AC NO: 43-6A

DATE: 11/11/77

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: AUTOMATIC PRESSURE ALTITUDE ENCODING SYSTEMS AND TRANSPONDERS MAINTENANCE AND INSPECTION PRACTICES

1. PURPOSE. This circular provides information concerning the installation of encoding altimeters based upon recently acquired operating experience and on the maintenance of ATC transponders.

2. CANCELLATION. AC 43-6 dated 9/19/74 is cancelled.

3. REFERENCES. FAR 91.177(a), FAR 43 Appendix F, FAR 91.36(b), FAR 37.197 (TSO C-88), and FAR 37.180 (TSO C-74).

4. BACKGROUND. Field experience has demonstrated the following problems have occurred following the installation of an encoding altimeter.

   a. Failure to ensure that the transponder and/or encoding altimeter are compatible with the altitude operating envelope of the aircraft in which they are installed.

   b. Installation not based upon approved data.

   c. Installation of servo controlled (nonreverting) altimeters without an adequate backup provision in the event of total electrical failure.

   d. Improper functional checkout after alteration (e.g., failure to perform a static system check or failure to correlate the altimeter indicated altitude to the altitude information being transmitted).

5. INSTALLATION. Any appropriately rated person (as specified in FAR 43.3) may perform an aircraft alteration which consists of installing an encoding altimeter, blind encoder or transponder system. The approval of the aircraft for return to service, however, can only be given by those persons authorized in FAR 43.7 after a suitable functional check has been performed, where applicable, in order to determine that the altered system will perform its intended function(s).

Initiated by: AFS-804

For those situations where the services of a certificated repair station are utilized for the installation of an automatic pressure altitude reporting system, or for any portion of such a system, we have listed several installation situations and the repair station ratings necessary to cover the particular situation. Any special or unusual situations, other than those listed, should be resolved with the local FAA district office.

Types of Installation	Repair Station Ratings
Encoding Altimeter	Airframe (A), Radio Class 3 (R-3), Instrument Class 1 (I-1), or Specialized Service (SS)
Digitizer (blind encoder)	A, R-3, I-1, or SS
Transponder and Encoding Altimeter	A, R-3, I-1, or SS

Any of the above listed repair station ratings could also be limited to specific make(s) and model(s) airframe, transponder, or encoding altimeter. Each installation should be made in accordance with approved data and the work performed or supervised by appropriately certificated personnel. Before attempting the installation of an aircraft altitude reporting system, the installing facility should assure the following:

a. The required test equipment, technical data, and qualified personnel are available to perform or arrange to have performed a static system check, as required by FAR 91.170, to verify the integrity of the newly installed or altered system.

b. The capability exists to determine the actual altitude information being transmitted by the transponder as referenced against the pilot's altimeter (altitude reference).

c. Appropriately rated or qualified personnel are available to perform any necessary structural modifications.

d. The facility is authorized to approve the aircraft for return to service after all alterations and testing are completed.

e. The data approval necessary for the substitution of an encoding altimeter for the altimeter currently shown on the aircraft's "approved equipment listing," is available.

6. APPROVED DATA ALTERNATIVES.

a. Manufacturer Drawings/Service Bulletins (FAA Approved) which list

approved replacement/substitution encoding altimeters or instructions for the installation of certain digitizers (blind encoders) may be used.

b. Where no prior approval has been given, a supplemental type certificate (STC) or field approval should be requested. The person approving the aircraft for return to service should comply with all provisions of FAR 43.9.

c. Field Approvals. In some cases, the facility making the installation meets the qualifications in paragraphs 5. a. through 5. e. and has demonstrated to the Administrator its ability to install this equipment on a representative number of similar type installations through prior field approvals. References to these previous approvals on FAA Form 337 (Major Repair and Alteration, Airframe, Powerplant, Propeller, or Appliance) would constitute previously approved data and may not require a separate field approval.

d. Alterations using data which do not differ appreciably from a previously approved alteration may not require new or additional approval. When questions arise, contact your local FAA field office for guidance.

7. TESTS AND INSPECTIONS. The purpose of FAR 91.177, ATC Transponder Tests and Inspections, is to ensure the use of a properly operating transponder in the National Airspace System. The following information sets forth one means, but not the only means, of demonstrating compliance with the maintenance requirements contained in FAR 91.177 and prescribed in FAR 43, Appendix F, governing the testing of ATC transponders.

a. Transponder tests and inspections FAR 91.177, FAR 43, Appendix F.

(1) Reply radio frequency. Interrogate the transponder and verify, by use of any frequency measuring technique, that the reply frequency is 1090+3 MHz. The accuracy of the measuring device should be at least $\pm$.5 MHz. In the event the frequency measurement is not conducted by radiated method, necessary compensations should be made for any frequency deviation which may occur due to installation.

(2) Suppression. Interrogate the transponder with a Mode 3/A interrogation signal at a nominal repetition rate of 235 (nominal is considered to be 235$\pm$5 IPS) interrogations per second and at a signal level 3 db above receiver minimum trigger level. Adjust P2 pulse equal in amplitude to P1 pulse and verify that the reply rate is no greater than 3 replies per second. (Percentage of reply should not exceed 1.0 percent.) Adjust P2 pulse amplitude 9 db less than P1 pulse, and verify that the reply rate is at least 211 replies per second.

(3) Receiver sensitivity. With the test set connected to the antenna end of the transmission line, or connected to the antenna terminal of the transponder with a correction for transmission line loss, interrogate the transponder with a Mode 3/A interrogation signal at any repetition rate recommended by the transponder manufacturer. When radiation techniques are used, the interrogation signal repetition rate should be a nominal 235 interrogations per second. This pulse repetition rate was selected to reduce interference to active aircraft in the air traffic control system. Adjust P1 and P3 equal in amplitude and apply a signal level known to be below receiver minimum trigger level (MTL). Increase the signal level until the transponder reply is 211 replies per second (90 percent reply rate). This is the receiver minimum trigger level (MTL). Verify the MTL is between 69 to 77 db below 1 milliwatt. Test equipment attenuator accuracy should be within ±3 db. Repeat the test using a Mode C interrogation signal and verify the MTL is within 1 db of the reading obtained on Mode 3/A.

b. Bench Tests. Transponders may be bench tested for compliance with FAR 43, Appendix F, and functionally checked after installation in the aircraft, provided that during the bench check the transponder operates into an antenna system presenting the same VSWR characteristics and cable attenuation as that in the airplane.

c. Portable line test equipment. Portable line test equipment may be used for any of the tests specified in paragraph 7 a. provided it is maintained under a regular calibration program acceptable to the Administrator. If portable test equipment is used with appropriate coupling to the aircraft antenna system, an additional 3 db tolerance is permitted to compensate for antenna coupling errors during receiver sensitivity measurements.

If the portable test equipment has a fixed R.F. output, it may be necessary to use a fixed precision attenuator in conjunction with a variable precision attenuator to determine the receiver minimum triggering level. Such attenuators should be maintained on a regular calibration schedule and have appropriate calibration charts. The repair facility is responsible for assuring the accuracy of the attenuators.

d. Removal and Replacement. Removal and replacement of transponder units, during the two-year period subsequent to testing in accordance with FAR 91.177, will not invalidate the test results. A repaired or replacement transponder may be installed without repeating FAR 91.177, provided the unit being installed has been tested by the agency for reply radio frequency, suppression, and receiver sensitivity in accordance with the manufacturer's instructions.

e. Maintenance Records. Maintenance record entries should be made in accordance with FAR 43.9.

8. AN ACCEPTABLE MEANS OF TESTING FOR COMPLIANCE WITH FAR 91.36(b).

a. FAR 91.36, Data correspondence between automatically reported pressure altitude data and the pilot's altitude reference states, in part, that:

> No person may operate any automatic pressure altitude reporting equipment associated with a radar beacon transponder --
>
> (b) Unless, as installed, that equipment was tested and calibrated to transmit altitude data corresponding within 125 feet (on a 95 percent probability basis) of the indicated or calibrated datum of the altimeter normally used to maintain flight altitude, with that altimeter referenced to 29.92 inches of mercury.

b. The following simplified test of the automatic pressure altitude transmission system data correspondence, as required by FAR 91.36(b), can be used to demonstrate compliance of a newly installed altitude reporting system. Connect the transponder test set directly to the antenna terminal of the transponder, or to the antenna end of the transmission line (so as not to radiate an interfering signal).

(1) All aircraft which have altitude reporting transponders installed (Mode C capability) should be checked to assure that only the framing pulses (F1 and F2) are transmitted in response to Mode C interrogations, when the altitude reporting feature is turned off.

(2) All transponder-equipped aircraft which have altitude reporting equipment installed should be tested at the flight levels set forth in Appendix 1 (Table 1 for encoding altimeters or Table 2 for blind encoders), by alternately interrogating the transponder on Mode 3/A and Mode C and observing either the pulse train output, or the decoded altitude display on those test sets capable of decoding the pulse train.

(3) Set the altimeter normally used to maintain flight altitude to 29.92 inches of mercury (1013.2 millibars).

(4) Select the test points called out in Tables 1 or 2 (sea level) and the maximum operating altitude of the aircraft. Test each of these test points for increasing altitude and for decreasing altitude.

(5) Apply pressure to the static system, or directly to altimeter.

If separate static systems serve altimeters and digitizers, simultaneously apply identical pressure to each. Approach each test point slowly, decreasing pressure for increasing altitude, and vice versa, until a transition to the test point value occurs in the digital output. Record the pilot's altimeter reading at the instant of transition.

(6) Encoding digitizers, which are separate units (blind encoders) having their own individual pressure sensor, should be checked against the pilot's altimeter upon installation to ensure that the overall system accuracy of FAR 91.36(b) is met. It will be necessary to perform a check of the system accuracy any time either the encoder or altimeter is replaced. Matched components should be identified and the calibration information recorded.

(a) The matched set (blind encoder and altimeter) should be shop tested and calibrated at ambient temperature.

(b) This abbreviated environmental temperature test is only valid when both units are installed in the same environmental location (i.e., both units mounted on instrument panel or in near vicinity of one another). Other installations require FAA Engineering approval.

(7) In addition, where an installation allows for the blind encoder to be connected to a static source other than the static source connected to the altimeter normally used to maintain flight altitude, the following corrections should be applied during certification of compliance to FAR 91.36(b):

(a) The difference between both static sources should be determined (in flight) and recorded. (This information may be available from the original aircraft certification data.)

(b) The differences determined in (a) above (static source errors) should be used as a correction factor when checking for compliance with FAR 91.36(b).

9. TESTING PRECAUTIONS AND INSTALLATION RECOMMENDATIONS.

a. Adequate precautions should be taken to avoid damage to any instruments connected to the aircraft pitot-static system, either by "TEE" connecting the pitot and static lines together, or by connecting the vacuum source directly to the altimeter and encoder when separate units are involved. The aircraft static system should be returned to ambient pressures prior to disconnecting pneumatic test equipment from aircraft/instruments. After completion of all testing, a leakage test of the static system should be performed if the static system has been opened.

b. In aircraft equipped with plastic pitot or static lines, adequate precaution should be taken to avoid collapsing the plastic tubing at the higher differential pressures.

c. The blind encoder or encoding altimeter should have an altitude encoding capability up to at least the service ceiling or maximum certificated altitude of the aircraft in which it is installed. If the altitude reporting system will not function throughout the aircraft operational envelope (up to the aircraft maximum operating altitude), a placard stating the aircraft altitude limitation should be installed.

d. The barometric correlation adjustment should not be adjusted in the field; changing this adjustment will nullify the correspondence between altimeter and its encoding digitizer or the associated blind encoder.

e. Some altimeters may exhibit a tendency toward jerkiness (when not under vibration). If the jerkiness appears excessive, then the friction test should be conducted as described in FAR 43, Appendix E(b)(iv).

f. Automatic altitude reporting system installations (either blind encoder or encoding altimeter types) may be shop tested for correspondence (using the transponder decoded output) and then functionally checked after installation in the aircraft, provided the same transponder encoding digitizer, altimeter and wiring harness, and coaxial cable are either installed in the aircraft or accurately compensated for.

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APPENDIX 1 - TABLES AND GLOSSARY

TABLE 1 ALTITUDE INFORMATION PULSE POSITIONS
(Encoding Altimeters)

RANGE (1)	PULSE POSITION (0 to 1 in a pulse position denotes absence or presence of a pulse, respectively)											
INCREMENTS (FEET)	D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4	Correspondence Tolerance
-50 to +50 (2)	0	0	0	0	0	0	1	1	0	1	0	(1)
950 to 1050	0	0	0	0	0	1	1	0	0	1	0	
1050 to 1150	0	0	0	0	0	1	1	0	1	1	0	
1250 to 1350	0	0	0	0	0	1	1	1	1	0	0	
1750 to 1850	0	0	0	0	0	1	0	1	0	0	1	
2550 to 2650	0	0	0	0	0	1	0	0	0	1	1	
2750 to 2850	0	0	0	0	1	1	0	0	0	0	1	
6750 to 6850	0	0	0	1	1	0	0	0	0	0	1	
14750 to 14850 (2)	0	0	1	1	0	0	0	0	0	0	1	
30750 to 30850 (3) Max Oper Alt	0	1	1	0	0	0	0	0	0	0	1	

NOTES:

(1) Reference FAR 43, Appendix E.

(2) Identifies transponder pulse positions and altitude limits necessary to check Class 1B and 2B transponders (equipment designed to operate at 15,000 feet and below; reference FAR 37.180).

(3) Identifies transponder pulse positions and altitude limits necessary to check Class 1A and 2A transponders (that equipment designed to operate above 15,000 feet; reference FAR 37.180).

TABLE 2 ALTITUDE INFORMATION PULSE POSITION
(Blind Encoders)

RANGE INCREMENTS (FEET)	PULSE POSITION (0 to 1 in a pulse position denotes absence or presence of a pulse, respectively)												
	D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4	(1) Altimeter Scale Error Tolerance	Correspondence Tolerance
-1050 to -950	0	0	0	0	0	0	0	0	0	1	0	±20	(1)
-50 to +50	0	0	0	0	0	0	1	1	0	1	0	±20	
450 to 550	0	0	0	0	0	0	1	0	0	1	0	±20	
950 to 1050	0	0	0	0	0	1	1	0	0	1	0	±20	
1050 to 1150	0	0	0	0	0	1	1	0	1	1	0	±20	
1250 to 1350	0	0	0	0	0	1	1	1	1	0	0	±23	
1450 to 1550	0	0	0	0	0	1	1	1	0	1	0	±25	
1750 to 1850	0	0	0	0	0	1	0	1	0	0	1	±27	
1950 to 2050	0	0	0	0	0	1	0	1	0	1	0	±30	
2550 to 2650	0	0	0	0	0	1	0	0	0	1	1	±30	
2650 to 2750	0	0	0	0	0	1	0	0	0	0	1	±30	
2950 to 3050	0	0	0	0	1	1	0	0	0	1	0	±30	
3950 to 4050	0	0	0	0	1	1	1	1	0	1	0	±35	
5950 to 6050	0	0	0	0	1	0	0	1	0	1	0	±40	
6750 to 6850	0	0	0	1	1	0	0	0	0	0	1	±48	
7950 to 8050	0	0	0	1	1	0	1	1	0	1	0	±60	
9960 to 10050	0	0	0	1	1	1	0	1	0	1	0	±80	
11950 to 12050	0	0	0	1	0	1	1	1	0	1	0	±90	
13950 to 14050	0	0	0	1	0	0	0	1	0	1	0	±100	
14750 to 14850	0	0	1	1	0	0	0	0	0	0	1	±104	
15959 to 16050	0	0	1	1	0	0	1	1	0	1	0	±110	
17950 to 18050	0	0	1	1	0	1	0	1	0	1	0	±120	
19950 to 20050	0	0	1	1	1	1	1	1	0	1	0	±130	
21950 to 22050	0	0	1	1	1	0	0	1	0	1	0	±140	
24950 to 25050	0	0	1	0	1	1	1	0	0	1	0	±155	
29950 to 30050	0	0	1	0	0	0	0	1	0	1	0	±180	
30750 to 30850	0	1	1	0	0	0	0	0	0	0	1	±184	
34950 to 35050	0	1	1	0	1	1	0	0	0	1	0	±205	
39950 to 40050	0	1	1	1	1	0	1	1	0	1	0	±230	
44950 to 45050	0	1	1	1	0	0	1	0	0	1	0	±255	
49950 to 50050	0	1	0	1	0	1	0	1	0	1	0	±280	

Glossary of Terms:

1. Approved: Unless used with reference to another person, means approved by the Administrator.

2. Blind Encoder (Digitizer): An altitude reporting encoder which is pressure operated, having no altitude display; is not part of a pressure/altitude indicating device or system; does not contain an external means for barometric setting; supplies the altitude reporting information to the A.T.C. transponder.

3. Data: Means any drawings, sketches, stress analysis, reports, operating limitations, or photographs which support or describe an alteration.

4. Encoding Altimeter (Pressure Altitude): An altitude indicator which displays to the pilot the pressure/altitude sensed by the device and produces an altitude reporting digital code output.

5. Indicated Datum of the Altimeter: Is the altitude displayed by the altimeter when an ideal absolute pressure is applied to the sensing member of the altimeter, and not corrected for instrument error (scale error), nor corrected for static source error.

6. Calibrated Datum of the Altimeter: Is the correction applied via a specific calibration card applicable to a specific altimeter to correct for instrument error (scale error) only.

7. Correspondence: Is the altimeter's displayed pressure/altitude (indicated or calibrated datum) compared to encoded altitude output from the blind encoder or encoding altimeter; for the entire period (from the moment that the code output changes to a value to the moment the code output changes to the next value while the pressure/altitude is changing) that output code remains at the same digital information.

8. Matched Components: Consist of an altimeter and a blind encoder which have been tested and calibrated together and, as a combination, meet the requirements of FAR 91.36(b).