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AEROSPACE STANDARD

AS 417

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Revised

AIR DATA COMPUTER

1. PURPOSE - This Aerospace Standard establishes the essential minimum safe performance standards for air data computers which supply data to display and other subsystems. The computer is primarily for use with turbine powered, subsonic, transport aircraft, the operation of which may subject the system to the environmental conditions specified in Section 3.3.

2. SCOPE - This Aerospace Standard covers an air data computer characterized by the concept of transducing and computing the majority of air data requirements for an aircraft. The display instruments and other using subsystems are not considered in this scope except where they perform computing operations for output parameters as covered by this specification. The computer may accept the inputs and provide the outputs listed in paragraphs 2.1 and 2.2 respectively. The computer may also provide an altitude encoder output for IFF Mark $\overline{X}$ (SIF)/Air Traffic Control Radar Beacon System SIF/ATCRBS; in which case AS 855* "Altitude Device Providing Outputs for Automatic Pressure Altitude Reporting" shall be referred to for applicable minimum standards. (Note - Reference to air data computer in subsequent paragraphs will be designated as "instrument".)

2.1 Inputs

a. Static pressure (P_{si}) from the aircraft static system.

b. Total pressure (P_t) from the aircraft pitot system.

c. Temperature (T_{ti}) from an externally mounted sensor.

d. Angle of attack (α_i) from an externally mounted sensor.

Note: Since each aircraft type has a particular static error, data showing the effect of angle of attack and Mach number functions on static pressure shall be supplied by the aircraft manufacturer or user.

2.2 Output Parameters (All corrected for the installation static pressure error)

a. Mach number (M) and/or functions of Mach number (M_h and $\dot{M}$)

b. True airspeed (V_t)

c. Pressure altitude (H) and/or other functions of static pressure (H_h, $\dot{H}$)

d. Computed airspeed, (V_c) and/or other functions of differential pressure (q_c)

e. Equivalent airspeed (V_E)

f. Static air temperature (T_s)

g. Maximum operating limit speed (V_{MO})

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h. True angle of attack (α_t)

2.3 Nomenclature - Symbols and definitions of terms used in this AS are:

P_{si} = Indicated static pressure as delivered through the aircraft static pressure system to the air data computer. In actual installation it may have errors as functions of Mach and/or angle of attack for probe position, or structure.

P_s = Static pressure - corrected for static position error as function of Mach and/or angle of attack.

P_t = Total pressure as delivered through the aircraft pitot pressure system to the air data computer.

αi = Indicated angle of attack - as measured by an angle of attack sensor. In actual installation it may have an error equal to one or more functions of Mach.

M = Mach number = $\left\{ 5 \left[\left(1 + \frac{P_t - P_s}{P_s} \right)^{2/7} - 1 \right] \right\}^{1/2}$

where M is 1 or less as limited by this AS.

M_h = Mach hold or ΔM.

$\dot{M}$ = Mach rate or $\frac{dM}{dt}$

C_s = Speed of sound

V_t = True airspeed = MC_s

H = Pressure altitude f(P_s) (NACA Report 1235, Model Atmosphere in Feet)

H_h = Altitude hold = ΔH

$\dot{H}$ = Altitude rate or $\frac{dH}{dt}$

V_c = Computed airspeed = Airspeed output of the computer corrected for static position error = $C_{so} \left\{ 5 \left[\left(\frac{P_t - P_s + 1}{P_o} \right)^{2/7} - 1 \right] \right\}^{1/2}$ where the subscript o denotes the model atmosphere S. L. value in appropriate terms for speed of sound (C_s) and pressure (P) for subsonic conditions.

$V_E = V_t \left(\frac{\rho}{\rho_o}\right)^{1/2}$ or $(K M P_s)^{1/2}$ where K = constant

q_c = Impact pressure = $P_t - P_s$

T_s = Static air temperature = $\frac{T_{Ti}}{(1 + 0.2KM^2)}$ (K = Temperature sensor recovery factor)

ρ = Air density

V_{MO} = Maximum operating limit speed = Maximum operating limit speed shall not be deliberately exceeded in any regime of flight except where a higher speed is specifically authorized for flight test or pilot training operations or in approved emergency procedures.

αt = True angle of attack = Indicated angle of attack corrected for the characteristic of the particular aircraft as to Mach number or other factors.

2.4 Standard Atmosphere Reference

NACA Report 1235 tables shall be used as the atmospheric data sources.
NASA TN-D822 tables shall be used as air speed data source.

3. GENERAL REQUIREMENTS

3.1 Materials 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 use in aircraft instruments.

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

3.2 Identification - The following information shall be legibly and permanently marked on the instrument or nameplate attached thereto:

a. Name of instrument - Air Data Computer
b. SAE AS 417
c. Manufacturer's part number
d. Manufacturer's serial number or date of manufacture
e. Manufacturer's name and/or trademark
f. Range - Subsonic / 50,000 ft
g. Rating

h. Explosion category
i. Aircraft identification

3.3 Environmental Conditions - The following conditions have been established as minimum 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 instrument shall function over the range of ambient temperatures as listed in Column A below and should not be adversely affected by exposure to the temperature shown in Column B below.

Instrument Location	A	B
Pressurized areas	-30 to 50 C	-65 to 70 C
Nonpressurized or external areas	-55 to 70 C	-65 to 70 C

3.3.2 Altitude - When installed in accordance with the instrument manufacturer's instructions, the instruments shall function from sea level up to the altitude and temperatures listed below. Altitude pressure values are per NACA Report 1235. The instruments shall not be adversely affected following exposure to extremes in pressure of 50 and 3 in. Hg abs external to the case with pitot and static ports connected to a pressure approximately 29.92 in. Hg abs.

Instrument Location	Altitude	Temperature
Pressurized areas	15,000 ft	50 C
Nonpressurized or external areas	60,000 ft	40 C

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

Instrument Location	Frequency (cps)	Max. Double Amplitude (In.)	Maximum Acceleration (g)
Fuselage			
Forward of Spar Area	5-500	0.036	2
Center of Spar Area	5-1000	0.036	4
Aft of Spar Area	5-500	0.036	7
	500-1000	-----	5
Vibration Isolated Rack	5-1000	0.030	1

3.3.4 Humidity - The instrument shall function and shall not be adversely affected following exposure to any relative humidity in the range from 0 to 95% at a temperature of approximately 70 C.

3.4 Explosion Category - The instrument component, when intended for installation either in uninhabited areas of nonpressurized aircraft or in nonpressurized areas of pressurized aircraft, shall not cause an explosion when operated in an explosive atmosphere. The component shall meet the requirements applicable to the explosion category below. Specifically, any instrument component which can be an ignition source and is intended for installation in an area in which combustible fluid or vapor may result from abnormal conditions, e.g. fuel line leakage, shall meet the requirements of Category I. If the intended location is an area where combustible fluid or vapor can occur during normal operation e.g., fuel tank, the instrument component shall meet the requirements of Category II listed below:

Category	Definition	Requirement
I	Explosion proofed: Case not designed to preclude flame or explosion propagation	Paragraph 7.7.1
II	Explosion proofed: Case designed to preclude flame or explosion propagation.	Paragraph 7.7.2
III	Hermetically sealed	Paragraph 6.7
IV	Instrument not capable of causing an explosion	Should not be capable of producing a capacitive or inductive spark of more than 0.2 millijoules of energy or a contact spark of more than 4.0 millijoules of energy.

3.5 Fire Hazard - The instrument shall be so designed to safeguard against hazards to the aircraft in the event of malfunction or failure, and the maximum operating temperature of surfaces of any instrument component contacted by combustible fuel or vapor shall not exceed 200 C due to self heating.

3.6 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 the electronic equipment installed in the same aircraft as the instrument. Reference RTCA 120-61/DC-108 including Appendix A available from Radio Technical Commission for Aeronautics, Building T-5, Room 1072, 16th and Constitution Avenue, N. W., Washington 25, D. C.

3.7 Magnetic Effect - The magnetic effect of the instrument shall not adversely affect the performance of other instruments installed in the same aircraft.

3.8 De-Compression - When installed in accordance with the instruments manufacturer's instructions the Air Data Computer shall function and not be adversely affected follow-

ing exposure to pressure decrease from 22 to 2 in. Hg abs in 2 seconds.

4. DETAIL REQUIREMENTS

4.1 Preflight Test Capability - If the instrument contains integral arrangements to permit preflight system checks on the operation of the instrument and/or in combination with other aircraft subsystems, interlock means shall be provided to inactivate any using subsystem which might be adversely affected during the self-test cycle. A malfunction in the self-test system which affects output signal accuracy of the computer shall be indicated in a positive manner.

4.2 Power Variation - The instrument shall properly function with ±15% variation in d-c voltage and/or ±10% variation in a-c voltage and ±5% variation in frequency.

4.3 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 phases required for the proper operation of the device. The failure indication signal of the computer is intended to be displayed on the visual indicators in a positive manner.

4.4 Monitors - The instrument may incorporate a monitor system for the purpose of providing a failure indication signal in event of some form of excessive servo to sensor follow-up or rebalance error. The failure indication signal may use the same circuits as the Power Malfunction Indication of paragraph 4.3; if not, it shall be similarly displayed. In event of a malfunction of the monitor system, it shall either have no effect on the output signal accuracy of the instrument, or shall indicate the resulting loss of accuracy in a positive manner.

4.5 Vibration to Minimize Friction - If vibration is required to minimize friction to meet accuracy requirements, it shall be the responsibility of the equipment manufacturer to provide notice to assure that this condition is met while the equipment is in normal operation.

4.6 Pressure Volume - The volume added to the aircraft pressure sense systems by the instrument shall not exceed the following values:

Static Pressure	30 cu in.
Total Pressure	30 cu in.

4.7 Hermetic Sealing - When hermetically sealed, the case shall be filled with an inert gas, free of dust particles, and sufficiently dry that moisture will not condense within the case at low temperatures causing malfunction of the mechanism.

4.8 Mounting - The mounting means shall be such that the instrument will satisfy the conditions necessary for shock and vibration tests.

4.9 Synchro Requirements - The synchro requirements should be in accordance with the conditions specified in the latest issue of ARP 461.

4.10 Pneumatic Connections - Total and static pressure fittings shall be permanently marked either on the fitting or on the computer case immediately adjacent to the fitting as indicated:

Function	Fitting Dimensions	Marking
Static Pressure	AN10050-6	"S"
Total Pressure	AN10040-4	"P"

4.11 Static Pressure Source Error - The instrument shall contain a means for correcting the computed outputs for static pressure source errors.

5. TEST CONDITIONS

5.1 Atmospheric Conditions - Unless otherwise specified, all tests required by this AS shall be made at an atmospheric pressure of approximately 29.92 in. Hg and at an ambient temperature of approximately 25 C, and at a relative humidity of not greater than 85%. When tests are conducted with the atmospheric pressure or the temperature differing materially from these values, allowance shall be made for the variation from the specified conditions.

5.2 Power Conditions - Unless otherwise specified herein, all tests shall be conducted with 115 volts 400 cps and 28 v d-c. The voltage and frequency shall be maintained within 2%.

5.3 Vibration to Minimize Friction - Unless otherwise specified herein, all tests for performance may be conducted with the instrument subjected to a vibration of 1/2 g maximum at any frequency between 10 to 60 cps.

5.4 Instrumentation for Performance Checks

5.4.1 Pressure - Two pressure references per ATA 34-10-2 "Recommended Test Procedures for Altimeters", March 1962, available from Air Transport Association of America, 1000 Connecticut Avenue, N.W., Washington 6, D. C. having:

1. Absolute accuracy of at least ±0.005 in. Hg.
2. Readability to 0.001 in. Hg.
3. Ability to maintain its setting within 0.002 in. Hg for at least two minutes.
4. Head vacuum reference - 10 microns or less.

5.4.2 Other Instrumentation - All other instrumentation used in the tests called out in this AS should have an accuracy at least 10 times better than the tolerances specified for the instrument under test.

5.5 Vibration Equipment - Vibration equipment shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the instrument at frequencies and amplitudes consistent with the requirements of paragraph 3.3.3.

5.6 Position - Unless otherwise specified herein, all tests shall be conducted with the instrument in its normal operating position on its normal mounting.

6. INDIVIDUAL PERFORMANCE TESTS - All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this Aerospace Standard, including the following requirements where applicable.

6.1 Scale Accuracy - Scale errors shall be determined in accordance with requirements of Table I and the following notes and entered in Table II for the particular aircraft concerned.

TABLE I NOTES

1. The accuracies in Table I are only for those signal outputs to supply visual display devices or indicators. Where an indicator is an integral part of the air data system because it contains computing functions of that system which can only be read on that indicator, the tolerance as so read shall not exceed 1.5 times that expressed in the Table thus allowing for transmission and readability errors. Other outputs of the air data system will as a minimum, be required to meet the accuracies for the particular using subsystem, i.e., auto-throttle, flight control, navigation etc., as expressed by such standards as may apply.

2. Intermediate range is to be a straight line connecting listed points.

3. The accuracy tolerance includes hysteresis, threshold and instrumentation errors as in paragraph 5.4.1 and 5.4.2.

4. Accuracies specified are for ambient temperature of 25 ±2 C. Above or below that temperature the tolerances may be increased an additional 1.0% of the tolerance per degree centigrade.

5. The tolerances shall be increased to allow for static pressure error. The value of this increase shall be equal to the allowed tolerance multiplied by the slope of the actual static error curve expressed in appropriate terms for the parameter considered. In addition, a fixed percentage of the actual static error correction shall be added to the unit tolerance to allow for characteristic reversal. The following equations define the total error allowance:

$$\pm \Delta H_T = \Delta H_{se} + \left[\left(\frac{\Delta H_p}{\Delta M} \right) \left(\Delta M_{se} \right) + 0.02\, H_p \right]$$

$$\pm \Delta M_T = \Delta M_{se} + \left[\left(\frac{\Delta M_p}{M} \right) \left(\Delta M_{se} \right) + 0.04\, M_p \right]$$

where:

ΔH_T = Total corrected altitude scale error in feet

ΔH_{se} = Altitude scale error without SEC correction in feet

$\frac{\Delta H_p}{\Delta M}$ = Slope of correction applied at any particular point on an aircraft operating curve

where:

ΔM_{se} = Mach computer scale error accuracy at the indicated Mach number

H_p = Actual amount of static position error correction required at a particular condition in feet

M_p = Actual amount of static position error correction required at a particular condition

$\frac{\Delta M_p}{\Delta M}$ = Slope of correction applied at a particular condition

Table II for a particular aircraft is prepared by summing the Table I tolerance with the tolerance increase calculated as defined in the preceding sentences for the prescribed test points and parameters and entered in the appropriate columns.

6. Slew rates between test points shall not exceed minimums of Table I by more than 10% during testing.

6.2 Servo Slew Rate - The servo slew rate shall be as specified in Table I column on minimum slew time. Drive the output of the parameter under test to the specified high limits of the respective range. By means of transfer valves and/or switches, simultaneously substitute a value of the parameter under test for the opposite or low range limit and start the stop clock or recorder.

TABLE I OUTPUT PERFORMANCE

Output Functions	Accuracy Range	Static Accuracy (See Notes)	Threshold	Min. Slew Time
M (Mach number)	0.3 to 1.0 Mach	±0.01 Mach from 0.3 to 0.4 Mach ±0.005 Mach from 0.5 to 0.95 Mach ±0.01 Mach at 1.0 Mach	0.001 Mach	48 seconds full range
V_t (true airspeed)	150 to 550 knots	±4 knots or 1%, whichever is greater	1.0 knot	Compatible with Mach and temperature
H (pressure altitude)	-1000 to 50,000 ft	±25 ft from -1000 to 10,000 ft ±50 ft at 20,000 ft ±75 ft at 30,000 ft ±100 ft at 40,000 ft ±125 ft at 50,000 ft	0.002 in. Hg	3.00 min. full range
V_c (computed airspeed)	50 to 500 knots	±5 knots at 50 knots ±2 knots at 100 knots ±2 knots at 200 knots ±4 knots at 500 knots	0.002 in. Hg or 0.5 knots, whichever is greater	Compatible with Mach
T_s (static air temperature)	-100 to +50 C	±1 C	0.25 C	2 minutes full range
α_t (true angle of attack)	25^o	0.25^o	0.10^o	2 seconds full range
H (rate of climb)	0 to ±20,000 ft per minute	5% of best straight line or 30 feet/minute whichever is greater	0.025 in. Hg per min.	Compatible with altitude
V_{MO} (maximum operating limit speed)	Defined by airframe requirement	±3 knots		Compatible with altitude
V_E (equivalent airspeed)	50 to 525 knots	±5 knots at 50 knots ±2 knots at 100 knots ±2 knots at 200 knots ±4 knots at 500 knots	Same as V_c	Compatible with Mach and altitude

TABLE II

ACCURACY REQUIREMENTS FOR ADC FOR AIRCRAFT IDENTIFIED AS

Test Point	Altitude Feet	Mach No.	Knots	Tot. Press. in In. Hg	Ind. Static Press. in In. Hg	Ind. Diff. Press. in In. Hg	Alt. Error ±ft.	Alt. Error $\pm P_s$ Hg"	Mach Error ±Mach	Mach Error $\pm q_c$ Hg"	IAS Error ±IAS	IAS Error $\pm q_c$ Hg
1	S. L.		66.10	30.1313								
2	↓		99.15	30.3952								
3	↓		152.04	31.0440								
4	↓	0.3	198.31	31.8491								
5	↓	0.4	264.41	33.4087								
6	↓	0.5	330.52	35.4930								
7	↓	0.6	396.62	38.1647								
8	10,000	0.4	220.60	22.9752								
9	↓	0.6	333.22	26.2459								
10	↓	0.8	448.24	31.3662								
11	20,000	0.5	227.73	16.3105								
12	↓	0.7	323.46	19.0728								
13	↓	0.9	423.29	23.2555								
14	30,000	0.6	222.81	11.3334								
15	↓	0.8	303.69	13.5444								
16	↓	.95	367.68	15. 8821								
17	40,000	0.7	208.86	7.6818								
18	↓	0.9	276.53	9.3664								
19	50,000	0.8	191.54	5.22036								
20	↓	.95	233. 53	6.1213								
21	60,000	.95	184.71	3.7854								

TABLE II (Cont'd)

Angle of Attack Only				Static Temperature				True Airspeed		
α_i	Mach	True	+Tolerance°	± Tolerance	Deg Kelvin	Deg C	Test Point	C_s in Knots	V_t in Knots	± Tolerance
				1°C	323.16	+50.0	1	700.54	70.05	
							2		105.08	
-5°	.3		±0.25				3		161.124	
	.5				288.16	15.0	4	661.03	198.309	
	.7						5		264.412	
	.9						6		330.515	
0°	.3						7		396.618	
	.5				268.348	-4.812	8	637.90	255.160	
	.7						9		382.740	
	.9						10		510.320	
5°	.3				248.536	-24.624	11	613.90	306.950	
	.5						12		429.730	
	.7						13		552.510	
	.9				228.724	-44.436	14	588.93	353.358	
10°	.3						15		471.144	
	.5						16		559.484	
15°	.3				216.660	-56.500	17	573.18	401.226	
	.4						18		515.862	
20°	.3						19		458.544	
							20		544.52	

6.3 Hysteresis - Hysteresis of the computer shall be less than 50 ft at 20,000 ft of altitude. This shall be determined by decreasing the pressure from 29.92 in. Hg to 13.750 in. Hg, taking care not to overshoot this point while controlling the manometer. Hold this pressure for at least two minutes before recording the altitude reading. Continue decreasing the pressure to approximately 3.0 in. of Hg. Reverse the pressure change and increase the pressure to 13.750 in. Hg taking care not to overshoot. Again, hold this pressure for at least two minutes before recording the altitude reading. The two readings in terms of altitude shall not differ by more than 50 ft, and both readings shall be within the tolerances determined and entered in Table II at check point 11.

6.4 Friction - The instrument shall be tested to demonstrate that the friction error tolerance shall not exceed 50% of the tolerance values of Table I at any 3 points selected at random within the range of each parameter. Friction error shall be the difference between two readings before and after vibration of 1/2 "G" maximum at any frequency between 10 to 60 cps as applied to the computer while energized and at the selected point in range.

6.5 Attitude Errors - The error in output obtained by orienting the equipment 90 degrees in any direction to its normal attitude shall be called attitude error. The attitude error in the instrument outputs listed shall not exceed 50% of the tolerance entered in Table II at any two representative conditions.

6.6 Leakage - The instrument shall have been de-energized at the conditions of paragraph 5.1 for at least one hour preceding this test. The test equipment volume (including manometers, tubing, etc.) shall not exceed 125 cu in. Test I: Apply pressure equivalent to 40,000 ft (5.53 in. Hg) with static and pitot connected together. Close off the pressure sources and check leakage for five minutes. Leakage should be less than 0.010 in. Hg per minute. Test II: Apply pressure equivalent to 15,000 ft (16.88 in. Hg) to P_s port with P_t port open to atmosphere; leakage should not be readable.

6.7 Sealing - Hermetically sealed components shall be tested for leaks by means of a mass spectrometer type of helium leak detector or equivalent. The leak rate shall not exceed 76 microns per hour per cubic foot of filling gas at a pressure differential of one atmosphere.

Note: A micron cubic feet/hour leak rate is defined as that gas leakage which would change the pressure of a one cubic foot volume by the amount of one micron (one millionth of a meter of mercury) in one hour.

6.8 Dielectric - Each instrument shall be tested by the method of inspection listed in paragraphs 6.8.1 and 6.8.2.

6.8.1 Insulation Resistance - The insulation resistance measured at 200 v 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.

6.8.2 Overpotential Tests - The instrument 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 paragraph 6.8.2.1 or 6.8.2.2, 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.

6.8.2.1 Hermetically sealed instruments shall be tested at five times the maximum circuit voltage up to a maximum of 200 v rms.

6.8.2.2 Circuits that operate at below 15 v are not to be subjected to overpotential tests.

7. QUALIFICATION TESTS - As many instruments as may be deemed necessary by the manufacturer to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturers recommendation.

7.1 Low Temperature Operation - The instrument shall be subjected to the applicable low ambient temperature listed in Column A of paragraph 3.3.1 for a period of five hours without operating. The instrument shall then meet, at that temperature, the tolerances entered in Table II for test points numbered 5, 9, 12, 15, 18 and individual performance tests of paragraphs 6.2 and 6.3.

7.2 High Temperature Operation - The instrument shall be subjected to the applicable high ambient temperature listed in Column A of paragraph 3.3.1 for a period of five hours without operating. (Electrical equipment shall be energized.) The instrument shall meet, at that temperature, the tolerances entered in Table II for test points numbered 4, 10, 13, 19 and individual performance tests of paragraph 6.2 and 6.3.

7.3 Extreme Temperature Exposure - The instrument shall be exposed alternately to the applicable low and high temperatures listed in Column B of paragraph 3.3.1 for a period of 24 hours at each extreme temperature, without operating. After a delay of three hours at room temperature, the instrument shall meet the tolerances entered in Table II for test points numbered 5, 8, 11, 16 and individual performance tests of paragraphs 6.2 and 6.3 at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.

7.4 Voltage Frequency - The instrument shall be tested for compliance to accuracy test points numbers 7, 10, 15, 18 of Table II at any voltage-frequency combination stated in paragraph 4.2.

7.5 Altitude - The instrument shall be subjected to the ambient temperature and pressure listed in paragraph 3.3.2 for a period of three hours while operating. The instrument shall then meet, at the conditions specified, the tolerance entered in Table II for test points 10, 13, 19 and individual performance tests of paragraphs 6.2 and 6.3. The instrument shall be exposed alternately to 50 in. Hg abs and 3 in. Hg abs nonoperating. The instrument shall meet the tolerances entered in Table II for test points 5, 12, 18 and individual performance tests of paragraphs 6.2 and 6.3.

7.6 Vibration - After completion of this vibration test, no damage shall be evident and the instrument shall meet the tolerances entered in Table II for test points 6, 10, 12, 18 and individual performance tests of paragraphs 6.2 and 6.3.

7.6.1 Resonance - The instrument, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in paragraph 3.3.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in paragraph 3.3.3.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in paragraph 3.3.3 at the resonant frequency for a period of one hour on each axis. If 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 3.3.3) 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 3.3.3 in 15-minute cycles for a period of one hour along each axis at an applied double amplitude specified in paragraph 3.3.3, or an acceleration specified in paragraph 3.3.3 whichever is the limiting value or a total of three hours for circular motion vibration, whichever is applicable. During this test the instrument shall not exceed 50% of the tolerance of the appropriate parameter in Table I while monitoring altitude and Mach hold and rate outputs at 10K ft, Mach 0.5 and 35K ft, Mach 0.8.

7.7 Explosion Proof - The instrument shall be subjected to whatever requirements are applicable for the specific category listed in paragraph 3.4. The following requirements cover only two categories.