

U. S. DEPARTMENT OF COMMERCE  
CIVIL AERONAUTICS ADMINISTRATION  
WASHINGTON 25, D. C.

TECHNICAL STANDARD ORDER

Regulations of the Administrator

Part 514

SUBJECT: AIRCRAFT FLIGHT RECORDER

TSO-C51

Part 514--Technical Standard Orders for Aircraft Materials,  
Parts, Processes, and Appliances

Under section 601 of the Civil Aeronautics Act of 1938 and the delegation of authority from the Civil Aeronautics Board in §3.18, 4a.31, 4b.18, 6.18, and 7.18 of the Civil Air Regulations, the Administrator of Civil Aeronautics is authorized to adopt performance standards and specifications of materials, parts, processes, and appliances used in aircraft as he may find necessary to implement the provisions of the Civil Air Regulations. The Administrator adopted the Technical Standard Order system as a means to carry out this delegated authority. This system, in brief, provides for CAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 514 of the Regulations of the Administrator contains two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders, such as "Method of Conformance," "Marking," and "Deviations." The provisions of Subpart A are repeated below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform. In accordance with the foregoing format the standards and specifications of the subject Technical Standard Order are set forth in the appropriate section of Subpart B. TECHNICAL STANDARD ORDERS MAY BE OBTAINED BY SENDING A REQUEST TO CAA, WASHINGTON 25, D. C.

SUBPART A--GENERAL

§514.1 *Basis and purpose*—(a) *Basis*. Section 601 of the Civil Aeronautics Act of 1938, as amended, and §§3.18, 4a.31, 4b.18, 6.18, 7.18 of the Civil Air Regulations.

(b) *Purpose*. The purpose of this part is to establish minimum performance standards for aircraft materials, parts, processes, and appliances which are to be used on civil aircraft of the United States, and to prescribe the manner by which the manufacturer must show compliance with such performance standards.

§514.2 *Method of conformance*. A manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B of this part, prior to distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance shall be signed by a person duly authorized by the manufacturer, and shall be furnished to the Chief, Aircraft Engineering Division, Office of Flight Operations and Airworthiness, Civil Aeronautics Administration, Washington 25, D. C.

If complaints of nonconformance with the

requirements of this Order are brought to the attention of the CAA and investigation indicates that such complaints are justified, the Administrator will take appropriate action to restrict the use of the product in civil aircraft.

§514.3 *Marking*. Materials, parts, processes, and appliances for which a statement of conformance has been submitted, shall be legibly and permanently marked with the following information:

(a) Name and address of the manufacturer responsible for compliance,

(b) Equipment name, or type or model designation,

(c) Weight to the nearest pound and fraction thereof,

(d) Serial number and/or date of manufacture, and

(e) Applicable Technical Standard Order (TSO) number.

§514.4 *Deviations*. No deviation will be granted from the performance standards established in Subpart B. Requests for deviation from other requirements of this part should be addressed to the Aircraft Engineering Division, Office of Flight Operations and Airworthiness, Civil Aeronautics Administration, Washington 25, D. C.

SUBPART B

§514.50 Aircraft flight recorder--TSO-C51--(a) Applicability--(1) Minimum performance standards. Minimum performance standards are hereby established for aircraft flight recorders which specifically are required to be approved for use in civil aircraft of the United States. Aircraft flight recorders eligible for installation in civil aircraft shall meet the standards set forth in CAA-CAB Standard, "Aircraft Flight Recorder", dated June 12, 1958.

(b) Marking. In addition to the markings in §514.3, the rating (nominal voltage and wattage) shall also be marked on the recorder.

(c) Data requirements. One copy each of the manufacturer's operating instructions, schematic diagrams, and installation procedures shall be furnished the Chief, Aircraft Engineering Division, Civil Aeronautics Administration, Washington 25, D. C., with the statement of conformance.

(d) Effective date. August 1, 1958.

(8/4/58)

June 12, 1958

CAA-CAB  
INSTRUMENT STANDARD  
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, unrestricted location,
  - Type II - Non-ejectable, restricted to any location more than  $\frac{1}{2}$  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:

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

- 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 32C.

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:

<u>Recorder Location in Airframe</u>	<u>Cycles Per Sec.</u>	<u>Max. Double Amplitude (Inches)</u>	<u>Max. Acceleration</u>
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 +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 25C. 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 of 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 of 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 is 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 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 3,000 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 compliance 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, and Fire Protection Tests: The humidity impact and the fire protection test shall be made in the following sequence:

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  $38^{\circ}\text{C}$ . 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 - 100g

Type III - Acceleration not less than the shock 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° from horizontal in the most critical direction.

- 7.8.3 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

- 7.8.4 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. Air Speed: 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.

TABLE I  
ALTITUDE RECORD ERROR TABLE

<u>Standard Altitude</u> Ft.	<u>Equivalent Pressure</u> <u>Mercury</u>		<u>Tolerance, Feet</u> <u>Plus or Minus</u>	
	MM	IN.HG	<u>Room Temp.</u> Sec. 6.1	<u>Low Temp.</u> Sec. 7.1
-1000	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	
1000	732.9	28.86	100	
1500	719.7	28.33	100	
2000	706.6	27.82	100	
3000	681.1	26.81	125	
4000	656.3	25.84	150	210
6000	609.0	23.98	150	250
8000	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	560
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	

TABLE II  
ALTITUDE TEST TABLE

<u>Tests</u>	<u>Reference Section</u>	<u>Tolerance in Feet</u>
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  
AIRSPPEED RECORD ERROR TABLE

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