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400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE AS402 REV. B

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Automatic Pilots

FOREWORD

Changes in this Revision are format/editorial only.

1. SCOPE:

This Aeronautical Standard covers Automatic Pilots intended for use on aircraft to automatically operate the aerodynamic controls to maintain flight and/or to provide maneuvering about the three axes through servo control.

1.1 Purpose:

To specify minimum requirements for Automatic Pilots primarily for use in reciprocating engine powered civil transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.

2. REFERENCES:

NACA Report 1235

3. GENERAL REQUIREMENTS:

3.1 Material and Workmanship:

3.1.1 Materials: Materials shall be of quality which experience and/or tests have demonstrated to be suitable and dependable for use in 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
b. SAE AS402B
c. Manufacturer's part number
d. Manufacturer's serial number or date of manufacture
e. Manufacturer's name and/or trade mark.

3.3 Environmental Conditions:

The following conditions have been established as minimum design requirements. Tests shall be conducted as specified in Section 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 temperatures shown in Column B.

TABLE 1

Instrument Location	A	B
Power Plant Accessory Compt.	-30 to 100 °C	-65 to 100 °C
Heated Areas (Temp. Controlled)	-30 to 50 °C	-65 to 70 °C
Unheated Areas (Temp. Uncont.)	-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 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and shall not be adversely affected when subjected to vibrations of the following characteristics:

TABLE 2

Instrument Location in Airframe	Cycles Per Second	Maximum Double Amplitude (Inches)	Maximum Acceleration
Power Plant Mounted	5-150	0.100	20 g
Wings and Empennage	5-500	0.036	10 g
Fuselage	5-500	0.036	5 g
Panel or Rack vibration isolated)	5-50	0.020	1.5 g

3.3.4 Altitude: The instruments 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 instruments shall not be adversely affected following exposure to an ambient pressure of 50 inches Hg absolute.

3.3.5 Explosive Atmosphere: All components located in the uninhabited areas of non-pressurized aircraft, or in the non-pressurized areas of pressurized aircraft shall not cause an explosion when operated in an explosive atmosphere.

3.3.6 Icing: All units which are mechanically coupled to the primary or trim aerodynamic controls shall function when exposed to icing as would be encountered under conditions of rapid changes in temperature, pressure and humidity.

3.4 Radio Interference:

The instruments 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.

3.5 Magnetic Effect:

The magnetic effect of the instruments shall not adversely affect the operation of other instruments installed in the same aircraft.

4. DETAIL REQUIREMENTS:

4.1 General:

4.1.1 Design Objective: The automatic pilot design objective shall be satisfactory performance and safety with the least monitoring and control.

4.2 Controls:

4.2.1 Disengagement: A positive means shall be provided to disengage the automatic pilot from the aircraft's control system.

4.2.2 Quick Release: Means shall be provided for a quick release of the automatic pilot control forces.

4.2.3 Controller: When a controller is provided, the design shall be such that, when installed in the aircraft, each manually operated control means which actuates the primary and/or trim aerodynamic controls shall operate in the plane and with the sense of direction of motion of the aircraft. The control sensing shall be plainly identified on or adjacent to each control.

4.3 Indications:

4.3.1 Means of Indication: The means of indication required in the following paragraphs shall include any means by which the pilot can be made cognizant of the condition, including control behavior.

4.3.2 Servo Effort Indication: Means shall be provided to clearly indicate the direction and relative magnitude of the primary pitch servo effort present, for the automatic pilot engaged condition. With the automatic pilot not engaged, the indications shall be representative of the servo signals present. The automatic pilot design shall be such that a similar means of indication can be added for the other two axes.

4.3.3 Servo Power Indication: Means shall be provided to indicate when the servos are mechanically engaged but are not electrically energized, if such condition is possible.

4.4 Control Range:

4.4.1 Corrective Control: The automatic pilot shall be capable of restoring the aircraft to the commanded attitude about the three axes throughout the following minimum ranges:

a. Pitch ±50°
b. Roll ±75°
c. Yaw ±20°

4.4.2 Command Control: Means shall be provided to limit maneuvering the aircraft through the automatic pilot controls, to the following maximum ranges:

a. Pitch ±30°
b. Bank ±45°
c. Turn Unlimited
angle to right or left

4.5 Safety Provisions:

4.5.1 System Interlock: Means shall be provided to prevent the automatic pilot engagement until it has reached a fully operable condition.

4.5.2 Servo Force: Means shall be provided to limit the maximum servo forces to a safe value as determined in specific applications. The servos shall be designed to withstand a minimum load of 2.5 times the maximum output of the servo applied in a manner similar to that found in actual installations, or as required by the actual aircraft control loads, whichever is the higher, plus any approved load applied by rigging tension.

4.5.3 Caging: Means shall be provided to indicate when the gyros are caged, except where it is not possible to leave them in a caged position.

4.5.4 Auxiliary Controls: There shall be no objectionable electrical interference between the automatic pilot and the accessory equipment designed to be operated with it. The automatic pilot shall not be the source of objectionable interference caused by radiation or feedback.

Special features incorporated as a part of the Automatic Pilot design, as integral or accessory components of the automatic pilot shall provide positive mechanical and/or electrical interlocks and sequencing in the order of engagement to preclude improper operation. For example:

a. Altitude Control - Pitch attitude correction shall be limited.
b. Flight Path Control - Pitch and roll attitude correction shall be limited.
c. Automatic Disengagement Control.
d. Automatic Trim Control.
e. Automatic Engine Throttle Control.
f. Automatic Mach/Airspeed Control.
g. Gyro Caging.

4.6 Reliability:

The automatic pilot design shall be such that should a single failure (except gyro mechanical failures) occur in the system, no signal shall result which would apply to the aircraft maximum servo control forces as determined in Paragraph 4.5.2, in more than one primary and trim aerodynamic axis.

4.7 Stability:

The roll, pitch, and yaw signal sources shall establish the areas about which the airplane is automatically controlled. The automatic pilot shall provide stabilized control about the referenced axis within safe limits as determined in specific applications.

4.8 Power Variations:

The automatic pilot shall function normally within voltage limits of ±10 percent of rated value, and/or frequency limits of ±5 percent of rated value, and/or pneumatic or hydraulic pressure limits of ±30 percent of rated value. These values shall be steady state conditions.

Transient variations within these limits and variations beyond these limits shall not cause unsafe control. As the specific application requires, variations beyond these limits shall not cause damage to the automatic pilot producing unsafe conditions.

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 25 °C and a relative humidity not greater than 85%. When tests are conducted with atmospheric pressure or temperature substantially different from these values, allowance shall be made for the variations from the specified conditions.

5.2 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 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.

6. INDIVIDUAL PERFORMANCE TESTS:

All of the components of the complete system shall be tested in accordance with the manufacturer's recommendations. The manufacturer shall conduct sufficient tests to prove compliance with this standard including the following requirements where applicable.

6.1 Dielectric:

Each instrument shall be tested by the methods of inspection listed in paragraphs 6.1.1 and 6.1.2.

6.1.1 Insulation Resistance: The insulation resistance measured at 200 volts DC 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 an RMS 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 insure proper electrical isolation 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 RMS.

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

7. QUALIFICATION TESTS:

As many instruments or components as deemed necessary by the manufacturer to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with his recommendations.

7.1 Low Temperature Operation:

Each component, or the complete system, after having been subjected to an ambient temperature of -30 or -55 °C as applicable (see Paragraph 3.3.1) for a period of 5 hours, without operating shall then meet the applicable requirements of Section 6 at that temperature.

7.2 High Temperature:

The requirements of Section 7.1 shall apply except that the exposure temperature shall be 50 °C, 70 °C, or 100 °C as applicable (see Paragraph 3.3.1).

7.3 Extreme Temperature Exposure:

The instruments or components shall, after alternate exposures to ambient temperatures of -65 °C and 70 °C or -65 °C and 100 °C as applicable (see Paragraph 3.3.1) for periods of 24 hours each and a delay of 3 hours following completion of the exposure, meet the applicable requirements of Section 6 at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperature specified herein.

7.4 Magnetic Effect:

Magnetic effect of the controller and of all components intended for mounting on the Pilot's panel shall be determined in terms of the deflection of a free magnetic 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 instruments in power-on condition.

7.5 Humidity:

The instrument shall be mounted in the normal operating position in a chamber maintained at a temperature of 70 ± 2 °C and a relative humidity of 95 ± 5 percent for a period of six hours. After this period, the heat shall be shut off and the instruments shall be allowed to cool for a period of 18 hours in this atmosphere in which the humidity rises to 100 percent as the temperature decreases to not more than 38 °C. 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.

Immediately after cycling, there shall be no evidence of damage or corrosion which affects performance following this test and the instrument shall meet the applicable requirements of Section 6. Insulation resistance and dielectric testing are not to be conducted upon completion of this test.