Figure RE101-2 and 10 dBpT more restrictive than the limit from TR-102323-R1, Figure 7-3. A reasonable compromise would be to defer to the 7cm curve in Figure RE101-2 from the MIL-STD 461D. <15>

The second issue is the addition of two limit curves, one for 7cm distance from device under test and one for 50 cm distance from device under test, with 34 dBpT separation at the low frequency end and 40 dBpT separation at the high frequency end. The MILSTD 461D shows a separation of 34 dBpT (factor of 50) between these two curves, presumably due to the magnetic field falling off inversely with distance squared. Here the error is that the magnetic flux does not fall off inversely with distance squared, but only inversely with distance. This error seems to have developed out of the interpretation of vector fields from a radiating antenna and is often referred to as Biot-Savart's Law or Amperes Circuital Law. Attachment 2 to this document discusses the issue in detail with references. The technical references reviewed by CHAR clearly state that the magnetic field due to a long straight wire will fall off inversely with distance. This being the case, the difference between the limits at 7 cm and 50 cm should only be 17 dBpT, not 34 dBpT. Because of this error, an equipment could pass the test at 7 cm, but fail at 50 cm.

The suggestion here is to adopt the limit from Figure RE101-2, MIL-STD 461D for 7 cm and eliminate the limit for 50 cm. <16>

Technical Responses

<15> The emissions envelopes for radiated magnetic fields will be modified to correct an error in establishing the appropriate levels. The envelope given in Figure RE101-2 of MIL-

STD 461D, which relates to radiated magnetic field emissions measured 7 cm away from equipment, was adopted as the basis for the 7 cm emissions envelope presented in DG-1029. However, adjustments were made to the MIL-STD 461D RE101 (radiated emissions, magnetic field, low frequency) operating envelopes for use in DG-1029. The rationale for these changes was that virtually no margin was allowed between this operating envelope for equipment emissions measured at a distance of 7 cm and the RS101 (radiated susceptibility, magnetic field, low frequency) operating envelope for radiated susceptibility over the same frequency range. Some margin was deemed necessary to control the potential future growth of radiated magnetic field levels within specific areas of nuclear power plants. In the absence of other technical considerations, the operating envelope for emissions measured 7 cm away from the equipment was lowered to be generally consistent with the operating envelope addressed in the SER on EPRI TR-102323. However, the comparable envelope presented in the April, 1994, version of EPRI TR-102323 was used as the basis for the adjustment. Since the September, 1994, version of EPRI TR-102323 was reviewed by NRC staff as the subject of the SER, outdated envelopes were used as the point of comparison for the RE101 operating envelopes. Thus, the level to which the RE101 envelopes in DG-1029 are adjusted will be corrected to be consistent at the lowest frequency with the operating envelope addressed in the SER on EPRI TR-102323.

<16> A review of the military rationale for the RE101 (radiated emissions, magnetic field) test determined that the emissions measurement at 50 cm away from the equipment under test is intended as an alternative to the measurement at a distance of 7 cm. Therefore, DG-1029 will be revised to clarify that the user has the option of measuring the equipment emissions at either distance. However, the argument that the RE101 operating envelope for emissions measured at 50 cm away from the equipment should be eliminated because of an error in the envelope is incorrect. The application of the Biot-Savart law [Jordan and Balmain (1968)] to the 50-cm operating envelope for radiating magnetic fields due to alternating current (i.e., varying with frequency) is a misapplication of the law. The Biot-Savart law applies to steady (dc) current flowing in a long wire. If the Biot-Savart law were extended to cover the case of an alternating current, it can be shown that the radiated magnetic fields do indeed fall off inversely with distance squared.

II. C. REGULATORY POSITION, Section 4, 4.6 RE102

The emission limits in Figure 4.6 appear to be taken from MIL-STD 461D, RE102-2 and were meant to apply to aircraft and space system applications. At 1 MHz, these limits, at 24 dBμV/m, are 50 dBμV/m more restrictive than the limits in TR-102323-R1, Figure 7-4. The survey data reported in NUREG/CR-6431, Table 6.2, indicate the highest observations are in excess of 107 dBμV/m. The TR-102323-R1 closely matches the FCC Part 18 Industrial Scientific and Medical Emission guidelines. The Figure 4.6 emission limits do not appear to be based on either the ORNL experience or the EPRI experience and would result in unreasonable requirements for equipment manufacturers.

The suggestion here is to use the existing Site Survey data to set reasonable emission limits, comparable to the TR-102323-R1 guidelines. <17>

Technical Response

<17> Using site survey data to establish operating envelopes is in contrast to the technical approach taken to develop the operating envelopes described in DG-1029. The technical basis for all the operating envelopes in DG-1029 begins with MIL-STD envelopes corresponding to the electromagnetic environment military ground facilities. The electromagnetic conditions in military ground facilities were judged to be comparable to that of nuclear power plants based on general layout and equipment type considerations. Plant emissions data from the EPRI and ORNL site surveys were employed to confirm the adequacy of the susceptibility envelopes presented in DG-1029. Without established control of all potential EMI emitters (as is the case on military platforms), it is difficult to provide a technical justification for equipment emissions envelopes based on measured data of current site conditions. Since a primary purpose of equipment emissions envelopes is to control the growth of the electromagnetic environment at a site and since there is no mechanism required to control emissions from new installations of nonsafety-related equipment, the adopted approach was to maintain the military emissions envelopes as a general rule. However, a review of the rationale for the MIL-STD operating envelopes indicates that there are some instances where MIL-STD envelopes are primarily intended to protect sensitive receivers, which would not be common in nuclear power plants. It has been determined that the MIL-STD 461D RE102 (radiated emissions, electric field, high frequency) envelopes are based on that consideration. Therefore, these envelopes will be modified based on the MIL-STD rationale and the comparable Federal Communications Commission (FCC) Part 15 and International Special Committee on Radio Interference (CISPR) limits for industrial class equipment. The modified RE102 envelope will actually be less restrictive over certain frequency bands than the emissions envelope endorsed by the SER on EPRI TR-102323.

The original RE102 operating envelope presented in DG-1029 was based on Fig. RE102-3 in MIL-STD 461D. The envelope for Army ground applications was selected. The envelope was extended below 2 MHz to provide complete coverage of the frequency range corresponding to the test method. The basis for the envelope from 10 kHz to 2 MHz is a relationship with CE102 (conducted emissions, power leads, high frequency), which addresses power quality issues [MIL-STD 461D App., p. A-25]. Thus, the emissions envelope was continuous over the frequency range corresponding to the test criteria in DG-1029 and provided consistent coverage compared to RE02 (radiated emissions, electric field, high frequency). Use of the restrictive Army emissions envelope was justified because the site survey data for electric fields, reported in NUREG/CR-6436, closely approach the 8 dB margin band below the RS103 (radiated susceptibility, electric field, high frequency) operating envelope. Therefore, close control of radiated electric field emissions seemed justified.

II. C. REGULATORY POSITION, Section 4, 4.7 RS101

The limits for this paragraph are the same as TR-102323-R1 and the MIL-STD461D Figure RS101-2. The TR-102323-R1 gives some suggestions for reducing susceptibility levels based on distance from magnetic sources or use of shields. Such discussion could be added to this paragraph. In addition, clarification could be added to note that this test represents reactive field coupling in the near field and is quite different from radiative wave coupling in the far field, in which the E-Field vector component is specified as a measure of the radiating electromagnetic wave. <18>

Technical Response

<18> Suggestions for reducing magnetic field susceptibility levels are not within the scope of the RS101 test criteria and can be found in IEEE Std 1050-1996. Regarding the second point of the comment, it seems unnecessary to include a discussion of coupling mechanisms in the presentation of test criteria for RS101 (radiated susceptibility, magnetic field, low frequency). The nature of the RS101 test is such that it does indeed represent reactive field coupling in the near field. This becomes obvious when reviewing the MIL-STD 462D test method.

II. C. REGULATORY POSITION, Section 4, 4.8 RS103

The limits for this paragraph first appear to be exactly the same as the limits recommended in TR-102323-R1, Figure 7-4. However, added detail in the second paragraph of 4.8 creates a test condition that would make it impossible to conduct a proper test. This detail is the requirement that the "impressed electric field level should be 10 V/m (rms), measured at the surface of the equipment under test with a field strength meter." <19>

This requirement for a field strength meter may be traced to the statement in MIL-STD 462 Method RS103, paragraph 3.d.(1) which states: "Placement of electric field sensors (see 3b). Position sensors 1 meter from, and directly opposite, the transmit antenna as shown in Figures RS103-2 and RS103-3. Do not place sensors directly at corners or edges of EUT components." (Electric field sensors are required for testing between 10 kHz and 1 GHz.)

The Appendix to MIL-STD 462, Test Method RS103 discusses the monitoring requirements on page A-69. This discussion includes both the electromagnetic wave and the E-field component and mentions the far field issue. Knowledge of traveling wave theory should prevent someone from placing an E-field sensor at the surface of a reflecting shield since the E-field from an impinging electromagnetic wave must go to zero at the surface of a reflecting shield. However, CHAR has on a number occasions observed a test laboratory placing an E-field sensor at the surface of the equipment under test, only to then announce that they have insufficient power to create 10 volts per meter at the surface of the equipment under test, or as in one case, announce that they had "burned up" the transmit antenna by driving too much power.

The procedure under MIL-STD 462C (and as an option in MIL-STD 462D) was to replace the equipment under test with a receiving antenna and calibrate the transmitting system to obtain an electromagnetic wave with an E-field strength of the desired level.

Then, the receiving antenna would be replaced with the equipment under test and the test system would be operated at the calibrated levels that create the desired electromagnetic wave. Any conductor exposed to this wave will disturb the EM environment—which in turn causes interfering signals to flow in these conductors. And, it is for this reason that it is important to expose interconnecting cables to the electromagnetic wave.

The MIL-STD 462D, Appendix, page A-70 makes mention that, "At frequencies where far-field conditions do not exist, sensors must be selected which have electric field sensing elements. Sensors which have magnetic field or power density and convert to electric field are not acceptable. Under far-field conditions, all sensors will produce the same results." Using the far-field definition for an Electric Dipole antenna being 8/2B, this translates to the lowest frequency that will produce far field affects at 1 meter to be 50 MHz. The comparable IEC Standard, IEC 1000-4-3 recognizes this limitation and starts their comparable E-Field radiation testing at 80 MHz, relying on the high frequency conducted test to cover the lower radio frequencies.

There are a number of suggestions for this paragraph. The first one is that the IEC 1000-4-3 is a better standard than the MIL-STD 461D, RS103. <20> The second suggestion is that if you are going add details to the referenced standard, they need to be correct and then you need to know where to stop. Either let the standard stand on its own feet or include all critical details. <21> The third suggestion is that some relief be given for the starting frequency, following the guidance in the IEC 1000-4-3. <22> The fourth suggestion is to extend the critical frequency to 10 GHz because the plants are starting to use cellular type communications that operate around 2 GHz — or give the plants relief from performing susceptibility testing at these frequencies. <23>

Technical Responses

<19> The comment is correct in its discussion of electric field measurement techniques. The statement in question will be changed to read: "The impressed electric field level should be 10 V/m (rms), measured in accordance with the techniques specified in the RS103 test method."

<20> While the observed value of the IEC 61000-4-3 may be true, the test method has yet to be formally reviewed by NRC. It is expected to be reviewed in conjunction with the entire series of IEC 61000-4 tests. The relative value of the IEC 61000-4-3 test method compared to the RS103 test method will be assessed at that time.

<21> The suggestion is valid and appears to be in reference to the erroneous statement in DG-1029 about measuring the electric field level at the surface of the equipment under test with a field strength meter. A correction to the statement is discussed in response <19>.

<22> Given that IEC 61000-4-3 has not been reviewed, that rationale for relief in the starting frequency for RS103 (radiated susceptibility, electric field, high frequency) has not been evaluated. However, a review of the rationale for MIL-STD 461D does indicate that such relief is permitted provided that the CS114 (conducted susceptibility, bulk cable

injection, high frequency) test is performed for the equipment under test. Therefore, DG-1029 will be revised to allow an exemption in the low frequency range (below 30 MHz) for the RS103 test provided the CS114 test is also conducted.

<23> The value of extending the RS103 (radiated susceptibility, electric field, high frequency) envelope to cover up to 10 GHz is recognized. However, the upper frequency for the RS103 test was set at 1 GHz for two reasons. First, the need for guidance on susceptibility levels above 1 GHz in nuclear power plants arose after the operating envelopes were adopted. In fact, there were no measurable emissions observed in the frequency range 1 GHz to 8 GHz during the site survey of nuclear power plants reported in NUREG/CR-6436. Second, the MIL-STD 461D RS103 envelope for military ground facilities is 50 V/m above 1 GHz. This envelope seems unsuitable for nuclear power plant application. Since the completion of the original research on the technical basis for DG-1029, cellular-type communications have become common in this frequency range, and the issue should be revisited. However, before guidance can be included, the technical basis for an acceptable operating envelope must be developed for this frequency range. In the interim, exclusion zones can be established through administrative controls to prohibit the activation of portable transceivers (communication devices) in areas where safety-related I&C systems have been installed. Thus, exclusion zones are a means to address the potential susceptibility issue.

II. C. REGULATORY POSITION, Section 5

CHAR Services has not bothered to review this section in detail, but notes that: First, the comments given for Section 4 can be generally applied also to this section. Second, the IEC Standard 1000-4 series is superior to both the C & D Versions of the MIL-STD461/462 and to force the U.S. Nuclear Power Plants to use a Standard that is different from the generally accepted international Standard will put the U.S. Industry at an economic disadvantage. <24>

Technical Response

<24> The IEC 61000-4 standard has not been formally reviewed since it was under development during the period in which the technical basis for DG-1029 was developed. Copies of IEC 61000-4 have only been available for a few months. It has been recommended in NUREG/CR-6431 that NRC review this standard for its applicability to the nuclear power plant environment. If appropriate, this standard could be endorsed and included in future regulatory guidance.

II. C. REGULATORY POSITION, Section 6

The information in this section closely follows IEEE Std C62.41 except that C62.41 describes (paragraph 8.5) five types of waveforms with two of them being recommended as standard and the others as additional. The standard waveforms are the 100 kHz Ring Wave and the Combination Wave. Section 6 of DG-1029 recommends the 100 kHz Ring Wave, the Combination Wave, and the 5/50ns EFT Burst. When compared to the IEC

1000-4 Series, the 100 kHz Ring Wave and Combination Wave would be called surge tests (IEC 1000-4-5) and the 5/50 ns EFT Burst would be called the EFT Burst test (IEC 1000-4-4).

While the IEEE Standards can be credited for providing the basic direction in this area, the IEC Standards are once again superior and are becoming the international standards. Further, the EFT Burst test was also first introduced by the IEC Standard. With this in mind, examining the IEC 1000-4-5 Standard for Surge tests, one finds that the Ring Wave is no longer recommended while the 10/1000 microsecond Wave (also in C62.41) is. There is sufficient basis to invalidate the Ring Wave test requirement since the ringing is the resonant response to an Impulse stimulation of a circuit — and in reality this ring frequency will change with each change to cabling or lumped elements in a system. There is also some basis for including the long 10/1000 microsecond waveform because of the spatial extent of the power distribution system in a power generating plant. <25>

The TR-102323-R1 allows use of a number of standards and recommends only the types of waveforms and the amplitude. The TR-102323-R1 test levels for the Combination Waveform Surge test are the same as DG-1029.

The TR-102323-R1 recommended levels for the EFT Burst test are at least a factor of two more restrictive than DG-1029 in that TR-102323-RI sets a test level of 3 kV as measured into a 50 ohm load applied to both the power leads and through a coupling clamp to the I/0 cables. Paragraph 6.3 of DG-1029 simply requires a test level of 3 kV. Further, the IEC 1000-4-4 recommends cutting this level in half when testing the I/0 cables. CHAR Services has observed that many EMI Test Laboratories will perform this test at 4 kV (open circuit measurement) on the power leads and 2 kV (open circuit measurement) on the I/0 cables and state that it satisfies the TR-102323-RI. In essence, this is the way the Digital Time Delay Relay (associated with Emergency Diesel Generator) was tested for Beaver Valley, which then later suffered failure due to EMI. And, which the NRC investigated thoroughly. <26>

The good news with regard to DG-1029 is that the relaxation of the EFT Burst test levels will make it much easier to qualify new equipment for EMI. And, it is encouraging to see that the NRC has backed off from their demand to the EPRI Working Group for TR-102323-R1 for the high test level.

The bad news is that, since the fast transients have been the cause of much of the EM interference, the reduced test levels may not be sufficient to establish electromagnetic compatibility.

Technical Response

<25> See response <24>. Since the IEC 61000-4 standard has not been reviewed, comment cannot be offered on the suggestion that there is sufficient basis to invalidate the Ring Wave requirement. It can only be stated that current guidance contained in IEEE C62.41-1991 (Reaffirmed in 1995) includes the 100 kHz Ring Wave as a standard waveform for

surge withstand testing. Thus, there is not sufficient technical justification to change the guidance in DG-1029.

<26> The power surge test criteria in IEEE Std C62.41-1991 (Reaffirmed in 1995) are only applicable to power leads. EPRI TR-102323 endorses the IEC 801-4 and 801-5 surge test criteria, and they are applicable to both power leads and signal lines. Because IEEE Std C62.41-1991 does not focus on signal line conducted susceptibility, the SER on EPRI TR-102323 is recognized as representing current guidance for addressing this issue. In the meantime, a separate investigation has been initiated by NRC to develop the technical basis for establishing appropriate signal line susceptibility test criteria. At present, the EFT Burst test level recommended by EPRI TR-102323 and DG-1029 for power leads are the same (i.e., 3 kV) and both test methods employ similar a similar coupling apparatus.

II. C. REGULATORY POSITION, Section 7

This paragraph defines the necessary elements to define electromagnetic compatibility. It is both necessary and well done.

Commentor III

III. A. INTRODUCTION, Page 2, fourth line

Use of the word "stressors" to characterize EMI/RFI and surges may be ambiguously interpreted. Although this term can be interpreted as benign, it can also be interpreted as an upset of equilibrium, suggesting an inevitable problem. I am concerned that the user or regulatory personnel may take the meaning as more than is intended by the author(s). I suggest that "stressor" be replaced with "condition" to communicate the intent more clearly. <27>

Technical Response

<27> To avoid the possibility of misinterpretation, the term "conditions" will be used in place of "stressors." However, research conducted for NRC has identified EMI/RFI and power surges as environmental "stressors" that can affect the performance of electrical equipment that is important to safety (such as that described in NUREG/CR-5700, NUREG/CR-5904, NUREG/CR-6406, NUREG/CR-6479, and NUREG/CR-6579). In this context, a "stressor" is a phenomenon that causes the safety-related equipment to exhibit a malfunction or degradation of performance beyond its specified operational tolerances.

III. IMPACT, Page 34, fourth line

"Plants that plan to upgrade safety-related I&C systems" might be a larger group than minimal costs might imply, depending on what constitutes an upgrade. If "upgrade" is specifically understood by all plants and inspectors, then this comment is simply a product of my limited knowledge. But if upgrade is subject to interpretation, the Impact statement should address in detail what change to the I&C systems would constitute an upgrade. <28>

Technical Response

<28> To more clearly define the scope of applicability for DG-1029, the terminology will be changed from "upgrade" to "modification to safety-related equipment." A modification is the introduction of equipment to a safety-related I&C system that differs from the original equipment in terms of technology, fabrication, functional configuration, or performance. For example, a modification might be the replacement of an original analog safety-related I&C system with a new digital safety-related I&C system or a new analog safety-related system of a different design. A modification is not intended to constitute the interchange of identical electrical parts during the repair or maintenance of a safety-related I&C system.

III. General Comment

If, in fact, the guidance given is consistent with established practices and does not unduly limit the ability of the plants to maintain/improve the I&C systems in place, the Reg guide appears to be a useful tool.

Commentor IV

IV. General Comments

In general, DG-1029 is overly prescriptive and contains too much technical detail for a Regulatory Guide. Regulatory Guides typically describe, in rather simple terms, the requirements to be met and are generally limited to a few pages. <29>

The guidance recommended by DG-1029 appears to depend heavily on testing, particularly testing during equipment installation. Such guidance would appear to be more applicable to new nuclear plants than to existing plants. Accomplishing such testing for existing power plants would be extremely costly and would involve a fair amount of risk (i.e., plant testing itself could generate EMC/RFI induced equipment misoperations). DG-1029 should be limited to new plant designs. However, the "Impact" section of DG-1029 states that the guide would apply to "...presently operating nuclear power plants that plan to upgrade safety-related I&C systems." Correction and treatment of Electromagnetic Interference/Radio-Frequency Interference (EMI/RFI) typically involves a "system level" approach. Thus it may not be possible to limit the application of DG-1029 requirements to "new" or "upgraded" equipment at existing plants. <30>

The types of testing described in DG-1029 appear to be more suitable to factory or qualification/certification type testing rather than field testing. The equipment and skills needed to conduct and evaluate the results of such testing are fairly specialized and not generally available at operating nuclear plants. In particular, the test methods of Sections 4 and 5 of DG-1029 describe and endorse a battery of tests of this nature. <31>

The proper application of Electromagnetic Interference/Radio-Frequency Interference (EMI/RFI) and SWC considerations is as much an art as a science. To some extent this is acknowledged in DG-1029 Section B (Discussion) which recognizes that the EMI/RFI practices endorsed by DG-1029 "...are only elements of the total package that is needed to ensure EMC within nuclear power plants." Although DG-1029 discusses several standards related to EMI/RFI and SWC, there are <u>many</u> more which may be applicable to a given installation. Simply discussing and endorsing a few standards might: (1) suggest these few are sufficient to provide adequate protection, and (2) impose overly restrictive requirements when other options may be available to more effectively address EMI/RFI considerations. <32>

"Low tech" methods of solving EMI/RFI concerns are not adequately addressed, or not addressed at all, in DG-1029. However, such methods are often the most effective, from both a cost and performance perspective. Examples of "low tech" methods include administrative exclusion of source of EMI/RFI, magnetic shielding, error checking schemes (typically applied to digital systems), etc. <33>

Technical Responses

<29> It is not the intent of DG-1029 to be prescriptive, but to provide a well-established, systematic approach based on consensus standards for ensuring EMC and the capability to withstand power surges in safety-related I&C equipment within the environment in which it operates. DG-1029 contains only as much technical detail as is needed to describe the design, installation, and testing practices acceptable to the NRC staff for addressing the effects of EMI/RFI and power surges on safety-related I&C equipment. The technical detail in DG-1029 is comparable to the detail in EPRI TR-102323.

<30> First, the regulatory position described in DG-1029 is consistent with the previous staff position expressed in the SER on EPRI TR-102323 in that each applies to both future nuclear power plants and to presently operating nuclear power plants that plan modifications of safety-related equipment. Neither position applies to existing equipment that is not scheduled for modification. Thus, existing installations of safety-related equipment are unaffected by EMC guidance. Second, there is apparently a misunderstanding of the application of DG-1029. The guidance in DG-1029 does depend heavily on testing, but <u>not</u> testing following equipment installation at a plant. The testing practices are not installation tests but rather are intended to be performed in a test facility or laboratory. The recommended design and installation practices are intended to minimize problems associated with installing safety-related I&C systems in future nuclear power plants and presently operating plants that are planning modifications.

<31> The types of EMI/RFI and power surge tests described in DG-1029 are intended to be performed in a test facility or laboratory. They are <u>not</u> intended for installation or field testing. To make this usage clear, a statement will be added to DG-1029 identifying these as laboratory, not site, tests.

<32> A number of technical standards were reviewed during the course of the investigation and the standards endorsed in DG-1029 were found to be applicable for establishing regulatory guidance that would provide a systematic approach to addressing EMC. NUREG/CR-5941 and NUREG/CR-6431 document the technical basis behind the selection of these standards. There are additional standards of interest that are either under development or have been developed since the investigation was completed. The regulatory position described in DG-1029 does not prohibit the use of any other standards, but gives guidance on one method that is acceptable to NRC staff. See response <7>.

<33> A number of "low tech" methods for solving EMI/RFI concerns are addressed in IEEE Std 1050-1996. These include wire and cable separations, shielding techniques, shielded enclosure integrity, apertures, gasketing, grounding techniques, EMI/RFI filters, and circuit board layouts. Other methods, like EMI/RFI source identification and exclusion zones, are discussed in DG-1029.

IV. C. REGULATORY POSITION, Section 6, 2nd paragraph

Section 6, Paragraph 2 of DG-1029, describes Location Categories (A, B, C) and Exposure Levels (High, Medium, Low) which are outlined in IEEE C62.41-1991. As stated in DG-1029, acceptable surge withstand capability (SWC) levels are "...based on a Category B location and a Low to Medium Exposure Level." Category B (feeders and short branch circuits with 10 meters from the service entrance) appears to be arbitrarily conservative for most nuclear plant circuits of concern. First, the term "service entrance" is not standard terminology used for nuclear plant electrical distribution systems. Thus, it is not clear where the service entrance is. Second, if one conservatively assumes the service entrance point is at the unit substation (medium to low voltage transition point), feeding I&C circuits of concern, most of these circuits would be Category A (long branch circuits greater than 10 meters from the service entrance). In any case, such detailed and prescriptive guidance is out of place in a Regulatory Guide. <34>

Technical Response

<34> The discussion in Section 6, paragraph 2 of DG-1029 is not prescriptive guidance but rather a description of the rationale for the selection of the withstand levels that are presented in the following sections. The endorsement of test methods and withstand levels represents the guidance of the regulatory position. It is not the intent of DG-1029 to classify by decree all locations in a nuclear power plant as belonging to a particular location category with a particular exposure level. Instead, the categories defined in IEEE C62.41-1991 (Reaffirmed in 1995) are identified along with the different exposure level groupings and then the basis for the withstand levels is stated (i.e., *Category B* locations with a *Low to Medium Exposure* level). The basis for the withstand levels was selected because it reasonably bounds projected surge conditions in nuclear power plants with adequate margin. In the same sense, the EMI/RFI operating envelopes reasonably bound the projected electromagnetic conditions in nuclear power plants with adequate margin.

In the context of IEEE Std C62.41-1991, "service entrance" is the point at which power enters a building or structure. Based on this description of "service entrance," it is true that a large number of the circuits in a nuclear power plant would be *Category A*. However, an assumption was made that *Category B* would be a reasonable bounding case for the exposure of most circuits to power surges. Details of the rationale for the Category and Exposure Level selections are provided in NUREG/CR-5941.

IV. C. REGULATORY POSITION, Section 7

Section 7 (Documentation), creates a new requirement for extensive documentation regarding compatibility of equipment. This section describes "...an electromagnetic compatibility report as part of a qualification file..." which would contain a number of elements making it similar in nature to an Environmental Qualification Data Package as is required by 10 CFR 50.49. This extensive new documentation requirement would not appear to be justified by the benefits that would be derived for existing plants. <35>

Technical Response

<35> Section 7 is not intended to create a new requirement for extensive documentation. The sentence describing "...an electromagnetic compatibility report as part of a qualification file..." will be changed to avoid misinterpretation. Instead the paragraph will read as follows: "The content of EMC documentation should contain the information listed below, as well as any additional information specified in the standards cited in this regulatory position." The referenced documentation should address necessary evidence that safety-related I&C equipment meets its specification requirements and is compatible with the projected electromagnetic environment, that the user adheres to acceptable installation practices, and that administrative controls have been established covering the allowable proximity of portable EMI/RFI sources. Such documented evidence is routinely required as quality assurance records to confirm that a design accommodates the effects of the service conditions to which it will be subjected. This documentation will benefit both future and existing plants.

IV. A. INTRODUCTION

Section A (Introduction), page 2, paragraph 2, makes the statement that "The technical basis behind selecting these particular practices is given in...a draft of NUREG/CR-6431..." Referencing a draft NUREG is in appropriate. The following paragraph (continued on page 3), in fact, states that "Draft regulatory guides have not received complete staff review; they therefore do not represent official NRC staff positions." The reference to the draft NUREG/CR-6431 should be removed from the guidance. <36>

Technical Response

<36> NUREG/CR-6431 will be finalized before the conclusive regulatory guide is issued so the referenced document will be a final, fully reviewed document. In addition, DG-1029 is being reviewed by NRC staff and the conclusive version will represent official NRC staff positions.

IV. B. DISCUSSION

Section B (Discussion), page 7, states that "It is suggested that, when feasible, the emissions from nonsafety-related systems be held to the same levels as safety-related systems." This statement could be construed in practice as a requirement and would increase the documentation burden described in comment 7 (see comment <35>) above. This sentence should be deleted. <37>

Technical Response

<37> There is no justification for deleting statement on nonsafety-related equipment emissions because it is part of the Discussion section and is not part of the regulatory position. However, the wording will be revised to add clarity to the point. The suggested practice

should not be construed as a requirement, nor is it indicated to be such. Indeed, it is clear in DG-1029 that nonsafety-related systems are not addressed by the regulatory position. The statement in question has value because it represents a caution to consider the consequences of emissions from new or modified nonsafety-related equipment, which can alter the electromagnetic service conditions for safety-related equipment.

Commentor V

V. General Comments

The test criteria listed and limit lines depicted in the draft RG appear to come from different documents. They appear to be from Military Standard MIL-STD 461D and C or the EPRI TR-102323, "Guidelines for EMI Testing in Power Plants," document. We recommend that the draft RG include information to clarify that the established limits/levels are a combination of various standards. <38>

The EPRI TR-102323 document allows plants to take credit for equipment which is commercially tested and approved for emissions in accordance with Federal Communications Commission (FCC) Part 15 Class A equipment. We recommend that this option be addressed in the draft RG. <39>

The EPRI TR-102323 document allows for the use of optional test methodology. The International Electrotechnical Commission (IEC) 801 series is one which parallels the military standards (MIL-STDs). We recommend that the NRC consider the use of alternate test methods. <40>

Presently we are finding that manufacturers of electronic equipment are supplying at no additional cost "certificates of compliance" to other standards (e.g., IEC). We recommend that the NRC consider including these other standards in the draft RG. <41>

Technical Responses

<38> A brief summary of the technical basis will be included in DG-1029 to clarify the source of the operating envelopes. The summary will state that the technical basis for all of the EMI/RFI operating envelopes in DG-1029 begins with MIL-STD envelopes corresponding to the electromagnetic environment military ground facilities, which were judged to be comparable to that of nuclear power plants based on general layout and equipment type considerations. From the MIL-STD starting point, susceptibility envelopes were adjusted to account for the plant emissions data available from the site surveys reported in NUREG/CR-6436 and in EPRI TR-102323. Adjustments to the emissions envelopes considered margin with the susceptibility envelopes and the primary intent of the MIL-STD envelopes (e.g., whether they were specified based on protecting sensitive receivers on military platforms). Finally, when changes to the operating envelopes were motivated by technical considerations, consistency among the envelopes for comparable test criteria from similar suites of test methods (e.g., between MIL-STD 461D and MIL-STD 461C or between the DG-1029 and the SER on EPRI TR-102323) was promoted and commercial emissions limits for industrial environments were factored into the adjustments. As it is stated in the INTRODUCTION section of DG-1029, greater detail on the technical basis for the operating envelopes is given in NUREG/CR-5941 and NUREG/CR-6431.

<39> The testing requirements for FCC Part 15 Class A equipment can be used to address some aspects of emissions testing for safety-related equipment in nuclear power plant. Part 15 of the FCC Rules requires that any Class A "digital devices" comply with specific conducted and radiated emissions limits for commercial environments. Conducted emissions are controlled in the frequency range 450 kHz to 30 MHz and radiated emissions are controlled in the frequency range 30 MHz to beyond 960 MHz. Following a review of the rationale for the RE102/RE02 (radiated emissions, electric field, high frequency) test and CE102/CE03 (conducted emissions, power leads, high frequency), the operating envelopes for those tests will be changed so that they encompass the FCC Class A and CISPR Class A requirements. Therefore, equipment that pass these commercial tests will meet the requirements for equipment emissions in DG-1029 over the same frequency ranges. However, the FCC (and CISPR) limits do not provide the same frequency coverage as DG-1029. Hence, equipment that passes the FCC tests may not necessarily pass the emissions tests addressed in the regulatory position described in DG-1029 in all frequency bands. Thus, evidence is required to show that equipment carrying FCC certification also satisfies the DG-1029 emissions criteria in the lower frequency bands.

<40> The regulatory position in DG-1029 does permit the use of alternate test methods. Tables 1 and 2 in DG-1029 identify optional suites of EMI/RFI test criteria from MIL-STD 461D and MIL-STD 461C, respectively, that are acceptable. The regulatory position described in DG-1029 does not encourage the mixing and matching of test criteria and methods. DG-1029 describes operating envelopes that are tailored for the specific test methods. In effect, a set of operating envelopes are established for the MIL-STD 461D criteria while another comparable set are established for the MIL-STD 461C criteria. The option of using complete test suites is appropriate while the mix-and-match option could result in confusing and unverifiable test results.

EPRI TR-102323 can be interpreted as allowing the user to mix and match tests from the MIL-STDs and IEC 801. Because of the mix-and-match option, EPRI TR-102323 gives generic test levels over extended frequency ranges rather than method-specific test levels framed in suitable units and frequency ranges. As a result the frequency ranges sometime extend beyond the ranges covered by some of the recommended test methods. Therefore, testing may be required over frequencies for which a particular test method has not been validated or for which the specified test equipment may not be designed to accommodate.

DG-1029 does not contain any guidance on the use of IEC 801 since the intent of the regulatory position is to endorse finalized standards for use in ensuring EMC. IEC 801 still contains draft parts that have not been approved by ballot. With the recent issuance of IEC 61000-4, it is not likely that IEC 801 will ever be finalized. IEC 61000-4 has not yet been reviewed so endorsement of that standard series is not within the scope of DG-1029. It should be noted that the use of IEC 801 by the nuclear power industry is not precluded by the regulatory position described in DG-1029. In fact, the SER on EPRI TR-102323 provides an acceptable method for the evaluation of EMC that includes IEC 801.

<41> "Certificates of compliance" are applicable as evidence that equipment is compatible with the electromagnetic environment given a valid technical basis. In effect, there should be technical justification given to support the equivalence of the test methods employed to those endorsed in DG-1029 or the SER on TR-102323 and to show that the test levels satisfy the corresponding operating envelopes over the frequency ranges identified in DG-1029 or the SER on TR-102323. Also see responses <39> and <40>.

V. B. DISCUSSION

Section B, "Discussion" (page 3). The first paragraph in this section indicates that plants should perform additional site surveys to determine the electrical noise present in the plant environment. However, the EPRI TR-102323 document made an effort to avoid performing these since they are considered unnecessary and uneconomical. Additional margin was incorporated in Revision 1 of TR-102323 which helped to eliminate the need to perform this additional site testing. <42>

The second paragraph in this section discusses miniaturized analog circuits. PECO Energy believes that the miniaturization of a hybrid circuit would tend to make the circuit less susceptible to interference than would a circuit spread out over a printed circuit board. We consider the work "miniaturized" to be misleading. One could infer that nonminiaturized analog circuits are less susceptible. <43>

Technical Responses

<42> It is not the intent of the regulatory position described in DG-1029 that plants should perform additional site surveys to determine the electrical noise present in the plant environment. The operating envelopes presented in DG-1029 are based on comparable military environments with adjustments to account for nuclear power plant emissions data and are generally applicable subject to the conditions of the regulatory position.

<43> The term "miniaturized" will be deleted to avoid confusion. The point in the discussion was that modern analog circuits may be more susceptible to EMI/RFI and power surges because these circuits operate at reduced voltage levels and faster operating speeds. These characteristics inherently imply that the voltage levels could be more easily masked by EMI/RFI and power surges and would likely be more susceptible to high frequency noise.

V. C. REGULATORY POSITION, Section 4

Section 4, "Test Methods, MIL-STD 462D" Subsection 4.8, "RS103 Radiated Susceptibility, Electric Fields" (page 17). This section discusses radiated electric fields in a frequency range of 10kHz to 1 GHz. At a recent industry meeting, the subject of portable communication equipment operating in the 1.9 GHz to 2.4 GHz range was discussed. We recommend that this be addressed in the draft RG. <44>

<44> See response <23>.

Commentor VI

VI. B. DISCUSSION, Page 5, 3rd paragraph

Reference to IEEE Std. 473-1985 is not appropriate for consideration of relaxing all operating envelopes and in fact it only covers radiated measurements from 10 kHz to 10 GHz. <45>

Technical Response

<45> The reference to IEEE Std 473-1985 (Reaffirmed in 1991) is not part of the regulatory position so it does not constitute a requirement. However, it does provide a best practice for conducting electromagnetic site surveys. This practice addresses periodic and random radiated electric and magnetic fields and conducted interference within the frequency range 10 kHz and 10 GHz. The reference to IEEE Std 473-1985 in the text is meant to convey that proven, systematic, and documented techniques are appropriate when collecting measurement data during a site survey. Also, any relaxation in the susceptibility envelopes should have a technical foundation based on plant emissions (radiated and conducted) data. Otherwise, the operating envelopes in DG-1029 should be employed.

VI. B. DISCUSSION, Page 6, 2nd paragraph

Lack of endorsement of IEC Std. 801 is not consistent with the EPRI Report TR-102323 guidance endorsed by the NRC staff via SER. Improvements and development of these standards should not preclude their endorsement by the staff. <46>

Technical Response

<46> It is true that DG-1029 is not strictly consistent with the SER on EPRI TR-102323 regarding the endorsement of IEC 801. However, the regulatory guide does not have to be identical with the SER. The absence of IEC 801 from DG-1029 does not preclude its use by the nuclear industry. In fact, the SER on EPRI TR-102323 provides an acceptable method for the evaluation of EMC that includes IEC 801. DG-1029 does not contain any guidance on the use of IEC 801 since the intent of the regulatory position is to endorse finalized standards for use in ensuring EMC. IEC 801 still contains draft parts that have not been approved by ballot. With the recent issuance of IEC 61000-4, "Electromagnetic Compatibility, Part 4: Testing and Measurement Techniques," it is not likely that IEC 801 will ever be finalized. IEC 61000-4 has not yet been reviewed so endorsement of that standard series is not within the scope of DG-1029.

VI. C. REGULATORY POSITION, Page 9, Section 3

Although endorsement of MIL-STD 461C & 462C demonstrates the acceptance of equipment previously tested and evaluated for the effects of EMI/RFI on equipment, this standard was superseded by MIL-STD 461D and 462D in January 1993. It should be made clear that new equipment should be tested and evaluated in accordance with the latest revision of the standard. <47>

Technical Response

<47> There is no prohibition against using the MIL-STD 461C test criteria to evaluate new equipment. MIL-STD 461D provides the latest revision of the test criteria (which includes improvements based on experience and the latest technical information), thus it is the primary focus of this guidance. However, guidance on the MIL-STD 461C counterparts to the MIL-STD 461D test criteria is also given. The rationale behind the optional specification of the "D" and "C" test criteria is to avoid placing an undue burden on the nuclear industry by limiting the available test resources to those test laboratories with the MIL-STD 462D test capability. It is intended that *either* the MIL-STD 461D *or* MIL-STD 461C test criteria be applied in its entirety, without selective application of individual criteria (i.e., no mixing and matching of the "D" and "C" test criteria). The MIL-STD test suites were developed to be internally consistent and to provide complementary coverage of EMI/RFI phenomena.

VI. C. REGULATORY POSITION, Page 11, 2nd paragraph

DG-1029 states that "Equipment tested under comparable power quality guidance should be exempt from this test." It is not clear what constitutes "comparable power quality guidance." Equipment should be exempt from CE101 testing when adequate demonstration for controlling low-frequency conducted emissions by design has been demonstrated. For most applications this is a low value-added test. <48>

Technical Response

<48> "Comparable power quality guidance" was intended to encompass any guidance at nuclear power plants that could serve the same purpose as the CE101 (conducted emissions, power leads, low frequency) test. This wording is unnecessarily vague so the exemption for these tests will be changed to more clearly reflects the basis for the envelopes and the justification required. The revised exemption will state that the envelopes are based on maintaining the harmonic distortion of the power distribution system within 5% total harmonic distortion of the supply voltage with any single harmonic being less than 3%. Therefore, the test can be exempted if it can be demonstrated that the power quality requirements of the new or modified equipment are consistent with the existing power supply and do not impose harmonic distortions on the existing power distribution system that exceed 5% THD or other power quality criteria established with a valid technical basis.

VI. C. REGULATORY POSITION, Page 11, Figure 4.1

The emissions limit for AC Power Leads is excessively restrictive compared to other standards. No justification was provided for deviation from the less restrictive equipment emissions limits previously endorsed for low-frequency conducted equipment emissions via TR-102323 and the newly established limits from MIL-STD 461D. For an endorsement of MILSTD 461D emissions limits, Figure CE101-4 for source voltages above 28 V would be more appropriate and not compromise adequate safety margin. <49>

Technical Response

<49> See response <10> for a discussion on the justification for the CE101 (conducted emissions, power leads, low frequency) envelopes. The CE101-4 envelope in MIL-STD 461D applies to Navy antisubmarine warfare and Army aircraft environments so it was not utilized as the basis for the CE101 operating envelope in DG-1029.

VI. C. REGULATORY POSITION, Page 12, Figure 4.2

No justification was provided for deviation from the less restrictive equipment emissions limits previously endorsed for high frequency conducted equipment emissions via TR-102323 and the more restrictive limits proposed from MIL-STD 461D. The previously established safety margin was adequate. <50>

Technical Response

<50> The justification for the CE102 (conducted emissions, power leads, high frequency) operating envelopes arises from the technical approach in their development. The CE102 operating envelopes for military ground facilities serve as the basis for the equivalent envelopes in DG-1029. The electromagnetic environment for military ground facilities was judged to be comparable to that for nuclear power plants based on general layout and equipment type considerations. The rationale in MIL-STD 461D Appendix [MIL-STD App., pp. A-24, A-25] states that the levels for the low frequency band of CE102 are set to address power quality, which is a common issue with nuclear power plant applications. A further review of the MIL-STD rationale finds the levels for the higher frequency band are based on controlling potential radiated EMI that could affect sensitive receivers, which are not normally present in nuclear power plants. Therefore, the equipment emissions envelopes for high frequency conducted emissions will be modified. The levels in the low frequency band of the MIL-STD emissions envelopes for CE102 will be adopted unchanged while the levels in the higher frequency band will raised for application to nuclear power plants based on commercial emissions limits for industrial environments.

VI. C. REGULATORY POSITION, Page 15, figure 4.5

No justification was provided for deviation from the less restrictive equipment emissions limits previously endorsed for low-frequency radiated equipment emissions via TR102323 and the more restrictive limits proposed from MIL-STD 461D. Equipment should be exempt from RE101 testing when adequate demonstration for controlling low-frequency radiated emissions by design has been demonstrated. For most applications this is a low value-added test due to the rapid decline of magnetic fields over short distances. <51>

Technical Response

<51> The justification for the RE101 (radiated emissions, magnetic field, low frequency) operating envelopes arises from the technical approach in their development. The envelopes in DG-1029 are more restrictive than the MIL-STD 461D RE101 operating envelopes for the reasons described in response <15>. As stated in response <15>, the 7-cm operating envelope for RE101 in DG-1029 will be modified and thus it will be generally consistent with the corresponding operating envelope addressed in the SER on EPRI TR-102323. An exemption is offered for equipment not intended to be installed in areas with other equipment sensitive to magnetic fields. This is because magnetic fields attenuate rapidly over short distances. No exemption is offered based on adequate demonstration by design, since it is felt that an adequate design is demonstrated by testing.

VI. C. REGULATORY POSITION, Page 16, Figure 4.6

The RE102 equipment emissions limit is excessively restrictive compared to other standards. No justification was provided for deviation from the less restrictive equipment emissions limits previously endorsed for high-frequency radiated equipment emissions via TR-102323 and the newly established limits from MIL-STD 461D. The previously established safety margin was adequate when considering the use of administrative controls. <52>

Technical Response

<52> The operating envelope will be modified based on technical considerations that are given in response <17>.

VI. C. REGULATORY POSITION, Page 16, 1st paragraph

RS101 is typically a low-value added test with few applications of concern due to the rapid decline of magnetic fields over short distances. The applications of concern should be clearly documented and this test be made optional for equipment outside the applications of concern. <53>

Technical Response

<53> Based on a review of the MIL-STD 461D specifications and rationale [MIL-STD 461D App.], an exemption will be included for these tests. The MIL-STD rationale states that this test is specialized with limited applicability and is "intended primarily to ensure that performance of equipment potentially sensitive to low frequency magnetic fields is not degraded." Therefore, an exemption will be allowed to exclude the RS101/RS01 (radiated susceptibility, magnetic field, low frequency) test for equipment provided that

the design and installation practices identified in IEEE 1050-1996 are followed and that the equipment is not scheduled to be installed in close proximity to sources of low frequency magnetic fields such as cathode ray tubes (CRTs), motors, cable bundles carrying high currents, etc. This is a valid test that can be used to encourage sound judgments about the placement of equipment within a plant. If equipment is sensitive to magnetic fields, its placement in the vicinity of equipment emitting strong magnetic fields should be avoided.

VI. C. REGULATORY POSITION, Pages 18-26, Section 5

Although endorsement of MIL-STD 461C & 462C demonstrates the acceptance of equipment previously tested and evaluated for the effects of EMI/RFI on equipment, this standard was superseded by MIL-STD 461D and 462D in January 1993. It should be made clear that new equipment should be tested and evaluated in accordance with the latest revision (Rev. D) of the standard. Both susceptibility and emissions limits should be comparable to those recommended from MIL-STD 461D providing due consideration for differences between the tests. Some differences in acceptable limits were noted. <54>

Technical Response

<54> See response <47> for the discussion on the use of MIL-STD 461C. The operating envelopes for MIL-STD 461D and MIL-STD 461C are comparable and due consideration is provided for differences between the tests. When evaluated in the context of the test methods being performed, there should be no difference in the applications of the operating envelopes.

VI. C. REGULATORY POSITION, Pages 26-30, Section 6

Endorsement of IEEE Stds C62.41 and C62.45 for surge withstand and electrically fast transients for the waveforms of Table 3 (page 26) was consistent with the endorsement of TR-102323 guidance for the same, however similar testing successfully performed in accordance with applicable IEC standards should be documented as acceptable. <55>

Technical Response

<55> The absence of IEC 801 from DG-1029 does not preclude its use by the nuclear industry. In fact, the SER on EPRI TR-102323 provides an acceptable method for the evaluation of EMC that includes IEC 801. DG-1029 does not contain any guidance on the use of IEC 801 since the intent of the regulatory position is to endorse finalized standards for use in ensuring EMC. IEC 801 still contains draft parts that have not been approved by ballot. With the recent issuance of IEC 61000-4, it is not likely that IEC 801 will ever be finalized. While IEC 61000-4 does offer guidance in the area of surge withstand capability, it has not yet been reviewed so endorsement of that standard series is not within the scope of DG-1029

VI. General Comments

The future of EMI/RFI testing is in International Electrotechnical Community (IEC) standard 1000 which should be endorsed by DG-1029. As noted in the conclusion of NUREG/CR-6431 the Department of Defense has moved away from the use of MIL-STD 461 & 462 and has instead emphasized the purchase of commercial-off-the-shelf (COTS) equipment with applicable commercial EMI/RFI testing qualifications. For a design guide applicable to future nuclear power plants, endorsement of an industry-supported standard like IEC-1000 is highly recommended. <56>

The extension of this design guide to new analog and hybrid systems of presently operating nuclear power plants planning on upgrading safety-related I&C systems has a significant cost impact. A cost versus safety benefit should be developed to justify this impact. <57>

A clear statement addressing backfit that "grandfathers" equipment and systems installed prior to the issuance of DG-1029 needs to be added to this regulatory guide. <58>

Technical Responses

<56> The recommendation that IEC 61000-4 be considered for endorsement is noted. However, the regulatory position described in DG-1029 is based on the evaluation of technical standards available during the period in which the technical basis was developed. Even though the IEC standard has been formally issued, copies of it have only been available for review in the last few months. It has been recommended in NUREG/CR-6431 that NRC follow the development of the commercial standards and review them for their applicability. If appropriate, these standards could be endorsed and included in future regulatory guidance.

<57> All new or modified safety-related equipment (including analog or hybrid equipment) must adhere to the environmental compatibility criterion (see General Design Criterion 4 in 10 CFR 50, App. A). The guidance presented in DG-1029 provides added clarity regarding means to establish evidence that equipment are compatible with particular environmental service conditions (i.e., electromagnetic and power surge conditions). The cost of implementing the regulatory guidance for new analog and hybrid systems, along with digital systems, is expected to be minimal because the guidance is consistent with current established practices presently being applied throughout the commercial power industry. The value of the regulatory guidance is that it offers clear guidance on necessary practices and a systematic approach.

<58> A statement will be added to the IMPLEMENTATION section of DG-1029 stating that no backfitting is intended or approved in connection with this guide. In addition, the term "upgrade" will be replaced with "modify" (see response <28>). This should provide sufficient clarity in that the regulatory position does not apply to existing equipment that is not scheduled for modification.

Commentor VII

VII. General Comments

EPRI Topical Report 102323

In a letter dated April 17, 1996, from Bruce Boger, NRC, to Carl Yoder, the NRC issued a Safety Evaluation Report (SER) accepting the Electric Power Research Institute Topical Report 102323 (EPRI TR-102323), "Guidelines for Electromagnetic Interference Testing in Power Plants." The draft regulatory guide states that the regulatory positions in the guide are intended to be consistent with the positions set forth in the SER. However, there are a number of significant differences between the EPRI report and the draft regulatory guide, some of which are identified in the following comments. The impact of these differences is significant in terms of the costs and resources necessary to implement the new guidance. The rationale and justification for these differences is not clearly established in the draft guide.

The guidance provided in the EPRI topical report is currently in use by the nuclear power industry. We strongly urge the NRC to revise the draft regulatory guide to more closely reflect the currently approved methodologies established in EPRI TR-102323 and the associated SER. <59>

Overly Conservative Emission Limit Criteria

The emissions limits reflected in the draft regulatory guide are very conservative. The large difference between the emissions and corresponding susceptibility limits of the cited MIL standards is understandable in light of the harsh and dense EMI environment associated with military platforms. However, nuclear plant EMI environments are less dense and less harsh and have been well characterized by the work associated with EPRI TR-102323. The EPRI-derived equipment emission limits were carefully selected based on the highest measured values at the vicinity of sensitive digital equipment by exercising nearby EMI emitters, i.e., worst-case conditions. A high degree of conservatism has already been factored in the allowable equipment emission limits and any further restrictions will unnecessarily raise the cost of future electronic equipment and result unnecessary emission mitigation measures by commercial nuclear power plant operators. <60>

Alternative Methods and Criteria

The draft regulatory guide is very prescriptive and provides few options beyond MILSTD testing. By comparison, guidance provided in EPRI TR-102323 recommends other standards, most significantly the European International Electrotechnical Commission (IEC) standards. Regulatory guides have traditionally described, in rather simple terms, the requirements to be met and the methods which NRC have found to acceptably meet these requirements. <61>

Multiple commercial qualification options for electronic control and instrumentation equipment is required. Several trends made such options imperative. Many more manufacturers of electronic control equipment seem to be gearing up to meet the acceptance criteria of commercial standards, particularly, internationally recognized standards. Additionally, as noted in NUREG/CR-6431, the U.S. Department of Defense is moving away from the use of MIL-STD 461/2 qualification in favor of commercial off-the-shelf (COTS) equipment with commercial EMI/RFI testing qualifications. Recognition of an industry supported standard, such as International Electrotechnical Community (IEC) standard 1000, needs to be given serious consideration. If such an option is not available, then these complementary trends may result in a U.S. nuclear power plant market having to pay high premiums for a unique set of qualification tests. <62>

Applicability to New and Replacement Equipment Only

The draft guide should be revised to clarify the applicability of the guidance to new and replacement equipment installed after initial acceptance of the guide by a nuclear power plant operator. <63>

Impact of Test Methods on Plant Operations

The guidance recommended by the draft regulatory guide appears to depend heavily on testing, particularly testing during equipment installation. Such guidance would appear to be more applicable to new nuclear plants than to existing plants. Accomplishing such testing for existing power plants would be extremely costly and would involve a fair amount of risk (i.e., plant testing itself could generate EMC/RFI induced equipment misoperations). <64>

The types of testing described in DG-1029 appear to be more suitable to factory or qualification/certification type testing rather than field testing. The equipment and skills needed to conduct and evaluate the results of such testing are fairly specialized and not generally available at operating nuclear plants. In particular, the test methods of Sections 4 and 5 of DG- 1029 describe and endorse a battery of tests of this nature. <65>

The approach outlined in EPRI TR-102323, which is to assure new equipment emissions are controlled by following EMI limiting practices, is a prudent and cost-effective approach. "Low tech" methods of addressing EMI concerns need to be considered by the draft regulatory guide. Such methods are often the most effective, from both cost and performance perspectives. Examples of "low tech" methods include administrative exclusion of sources of EMI/RFI, magnetic shielding and error checking schemes (typically applied to digital systems). <66>

Clarification of Source/Basis of Cited Criteria

The test criteria and limit lines appear to come from different documents. They appear to be from MIL-STD 461D and C or EPRI TR-102323. The source/basis for individual limits/levels should be identified. <67>

Technical Responses

<60> The regulatory guidance in DG-1029 is intended to be consistent with the position set forth in the SER on EPRI TR-102323. DG-1029 complements the position expressed in the SER by improving the technical basis for evaluating EMI/RFI and power surges. The positions described in each document endorse EMI/RFI-limiting practices based on IEEE 1050, endorse test criteria and test methods for susceptibility, emissions, and SWC to evaluate safety-related I&C systems, and identify appropriate operating envelopes for susceptibility, emissions, and surge withstand testing. The differences that exist between the regulatory position described in DG-1029 and the staff position expressed in the SER result because of additional insight gained as part of the NRC-sponsored confirmatory research to develop the supporting technical basis for this position. It is intended for the regulatory position described in DG-1029 to provide additional clarity in guidance on the use of test criteria from consensus standards and on the operating envelopes for the nuclear power plant environment. The regulatory position described in DG-1029 will reflect one approved methodology for addressing issues of EMC for safety-related I&C systems when it is finalized. Further clarification is given below on the comparison between DG-1029 and the SER and on the rationale for differences between the two positions.

Applicability — DG-1029 applies to safety-related I&C equipment (digital, analog, and hybrid) for all new installations or modifications to existing equipment while the SER on EPRI TR-102323 addresses only digital safety-related equipment. Thus, DG-1029 addresses the absence of guidance on the means for evaluating the EMC of analog and mixed analog/digital safety-related equipment.

EMI/RFI Limiting Practices — The position in DG-1029 focuses on a consensus standard that is widely available to the general public. DG-1029 endorses IEEE Std 1050-1996 with one exception, while the SER accepts similar guidance in Ch. 6 of EPRI TR-102323. EPRI TR-102323 references IEEE Std 1050-1989 for grounding practices and then references EPRI TR-102400 for more detailed guidance on EMI/RFI limiting practices. NUREG/CR-5941 documents the evaluation of IEEE Std 1050-1989 and recommends four exceptions (three of which were addressed in the 1996 revision of the standard).

Test Criteria — The SER on EPRI TR-102323 addresses test criteria and methods from IEC 801, while DG-1029 does not. The intent of the regulatory position described in DG-1029 is to endorse finalized (i.e., balloted and approved) standards for use in ensuring EMC. IEC 801 still contains draft parts that have not been approved by ballot. With the recent issuance of IEC 61000-4, it is not likely that IEC 801 will ever be finalized. Therefore, IEC 801 was not included for endorsement in DG-1029. IEC 61000-4 has not yet been reviewed so endorsement of that standard series is not within the scope of DG-1029.

Test Methods — DG-1029 offers the option of using complete test suites for EMI/RFI evaluations from either MIL-STD 462D or MIL-STD 462, which are comparable versions from the same family of tests. The SER accepts the EPRI TR-102323 approach that can be interpreted as allowing the user to mix and match tests from the MIL-STDs and IEC 801. The suite of test methods in each MIL-STD were developed to be internally consistent and to provide complementary coverage of EMI/RFI phenomena. For example, applying low and high frequency conducted emissions tests from MIL-STD 462D (CE101 and CE103) as well as low and high frequency conducted susceptibility tests from the same standard (CS101 and CS114) gives acceptable coverage of the conducted continuous wave EMI phenomenon. Such coverage may need to be demonstrated when selecting test methods from different standards.

Test Levels — DG-1029 endorses operating envelopes that are tailored for the specific test methods. In effect, a set of operating envelopes are established for the MIL-STD 461D criteria, while another comparable set are established for the MIL-STD 461C criteria. EPRI TR-102323 gives generic test levels over extended frequency ranges, rather than method-specific test levels framed in suitable units and frequency ranges. As a result, the frequency ranges sometime extend beyond the ranges covered by some of the recommended test methods. Therefore, testing may be required over frequencies for which a particular test method has not been validated or for which the specified test equipment may not be designed to accommodate. The SER accepts this approach provided the user supplies justification that the results are valid over the entire frequency range. An additional distinction arises from the fact that the operating envelopes presented in DG-1029 are supported by a clearly defined technical basis that accounts for military experience, nuclear power plant emissions data, and industrial emissions limits. These operating envelopes also provide some benefits through frequency range exemptions and relaxation factors for test levels.

Documentation — DG-1029 clarifies the level of evidence that is acceptable for EMI/RFI and power surge withstand qualification. Documentation guidance is intended to relieve some uncertainty in the process of establishing an acceptable level of EMC. In any event, quality assurance records are required for safety-related equipment as a criterion in 10 CFR 50, App. B.

Mechanism for Update — NRC has existing mechanisms to allow the revision of the guidance provided in DG-1029. Although revision 1 of EPRI TR-102323 was published to incorporate technical agreements expressed in the SER, EPRI typically does not revise its reports following publication. In any event, there is no clearly defined mechanism for triggering a revision to EPRI TR-102323. Regulatory guides typically endorse widely available, consensus standards that are governed by a committee of stakeholders from the user domain and are subject to periodic review. While it is proposed that EPRI TR-

102323 be adopted as an ISA standard, that action is uncertain given the issuance of IEC 61000-4.

<60> The equipment emissions operating envelopes described in DG-1029 have a clear technical basis that accounts for military experience, nuclear power plant emissions data, and industrial emissions limits. These envelopes are based on the equipment emissions operating envelopes for military ground facilities that are presented in MIL-STD 461D and MIL-STD 461C. The electromagnetic environment in military ground facilities is judged to be comparable to that for nuclear power plants based on general layout and equipment type considerations. Based on a review of the MIL-STD rationale for emissions testing, there will be some modification of these envelopes to give greater consideration of the primary intent of the MIL-STD envelopes. The MIL-STD rationale indicates that there are some instances where MIL-STD envelopes are primarily intended to protect sensitive receivers, which would not be common in nuclear power plants. In those cases, the FCC Part 15 and CISPR limits for industrial class equipment will be factored into adjustments of the MIL-STD envelopes. On the other hand, the MIL-STD rationale for some emissions envelopes is clearly applicable to nuclear power plants (e.g., maintaining THD on power distribution systems to 5% or less). In those cases, the MIL-STD envelopes remain unchanged for use in DG-1029. Following modifications based on updated rationales, there will remain some cases where the emissions envelopes in the draft regulatory guide differ with the envelopes addressed by the SER. However, the emissions envelopes described in DG-1029 will be more in line with those endorsed in the SER on EPRI TR-102323.

<61> See responses <29>, <32>, and <59>.

<62> See response <56>.

<63> See response <58>.

<64> See response <30>.

<65> See response <31>.

<66> See response <33>.

<67> See response <38>.

VII. A. INTRODUCTION, Page 2, 2nd paragraph

Section A, page 2, paragraph 2, makes the statement, "The technical basis behind selecting these particular practices is given in... a draft of NUREG/CR-6431..." The finalization of this draft NUREG could potentially impact the guidance provided in the draft regulatory guide. It is requested that finalization of the draft regulatory guide be withheld until all reference sources are completed. <68>

Technical Response

<68> See response <36>.

VII. B. DISCUSSION, Page 3

The second paragraph discusses miniaturized analog circuits. It is felt that the miniaturization of a hybrid circuit would tend to make the circuit less susceptible than a circuit spread out over a printed circuit board. We believe that the word "miniaturized" is misleading. One could infer that non-miniaturized analog circuits are less susceptible. <69>

Technical Response

<69> See response <43>.

VII. B. DISCUSSION, Page 5, 3rd paragraph

This paragraph states that relaxation of operating envelopes should be in accordance with IEEE Standard 473-1985. This standard only covers radiated measurements from 10 kHz to 10 GHz, thus, is not appropriate for consideration of all operating envelopes. <70>

Technical Response

<70> See response <45>.

VII. B. DISCUSSION, Page 6, 2nd paragraph

The draft regulatory guide does not endorse IEC Std. 801. This is not consistent with the SER issued on EPRI TR-102323. Standards currently approved for use by the NRC should be addressed in the draft regulatory guide. <71>

The lack of a test on conducted susceptibility on I/O lines significantly impacts the overall completeness of the draft regulatory guide. The methodology described in EPRI TR-102323 should be added to the draft regulatory guide to address this need. <72>

Technical Responses

<71> See response <46>.

<72> See response <1>.

VII. B. DISCUSSION, Page 6, 3rd paragraph

The prohibition of mixing test plans is too restrictive and limits the flexibility necessary in today's electronic equipment marketplace. This draft regulatory guide should define required tests and provide examples of acceptable test methodologies. <73>

Technical Response

<73> See responses <7> and <40>.

VII. C. REGULATORY POSITION, Section 1

DG-1029 states, "The design specifications that should be maintained and controlled include wire and cable separations, shielding techniques, shielded enclosure integrity, apertures, gasketing, grounding techniques, EMI/RFI filters, and circuit board layouts."

This is the only statement on maintenance but the draft regulatory guide does not provide guidance on how this maintenance should be conducted. For example, "Does this imply periodic testing to insure emission or susceptibility levels have not changed?" Several other maintenance issues could also be implied. The draft regulatory guide should clarify the intent of this statement. <74>

Technical Response

<74> The intent of this statement is to describe some of the design specifications that should be maintained and controlled as part of a configuration control scheme for safety-related I&C systems. The purpose of the control scheme is to maintain the desired configuration of equipment and document any changes that are made. The means for accomplishing this configuration control are up to the user. Design control and quality assurance records for safety-related equipment are required under 10 CFR 50, App. B.

VII. C. REGULATORY POSITION, Section 1, Page 7

The Regulatory Position in Section C.1 states, "The electromagnetic conditions at the point of installation for safety-related I&C systems should be assessed to identify any unique EMI/RFI sources that may generate local interference. Steps should be taken during installation to ensure that the systems are not exposed to EMI/RFI levels from the identified sources that are greater than 8 dB below the specified operating envelopes."

The concern here is that transient EMI sources, as opposed to steady-state or continuous sources, are more likely to define the bounding emissions environment. Therefore, emissions measurements require energizing or cycling equipment during testing to identify the effects of transients on the measured emission levels. In addition, transients will vary depending when, on a waveform, the circuit is interrupted, energized, etc. Hence, repetitive tests may be necessary to define the bounding conditions.

The intentional cycling of equipment, to the extent necessary to define the bounding conditions, is not desirable. The intent of the testing performed by EPRI was to identify appropriate operating envelopes for equipment and systems intended for selected locations without requiring additional plant-specific electromagnetic measurements.

It is preferable to rely upon the methodology of EPRI TR-102323 which defines appropriate operating envelopes based upon testing performed at several different facilities during periods when proper data could be gathered. This, combined with ongoing testing by EPRI as opportunities arise, is a better approach. <75>

Technical Response

<75> The regulatory position in DG-1029 does not require additional site measurements. The operating envelopes presented in DG-1029 are based on MIL-STD operating envelopes for comparable military facilities. The suitability of the operating envelopes to address the nuclear power plant environment has been confirmed with high confidence by long-term site measurements at several nuclear power units, as well as by the data reported in EPRI TR-102323. However, the volume of data available cannot provide complete assurance that the envelopes bound all possible EMI/RFI events at every nuclear power plant. It is possible that there are significant EMI/RFI emitters at some power plants that were not adequately characterized by site surveys conducted to date. Thus, the intent of the position in Section C.1 of DG-1029 (stating the 8 dB plant emissions margin and identifying the need for an assessment of electromagnetic conditions) is to ensure that the operating envelopes are not indiscriminately applied and that their integrity is maintained. Some effort is necessary on the part of the user of this guidance to demonstrate an understanding of the electromagnetic environment at the point of installation. Through such an assessment, the possibility that safety-related equipment will be installed adjacent to strong EMI/RFI emitters can be reduced and the applicability of the operating envelopes in DG-1029 can be confirmed. Thus, the practical consequence of the position is not necessarily to encourage testing of the EMI/RFI sources in the area where safety-related I&C systems will be installed, but to promote an assessment (or evaluation) of the types of EMI/RFI sources in the area. Of course, testing might be one of the assessment tools. Other ways to assess the EMI/RFI sources can include review of existing EMI/RFI test reports on equipment comparable to that located at the site, vendor materials and manuals, or previous measurements at similar sites; identification of known characteristics (e.g., radios are narrowband sources and arc welders are broadband sources); and application of analytical models. It should be noted that the staff position expressed in the SER on EPRI TR-102323 accepts the use of the envelopes contained in that document without the need for a plant-specific EMI survey if the plant-specific electromagnetic environment is confirmed to be similar to the seven plants that participated in the EPRI survey.

VII. C. REGULATORY POSITION, Page 11, Section 4, 4.1 CE101

DG-1029 states, "Equipment tested under comparable power quality guidance should be exempt from this test." It is not clear what constitutes "comparable power quality guidance." Equipment should be exempt from CE 101 testing when adequate demonstration for controlling low-frequency conducted emissions by design has been demonstrated. For most applications this is a low value-added test. <76>

Technical Response

<76> See response <48>.

VII. C. REGULATORY POSITION, Page 11, Section 4, Figure 4.1

The emissions limit for AC Power Leads is excessively restrictive compared to other standards. No justification is provided for deviation from the less restrictive equipment emissions limits previously endorsed for low-frequency conducted equipment emissions, via EPRI TR-102323 and the newly established limits from MIL-STD 461D. For an endorsement of MIL-STD 461D emissions limits, Figure CE101-4 for source voltages above 28V would be more appropriate and not compromise the adequate safety margin. <77>

Technical Response

<77> See response <49>.

VII. C. REGULATORY POSITION, Page 12, Section 4, Figure 4.2

DG-1029 does not provide a rationale for deviation from the less restrictive equipment emissions limits previously endorsed for high-frequency conducted equipment emissions, via the NRC Safety Evaluation Report on EPRI TR-102323 and the more restrictive limits proposed from MIL-STD 461D. The previously established safety margin is adequate. <78>

Technical Response

<78> See response <50>.

VII. C. REGULATORY POSITION, Page 15, Section 4, Figure 4.5

DG-1029 does not provide a rationale for deviation from the less restrictive equipment emissions limits previously endorsed for low-frequency radiated equipment emissions, via the NRC Safety Evaluation Report on EPRI TR-102323, and the more restrictive limits proposed from MIL-STD 461D. Equipment should be exempt from RE101 testing when adequate demonstration for controlling low-frequency radiated emissions by design has been demonstrated. For most applications this is a low value-added test due to the rapid decline of magnetic fields over short distances. <79>

Technical Response

<79> See responses <15> and <51>.

VII. C. REGULATORY POSITION, Page 16, Section 4, Figure 4.6

The RE102 equipment emissions limit is excessively restrictive compared to other standards. No justification is provided for deviation from the less restrictive equipment emissions limits previously endorsed for high-frequency radiated equipment emissions, via the NRC Safety Evaluation Report on EPRI TR-102323 and the newly established limits from MIL-STD 461D. The previously established safety margin was adequate when augmented with administrative controls. <80>

Technical Response

<80> See response <52>.

VII. C. REGULATORY POSITION, Page 16, Section 4, 4.7 RS101, 1st paragraph

RS101 is typically a low value-added test with few applications of concern due to the rapid decline of magnetic fields over short distances. The applications of concern should be clearly documented and this test should be made optional for equipment outside these applications. <81>

Technical Response

<81> See response <53>.

VII. C. REGULATORY POSITION, Section 5

The limits for conducted emissions in EPRI TR-102323 are less restrictive than the limit recommended by DG-1029. Since this guide applies to power plants and not sensitive military systems, the limits of the EPRI report are appropriate and the draft regulatory guide provides no justification for deviation from this accepted approach. <82>

Technical Response

<82> The justification for the conducted emissions operating envelopes given in DG-1029 is as follows. The DG-1029 envelopes are based on the MIL-STD 461C and MIL-STD 461D equipment emissions envelopes for military ground facilities. The electromagnetic environment for military ground facilities is judged to be comparable (based on general layout and equipment type considerations) to that projected for nuclear power plants. In addition, site survey findings support the similarity of these environments based on comparisons of the data with susceptibility envelopes established for military equipment. The MIL-STD rationale indicates that a primary motivation for the conducted emissions envelopes is to maintain THD on power distribution systems to 5% or less. Indeed, the

rationale in the Appendix of MIL-STD 461D states that THD greater than "5% is above the tolerance of most electronic equipment, induction motors, magnetic devices, and measuring devices." Such power quality control is clearly appropriate for nuclear power plants. However, the MIL-STD rationale indicates that the upper band of the high frequency conducted emissions envelopes is primarily intended to protect sensitive receivers, which would not be common in nuclear power plants. Therefore, these envelopes will be modified with the FCC Part 15 and CISPR limits for industrial class equipment factored into those adjustments. Following modifications based on updated rationales, there will remain some cases where the conducted emissions envelopes in the draft regulatory guide differ with the envelopes addressed by the SER. However, the emissions envelopes described in DG-1029 will be more in line with those endorsed in the SER on EPRI TR-102323. See responses <10> and <50> for more detail.

VII. C. REGULATORY POSITION, Pages 26-30, Section 6

Endorsement of IEEE Standards C62.41 and C62.45 for surge withstand and electrically fast transients for the waveforms of Table 3 (page 26) is consistent with the endorsement of EPRI TR-102323 guidance for the same. However, similar testing successfully performed in accordance with applicable IEC standards should be documented as acceptable. <83>

Technical Response

<83> See response <55>.

VII. C. REGULATORY POSITION, Section 6, Page 26, 2nd paragraph

This section describes Location Categories (A, B, C) and Exposure Levels (High, Medium, Low) which are outlined in IEEE C62.41-1991. As stated in DG-1029, acceptable surge withstand capability (SWC) levels are "...based on a Category B location and a Low to Medium Exposure Level." Category B (feeders and short branch circuits within 10 meters from the service entrance) appears to be arbitrarily conservative for most nuclear plant circuits of concern. First, the term "service entrance" is not standard terminology used for nuclear plant electrical distribution systems. Thus, it is not clear where the service entrance is. Second, if one conservatively assumes the service entrance point is at the unit substation (medium to low voltage transition point), feeding I&C circuits of concern, most of these circuits would be Category A (long branch circuits greater than 10 meters from the service entrance). In any case, such detailed and prescriptive guidance is out of place in a regulatory guide. <84>

Technical Response

<84> See response <34>.

VII. C. REGULATORY POSITION, Section 7

Section 7, "Documentation" states, "Documentation should be maintained to provide evidence that safety-related I&C equipment meets its specification requirements and is compatible with the projected environment. Data used to demonstrate the compatibility of the equipment with its projected environment should be pertinent to the application and be organized in a readily understandable and traceable manner that permits independent auditing of the conclusion presented. The user should maintain an electromagnetic compatibility report as part of a qualification file."

Guidance on at least part of the expected contents of the qualification file mentioned above is then provided in the draft. The suggested minimum contents do not contain any information on maintenance requirements. Also, this section and others should be modified to clarify that this guidance applies to new equipment. <85>

This section creates a new requirement for extensive documentation regarding compatibility of equipment. This section describes "...an electromagnetic compatibility report as part of a qualification file...." which would contain a number of elements making it similar in nature to an Environmental Qualification Data Package as is required by 10 CFR 50.49. This extensive new documentation requirement would not appear to be justified by the benefits that would be derived for existing plants. <86>

Technical Responses

<85> The EMI/RFI and power surge withstand practices endorsed by DG-1029 are only elements of the total package that is needed to ensure EMC within nuclear power plants. Maintenance is another element, but is not covered in detail by the guidance in DG-1029. However, the requirements of 10 CFR 50, App. B apply to all safety-related equipment. Clarification on the application of this regulatory position can be found in the IMPACT STATEMENT of DG-1029, which states that "the guide would apply to both future nuclear power plants and to presently operating nuclear power plants that plan to upgrade safety-related I&C systems." To avoid potential misinterpretation, the term "upgrade" will be replaced with "modify" (see response <28>).

<86> See response <35>.

VII. VALUE/IMPACT Statement, page 34

The draft regulatory guide is stated to apply to analog, digital, and hybrid safety-related I&C equipment. Application of the same set of testing requirements to both digital and analog equipment is not appropriate. Analog equipment typically has bandwidths orders of magnitude less than digital equipment. Therefore, consideration should be given to the bandwidth of the instrument, plant limiting practices, and the installation environment when determining which electromagnetic compatibility tests should be performed. <87> In addition, the draft regulatory guide should provide a definition of "hybrid I&C equipment." <88>

Technical Response

<87> The application of the same set of testing criteria is appropriate for both analog and digital equipment. While the specifics of the testing procedures (e.g., bandwidths, dwell times, etc.) for analog and digital equipment are likely to be different, they could also be significantly different for two analog systems that are dissimilar in design. The characteristics of a specific equipment design are identified in the equipment specification, which is the basis for defining acceptable performance in the test plan. Therefore, the variability of performance metrics is taken into account in the guidance provided by DG-1029. Plant limiting practices and the installation environment were considered in the development of electromagnetic operating envelopes.

<88> An explanation of "hybrid" for I&C equipment is a combination of analog and digital electronics in the equipment, with the equipment providing the same function(s) as totally analog or totally digital equipment. A notation will be added in DG-1029 to clarify the meaning of the term.

VII. VALUE/IMPACT Statement, pages 33-34

DG-1029 states, "Therefore, costs associated with the implementation of this guide are expected to be minimal." The basis for this statement is the claim that this guidance is consistent with established practices currently applied throughout the commercial power industry.

Implementation of the guidance provided in the draft regulatory guide is expected to significantly increase costs above those currently being experienced. Factors which contribute to the increase cost include:

1. The cost of EMI/RFI testing for all of the replacement equipment that will be needed over the next several years. This cost will be especially high if the draft guidance is applied to all equipment, including non safety-related equipment.

2. The cost of providing adequate assurance that the design of this equipment is being maintained.

3. The cost of developing and implementing programmatic controls to insure that all of the necessary EMI/RFI requirements are met, including documentation, maintenance, design, unintentional emissions, intentional emissions, etc.

Contrary to the NRC's assertion in the statement of Impact, the costs to the industry to augment current programs are likely to be significant without a significant benefit to the public health and safety. <89>

Technical Response

<89> The additional costs associated with the implementation of the draft regulatory guide are expected to be minimal as compared to the current established practices presently being applied throughout the commercial power industry. Until recently, NRC provided EMI/RFI and power surge withstand guidance on a case by case basis. In the SER on EPRI TR-102323, the NRC staff found the guidance described in that document, which involved a similar level of testing, to be acceptable as one approach to contributing to EMC. The regulatory position in DG-1029 represents another acceptable method which is similar in approach to the guidance in EPRI TR-102323.

The regulatory positions in the SER and DG-1029 are intended to describe systematic approaches that yield defensible results and alleviate the need for site surveys. The staff position expressed in the SER requires that plants undergoing a new installation or modification of safety-related equipment confirm that their electromagnetic environment is indeed similar to one of the seven plants where site survey data was collected by EPRI. The staff position expressed in DG-1029 requires an assessment of the local electromagnetic environment to identify any unique EMI/RFI emitters. Therefore, application of the operating envelopes endorsed by either position should not require additional measurements in most cases.

While there are some instances where the operating envelopes in the draft regulatory guide differ with the envelopes addressed by the SER, the application of the operating envelopes presented in DG-1029 should not cause an undue burden. In fact, the susceptibility envelopes presented in DG-1029 are, in some cases, less restrictive than those endorsed by the SER. The emissions envelopes presented in DG-1029 will be modified based on an updated rationale and will be more in line with those endorsed by the SER on EPRI TR-102323. These envelopes will fully encompass the FCC Part 15 Class A and CISPR Class A emissions limits for industrial environments. Therefore, some credit can be taken for commercial equipment certification. In addition, since the operating envelopes are tailored to each particular test method in DG-1029, there is no added burden required for justification of the use of those test methods over extended frequency ranges. Finally, the DG-1029 operating envelopes also provide some benefits through frequency range exemptions and relaxation factors for test levels.

Regarding the identified cost factors, the EMI/RFI and surge withstand testing costs should be equivalent to those incurred under the guidance given in EPRI TR-102323. Also, as a point of clarification, the regulatory position only applies to new or modified safety-related I&C systems. Hence, there is no extension of the regulatory position to nonsafety-related equipment or to existing safety-related equipment. Finally, the costs of assuring equipment designs are being maintained and establishing programmatic controls to ensure necessary EMI/RFI requirements are met should not appreciably differ from the costs that can be reasonably expected from the application of the requirements in 10 CFR 50, App. B. Indeed, design control, test control, and quality assurance records are already necessary elements for the qualification or dedication of any safety-related equipment.

Commentor VIII

VIII. General Comments

Virginia Power is concerned that the adoption of the draft regulatory guide will cause confusion with regard to Electromagnetic Interference (EMI) and Radio-Frequency Interference (RFI) testing limits due to conflicting requirements. NUREG-0800, "Standard Review Plan," as well as the draft regulatory guide, accepts the Electric Power Research Institute (EPRI) Topical Report TR-102323, "Guidelines for Electromagnetic Interference Testing in Power Plants," as an adequate means for qualifying new, safety-related instrumentation and control equipment for use in a power plant. However, the limit curves contained in the draft regulatory guide are not consistent with the limit curves contained in the EPRI Topical Report. We believe that it is unwise to issue a set of limits which conflict with existing approved limits. Furthermore, since we believe that industry standards should be endorsed where possible in lieu of individual regulatory requirements, we recommend the continued use of EPRI TR-102323 as the industry-endorsed NRC standard for EMI/RFI testing. <90>

Virginia Power has concluded that the adoption of the draft regulatory guide will impose more restrictive EMI/RFI emission limits than the existing industry standards without an increase benefit to plant safety. The use of existing Electromagnetic Compatibility (EMC) guidelines and limits contained with EPRI TR-102323 are sufficient to ensure that future digital and analog equipment will be compatible with other new and existing plant equipment. EPRI TR-102323 has adequate margin between emissions and susceptibility and has sufficiently conservative absolute limits to ensure EMC. We endorse the continued use of EPRI TR-102323 as the NRC recommended industry standard. <91>

Finally, Virginia Power is concerned that the adoption of the draft regulatory guide may reduce the availability of EMI/RFI qualified equipment and suppliers. With more restrictive limits on equipment EMI/RFI emissions, suppliers will be forced to either upgrade their equipment or drop their product line to nuclear plants. We believe that suppliers should focus on a single standard in lieu of two separate standards which has the potential to increase equipment costs without an increase benefit to plant safety. Continued use of EPRI TR-102323 alleviates any unnecessarily restrictive limits on equipment EMI/RFI emissions and allows the industry to focus on one standard. <92>

Technical Responses

<90> The continued use of the SER on EPRI TR-102323 by the nuclear power industry is not precluded by the regulatory position described in DG-1029. However, DG-1029 presents clarification of the staff position on EMC that accounts for updated industrial guidance (e.g., the latest revision of IEEE 1050) and recent technical findings (e.g., more data characterizing the electromagnetic environment at nuclear power plants). The SER and DG-1029 each represent acceptable methods for addressing EMC in safety-related I&C systems. The approach in each guidance is similar and many of the same testing standards are endorsed. Therefore, no confusion should result.

It is felt that the guidance in the draft regulatory guide is clear in its approach and will yield results that can be easily defended. In addition, the draft regulatory guidance endorses standards available to the general public that are comprehensive in nature and represent finalized methods from various organizations. While EPRI TR-102323 remains as an approved method for the industry, DG-1029 provides needed guidance for safety-related analog and hybrid equipment while also supplying additional clarity on the means for evaluating digital equipment. Therefore, DG-1029 represents a comprehensive, straightforward approach to establishing evidence that demonstrates the EMC of new or modified safety-related equipment.

<91> See response <60>.

<92> The adoption of the draft regulatory guide should not reduce the availability of EMI/RFI-qualified equipment suppliers. The regulatory position offers clear guidance on the acceptable application of consensus standards that are well-established and widely available so it should help the suppliers focus their EMC efforts. There are some instances where the operating envelopes in the draft regulatory guide differ with envelopes addressed by the SER on EPRI TR-102323. However, there is a solid technical basis for the establishment of the envelopes in DG-1029. In addition, there will be some modifications to the emissions envelopes in DG-1029 that will enhance the consistency between the SER and DG-1029. Finally, the continued use of the guidance endorsed by the SER on EPRI TR-102323 is not prohibited by DG-1029.

Commentor IX

IX. General Comments

General: The draft Regulatory Guide should address the currently approved methodologies established in EPRI Topical Report TR-102323, "Guidelines for Electromagnetic Interference Testing in Power Plants," and the associated NRC Safety Evaluation Report dated April 17, 1996. The EPRI Topical Report is a sound basis for EMI/RFI programs and is in use by the industry. <93>

Alternative Methods and Criteria: The draft regulatory guide is very prescriptive and provides few options beyond MIL-STD testing. Regulatory Guides have traditionally described, in rather simple terms, the requirements to be met and the methods which NRC have found to acceptably meet these requirements. <94>

The evolution of electronic control equipment and suppliers requires the maintenance of multiple commercial qualification options. Several trends made such options imperative. Many more manufacturers of electronic control equipment seem to be gearing up to meet the acceptance criteria of commercial standards particularly internationally recognized standards. Additionally, as noted in NUREG/CR-6431, the Department of Defense is moving away from the use of MIL-STD 461/2 qualification in favor of Commercial-off-the-shelf (COTS) equipment with commercial EMI/RFI testing qualifications. Recognition of an industry supported standard like International Electrotechnical Community (IEC) standard 1000 needs to be given serious consideration. If such an option is not available, then these complementary trends may result in a U.S. nuclear power plant market having to pay high premiums for a unique set of qualification tests. <95>

Applicability to New and Replacement Equipment Only: The draft guide should be revised to clarify the applicability of the guidance to new and replacement equipment installed after initial acceptance of the guide by a nuclear power plant operator. <96>

Impact of Test Methods on Plant Operations: The guidance recommended by the draft regulatory guide appears to depend heavily on testing, particularly testing during equipment installation. Such guidance would appear to be more applicable to new nuclear plants than to existing plants. Accomplishing such testing for existing power plants would be extremely costly and would involve a fair amount of risk (i.e. plant testing itself could generate EMI/RFI induced equipment misoperations). <97>

The types of testing described in DG-1029 appear to be more suitable to factory or qualification/certification type testing rather than field testing. The equipment and skills needed to conduct and evaluate the results of such testing are fairly specialized and not generally available at operating nuclear plants. In particular, the test methods of Sections 4 and 5 of DG-1029 describe and endorse a battery of tests of this nature. <98>

"Low tech" methods of addressing EMI/RFI concerns need to be considered by the draft regulatory guide. Such methods are often the most effective, from both a cost and performance perspective. Examples of "low tech" methods include administrative exclusion of sources of EMI/RFI, magnetic shielding and error checking schemes (typically applied to digital systems). <99>

Technical Responses

<93> See response <59>.

<94> See responses <29>, <32>, and <59>.

<95> See response <56>.

<96> See response <58>.

<97> See response <30>.

<98> See response <31>.

<99> See response <33>.

IX. A. INTRODUCTION, Page 2, 2nd paragraph

Section A. page 2, paragraph 2, makes the statement that "The technical basis behind selecting these particular practices is given in... a draft of NUREG/CR-6431..." The finalization of this draft NUREG could potentially impact the guidance provided in the draft regulatory guide. It is requested that finalization of the draft regulatory guide be withheld until all reference sources are completed. <100>

Technical Response

<100> See response <36>.

IX. B. DISCUSSION

A significant majority of all electrical noise is conductively coupled and is a design and maintenance issue for operating plants. The issue is addressed by the implementation of design and installation practices for instrumentation grounding provided by IEEE Std. 1050-1996. This standard is endorsed by the draft regulatory guide. EPRI TR-102323 also addresses conducted susceptibility and should be addressed by the regulatory guide. <101>

Technical Response

<101> The guidance on conducted susceptibility given in EPRI TR-102323 is addressed by the staff position described in the SER on that document. It is not necessary to replicate that guidance in DG-1029. This draft regulatory guide focuses on endorsement of consensus standards, which are widely available, that address issues of EMC, such as conductively-coupled electrical noise.

IX. C. REGULATORY POSITION

The first sentence of this position implies that there are new requirements for the design of safety-related instruments to assure "that structures, systems, and components important to safety are designed to accommodate the effects and to be compatible with the environmental conditions associated with nuclear power plant service conditions." IEEE Std. 279, paragraph 3 (7) and (8), which is endorsed by 10CFR50.55a(h), specifically require consideration of service conditions that can affect the performance of safety-related equipment that perform a protection function. It is suggested that the "Introduction" section address the environmental design bases requirements for safety-related equipment stated in IEEE Std. 279. <102>

Technical Response

<102> A discussion of the environmental design basis requirements in IEEE 279 would only revisit considerations that all already addressed in the "Introduction" section of DG-1029. Documentation of the principle design criteria and design bases are required in 10 CFR 50.34(a)(3). IEEE 279-1971 is endorsed in 10 CFR 50.55a(h) as applicable for establishing the design bases for a nuclear facility, which includes addressing the environmental compatibility criterion (see General Design Criterion (GDC) 4 in 10 CFR 50, App. A). The guidance presented in DG-1029 complements the guidance in IEEE 279-1971, paragraph 3 (7) and (8), by providing added clarity regarding means to account for particular environmental service conditions (i.e., electromagnetic and power surge conditions). Since the Introduction of DG-1029 discusses the regulatory basis for the guide (in particular, GDC 4, which is the root of the environmental design bases requirements in IEEE 279-1971), it is not necessary to extend the discussion to endorsed standards that amplify the need to address environmental service conditions in the development of the design bases for protection systems.

Regarding the question of whether new design requirements are implied in the regulatory position described in DG-1029, the first sentence of Section 1 states that "Establishing and continuing an electromagnetic compatibility program for safety-related I&C systems in nuclear power plants contributes to the assurance that structures, systems and components important to safety are designed to accommodate the effects (of) and to be compatible with the environmental conditions associated with nuclear power plant service conditions." This is not a statement identifying new requirements for the design of safety-related I&C equipment since the electromagnetic environment in a nuclear power plant is an element of the service conditions for equipment at a plant and since compatibility with environmental service conditions is an established requirement (GDC 4). The statement is an acknowledgment that an EMC program can contribute to satisfying the regulations stated in 10 CFR 50.

IX. C. REGULATORY POSITION, Section 1

The statement in paragraph 2 that the limit for EMI/RFI exposure is 8 dB below the specified operating envelope(s) is not consistent with MIL-STD 462D which states a value of 6 dB. <103>

Technical Response

<103> The 8 dB value was derived by NRC staff as a buffer between allowable plant emissions levels and acceptable susceptibility levels to account for potential measurement errors in existing site survey data, the possible impact of unaddressed environmental conditions, and potential growth in a plant's electromagnetic environment over time. This 8 dB margin was expressed in the staff position described in the SER on EPRI TR-102323.

IX. C. REGULATORY POSITION, Section 3

MIL-STD 461D, 11 January 1993 superseded MIL-STD 461C, 4 August 1986. Paragraph 4 of the "Foreword" of 461D states that substantial changes were made from previous editions. Some requirements were eliminated, others significantly changed, and new requirements added. Thus, unless there is a compelling regulatory reason for endorsement of 461C, it would seem that the regulatory guide should endorse the most recent release of the standard. <104>

Technical Response

<104> See response <47>.

IX. C. REGULATORY POSITION, Section 4

The introductory paragraph should indicate that the associated operating envelopes are based on the limits specified in MIL-STD 461D. <105>

Technical Response

<105> The suggestion will be adopted by adding summary information to DG-1029 indicating the source of the operating envelopes. The more detailed rationale for each envelope will be described in NUREG/CR-6431. The operating envelopes are modeled after the MIL-STD 461D operating envelopes for similar military environments. However, some of the operating envelopes vary in amplitude and shape from the MIL-STD 461D envelopes because of necessary adjustments that are based on site survey emissions data and meet the goal of establishing comparable assurance that equipment will indeed be compatible with the projected electromagnetic environment.

IX. C. REGULATORY POSITION, Section 4, 4.1 CE101

The CE101 emission limits given in MIL-STD 461D are different than those shown in Figure 4.1. The values given in Figure 4.1 are based on the limits given in CE01 of 461C. An example of mixing two different sets of requirements-see statement in regulatory position C.3 that specifies no mixing and matching of test criteria. <106>

Technical Response

<106> There is actually no mixing and matching of test criteria between MIL-STD 461D CE101 (conducted emissions, power leads, low frequency) and MIL-STD 461C CE01 (conducted emissions, power leads, low frequency). The test criteria are distinctively called out for each method as part of the corresponding suite of test criteria. However, the comment does identify the common heritage of the operating envelopes. Since MIL-STD 461D CE101 provides no guidance on operating envelopes for military ground facilities, which have been identified as having electromagnetic conditions most comparable to nuclear power plants, it was appropriate to adopt the operating envelopes from MIL-STD 461C CE01. The technical basis for establishing immunity levels for a particular phenomenon (e.g., conducted EMI/RFI) over a selected frequency range (e.g., 30 Hz to 50 kHz) is not dependent on testing criteria or methods but rather on the environment in which the equipment will be installed. Therefore, the caution against mixing and matching test criteria and methods is not violated.

IX. C. REGULATORY POSITION, Section 4, Figure 4.3

The end point shown in Figure 4.3 as 127 dB at approximately 50 kHz does not agree with the end point shown in Figure CS101-1 in 461D (116 dB at 50 kHz). <107>

Technical Response

<107> The observation is accurate and the CS101 (conducted susceptibility, power leads, low frequency) operating envelope will be adjusted at the high frequency endpoint to correct the discrepancy.

IX. C. REGULATORY POSITION, Section 4, Figure 4.4

The operating envelope shown in Figure 4.4 does not agree with Figure CS114-1 of 461D. It should be noted that CS101-1 shows a decrease in the envelope below 1 MHz. For the most limiting curve the decrease is 40 dB at 10 kHz. <108>

Technical Response

<108> See response <13>.

IX. C. REGULATORY POSITION, Section 4, Figure 4.5

Figure 4.5 limits do not agree with RE101-1 or RE101-2 of 461D or Figure 6-13 (RE01) of 461C. <109>

Technical Response

<109> See response <15>.

IX. C. REGULATORY POSITION, Section 4, figure 4.7

Figure 4.7 operating limits are different than those limits shown in Figure RS101-1 of 461D. <110>

Technical Response

<110> The RS101 (radiated susceptibility, magnetic field) operating envelope in DG-1029 is the same as the operating envelope in Figure RS101-2 of MIL-STD 461D. This envelope is for Army applications (i.e., military ground facilities), as opposed to the envelope in Figure RS101-1, which is for Navy applications.

IX. C. REGULATORY POSITION, Section 5

The foreword of MIL-STD 462D, paragraph 4, states that this standard is designated at revision "D" to coincide with its companion document, MIL-STD 461. Revisions "A," "B," and "C" of MIL-STD 462 were never issued. Therefore, the requirements given in this position should be re-evaluated and, if applicable, addressed in Regulatory Position C.4. <111>

Technical Response

<111> The nomenclature associated with assigning the MIL-STD 461 and MIL-STD 462 updates with the same "D" version designation is new. Previous revisions of MIL-STD 461 were designated as "A", "B", or "C". Previous revisions of MIL-STD 462 were designated as "Notice 1" through "Notice 6". This is really an issue of nomenclature and has nothing to do with whether previous versions of MIL-STD 462 are applicable. The test criteria in MIL-STD 461C reference corresponding test methods related to specific notices to MIL-STD 462 depending on whether the testing is being performed for the Army, Navy, or Air Force.

IX. C. REGULATORY POSITION, Section 6

Section C.6. page 26, paragraph 2, describes Location Categories (A, B, C) and Exposure Levels (High, Medium, Low) which are outlined in IEEE C62.41-1991. As stated in DG-1029, acceptable surge withstand capability (SWC) levels are "...based on a Category B location and a Low to Medium Exposure Level." Category B (feeders and short branch circuits within 10 meters from the service entrance) appears to be arbitrarily conservative for most nuclear plant circuits of concern. First, the term "service entrance" is not standard terminology used for nuclear plant electrical distribution systems. Thus, it is not clear where the service entrance is. Second, if one conservatively assumes the service entrance point is at the unit substation (medium to low voltage transition point), feeding I&C circuits of concern, most of these circuits would be Category A (long branch circuits greater than 10 meters from the service entrance). In any case, such detailed and prescriptive guidance is out of place in a Regulatory Guide. <112>

Technical Response

<112> See response <34>.

IX. C. REGULATORY POSITION, Section 6

IEEE Std. C62.41, "IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits," addresses industrial and residential systems and equipment. Power generation station grounding and surge protection is based on industry design standards and implemented by means of a design specification. The design specification is generally more specific in the degree of protection and testing required by the design. The guidance provided by this regulatory position does not help the designer for addressing power related interference problems

The I&C's susceptibility to power line fluctuations is characterized by several different parameters including voltage level, frequency stability, harmonic distortion, noise, etc. A parameter like voltage level is a result of the power source alone. Harmonic distortion, noise or phase voltage imbalance is determined by an interaction of the computer load and the power source. Specifications for power supply equipment address these effects by means of acceptable tolerances for:

- Voltage regulation
- Voltage disturbances (momentary under-voltage, transient overvoltage)
- Voltage harmonic distortion
- Noise
- Frequency variation
- Frequency rate-of-change
- 3-Phase voltage unbalance
- 3-Phase load unbalance
- Power factor
- Load demand

Power source specifications are determined by calculations by the designer on the basis of the design requirements for the station. The designer may use guidance provided in the National Electrical Code (not mandatory) and IEEE Std. 493 (IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems) to establish design requirements. <113>

Technical Responses

<113> DG-1029 does not contain specific guidance on power system design or power quality testing standards. The focus of DG-1029 is on equipment, not power distribution systems. Therefore, the intent of this portion of the regulatory position described in DG-1029 is not to address all aspects of power-related design issues in detail but rather to indicate the degree of surge protection and the level of power distortions that are acceptable and to identify test criteria and test methods that are appropriate for validating the efficacy of the means of protection applied in a design. The power surge guidance in DG-1029 provides information on surge voltages in low-voltage ac power circuits. With this information, equipment designers and users can evaluate their operating environment to determine the need for surge-protective devices. The implementation of surge protection is a part of the power system design specifications and detailed guidance on the means to establish design requirements is not within the scope of this regulatory position.

IX. VALUE/IMPACT Statement, Pages 33-34

"Therefore, costs associated with the implementation of this guide are expected to be minimal." The basis for this statement is the claim that this guidance is consistent with established practices currently applied throughout the commercial power industry.

Implementation of the guidance provided in the draft regulatory guide is expected to significantly increase costs above those currently being experienced. Factors that contribute to the increased costs include:

- The cost of EMI/RFI testing for all of the replacement equipment that will be needed over the next several years. This cost will be especially high if the draft guidance is applied to all equipment, including non safety-related equipment.
- The cost of providing adequate assurance that the design of this equipment is being maintained.
- The cost of developing and implementing programmatic controls to insure that all of the necessary EMI/RFI requirements are met, including documentation, maintenance, design, unintentional emissions, intentional emissions, etc.

Contrary to the NRC's assertion in the statement of Impact, the costs to the industry to augment current environmental programs are likely to be significant without a significant benefit to the public health and safety. <114>

When approved, draft Regulatory Guide DG-1029 could be considered to impose a regulatory staff position that is either new or different from a previously applicable staff position. The imposition of a new or different staff position would require a backfit analysis in accordance with 10 CFR 50.109. <115>

Technical Responses

<114> See response <89>.

<115> The regulatory position described in DG-1029 is consistent with the previous staff position expressed in the SER on EPRI TR-102323. Therefore, no backfit analysis is necessary. Additionally, since DG-1029 applies to new installations and modifications of equipment, existing installations of safety-related equipment are unaffected by this guidance.

D. DG-1029 Change Proposals

A. INTRODUCTION

The term "stressors" in the 2nd paragraph, 1st sentence will be changed to "conditions."

Note: The term will be changed to avoid the possibility of misinterpretation. However, the term is proper since a "stressor" is a phenomenon that causes the safety-related equipment to exhibit a malfunction or degradation of performance beyond its specified operational tolerances.

The reference to NUREG/CR-6431 will be updated to reflect the final published version (expected in December, 1998).

B. DISCUSSION

The text in this section will be reorganized to clearly indicate the continued acceptability of EPRI TR-102323 as one method for addressing EMC and to emphasize that DG-1029 complements the position set forth in the SER by improving the technical basis for evaluating EMI/RFI and power surges.

Note: Several commentors indicated concern about the status of the guidance addressed in the SER on EPRI TR-102323. DG-1029 and the SER each represent acceptable methods for addressing EMC.

The term "miniaturized" in the 2nd paragraph, 3rd sentence will be deleted.

Note: The point in the discussion was that modern analog circuits may be more susceptible to EMI/RFI and power surges because these circuits operate at reduced voltage levels and faster operating speeds, not because they are miniaturized.

The term "hybrid" in the last sentence of the 11th paragraph (page 7) will be defined by the following:

"hybrid (i.e., combined analog and digital electronics)"

C. REGULATORY POSITION, Section 1

The term "upgrades" in the 2nd sentence of the 1st paragraph will be changed to "modifications."

The following sentences will be added at the end of the 1st paragraph:

"This guidance is applicable to analog, digital, or hybrid (i.e., combined analog and digital electronics) equipment for all new safety-related systems or modifications to existing safety-related systems. The endorsed test methods for evaluating the electromagnetic emissions, EMI/RFI susceptibility and power surge withstand capability of safety-related equipment are intended for application in test facilities or laboratories prior to installation."

Note: These clarifications should eliminate the apparent confusion concerning the proper application of the test methods.

C. REGULATORY POSITION, Section 3

The following sentences will be added after the 1st sentence of the 1st paragraph:

"MIL-STD 461D provides the latest revision of the test criteria (which includes improvements based on experience and the latest technical information), thus it represents current practice. However, guidance on the MIL-STD 461C counterparts to the MIL-STD 461D test criteria is also given to avoid placing an undue burden on the nuclear industry by limiting the available test resources to those test laboratories with the MIL-STD 462D test capability."

Note: This explanation should further clarify the use of the test criteria by indicating that the MIL-STD 461D test criteria are the primary focus of the guidance. The option of the MIL-STD 461C test criteria allows flexibility to help avoid overly prescriptive guidance.

The term "transients" in the 3rd sentence of the 1st paragraph will be deleted to accurately reflect the phenomena covered by the test criteria.

The following paragraph will be added after the 2nd paragraph:

"The technical basis for the operating envelopes begins with MIL-STD envelopes corresponding to the electromagnetic environment military ground facilities, which were judged to be comparable to that of nuclear power plants based on general layout and equipment type considerations. Plant emissions data were used to confirm the adequacy of the operating envelopes. From the MIL-STD starting point, susceptibility envelopes were adjusted to account for the plant emissions data available from the site surveys reported in NUREG/CR-6436, "Survey of Ambient Electromagnetic and Radio-Frequency Interference Levels in Nuclear Power Plants," (November 1996) and in EPRI TR-102323. Adjustments to the emissions envelopes considered margin with the susceptibility envelopes and the primary intent of the MIL-STD envelopes (e.g., whether the envelopes were based on protecting sensitive receivers on military platforms). Finally, when changes to the operating envelopes from the MIL-STD origin were motivated by technical considerations, consistency among the envelopes for comparable test criteria was promoted and commercial emissions limits for industrial environments were factored into the adjustments of the envelopes."

Note: This summary of the supporting technical basis will clarify the source of the operating envelopes. It is stated in the INTRODUCTION section of DG-1029 that the details of the technical basis for the operating envelopes are given in NUREG/CR-5941 and NUREG/CR-6431.

C. REGULATORY POSITION, Section 4.1

The 2nd sentence of the 1st paragraph will be revised to read:

"Equipment should be exempt from this test if the following two conditions exist. First, the power quality requirements of the equipment are consistent with the existing power supply. Second, the equipment will not impose additional harmonic distortions on the existing power distribution system that exceed 5% total harmonic distortion (THD) or other power quality criteria established with a valid technical basis."

Note: The phrase "comparable power quality guidance" was unnecessarily vague so the exemption will be more clearly expressed.

The 4th and 5th sentences of the 1st paragraph will be revised to read:

"Conducted emissions on power leads should not exceed the applicable root mean square (rms) values shown in figure 4.1 for dc-operated equipment and in Figure 4.2 for ac-operated equipment. Alternate envelopes are given for ac-operated equipment based on power consumption (less than or equal to 1 kVA and greater than 1 kVA). For ac-operated equipment with a fundamental current (i.e., load current at the power line frequency) greater than 1 ampere, the envelopes in Figure 4.2 may be relaxed as follows:

dB relaxation = 20 log(fundamental current)."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY POSITION, Section 4.1, Figure 4.1

The figure illustrating the CE101 (conducted emissions, power leads, low frequency) operating envelopes will be replaced by two figures showing the operating envelope for dc power leads and the modified operating envelopes for ac power leads (see attached figures). Thus Figure 4.1 becomes Figures 4.1 and 4.2.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale and address the technical observation that certain devices could not pass the existing ac emissions limit at 60 Hz.

C. REGULATORY POSITION, Section 4.2, Figure 4.2

The figure illustrating the CE102 (conducted emissions, power leads, high frequency) operating envelopes will be replaced by a new figure showing the modified operating envelopes (see attached figure). Also, Figure 4.2 becomes Figure 4.3.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 4.3

The following sentence will be added after the 1st sentence of the 2nd paragraph:

"Alternate envelopes are given for equipment with nominal source voltages at or below 28 V and those operating above 28 V."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY POSITION, Section 4.3, Figure 4.3

The figure illustrating the CS101 (conducted susceptibility, power leads, low frequency) operating envelopes will be replaced by a new figure showing the modified operating envelopes (see attached figure). Also, Figure 4.3 becomes Figure 4.4.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 4.4

The following sentence will be added after the 2nd sentence of the 1st paragraph:

"Equipment tested under the RS103 test may exempt application of this test in the frequency band from 30 MHz to 400 MHz."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY POSITION, Section 4.4, Figure 4.4

Figure 4.4 becomes Figure 4.5.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 4.5

The 5th sentence of the 1st paragraph will be revised as follows:

"Magnetic field emissions should not be radiated in excess of the levels shown in Figure 4.6. Magnetic field emissions may be measured at either one of the specified distances of 7 cm or 50 cm and compared against the corresponding envelope."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY-POSITION, Section 4.5, Figure 4.5

The figure illustrating the RE101 (radiated emissions, magnetic field, low frequency) operating envelopes will be replaced by a new figure showing the modified operating envelopes (see attached figure). Also, Figure 4.5 becomes Figure 4.6.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 4.6, Figure 4.6

The figure illustrating the RE102 (radiated emissions, electric field, high frequency) operating envelopes will be replaced by a new figure showing the modified operating envelopes (see attached figure). Also, Figure 4.6 becomes Figure 4.7.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 4.7

The following sentence will be added after the 1st sentence of the 1st paragraph:

"Equipment that is not intended to be installed in areas with strong sources of magnetic fields (e.g., CRTs, motors, cable bundles carrying high currents, etc.) and that follows the limiting practices endorsed in this regulatory guide should be exempt from this test."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY POSITION, Section 4.7, Figure 4.7

The figure illustrating the RS101 (radiated susceptibility, magnetic field, low frequency) operating envelopes will be replaced by a new figure showing the modified operating envelopes (see attached figure). Also, Figure 4.7 becomes Figure 4.8.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 4.8

The following sentence will be added after the 2nd sentence of the 1st paragraph:

"Equipment tested under the CS114 test may exempt application of this test in the frequency band from 10 kHz to 30 MHz."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

The 2nd sentence of the 2nd paragraph will be changed to read:

"The impressed electric field level should be 10 V/m (rms), measured in accordance with the techniques specified in the RS103 test method."

C. REGULATORY POSITION, Section 5.1

The 2nd sentence of the 1st paragraph will be revised to read:

"Equipment should be exempt from this test if the following two conditions exist. First, the power quality requirements of the equipment are consistent with the existing power supply. Second, the equipment will not impose additional harmonic distortions on the existing power distribution system that exceed 5% total harmonic distortion (THD) or other power quality criteria established with a valid technical basis."

Note: The phrase "comparable power quality guidance" was unnecessarily vague so the exemption will be more clearly expressed.

The 3rd sentence of the 2nd paragraph will be revised to read:

"The CE01 test is applicable for emissions on ac power leads from the power line frequency to 15 kHz for low power consumption equipment (less than or equal to 1 kVA) and from the first harmonic of the power line frequency to 15 kHz for high power consumption equipment (greater than 1 kVA)."

The following sentence will be appended to the 2nd paragraph.

"For ac-operated equipment with a fundamental current (i.e., load current at the power line frequency) greater than 1 ampere, the envelopes in Figure 5.2 may be relaxed as follows:

$$\text{dB relaxation} = 20 \log(\text{fundamental current})."$$

Note: These changes will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY POSITION, Section 5.1, Figure 5.2

The figure illustrating the CE01 (conducted emissions, power leads, low frequency) operating envelopes for ac power leads will be replaced by a figure showing the modified operating envelopes for ac power leads (see attached figures).

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale and address the technical observation that certain devices could not pass the existing ac emissions limit at 60 Hz.

C. REGULATORY POSITION, Section 5.2

The 4th sentence of the 1st paragraph will be revised to read:

"Conducted emissions should not appear on the power leads in excess of the rms values shown in Figure 5.3 for narrowband emissions. Broadband emissions measurements are not necessary."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY POSITION, Section 5.2, Figures 5.3 and 5.4

The figure illustrating the CE03 (conducted emissions, power leads, high frequency) operating envelope for narrowband emissions will be replaced by a new figure showing the modified operating envelopes (see attached figure). Figure 5.4 will be deleted.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 5.3, Figure 5.5

Figure 5.5 becomes Figure 5.4.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 5.5, Figure 5.6

The figure illustrating the RE01 (radiated emissions, magnetic field, low frequency) operating envelope will be replaced by a new figure showing the modified operating envelope (see attached figure). Also, Figure 5.6 becomes Figure 5.5.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 5.6

The 4th sentence of the 1st paragraph will be revised to read:

"Radiated electric field emissions should not appear at the receiving antennas in excess of the rms values shown in Figure 5.6 for narrowband emissions. Broadband emissions measurements are not necessary."

The following paragraph will be added after the 1st paragraph.

"The terms *narrowband* and *broadband* refer to the values for the measurement receiver bandwidths to be employed during the emissions testing. A factor of 10 is typically specified as the separation between the narrowband and broadband bandwidths, and it is used to differentiate between narrowband and broadband interference sources. If the interference is broadband (e.g., arc welders and motors), a reduction in the bandwidth by a factor of 10 on the measurement receiver should result in at least a 6 dB drop in the interference level. Otherwise, the interference is considered to be narrowband (e.g., two-way radios)."

Note: These changes will reflect the updated rationale of the DG-1029 operating envelopes and add to the clarity of the guidance.

C. REGULATORY POSITION, Section 5.6, Figures 5.7 and 5.8

The figure illustrating the RE102 (radiated emissions, electric field, high frequency) operating envelope for narrowband emissions will be replaced by a new figure showing the modified operating envelope (see attached figure). Figure 5.8 will be deleted. Also, Figure 5.7 becomes Figure 5.6.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 5.7

The following sentence will be added after the 1st sentence of the 1st paragraph:

"Equipment that is not intended to be installed in areas with strong sources of magnetic fields (e.g., CRTs, motors, cable bundles carrying high currents, etc.) and that follows the limiting practices endorsed in this regulatory guide should be exempt from this test."

Note: This change will reflect the updated rationale of the DG-1029 operating envelopes.

C. REGULATORY POSITION, Section 5.7, Figure 5.9

Figure 5.9 becomes Figure 5.7.

Note: The revision of the DG-1029 operating envelopes will reflect the updated rationale.

C. REGULATORY POSITION, Section 6

The 2nd paragraph will be replaced by the following:

"General withstand levels that are acceptable to the NRC staff are given with each surge waveform. IEEE Std C62.41-1991 describes location categories and exposure levels that define applicable amplitudes for the surge waveforms that should provide an appropriate degree of SWC. Location categories depend on the proximity of equipment to the service entrance and the associated line impedance. Exposure levels relate to the rate of surge occurrence versus the voltage level (e.g., surge crest) to which equipment is exposed. The withstand levels presented in this regulatory position are based on *Category B* locations with *Low to Medium Exposure* levels. *Category B* covers feeders and short branch circuits less than 10 meters from the service entrance. *Low to Medium Exposure* levels encompass systems in areas with little load or capacitor switching and low-power surge activity to areas with significant switching transients or medium- to high-power surge activity. The basis for the withstand levels provides reasonable assurance that the general power surge environment in nuclear power plants is adequately characterized. The withstand levels are acceptable for locations where safety-related I&C systems either are or are likely to be installed and include control rooms, remote shutdown panels, cable spreading rooms, equipment rooms, auxiliary instrument rooms, relay rooms, and other areas (e.g., the turbine deck) where safety-related I&C system installations are planned."

Note: The discussion of the rationale for the selection of the withstand levels was confused by some commentors as being guidance that established by decree a classification of all plant locations. The text is changed to more clearly indicate that the basis for the withstand levels was selected because it provides the necessary conservatism to reasonably bound projected surge conditions in nuclear power plants with adequate margin.

C. REGULATORY POSITION, Section 6.2

The 3rd sentence of the 2nd paragraph will be changed to read:

"The virtual origin is the point where a straight line between the 30% and 90% points on the leading edge of the waveform intersects the V=0 line for the open-circuit voltage and the I=0 line for the short-circuit current."

C. REGULATORY POSITION, Section 6.3

The following sentences will be added at the end of the 1st paragraph:

"The number of pulses in a burst is determined by the pulse frequency. For peaks ≤2 kV, the frequency shall be 5 kHz ±1 kHz. For peaks >2 kV, the frequency shall be 2.5 kHz ±0.5 kHz. The differences in repetition rates are not intended to reflect characteristics of the power surge environment but to accommodate existing limitations in pulse generator performance."

Note: Including more detailed information from IEEE Std C62.41-1991 (Reaffirmed in 1995) should provide greater clarity on the application of the test criteria.

C. REGULATORY POSITION, Section 7

The 1st sentence of the 1st paragraph will be changed to begin as follows:

"Electromagnetic compatibility documentation should provide evidence that ..."

The 2nd paragraph will be changed to read:

"The content of electromagnetic compatibility documentation should contain the information listed below, as well as any additional information specified in the standards cited in this regulatory position. These items could be included as part of a qualification or dedication file."

The term "report" in the fifth item (5) of documentation information list on page 32 will be changed to "results."

Note: Section 7 is not intended to create a new requirement for extensive documentation.

D. IMPLEMENTATION

The following sentence will be appended to the first paragraph.

"No backfitting is intended or approved in connection with this guide."

The 2nd paragraph will be rewritten as follows:

"Except in those cases in which an applicant or licensee proposes acceptable alternative practices for complying with the specified portions of the NRC's regulations, the methods to be described in this guide will be used in the evaluation of submittals in connection with applications for construction permits and operating licenses. This guide will also be used to evaluate submittals from operating reactor licensees that propose system modifications voluntarily initiated by the licensee if there is a clear nexus between the proposed modifications and this guidance."

Note: These changes should clarify the applicability of this guidance.

Value/Impact Statement

The term "upgrade" in the last sentence of the last paragraph will be changed to "modify."

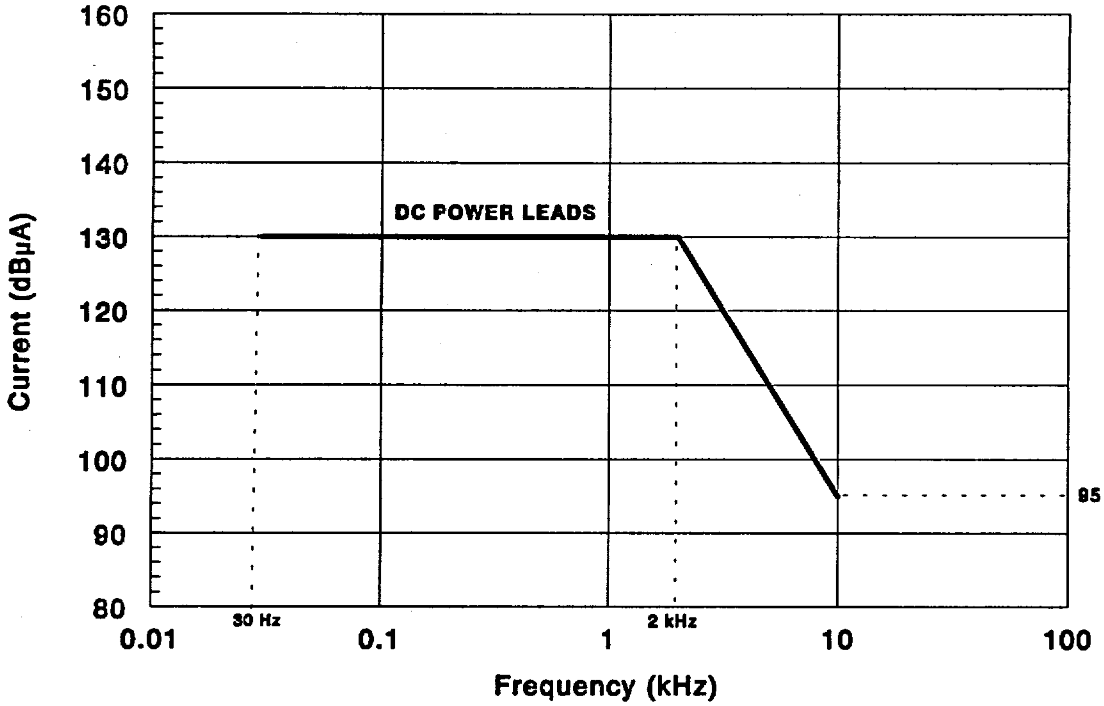

Figure 4.1 CE101 Emissions Envelope for dc Power Leads

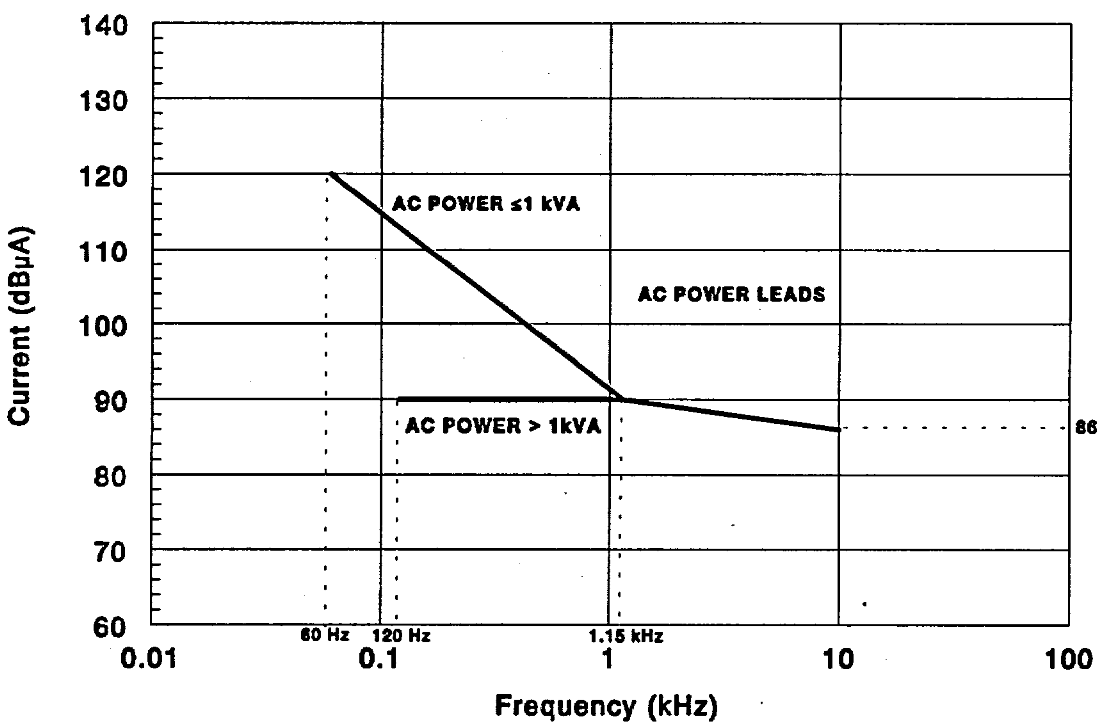

Figure 4.2 CE101 Emissions Envelopes for ac Power Leads

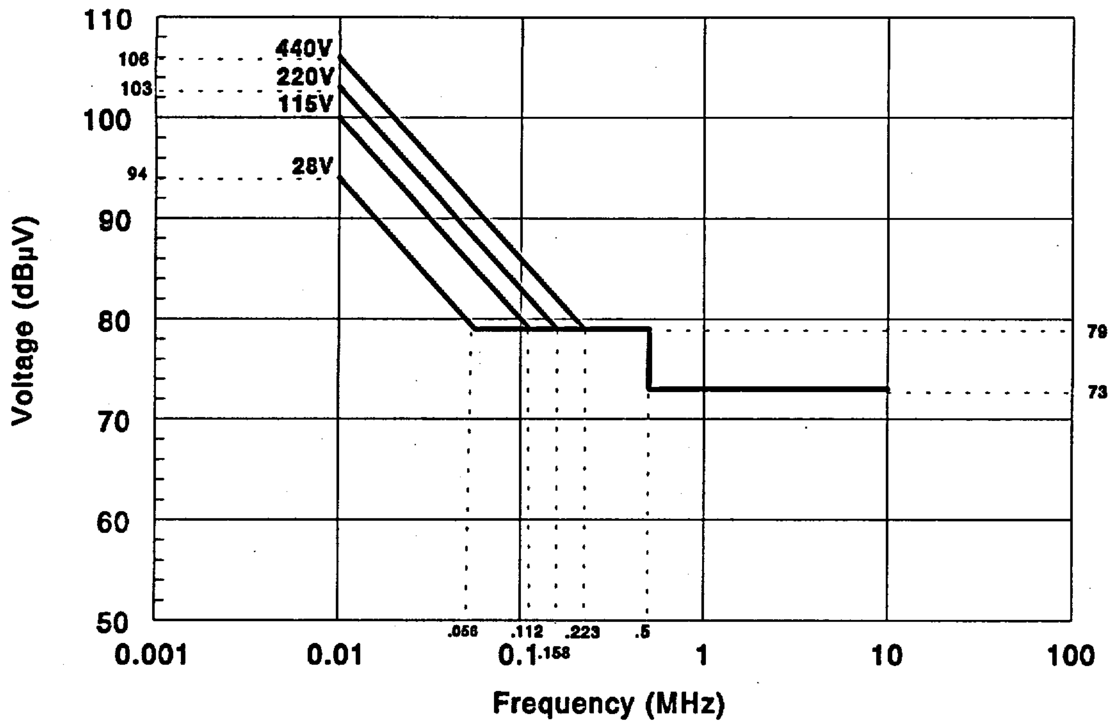

Figure 4.3 CE102 Emissions Envelopes

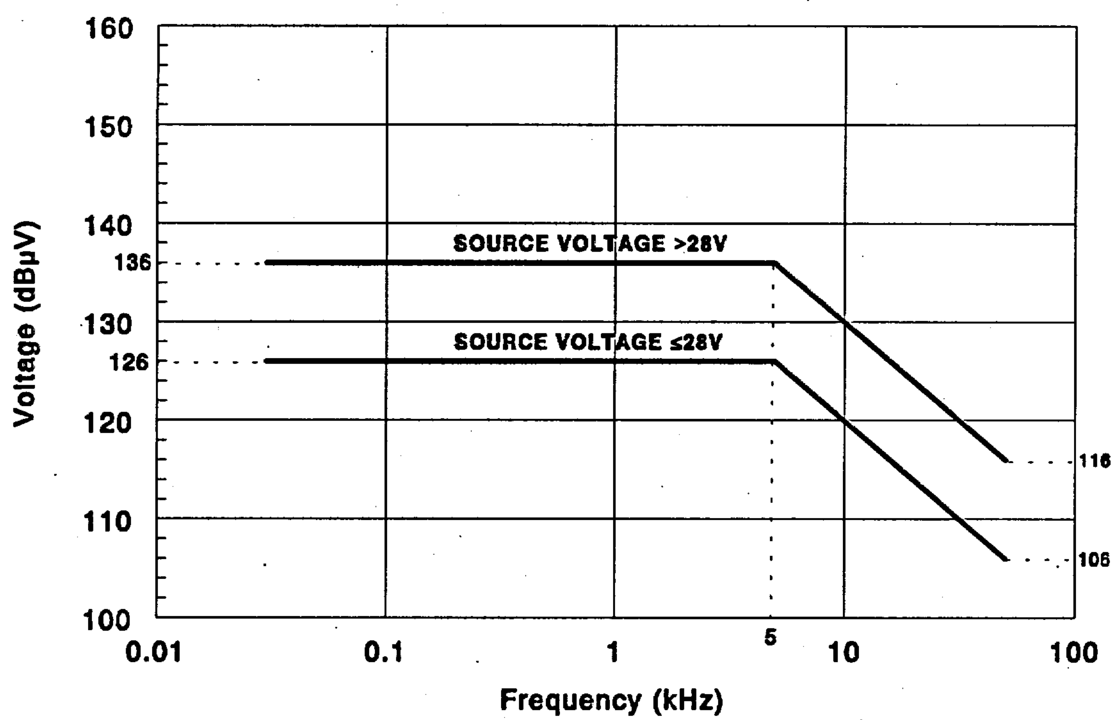

Figure 4.4 CS101 Operating Envelopes

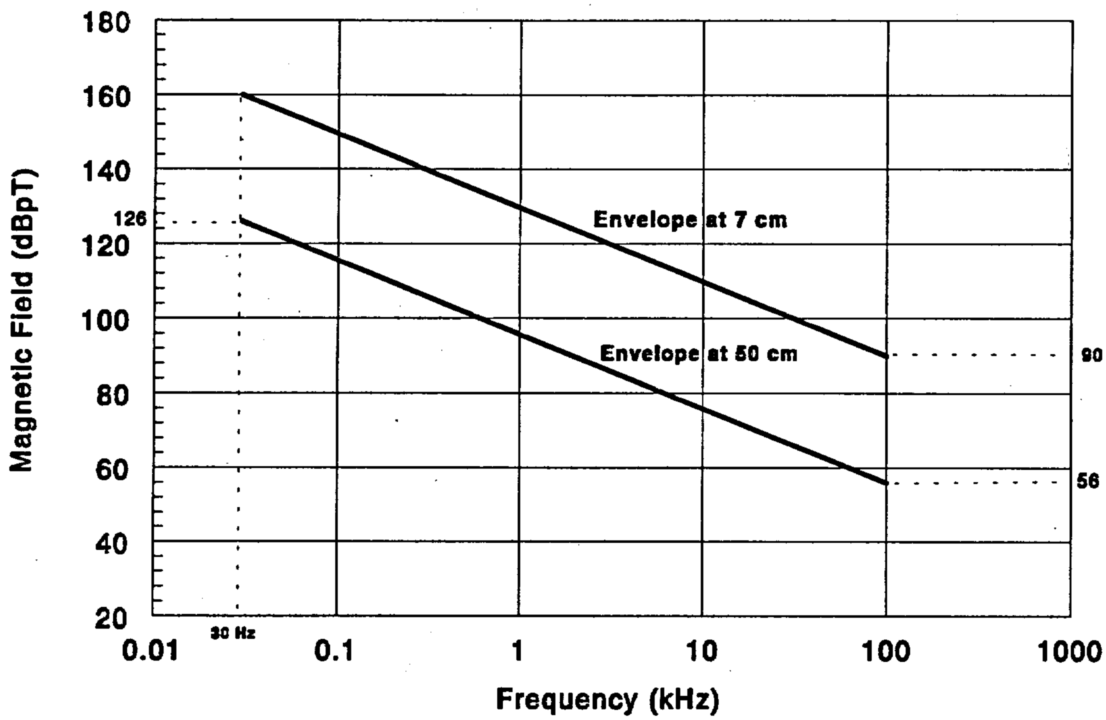

Figure 4.6 RE101 Magnetic Field Emissions Envelopes

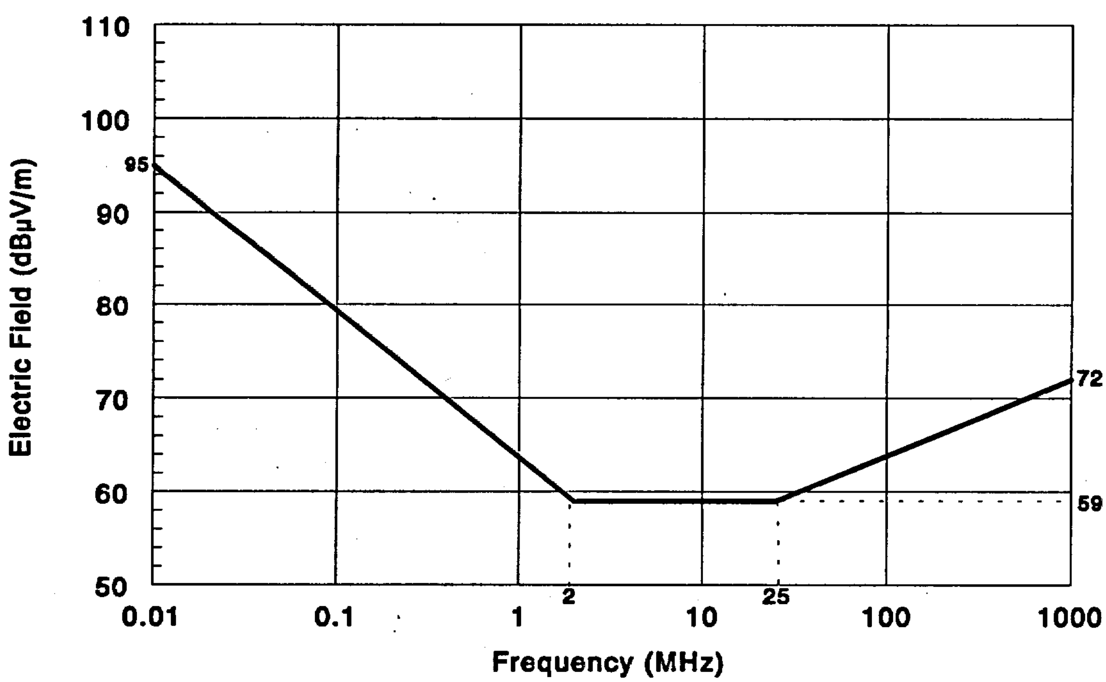

Figure 4.7 RE102 Emissions Envelope

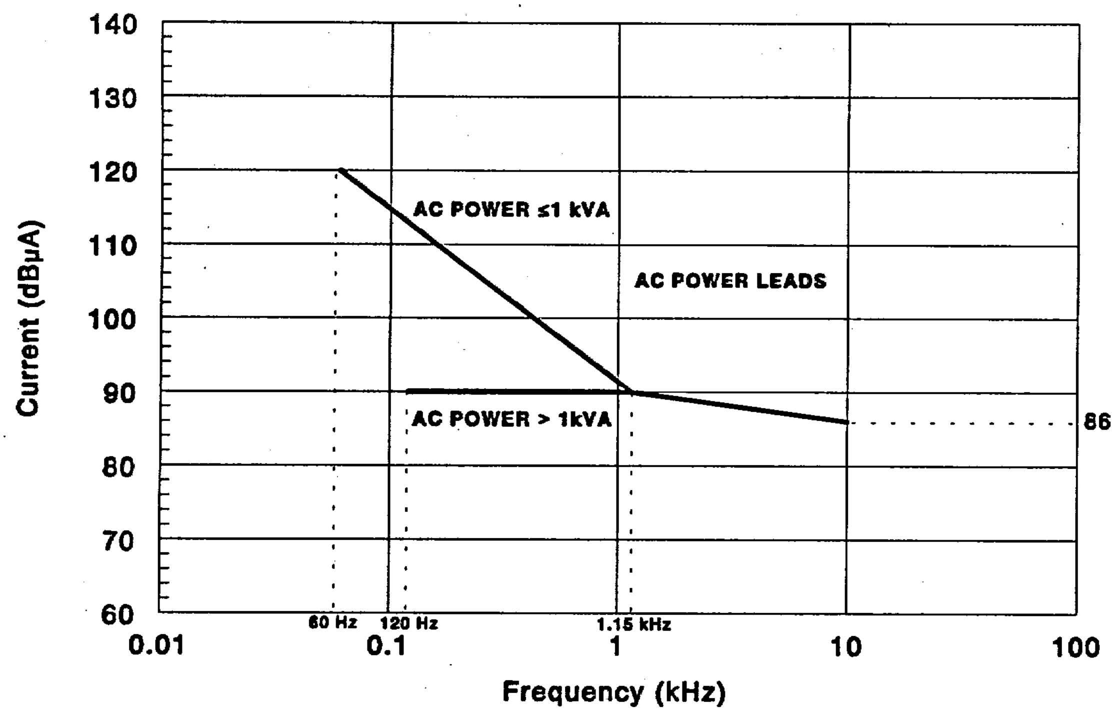

Figure 5.2 CE01 Emissions Envelope for ac Power Leads

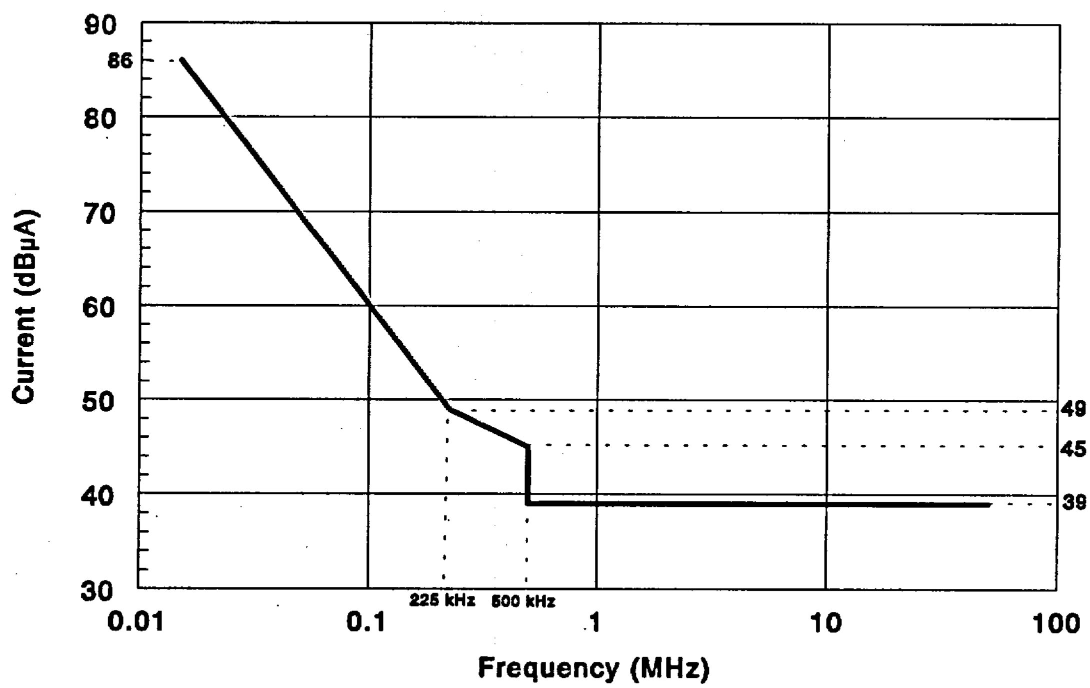

Figure 5.3 CE03 Narrowband Emissions Envelope

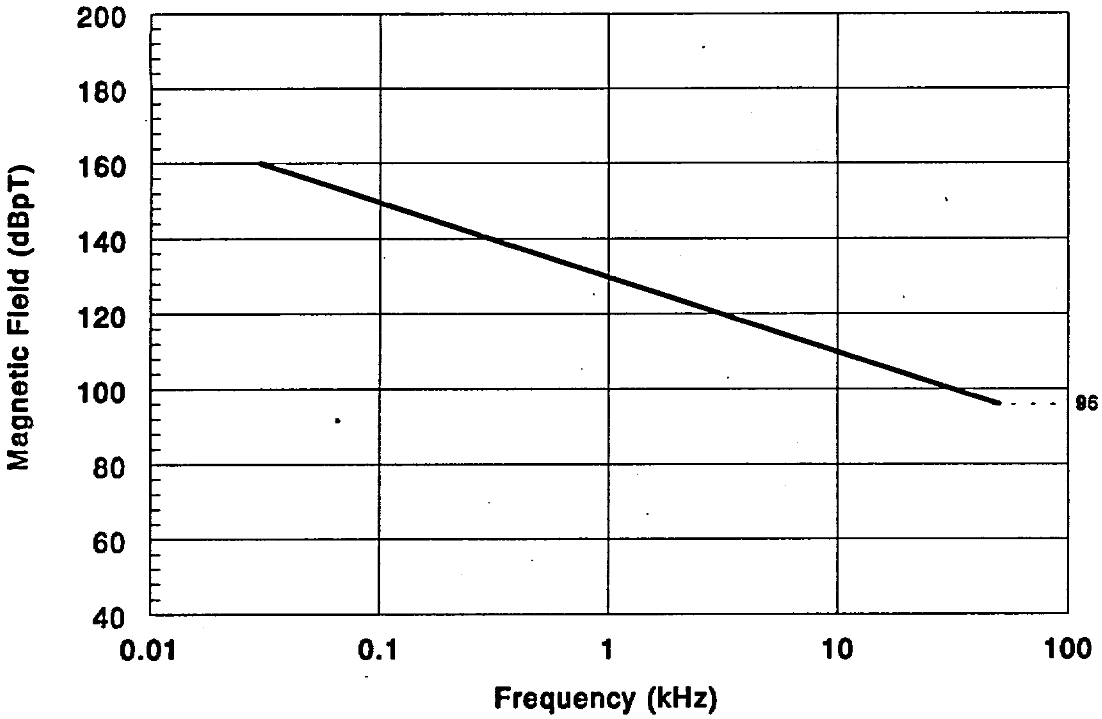

Figure 5.5 RE01 Magnetic Field Emissions Envelope

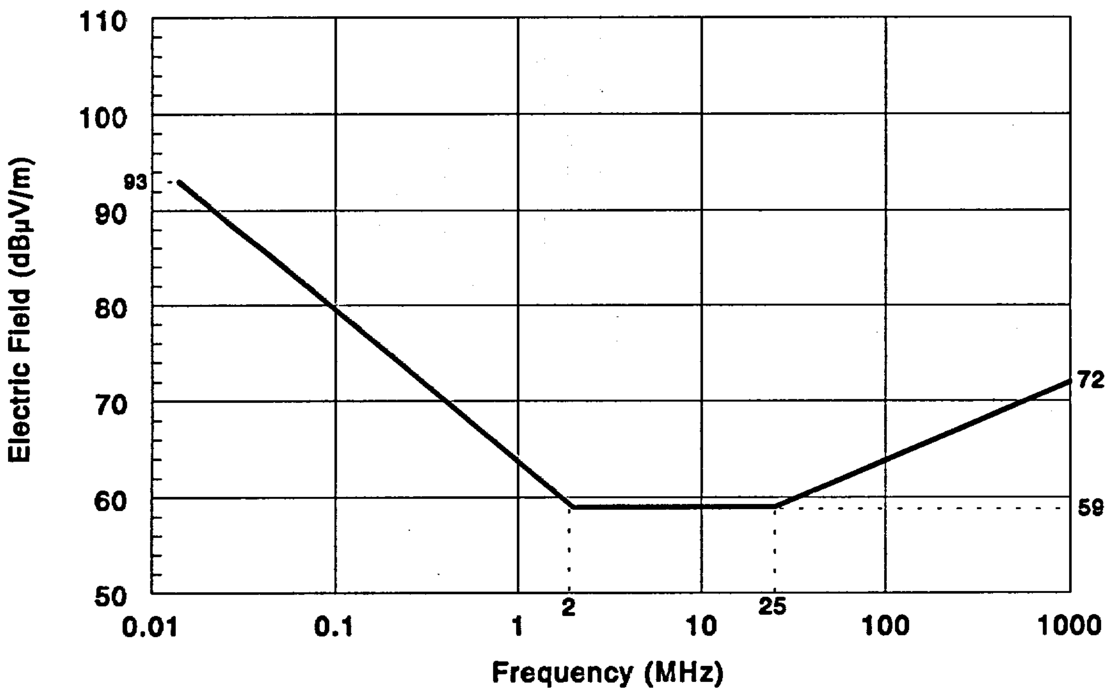

Figure 5.6 RE02 Narrowband Emissions Envelope

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