Military EMC Testing

Presented By:
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EMC Testing vs. Environmental Testing – Earthquake!
EMC Testing vs. Environmental Testing – Wind (& Rain)!
EMC Testing vs. Environmental Testing – Fire!
EMC Testing for Military Equipment

Unlike many Environmental tests, EMC testing is typically not very interesting to watch – in fact, it is boring... But we LIKE it that way!!

This talk will be an overview of the EMC testing requirements for Military equipment and systems.

Although EMC testing can (and should) be boring, the hope is that this talk will NOT be boring – but this depends at least in part on YOUR participation.

But if you do fall asleep, I will not take offense – as long as you don’t snore…
Military EMC Environments Can Be Harsh
The Consequences of an EMC Problem can be (and have been) Severe (and Tragic)...

- USS Forrestal
- Falklands war
- F-111s over Libya
- UH-60 problems
- Joint ops problems in Somalia & Iraq
EMC Testing – Military

EMC is Required by Military Regulations – Though enforcement is not universal…

EMC testing requirements are based on the Environment(s) of Intended Use:

- **Ground**
  - Vehicles, Personnel, Buildings

- **Aircraft**
  - Air Force, Army, Navy

- **Shipboard**
  - Army/Navy, Above/Below Decks, Submarines

Susceptibility test levels and Emission limits are different based on the installation (“Platform”) where the system is used

Standard for Military EMC in the US (and in most of the rest of the world) is MIL-STD-461G
Before MIL-STD-461….

- In the OLD Days….
  - Each Service (Army, Navy, Air Force) had separate EMC requirements and tests.
  - In some cases, a new platform (ship, airplane, vehicle) would have completely new and different EMC specifications!
MIL-STD-461 History

- Written by the Tri-Service Working Group
- MIL-STD-461 (and 462) published in 1967
  - 461: Requirements
  - 462: Test Methods and Procedures
- MIL-STD-461A published in 1968
- MIL-STD-461B published in 1980
- MIL-STD-461C published in 1986
- MIL-STD-461D published in 1993
  - MIL-STD-462D also published in 1993
  - Multiple “Notices” for MIL-STD-462 released between 1967 and 1993
- MIL-STD-461E published in 1999, incorporating test methods from 462
- MIL-STD-461G published in 2015
  - Significant Change in Section 4 “General Requirements”
    - “After the initial calibration, passive devices such as measurement antennas, current probes, and LISNs, require no further formal calibration unless the device is repaired. The measurement system integrity check in the procedures is sufficient to determine acceptability of passive devices.”
“requirements for the control of electromagnetic interference characteristics of subsystems and equipment”

“This standard establishes interface and associated verification requirements for the control of the electromagnetic interference (EMI) emission and susceptibility characteristics of electronic, electrical, and electromechanical equipment and subsystems designed or procured for use by activities and agencies of the Department of Defense (DoD).”

19 Tests Methods with requirements and procedures

- 3 Conducted Emissions
- 10 Conducted Susceptibility
- 3 Radiated Emissions
- 3 Radiated Susceptibility

Appendix A: Detailed and extensive “Application Guide”
Related Standards

- RTCA/DO-160: Environmental Conditions and Test Procedures for Airborne Equipment
- MIL-STD-704: Power Input Requirements for Aircraft
- MIL-STD-1275: Power Input Requirements for Ground Vehicles
- MIL-STD-1399, Section 300: Power Input Requirements for Ships
- MIL-STD-464: Electromagnetic Environments
- ADS-37A-PRF: EMI Performance and Verification Requirements for (Army) Aviation Systems
Published by RTCA, Inc., a Not-for-Profit corporation

“Environmental Conditions and Test Procedures for Airborne Equipment”

... defines a series of minimum standard environmental test conditions (categories) and applicable test procedures for airborne equipment. The purpose of these tests is to provide a laboratory means of determining the performance characteristics of airborne equipment in environmental conditions representative of those which may be encountered in airborne operation of the equipment.

3 sections of General Information
13 sections covering the Physical Environment
10 sections on Electrical / Electromagnetic Environment
3 appendices
# MIL-STD-461G and DO-160G

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<th>Test</th>
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</tbody>
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- MIL-STD-461G CE106, RE103, CS103, CS104, CS105: equivalent tests in FAA regulations (TSO MOPS)
- DO-160G Section 23 (Direct Strike Lightning): equivalent requirements in MIL-STD-464C
- MIL-STD-461G RS105 (NEMP): no equivalent test in DO-160G or FAA regulations (yet)
## MIL-STD-461G Test Methods

<table>
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<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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<td>Conducted Emissions, Audio Frequency Currents, Power Leads</td>
</tr>
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<td>CE106</td>
<td>Conducted Emissions, Antenna Port</td>
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<tr>
<td>CS101</td>
<td>Conducted Susceptibility, Power Leads</td>
</tr>
<tr>
<td>CS103</td>
<td>Conducted Susceptibility, Antenna Port, Intermodulation</td>
</tr>
<tr>
<td>CS104</td>
<td>Conducted Susceptibility, Antenna Port, Rejection of Undesired Signals</td>
</tr>
<tr>
<td>CS105</td>
<td>Conducted Susceptibility, Antenna Port, Cross-Modulation</td>
</tr>
<tr>
<td>CS109</td>
<td>Conducted Susceptibility, Structure Current</td>
</tr>
<tr>
<td>CS114</td>
<td>Conducted Susceptibility, Bulk Cable Injection</td>
</tr>
<tr>
<td>CS115</td>
<td>Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation</td>
</tr>
<tr>
<td>CS116</td>
<td>Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads</td>
</tr>
<tr>
<td>CS117</td>
<td>Conducted Susceptibility, Lightning Induced Transients, Cables and Power Leads</td>
</tr>
<tr>
<td>CS118</td>
<td>Conducted Susceptibility, Personnel Borne Electrostatic Discharge</td>
</tr>
<tr>
<td>RE101</td>
<td>Radiated Emissions, Magnetic Field</td>
</tr>
<tr>
<td>RE102</td>
<td>Radiated Emissions, Electric Field</td>
</tr>
<tr>
<td>RE103</td>
<td>Radiated Emissions, Antenna Spurious and Harmonic Outputs</td>
</tr>
<tr>
<td>RS101</td>
<td>Radiated Susceptibility, Magnetic Field</td>
</tr>
<tr>
<td>RS103</td>
<td>Radiated Susceptibility, Electric Field</td>
</tr>
<tr>
<td>RS105</td>
<td>Radiated Susceptibility, Transient Electromagnetic Field</td>
</tr>
</tbody>
</table>
# MIL-STD-461G Test Method Applicability

<table>
<thead>
<tr>
<th>Equipment and Subsystems Installed In, On, or Launched From the Following Platforms or Installations</th>
<th>Requirement Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Ships</td>
<td>A A L A S L S L A S A L S A A L A L</td>
</tr>
<tr>
<td>Submarines</td>
<td>A A L A S L S L A S L S A A L A L</td>
</tr>
<tr>
<td>Aircraft, Army, Including Flight Line</td>
<td>A A L A S S S A A A A A L A A A L</td>
</tr>
<tr>
<td>Aircraft, Navy</td>
<td>L A A L A S S S A A A A A L A A L</td>
</tr>
<tr>
<td>Aircraft, Air Force</td>
<td>A L A S S S A A A A L A A A L</td>
</tr>
<tr>
<td>Space Systems, Including Launch Vehicles</td>
<td>A L A S S S A A A L A L A A</td>
</tr>
<tr>
<td>Ground, Army</td>
<td>A L A S S S A A A A A L L A</td>
</tr>
<tr>
<td>Ground, Navy</td>
<td>A L A S S S A A A A A L L A</td>
</tr>
<tr>
<td>Ground, Air Force</td>
<td>A L A S S S A A A A A L A A</td>
</tr>
</tbody>
</table>

**Legend:**

- **A**: Applicable
- **L**: Limited as specified in the individual sections of this standard.
- **S**: Procuring activity must specify in procurement documentation.
CE101

0.03-10kHz, power leads only, measured with a current probe

FIGURE CE101-1. CE101 limit for surface ships and submarine applications, DC.

FIGURE CE101-2. CE101 limit for surface ships and submarine applications, 60 Hz.
FIGURE CE101-3. CE101 limit for surface ships and submarine applications, 400 Hz.

FIGURE CE101-4. CE101 limit for Navy ASW aircraft and Army aircraft (including flight line) applications.
CE102: Conducted Emissions, Radio Frequency Potential, Power Leads
- 0.01 to 10MHz, power leads only
- 5 limits depending upon input voltage
- Measurement using LISN RF port
- No significant change for MIL-STD-461G

<table>
<thead>
<tr>
<th>NOMINAL EUT SOURCE VOLTAGE (AC&amp;DC)</th>
<th>LIMIT RELAXATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>28V</td>
<td>BASIC CURVE</td>
</tr>
<tr>
<td>115V</td>
<td>Basic Curve</td>
</tr>
<tr>
<td>220V</td>
<td>6dB</td>
</tr>
<tr>
<td>270V</td>
<td>9dB</td>
</tr>
<tr>
<td>440V</td>
<td>10dB</td>
</tr>
<tr>
<td>600V</td>
<td>12dB</td>
</tr>
</tbody>
</table>

Limit Level (dB) vs. Frequency (Hz)
CE102 Test Setup
CE106

CE106: Conducted Emissions, Antenna Port

Limits:

- Receivers, Transmitters and amplifiers (standby mode): 34 dBμV
- Transmitters and amplifiers (transmit mode):
  - Harmonics, except the second and third, and all other spurious emissions shall be at least 80 dB down from the level at the fundamental.
  - The second and third harmonics shall be suppressed to a level of -20 dBm or 80 dB below the fundamental, whichever requires less suppression.
  - For Navy shipboard applications, the second and third harmonics will be suppressed to a level of -20 dBm and all other harmonics and spurious emissions shall be suppressed to -40 dBm, except if the duty cycle of the emissions are less than 0.2%, then the limit may be relaxed to 0 dBm.
CE106 Test Setup
CS101: Conducted Susceptibility, Power Leads

- 0.03 to 150kHz frequency range; test levels up to 8% of input rms voltage
- 2 test levels: 28V or less; >28V
- Pre-calibrated power limit up to 80W
- No significant changes for MIL-STD-461G
CS101 Test Setup
CS101 Test Levels

![Graph showing limit levels for different frequencies and voltages. Curves #1 and #2 are depicted. The graph includes a table with nominal EUT source voltage and applicable curves.](image-url)
CS103/104/105

- CS103: Conducted Susceptibility, Antenna Port, Intermodulation
- CS104: Conducted Susceptibility, Antenna Port, Rejection of Undesired Signals
- CS105: Conducted Susceptibility, Antenna Port, Cross Modulation
CS103/104/105 Test Setup
CS106 (MIL-STD-461F)

- CS106: Conducted Susceptibility, Transients, Power Leads
  - 5 micro-second spike
  - $\leq 2$ ohm source impedance
  - 400V test level, pre-calibrated across 5 ohms
  - Eliminated in 461G
CS106 Test Setup
Conducted Susceptibility, Structure Current

- 0.06 to 100kHz frequency range, 1 test level
- No significant changes for 461G
CS114: Conducted Susceptibility, Bulk Cable Injection
- 0.01 to 200MHz, 1kHz SW modulation only
- 5 test levels ("Curves") depending upon the details of the installation/platform
- Special 4-10kHz test for Navy ships & submarines at 77dBuA
- Pre-calibration in a 50 ohm fixture, induced current monitored during test
- Significant change for MIL-STD-461G: Test System Verification with monitor probe in a 2nd 50 ohm fixture
CS114 Test Levels

THE APPROPRIATE LIMIT CURVE SHALL BE DETERMINED FROM TABLE VI.
## CS114 Test Level Applicability

<table>
<thead>
<tr>
<th>PLATFORM</th>
<th>AIRCRAFT (EXTERNAL OR SAFETY CRITICAL)</th>
<th>AIRCRAFT INTERNAL</th>
<th>ALL SHIPS (ABOVE DECK &amp; EXPOSED BELOW DECK) AND SUBMARINES (EXTERNAL)*</th>
<th>SHIPS (METALLIC) (BELOW DECKS)</th>
<th>SHIPS (NON-METALLIC) (BELOW DECK)**</th>
<th>SUBMARINE (INTERNAL)</th>
<th>GROUND</th>
<th>SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY RANGE</td>
<td>4 kHz to 1 MHz</td>
<td>N</td>
<td>-</td>
<td>-</td>
<td>77 dBμA</td>
<td>77 dBμA</td>
<td>77 dBμA</td>
<td>77 dBμA</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>AF</td>
<td>5</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>10 kHz to 2 MHz</td>
<td>A</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>AF</td>
<td>5</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 MHz to 30 MHz</td>
<td>A</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>AF</td>
<td>5</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>30 MHz to 200 MHz</td>
<td>A</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td></td>
<td>AF</td>
<td>5</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>
CS114 Calibration and Verification Setups

**Figure CS114-3.** Calibration setup.

**Figure CS114-4.** Verification setup.
CS115/CS116

➢ CS115: Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation
  ➢ 30 nSec pulse, 30 Hz rep rate, 1 test level: 5A peak, pre-calibrated in 50 ohm fixture

➢ CS116: Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads
  ➢ 0.01, 0.1, 1, 10, 30, & 100MHz test frequencies
  ➢ Test levels up to 10A peak, pre-calibrated in 50 ohm fixture or actual induced current during test

➢ No significant changes for 461G
  ➢ 461E: Air Force test level for CS116 = 5A max
CS115 Test Waveform

30 ns. (Minimum)

REpetition Rate = 30 Hz

PULSE WIDTH MAINTAINED
AT ≥ 30 NANOSECONDS

RISETIME AND FALLTIME
MAINTAINED AT ≤ 2 NANOSECONDS
CS116 Test Levels

NOTES:
1. Normalized waveform: $e^{-\frac{\pi f t}{Q}} \sin(2\pi ft)$
   Where:
   $f$ = Frequency (Hz)
   $t$ = Time (sec)
   $Q$ = Damping factor, 15 ±5

2. Damping factor ($Q$) shall be determined as follows:
   
   $$Q = \frac{2(N - 1)}{\ln(I_p/I_N)}$$

   Where:
   $Q$ = Damping factor
   $N$ = Cycle number (i.e., $N = 2, 3, 4, 5, \ldots$)
   $I_p$ = Peak current at 1st cycle
   $I_N$ = Peak current at cycle closest to 50% decay
   In = Natural log

3. $I_p$ as specified in Figure CS116-2
CS115/CS116 Calibration and Test Setups
Lightning
Lightning
CS117: Conducted Susceptibility, Lightning Induced Transients, Cables and Power Leads.

- NEW for MIL-STD-461G
- Multiple Burst and Multiple Stroke waveforms applied to interconnecting cables and power leads
- Pin Injection tests NOT performed
- Cable Induction only, Ground Injection not supported
- 6 Waveforms, 2 Test Levels (Internal or External Equipment)
- Test Levels given for full cables and individual power leads
- Multiple Stroke Waveform 1, 2, & 3 required for all installations
- Multiple Stroke Waveform 4 & 5A required for installations in areas with composites
- Multiple Burst Waveform 3 required for all installations
- Multiple Burst Waveform 6 required for installations that “…utilize short, low impedance cable bundle installations.” – such as engine harnesses
## CS117 Waveforms and Test Levels

### Multiple Stroke

<table>
<thead>
<tr>
<th>Applicability</th>
<th>Test Description</th>
<th>Internal Equipment Levels**</th>
<th>External Equipment Levels**</th>
</tr>
</thead>
</table>
| All equipment installations | Waveform 2 (WF2)/ Waveform 1 (WF1) | First Stroke  
  $V_1 = 300 \text{ V (WF2)}$  
  $I_1 = 600 \text{ A (WF1)}$  
  $I_2 = 60 \text{ A}$  
  Subsequent Stokes  
  $V_1 = 150 \text{ V (WF2)}$  
  $I_1 = 150 \text{ A (WF1)}$  
  $I_2 = 30 \text{ A}$  | First Stroke  
  $V_1 = 750 \text{ V (WF2)}$  
  $I_1 = 1500 \text{ A (WF1)}$  
  $I_2 = 150 \text{ A}$  |
| All equipment installations | Waveform 3 (WF3) – 1 MHz and 10 MHz | First Stroke  
  $V_1 = 600 \text{ V (WF3)}$  
  $I_1 = 120 \text{ A (WF3)}$  
  $I_2 = 24 \text{ A}$  
  Subsequent Stokes  
  $V_1 = 300 \text{ V (WF3)}$  
  $I_1 = 60 \text{ A (WF3)}$  
  $I_2 = 12 \text{ A}$  | First Stroke  
  $V_1 = 1500 \text{ V (WF3)}$  
  $I_1 = 300 \text{ A (WF3)}$  
  $I_2 = 60 \text{ A}$  |
| Equipment installations routed in areas with composite skin structure. | Waveform 4 (WF4)/ Waveform 5A (WF5A) | First Stroke  
  $V_1 = 300 \text{ V (WF4)}$  
  $I_1 = 1000 \text{ A (WF5A)}$  
  $I_2 = 300 \text{ A}$  
  Subsequent Stokes  
  $V_1 = 75 \text{ V (WF4)}$  
  $I_1 = 200 \text{ A (WF5A)}$  
  $I_2 = 150 \text{ A}$  | First Stroke  
  $V_1 = 750 \text{ V (WF4)}$  
  $I_1 = 2000 \text{ A (WF5A)}$  
  $I_2 = 750 \text{ A}$  |

### Multiple Burst

<table>
<thead>
<tr>
<th>Applicability</th>
<th>Test Description</th>
<th>Internal Equipment Levels**</th>
<th>External Equipment Levels**</th>
</tr>
</thead>
<tbody>
<tr>
<td>All equipment installations</td>
<td>Waveform 3 (WF3) – 1 MHz and 10 MHz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
  $V_1 = 360 \text{ V (WF3)}$  
  $I_1 = 6 \text{ A (WF3)}$  |  
  $V_1 = 900 \text{ V (WF3)}$  
  $I_1 = 15 \text{ A (WF3)}$  |
| Equipment installations that utilize short, low impedance cable bundle installations. | Waveform 6 (WF6) |  
  $V_1 = 600 \text{ V (WF6)}$  
  $I_1 = 30 \text{ A (WF6)}$  |  
  $V_1 = 1500 \text{ V (WF6)}$  
  $I_1 = 75 \text{ A (WF6)}$  |
Waveform 1

T1 = 6.4 microseconds ±20%
T2 = 69 microseconds ±20%
Waveform 2

$V$

$T_1 = 340$ nanoseconds maximum
$T_2 = 6.4$ microseconds ± 20%
Waveform 3

NOTE:
The waveshape may have either a damped sine or cosine waveshape.
Waveform 6

T1 = 0.25 microseconds ±20%
T2 = 4 microseconds ±20%
Multiple Stroke Waveform

1st Transient Test Level

Subsequent Transient Test Level

1st Transient

Thirteen Subsequent Transients

10 ms \leq \Delta t \leq 200 ms

T

1.5 Seconds

For combined Single-Stroke and Multiple-Stroke test, 1st stroke = SS level, Subsequent strokes = MS level
Multiple Burst Waveform

One burst is composed of 20 pulses.

One Burst consisting of 20 pulses

$30\text{ms} \leq \Delta t \leq 300\text{ms}$
CS117 Cable Injection Lightning Test Setup
Electrostatic Discharge
- NEW for MIL-STD-461G
- Patterned after EN 61000-4-2 (150pF & 330 ohm)
- Contact Discharge at +/-8 kV for conductive surfaces
- Air Discharge at +/-2 kV to +/-15 kV only required where Contact Discharge cannot be applied
- Connector pins are NOT tested
- ESD Generator must be calibrated using a precision (expensive) target and a 1 GHz (expensive) digital oscilloscope, before EVERY TEST
FIGURE CS118-4. Ideal contact discharge current waveform at 8 kV.
CS118 Calibration Setup
CS118 Test Setup
RE101: Audio Frequency Magnetic Field Emissions
- Measurement made with a small loop antenna, 7cm from EUT surface
- 30Hz to 100kHz
- 2 Limits: Army & Navy
- No significant changes for 461G
FIGURE RE101-1. RE101 limit for all Army applications.

FIGURE RE101-2. RE101 limit for all Navy applications.
RE101 Test Setup
RE102/RE103

- **RE102: Radiated Emissions, Electric Field**
  - Anechoic Chamber only
  - 9 limits (10kHz to 18GHz or 2MHz to 18GHz) depending upon details of installation
  - Significant change for MIL-STD-461G: Note stating - “Testing is required up to 1 GHz or 10 times the highest intentionally generated frequency within the EUT, whichever is greater.” - HAS BEEN DELETED. Testing to 18GHz is now REQUIRED for ALL equipment and systems.

- **RE103: Radiated Emissions, Antenna Spurious and Harmonic Outputs**
  - Used only when CE106 is not possible
  - Setups similar to RE102
  - Limits:
    - Harmonics, except the second and third, and all other spurious emissions shall be at least 80 dB down from the level at the fundamental.
    - The second and third harmonics shall be suppressed to a level of -20 dBm or 80 dB below the fundamental, whichever requires less suppression.
    - For Navy shipboard applications, the second and third harmonics will be suppressed to a level of -20 dBm and all other harmonics and spurious emissions shall be suppressed to -40 dBm, except if the duty cycle of the emissions are less than 0.2%, then the limit may be relaxed to 0 dBm.
FIGURE RE102.1. RE102 limit for surface ship applications.

FIGURE RE102.2. RE102 limit for submarine applications.
RE102 Limit - Ground
RE102 Test Setup
RS101: Radiated Susceptibility, Magnetic Field
- Small radiating loop antenna, 5cm from EUT surface
- 30Hz to 100kHz
- 2 Limits: Army & Navy
- No significant changes for 461G
RS101 Test Levels

Navy

Army
RS101 Test Setup
RS103: Radiated Susceptibility, Electric Field

- Test levels from 5V/m to 200V/m, 1kHz SW only
- 30MHz to 18GHz applicable for all, 2-30MHz and/or 18-40GHz optional (must be specified)
- Frequency step size varies with frequency range (5% to 0.25%); 3 second minimum dwell time
- Anechoic Chamber Method
  - Placement and performance of RF Absorber is specified
  - “Real-time” E-field measurement during test using E-field sensors
  - Sensors placed on or near the EUT, directly opposite the transmitting antenna
  - <200MHz, antenna is centered on the “test setup boundary”
  - >200MHz, EUT and the first 35cm or 7cm of cabling must be within the 3dB beamwidth of the antenna
  - Vertical (>2MHz) and Horizontal (>30MHz) antenna polarizations and a 1 meter antenna distance required
  - “EUTs shall be oriented such that surfaces which … respond most readily to radiated signals face the … antennas ” ;(-)
  - Significant change for MIL-STD-461G: No option for anechoic chamber field measurement with receive antenna

- Reverberation Chamber Method
  - >200MHz only, mode-tuned only
  - Lowest usable frequency for a given chamber is based on chamber size (volume)
  - Chamber calibration with EUT in place using E-field sensor or (>1GHz) receive antenna (2 different equations)
  - Number of Tuner steps (12 to 50) is specified by frequency range
## TABLE XI. RS103 limits.

<table>
<thead>
<tr>
<th>FREQUENCY RANGE</th>
<th>AIRCRAFT (EXTERNAL OR SAFETY CRITICAL)</th>
<th>AIRCRAFT INTERNAL</th>
<th>ALL SHIPS (ABOVE DECK &amp; EXPOSED BELOW DECK) AND SUBMARINES (EXTERNAL)</th>
<th>SHIPS (METALLIC) (BELOW DECKS)</th>
<th>SHIPS (NON-METALLIC) (BELOW DECK)**</th>
<th>SUBMARINE (INTERNAL)</th>
<th>GROUND</th>
<th>SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 MHz to 30 MHz</td>
<td>A 200</td>
<td>200</td>
<td>200</td>
<td>10</td>
<td>50</td>
<td>5</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
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<td>N 200</td>
<td>200</td>
<td>200</td>
<td>10</td>
<td>50</td>
<td>5</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>AF 200</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>30 MHz to 1 GHz</td>
<td>A 200</td>
<td>200</td>
<td>200</td>
<td>10</td>
<td>10</td>
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<td>20</td>
</tr>
<tr>
<td></td>
<td>N 200</td>
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<td>20</td>
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<td></td>
<td>AF 200</td>
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<td>20</td>
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<tr>
<td>1 GHz to 18 GHz</td>
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<tr>
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<td>AF 200</td>
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<td>-</td>
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<td>50</td>
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</tr>
</tbody>
</table>

**KEY:**
- A = Army
- N = Navy
- AF = Air Force

* For equipment located external to the pressure hull of a submarine but within the superstructure, use SHIPS (METALLIC) (BELOW DECK)

** For equipment located in the hanger deck of Aircraft Carriers
RS103 Test Setup
RS103 Test Setup
RS105

- RS105: Radiated Susceptibility, Transient Electromagnetic Field
  - Test level 50kV/m
  - Anechoic chamber required
MIL-STD-461G incorporates significant changes:
- Section 4 – Calibration of passive devices
- CS106 eliminated
- CS114 – system verification procedure expanded
- CS117 added
- CS118 added
- RE102 – option to limit frequency range to 1GHz eliminated
- RS103 – option to measure field level with antenna eliminated
Questions?
Thank you!