Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C178a

Effective
Date: 04/14/20

Technical Standard Order

Subject: ***Aircraft Circuit Breakers***

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of TSO design approval (LODA). In it, we (the Federal Aviation Administration, (FAA)) tell you what minimum performance standards (MPS) your aircraft circuit breaker must meet for approval and identification with the applicable TSO marking.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

a. TSO-C178 will also remain effective until 18 months after publication date. After this date, we will no longer accept applications for TSO-C178.

b. Aircraft circuit breakers approved under a previous TSOA may still be manufactured under the provisions of its original approval.

3. REQUIREMENTS. New models of aircraft circuit breakers identified and manufactured on or after the effective date of this TSO must meet the requirements in Table 1 for the intended equipment class.

Table 1: Equipment Class Requirements

Equipment Class	Equipment Type	Minimum Performance Standards
1	Alternating Current (AC) Arc Fault Circuit Breakers	Section 3 of SAE Aerospace Standard (AS) 5692A, *ARC Fault Circuit Breaker (AFCB), Aircraft, Trip-Free Single Phase 115 VAC, 400 Hz – Constant Frequency*, December 2009

Equipment Class	Equipment Type	Minimum Performance Standards
2	Direct Current (DC) Arc Fault Circuit Breakers	Section 3 of SAE Aerospace Standard (AS) 6019, *ARC Fault Circuit Breaker (AFCB), Aircraft, Trip-Free 28 VDC*, June 2012
3	AC or DC Thermal Circuit Breakers	Section 3 of SAE Aerospace Standard (AS) 58091A, *Circuit Breakers, Trip-Free, Aircraft General Specification For*, May 2012

a. Functionality. This TSO's standards apply to equipment intended to provide:

- Equipment Class 1 **–** Arc Fault and thermal protection for VAC applications
- Equipment Class 2 **–** Arc Fault and thermal protection for VDC applications
- Equipment Class 3 **–** Thermal protection for VAC or VDC applications

b. There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classification for which the equipment is designed.

c. Functional Qualification. Demonstrate the required functional performance under the test conditions specified in Table 2 for each included equipment class.

Table 2: Equipment Class Functional Qualification

Equipment Class	Equipment Type	Functional Qualification
1	AC Arc Fault Circuit Breakers	Sections 4.5 and 4.7 of SAE AS 5692A
2	DC Arc Fault Circuit Breakers	Sections 4.5 and 4.7 of SAE AS 6019
3	AC or DC Thermal Circuit Breakers	Sections 4.5 and 4.7 of SAE AS 58091A

d. Environmental Qualification. Demonstrate the required performance under the test conditions specified in SAE AS 5692A, sections 4.5 and 4.7, SAE AS 6019, sections 4.5 and 4.7, or SAE AS 58091A, sections 4.5 and 4.7 using standard environmental conditions and test procedures appropriate for airborne equipment. You may use a different standard environmental condition and test procedure than described in SAE AS 5692A, AS 6019, or AS 58091A provided the standard is appropriate for the aircraft circuit breaker equipment.

Note: The use of RTCA/DO-160D (with Changes 1 and 2 only, without Change 3 incorporated) or earlier versions is generally not considered

appropriate and will require substantiation via the deviation process as discussed in paragraph **3.g** of this TSO.

e. Software Qualification. If the article includes software, develop the software according to RTCA, Inc., document RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 13, 2011, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph **3.b** of this TSO. You may also develop the software according to RTCA, Inc., document RTCA/DO-178B, dated December 1, 1992, if you follow the guidance in AC 20- 115D, *Airborne Software Development Assurance Using EUROCAE ED-12() and RTCA DO-178()*, dated July 21, 2017, or latest revision.

f. Electronic Hardware Qualification. If the article includes complex custom airborne electronic hardware, then develop the component according to RTCA, Inc., Document RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, dated April 19, 2000, to at least the design assurance level consistent with the failure condition classification defined in paragraph **3.b** of this TSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

g. Deviations. We have provisions for using alternate or equivalent means of compliance with the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation pursuant to Title 14 of the Code of Federal Regulations (CFR) 21.618.

4. MARKING.

a. Mark at least one major component permanently and legibly with all of the information in 14 CFR 45.15(b). Mark the Equipment Class from Table 1 above on each article.

b. If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

c. You may use electronic part marking to identify software or airborne electronic hardware components by embedding the identification within the hardware component itself (using software) rather than marking it on the equipment nameplate. If electronic marking is used, it must be readily accessible without the use of special tools or equipment.

5. APPLICATION DATA REQUIREMENTS.

You must give the FAA Aircraft Certification Office (ACO) branch manager responsible for your facility a statement of conformance, pursuant to 14 CFR 21.603(a)(1) and one copy each of the following technical data to support your design and production approval. LODA applicants must submit the same data (excluding paragraph **5.g**) through their civil aviation authority.

a. Manuals containing the following:

(1) Operating instructions and article limitations sufficient to describe the equipment's operational capability.

(2) Detailed description of any deviations.

(3) Installation procedures and limitations sufficient to ensure that the aircraft circuit breaker equipment, when installed according to the installation or operational procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must also include a note with the following statement:

> "This article meets the minimum requirements of TSO-C178a. Installation of this article requires separate approval."

(4) For each unique configuration of software and airborne electronic hardware, reference the following:

(a) Software part number including revision and design assurance level,

(b) Airborne electronic hardware part number including revision and design assurance level, and

(c) Functional Description

(5) A summary of the test conditions used for environmental qualifications for each component of the article. For example, a form as described in RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, Appendix A.

(6) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the aircraft circuit breaker equipment.

(7) By-part-number list of replaceable components that makes up the aircraft circuit breaker equipment. Include vendor part number cross-references, when applicable.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the aircraft circuit breaker equipment continues to meet the TSO approved design. Include recommended inspection intervals and service life, as appropriate.

c. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and a software accomplishment summary.

d. If the article includes simple or complex custom airborne electronic hardware: a plan for hardware aspects of certification (PHAC), a hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. A drawing depicting how the article will be marked with the information required by paragraph **4** of this TSO.

f. Identify functionality contained in the article not evaluated under paragraph **3** of this TSO (defined as non-TSO functions). Non-TSO functions can be accepted in parallel with the TSOA. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:

(1) Description of the non-TSO function(s), such as performance specifications, failure condition classifications, software, hardware, and environmental qualification levels. Include a statement confirming that the non-TSO function(s) do not interfere with the article's compliance with the requirements of paragraph **3**.

(2) Installation procedures and limitations sufficient to ensure that the non-TSO function(s) meets the declared functions and performance specification(s) described in paragraph **5.f.(1).**

(3) Instructions for continued performance applicable to the non-TSO function(s) described in paragraph **5.f.(1).**

(4) Interface requirements and applicable installation test procedures to ensure compliance with the non-TSO function(s) performance data defined in paragraph **5.f.(1).**

(5) Test plans and analysis, as appropriate, to verify that the performance of the hosting TSO article is not affected by the non-TSO function(s).

(6) Test plans and analysis, as appropriate, to verify that the function and performance of the non-TSO function(s) as described in paragraph **5.f.(1).**

g. The quality manual required by 14 CFR 21.608, including functional test specifications. The quality system must ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS and reject the article accordingly. Applicants who currently hold TSOAs must submit revisions to the existing quality manual as necessary (not required for LODA applicants).

h. A document describing how your organization complies with the provisions of § 21.605.

i. Material and process specifications list.

j. A list of all drawings and processes (including revision level) that define the article's design.

k. Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3.c** of this TSO.

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to the responsible ACO, have the following technical data available for review by the responsible ACO:

Note: The following data for a LODA applicant may be made available for review through its CAA. Refer to the applicable bilateral agreement for specific details regarding access to this data.

a. Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

b. Article calibration procedures.

c. Schematic drawings.

d. Wiring diagrams.

e. Material and process specifications.

f. The results of the environmental qualification tests conducted according to paragraph **3.d** of this TSO.

g. If the article includes software, the appropriate documentation defined in RTCA/DO-178B or RTCA/DO-178C specified in paragraph **3.e** of this TSO, including all data supporting the applicable objectives in Annex A, *Process Objectives and Outputs by Software Level*, of RTCA/DO-178B or RTCA/DO-178C.

h. If the article includes complex custom airborne electronic hardware, the appropriate hardware life-cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-1. For simple custom airborne electronic hardware, the following data are required: test cases or procedures, test results, test coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.

i. If the article contains non-TSO function(s), you must also make items **6.a** through **6.h** available as they pertain to the non-TSO function(s).

7. FURNISHED DATA REQUIREMENTS.

a. When furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy or online access to the data in paragraphs **5.a** and **5.b** of this TSO.

b. If the article contains declared non-TSO function(s), include one copy of the data in paragraphs **5.f.(1)** through **5.f.(4).**

c. If the article contains software, include one copy of the Open Problem Report (OPR) summary to type certification, supplemental type certification, or amended type certification design approval holders.

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington, DC 20036. Telephone: (202) 833-9339; fax: (202) 833-9434. You can also order copies online at www.rtca.org.

b. Order SAE documents from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Telephone: (724) 776-4970; fax: (724) 776-0790. You can also order copies online at www.sae.org.

c. Order copies of parts 21 and 45 from the Superintendent of Documents, Government Publishing Office, PO Box 979050, St. Louis, MO 63197-9000. Telephone: (202) 512-1800; fax: (202) 512-2104. You can also order copies online at www.gpo.gov.

d. You can find a current list of TSOs and advisory circulars at http://rgl.faa.gov/. You will also find the TSO Index of Articles at the same site.

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