NOTE: This amendment contains TSO-C88

Advance Copy

Title 14—AERONAUTICS AND SPACE

Chapter I—Federal Aviation Agency

[Docket No. 7269; Amdt. No. 37-11]

PART 37—TECHNICAL STANDARD ORDER AUTHORIZATIONS

Automatic Pressure Altitude Digitizer Equipment, TSO-C88

The purpose of this amendment is to establish the minimum performance standards that 100-foot increment digitizing equipment must meet in order for a manufacturer to identify it with the applicable Technical Standard Order (TSO) designation. This action was published as a notice of proposed rule making (31 F.R. 5454, Apr. 6, 1966), and circulated as Notice No. 66-11.

Digitizer equipment comprises only one element of the complete system required for automatic altitude reporting. By separate rule-making action, the Agency is also revising the present minimum performance standard (TSO-C74a) for ATC transponder equipment by providing for an automatic altitude reply capability.

As stated in Notice 66-11, the Datex Corp., Monrovia, Calif., owns U.S. Patent No. 3,165,731 issued January 12, 1965, in the name of Carl P. Spaulding, and claims it covers digitizer equipment employing the parallel digital code set forth in the International (ICAO) Code for SSR Pressure Altitude Transmission (ICAO International Standards and Recommended Practices; Aeronautical Telecommunications, Annex 10, Volume I, Part I, Equipment and Systems).

The FAA takes no position on whether the patent (1) is valid, or (2) covers the ICAO Code so that use of the code might infringe the patent. However, in order to assure that the equipment covered by the TSO will be readily available at reasonable cost, the FAA has obtained an agreement for the granting of nonexclusive licenses on reasonable terms for the manufacture, use, or sale of the equipment claimed to be covered by the patent.

Numerous comments have been received in response to Notice 66-11. The more pertinent of these comments, together with the changes in the proposal resulting therefrom, are discussed in detail hereinafter.

Comments have been received concerning the applicability provision of the TSO, suggesting that the TSO should be applicable only to air carriers and that while minimum standards are needed to prevent system degradation, they should be issued in some form other than a TSO. In response to this comment, the Agency considers it appropriate to point out once again that the performance standards set forth in this TSO are mandatory only for equipment manufacturers who wish to obtain TSO authorization covering digitizer equipment. As the preamble to Notice 66-11 stated, this TSO is not directed to persons who install or use digitizer equipment in aircraft. Therefore, reference to "air carriers" in the applicability provision of the TSO would be both meaningless and confusing.

At the present time, TSO approval of a digitizer is not necessary in order to obtain approval for the installation of the digitizer and such installation may be made (notwithstanding the adoption of this TSO) without necessarily meeting the TSO performance standards. However, as the Agency indicated in Advance Notice 65-9 (Airborne Radio Navigation and Communication Equipment for General Aviation Aircraft, and related Considerations) all digitizer equipment must be capable of meeting a minimum level of performance (although not necessarily those in this TSO) if airborne equipment interference is to be avoided and safe passage of aircraft in the National Airspace System is to be realized. In that notice the Agency proposed, among other things, the development of "essential system characteristics" and "minimum performance standards" for equipment providing an automatic altitude reporting capability. Essential system characteristics, as outlined in that notice, are those the equipment must have if its operation is not to impair the use of the airspace environment by others, nor create a hazard. Minimum performance standards are those the equipment must meet to insure acceptable accuracy for IFR operations in controlled airspace. These characteristics and standards are still under development by the Agency and the matters raised by the subject comments will be considered in developing the necessary standards and characteristics. When completed, they will be the subject of a separate notice of proposed rule-making action. The present TSO action is in no way indicative of the course of action that the Agency may take in future rule making under Notice 65-9.

A comment was also made that paragraph 3.6(b) of the proposed Federal Aviation Standard should be amended to make it clear that separate warning of power failure of the digitizer alone, when it is part of a larger system, is not required. The Agency agrees with this comment and paragraph 3.6(b) now requires that the equipment must provide for operation of a warning device in the event of a loss of system power. Another comment objected to monitoring power in equipment where the digitizer is supplied power from the transponder, pointing out that such power failure is the least likely to occur of all kinds of possible failures and when it does, it becomes immediately known to the ground controller by the absence of altitude reply. However, it appears that the commentator overlooked the parenthetical statement in paragraph 3.6 which would exclude equipment in which the transponder furnishes excitation power to the digitizer code wheel to form the electrical code output for return to the transponder. The standard applies to the input electrical power, if used, which moves the encoder shaft in direct relation to pressure altitude. To prevent any possible confusion in this regard, the Agency has amended the first sentence to make it clear that the electrical power referred to is the electrical power used to drive the digitizer.

In a comment concerning the performance of the digitizer equipment it was suggested that to avoid misconstruction, the parenthetical statement "based on 29.9213 inches of mercury absolute" set forth in paragraph 3.7.3 should be changed to read "when corrected for the difference between the altimeter barometric setting and 29.9213 inches of mercury absolute." The Agency agrees with this suggestion since it is possible to interpret the proposed standard as requiring the display to have a fixed datum reference of 29.9213 inches of mercury. The Standard has been changed accordingly. In this connection, another comment stated that paragraph 3.7.3 is restrictive and does not recognize individual equipment tolerances in the total system tolerance. Two examples are presented to illustrate this point. The first example compares a pilot's altimeter display from an air data computer with the digitizer output and concludes that ±25-feet tolerance cannot be met and must be greater than the ±50 feet specified in paragraph 3.7.2. The second example again compares a pilot's altimeter with the digitized output concluding that ±125-feet correspondence cannot be achieved in view of the large errors possible in the pilot's altimeter itself which is not considered. Neither of these examples, however, illustrate the requirements of this Standard since it is concerned only with the reproduction and display of the pressure altitude as actually fed to the digitizer and involves a relatively simple device which can easily do this within ±25 feet. The ±125-feet correspondence tolerance involves adding to ±25 feet the total tolerance of the digitizing process which is easily performed within ±100 feet. Aneroid and other instrument errors as assumed in the comment are not involved in this process.

Various comments were made concerning the provisions of paragraph 3.9—*Radio Interference*. The Agency in general concurs with these comments and agrees that the proposed Standard places an unrealistic burden on the digitizer manufacturer to effectively control all likely combinations of system installation factors including associated quipment interface relations. It is recognized that the airplane system modifier must make the complete automatic altitude reporting system work properly and it can be expected that should an RF interference problem be encountered, he is in the best position to incorporate effec-

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tive suppression features. This coupled with RF interference testing required of the transponder, which normally incorporates suppression filtering of the digitizer brush contact noise, should adequately provide for handling digitzer produced RF interference energy should this occur. Therefore, the proposed requirement covering radio interference has been eliminated from the Standard.

A comment recommended that the test condition should specify the use of geometric altitude tables of the U.S. standard atmosphere since both geometric and geopotential tables are provided. However, the Agency considers that it would be incorrect to use the geometric altitude (Z) tables as suggested because pressure sensitive altimeters which furnish altitude data to the digitizer indicate geopotential altitude (H) and not a physical height (as with a tape measure). The difference, though small at low altitudes, is 120 feet at 50,000 feet (H). To clarify the matter, the Standard has been amended to specify "geopotential altitude tables."

With respect to section 5—*Required tests, of* the proposed Standard, it was suggested that the table be changed to allow testing at the transition point, either "leading" or "lagging," e.g., the 0 digital output could be checked at +50 ±50 feet or at −50±50 feet. The Agency agrees that acceptable results could be obtained by testing for transition from either direction, e.g., by slowly increasing the pressure input (leading) or by slowly decreasing the input (lagging). The table has therefore been changed to permit manufacturers the choice of test direction as suggested. It was further suggested that the Standard should be revised to apply to digital type air data computers which provide a digitized output by computation and conversion of the computation. It was also pointed out that there seems to be no reason to specify in paragraph 5.1.1 an altimeter tolerance of ±50 feet; it is more desirable to specify a ±50-foot tolerance between the output to the altimeter and the digitizer output. In response to this comment, it should be made clear that the Standard is not directed to one kind of digitizer and it is not intended to exclude any equipment which falls within the definition set forth in paragraph 1.2. Moreover, paragraph 5.1.1 supplements the Standard Test Procedures when applied to those packaged combination devices where it is impractical to perform transition point accuracy check tests except by directly applying air pressure. The Standard permits allowance for the instrument errors involved. For combination devices like air data computers, the same considerations may apply. In such cases, errors of pressure measurement, computation, and presentation of altitude equivalent input to the digitizing device are equally involved. The suggested ±50-foot tolerance (between the output to the altimeter and the digitizer output) for combination devices such as air data computers is apparently based on the assumption that under paragraph 5.1.1 of the Standard, the input pressure must be used as the altitude-equivalent input in showing compliance with the test in paragraph 5.1. This is not so, and to avoid this kind of misunderstanding, paragraph 5.1.1 has been revised to state that for combination devices, if pressure is used as the altitude-equivalent input in showing compliance with the Standard, the tolerance specified may be increased by the applicable altimeter tolerance.

A comment was received concerning the need to provide sufficient coverage in the TSO for multiple transponder usage and suggested three specific factors as important to fully insure compatibility. This would require the addition of specific design requirements concerning these factors. As proposed, the Standard specifies that when compatibility and matching of characteristics with other airborne equipment is necessary, the digitizer must be so identified and limitations and installation proceedings established to accomplish this. Since the addition of detailed design standards for this purpose would unduly restrict designers and hamper design development, the Agency does not consider that a change in Standard as suggested is appropriate.

A suggestion was also made that the altimeter system that controls the automatic pressure altitude digitizer equipment should have the accuracy of the current state-of-the-art. Thus, as expressly stated in the proposal, where the digitizer forms part of an aircraft system such as an altimeter, the Standard applies only to the digitizing equipment. The altimeter is covered by other airworthiness requirements and any increase in the minimums applicable to such altimeters would require action to those requirements and not this TSO.

A comment was made that the Federal Aviation Agency should do something to upgrade altimetry systems which feed altitude information to the digitizer-transponder to preclude the use of an unacceptable altimetry system causing such differences in the flight plan and ground display as to negate the prime purpose of the system. While the question of upgrading of altimetry systems is beyond the scope of Notice 66–11, which deals only with devices that transform available altitude data into signals for transmission to ground stations, it should be pointed out that rules have been adopted aimed at improving altimetry (Amdts. 23–1, 25–5, 43–2, 91–20). Moreover, as the preamble to those regulations indicate, future rule making designed to improve altimetry is under consideration. It was further suggested that the Federal Aviation Agency should require a pilot readout display for the system, not merely indicate that one might be included. The matter of a required pilot display of the altitude information being reported to the ground is an installation problem and is outside the scope of this notice. However, it will be considered in connection with future and separate rule making concerning transponder-digitizer system installations.

A suggestion was made that the performance requirements of paragraph 3.7.2 should be changed to make it clear that by the words "same device" the Agency includes properly identified matched components. The Agency sees merit in this suggestion and the paragraph.

In response to comments, the Agency has made several minor changes to paragraph 3.7.3 of the proposal. In this connection, the word "cockpit" has been removed because parts of the system could be located outside the cockpit. Since the terms "pressure analogue information" and "altitude" mean the same thing and since the term "altitude" is more commonly used and more likely to be understood, the Agency considers it appropriate to use "altitude" in place of "pressure analogue information." The words "to the pilot" as used in the third sentence of that paragraph are inconsistent with the reference to a "display in the cockpit" as used in the first sentence. Therefore, the phrase "to the pilot" has been deleted.

Since a prototype article is not necessarily similar to the production article, the requirements of paragraph 5.1 have been revised to make it clear that the article to be tested must be a prototype of the production article.

Other changes of an editorial or clarifying nature have been made to the TSO as proposed. They are not substantive and do not impose any additional burden on regulated persons.

Interested persons have been afforded the opportunity to participate in the making of this amendment. All relevant material submitted has been fully considered.

(Secs. 313(a), 601, Federal Aviation Act of 1958; 49 U.S.C. 1354(a), 1421)

In consideration of the foregoing, Part 37 of the Federal Aviation Regulations is amended by adding a new § 37.197 to read as set forth hereinafter, effective February 10, 1967.

Issued in Washington, D.C., on December 30, 1966.

C. W. WALKER,
Director, Flight Standards Service.

§ 37.197 Automatic pressure altitude digitizer equipment; TSO–C88.

(a) *Applicability.* This technical standard order prescribes the minimum performance standards which automatic pressure altitude digitizer equipment must meet in order to be identified with the applicable TSO marking. New models of the equipment that are to be so identified and that are manufactured on or after February 10, 1967, must meet the "Federal Aviation Agency Standard for Automatic Pressure Altitude Digitizer Equipment," set forth at the end of this section.

(b) *Data requirements.* In accordance with § 37.5, the manufacturer must furnish the Chief, Engineering and Manfacturing Branch, Flight Standards Division, Federal Aviation Agency, in the region in which the manufacturer is located, the following technical data:

(1) Seven copies of the manufacturer's operating instructions, equipment limitations (including environmental conditions, and where compatibility with other airborne equipment is required, identification of all characteristics to assure proper matching) and installation procedures; and

(2) One copy of the manufacturer's test report.

(c) *Previously approved equipment.* Automatic pressure altitude digitizer models approved prior to February 10, 1967, may continue to be manufactured under the provisions of their original approval.

FEDERAL AVIATION AGENCY STANDARD

AUTOMATIC PRESSURE ALTITUDE DIGITIZER EQUIPMENT

1. *Purpose.* 1.1 This document specifies minimum performance standards and test procedures for 100-foot increment automatic altitude digitizing equipment which is to be approved under this Standard.

1.2 The digitizer equipment is defined as the combination of components needed for conversion of an input related to pressure altitude into the parallel digital code set forth in the International (ICAO) Standard Code for SSR Pressure Altitude Transmission.

2. *General requirements.* 2.1 To be eligible for approval under a TSO authorization, each automatic altitude reporting digitizer equipment manufactured must comply with the requirements of this Standard up to its maximum range as indicated on the equipment nameplate.

2.2 The digitized altitude output must be in accordance with the International (ICAO) Standard Code for SSR Pressure Altitude Transmission contained in ICAO International Standards and Recommended Practices; Aeronautical Telecommunications, Annex 10, Volume I, Part I, Equipment and Systems. This ICAO code is the same as specified in the U.S. National Standard for Common System Component Characteristics for the IFF Mark X (SIF)/Air Traffic Control Radar Beacon System SIF/ATCRBS as amended December 27, 1963.

2.3 In those cases where the digitizing equipment forms part of an aircraft system such as an altimeter, an air data computer, or an ATC transponder, this Standard applies only to the digitizing equipment element as defined in paragraph 1.2. The other elements are covered by separate airworthiness requirements, technical standard orders, and operating rules.

3. *Detail requirements*—3.1 *Marking.* In addition to the information required to be marked by § 37.7(d), the information must include the maximum operating altitude.

3.2 *Accessibility of controls.* Controls which are not normally adjusted in flight must not be readily accessible to flight personnel.

3.3 *Compatibility of components.* The automatic altitude digitizer equipment may be qualified either separately or in association with a pressure altitude device and/or an ATC transponder. If the digitizer equipment is qualified separately, but requires matching, it must be identified in a manner that will assure proper matching.

3.4 *Operating range.* The operating range for all digitizers must begin at or below −1,000 feet. The upper limit must be as indicated on equipment nameplate.

3.5 *Pressure datum.* The digitized altitude information transmitted to the transponder must be referenced to 29.9213 inches of mercury, absolute (1013.25 millibars). If the digitizer equipment is part of an altimeter system, the altimeter barometric setting system must not affect this pressure datum.

3.6 *Power loss.* If electrical power is used to drive the digitizer, means must be incorporated in the equipment to detect loss of power or the effect thereof (not including excitation power from the ATC transponder). Under this failure condition the equipment must—

(a) Deactivate the digitizer output in a manner which removes the altitude information pulses; and

(b) Provide for operation of a warning device in the event of loss of digitizer drive power.

3.7 *Performance.* 3.7.1 The digitizer equipment must be capable of functioning and not be adversely affected over the ranges of conditions expected in the environment in which the equipment is to be used.

3.7.2 The digitizer must reproduce its input (related to pressure altitude) in digital form with a tolerance of ±50 feet measured at the transition points. When the pressure altitude information and the digitizer are incorporated in the same device (including properly identified matched components in accordance with § 3.3), the total tolerance of the combination must not exceed the applicable altimeter tolerance plus a maximum digitizing error increment of 50 feet at the transition points.

3.7.3 If the pressure altitude input which drives the digitizer also actuates a display in the cockpit, the system, including the display indicator, must meet the accuracy requirements applicable to the pilot's altimeter. The information fed to the digitizer and the displayed altitude shall agree within ±25 feet. The altitude displayed (when corrected for the difference between the altimeter barometric setting and 29.9213 inches of mercury, absolute) must correspond with the digitized information given to the transponder within ±125 feet on a 95 percent probability basis.

3.8 *Power variation.* The device must properly function with plus or minus 15 percent variation in d.c. voltage and/or plus or minus 10 percent variation in a.c. voltage and plus or minus 5 percent variation in frequency.

4. *Test conditions.* 4.1 Unless otherwise specified herein, all tests must be conducted under the conditions specified in paragraph 3.7.1. Standard pressures used in testing must conform with the U.S. Standard Atmosphere, 1962. (Geopotential altitude tables.)

5. *Required tests.* 5.1 A prototype of a production article of digitizer equipment must be tested to show compliance with the performance requirements in paragraph 3.7 and the additional requirements in paragraph 3.8. After these tests have been completed, the prototype must be subjected to the following test: The digitizer altitude-equivalent input must slowly be changed in altitude, either increasing or decreasing in value, until a transition to the values shown in Column (A) occurs in the digital output. The altitude input reading at transition must be as shown in Column (B), if increasing values of altitude input are used; or in Column (C), if decreasing altitude inputs are used. The table is to be used to the maximum altitude as shown on the equipment nameplate.

READING OF ALTITUDE-EQUIVALENT INPUT

(A) Digital output (in feet)	(B) Increasing altitude (in feet)	(C) Decreasing altitude (in feet)
0	−50±50	+50±50
10,000	9,950±50	10,050±50
20,000	19,950±50	20,050±50
40,000	39,950±50	40,050±50
60,000	59,950±50	60,050±50
80,000	79,950±50	80,050±50

5.1.1 For combination devices, if pressure is used as the altitude-equivalent input in showing compliance with para 5.1, the tolerance specified may be increased by the applicable altimeter tolerance.

5.2 The manufacturers must determine the presence of each required digitizer coded position.