



Department of Transportation  
**Federal Aviation Administration**  
Aircraft Certification Service  
Washington, D.C.

**TSO-C116a**

Effective  
Date: mm/dd/08

# Technical Standard Order

*PROPOSED*

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**Subject: CREWMEMBER PORTABLE PROTECTIVE BREATHING EQUIPMENT**

1. **PURPOSE.** This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, or FAA) tell you what minimum performance standards (MPS) your crewmember portable protective breathing equipment (PBE) must first meet for approval and identification with the applicable TSO marking.
2. **APPLICABILITY.** This TSO affects new applications submitted after its effective date.
  - a. All prior revisions to this TSO are no longer effective. Generally we will not accept applications after the effective date of this TSO. However, we may do so up to six months after it, if we know that you were working against the earlier MPS before the new change became effective.
  - b. Crewmember portable PBE approved under a previous TSOA/LODA may still be manufactured under the provisions of their original approval.
  - c. Major design changes to crewmember portable PBE approved under this TSO will require a new authorization. See Title 14 of the Code of Federal Regulations (14 CFR) § 21.611(b).
3. **REQUIREMENTS.** New models of crewmember portable PBE identified and manufactured on or after the effective date of this TSO must meet the MPS qualification and documentation requirements in appendix 1 of this TSO.
  - a. **Functionality.** This TSO's standards apply to equipment intended to provide any crewmember with portable PBE using a breathable gas, suitable for emergency conditions under the test conditions specified. This equipment may be used to administer supplemental oxygen or first aid oxygen to occupants, if oxygen is used as the breathable gas.
  - b. **Functional Qualification.** See appendix 1 of this TSO.
  - c. **Environmental Qualification.** See appendix 1 of this TSO.

d. **Software Qualification.** See appendix 1 of this TSO.

e. **Electronic Hardware Qualification.** See appendix 1 of this TSO.

f. **Deviations.** We have provisions for using alternate or equivalent means of compliance to 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 under 14 CFR § 21.609 before submitting your data package.

#### 4. **MARKING.**

a. Mark at least one major component permanently and legibly with all the information in 14 CFR § 21.607(d), except for 14 CFR § 21.607(d)(2). Use the name, type, and part number. Do not use the optional model number.

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

- (1) Each component that is easily removable (without hand tools),
- (2) Each interchangeable element, and
- (3) Each subassembly of the article that you determined may be interchangeable.

c. Identifying deviations granted to the article by marking "Deviation. See installation/instruction manual (IM)" after the TSO number. You can abbreviate the marking to "(Dev. See IM)."

d. Optional marking is permitted to allow aircraft-specific or operational-specific installation limitations, such as: **"FOR USE ON *insert aircraft type or serial number* ONLY," "FOR USE ON AIRCRAFT USED IN PART *insert number* OPERATIONS ONLY," "FOR MILITARY USE ONLY," or "SEE DRAWING NO. *insert number* FOR INSTALLATION LIMITATIONS."**

5. **APPLICATION DATA REQUIREMENTS.** As a TSO manufacturer-applicant, you must give the FAA aircraft certification office (ACO) manager responsible for your facilities a statement of conformance, as specified 14 CFR § 21.605(a)(1) and one copy each of the following technical data to support your design and production approval. (Under 14 CFR § 21.617(a)(2), LODA applicants only submit the technical design data through their civil aviation authority:)

a. Operating instructions and equipment limitations in an IM, sufficient to describe the equipment's operational capability. Describe any deviations in detail. If needed, identify equipment by part number, version, revision, and criticality level of software/hardware, classification for use, and environmental categories.

**b.** Installation procedures and limitations in an IM, sufficient to ensure that the crewmember portable PBE, when installed according to the installation procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. Finally, the limitations must include a note with the following statement:

The conditions and tests for TSO approval of this article are minimum performance standards. Those installing this article, on or in a specific type or class of aircraft, must determine that the aircraft installation conditions are within the TSO standards. TSO articles must have separate approval for installation in an aircraft. The article may be installed only according to 14 CFR part 43 or the applicable airworthiness requirements.

- c.** Schematic drawings of the installation procedures.
- d.** Wiring diagrams of the installation procedures.
- e.** List of components, by part number, that make up the crewmember portable PBE complying with the standards prescribed under this TSO. Include vendor part number cross-references, when applicable.
- f.** A component maintenance manual (CMM), covering periodic maintenance, calibration, and repair, for the continued airworthiness of installed crewmember portable PBE. Include recommended inspection intervals and service life. Describe the details of deviations granted, as noted in paragraph **5.a** of this TSO.
- g.** Material and process specifications list.
- h.** The quality control system (QCS) description required by 14 CFR §§ 21.143 and 21.605(a)(3), including functional test specifications. The QCS should ensure that you will detect any change to the equipment that could adversely affect compliance with the TSO MPS, and reject the item accordingly. (Not required for LODA applicants.)
- i.** Manufacturer's TSO qualification test report.
- j.** Nameplate drawing with the information required by paragraph **4** of this TSO.
- k.** List of all drawings and processes (including revision level) that define the article's design. For a minor change, follow the directions in 14 CFR § 21.611(a). Show any revisions to the drawing list only on our request.
- l.** An environmental qualifications form as described in the environmental qualifications documents in appendix 1 of this TSO for each component of the system.

**6. MANUFACTURER DATA REQUIREMENTS.** Besides the data given directly to us, have the following technical data available for review by the responsible ACO or civil aviation authority:

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

b. Equipment calibration procedures.

c. Corrective maintenance procedures within 12 months after TSOA or LODA.

d. Schematic drawings.

e. Wiring diagrams.

f. Material and process specifications.

g. Results of the environmental qualification tests conducted per appendix 1 of this TSO.

**7. FURNISHED DATA REQUIREMENTS.** If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy of the data in paragraphs **5.a** through **5.f** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued airworthiness, of the crewmember portable PBE.

**8. HOW TO GET REFERENCED DOCUMENTS.**

a. Order RTCA documents from RTCA Inc., 1828 L Street NW, Suite 805, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at [www.rtca.org](http://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](http://www.sae.org).

c. Order ASTM documents from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959. Telephone (610) 832-9500, fax (610) 832-9555. You can also order copies online at [www.astm.org](http://www.astm.org).

d. Order copies of 14 CFR part 21, Subpart O, from the Superintendent of Documents, Government Printing Office, P.O. Box 37154, Pittsburgh PA 15250-7954. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at [www.access.gpo.gov](http://www.access.gpo.gov). Select "Access," then "Online Bookstore." Select "Aviation," then "Code of Federal Regulations."

e. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at <http://rgl.faa.gov>. You will also find the TSO Index of Articles at the same site.

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**APPENDIX 1. FAA MPS FOR CREWMEMBER  
PORTABLE PBE**

**1-1 SCOPE.** These standards apply to PBE that gives crewmembers the ability to locate and combat a fire in the airplane cabin or any other accessible compartment at normal cabin altitudes (up to 8000 feet equivalent).

**1-2 DESIGN, CONSTRUCTION AND FUNCTION.** Portable PBE must be a self-contained device that complies with the following:

**a. Breathable Gas.** The device must contain a supply of breathable gas.

(1) The breathable gas source may be either oxygen or air.

(2) Use of a chemical oxygen generator is an acceptable alternative.

(3) Breathable gas must meet the gas standard for purity, SAE International's Aerospace Standard (AS)8010 Rev C, *Aviator's Breathing Oxygen Purity Standard*, dated December 2002. For air, comply with the purity standards in AS8010C Table 2, Constituent Maximum Concentrations for Chemical Oxygen. Use Type IV for emergency-use chemical oxygen supply.

**b. Materials.** Ensure that the material and fabrication of the unit is puncture/tear resistant and meet the following standards.

- ASTM International's publication D1922 Rev A, *Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method*, dated April 1, 2006.
- ASTM D1004, *Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting*, dated April 1, 2007.
- ASTM D2582, *Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting*, dated March 1, 2007

**c. Sizing.** Portable PBE must adequately protect any adult user as follows:

(1) The 5th percentile female (107 lbs) (neck size circumference 11.1 inches).

(2) The 95th percentile male (220 lbs) (neck size circumference 16.4 inches).

(3) PBE must accommodate spectacle users.

(4) Include limitations or recommendations for using PBE with long hair and/or beards in the IM/CMM (required in paragraph 5.b of this TSO), which is furnished with the manufactured units.

(5) The size of the portable PBE unit when donned must allow the wearer to pass through any access opening 18 inches (460mm) x 18 inches (460mm) to investigate and/or combat an inflight fire.

**d. Functionality.** The intended function of portable PBE is as follows:

- (1) Wears comfortably in use, leaving both hands free.
- (2) Does not become displaced during the normal tasks of locating and combating a fire (crawling, kneeling, running actions, and so forth).
- (3) Provides adequate vision for its intended use, including provisions for fog and condensation.
- (4) Allows intelligible two-way communication, including the use of airplane interphone and megaphone. User must be able to communicate with another user or nonuser at a distance of at least four meters. Use a background noise of 65db and a user communication sound level of 85db or equivalent method.
- (5) Failure to operate, or to failure to continue operation, must be readily apparent to the user wearing the equipment.
- (6) Has a means for any crewmember to determine the serviceability of the unit in its stowed condition.
- (7) Has a stated reliability with an appropriate confidence level to establish any shelf life, operational limit and/or maintenance interval.

**e. Donning and Stowage.** Unit must be easily put on and activated, after the user gains access to the stowed unit within 15 seconds. It must be easy to remove. The unit must not cause a hazard when stored, in use, or during inadvertent operation. Stowed portable PBE must not be adversely affected by environmental extremes. See paragraph 1-5 below for the applicable sections of RTCA/DO-160E when demonstrating compliance.

**1-3. PERFORMANCE.** Crewmember portable PBE must protect the adult wearer, identified in paragraph 1-2c above, as follows:

**a. Breathable Gas.** Provide enough breathable gas under the following workload profile, at an ambient temperature of 70°F (21°C), at sea level and 8000 feet altitude:

<i>Minutes at...</i>	<i>Watts per pound of body weight</i>
0 to 05	0.33
5 to 07	0.66
7 to 12	0.50
12 to 14	0.66
14 to 15	0.33

**NOTE:** Perform this test in sequence.

**b.** Average inspiratory limits must be within the following:

(1) Carbon dioxide concentration level at mouth/nose must not exceed 4 percent at sea level. Concentration may increase to 5 percent at sea level for a period not to exceed 2 minutes.

(2) Carbon monoxide level must not exceed 50 ppm, time weighted average.

(3) Chloride level must not exceed 1 ppm, time weighted average.

**c.** When a user puts on PBE, the unit must be self-purging by enough breathable gas to ensure one complete dead volume displacement within 20 seconds of initial operation.

**d. Smoke and Toxic Fume Protection.** Unit must protect the user against toxic fumes and smoke.

(1) User eyes, nose, and mouth must be protected to 0.05 mean contaminant protection factor during the work profile stated in paragraph 1-3a above.

(2) Use the test procedures in SAE International Aerospace Standards (AS) 8031 Rev A, *Personal Protective Devices for Toxic and Irritating Atmospheres. Air Transport Flight Deck (Sedentary) Crewmembers*, dated March 1999. While you may use an alternative for a challenge gas, we don't accept the use of aerosols, such as sodium chloride (NaCl) or corn oil. Component sensitivity to particle size and the potential to precipitate on the unit surface are considerations that make aerosols unacceptable to measure a contaminant protection factor.

**e.** Internal temperature of the unit must not exceed 40° wet bulb at an ambient temperature of 70°F (21°C).

**f.** Internal temperature of the unit must not exceed 122°F (50°C) wet bulb for a 2-minute exposure, at an ambient temperature of (212°F)100°C.

**g.** Breathing inspiration/expiration resistance must not exceed  $\pm 3 \frac{1}{2}$  inches of water from sea level to 8000 feet altitude, as measured at the mouth.

**h.** Unit must operate at a mean positive pressure and incorporate relief valve(s) to prevent overpressure.

**i.** Design the unit for peak breathing flows of 250 liters per minute (LPM) and ensure that the unit is capable of 80 liter-minute volume for a 30-second period at any time throughout operation.

**NOTE:** Base the test protocol to establish the combined performance requirement of the work load profile and contaminant levels on testing 24 persons representing the stated population range.

**1-4. FUNCTIONAL QUALIFICATION.** Demonstrate the required performance under the test conditions in paragraphs 1-2 or 1-3 of this appendix.

**1-5. ENVIRONMENTAL QUALIFICATION.** Test the equipment according to RTCA, Inc. document RTCA/DO-160E, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 9, 2004, or the most current revision. Standards for crewmember portable PBE are in SAE AS 4950B, *Design and Performance Criteria Transport Aircraft Portable Megaphones*, dated March 2007, Section 5.

**1-6. SOFTWARE QUALIFICATION.** If the article includes a digital computer, develop the software according to RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 1, 1992 or the most current revision.

**1-7. ELECTRONIC HARDWARE QUALIFICATION.** If the article includes complex electronic hardware, develop the component to the guidance in FAA advisory circular (AC) 20-152, *RTCA, Inc document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware*.

**1-8. FLAMMABILITY.** All materials used in the article and any container/case (including insulation on electrical wires) in a typical installed arrangement must be self-extinguishing. Materials must comply with 14 CFR§ 25.853(a). Apply 14 CFR part 25, Appendix F Part I (a)(1)(ii).

a. Any exposed portions of the unit and stowage case must withstand a radiant heat flux of 1.0 BTU/ft<sup>2</sup> per second for 60 seconds, and remain functional when exposed to it.

b. The radiant heat flux source must be of sufficient size so the article, any container/case, and exposed parts of the unit are exposed in a manner that creates the heat flux at all the surfaces.

c. Unit must also protect the user's head and neck from dripping 392°F (200°C) plastic materials and withstand a 1832°F (1000°C) flame for 5 seconds without material penetration while operating.

(1) Protection from dripping plastic material may be accomplished by a number of methods. One method is to ignite a polypropylene rod and allow the drops to impinge on the various external materials, seams, and transparency. Adjust the drop height so that the drop contact temperature is at least 392°F (200°C).

(2) The 5-second 1832°F (1000°C) test is meant to protect a crewmember wearing the PBE from an unexpected flame lick. The two main concerns are failure of the unit that would injure the wearer, and leakage of the breathable atmosphere that could produce an explosion or hazard. The test rig must expose the unit, while operating, to a 1832°F (1000°C) flame envelope. One company has used German Teklu burners with a flow rate of about 21 liters per minute. The flow rate and distance of the burner to the surface of the PBE unit being tested should be adjusted to obtain the required temperature. In most cases the flame plume developed

will not expose the complete unit. You can pass a segment through the flame plume to obtain the 5-second exposure period and then rotate it to the next segment and pass it through the flame plume, and so forth, until the complete unit has been tested. Making a visual (videotape) record of this test might be useful documentation, in addition to the measured parameters.

**d. Heat Release and Smoke Density.** Exposed panels/surfaces totaling more than one square foot in surface area must meet the heat release and smoke density requirements of 14 CFR § 25.853 and 14 CFR part 25, Appendix F, Parts IV and V

**e. Battery Qualification.** If the equipment uses a battery as a power source, the battery must meet the applicable battery standards:

(1) TSO-C142a, *Non-Rechargeable Lithium Cells and Batteries* (see RTCA, Inc. document RTCA/DO-227, *Minimum Operational Performance Standards for Lithium Batteries*, dated June 23, 1995), or the most current revision.

(2) TSO-C179, *Rechargeable Lithium Cells and Lithium Batteries* (see UL 1642, *Standard for Safety for Lithium Batteries*, fourth edition, dated September 19, 2005).

**1-9. REFERENCES.** The following may help you develop a PBE design and/or gain FAA approval of the basic design. They are not of themselves FAA requirements, and may differ from the TSO requirements, which take precedence:

**a.** SAE AS8047, (Class 1) *Performance Standard for Cabin Crew Portable Protective Breathing Equipment for Use During Aircraft Emergencies*, dated June 2002.

**b.** FAA-AM-78-41, *A Study of Workload and Oxygen Consumption for Airline Cabin Crew Member During a Simulated Inflight Smoke/Fire Emergency*.

**c.** ASTM D1149, *Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber*, dated November 10, 1999.

**d.** ASTM D624, *Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*, dated July 10, 2000.

**e.** ASTM D750, *Standard Test Method for Rubber Deterioration Using Artificial Weathering Apparatus Rubber Deterioration*, dated December 1, 2006.

**f.** ASTM D228, *Abrasion Resistance*, dated May 1, 2006.