



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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DATE OF MEETING

01/16/2001

The attached document(s), which was/were handed out in this meeting, is/are to be placed in the public domain as soon as possible. The minutes of the meeting will be issued in the near future. Following are administrative details regarding this meeting:

Docket Number(s)

PROJECT NO. 669

Plant/Facility Name

EPRI

TAC Number(s) (if available)

Reference Meeting Notice

DECEMBER 29,2000

Purpose of Meeting
(copy from meeting notice)

TO DISCUSS EPRI'S REPORT TR-102323-R2,

"GUIDELINES FOR EMI TESTING IN POWER

PLANTS"

NAME OF PERSON WHO ISSUED MEETING NOTICE

L. N. OLSHAN

TITLE

PROJECT MANAGER

OFFICE

NRR

DIVISION

DLPM

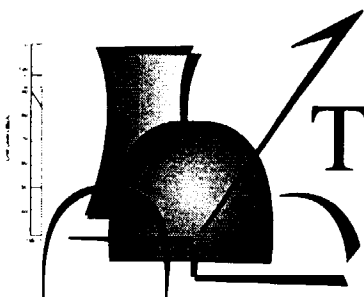
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PD II-1

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TR-102323 Revision 2 EMI Guidelines

The EPRI EMI Working Group

Group Chairman: Jim Shank (PSEG Nuclear)

EPRI Project Manager: Ramesh Shankar

704-547-6127

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EPRI Charlotte

Science & Technology Division

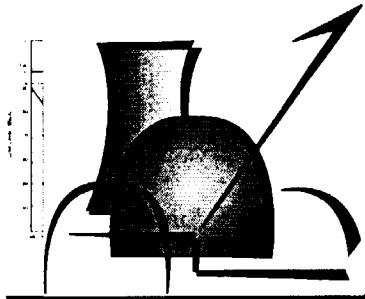
U.S. NRC- EPRI EMI Working Group Meeting

U.S. NRC

White Flint, MD

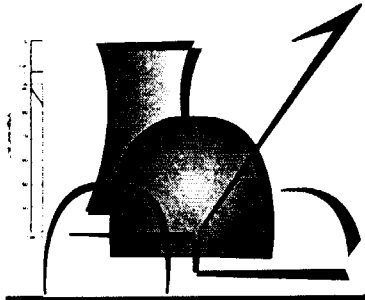
January 16, 2001

EPRI



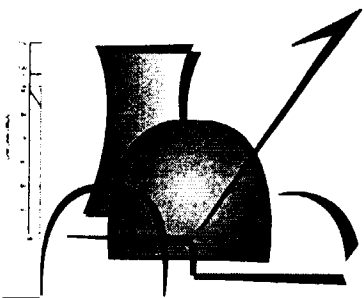
EMI Working Group Members

- Rick Brehm - TVA
- Finbarr O'Connor – IIT Research Institute
- Rober Carritte – MPR Associates, Inc.
- James Press – National Technical Systems
- Norman Eisenmann – Entergy
- James W. Shank – PSEG Nuclear
- Joseph Hazeltine – Wyle Laboratories, Inc.
- Ramesh Shankar – EPRI
- Sang D. Lee – Southern Nuclear
- Moazam Syed – TXU Electric
- Wade Messer – Duke Energy
- Carl Vitalbo – Westinghouse Electric Co.



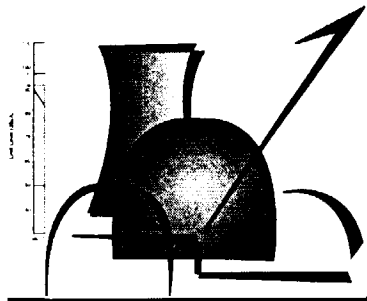
TR-102323 Rev. 2 Purpose & Scope

- Revise Testing Standards & Limits
 - Update recommended and referenced standards
 - Focus on endorsement of commercial standards where possible
 - Incorporate lessons learned
- Improve understanding of the applicability of requirements
- Seeking NRC endorsement



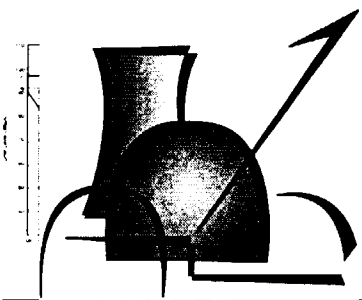
Reg. Guide 1.180 & TR-102323-R1

- Regulatory Guide 1.180 “Guidelines for EMI...”, 1/2000
- Identical approach to TR-102323-R1
- Major differences:
 - Emissions Testing Limits
 - Endorsement of the IEC Standard
- EPRI-NRC Subgroup Formed to Review ORNL Plant Emissions Data
- Joint NRC-EPRI-DOE Project recommended



EMI Working Group

- Working Group identified 30+ issues for resolution in TR-102323-R1
 - Susceptibility and Emissions testing limits and frequencies
 - Updating reference to Standards
 - General Testing requirements (systems vs components tests, e.g.)
 - Graded EMI Environments
 - Updating section on Limiting Practice
 - Guidance on acceptance of commercial equipment tests
 - (“CE” mark, FCC Testing, etc.)
 - Document User Friendliness



TR-102323-R2

Relief in some susceptibility and emission limits

Scope of testing for other than safety-related equipment included

Endorses equipment qualified to IEC testing standards where possible

Qualification, testing philosophy and limiting practices unchanged

Eases Compliance

Clarifies applicability of testing for non-safety related equipment and equipment important to power production.

Reduces testing burden and improves number of design options

Maintain continuity

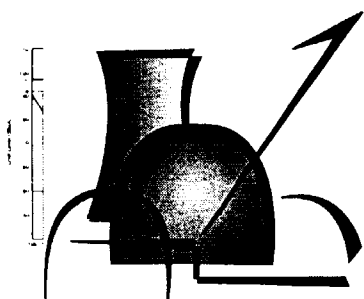


Table 5.1 Testing Applicability

	Susceptibility Tests							Emissions Tests			
	Conducted		Radiated		Surge	EF T	ES D	Conducted		Radiated	
	Low-Frequency	High-Frequency	Low-Frequency	High-Frequency				Low-Frequency	High-Frequency	Low-Frequency	High-Frequency
Safety-Related	A	A	E	A	A	A	O	E	E	E	A
Important to Power Production	R	R	E	R	R	R	O	E	E	E	A
Non-Safety-Related	O	O	O	O	O	O	O	E	E	E	A

A = Applicable. These tests shall be performed, or an exemption including a technical justification for why the test is not required shall be documented.

E = Evaluate. These tests shall be performed, or design features/conditions as specified for each test type shall be satisfied. If testing is not performed, the design conditions/features that address this equipment emissions source shall be documented.

R = Recommended. These tests should be performed, or an exemption including a technical justification for why the test is not needed should be documented.

O = Optional. These tests are optional. Noise sources local to the equipment and installation practices should be considered in determining susceptibility testing needs for non-safety-related equipment.

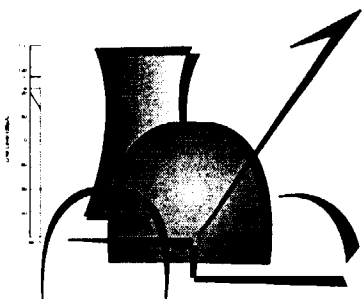


Table 5.2 Susceptibility Testing Standards

Susceptibility Tests		
	MIL-STD-461E	Commercial Standard
Low-Frequency Conducted	CS101	IEC EN 61000 Part 4 Section 13
High-Frequency Conducted	CS114	IEC EN 61000 Part 4 Section 6
Low-Frequency Radiated	RS101	IEC EN 61000 Part 4 Sections 8, 9, and 10
High-Frequency Radiated	RS103	IEC EN 61000 Part 4 Section 3
Surge	CS116	IEC EN 61000 Part 4 Section 5
Electrically-Fast Transient	CS115	IEC EN 61000 Part 4 Section 4
Electrostatic Discharge	N/A	IEC EN 61000 Part 4 Section 2

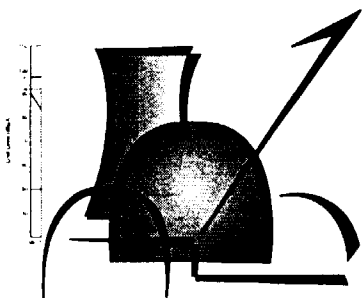
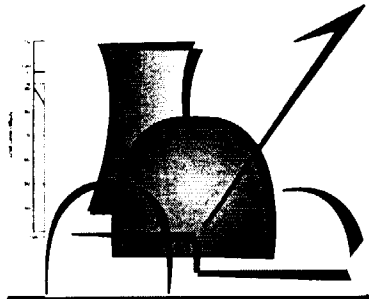


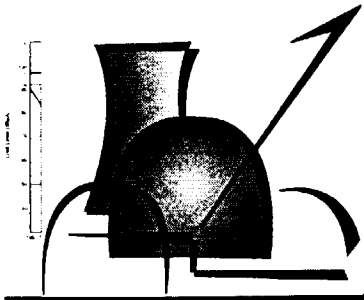
Table 5.2 Emissions Testing Standards

Emissions Tests		
	MIL-STD-461E	Commercial Standard
Low-Frequency Conducted	CE101	IEC EN 61000 Part 3 Section 2
High-Frequency Conducted	CE102	None
Low-Frequency Radiated	RE101	None
High-Frequency Radiated	RE102	FCC 47 CFR Part 15 or EN 55022



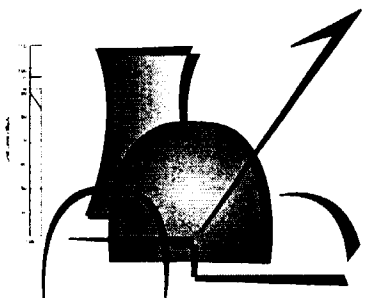
Low-Frequency Conducted Susceptibility Testing

- High frequency roll-off beyond 5 kHz
- Introduced a new level for EUT operating at 28 VDC or below
- Low frequency starting point of 2nd harmonic of power frequency
- These changes are consistent with MIL-STD-461E and RG 1.180

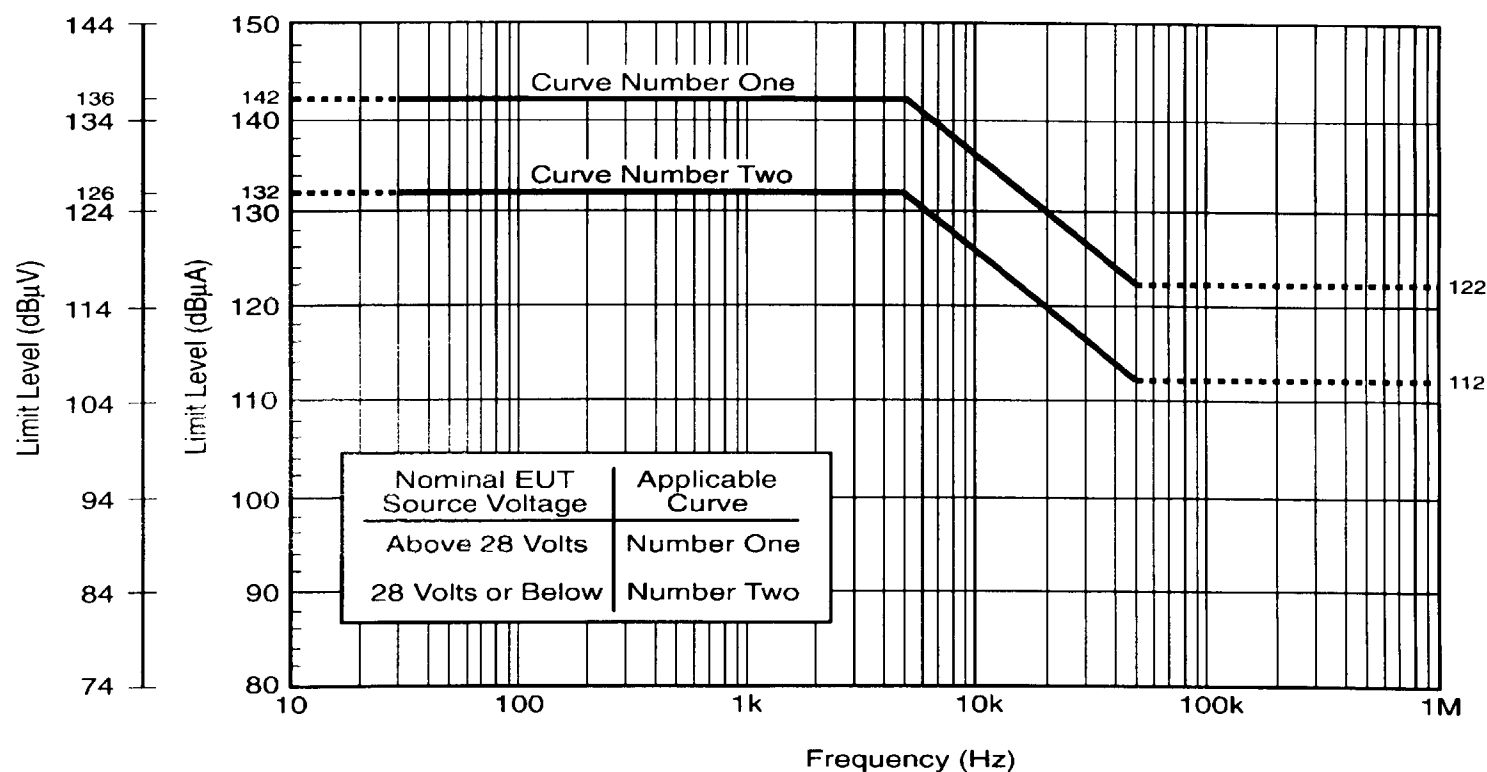


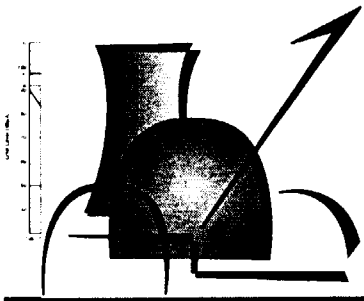
Low-Frequency Conducted Susceptibility Testing

- We now accept testing in accordance with IEC 61000-4-13 to Class 3 limits
- The CS101 and 61000-4-13 testing methodologies are similar; however, the most significant difference is that 4-13 terminates at 2.4 kHz. This issue has been addressed by documenting that this test is not acceptable if EUT will be exposed to switching power supplies, static frequency converters, induction motors, welding machines or similar equipment



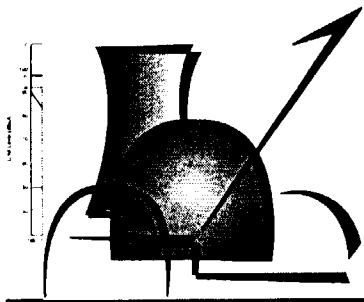
Low-Frequency Conducted Susceptibility Testing Limit





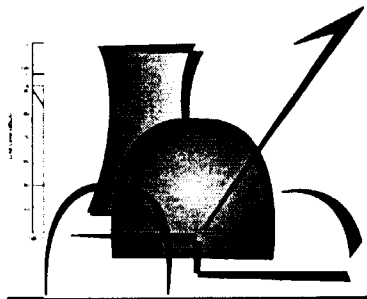
High-Frequency Conducted Susceptibility Testing

- Added new limit for signal cables
- Previous limit was established based on plant emissions measured on power cables, therefore a new limit was introduced to allow relaxation for signal cables based on 461E CS114 Curve #2 which is supported by comparison with collected plant emissions data beyond 1 MHz.



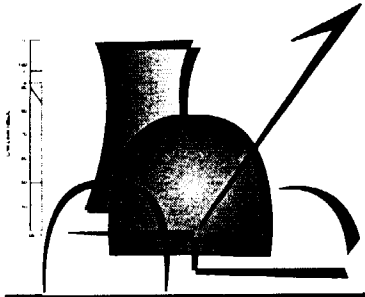
High-Frequency Conducted Susceptibility Testing

- Limit reduced for power cables from 103 dB μ A to 97 dB μ A .
- The limit was reduced to allow for relaxation and a new margin of 6 dB μ A. The new limit of 97 dB μ A was selected because it aligns with 461E limit Curve #4
- High frequency roll-off beyond 20 MHz
- The previous limit was flat across all tested frequencies. The high frequency roll-off brings this test into better alignment with 461E CS114 and Reg. Guide 1.180

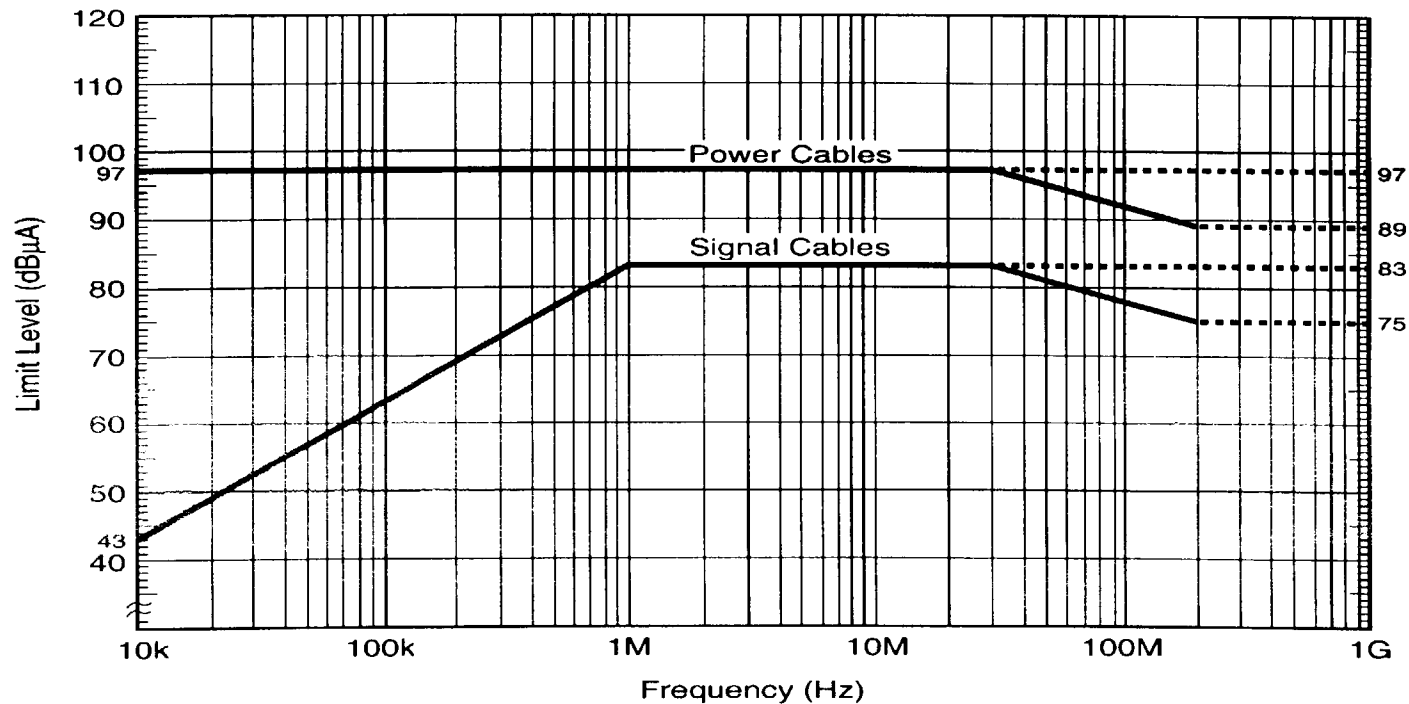


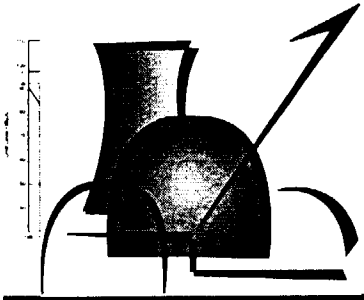
High-Frequency Conducted Susceptibility Testing

- Testing terminates at 200 MHz as opposed to 400 MHz
- There is no need to perform this test above 200 MHz since high frequency radiated testing starts at 2MHz. This change also brings this test into better alignment with 461E CS114 and Reg. Guide 1.180



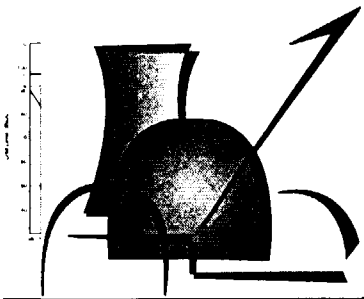
High-Frequency Conducted Susceptibility Testing Limit



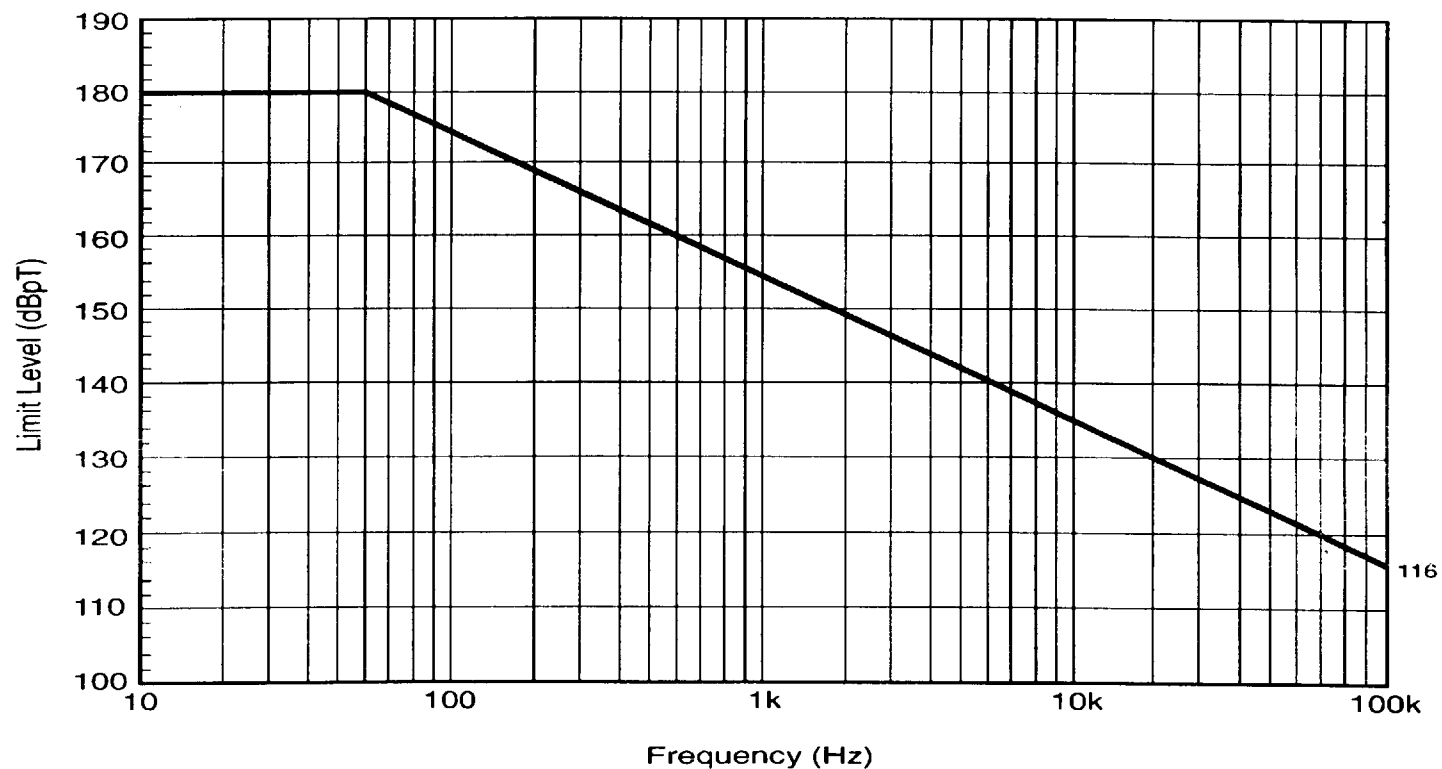


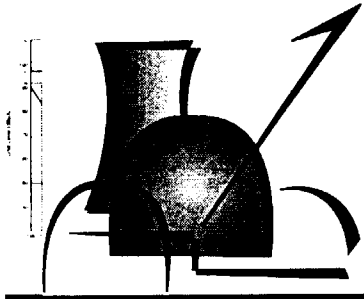
Low-Frequency Radiated Susceptibility Testing

- Endorsement of IEC 61000-4-8
- Although there are major differences in the scope and methodology of the MIL-STD 461E RS101 test and the IEC 61000-4-8 test, this test meets the intent of demonstrating immunity of equipment to radiated magnetic fields



Low-Frequency Radiated Susceptibility Testing Limit





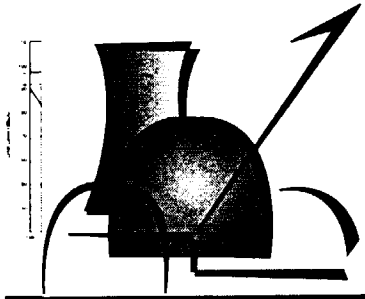
High-Frequency Radiated Susceptibility Testing

- Allowance to start test at 30 MHz provided test CS114 or 61000-4-6 is also performed
- This change brings this test recommendation into better alignment with 461E RS103 and Reg. Guide 1.180
- Extended tested frequency range from 1 GHz to 10 GHz
- Extending the tested frequency range was necessary to address the increased demand and use of equipment operating at frequencies above 1 GHz



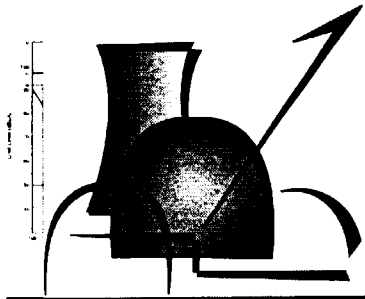
Surge

- Reduced secondary or derived power distribution system voltage test limit from 3 kV to 2 kV. Increased primary power connected to external lines voltage test limit from 3 kV to 4 kV. Reduced shields & ground leads connected to remote (> 30m) grounds voltage test limit from 3 kV to 2 kV
- This change brings this test recommendation into better alignment with IEC 61000-4-5 and is supported by the existing compatibility margins documented in TR-102323. The changes noted above are changes to both TR-102323 Rev. 1 and R.G. 1.180 which both currently specify 3 kV limits



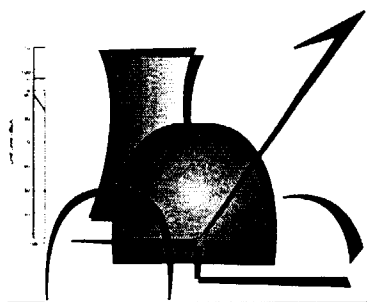
Electrically-Fast Transients/Bursts

- Differentiated testing for power ports vs. I/O, data & control ports. Specified the use of the coupling/decoupling network for testing power ports. Allowed the use of the coupling clamp for testing I/O, data and control ports
- This change brings this test recommendation into better alignment with IEC 61000-4-4



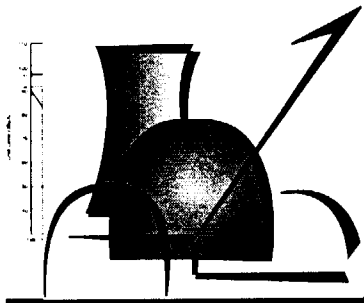
Electrically-Fast Transients/Bursts

- Reduced testing level for power ports voltage from 3 kV to 2 kV. Reduced testing level for I/O, data and control ports from 3 kV to 1 kV. Specified that Control ports that control unsuppressed inductive loads shall be tested to $\pm 2 \text{ kV}_{\text{p-p}}$. Specified that Input/Output (I/O), data and control cables routed with power supply or control cables with unsuppressed inductive loads shall also be tested to $\pm 2 \text{ kV}_{\text{p-p}}$
- This change brings this test recommendation into better alignment with IEC 61000-4-4 and is supported by the existing compatibility margins documented in TR-102323. The changes noted above are changes to both TR-102323 Rev. 1 and R.G. 1.180 which both currently specify 3 kV limits for all connection ports



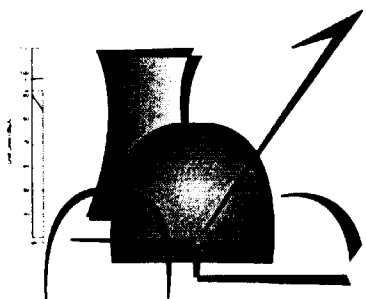
Low-Frequency Conducted Emissions Testing

- Introduced a new level for EUT operating at 28 VDC or below
- These changes are consistent with MIL-STD-461E for Navy & Army aircraft; however, RG 1.180 specifies limits that most closely match a submarine platform.
- Low frequency starting point of 2nd harmonic of power frequency
- These changes are consistent with MIL-STD-461E and RG 1.180

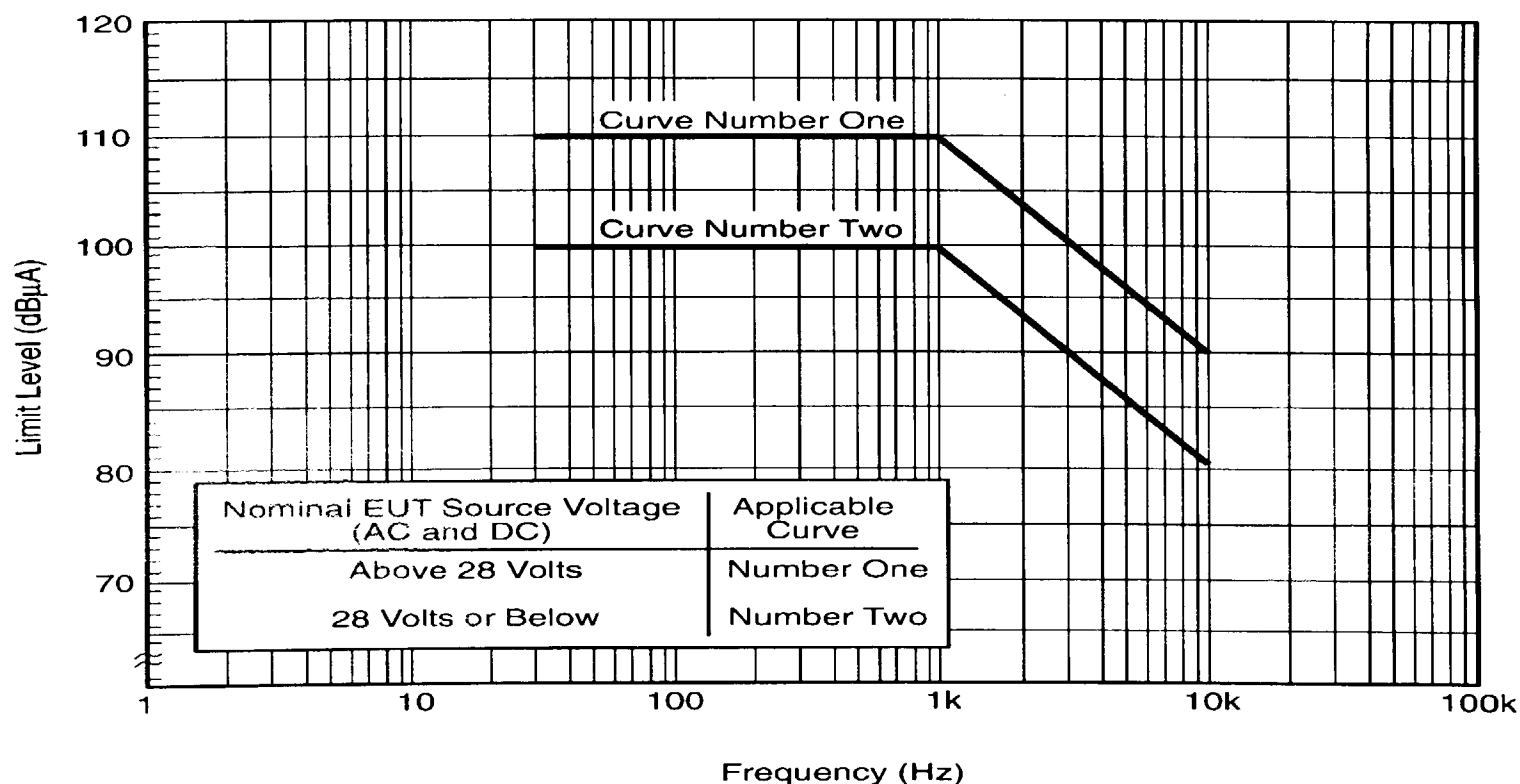


Low-Frequency Conducted Emissions Testing

- We now allow a db relaxation limit defined as $\text{db Relaxation} = 20 \log (\text{Fundamental Power Frequency Current})$
- These changes are consistent with RG 1.180; however, MIL-STD-461E does not specify a limit dB relaxation for CE101-4 (Navy & Army aircraft)
- Reduced TR-102323 Rev. 1 limit (more restrictive) from 122 dB μ A at 30Hz to 110 dB μ A at 60 Hz for source voltages greater than 28 V and down to 100 dB μ A for source voltages less than or equal to 28 V
- Because the primary concern of this test is to control fundamental power frequency harmonics, reduction of the limit up to 1kHz is appropriate



Low-Frequency Conducted Emissions Testing Limit

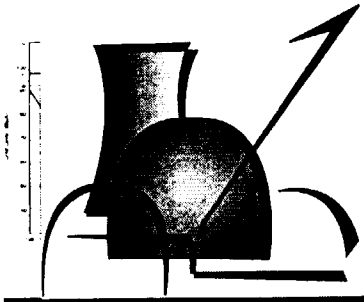


Note:

For equipment and subsystems with a fundamental current greater than one ampere, the limit shall be relaxed as follows:

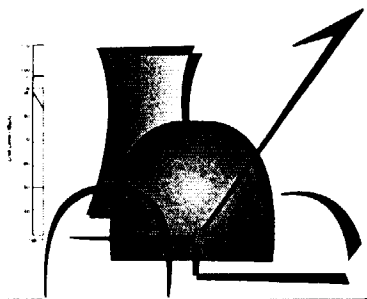
dB Relaxation = $20 \log (\text{Fundamental Power Frequency Current})$



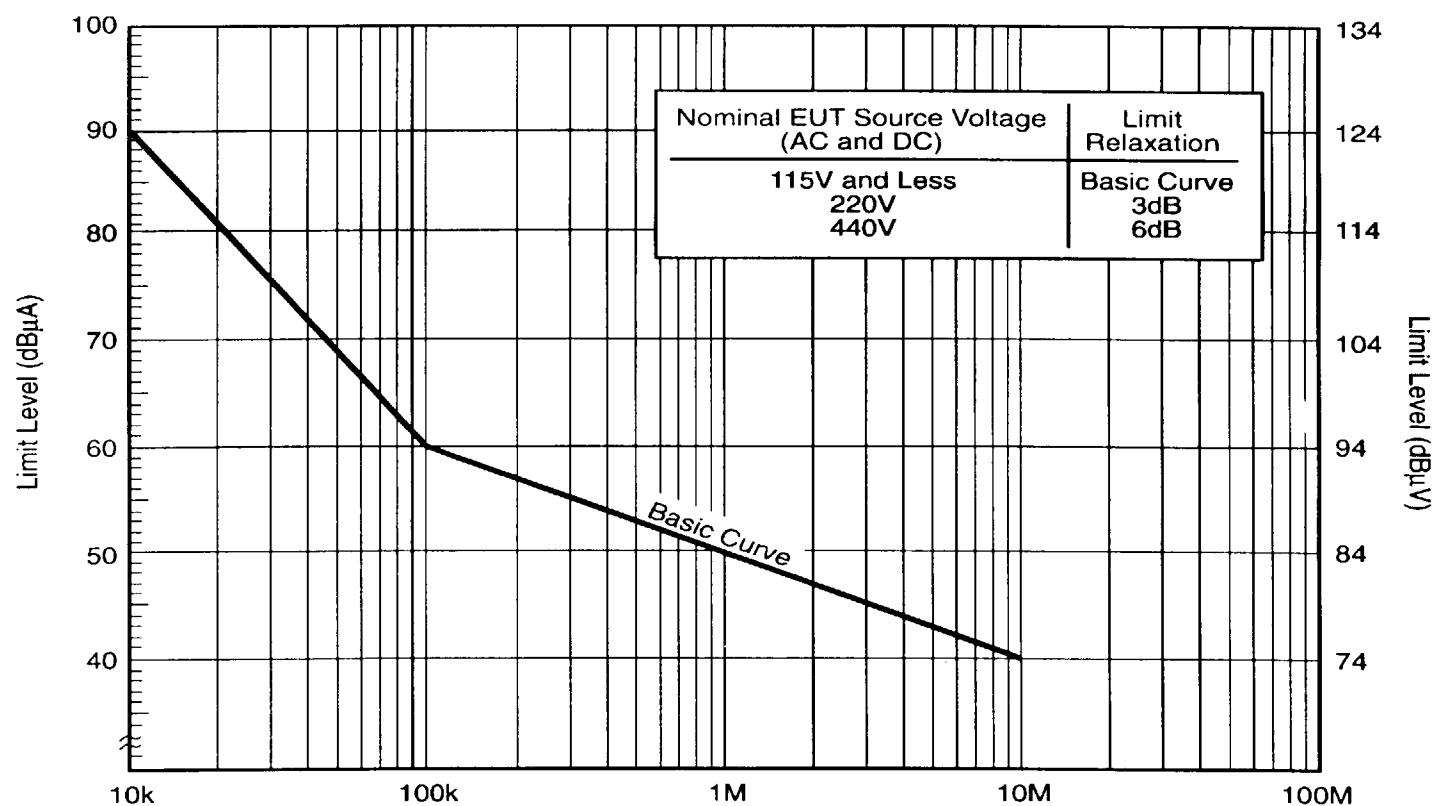


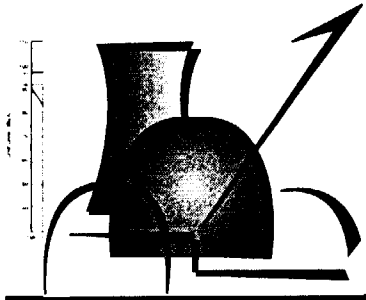
High-Frequency Conducted Emissions Testing

- Changed part of limit curve from 78 dB μ A at 50 kHz & 60 dB μ A at 100 kHz to 90 dB μ A at 10 kHz & 60 dB μ A at 100 kHz. This change effectively reduced the TR-102323 Rev. 1 limit (more restrictive) from 50 kHz to 100 kHz
- This change was necessary to support starting this test at 10 kHz. The new section of the limit curve remains at or below the highest composite plant emissions level
- Change tested frequency range from 50 kHz - 400 MHz to 10 kHz - 10 MHz and the allowance of a db relaxation limit for equipment operating voltages above 115 VAC
- These changes were made to better align these tests with the recommendations of MIL-STD-461E & R.G. 1.180



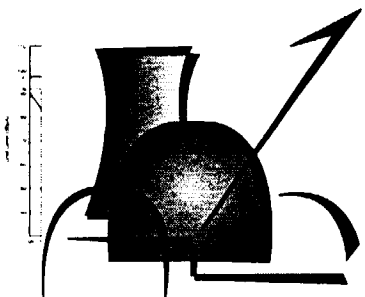
High-Frequency Conducted Emissions Testing Limit



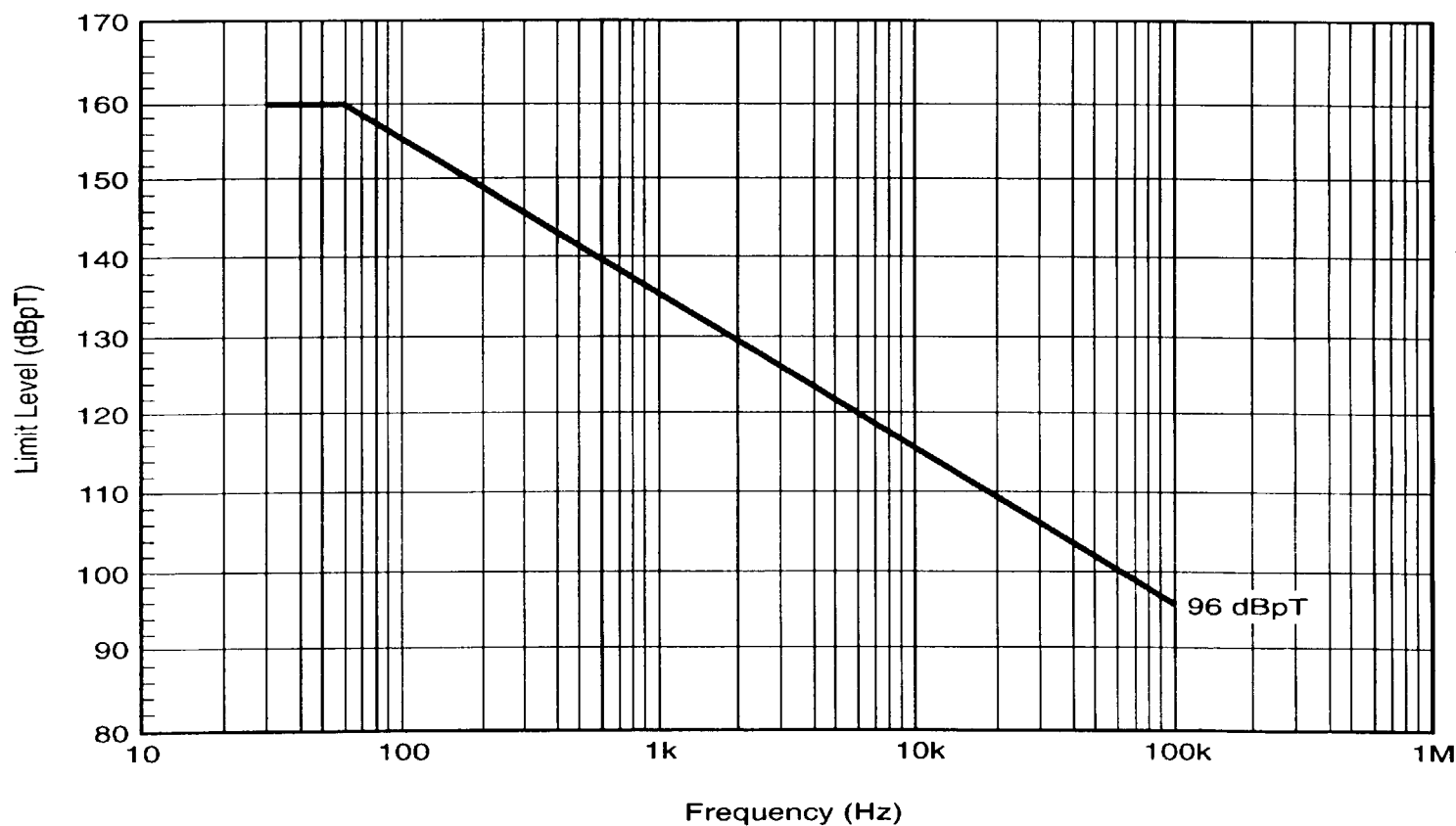


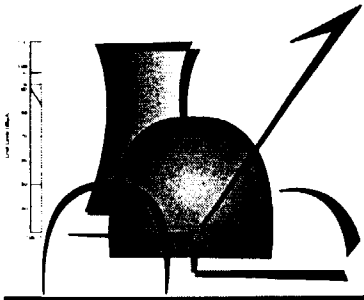
Low-Frequency Radiated Emissions Testing

- Specified measurements be performed at 7 cm
- This change was made to better align this test with the recommendations of MIL-STD-461E



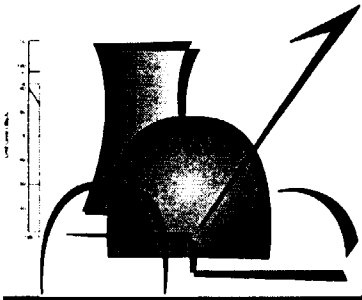
Low-Frequency Radiated Emissions Testing Limit





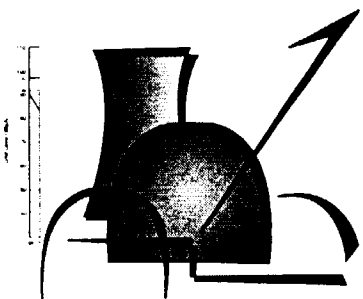
High-Frequency Radiated Emissions Testing

- Changed limit curve to allow the maximum allowable equipment emissions from either TR-102323 Rev. 1 or R.G. 1.180 from 10 kHz to 1 GHz
- This change was made to provide testing relief where it was supported by either TR-102323 Rev. 1 or R.G. 1.180 while still maintaining equipment emissions levels low enough to prevent significant increases in plant emissions levels
- Extended tested frequency range from 1 GHz to 10 GHz or 10 times the highest intentionally generated frequency within the equipment under test, whichever is greater
- Extending the tested frequency range was necessary to address the increased demand and use of equipment operating at frequencies above 1 GHz

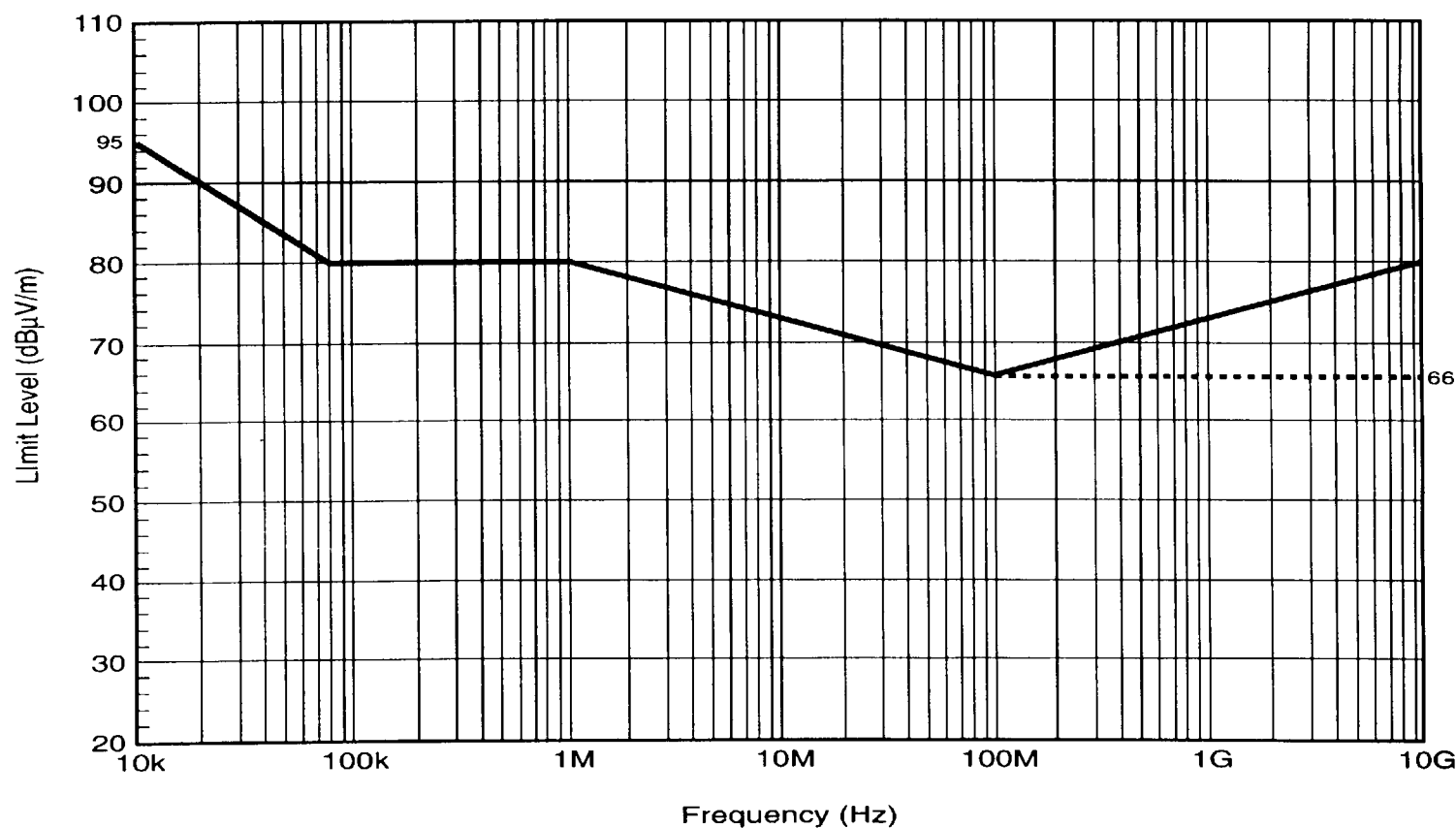


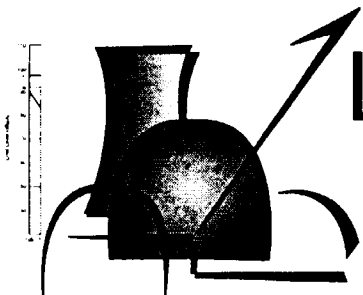
High-Frequency Radiated Emissions Testing

- Endorsed testing in accordance with commercial standards FCC 47CFR Part 15 Class A or B and EN 55022 Class A or B
- Although there are differences in the methodology and range of tested frequencies, this test controls equipment emissions to prevent an increase in plant emissions that would potentially invalidate the susceptibility limit. This change is acceptable due to the large margin ($> 43 \text{ dB}\mu\text{V/m}$) between the emissions and susceptibility limits.

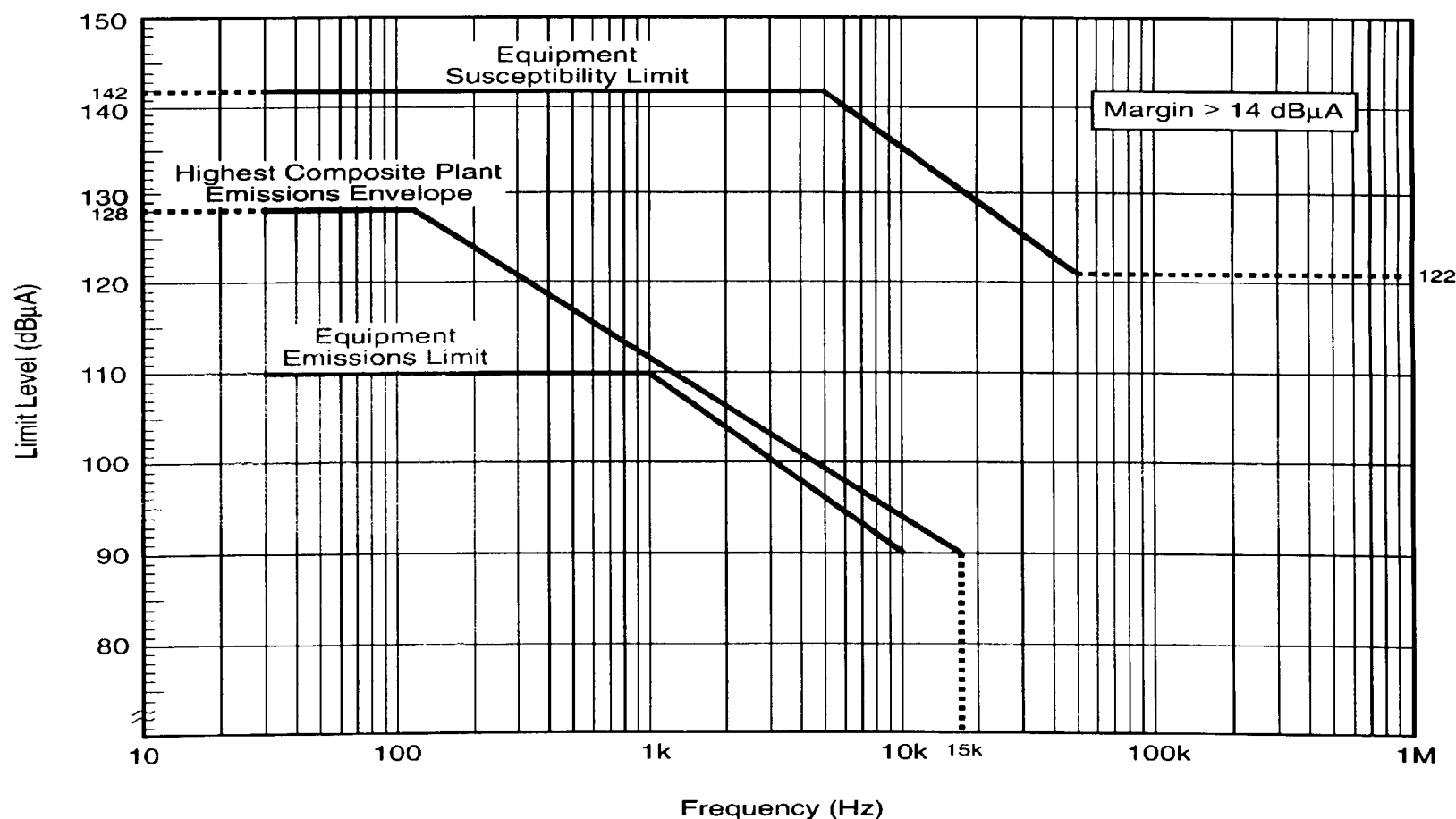


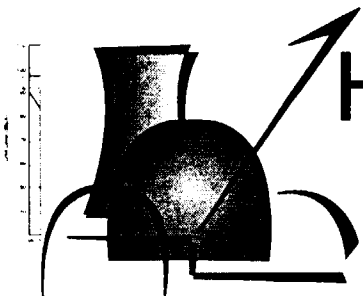
High-Frequency Radiated Emissions Testing Limit



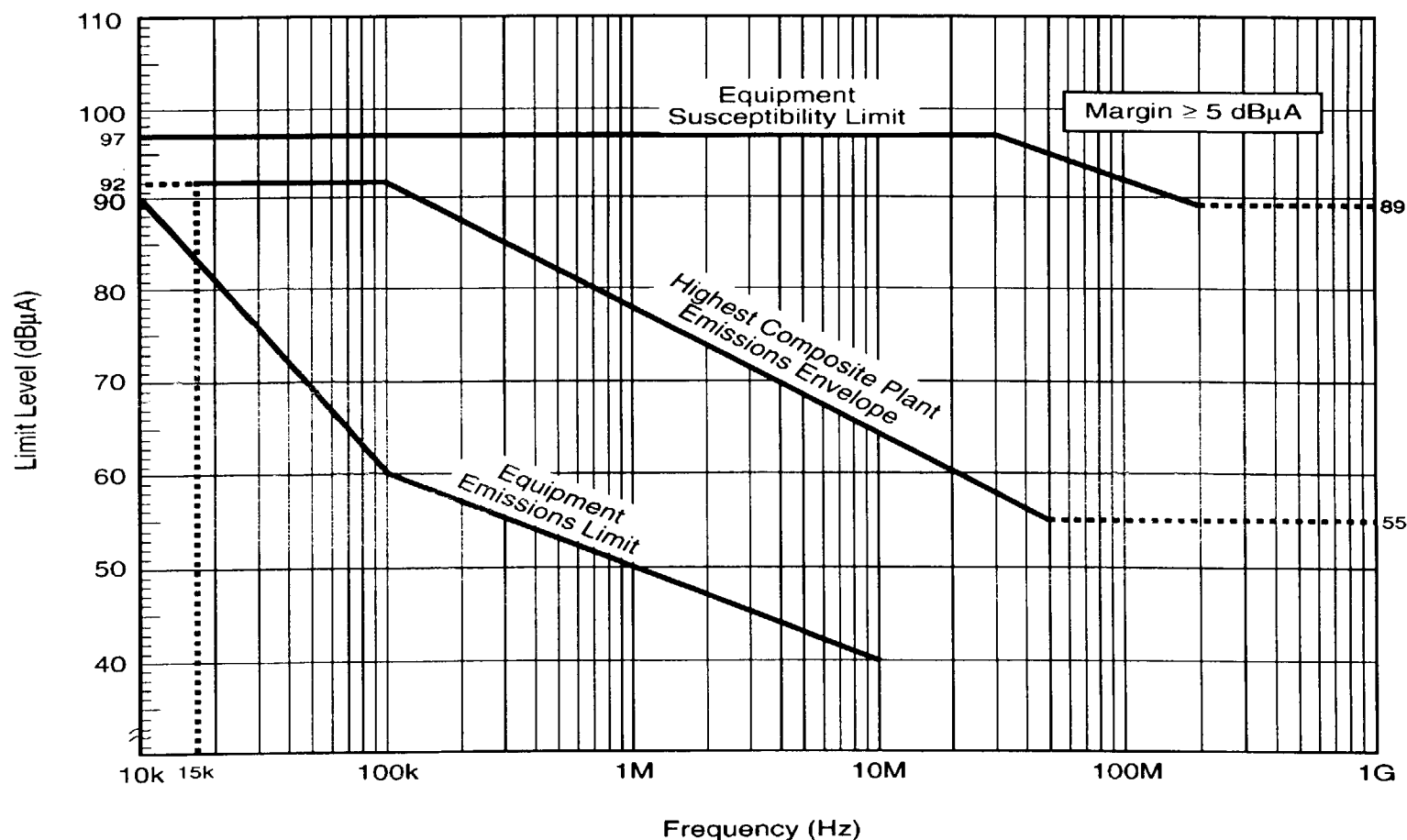


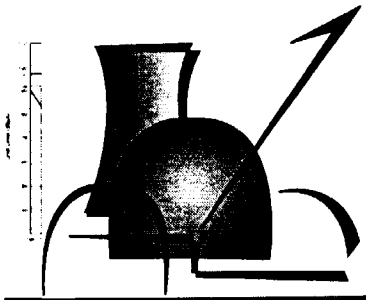
Low-Frequency Conducted Testing Limits and Margin Analysis



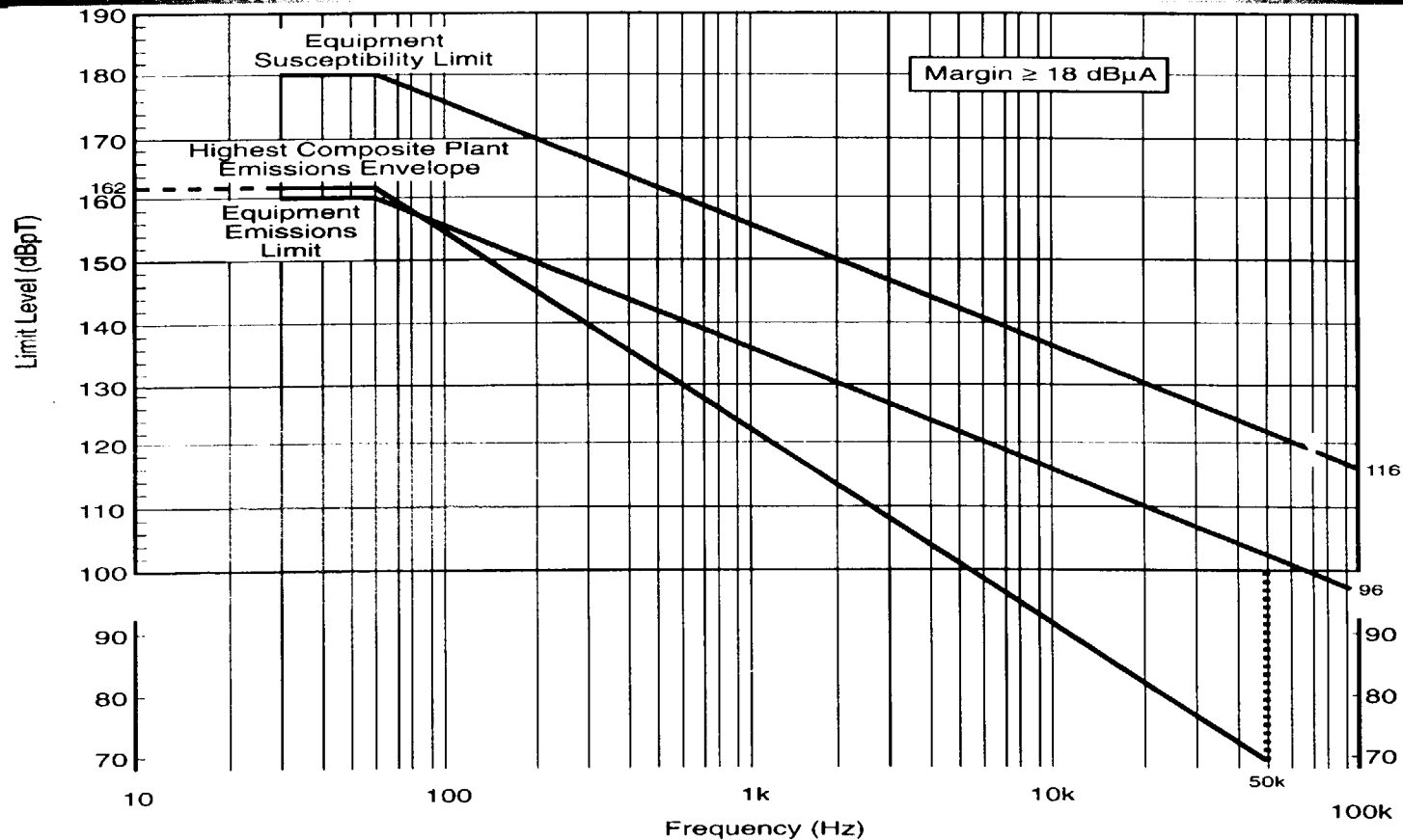


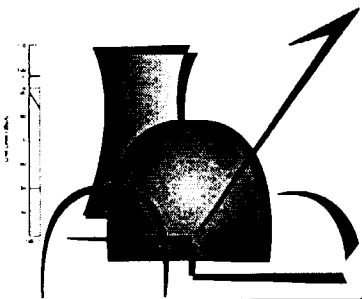
High-Frequency Conducted Testing Limits and Margin Analysis



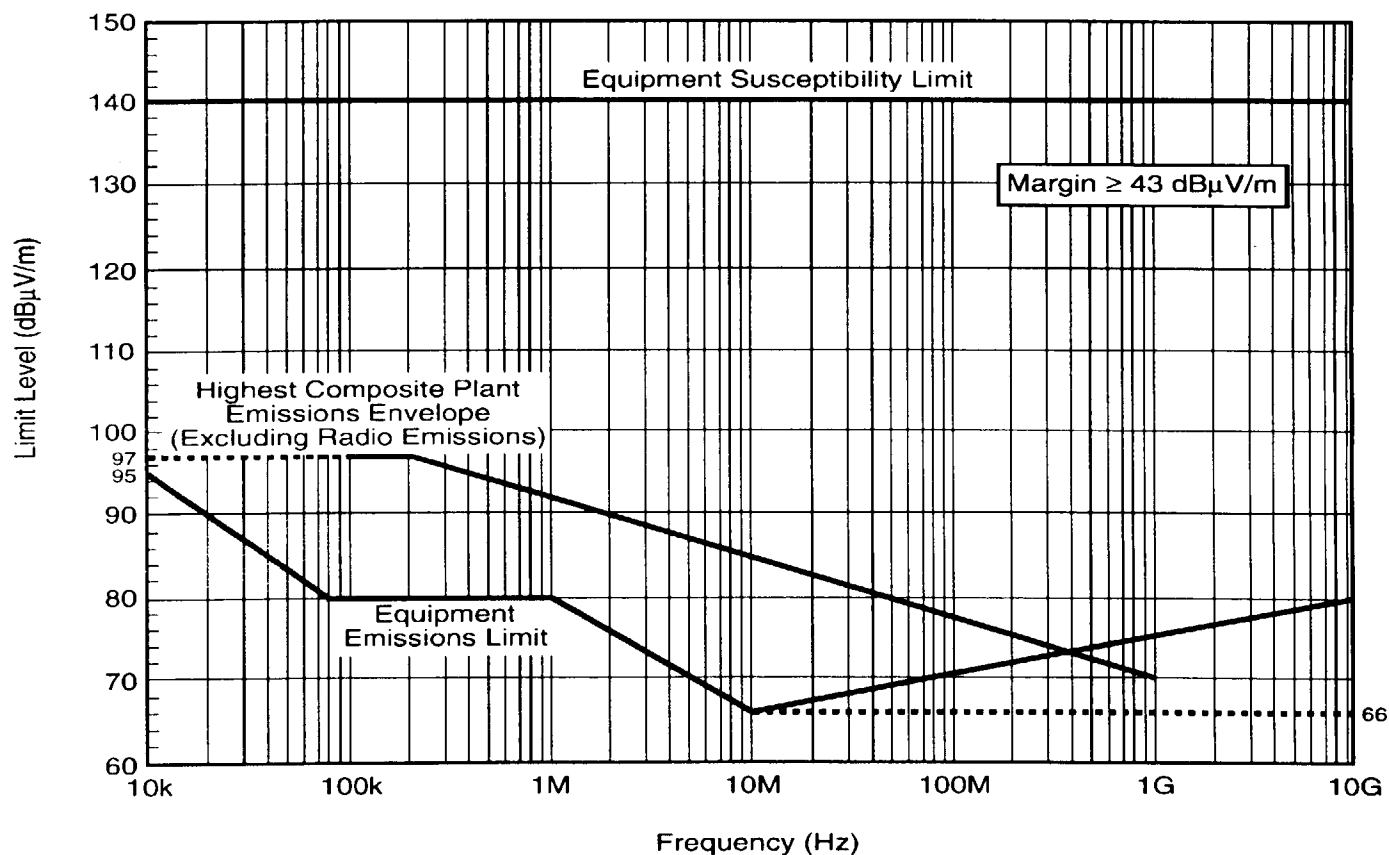


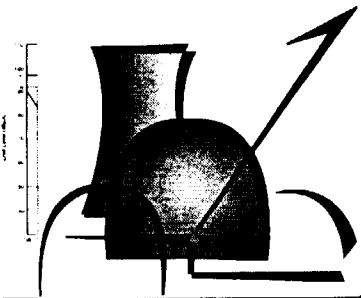
Low-Frequency Radiated Testing Limits and Margin Analysis



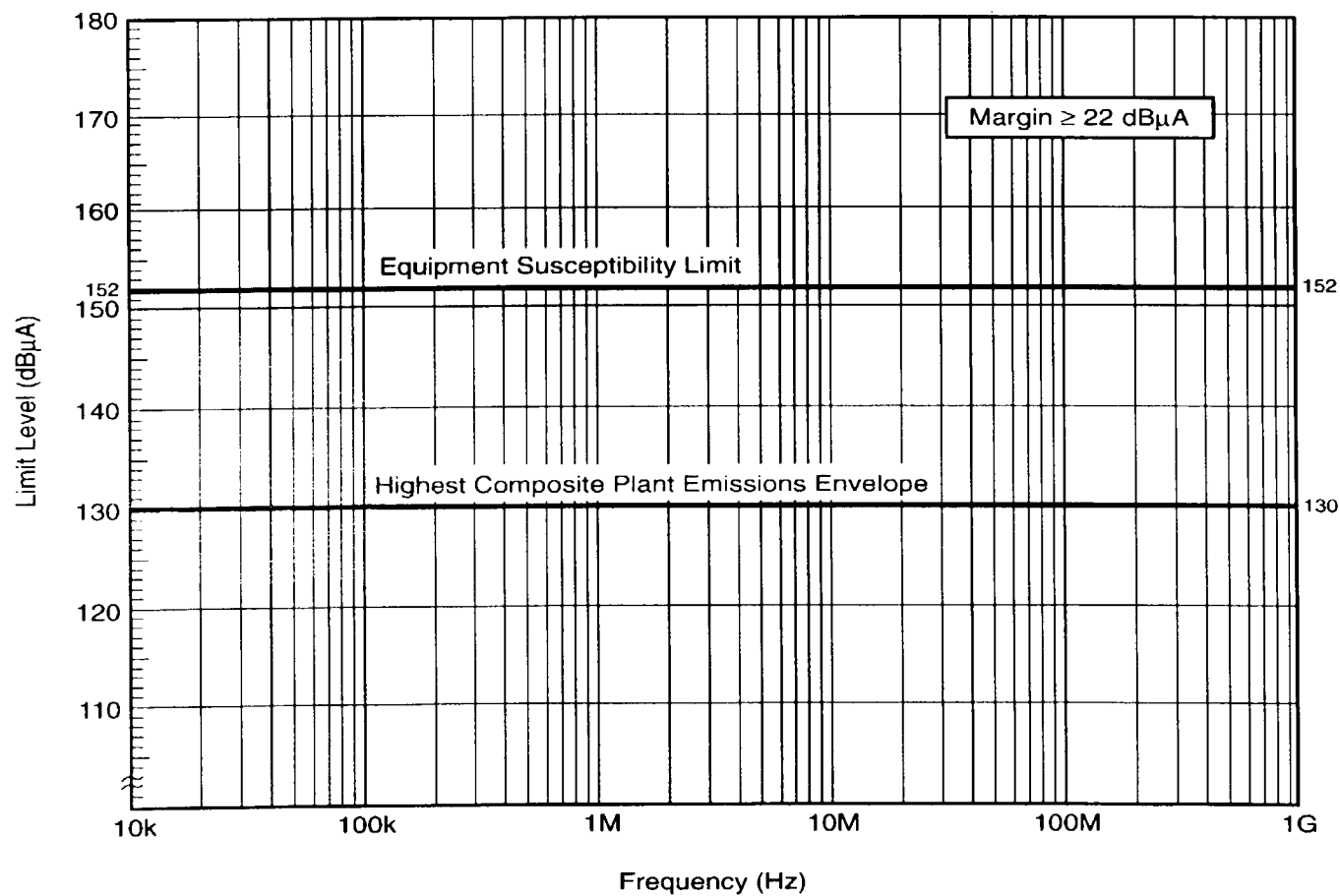


High-Frequency Radiated Testing Limits and Margin Analysis





Transient Testing Limit Analysis





Summary

- TR-102323 Revision 2 complete
- Includes Changes to Testing Standards & Limits:
 - Updates recommended and referenced standards
 - Focuses on endorsement of commercial standards where possible
 - Incorporates lessons learned
- Improves understanding of the applicability of requirements
- Working Group now seeking NRC review and endorsement