

Application Note

Aerospace and Defense EMC Testing

Introduction to MIL-STD-461 Requirements

Document Version: 1.0

Date: November 2025

Applicable Standards: MIL-STD-461G, MIL-STD-464C, DO-160G



1. Introduction to MIL-STD-461

MIL-STD-461 establishes electromagnetic interference (EMI) requirements and test methods for military and aerospace systems. The standard ensures equipment can operate in the harsh electromagnetic environment of military platforms including aircraft, ships, ground vehicles, and spacecraft without interfering with mission-critical systems or being susceptible to electromagnetic threats.

This application note provides comprehensive guidance on MIL-STD-461 compliance testing, covering emissions and susceptibility requirements, test procedures, and practical considerations for military and aerospace equipment. Understanding MIL-STD-461 is essential for defense contractors and suppliers to the aerospace industry.

1.1 Evolution of MIL-STD-461

MIL-STD-461 has evolved through multiple revisions since its initial publication in 1967. Each revision reflects advances in technology, lessons learned from field experience, and changing operational requirements. Revision G, published in 2015, is the current version widely used for new programs.

Revision	Year	Key Changes	Status
Rev D	1993	Simplified test methods	Inactive
Rev E	1999	Extended frequency ranges	Superseded
Rev F	2007	Platform-specific requirements	Legacy programs
Rev G	2015	Updated limits, new test methods	Current version

2. Test Categories and Requirements

MIL-STD-461G defines two main categories of tests: **Emissions (CE and RE)** and **Susceptibility (CS and RS)**. Each category includes multiple test requirements addressing different frequency ranges, coupling paths, and electromagnetic phenomena. Platform-specific applicability is defined in the standard.

2.1 Conducted Emissions (CE) Tests

CE101: Conducted Emissions, Audio Frequency (30 Hz - 10 kHz)

Measures low-frequency emissions on AC and DC power leads. Applicable to equipment connected to power sources shared with audio frequency equipment or sensitive control circuits.

Limit: 110 dB μ A (peak) below 1 kHz, decreasing to 90 dB μ A at 10 kHz.

Recommended Com-Power Equipment:

- **LISNs for CE101:** [Three-Phase LISN Series](#) - Available in 16A to 100A current ratings, specifically designed for MIL-STD-461 testing

CE102: Conducted Emissions, Power Leads (10 kHz - 10 MHz)

Most commonly applied conducted emissions test. Measures RF noise voltage on AC and DC power leads using 50 μ H / 5 μ H Line Impedance Stabilization Network (LISN).

Limits: Typically 80-100 dB μ V depending on frequency and platform.

Recommended Com-Power Equipment:

- [LI-325C LISN](#) - Compliant with MIL-STD-461, RTCA DO-160, CISPR 25, and CISPR 16-1-2, includes air-core inductors to prevent saturation
- [LI-350 LISN](#) - 50A rating, 10 kHz to 400 MHz, fully compliant with MIL-STD 461F and RTCA DO-160
- [LI-400C LISN](#) - Specifically designed for MIL-STD-461 compliance with Superior Electric SUPERCON® shrouded sockets
- [Three-Phase LISNs for MIL-STD-461](#) - Complete 3-phase solutions for CE102 testing

CE106: Conducted Emissions, Antenna Terminal (10 kHz - 40 GHz)

Applies to equipment with antenna connections. Measures spurious emissions and harmonic radiation from transmitters. Critical for RF systems to prevent interference with other communication systems.

Limits: Depend on transmitter power and frequency.

Recommended Com-Power Equipment:

- **EMI Receivers/Spectrum Analyzers:** [Com-Power Spectrum Analyzers](#) for measuring antenna terminal emissions

2.2 Radiated Emissions (RE) Tests

RE101: Radiated Emissions, Magnetic Field (30 Hz - 100 kHz)

Measures low-frequency magnetic field emissions. Primarily applies to equipment with power transformers, inductors, or high-current loops.

Test distance: 7 cm from equipment surface

Limits: 58-84 dBpT depending on frequency and platform

Recommended Com-Power Equipment:

- **Magnetic Field Probes:** Specialized probes for RE101 low-frequency magnetic field measurements

RE102: Radiated Emissions, Electric Field (10 kHz - 18 GHz)

Most stringent radiated emissions test. Measures electric field strength at 1 meter from equipment. Broadband and narrowband limits apply.

Typical limits: 24-54 dBμV/m from 10 kHz-18 GHz depending on platform. Army limit is most stringent.

Recommended Com-Power Equipment:

- [Active Monopole Antenna \(41 inch\)](#) - Rod antenna for MIL-STD-461 electric field testing below 30 MHz
 - [Biconical Antennas](#) - Ideal for 10-200 MHz range, suitable for vertical and horizontal NSA measurements
 - [AC-220 CombiLog Antenna](#) - Optimized hybrid antenna, 20 MHz to 2 GHz, reduces testing time by 30%
 - [ACL-6000 CombiLog Antenna](#) - Advanced hybrid antenna, 30 MHz to 6 GHz receiving, 80 MHz to 6 GHz transmitting
 - **Log-Periodic Antennas:** For 200 MHz-2 GHz frequency coverage
 - **Horn Antennas:** Active and passive options for 1-40 GHz measurements
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2.3 Conducted Susceptibility (CS) Tests

CS101: Conducted Susceptibility, Power Leads (30 Hz - 150 kHz)

Injects low-frequency interference signals onto power leads. Simulates power line harmonics and transients.

Test levels: 2-120V RMS depending on frequency and platform

Uses: 50 μH LISN for test signal injection

Recommended Com-Power Equipment:

- [LI-325C LISN](#) - For CS101 signal injection and measurement

CS103: Conducted Susceptibility, Antenna Port (15 kHz - 10 GHz)

Applies to equipment with external antennas. Injects high-level interference signals into antenna terminals. CW and pulse modulation.

Test levels: -30 to +13 dBm depending on frequency

Verifies: Receiver immunity to out-of-band signals

Recommended Com-Power Equipment:

- [ACS-230 Series RF Power Amplifiers](#) - For signal injection into antenna ports
- **RF Signal Generators:** Com-Power spectrum analyzers with signal generation capability

CS114: Conducted Susceptibility, Bulk Cable Injection (10 kHz - 200 MHz)

Simulates coupling from external electromagnetic fields onto cables. Injects RF current using injection probe.

Frequency range: 10 kHz-200 MHz (extended to 400 MHz for some applications)

Injection levels: Typically 60-140 mA

Recommended Com-Power Equipment:

- [CLCI-100 Bulk Current Injection Probe](#) - 10 kHz to 100 MHz, 40 mm aperture, 100W rated, ideal for CS114 testing
- [CLCI-400 Bulk Current Injection Probe](#) - 10 kHz to 400 MHz, MIL-STD-461 and RTCA DO-160 compliant
- [CLCE-332 Current Monitoring Probe](#) - 9 kHz to 300 MHz for monitoring injection current
- [ACS-230-25W RF Amplifier](#) - 25W output, 150 kHz-230 MHz, for driving injection probes
- [ACS-230-50W RF Amplifier](#) - 50W output for higher test levels
- [ACS-250-100W RF Amplifier](#) - 100W output, 150 kHz-250 MHz, for maximum power requirements
- [Probe Calibration Fixtures](#) - FCLCE-332 and similar for accurate probe calibration

CS115: Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation

Uses damped sinusoidal pulses to simulate lightning-induced transients on cables. More efficient than swept CW for wideband testing.

Probe current: 60 A peak

Pulse width: 100-300 ns depending on frequency

Recommended Com-Power Equipment:

- [CLCI-400 Bulk Current Injection Probe](#) - Suitable for impulse excitation testing with appropriate pulse generator
- Specialized impulse generators (contact Com-Power for recommendations)

2.4 Radiated Susceptibility (RS) Tests

RS101: Radiated Susceptibility, Magnetic Field (30 Hz - 100 kHz)

Exposes equipment to low-frequency magnetic fields from large loop antennas or Helmholtz coils.

Test levels: 0.32-320 A/m depending on frequency and platform

Critical for: Equipment with magnetic sensors or sensitive analog circuits

Recommended Com-Power Equipment:

- [Magnetic Field Generators](#) - For creating controlled low-frequency magnetic fields
- Helmholtz coils and loop antennas for RS101 testing

RS103: Radiated Susceptibility, Electric Field (10 kHz - 40 GHz)

Most comprehensive radiated immunity test. Equipment exposed to amplitude-modulated RF fields.

Test levels: 20-200 V/m depending on frequency, platform, and location

Uses: Anechoic chamber with various antenna types across frequency range

Recommended Com-Power Equipment:

- [AC-220 CombiLog Antenna](#) - Transmitting antenna 80 MHz-2 GHz, 500W power handling
- [ACL-6000 CombiLog Antenna](#) - Transmitting antenna 80 MHz-6 GHz
- [High-Power RF Amplifiers:](#)
 - 10 kHz-1 GHz: 200-400W amplifiers available
 - 1-18 GHz: 100-200W amplifiers available
 - Contact Com-Power for specific high-power amplifier configurations
- [Biconical Antennas](#) - For 10-200 MHz transmitting
- [Log-Periodic Antennas](#) - For 200 MHz-2 GHz transmitting
- [Horn Antennas](#) - Active and passive for 1-40 GHz transmitting
- [Field Strength Monitors with Isotropic Probes](#) - For field uniformity verification

RS105: Radiated Susceptibility, Transient Electromagnetic Field

Simulates electromagnetic pulse (EMP) from nuclear detonation or high-altitude electromagnetic pulse (HEMP). Uses special pulse generators and simulators.

Test levels and waveforms: Classified for most military applications

Recommended Com-Power Equipment:

- Contact Com-Power for specialized EMP simulation equipment and test solutions
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3. Test Equipment and Facilities

MIL-STD-461 testing requires specialized equipment and test facilities. This section describes essential equipment, calibration requirements, and facility specifications for emissions and susceptibility testing.

3.1 Emissions Test Equipment

Essential Equipment:

- **EMI Test Receiver** compliant with MIL-STD-461 requirements (10 kHz - 40 GHz)
 - [Com-Power Spectrum Analyzers](#) - Pre-compliance and full compliance options
- **50 μ H / 5 μ H LISN** for conducted emissions testing
 - [Com-Power LISN Product Line](#):
 - [LI-325C](#) - 25A, MIL-STD-461 compliant
 - [LI-350](#) - 50A, 10 kHz-400 MHz
 - [LI-400C](#) - MIL-STD-461 specific design
 - [LI-1100](#) - 100A commercial/military
 - [Three-Phase LISNs](#) - 16A to 100A ratings
 - [Tempest LISNs \(LIP-120 & LIP-1000\)](#) - 5 kHz-1 GHz for classified testing
- **Broadband Antennas** ([Com-Power Antenna Product Line](#)):
 - **Rod Antenna (30 Hz-30 MHz)**: Active Monopole (41 inch) for MIL-STD-461
 - **Biconical (10-200 MHz)**: Multiple models for emissions testing
 - **Log-periodic (200 MHz-2 GHz)**: Lightweight and rugged designs
 - **Horn (1-40 GHz)**: Active and passive options available
 - **Hybrid CombiLog Antennas**:
 - [AC-220](#) - 20 MHz-2 GHz
 - [ACL-6000](#) - 30 MHz-6 GHz
- **Magnetic Field Probes** for RE101 testing
 - Available through Com-Power - contact for specific models
- **Preamplifiers** with low noise figure for low-level measurements
 - [Com-Power Preamplifiers](#) - Built into active antennas or standalone
- **Calibrated Test Cables and Adapters** with known insertion loss
 - Available through Com-Power with full calibration data
- **Current Monitor Probes** for conducted emissions monitoring:
 - [CLCE-332](#) - 9 kHz-300 MHz, 32 mm aperture
 - [CLCE-438](#) - 9 kHz-400 MHz, 38 mm aperture
 - [CLCE-452 V2](#) - 9 kHz-400 MHz, 52 mm aperture
 - [CLCE-1032](#) - Up to 1 GHz, 32 mm aperture
- **Transient Limiters** for instrument protection:
 - [LIT-153A](#) - 150 kHz-30 MHz, 10 dB, protects spectrum analyzer input

3.2 Susceptibility Test Equipment

Essential Equipment:

- **RF Signal Generators** with modulation capability
 - Available through Com-Power spectrum analyzers with signal generation
- **Power Amplifiers** ([Com-Power RF Amplifier Product Line](#)):

- **10 kHz-1 GHz (25-100W):**
 - [ACS-230-25W](#) - 150 kHz-230 MHz, 25W, IEC 61000-4-6 compliant
 - [ACS-230-50W](#) - 150 kHz-230 MHz, 50W
 - [ACS-250-100W](#) - 150 kHz-250 MHz, 100W
- **1-18 GHz (100-200W):** Contact Com-Power for high-frequency amplifier solutions
- **18-40 GHz (50W):** Contact Com-Power for millimeter-wave amplifiers
- **Transmit Antennas** matched to test frequency ranges
 - [Com-Power Transmitting Antennas:](#)
 - [AC-220 CombiLog](#) - 80 MHz-2 GHz, 500W power handling
 - [ACL-6000 CombiLog](#) - 80 MHz-6 GHz
 - **Biconical, Log-Periodic, and Horn Antennas** - Full range available
- **Field Strength Monitors** with isotropic probes
 - Contact Com-Power for field monitoring solutions
- **Current Injection Probes** for CS114/CS115 ([Com-Power Injection Probes](#)):
 - [CLCI-100](#) - 10 kHz-100 MHz, 40 mm aperture, 100W
 - [CLCI-400](#) - 10 kHz-400 MHz, MIL-STD-461 and DO-160 compliant
- **Helmholtz Coils or Loop Antennas** for low-frequency magnetic field testing
 - [Magnetic Field Generators](#) from Com-Power
- **Coupling/Decoupling Networks (CDNs)** for conducted immunity
 - [Com-Power CDN Products](#) - Wide variety for IEC 61000-4-6
- **Complete Test Systems:**
 - [Conducted Immunity System \(CIS\) Series:](#)
 - [CIS-25](#) - 25W system with CDN
 - [CIS-50](#) - 50W system with CDN
 - [CIS-100](#) - 100W system with CDN
 - Each system includes amplifier, CDN, directional coupler, adapters, and optional CSAT software for test automation

3.3 Test Facilities

MIL-STD-461 specifies test facility requirements including shielding effectiveness, chamber dimensions, and measurement uncertainties. Facilities must be validated periodically using antenna sweeps and ambient measurements.

Facility Requirements:

- **Shielded Enclosure:** >80 dB shielding effectiveness 10 kHz - 40 GHz
- **RF Absorber Coverage** for radiated tests (typically hybrid ferrite and foam)
- **Ground Plane:** 2m beyond EUT perimeter, <2.5 mΩ DC resistance
- **Minimum Chamber Dimensions** for RE102/RS103: 3m (H) x 4m (W) x 5m (L)
- **Filtered Power Distribution** with <1 μV ambient noise

Com-Power Support for Test Facilities:

- Com-Power provides consultation and equipment recommendations for facility setup
- Complete turnkey solutions available for MIL-STD-461 test labs
- Calibration services and NIST-traceable certificates for all equipment
- Technical support for test setup and procedure optimization

4. Platform-Specific Requirements

MIL-STD-461G tailors requirements based on the intended platform (Army, Navy, Air Force, Space). Each service has unique electromagnetic environments and mission requirements that influence applicable tests and limits.

4.1 Army Platforms

Army ground vehicles and equipment face harsh electromagnetic environments with high vibration, temperature extremes, and proximity to high-power transmitters. Army requirements are generally most stringent for RE102 emissions.

Key Army Requirements:

- **RE102:** Stringent broadband limits (24 dBμV/m at 1 meter)
- **RS103:** High field strengths (200 V/m typical)
- **All conducted tests typically required**

Recommended Com-Power Solutions:

- Complete [LISN sets](#) for conducted emissions
- [High-performance antennas](#) for stringent RE102 limits
- [High-power amplifiers](#) for 200 V/m RS103 testing
- [Current probes](#) for cable injection tests

4.2 Navy Platforms

Naval ships and submarines present unique challenges in a saltwater environment, with high-power radar systems and metal structures that create complex electromagnetic coupling. Equipment must withstand electromagnetic effects from shipboard systems and external threats.

Recommended Com-Power Solutions:

- Ruggedized equipment suitable for naval environments
- Complete test systems for shipboard installations
- Contact Com-Power for navy-specific equipment configurations

4.3 Air Force Platforms

Aircraft equipment must operate reliably in high-altitude environments, across wide temperature ranges, and in close proximity to aircraft radar and communication systems. Weight and size constraints require careful EMI filter design.

Recommended Com-Power Solutions:

- [DO-160 compliant LISNs](#) (also meets MIL-STD-461)
- Lightweight [antenna solutions](#)
- Compact test equipment for aircraft integration testing

4.4 Space Platforms

Space systems face an extreme electromagnetic environment from radiation, plasma, and solar activity. Testing includes specialized requirements for launch, orbit, and deep space operations.

Recommended Com-Power Solutions:

- High-frequency test equipment up to 40 GHz
 - Specialized [TEMPEST LISNs](#) for classified space applications
 - Contact Com-Power for space-qualified testing solutions
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Additional Com-Power Resources

Technical Support and Services

- **3-Year Warranty** on all Com-Power products
- **NIST-Traceable Calibration** with every unit
- **Optional ISO 17025 Certification** for regulated industries
- **Technical Support** for test setup and troubleshooting
- **Custom Solutions** available for special applications

Product Categories

- [Complete LISN Product Line](#) - Single-phase, three-phase, TEMPEST
- [Comprehensive Antenna Selection](#) - 9 kHz to 40 GHz coverage
- [RF Power Amplifiers](#) - 25W to 100W+ options
- [Current Probes](#) - Monitoring and injection types
- [Spectrum Analyzers](#) - Pre-compliance and compliance
- [Complete Test Systems](#) - Turnkey conducted immunity solutions
- [Comb Generators](#) - CGO-520 and other reference sources
- [Transient Limiters](#) - Instrument protection

Contact Information

Website: www.com-power.com

For quotes, technical questions, or custom solutions, visit the Com-Power website or contact their sales and engineering teams.

Document Notes

This updated guide integrates Com-Power Corporation's comprehensive test equipment solutions for MIL-STD-461G electromagnetic compatibility testing. Com-Power has been a trusted supplier of EMC test equipment for over 15 years, providing high-quality products that meet or exceed military and commercial EMC standards.

All Com-Power products mentioned are individually calibrated and include:

- NIST-traceable calibration certificates
- Comprehensive technical documentation

- 3-year manufacturer warranty
- Worldwide technical support

For the most current product specifications, pricing, and availability, please visit www.com-power.com or contact Com-Power directly.



5. Conclusion

MIL-STD-461 compliance is essential for military and aerospace equipment to ensure operational effectiveness and mission success. The standard's comprehensive approach addresses both equipment-generated interference and equipment susceptibility to electromagnetic threats.

Key Success Factors:

1. Understand platform-specific requirements early in design
2. Implement EMI design best practices from concept phase
3. Conduct pre-compliance testing during development
4. Work with experienced MIL-STD-461 test laboratories
5. Maintain comprehensive test documentation

6. References

6. MIL-STD-461G, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 2015
7. MIL-STD-464C, Electromagnetic Environmental Effects Requirements for Systems, 2010
8. RTCA DO-160G, Environmental Conditions and Test Procedures for Airborne Equipment, 2010

For MIL-STD-461 test equipment and compliance support,

contact Com-Power Corporation

www.com-power.com

