

Cancelled
Replaced C124

TECHNICAL STANDARD ORDER

Aircraft flight recorder—TSO-C51a.

(a) *Applicability.* This technical standard order prescribes minimum performance standards that aircraft flight recorders must meet in order to be identified with the applicable TSO marking. New models of flight recorders that are to be identified and that are manufactured on or after the effective date of this section must meet the Minimum Performance Standard for Aircraft Flight Recorders set forth at the end of this section.

(b) *Marking.* In addition to the markings required by § 37.7, the rating (nominal voltage and wattage) must also be marked on the recorder.

(c) *Data requirements.* The manufacturer must furnish the Chief, Engineering and Manufacturing Branch (in the case of the Western Region, the Chief, Aircraft Engineering Division), Flight Standards Division, Federal Aviation Administration, in the region where the manufacturer is located, the following technical data:

(1) Six copies of the manufacturer's operating instructions, equipment limitations, and installation procedures.

(2) One copy of the manufacturer's test report.

MINIMUM PERFORMANCE STANDARDS FOR AIRCRAFT FLIGHT RECORDER

1. *Purpose.*
To establish minimum requirements for approved Aircraft Flight Recorders to be used in aircraft primarily for accident analysis, the operation of which may subject the recorder to environmental conditions specified in Section 3.

2. *Scope.*
This standard covers three basic types of aircraft flight recorders for recording time, air speed, altitude, vertical acceleration, and heading. The intelligence received by the record medium can be from direct and/or remote sensors.

- 2.1 *Definition of the Types:*
- Type I—Non-ejectable,
 - Type II—Non-ejectable, restricted to any location more than 1/2 of the wing root chord from the main wing structure through the fuselage and from any fuel tanks,
 - Type III—Ejectable, unrestricted location.

3. *General Requirements.*
3.1 *Environmental Conditions:* The following conditions have been established as design requirements only. Tests shall be conducted as specified in Sections 5, 6, and 7.

3.1.1 *Temperature:* When installed in accordance with the instrument manufacturer's instructions, the recorder shall function over the range of ambient temperature shown in Column A below and shall not be adversely affected by exposure to the range of temperature shown in Column B below:

Instrument Location	A	B
Heated Areas (Temperature Controlled)	-30° to 50°C	-65° to 70°C
Unheated Areas (Temperature Uncontrolled)	-55° to 70°C	-65° to 70°C

3.1.2 *Humidity:* The recorder shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95% at a temperature of approximately 32°C.

3.1.3 *Vibration:* When installed in accordance with the instrument manufacturer's instructions, the recorder shall function properly and shall not be adversely affected when subjected to vibrations of the following characteristics:

Recorder Location in Airframe	Cycles Per Sec.	Max. Double Amplitude (Inches)	Max. Acceleration
Airframe Structure Mounted	5-500	0.036	10g

3.1.4 *Altitude:* The recorder shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 to 50,000 feet standard altitude, per NACA Report No. 1235, except as limited by the application of Paragraph 3.1.1. The recorder shall not be adversely affected following exposure to extremes in ambient pressures of 50 and 3 in. Hg. absolute.

3.1.5 *Radio Interference:* The recorder shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft, either by radiation or feed-back, in electronic equipment installed in the same aircraft as the recorder.

3.1.6 *Magnetic Effect:* The magnetic effect of the recorder shall not adversely affect the operation of the other instruments installed in the same aircraft.

4. Detail Requirements.

4.1 Recording Medium: The record medium shall conform to the following requirements:

a. The recording medium of recorders employing mechanical inscribed markings shall advance at a rate of not less than 6 inches per hour, and that of recorders employing other means of recording shall advance at a rate sufficient to permit resolution within the accuracy prescribed in section 4.3.

b. The recording medium shall provide a recording of the required data for at least the total elapsed operating time of a flight for which the aircraft might be used.

c. The recording medium shall not be subject to deterioration or distortion of the recorded data within the limits specified herein.

4.2 Recording Intervals and Ranges:

a. Time: The time lapse shall be recorded at intervals of not more than one minute.

b. Pressure Altitude: —1000 to 50,000 feet of standard atmosphere pressures, and shall be recorded at intervals of not more than one second.

c. Vertical Acceleration: +6 to —3g, and shall be recorded at intervals of not more than 1/10 of one second, or at intervals of one second in which peak accelerations are recorded.

d. Air Speed: 100 to 450 knots IAS, and shall be recorded at intervals of not more than one second.

e. Heading: 360 degrees azimuth, and shall be recorded at intervals of not more than one second.

4.3 Record Resolution: The record resolution shall be such that the data can be analyzed with the accuracy specified in section 6.

4.4 Record Protection: The recorder shall be of such design that the recorded data will be protected against damage by fire, impact, and water within the limits specified herein.

4.5 Pressure Altitude: The terms of pressure altitude shall conform to Tables I and II.

4.6 Air Speed: The terms of air speed shall conform to Table III.

4.7 Power Variations: All units shall properly function with $\pm 10\%$ to -20% variation in DC voltage and/or $\pm 10\%$ variation in AC voltage and $\pm 5\%$ in frequency, provided the AC voltage and frequency vary in the same direction. The recorder shall not be damaged when subjected to lower voltages.

4.8 Power Malfunction Indication: A means shall be provided for indicating when adequate power is not being received by the recorder for proper operation.

4.9 Automatic Ejection: The automatic ejection provision of Type III recorders, including the structure holding the ejectable portion, shall be capable of operating when subjected to inertia loads corresponding to an acceleration of 6g's acting in any direction.

5. Test Conditions.

5.1 Atmospheric Conditions: Unless otherwise specified all tests required by this standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25° C. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowance shall be made for the variation from the specified conditions.

5.2 Vibration (to minimize friction): Unless otherwise specified all tests for performance may be made with the recorder subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double amplitude as used herein indicates total displacement from positive maximum to negative maximum.

5.3 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of section 3.1.3 with the following characteristics:

5.3.1 Linear Motion Vibration: Vibration equipment for testing airframe structure-mounted recorders or portions thereof shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the test specimen.

5.3.2 Circular Motion Vibration: Vibration equipment for testing shock-mounted recorders or portions thereof shall be such that a point on the case will describe, in a plane inclined 45 degrees to the horizontal plane, a circle, the diameter of which shall be equal to the double amplitude.

5.4 Position: All tests shall be conducted with the recorder mounted in its normal operating position.

5.5 Test Voltage: All tests for performance shall be conducted at the voltage rating recommended by the manufacturer.

5.6 Power Conditions: All tests for performance shall be conducted at the power rating recommended by the manufacturer.

6. Allowable Record Errors.

6.1 Altitude Record Error: The recorder shall be tested for allowable error at the test points specified in Table I on decreasing and increasing pressure. The rate of change in pressure during this test shall not be less than 3000 feet per minute. On decreasing pressure, the pressure shall be brought down to, but shall not exceed, the specified test point. On increasing pressure, the pressure shall be brought up to, but shall not exceed, the specified test point. Within one minute after applying the specified pressure, the error in the record shall not exceed the tolerance values indicated in Table I for each test point.

6.2 Acceleration Record Error: The acceleration error shall not exceed plus or minus 0.2G in a stabilized condition, and the total error in following a single, triangular, acceleration pulse of $\frac{1}{2}$ second duration or greater, shall be no more than 10% of the acceleration. (An analytical evaluation is considered acceptable).

6.3 Time Scale Record Error: The time lapse error shall not exceed plus or minus 1.0% during an eight hour period.

6.4 Air Speed Record Error: The recorder shall be tested for allowable error at the test points specified in Table III on increasing and decreasing speeds. The allowable error shall not exceed the tolerance values specified in Table III.

6.5 Heading Record Error: The heading record error shall not exceed plus or minus 2 degrees when measured at 15 degree intervals over 360 degrees in azimuth. This error is the difference between the sensor and the recorder.

7. Performance Tests.

The following tests, in addition to any others deemed necessary by the manufacturer, shall be the basis for determining compliance with the performance requirements of this standard.

7.1 Room Temperature: The recorder shall be tested at room temperature to determine compliance with the requirements under section 6.

7.2 Low Temperature: The recorder shall be subjected to an ambient temperature of minus 55° C for five hours and while still exposed to this temperature it shall be tested to determine compliance with the requirements under section 6.

7.3 High Temperature: The recorder shall be subjected to an ambient temperature of 50° C for five hours and while still exposed to this temperature it shall be tested to determine compliance with the room temperature accuracies under section 6.

7.4 Extreme Temperature Exposure: The recorder, after exposure to an ambient temperature of 70° C for 24 hours followed by exposure to -65° C for 24 hours followed immediately by exposure to room temperature for not more than three hours, shall meet the requirements of section 7.1. There shall be no evidence of damage as a result of exposure to the extreme temperatures.

7.5 Hysteresis: Not more than 15 minutes after the altitude sensor has been first subjected to the pressure corresponding to standard altitude of 50,000 feet, the pressure shall be increased at a rate corresponding to a decrease in altitude of not less than 8,000 feet per minute until the pressure corresponding to 25,000 feet is reached. Within 10 seconds the error shall not exceed the room temperature error at this test point by more than 100 feet. The altitude sensor shall remain at this pressure for not more than 15 minutes before the test to determine com-

pliance with Table II is made, after which the pressure shall be further increased at the above rate until the pressure corresponding to 20,000 feet is reached. The altitude sensor shall remain at this pressure for not more than ten minutes before the test to determine compliance with Table II is made. The pressure shall be further increased at the above rate until atmospheric pressure is reached.

7.6 After Effect: Not more than five minutes after the completion of the hysteresis test, the altitude record shall have returned to its original recording, corrected for any change in atmospheric pressure, within the tolerance shown in Table II.

7.7 Vibration:

7.7.1 Resonance: The recorder, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in section 3.1.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in section 3.1.3.

The recorder shall then be subjected to a vibration at the appropriate maximum double amplitude or maximum acceleration specified in section 3.1.3 at the resonant frequency for a period of one hour in each axis or with circular motion vibration, whichever is applicable. When more than one resonant frequency is encountered with vibration applied along any one axis, a test period may be accomplished at the most severe resonance, or the period may be divided among the resonant frequencies, whichever shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the recorder shall be vibrated for two hours in accordance with the vibration requirements of section 3.1.3 at the maximum double amplitude and the frequency to provide the maximum acceleration.

7.7.2 Cycling: The recorder, while operating, shall be tested with the frequency cycled between limits specified in section 3.1.3 in 15 minute cycles for a period of one hour in each axis at an applied double amplitude specified in section 3.1.3, or an acceleration specified in section 3.1.3, whichever is the limiting value. After the completion of this vibration test, no damage shall be evident and the recorder shall meet the requirements of section 6.

7.8 Humidity, water, impact, penetration resistance, static crush, and fire protection tests: The humidity, impact, penetration resistance, static crush, and fire protection tests shall be made in the following se-

quence on the same recorder without the need for repairs.

7.8.1 Humidity: The recorder shall be mounted in a chamber maintained at a temperature of $70 \pm 2^\circ \text{C}$ and a relative humidity of $95 \pm 5\%$ for a period of 6 hours. After this period the heat should be shut off and the recorder should be allowed to cool for a period of 18 hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not more than 38°C . This complete cycle should be conducted fifteen (15) times.

Immediately after cycling, the recorder shall be subjected to the Record Error Tests of Section 6.

7.8.2 Impact: The intelligence on the record medium shall be capable of being analyzed after the recorder has been subjected to the following impact shock: Types I and II—Half sine wave impact shocks applied to each of the three main orthogonal axes and having a peak acceleration magnitude of 1,000 g with a time duration of at least five milliseconds. Type III—Acceleration not less than the shocks developed on contact with a horizontal rock surface, considering the direction of ejection and any provisions for alleviation of shock. With regard to the former, the aircraft shall be assumed to be tilted at least 30 degrees from horizontal in the most critical direction.

7.8.3 Penetration Resistance (Type I and II Recorders Only): The intelligence on the record me-

dium shall be capable of being analyzed after the recorder has been subjected to an impact force equal to a 500-pound steel bar which is dropped from a height of 10 feet to strike each side of the enclosure in the most critical plane. The point of contact of the bar shall have an area that is no greater than 0.05 square inches. The longitudinal axis of the bar shall be vertical at the time of impact.

NOTE: The object of this test is to achieve protection of the record medium from possible damage caused by airframe structural members striking the recorder case during crash impact.

7.8.4 Static crush (Type I and II recorders only): The intelligence on the record medium shall be capable of being analyzed after the recorder has been subjected to a static crush force of 5,000 pounds applied continuously, but not simultaneously to each of the three main orthogonal axes for a test period of five minutes.

7.8.5 Fire Protection: The record medium shall remain intact so that the intelligence can be analyzed after the recorder is exposed to flames of 1100°C enveloping at least 50 percent of the outside area of the case for the following periods of time:

- Type I—30 minutes
- Type II—15 minutes
- Type III—1.5 minutes

TABLE I—Altitude Record Error Table.

Standard Altitude (Feet)	Equivalent Pressure Mercury		Tolerance, Feet Plus or Minus	
	MM	IN. HG	Room Temp. (Sec. 6.1)	Low Temp. (Sec. 7.1)
-1,000	787.9	31.02	100	150
-500	773.8	30.47	100	---
0	760.0	29.92	100	150
500	746.4	29.39	100	---
1,000	732.9	28.86	100	---
1,500	719.7	28.33	100	---
2,000	706.6	27.82	100	---
3,000	681.1	26.81	125	---
4,000	656.3	25.84	150	210
6,000	609.0	23.98	150	250
8,000	564.4	22.22	150	---
10,000	522.6	20.58	150	---
12,000	483.3	19.03	180	350
14,000	446.4	17.57	210	---
16,000	411.8	16.21	240	---
18,000	379.4	14.94	270	450
20,000	349.1	13.75	300	---
22,000	320.8	12.63	335	---
25,000	281.9	11.10	375	580
30,000	225.6	8.88	450	600
35,000	178.7	7.04	525	730
40,000	140.7	5.54	600	800
50,000	87.3	3.44	700	---

7.8.6 *Water Protection*: The intelligence on the record medium shall be capable of remaining permanent and reproducible after the record medium has been immersed in seawater for 36 hours.

7.9 *Position Error*: The recorder shall meet the following requirements when turned from its normal operating position through 90° forward and back, and left and right where applicable:

- a. Time: Section 6.3
- b. Altitude: Section 6.1, except that the tolerance may be increased by 25 feet
- c. Acceleration: Section 6.2
- d. Airspeed: Section 6.4
- e. Heading: Section 6.5

7.10 *Dielectric*: The insulation shall be subjected to a dielectric test with an RMS voltage at a commercial frequency applied for a period of five seconds, equivalent to five times normal circuit operating voltage, except where circuits include components for which such a test would be inappropriate, the test voltage shall be 1.25 times normal circuit operating voltage. The insulation resistance shall not be less than 20 megohms at that voltage.

7.11 *Automatic Ejection Means*: The automatic ejection means for Type III recorders shall be tested to demonstrate that it is capable of ejecting the recorder from its mounting when subjected to forward acting inertia loads of 5g's to 6g's.

8.0 *Recorder Color*: The exterior surface of the recorder must be finished in either a bright orange or a bright yellow color.

TABLE II—Altitude Test Table.

<i>Tests</i>	<i>Reference Section</i>	<i>Tolerance in Feet</i>
Hysteresis:	7.4	---
First test point 25,000 ---	--	90*
Second test point 20,000 --	--	90*
After effect test -----	7.5	50

*In excess of the room temperature error.

TABLE III—Airspeed Record Error Table.

<i>Standard Airspeed (Knots)</i>	<i>Tolerance, Knots Plus or Minus</i>	
	<i>Room Temp. (Sec. 6.1)</i>	<i>Low Temp. (Sec. 7.1)</i>
100	10	12
150	10	12
200	10	12
250	10	12
300	10	12
350	10	12
400	10	12
450	10	12