



Guide to Marine EMC

Regulations, Tests, Preparation



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Complete EMC & Environmental Stress Testing

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This guide describes the electromagnetic compatibility (EMC) and wireless device regulations that apply to marine equipment and systems. It covers regulatory requirements for recreational boats and commercial ships in the United States, Canada, and the European Union. The broader application of the commercial shipping regulations also extend globally through individual country agreements to follow the International Maritime Organization Convention for the Safety of Life At Sea (SOLAS).

These regulations are developed by marine industry manufacturers along with national governments to ensure the safety of boating and commercial shipping. In addition, this guide identifies national spectrum agency regulations that ensure reliable radio communications for citizens.



1 Electromagnetic Compatibility for the Marine Environment

Recreational Craft EMC Environment

- Internal combustion engines
- Handheld wireless transmitters
- Close proximity to harnesses and electronic controls
- Non-metallic hulls and structures

Commercial Ship EMC Environment

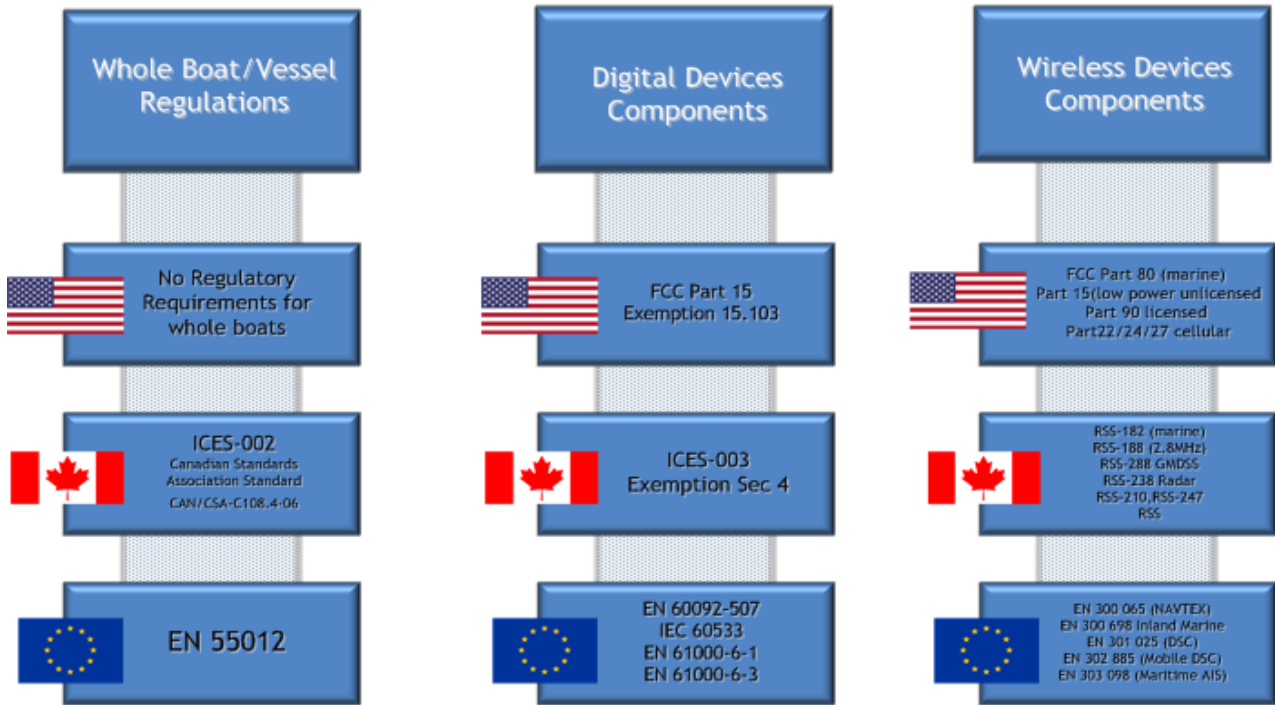
- Receivers at 156-165MHz, 2.182Mhz
- High Power Navigation Radar
- Long-range Communications Transmitters
- Heavy Electro-mechanical Machinery

Electromagnetic compatibility (EMC) addresses two concerns; first, the ability of a device to limit its radio frequency emissions so as to not interfere with other nearby devices, in particular radio receivers; and second, the ability of a device to operate as required in the presence of electrical and electromagnetic interference and other electrical threats.

The electromagnetic environment for recreational craft is unique in that pleasure craft are typically small spaces and RF transmitters and communications receivers used on board are in close proximity to controls, wiring harnesses, and other wireless devices.

The electromagnetic environment for commercial ships includes high power communication radios and navigation radar. Reliable functioning of these devices is critical for the safety of the ship they are on and to nearby passing vessels. Ship radios are used to communicate potentially life-threatening conditions and to receive distress signals from other vessels. It is vitally important that on-board radio receivers are not interfered with by other electrical and electronic systems.

Recreational and Pleasure Craft



2 Recreational Craft EMC Regulations

American Boat and Yacht Council (ABYC)

ABYC S-31 includes electrical and EMC requirements for recreational craft and marine equipment. This standard is voluntary and is a well recognized industry practice. It is not a government regulatory requirement or a "certification". Compliance with ABYC-S31 typically covers the requirements for most other countries.

For recreational craft the EMC requirements in the US, Canada, and the European Union include standards for the entire boats as well as requirements for electronic modules and wireless transmitters. Not all markets have the same requirements so boat builders and other marine equipment manufacturers need to identify the appropriate standards and conformity assessment processes for the markets they serve and for the types of equipment they provide.

This guide addresses only EMC requirements. Many other marine regulations exist for water craft such as those for boat construction, life-saving equipment, and fire extinguishers, to name a few. For marine safety regulations other than EMC, manufacturers should consult with the US Coast Guard, Transport Canada, and the European Union Recreational Craft Directive.

Recreational & Pleasure Craft



EMC Regulations for Whole Boat/Vessels

In the United States, there are no government mandated EMC regulatory requirements that apply to whole boats from either the FCC or the US Coast Guard.

However, in Canada and in the European Union there are RF emissions standards for boats having spark ignition internal combustion engines. These requirements apply to boats having hull lengths up to 15 meters. The tests and limits follow the international standard CISPR 12 which is intended to protect off-board receivers. Off-board receivers in this context generally include domestically used TV and sound radio receivers. These requirements protect receivers over the range of 30MHz-1000MHz.

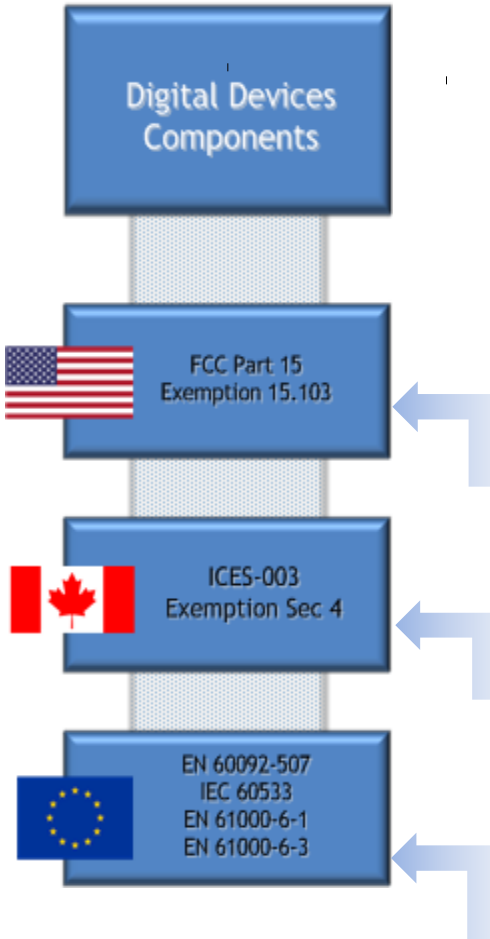
In Canada, the radiated emissions requirement ICES-002 is the whole boat emissions test standard. It references the Canadian standard CAN/CSA-C108.4-06 which tailors CISPR 12:2001 to apply limits for broadband emissions only.

In the European Union, EN 55012 is the harmonized standard for the CE Marking EMC Directive and it is the radiated emissions requirement for boats with internal combustion engines. It references CISPR 12:2007 and includes both broadband and narrowband emissions limits.

In general there are no government mandated whole boat "immunity" standards. However boat builders should perform a risk assessment to address potential hazards for an assembled boat . Recreational craft should be configured with subsystems that are EMC robust.

Recreational & Pleasure Craft

EMC Regulations for Electronic Subassemblies



Electronic subassemblies (ESAs) are individual components and controls placed on-board to provide propulsion, steering, and other boat safety or enhancement functions. Electronic sub-assemblies include modules integrated by the boat-builder at the time of initial manufacturing, devices added by value-added resellers, as well as aftermarket products added by the boat owner. ESAs may be digital electronics or electronic modules with wireless functionality. Different requirements apply for digital ESAs compared to devices that are RF transmitters and receivers.

In the US, the FCC requirements for digital electronics are in 47CFR Part 15B. However, the FCC provides an exemption for unintentional radiators used exclusively on transportation vehicles, including boats, so digital devices used exclusively on boats are exempt from formal digital device testing (see 15.103(a)).

In Canada, ICES-003 is the requirement for digital devices. Products that are not factory installed by the boat-builder must comply with ICES-003. These requirements follow the international standard CISPR 22 for Information Technology Equipment (ITE) applying the Class B limits for radiated emissions.

In the European Union, the Recreational Craft Directive (RCD) 2013/53/EU establishes the regulations for recreational boat safety. The technical requirements are posted as harmonized standard in the Official Journal (OJ) for the RCD. For example EN 25197 identifies requirements for electrical/electronic steering, shift and throttle and dynamic position control systems and these requirements include EMC. Standards listed in the RCD OJ for a specific boat system should be applied first for a technical assessment. When a device specific standard is not listed in the RCD OJ then EN 60092-507:2015 is the generic technical standard for boat electrical systems and it will apply.

EN 60092-507 covers pleasure craft measuring 24-50 meters and it specifies EMC per IEC 60533 and IEC 60945 for recreational and commercial vessels.

Harmonized standards for the Recreational Craft Directive are posted on the Europa website. Link to ec.europa.eu and search "Official Journal Harmonized Standards Recreational Craft Directive"

Recreational & Pleasure Craft

EMC Regulations for Wireless Devices

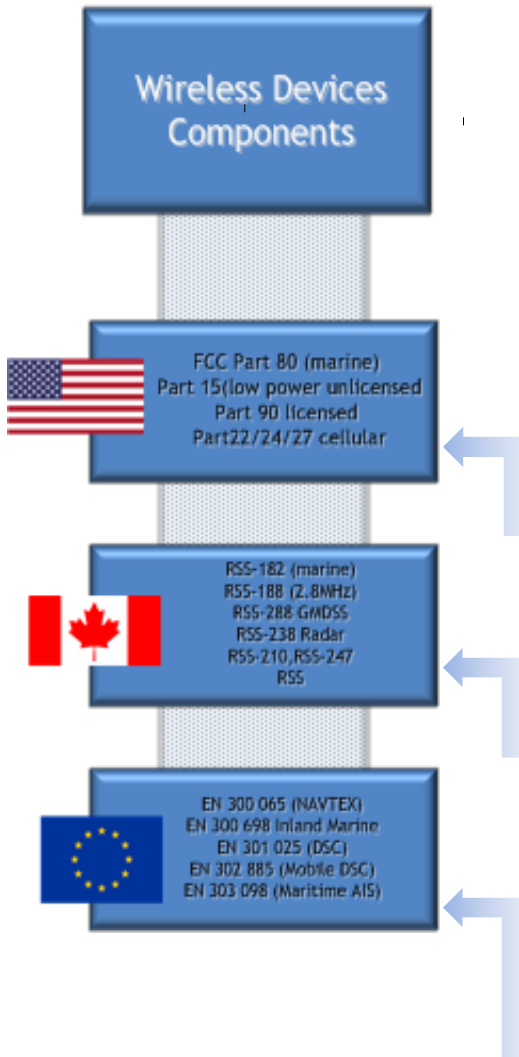
Wireless devices used on recreational craft must comply with spectrum agency requirements such as those of the FCC, Canada Innovation, Science, and Economic Development (ISED), and European Union Radio Equipment Directive (RED). In certain cases marine safety agency regulations, i.e. USCG, Marine Equipment Directive also apply.

The FCC regulations for marine band radio communication equipment are covered in FCC Part 80. For low power transmitters such as Bluetooth, WiFi, or Zigbee the Part 15 regulations apply. Cellular transmitters integrated on boats will need to comply with Part 22, 24, or 27. Any type of intentional transmitter, i.e. low power or licensed, used on a recreational craft will need to comply with testing and certification before it can be brought to market.

The Canadian regulations for marine band radios as well as low power transmitters are mostly aligned with those of the FCC. Marine band Canadian RSS standards (188/182/288/238) apply for VHF safety bands and radar. For low power transmitters such as Bluetooth, WiFi, or Zigbee the RSS-210, and RSS-247 apply. Cellular transmitters integrated on boats will need to comply with Canadian telecom standards. Similar to FCC, intentional transmitters used in Canada will need to be tested and certified to Canadian transmitter regulations before put into operation.

In the European Union, the Radio Equipment Directive (RED) is the regulatory requirement for low power transmitters and certain marine band systems. Low power transmitters and receivers will need to comply with the RED requirements for effective use of spectrum, EMC, and electrical safety.

Radio communication and navigation equipment in the EU that fall under the scope of the IMO SOLAS Convention will also need to be type approved per the Marine Equipment Directive (MED).



Equipment manufacturers should confirm if the transmit frequency is allowed in the markets where their wireless product is used.



The International Maritime Organization (IMO) is an agency of the United Nations responsible for developing the regulatory framework for merchant ships engaged in international travel. In particular the IMO treaty on the International Convention for the Safety of Life at Sea (SOLAS) requires country signatories to comply with safety standards and processes, some of which reference to EMC standards.

The IMO SOLAS requirements are comprehensive and cover all aspects of a ship's design, construction, and functional systems including communications, navigation, machinery and electrical installations, and fire safety.

As of March 2016, the IMO counted 162 countries signed to the SOLAS Convention which covers about 99% of merchant ships around the world in terms of gross tonnage.

3 Commercial Ship EMC Regulations

US Coast Guard
46 CFR Part 161- for marine safety
47 CFR Part 80- for spectrum

Transport Canada
RSS standards for Spectrum

Marine Equipment Directive
(MED) 96/98/EC

Merchant ships flagged in the United States must comply with US Coast Guard requirements. As a signatory to the IMO treaties the US has incorporated the IMO SOLAS Conventions into its maritime regulations.

Similarly, Canada is a SOLAS treaty signatory and the commercial shipping regulations through Transport Canada also adopt the IMO SOLAS Conventions as the foundation for their maritime regulations.

In the European Union, the Marine Equipment Directive (MED) 96/98/EC is the regulatory requirement for commercial ships. European flagged ships must comply with the requirements in the MED which are based on the SOLAS convention.



International Association
of Classification
Societies

In order to confirm that a ship's electrical systems comply with the SOLAS Conventions the maritime industry has adopted a type approval process for the evaluation, test, and certification of electrical devices for regulatory compliance. The type approval process is referred to as marine classification and the organizations that perform the marine certifications in accordance with SOLAS regulations are classification societies.

There are over 50 classification societies that engage in the type approval of marine equipment. Of the 50, twelve are members of the International Association of Classification Societies (IACS). The IACS is a non-governmental industry organization and provides oversight to the type approval process. The IACS also facilitates the development of consensus standards and test methods that enhance maritime safety. For EMC, the IACS unified requirements UR E10 cover standards for equipment on commercial ships. Each class society can set more stringent requirements, but UR E10 establishes the minimum.

IACS Members

- *Lloyd's Register*
- *Bureau Veritas*
- *Croatian Register of Shipping*
- *Registro Italiano Navale*
- *American Bureau of Shipping*
- *DNV GL*
- *Nippon Kaiji Kyokai (ClassNK)*
- *Russian Maritime Register of Shipping*
- *Polish Register of Shipping*
- *China Classification Society*
- *Korean Register of Shipping*
- *Indian Register of Shipping*

The SOLAS conventions are supplemented with updates and IMO Resolutions such as A.813(19):1995 which calls for IEC publications 533 and 945 as the EMC operational and safety for electrical and electronic systems on ships. Other similar IMO Resolutions include A.694(17) which establishes a standardized approach to Global Maritime Distress and Safety Systems (GMDSS).

The IACS standard UR E10 along with most commercial ship EMC regulations in the US, Canada, and the European Union follow IEC 60533 and IEC 60092-504 for electrical equipment and IEC 60945 for radio communication and navigation systems. These tests evaluate a product from the EMC and safety perspective. Other transmitter specific tests may also apply for radios and radar.

IACS UR E10 EMC Regulations Tests, Levels, Limits

Power Supply variations:

AC Combinations +/- 6 & 10 % Voltage , +/-5%
Freq Variations
AC Transient Comb +/- 20% Voltage, +/- 10%
Freq Variations
DC +/-10% voltage tol, 5% voltage cyclic var,
10% ripple

Electrostatic Discharge

IEC 61000-4-2
Contact discharge: 6kV
Air discharge: 2kV, 4kV, 8kV

Radiated Susceptibility

IEC 61000-4-3
80 MHz to 2 GHz, 10V/m
80%AM modulated at 1kHz

Conducted Low Freq Immunity

AC Mains- 10% of Vnom to 15th harmonic
reducing to 1% at 100th & 1% 100th-200th min
3Vrms, max 2W.
DC Mains- 50Hz-10kHz at 10% of Vnom max
2W.

Conducted Radio Freq Immunity

IEC 61000-4-6
AC, DC, I/O ports & signal control lines: 150kHz-
80MHz
3Vrms, 80% AM 1kHz 80%AM modulated at
1kHz. [10Vrms at 10 spot frequencies]

Electrical Fast Transients

IEC 61000-4-4
2kV L-E, 1kV Signal & I/O leads Tr=5n /
T50=50ns

Power Line Surge

IEC 61000-4-5
1kV L-E, 0.5kV L-E. 1.2 x 50usec, SCC 8 x 20us.

Conducted Emissions

CISPR 16-2-3
AC & DC Mains 10kHz-30MHz Class A or B

Radiated Emissions

CISPR 16-2-3
150kHz-2GHz
(24 dBµV/m 156-165MHz) Class A or B

The EMC requirements specified in IACS UR E10 include both radio frequency immunity and emissions. They also cover electrical steady state and transient immunity tests.

Most marine classification societies have EMC standards that prescribe test methods, levels, and limits but they typically follow the IACS E10 requirements. For example,

Lloyd's Register- Test Specification 1 July 2015

DNV-GL- DNVGL-CG-0339 Nov 2015

The immunity test levels and test methods in UR E10 are generally consistent with the generic EMC standards for the industrial environment. The power supply variations test and the conducted low frequency test are unique to the marine environment.

In addition to performing the test at the prescribed immunity levels, manufacturers need to evaluate the performance of the device and apply the correct performance criterion. Critical systems and for continuous phenomena (Performance Criteria A) typically must continue to operate as intended during and after the test with no degradation of performance or loss of function. Performance criterion B for transient phenomena allows degradation or loss of function or performance that is self-recoverable. However no change of actual operating state or stored data is allowed.

Marine EMC Standards

IACS UR E10

(IEC 60549 / IEC 60533 / IEC 60092-504)

The conducted (CE) and radiated emissions (RE) standards for marine applications cover a wider frequency range than general purpose commercial or industrial EMC standards. CE begins at 10kHz (to 30MHz) and RE begins at 150kHz (to 2GHz). Both CE and RE standards apply a more strict limit for equipment used on the bridge or deck zones (Class B) compared to equipment below deck and considered general power distribution zone (Class A). The tighter bridge and deck limits are applied to protect communications and navigation equipment which are typically in close proximity to these bridge and deck zones. In addition, the 156-165MHz range includes a very tight emissions limit of 24dbµV/m to protect the marine VHF radio communications.

Recreational Craft

1- Determine All Applicable Requirements

3- Perform Testing and Analysis

3- Prepare Technical File

4- Label Device and Issue DoC

5- Maintain Technical File and Continuing Compliance



4

Conformity Assessment- Recreational Craft

Canada Product Markings

- ICES-002 Compliance:
“CAN ICES-2/NMB-2”
- ICES-003 Compliance:
* Class A or B
“CAN ICES-3 (*)/NMB-3(*)”

EU Product Markings include:

“CE” Mark

Manufacture Name

Manufacturer contact information

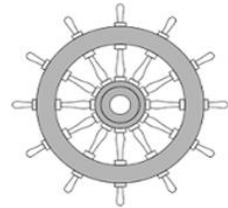
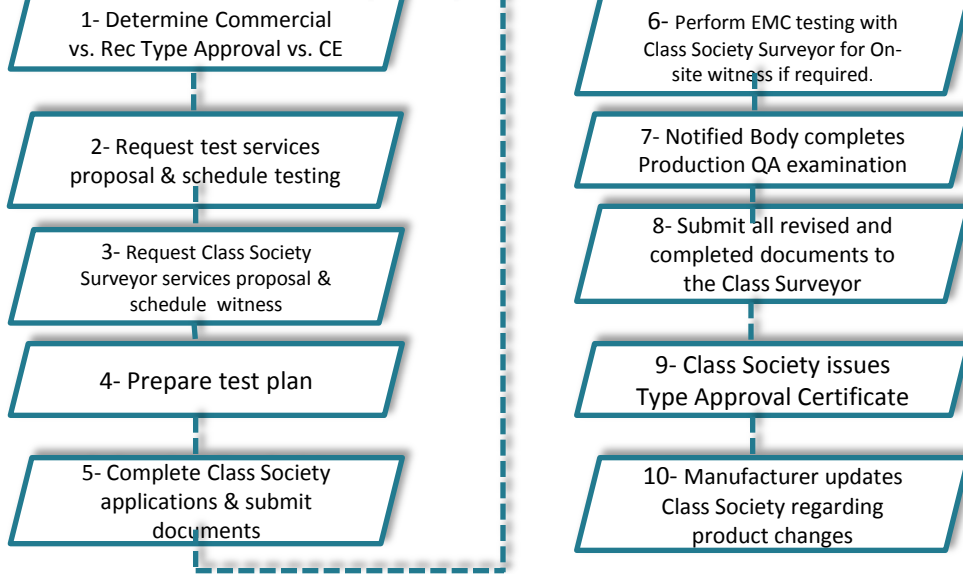
Product tradename

For recreational craft and pleasure boats the EMC conformity assessment process is a manufacturer’s self declaration.

In Canada, a manufacturer declares compliance for boat level emissions testing per ICES-002 and for electronic sub assemblies per ICES-003. Compliant products need to be labeled with the appropriate statements and information. In Canada and the US, intentional transmitters must be tested, certified, and labeled accordingly.

In Europe, the EMC conformity assessment process for an entire boat (EN 55012) and for electronic systems per the RCD or EMC Directives is typically a manufacturers self declaration. Radio transmitters are also self-declared compliant but a notified body may be required when a harmonized standard is not applied in full.

Commercial Ships



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Conformity Assessment- Commercial Ships

The process for commercial marine EMC type approval will depend on the classification agency that is contracted for the service. Each of the IACS agencies has their own requirements but at a minimum a completed application is required along with submittal data such as drawings, data sheets, and test plans.

The type approval will also require an evaluation of the manufacturers ISO 9000 quality management system. In some cases the quality registration certificates are sufficient but in other instances a quality system assessment will need to be conducted by a local surveyor. Some products also may require production surveillance on an annual basis to confirm continuing compliance.



5

Prepare for Testing

Typical Schedule Lead Times

EMC Testing at Elite 2-4 weeks

ENV Testing at Elite 1-3 weeks

IACS Surveyor Witness Services 8-12 weeks.

Elite report delivery is 10 days after completion of testing.

Manufacturers can take several steps to ensure their marine EMC test processes are successful. Good planning and test preparation are the key.

One of the first is to develop a test plan and communicate the plan details with the marine surveyors, test lab, and other conformity assessment service providers. The test plan should provide the following details:

- Detailed equipment description, photos, software, etc.
- Signal leads, I/O leads, output leads
- Simulated output loads and wired interfaces
- Input power requirements
- Modes of operation during test
- Allowable performance criteria and tolerances
- Sample quantities

The equipment manufacturer will need to provide suitable harnesses with sufficient cable lengths to extend into an EMC test chamber. Communications cables such as those for Ethernet or CAN may need to be configured with a fiber optic chamber interface. For those products that include wireless connectivity, the manufacturer will need to configure the transceiver to operate in the modes specified for measuring the transmitter and receiver performance. Detailed operating instructions are always required.

Finally, communicate early with the marine surveyors and test lab and confirm schedule and availability at least 8-12 weeks in advance. Good planning will ensure your project is completed on time.



Contact Elite today... Our Experts, Your Timing, Best Value

Let us know how we can help you succeed with your product development.

Why Trust Elite?

- *60+ years of EMC testing experience*
- *30+ EMC test engineers and iNARTE organizational certification*
- *20+ years of continuous ISO 17025 accreditation.*
- *Combined EMC and Environmental Testing in one location to save time and expense for test witnesses*

Marine EMC testing can be a challenging process, but with the support of Elite engineers you can rest assured that you're working with the most knowledgeable, best equipped, and best value service provider in the industry. Contact the following Elite personnel to get your project started on the right path.

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