FEDERAL AVIATION AGENCY

Washington 25, D. C.

TECHNICAL STANDARD ORDER

Regulations of the Administrator

Part 514

SUBJECT: **FLIGHT DIRECTORS** **TSO-C52a**

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Technical Standard Orders for Aircraft Materials, Parts, Processes, and Appliances

Part 514 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.31, 4b.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-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 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

SUBPART A--GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, processes, or appliance for which standards are established in Subpart B, prior to its 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 must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Flight Standards Service, Federal Aviation Agency, Washington 25, D. C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:

(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.

In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 514.

§ 514.51 Flight directors - TSO-C52a-- (a) Applicability - (1) Minimum performance standards. Minimum performance standards are hereby established for flight directors which specifically are required to be approved for use on civil aircraft of the United States. New models of flight directors manufactured for installation on civil aircraft on or after September 15, 1961, shall meet the standards set forth in SAE Aeronautical Standard AS-420A, "Flight Directors," revised November 15, 1959,[1/] with exceptions and additions to the standards listed in subparagraph (2) of this paragraph.

(2) Exceptions and additions. (i) The following specifically numbered parts in AS-420A do not concern minimum performance and therefore are not essential to compliance with this section: parts: 3.1; 3.1.1; 3.1.2; 3.2(a), (b), (c), (d), (e); and 4.1.1.3.

(ii) In lieu of part 7, it is a requirement that flight directors covered by this section be capable of successfully passing the tests in parts 7.1 through 7.6.

(iii) Thermal shock: This test shall apply to any hermetically sealed components. The component shall be subjected to four cycles of exposure to water at $85^{\circ} \pm 2^{\circ}$ C. and $5^{\circ} \pm 2^{\circ}$ C. without evidence of moisture penetration or damage to coating or enclosure. Each cycle of the test shall consist of immersing the component in water at $85^{\circ} \pm 2^{\circ}$ C. for a period of 30 minutes, and then within 5 seconds of removal from the bath, the component shall be immersed for a period of 30 minutes in the other bath maintained at $5^{\circ} \pm 2^{\circ}$ C. This cycle shall be repeated continuously, one cycle following the other until four cycles have been completed. Following this test, the component shall be subjected to the Sealing test specified in (iv). No leakage shall occur as a result of this test.

(iv) Sealing: This performance test shall apply to each hermetically sealed instrument. The instrument shall be immersed in a suitable liquid, such as water. The absolute pressure of the air above the liquid shall then be reduced to approximately one inch of mercury (Hg) and maintained for one minute, or until air bubbles cease to be given off by the liquid, whichever is longer. The absolute pressure shall then be increased by 2 1/2 inches Hg. Any bubbles coming from within the indicator case shall be considered as leakage and shall be cause for rejection. Bubbles which are the result of entrapped air in the various exterior parts of the case shall not be considered as leakage. Other test methods which provide evidence equal to the immersion test of the integrity of the instrument's seals may be used. If the instrument incorporates nonhermetically sealed appurtenances, such as a case extension, these appurtenances may be removed prior to the sealing test.

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1/Copies may be obtained from the Society of Automotive Engineers, 485 Lexington Avenue, New York 17, New York.

(v) In addition to paragraph 4.6.2, the indicating means shall be readily discernible under any lighting condition normally encountered in aircraft.

(b) Marking. In addition to the markings specified in Subpart A, range and rating shall be shown.

(c) Data requirements. (1) The manufacturer shall maintain a current file of complete design data.

(2) The manufacturer shall maintain a current file of complete data describing the inspection and test procedures applicable to his product. (See paragraph (d) of this section.)

(3) Six copies each, except where noted, of the following shall be furnished to the Chief, Engineering and Manufacturing Division, Flight Standards Service, Federal Aviation Agency, Washington 25, D. C.

(i) Manufacturer's operating instructions and instrument limitations.

(ii) Drawings of major components or photographs showing exploded views of instruments.

(iii) Installation procedures with applicable schematic drawings, wiring diagrams, and specifications. Indicate any limitations, restrictions, or other conditions pertinent to installation with the statement of conformance certifying that the instrument conforms to this section.

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

(d) Quality control. Each flight director shall be produced under a quality control system, established by the manufacturer, which will assure that each flight director is in conformity with the requirements of this section and is in condition for safe operation. This system shall be described in the data required under paragraph (c)(2) of this section. A representative of the Administrator shall be permitted to make such inspections and tests at the manufacturer's facility as may be necessary to determine compliance with the requirements of this section.

(e) Previously approved equipment. Flight directors approved by the Administrator prior to September 15, 1961, may continue to be manufactured under the provisions of their original approval.

(f) Effective date. September 15, 1961.

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# AERONAUTICAL STANDARD AS 420A

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## FLIGHT DIRECTORS

1. PURPOSE: To specify minimum requirements for Flight Directors primarily for use in reciprocating engine powered civil transport aircraft, the operation of which may subject the instrument to the environmental conditions specified in Section 3.3.

2. SCOPE: This Aeronautical Standard covers Flight Directors for use on aircraft to indicate to the pilot, by visual means, the correct control application for the operation of an aircraft in accordance with a preselected flight plan.

3. GENERAL REQUIREMENTS:

3.1 Material and Workmanship:

3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for aircraft instruments.

3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 Identification: The following information shall be legibly and permanently marked on each of the major components or attached thereto:

a. Name of the unit and type of Flight Director.

b. SAE AS-420A.

c. Manufacturer's part number.

d. Manufacturer's serial number or date of manufacture.

e. Manufacturer's name and/or trademark.

3.3 Environmental Conditions: The following conditions have been established as minimum design requirements. Tests shall be conducted as specified in Sections 5, 6 and 7.

3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function over the range of ambient temperatures shown in Column A below, and shall not be adversely affected by exposure to the temperatures 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 |

3.3.2 Humidity: The instruments 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.

3.3.3 Altitude: The instrument shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 to 40,000 feet standard altitude, per NACA Report 1235, except as limited by the application of paragraph 3.3.1. The instrument shall not be adversely affected following exposure to an ambient pressure of 50 in.Hg. absolute.

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

| Instrument Location in Airframe | Cycles Per Sec. | Max. Double Amplitude (Inches) | Max. Acceleration |
|---|---|---|---|
| Fuselage | 5-500 | 0.036 | 5 g |
| Panel or Rack (Vibration Isolated) | 5-50 | 0.020 | 1.5 g |

3.4 Radio Interference: The instrument shall not be the source of objectionable interference under operating conditions at any frequencies used on aircraft, either by radiation or feedback, in electronic equipment installed in the same aircraft as the instrument.

4. DETAIL REQUIREMENTS:

4.1 Indication:

4.1.1 Flight Director Indicator:

4.1.1.1 Lateral Steering Control Indication: When a means of indication for lateral steering control is provided, the sensing of this command presentation should be such that the aircraft is flown toward the indication to satisfy the command (i.e., consistent with "fly to needle" type of instrumentation sensing).

While not limited to the following signals, any one, or combination of these signals, shall produce an indication of the correct control application to maintain flight along a prescribed flight path.

a. Angular displacement of the aircraft about the roll axis.

b. Angular displacement of the aircraft in heading from a reference heading.

c. Lateral displacement of the aircraft with respect to a lateral course.

4.1.1.2 Vertical Steering Control Indication: When a means of indication for vertical steering control is provided the sensing of this command presentation should be such that the aircraft is flown toward the indication to satisfy the command (i.e. consistent with "fly to needle" type of instrumentation sensing).

While not limited to the following signals, any one, or combination of these signals shall produce an indication of correct control application to maintain flight along a prescribed flight path

a. Angular displacement of the aircraft about the pitch axis from the (reference) pitch attitude.

b. Vertical displacement of the aircraft with respect to the glide slope.

c. Vertical displacement of the aircraft from an altitude reference, whenever altitude control is provided in the equipment.

4.1.1.3 Dial Finish: Unless otherwise specified by the user, matte white material shall be applied to major graduations, numbers and pointers. Non-functional surfaces and markings shall be a durable dull black.

4.2 Heading and Course Selectors:

4.2.1 Heading Selector: Means shall be provided to permit setting the desired magnetic heading into the Flight Direction System. Indication of the heading selected shall be continuously provided.

4.2.2 Radio Course Selector: If a radio navigation reference is included, means shall be provided to permit setting the desired radio course into the Flight Direction System. Indication of the course selected shall be continuously provided.

4.3 Manual Pitch Knob: Means shall be provided for manually setting the pitch control pointer to zero reference during climbs and descent so as to indicate correct control application to seek and maintain flight at the desired pitch angle. This manual setting feature may be ineffective during approach and constant altitude modes of operation.

4.4 Function Selector (s): Means shall be provided for selecting the mode of operation (as applicable). The following are examples of possible modes of operation.

a. Hold attitude
b. Hold heading
c. Hold radio course
d. Approach (ILS)
e. Hold altitude
f. Hold airspeed

4.5 Attitude Limiter: Provisions shall be made to limit, either electrically or visually, the control indications commanded by the system so that a preset maximum value of bank and pitch shall not be exceeded.

4.6 Safety Provisions:

4.6.1 Interlock Provisions: Provisions shall be made to prevent simultaneous applications of control signals which would result in unsafe command indications. As an example, simultaneous application of approach and constant altitude control signals would be considered unsafe.

4.6.2 Power Malfunction Indication: Means shall be incorporated in the instrument to indicate when adequate power (voltage and/or current) is not being made available to all of the phases required for the proper operation of the instrument. The indicating means shall indicate a failure or a malfunction in a positive manner.

4.6.3 Reliability: The Flight Director design shall be such as to preclude (insofar as possible) any hazardous maneuver resulting from malfunction. Where practical an indicating means should be provided to warn against malfunctions.

4.7 Power Variations: The instruments shall function with ±15% variation in DC voltage and/or ±10% variation in AC voltage and ±5% frequency.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25C and a relative humidity of not greater than 85%. 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:

5.2.1 Vibration to Minimize Friction: Unless otherwise specified, all tests for performance may be conducted with the instrument 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 the total displacement from positive maximum to negative maximum.

5.3 Vibration Equipment: Vibration equipment of either of the following types shall be used which will provide frequencies and amplitudes consistent with the requirements of Section 3.3.4 with the following characteristics.

Linear Motion Vibration: Vibration equipment shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the instrument.

Circular Motion Vibration: Vibration equipment shall be such that a point on the instrument case will describe a circle, in a plane inclined 45 degrees to the horizontal plane, the diameter of which is equal to the double amplitude specified.

5.4 Power Conditions: Unless otherwise specified, all tests shall be conducted at the power rating recommended by the manufacturer.

5.5 Position: Unless otherwise specified, all tests shall be conducted with the units mounted in their normal operating position.

6. INDIVIDUAL PERFORMANCE TESTS: All of the various units or complete system shall be tested in accordance with the manufacturer's recommendations. The manufacturer shall conduct sufficient tests to prove compliance with this Aeronautical Standard, including the following requirements, where applicable.

6.1 Dielectric: Each instrument shall be tested by the methods of inspection listed in paragraph 6.1.1 and 6.1.2.

6.1.1 Insulation Resistance: The insulation resistance measured at 200 volts D.C. for five seconds between all electrical circuits connected together and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc. since this measurement is intended only to determine adequacy of insulation.

6.1.2 Overpotential Tests: Equipment shall not be damaged by the application of a test potential between electrical circuits, and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with the R.M.S. value of five times the maximum circuit voltage or per paragraphs 6.1.2.1 or 6.1.2.2 whichever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for five seconds, and then reduced at a uniform rate to zero.

Since these tests are intended to assure proper electrical insulation of the circuit components in question, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

6.1.2.1 Hermetically sealed instruments shall be tested at 200 volts R.M.S.

6.1.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.

7. QUALIFICATION TESTS: As many instruments or components as deemed necessary to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturer's recommendations. After completion of all other qualification tests each component shall be tested and shall meet the requirements of Section 6.1 Dielectric.

7.1 Low Temperature Operation: The instrument after having been subjected to an ambient temperature of -30C or -55C as applicable (see Paragraph 3.3.1), for a period of three hours, without operating, shall then meet the applicable requirements of Section 6 (other than 6.1 Dielectric) at that temperature.

7.2 High Temperature: The requirements of Section 7.1 shall apply except that the exposure temperature shall be 50C or 70C, as applicable (see Paragraph 3.3.1).

7.3 Extreme Temperature Exposure: The instrument or components shall, after alternate exposure to ambient temperatures of -65°C and 70°C, for a period of twenty-four hours each, and a delay of three hours at room temperature (25C) following completion of the exposure, meet the applicable requirements of Section 6 (other than 6.1 Dielectric). There shall be no evidence of damage, which would adversely effect performance as a result of exposure to the extreme temperature specified herein.

7.4 Magnetic Effect: Magnetic effect of the function selector and all indicators shall be determined in terms of the deflection of a free magnet approximately 1-1/2 inches long, in a magnetic field with a horizontal intensity of 0.18 (±.01) gauss when the units are held in various positions on an east-west line 12 inches from the center of the magnet. The maximum deflection of the magnet shall not exceed five degrees. Tests shall be made with the instruments in both power-on and power-off conditions.

7.5 Humidity: The instrument shall be mounted in its normal operation position in a chamber and maintained at a temperature of 70, ±2C, and a relative humidity of 95, ±5% for a period of 6 hours. After this period the heat shall be shut off and the instrument shall 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 38C. This complete cycle shall be conducted:

a. Five times for instruments located in uncontrolled temperature areas.

b. Once for instruments located in controlled temperature areas.

There shall be no evidence of damage or corrosion following this test which would adversely affect the performance of the system or the components thereof. The instrument shall meet the applicable requirements of section 6 (other than 6.1 Dielectric).

7.6 Vibration:

7.6.1 Resonance: The instrument, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in Paragraph 3.3.4 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 Paragraph 3.3.4.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in Paragraph 3.3.4 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 instrument shall be vibrated for two hours in accordance with the vibration requirements schedule (paragraph 3.3.4) at the maximum double amplitude and the frequency to provide the maximum acceleration.

7.6.2 Cycling: The instrument, while operating, shall be tested with the frequency cycled between limits specified in Paragraph 3.3.4 in 15 minute cycles for a period of one hour in each axis at the applied double amplitude specified in Paragraph 3.3.4 or an acceleration specified in 3.3.4 whichever is the limiting value or a total of three hours for circular motion vibration, whichever is applicable.

After the completion of this vibration test, no damage shall be evident and the instrument shall meet the applicable requirements of Section 6 (including Paragraph 6.1 Dielectric).