ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C.

Subject: MINIMUM BAROMETRY FOR CALIBRATION AND TEST OF ATMOSPHERIC PRESSURE INSTRUMENTS

1. PURPOSE. This advisory circular (AC) provides guidance material which may be used to determine the adequacy of barometers used in the calibration of aircraft static instruments. It explains barometric accuracy requirements and provides general information pertaining to altitude and atmospheric pressure measurement. Additional information concerning the general operation, calibration, and maintenance of barometers is presented.

2. CANCELLATION. AC 43-2A, Minimum Barometry for Calibration and Test of Atmospheric Pressure Instruments, dated August 22, 1974, is cancelled.

3. BACKGROUND. The Federal Aviation Administration (FAA) has long recognized the direct relation that exists between altimeter accuracy and the efficiency with which the available airspace can be utilized. Accurate altimetry contributes to collision avoidance and terrain clearance. To improve safety in this area, the agency adopted rules prescribing periodic tests of aircraft altimeter systems. Following is a general discussion of each of the major areas of barometry which concern persons using barometers in aviation.

4. BASIC REFERENCE. The National Bureau of Standards of the Department of Commerce published Monograph 8 entitled "Mercury Barometers and Manometers." This excellent publication was prepared to fill the need of manufacturers and users of barometers for information which was scattered through the literature and, in some cases, was unpublished. The definitions and terminology used in the monograph will be used in this AC. Monograph 8 describes the variety of design elements which are critical in obtaining precision and accuracy from these instruments. It may be purchased from the Superintendent of Documents, United States Government Printing Office, Washington, D.C. 20402.

5. THE STANDARD ATMOSPHERE. Prior to 1964, the standard atmosphere against which all altimeters and barometers were calibrated was established in International Civil Aviation Organization Document Number 7488 or

National Aeronautics and Space Administration Technical Report No. 1235. These tables are satisfactory for use up to 65,800 feet which is above the certificated limit of current civilian aircraft. Facilities which maintain and service military instruments or barometric equipment whose range extends above 65,000 feet should consult the appropriate charts for the altitudes. The book, "U.S. Standard Atmosphere 1976" discusses the high altitude temperature difference and associated pressures and defines the standard conditions for pressure measurements.

6. STANDARD BAROMETERS. A standard barometer is one which is capable of accuracy at least equal to, and preferably superior to, a calibrating barometer. In some cases, it may be used in the final calibration of altimeters.

a. Accuracy. Most sensitive altimeters used in civil aircraft are manufactured in accordance with FAA Technical Standard Orders C10a and C10b, or in accordance with military specifications which allow indication tolerances of +20 feet over the range -1000 to +1000 feet. Higher tolerances are allowed as the altitude increases. The accuracy of the measuring device should exceed that specified for the device being measured. Facilities conducting tests usually allow for this uncertainty to assure compliance with the Federal Aviation Regulations (FAR) and tolerance specified by the manufacturer. Barometers which have an accuracy or uncertainty of .02 inches of mercury (Hg) will result in errors of 18.6 feet at sea level and, therefore, are generally unsuitable for calibrating sensitive altimeters.

b. Calibration. The barometer should be calibrated against a primary standard or a transfer standard of known accuracy whose calibration is traceable to the National Bureau of Standards. This calibration will normally be performed by the manufacturer when the instrument is built or overhauled, and should be on a chart handy to the instrument technician. High quality barometers provide for checking the zero adjustment and, if properly used and maintained, need only be calibrated at overhaul. Should the technician using the barometer not wish to check its zero adjustment the local pressure reading can be compared against that of a similar barometer. This check, if properly applied, is sufficient to show up errors. The readings must be corrected for the difference in instrument height.

c. Level. The level of the barometer should be maintained within one minute of arc. Most units easily accomplish this with built-in spirit levels.

d. The Scale. The instrument scale should be marked so that it can be read to .001-inch of mercury and should indicate from zero to 800 mm or zero to 31.5 inches of mercury. Regular weather barometers with short scales are not satisfactory for altimeter calibration since they are only readable over a small band around sea level pressure. A readout assembly should be used to reduce parallax errors and to make the scale easier to read.

e. Temperature. The instrument temperature should be determined from a thermometer either affixed to the instrument or in the temperature-controlled barometer cabinet. The thermometer should be accurate to .5° centigrade (.9° Fahrenheit) or better (reference Monograph 8), or its accuracy should be matched to the accuracy of the temperature-compensating device. The temperature of the instrument should be kept as constant as practicable. The barometer should be installed where the temperature is controlled within ± 10° Fahrenheit. If any changes of temperature over ± 10°F occur, the barometer should be allowed to stabilize for five hours before attempting to use it for altimeter calibration. Inadequate temperature control and correction cause barometer error.

f. Correction for Local Gravity. The local gravity value should be determined by one of the methods referenced in the NBS Monograph 8, or by contacting the regional Coast and Geodetic Survey office and obtaining the latest gravimetric value for the area in which the barometer is located. The local gravity value should be corrected for elevation differences.

g. Tables. Tables used to correct barometer readings for gravity and/or temperature should be kept close to the instrument and used by the technician to assure accurate pressure measurement. Any method of preparing this table is satisfactory if its use results in required accuracy.

h. Automatic Correcting Devices. If automatic correcting devices are attached to the barometer, the temperature corrector should have scales capable of being set to .5°C (.9°F), and the local gravity corrector should have scales capable of being set to .15 centimeter per second squared. These scales should be positioned so that the technician can see them easily and thus assure that proper corrections are applied. Automatic correcting devices make barometers easier to use, and barometers so equipped give consistently better results since they reduce the computations required of the technician.

i. Capillary Depression. Capillary depression errors and tube bore diameters are discussed in the NBS Monograph 8. To obtain an accuracy of .004-inch of mercury, a tube with a bore of not less than 1/2 inch in diameter should be used. The cleanliness of the tube bore and the mercury affect the shape of the meniscus and the accuracy of the instrument.

j. The Vacuum. The use of a vacuum pump and McLeod gauge to measure the pressure above the mercury is the best method of establishing and checking the vacuum. Pressures of 15 microns or less are satisfactory. Instruments equipped with a mercury seal (one-way check valve) should have the vacuum checked frequently and should not be subjected to high slew rates. A high slew rate or the rapid movement of mercury from the cistern into the instrument tube increases the possibility of damage to the instrument and loss of mercury.

k. Operating and Maintenance Instructions. A handbook or manual should be prepared for each barometer and should be immediately available to the technician. This manual is normally prepared by the manufacturer. It should contain at least:

(1) The accuracy and range of the instrument;

(2) Operating instructions covering each operation of the instrument and its accessories; and

(3) A periodic inspection and maintenance guide which clearly establishes the daily, weekly, or monthly inspection or maintenance requirements necessary to maintain the instrument and accessories to their original standards. The facility should keep those records of the instrument maintenance, inspection, and calibration necessary to support its existing accuracy.

7. THE WORKING STANDARD BAROMETER. Shops which repair and calibrate altimeters should have a working standard barometer with a repeatable accuracy appropriate to the type of altimeters to be worked on. This barometer may be the shop standard as well as the working barometer. In most small repair facilities, it will be used to serve both purposes. Strict adherence to good maintenance practices is required in either case. The working barometer should be of high quality, capable of a wide range of performance, and relatively insensitive to handling.

a. Pressure measuring devices used in the rough calibration of pitot/static instruments may be either mercury or aneroid barometers with wider tolerances. However, the instrument used for final calibration of nonsensitive altimeters or sensitive altimeters certificated for use below 35,000 feet, should have a repeatable accuracy of at least .01-inch. Sensitive altimeters, altitude hold devices, altimeters used in Category II landing systems, or servoed equipment associated with air data computers, usually require test and calibration equipment with repeatable accuracies of .005-inch Hg or better.

b. When selecting the working barometer, assure that its errors do not exceed the tolerance of the equipment being tested. It would be well to assure that the instrument used in final calibration has an error no more than 1/4 the tolerance allowed for the instrument being tested.

c. Mercurial barometric equipment is sensitive to temperature changes, airborne impurities, rough handling, and vacuum loss. The fixed cistern barometer also has problems associated with mercury loss. These possible sources of error must be understood in relation to the specific equipment being used by the repair facility; take positive action to eliminate them or reduce their effect.

8. BAROMETER INSPECTION SCHEDULE. FAA Technical Report No. RD-64-119, "Pressure Measurement for Pressure Altimetry," August 1964, suggests the following schedule which may be used to the advantage of those facilities not having an established barometer maintenance program. The Technical Report contains detailed maintenance instructions. Only the schedule of the report is reproduced in this AC.

PROCEDURE	FREQUENCY Daily	Weekly	Monthly
(a) Compare shop altimeter calibrating barometers with each other (and with shop standard barometer, if used).	X		
(b) Check reference vacuum of calibrating barometer.	X		
(c) Visually check packing glands and cistern seals for leaks.	X		
(d) Check electronic scanning devices.	X		
(e) Make comparision reading with the shop standard barometer. In lieu thereof, a comparision can be made between shop barometers and the nearest National Weather Service mercurial barometer.		X	
(f) Test cistern for leaks.		X	
(g) Check temperature and gravity compensating devices (other than those on barometers using lead screws for readout) for accuracy.			X*
(h) Check zero of readout device on barometers using lead screw.			X**

*Must also be checked after overhaul
**Must also be checked after glassware has been washed and mercury changed.

9. SHOP PRACTICE. Good shop practice should be adhered to regardless of the type of test equipment being used. Consideration should be given to the following:

a. Use clean, dry air or nitrogen in the test equipment to prevent contamination by airborne polluting agents such as industrial smoke and dust. Isolation filters should be considered. Minor fouling of the mercury or mercury droplets adhering to the tube will make the barometer inaccurate.

b. Use the barometer system in a clean, vibration-free area.

c. Make corrections for significant differences in height between the barometer reservoir and the vacuum chamber in which tests are conducted.

d. A barometer located near a radiator or window will exhibit excessive temperature fluctuations.

e. If two or more barometers are present in the shop, use comparison graphs to readily show any deterioration of one of the instruments.

f. Use virgin, clean, triple-distilled mercury of instrument grade, or American Chemical Society (ACS) reagent grade in all manometers. Mercury is toxic - take care when handling it.

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