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DATE: 9/19/74

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

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

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

2. CANCELLATION. AC 43-204A dated January 11, 1974, and AC 20-58A dated April 28, 1969, are cancelled.

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

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 dual servo controlled (non-reverting) 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 pitot-static system check or failure to correlate the altimeter indicated altitude to the altitude 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 the altered system shall perform its intended functions(s).

Initiated by: AFS-350

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 and 4 (I-1, -4) or Specialized Service (SS)
Digitizer (blind encoder)	A, R-3, I-4, or SS
Transponder and Encoding Altimeter	A, R-3, I-1, -4; or SS

Any of the above listed repair station ratings could also be limited to a 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 pitot-static system check, as required by FAR 91.170 in order 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 (the proper ratings for the type installation).

e. The approval necessary for the substitution of an encoding altimeter for the altimeter currently shown on the aircraft "approved equipment listing." In some cases the airframe manufacturers may have received FAA approval for a replacement encoding altimeter and issued an approved service bulletin. Where no prior approval has been given, a supplemental type certificate (STC) should be requested or a properly executed Major Repair and Alteration (Airframe, Powerplant, Propeller, or Appliance) FAA Form 337 OMB No. 04-R060.1 indicating field approval should be used. Each person approving the aircraft for return to service should comply with the provisions of FAR 43.9 as to content, form, and disposition of the record.

6. TESTS AND INSPECTIONS. 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±3MHz. The accuracy of the measuring device should be at least ± .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 ± 5 IPS) interrogations per second and at a signal level 3db 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. (Percertage of reply should not exceed 1.0 percent). Adjust P2 pulse amplitude 9db less than P1 pulse and verify that the reply rate is at least 211 replies per second (percentage of reply rate a minimum of 90 percent).

(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 and 77 db below 1 milliwatt. Test equipment attenuator accuracy should be within ± 3db. Repeat the test using a Mode C interrogation signal and verify the MTL is within 1db of the reading obtained on Mode 3/A.

(4) When transponders are bench-checked, the manufacturer's recommendations should be used.

b. Portable line test equipment. Portable line test equipment may be used for any of the tests specified in paragraph 6 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 3db 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 in order 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.

7. AN ACCEPTABLE MEANS OF TESTING FOR COMPLIANCE WITH FAR 91.36(b). The replacement of a combination device (digitizer and altitude display; i.e., encoding altimeter) bearing the "TSO C-88" marking does not need any testing(other than a functional ground check upon installation) since the equipment manufacturer has already certified that the combination device meets the standards of FAR 91.36(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.

a. Procedure. With the aircraft on the ground 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 the framing pulses only (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 encoders installed should be tested at the flight levels set forth in Table 1 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 Table 1 between zero (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. If separate static systems serve altimeters and digitizers, apply identical pressure simultaneously 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 in the digitizer.

(6) The installation is acceptable if the altimeter normally used to maintain flight altitude corresponds with the output of the digitizer within ± 125 feet at each test point and within ± 87 feet at no less than 70 percent of the test points.

(7) Encoding digitizers which are separate units (blind encoders) having their own individual aneroid 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 anytime either the encoder or altimeter is replaced. Matched units should be identified and the calibration information recorded.

b. Table No. 2 represents one method of demonstrating compliance with FAR 91.36(b) when dealing with a blind encoder and its associated altimeter.

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TABLE 1 ALTITUDE INFORMATION PULSE POSITIONS

(Encoding Altimeters)

RANGE (1) 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
-50 to +50			0	0	0	0	0	0	1	1	0	1	0
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)(4)	0	0	1	1	0	0	0	0	0	0	1
30750 to 30850		(3)(4)	0	1	1	0	0	0	0	0	0	0	1
Max Oper Alt													

NOTES:

(1) Adequate precaution should be taken to avoid damage to any instruments connected to the aircraft pitot-static system. The aircraft pitot-static system should be returned to ambient pressures prior to disconnecting pneumatic test equipment from aircraft/instruments.

(2) Identifies transponder pulse positions necessary to check Class 1B and 2B transponders (equipment designed to operate at 15000 feet and below).

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

(4) In aircraft equipped with plastic pitot or static lines adequate precaution should be taken to avoid collapsing the plastic tubing at the higher pressured differentials.

TABLE 2 ALTITUDE INFORMATION PULSE POSITIONS
(Blind Encoders)

Altitude Feet	Inches of Mercury Equivalent Pressure	PULSE POSITION (0 to 1 in a pulse position denotes absence or presence of a pulse, respectively)											(1)Altimeter Tolerance in feet	(2)Encoded Information Tolerance
		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4		
-1000	31.018	0	0	0	0	0	0	0	0	0	1	0	± 20	± 125 ft.
0	29.9213	0	0	0	0	0	0	1	1	0	1	0	± 20	± 125 ft.
500	29.385	0	0	0	0	0	0	1	0	0	1	0	± 20	± 125 ft.
1000	28.856	0	0	0	0	0	1	1	0	0	1	0	± 20	± 125 ft.
1100	28.750	0	0	0	0	0	1	1	0	1	1	0	± 20	± 125 ft.
1300	28.542	0	0	0	0	0	1	1	1	1	0	0	± 23	± 125 ft.
1500	28.335	0	0	0	0	0	1	1	1	0	1	0	± 25	± 125 ft.
1800	28.025	0	0	0	0	0	1	0	1	0	0	1	± 27	± 125 ft.
2000	27.821	0	0	0	0	0	1	0	1	0	1	0	± 30	± 125 ft.
2600	27.215	0	0	0	0	0	1	0	0	0	1	1	± 30	± 125 ft.
2700	27.115	0	0	0	0	0	1	0	0	0	0	1	± 30	± 125 ft.
3000	26.817	0	0	0	0	1	1	0	0	0	1	0	± 30	± 125 ft.
4000	25.842	0	0	0	0	1	1	1	1	0	1	0	± 35	± 125 ft.
6000	23.978	0	0	0	0	1	0	0	1	0	1	0	± 40	± 125 ft.
6800	23.264	0	0	0	1	1	0	0	0	0	0	1	± 48	± 125 ft.
8000	22.225	0	0	0	1	1	0	1	1	0	1	0	± 60	± 125 ft.
10000	20.577	0	0	0	1	1	1	0	1	0	1	0	± 80	± 125 ft.
12000	19.029	0	0	0	1	0	1	1	1	0	1	0	± 90	± 125 ft.
14000	17.577	0	0	0	1	0	0	0	1	0	1	0	± 100	± 125 ft.
14800	17.022	0	0	1	1	0	0	0	0	0	0	1	± 104	± 125 ft.
16000	16.216	0	0	1	1	0	0	1	1	0	1	0	± 110	± 125 ft.
18000	14.942	0	0	1	1	0	1	0	1	0	1	0	± 120	± 125 ft.
20000	13.750	0	0	1	1	1	1	1	1	0	1	0	± 130	± 125 ft.
22000	12.636	0	0	1	1	1	0	0	1	0	1	0	± 140	± 125 ft.
25000	11.104	0	0	1	0	1	1	1	0	0	1	0	± 155	± 125 ft.
30000	8.885	0	0	1	0	0	0	0	1	0	1	0	± 180	± 125 ft.
30800	8.567	0	1	1	0	0	0	0	0	0	0	1	± 184	± 125 ft.
35000	7.041	0	1	1	0	1	1	0	0	0	1	0	± 205	± 125 ft.
40000	5.538	0	1	1	1	1	0	1	1	0	1	0	± 230	± 125 ft.
45000	4.355	0	1	1	1	0	0	1	0	0	1	0	± 255	± 125 ft.
50000	3.425	0	1	0	1	0	1	0	1	0	1	0	± 280	± 125 ft.

NOTES:

(1) Reference FAR 43 Appendix E

(2) The displayed indicated pressure altitude shall correspond to the encoded (digitizer) output value to within ± 125 feet during the entire interval that the encoded output remains at the test value. The correspondence tolerance of 125 feet must be maintained throughout the stated altitude and environmental range.