Society of Automotive Engineers, Inc.
29 West 39th Street
New York City

AERONAUTICAL STANDARD AS 402

AUTOMATIC PILOTS

Issued 8-1-47
Revised

1. PURPOSE: To specify minimum requirements for automatic pilots for use in aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.4.

2. SCOPE: This specification covers all gyroscopic and servo control types of automatic pilots intended for use on aircraft to operate automatically the control surfaces of the aircraft to maintain a stabilized flight attitude with respect to the longitudinal, lateral and vertical axes, and to provide for maneuvering the airplane through servo control.

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 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 radio sets installed in the same aircraft as the instrument.

3.3 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 automatic pilot
(b) SAE Spec. AS 402
(c) Rating (electrical or vacuum power supply and maximum servo output where applicable)
(d) Manufacturer's part number
(e) Manufacturer's serial number or date of manufacture
(f) Manufacturer's name and/or trade mark

3.4 Environmental Conditions: The following conditions have been established as design criteria only. Tests shall be conducted as specified in sections 5, 6, and 7.

3.4.1 Temperature: When located in accordance with the instrument manufacturer's instruction, the units shall function over the range of ambient temperatures as listed in Column A below and shall not be adversely affected by exposure to the temperature shown in Column B below:

Instrument Location	A	B
Power Plant Accessory Compartment	-30 to 130 C	-65 to 130 C
Heated Areas (Temperature Controlled)	-30 to 50 C	-65 to 70 C
Unheated Areas (Temperature Uncontrolled)	-55 to 70 C	-65 to 70 C

3.4.2 Humidity: All units shall function and not be adversely affected when exposed to a relative humidity up to and including 95 percent at a temperature of approximately 32C.

3.4.3 Altitude: All units shall function and not be adversely affected when exposed to a pressure and temperature range equivalent to -1000 feet to 40,000 feet standard altitude, except as limited by application of Section 3.4.1.

3.4.4 Vibration: When installed in accordance with instrument manufacturer's instructions, all units shall function and shall not be adversely affected when subjected to vibrations having characteristics likely to be encountered at the locations in the aircraft where the units are to be installed.

4. DETAIL REQUIREMENTS:

4.1 Instrumentation:

4.1.1 Direction Indication: If aircraft direction indication is provided it shall be in accordance with AS 397 or AS 399.

4.1.2 Bank and Pitch Indication: If aircraft bank and/or pitch indication is provided it shall be in accordance with AS 396.

4.1.3 Servo Signal Indication: Means shall be provided to clearly indicate the magnitude and direction of servo signal present, except where automatic synchronization is provided. Then, yaw and roll signal need not be indicated. With the automatic pilot engaged, the pitch axis indication shall be representative of control surface load.

4.1.4 Engagement Indication: Means shall be provided to clearly indicate whether the automatic pilot servos are in the engaged or disengaged position.

4.1.5 System Power Indication: Means shall be provided to permit operation of a device to indicate whether or not the instrument is receiving power.

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

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

4.1.8 Interlock Indication: The operation of any protective interlock device which renders any part of the system inoperative shall be indicated.

4.2 Control Range:

4.2.1 Corrective Control: The automatic pilot shall give stabilized control about the three axes throughout the following minimum ranges:

(a) Pitch ± 50°
(b) Roll ± 75°
(c) Yaw ± 20°

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

(a) Pitch ± 30°
(b) Bank ± 45°
(c) Turn = unlimited angle to the right or left

4.3 On-Off Control: Means shall be provided, either electrical or mechanical, to permit the automatic pilot to be put in operation and to remove it from operation.

4.4 Safety Provisions:

4.4.1 Servo Force: Means shall be provided to limit the servo force to a safe value as determined in specific applications. The mounting base and housing of the servos shall be designed to withstand a load of 1.5 times the maximum output of the servo applied in a manner similar to that found in actual installation.

4.4.2 Interlock Provisions: A means shall be provided to prevent the servo system from becoming operative until the automatic pilot is ready for operation.

4.4.3 Indicator Power Source: When the pitch and bank and/or azimuth units furnish an indicating reference, either directly or by repeaters, the automatic pilot shall be so designed that they become operative simultaneously with the turning on of the aircraft power source.

4.4.4 Special Features: When special features are incorporated in the design of the automatic pilot (either integral or as accessories) they shall provide adequate interlocks, electrical and/or mechanical to prevent improper operation. For example:

(a) Coordinated turn control - Bank shall be limited
(b) Altitude control - Pitch attitude correction shall be limited
(c) Glide path control - Pitch attitude correction shall be limited

4.4.5 Servo Disengaging Means: A positive mechanical means, independent of the aircraft power supply, shall be provided to disengage the servos from the aircraft control system. When the servos are disengaged, the manual control of the aircraft shall not be objectionably affected.

4.4.6 Emergency Release: Means shall be provided for releasing the automatic control. The actuating device shall be suitable for mounting on the control wheel.

4.4.7 Reliability: Insofar as practicable, without affecting its normal operation, the automatic pilot design shall be such that should a failure occur in the system, no signal shall occur which would apply hazardous control to the airplane.

4.5 Stability: The roll, pitch and yaw signal sources shall establish the three axes about which the airplane is automatically controlled. The automatic pilot shall provide flight attitude stabilization, in smooth air, within 1 degree of selected attitude and heading about the above reference axes.

4.6 Power Variations: All units shall properly function with a voltage and frequency variation of ± 10% of the rated value (provided the A.C. voltage and frequency vary in the same direction), and/or ± 30% of the rated vacuum or hydraulic pressure. Power variations beyond these limits shall not cause adverse control.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions: Unless otherwise specified, the tests shall be accomplished at atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 22C. When tests are made with atmospheric pressure or temperature substantially different from these values, allowance shall be made for the difference from the specified conditions.

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

5.3 Power Conditions: Unless otherwise specified all tests for performance shall be conducted at the power rating recommended by the manufacturer.

5.4 Vibration Stand: A vibration stand shall be used which will vibrate at any desired frequency between 500 and 3000 cycles per minute and shall subject the instrument to vibration such that a point on the instrument case will describe in a plane inclined 45 degrees to the horizontal plane, a circle, the diameter of which is equal to the amplitude specified herein.

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 specification, including the following requirements where applicable.

6.1 Dielectric: Insulation shall be subjected to a dielectric test with a R.M.S. voltage at a commercial frequency applied for a period of five seconds equivalent to five times normal circuit operating voltage except where circuits include condensers or other components for which such a test would be inappropriate; then the test voltage shall be 1.25 times circuit operating voltage. The insulation resistance shall not be less than 20 megohms at that voltage.

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.

7.1 Low Temperature Operation: Each component, or the complete system, after having been subjected to an ambient temperature of -30C or -55C as applicable (see Par. 3.4.1) for a period of 5 hours, without operating, shall then meet the 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 50C, 70C, or 130C as applicable (See Par. 3.4.1).

7.3 Extreme Temperature Exposure: The instrument or components shall, after alternate exposures to ambient temperatures of -65C and 70C or -65C and 130C as applicable (See Par. 3.4.1) for periods of 24 hours each and a delay of 3 hours following completion of the exposure, meet the 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 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 instruments in power-on condition.