



# Advisory Circular

**Subject: Electromagnetic Compatibility Testing of Electrical and Electronic Equipment**

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## 1.0 INTRODUCTION

This Advisory Circular (AC) is provided for information and guidance purposes. It may describe an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards.

### 1.1 Purpose

The purpose of this document is to provide guidance with respect to compliance with electromagnetic compatibility (EMC) requirements in order to obtain approval for the installation of electrical and electronic equipment on any category of aircraft.

### 1.2 Applicability

This document is applicable to all Transport Canada Civil Aviation (TCCA) employees and to individuals and organizations when they are exercising privileges granted to them under an External Ministerial Delegation of Authority. This information is also available to the aviation industry for information purposes.

### 1.3 Description of Changes

Not applicable. This document is a new issue.

## 2.0 REFERENCES AND REQUIREMENTS

### 2.1 Reference Documents

It is intended that the following reference materials be used in conjunction with this document:

- (a) Chapter 523 of the *Airworthiness Manual (AWM)—Normal, Utility, Aerobatic and Commuter Category Aeroplanes*;
- (b) Chapter 525 of the AWM—*Transport Category Aeroplanes*;
- (c) Chapter 527 of the AWM—*Normal Category Rotorcraft*;
- (d) Chapter 529 of the AWM—*Transport Category Rotorcraft*;
- (e) Airworthiness Notice (AN)-B043, Edition 02—*Conformity Inspection Associated with Appliance Type Certification or Modification/Repair Approval Projects*;
- (f) Federal Aviation Administration (FAA) Advisory Circular (AC) 20-41A—*Substitute Technical Standard Order (TSO) Aircraft Equipment*;
- (g) FAA AC 20-130A—*Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors*;
- (h) FAA AC 20-138A—*Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment*;
- (i) FAA AC 23-17B—*Systems and Equipment Guide for Certification of Part 23 Airplanes and Airships*;
- (j) FAA AC 23.1309-1C—*Equipment, Systems, and Installations in Part 23 Airplanes*;
- (k) FAA AC 25-10—*Guidance for Installation of Miscellaneous, Non-required Electrical Equipment*;
- (l) FAA AC 25.1309-1A—*System Design and Analysis*;
- (m) FAA AC 27-1B—*Certification of Normal Category Rotorcraft*;
- (n) FAA AC 29-2C—*Certification of Transport Category Rotorcraft*;

- (o) FAA AC 43.13-1B—*Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair*;
- (p) Radio Technical Commission for Aeronautics Inc. (RTCA) Document (DO)-160E—*Environmental Conditions and Test Procedures for Airborne Equipment*;
- (q) Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 1870—*Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety*;
- (r) U.S. Military Standard (MIL-STD)-464—Department of Defence Interface Standard—*Electromagnetic Environmental Effects Requirements for Systems*;
- (s) U.S. Department of Transportation DOT/FAA/CT-86/40—*Aircraft Electromagnetic Compatibility*; and
- (t) European Organisation for Civil Aviation Equipment (EuroCAE) ED-14E—*Environmental Conditions and Test Procedures for Airborne Equipment*.

## 2.2 Cancelled Documents

Not applicable.

## 2.3 Definitions and Abbreviations

The following definitions and terms are used in this document:

- (a) **Electromagnetic Compatibility (EMC)** means the ability of any electrical or electronic equipment to simultaneously operate without suffering or causing adverse degradation in performance attributed to the interaction with electromagnetic energy present in the intended operational environment.
- (b) **Electromagnetic Interference (EMI)** means the phenomenon occurring when electromagnetic energy present in the intended operational environment interacts with the electrical or electronic equipment causing unacceptable or undesirable responses, malfunctions, interruptions, or degradations in its performance.
- (c) **EMC Test** means an aircraft level test intended to evaluate the electromagnetic compatibility (EMC) between electrical and electronic equipment installed on board the aircraft when operated simultaneously.
- (d) **EMI Source** means a source of electromagnetic energy that has the potential to interfere with the normal operation of other electrical or electronic equipment.
- (e) **EMI Victim** means electrical or electronic equipment identified as likely to be affected by electromagnetic energy generated by other electrical or electronic equipment.
- (f) **Required equipment** means the electrical and electronic equipment installed on the aircraft to perform a required function prescribed either by the type certificate or by the operating regulations applicable to the aircraft.
- (g) **Source/Victim Matrix** provides a means for identifying the equipment considered sources and potential victims of interference and the equipment combinations that must be tested when performing an aircraft EMC Test. The matrix may be populated by identifying the equipment by type or by specifying the function performed by the equipment. Source/Victim Matrix examples for a simple aircraft are presented in Appendix A.

## 3.0 BACKGROUND

- (1) Modern aircraft rely extensively on electrical and electronic equipment to provide various aircraft functions. This equipment and its interconnecting wiring will unavoidably generate, or be exposed

to, an electromagnetic environment that may consists of electrical fields, magnetic fields or electromagnetic fields spanning over a wide range of frequencies and levels. The resulting electromagnetic fields may couple into interconnecting wiring and equipment apertures and may cause malfunctions, upsets or failures. It should be noted that the term “electromagnetic field” in this document will also be used to denote the contribution of the “electrical” and “magnetic” fields to the operational environment.

- (2) This guidance material was developed to standardize the interpretation and the application of the relevant airworthiness standards. The relevant airworthiness standards include:
- (a) subsection 523.1431(b) of the AWM;
  - (b) subsection 525.1353(a) of the AWM;
  - (c) subsection 525.1431(c) of the AWM;
  - (d) subsection 527.1301(d) of the AWM;
  - (e) subsection 527.1309(a) of the AWM;
  - (f) subsection 529.1353(a) of the AWM; and
  - (g) subsections 529.1431(a) and (b) of the AWM.

#### **4.0 ACCEPTABLE MEANS OF COMPLIANCE**

- (1) The airworthiness standards specified in subsection 3.0(2) of this document require that:
- (a) Equipment and installation designers ensure that electrical and electronic equipment, when installed on board an aircraft, can be simultaneously operated without resulting in adverse effects on the aircraft. This is normally accomplished by specifying adequate susceptibility and emission requirements for equipment qualification, and by specifying adequate grounding, bonding, shielding and terminations, as well as separation requirements for equipment installation.
  - (b) Electrical and electronic equipment be tested to the appropriate environmental categories for emission and susceptibility using acceptable environmental test conditions and test procedures for airborne equipment. The levels selected for testing should therefore be compatible with those levels expected in the aircraft where the equipment and its interconnecting wiring are located. It should be noted that, although equipment may have been qualified to certain emission and susceptibility categories, this alone is not normally sufficient without further evaluation at the aircraft level.
  - (c) Electrical and electronic equipment when being installed, whether as part of a new aircraft type or as a modification to an existing one, must evaluate the potential effects of exposure to the electromagnetic environment of the aircraft by appropriate means of compliance, considering the equipment as either a potential source of interference, or a potential victim, or both. The applicant must show that the installation complies with the airworthiness standards. An EMC test, which is intended to reveal any electromagnetic interference (EMI) and to evaluate its effect on the aircraft, is performed to satisfy the requirement.
- (2) The acceptable means of compliance may be:
- (a) compliance by EMC test as per section 5.0; or
  - (b) compliance by similarity as per section 6.0.

## 5.0 COMPLIANCE BY EMC TEST

- (1) This subsection outlines a method for performing an EMC test. It denotes the minimum information that should be included in the applicant's EMC test plan and the associated EMC test report. The content of the EMC test plan and report should reflect the category and complexity of the particular aircraft. It should also be noted that the following guidance does not define either a format or a layout for the plan and the report.
- (2) The objective of the EMC test is to reveal any EMI by observing the behaviour of aircraft systems. A qualitative assessment will subsequently be performed to classify the effects of the EMI on the aircraft as either adverse or non-adverse.

### 5.1 EMC Test Plan

The applicant should prepare an EMC test plan containing the following information:

- (a) Aircraft and equipment configuration:

The EMC test plan should define the aircraft and equipment configuration, or configurations, to be evaluated that are traceable to engineering drawings or aircraft records, as applicable.
- (b) The test plan should contain the following test conditions:
  - (i) The EMC test plan should specify the relevant test conditions and assumptions for conducting the EMC test. The applicant should identify any prerequisite or aircraft preconditioning for conducting the EMC test.
  - (ii) As a general practice, the test conditions should be selected on the basis of establishing a test environment that will be reasonably likely to reveal any EMI.
  - (iii) The correct functioning of all the electrical and electronic equipment should be verified before commencing the EMC test.
  - (iv) Doors and windows should be closed. Ground testing should be conducted without dependence on ground support equipment. Aircraft engine(s), and auxiliary power unit(s) when installed, should be used for electrical and hydraulic power generation and to supply the environmental control systems.
  - (v) The normal practice for communication and navigation equipment is to select three test frequencies, one at the lower end, one at mid-range and one at the higher end of the operating range. Additional test frequencies should be specified for equipment where potential susceptibility is known to exist, as denoted by advisory material or by experience. For example, a global positioning system (GPS) is a known potential EMI victim to EMI sources like very high frequencies (VHF), satellite communications (SATCOM), and traffic alert and collision avoidance systems (TCAS). Furthermore, additional test frequencies may be necessary when an engineering assessment has identified potential interferences at common operating frequencies or harmonic components thereof.
  - (vi) It should be specified that the EMC test shall be conducted by means of a comprehensive ground test prior to a test flight if a test flight is at all required. It should be noted that the conditions of flight may be simulated for the purpose of exercising aircraft functions while on the ground. However, a test flight will be required when equipment cannot be operated or adequately evaluated by a ground test.
- (c) The EMC test plan should contain the following test procedures:
  - (i) The EMC test plan should describe the procedures and detailed instructions for the execution of the test for each configuration that is to be evaluated.

- (ii) The test procedures should also define the methodology for recording the test results and relevant observations, and may provide a sample datasheet or test log.
- (d) The EMC test plan should identify all test equipment:
  - (i) The EMC test plan should identify all test equipment required for the purpose of simulating aircraft systems. The test equipment positioning with respect to the aircraft, as well as the control settings, should be specified.
  - (ii) Optionally, an applicant may elect to use special test equipment to obtain quantitative measurements in order to identify susceptibilities affecting critical aircraft equipment or systems, for example: full authority digital engine control (FADEC) and fly-by-wire. When this method is used, the applicant should identify the special test equipment and the control settings, and should take the necessary precautions to avoid invalidating the EMC test results.
- (e) The applicant should identify the equipment considered to be an EMI source and a potential EMI victim. To this end, it is recommended that a source/victim matrix be prepared to help record any EMI noted during the EMC test.
  - (i) The matrix would normally include all the installed electrical and electronic equipment shown as both potential EMI victims and sources. However, it may be possible to reduce the number of source/victim pairs when engineering judgement determines that the electromagnetic emissions of an equipment is insignificant when compared to other EMI sources within the same area of the aircraft. The applicant should include appropriate justification in the EMC test plan when this approach is used.
  - (ii) All modes of operation for each piece of equipment would normally be evaluated. For modern equipment that integrate a large number of functions and have many modes of operation, it may be determined that evaluating only a representative subset of functions and modes of operation is sufficient to adequately reveal any EMI. Such determination should be based on sound engineering judgement with appropriate substantiation included in the EMC test plan.

## 5.2 EMC Test Report

The applicant should prepare an EMC test report containing the following information:

- (a) Conformity inspection record. The EMC test report should contain evidence of a conformity inspection carried out for each configuration to be evaluated on the test aircraft. It is the applicant's responsibility to conduct a conformity inspection and maintain suitable records. As a general practice, any deviation from the configuration defined by the EMC test plan should be duly recorded, and the test results validated.
- (b) The accountable TCCA office may also elect to perform a conformity inspection independently to that of the applicant, as highlighted by AN-B043.
- (c) Test summary. The EMC test report should document the details of the execution of the EMC test plan, including the test results. The date, test location, personnel involved, aircraft serial number, and any other relevant information should also be included. Test logs, engineering notes, datasheets and other relevant documents should be appended to the EMC test report.
- (d) Assessment of results. Any EMI noted during the EMC test should be evaluated with respect to the criticality of the function performed by the equipment, the severity of the effects and their consequences on the safe operation of the aircraft. The evaluation should consider factors such as:

- (i) the function performed by the equipment affected,
  - (ii) the impact on the pilot's workload, whether the affected system recovers automatically or pilot action is required;
  - (iii) the severity and duration of the effect(s), whether nuisance or misleading information is presented to the pilot;
  - (iv) the phase of flight in which the EMI could occur; and
  - (v) any other factors considered relevant to the safe operation of the subject aircraft.
- (e) EMI determined to pose adverse effects on the safe operation of the aircraft will either require corrective action and retesting, or appropriate mitigation. EMI considered to pose no adverse effects must nonetheless be identified in the test report with an appropriate substantiation for this disposition.
- (f) Adequate mitigation may consist of a flight manual or pilot operating handbook procedure restricting the use of equipment or inhibiting its use during a specified phase of flight. A placard in the aircraft or notes in the flight manual or pilot-operating handbook may also be found adequate. The mitigating method proposed by the applicant should be discussed with the accountable TCCA office prior to its implementation.

## **6.0 COMPLIANCE BY SIMILARITY**

- (1) In exceptional situations, and under the following guidelines, it may be possible for the applicant to substantiate EMC based on evidence other than the results of an aircraft level EMC test. For example, it may be possible for an applicant to apply similarity as the means of compliance for the replacement of electrical or electronic equipment by a unit of identical form, fit and function. In other words, there are no physical changes to the installed location, mounting and wiring provisions, or changes in the function and operation of that equipment.
- (2) However, to claim similarity, the applicant must show that the emission and susceptibility signatures (frequency spectrum and measured levels) of the new equipment established by the applicable test conditions, using acceptable environmental test standards, as defined by RTCA DO-160E or EuroCAE ED-14E, are equivalent in every respect to those of the equipment being replaced. Sound engineering judgement is required when assessing the qualification data used to substantiate compliance by similarity.
- (3) The use of similarity as the means of compliance may not be acceptable for equipment performing a critical aircraft function and should be discussed with TCCA.

## 7.0 CONTACT OFFICE

For more information please contact the:  
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Suggestions for amendment to this document are invited, and should be submitted via the Transport Canada Civil Aviation Issues Reporting System(CAIRS) at the following Internet address:

[www.tc.gc.ca/CAIRS](http://www.tc.gc.ca/CAIRS)

or by e-mail at: [CAIRS\\_NCR@tc.gc.ca](mailto:CAIRS_NCR@tc.gc.ca)

*Original signed by*

D.B. Sherritt  
Director, Standards  
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**APPENDIX A—SOURCE/VICTIM MATRIX EXAMPLES FOR A SIMPLE AIRCRAFT**

	Victims	Equipment A	Equipment B	Equipment C	Equipment D	Equipment E	Equipment F
Sources							
Equipment A		n/a					
Equipment B			n/a				
Equipment C				n/a			
Equipment D					n/a		
Equipment E						n/a	
Equipment F							n/a

**Figure A-1:** Example of a source/victim matrix used in an EMC test plan for a simple aircraft

	Victims	Equipment A	Equipment B	Equipment C	Equipment D	Equipment E	Equipment F
Sources							
Equipment A		n/a	EMC	EMC	EMC	EMC	EMC
Equipment B		EMC	n/a	EMC	EMC	EMC	EMC
Equipment C		<b>EMI</b>	EMC	n/a	EMC	<b>EMI</b>	EMC
Equipment D		EMC	EMC	EMC	n/a	EMC	EMC
Equipment E		EMC	EMC	EMC	EMC	n/a	EMC
Equipment F		EMC	EMC	EMC	EMC	EMC	n/a

**Figure A-2:** Example of a source/victim matrix presented as test evidence in the EMC test report for a simple aircraft