This document contains TSO-C3b

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Title 14—AERONAUTICS AND SPACE

Chapter I—Federal Aviation Administration, Department of Transportation

[Docket No. 7723; Amdt. No. 37-13]

PART 37—TECHNICAL STANDARD ORDER AUTHORIZATION

Turn-and-Slip Indicator—TSO-C3b

The purpose of this amendment is to revise the Technical Standard Order (TSO) for "Turn-and-Bank Indicator" contained in § 37.113 of the Federal Aviation Regulations. This action was published as a Notice of Proposed Rule Making (31 F.R. 14599, November 16, 1966) and circulated as Notice No. 66-39 dated November 7, 1966.

Notice 66-39 proposed to amend TSO-C3a by adopting the industry-accepted title "Turn-and-Slip Indicator" and by making other changes with regard to the indicator face, power variations, radio interference and magnetic disturbance limitations, and performance standards relating to instrument sensitivity and environmental conditions. The Notice also proposed to add a safeguard against fire hazards due to improper operation of the instrument and further to delete from the present TSO as being unnecessary, standards relating to qualification testing, dual markings, dielectric standards, and case leakage.

A number of comments were received in response to the Notice. These generally favored the proposed action, although in some instances they contained recommendations for further changes. The comments, together with the changes to the proposal resulting therefrom are discussed in detail hereinafter.

One commentator noted that instruments meeting this technical standard order would probably be too expensive for most general aviation airplanes and would be of much higher quality than necessary. It was this commentator's concern that if the FAA were to use this TSO as a guide in certifying turn-and-slip indicators approved as part of the airplane type design, the cost effect would be the same as if all indicators were required to be TSO-approved in the first place.

In this connection, the applicability paragraph, § 37.113(a) of the proposal, makes it clear that the standards set forth in the TSO are those that an instrument must meet in order to be identified with the applicable TSO marking. Furthermore, FAR § 21.305 provides that articles (i.e., materials, parts or appliances) may be approved, among other ways, either under a TSO or in conjunction with the type certification procedures for a product. These are separate and distinct methods of approval. Approval of an instrument in conjunction with the type certification of an aircraft does not require a showing of compliance with the TSO applicable to that instrument.

It was recommended that the data requirements proposed in § 37.113(c) be amended to require the manufacturer to submit his overhaul manual and parts lists in addition to the items there stated. Such a requirement, while it may have merit, would present a substantive change which is beyond the scope of the Notice. However, it might well be considered as a general requirement having potential applicability to all TSO's. Accordingly, while the recommendation must be rejected insofar as the present rule-making action is concerned, it is being given further consideration by the FAA.

In response to various recommendations, section 1, Purpose, of the TSO has been rewritten, following the format of other recently issued TSO's to state more clearly that the TSO provides standards applicable to the indicators which are to be approved under the TSO. Insofar as the proposed section 1 contained information relative to turn-and-slip indicator usage as an aid to the pilot, such information has been incorporated into the section of the TSO covering its scope.

With reference to the clause in proposed section 3.2(a) that would permit an indicator means other than a pointer, one commentator suggested it be rewritten since section 3.3(f)(1) was limited to a pointer. Another commentator wanted to know what means other than a pointer may be used, and requested definition of "conforming to the standards of this TSO".

The FAA agrees with the first of the foregoing comments to the extent that proposed section 3.3(f)(1) seemingly excluded any means other than a pointer. Such, however, was not the intent, and section 3.2(a) was purposely drafted to allow industry to develop improved presentations through the use of indices other than conventional pointer-ball arrangements. Suitable changes, as discussed below, have been made to proposed section 3.3(f)(1) [now section 3.3(e)(1)] to bring it into conformity with the broader intent of section 3.2(a). With regard to the other comments, the FAA does not wish to prescribe or limit the means that would be acceptable in meeting the intent of the TSO. The FAA encourages the development of new, presently undefined and, hopefully, superior presentations. However, any such new indicating means must also be shown to meet all of the applicable requirements of the TSO, in other words, must conform to the standards of this TSO.

A number of comments were directed to the power variation requirements proposed in section 3.2(b). With respect to the request that we clarify "rated D.C. voltage", it should be pointed out that it was intended that the applicant would select the voltage for which his instrument is rated and which would be marked on the instrument name plate and set forth in the required operating instructions and equipment limitations. This would constitute the rated voltage and would inform the user concerning the need for compatibility in the electrical system to assure a supply of properly rated power to the terminals of the instrument. In this connection, section 37.113(b) has been revised to make it clear that voltage is included in the electrical rating required to be marked on instruments.

Another commentator stated that the term "function properly" as used in section 3.2(b) and the term "must function" as used in section 4 should be defined more clearly and asked what degree of accuracy this means. Although these terms are used in the current TSO, the FAA agrees that the requirement could be expressed more clearly. In this regard, the requirements of sections 3.2(b) and 4 have been changed to make it clear that the terms "function properly" and "must function" mean that the instrument must provide reasonably reliable and useful indications of aircraft turning and slip motions under the extremes of the power variation and environmental conditions specified in these sections.

Changes to the numerical values of the permissible electrical power variations proposed in section 3.2(b) were also recommended on the ground that such changes would bring the requirements into agreement with military standards alleged to reflect the capability of present day electrical systems. The comment, however, presented no justification for the recommendation nor is the FAA aware of any compelling reasons to change the standard to agree with the military specification. The power variation limits as proposed are consistent with limits used throughout the TSO system and are being retained.

Comments were also received recom-

(As published in the Federal Register [32 F.R. 12106] on August 23, 1967)

mending that the term "proper operation" as used in connection with the requirement covering power malfunction indication in proposed section 3.2(c), be defined. It was suggested that reference to the power variations set forth in proposed section 3.2(b) should be used to establish the power level for proper operation. It was intended that power malfunction indication be given when power levels drop below the value required for dependable indications of aircraft motions (i.e., the power limits set forth in section 3.2(b)). Accordingly, section 3.2(c) has been amended to make it clear that the warning indication of power insufficiency must appear when power being supplied is below the lower limits stated in section 3.2(b). The FAA likewise agrees with a further suggestion that the first sentence of section 3.2(c) be deleted inasmuch as means for indicating adequacy of power in Type I instruments are usually part of a system installation provided by the aircraft manufacturer rather than an integral part of the instrument itself. The FAA does not agree, however, with another contention that power malfunction indicators, in all but AC-powered instruments, are of insufficient value to warrant their cost. It was the position of this commentator that power loss is only one possible mode of failure, others being spin bearing or motor brush failure, and that the best indication of failure, regardless of mode, is a "dead needle". We might agree that if all failures were of the type that produced instantaneous stoppage of gyros, a dead needle might provide adequate warning. However, the intent of section 3.2(c), as the catchline suggests, is to provide indication of power malfunction in which case there would be a slow, probably imperceptible, loss of gyro performance during a relatively long "run down" time which could produce improper indications before the needle actually goes dead.

With respect to the proposed section 3.3 design requirements, one commentator recommended addition of a standard that would specify the direction of rotor rotation. The commentator, however, presented no substantiation or theory that would relate the direction of rotation to improved performance or more reliable indications. Standards for turn-and-bank indicators to date have not specified the direction of rotation and the FAA is not aware that the direction of rotation is significant insofar as safe operation of the instrument is concerned. The recommendation has, therefore, not been accepted.

The FAA must reject a suggestion that the maximum operating temperature of external surfaces be limited to 200° F. instead of 200° C. as proposed. No reasons or substantiating data were presented to support the more severe standard, and the FAA believes that 200° C. is adequate to protect against ignition of fluids and vapors likely to be liberated in the cockpit.

With reference to the radio interference design requirements, one commentator noted that proposed section 3.3(b) and Figure 1 did not specify the conditions under which the conducted and radiated noise levels were to be measured and, in fact, that there are many ways in which to make the measurements and yet remain within limiting values. Further investigation also indicates that the criteria as it was proposed is frequency-limited to 25 MCS and affords no protection to aeronautical equipment operating above that value. The FAA, therefore, believes that the matter requires further study in order to develop a more effective standard that will be applicable to all aircraft instruments and equipment. Proposed 3.3(b) and Figure 1 have, accordingly, been deleted and succeeding paragraphs relettered.

The FAA agrees with a recommendation that the field intensity and size of magnet, required to measure magnetic effect, be specified, and section 3.3(c) has been amended accordingly. However, an accompanying suggested detailed test procedure in this regard is not required and has not been adopted.

While there may be some merit in a recommendation that would permit a 20-degree visibility limit for instruments using wedge lighting, the 30-degree criteria has been the standard for many years and is applicable to all instruments. While in certain instances, 30 degrees may be determined to be overly restrictive, any change in this regard must be considered with a view towards its applicability to all instruments and is, therefore, beyond the scope of this particular rule-making action. Section 3.3 (d), [now section 3.3(c)], has been retained as proposed.

A number of comments were directed toward the slip indicator damping characteristics proposed in section 3.3(e)(1) [now section 3.3(d)(1)]. One commentator stated his belief that since the 0.2 second response time was indicative of aircraft capable of high roll rates, there was need for a damping fluid having a smaller range of viscosity. In this connection, however, the 0.2 second response time, which corresponds to an airplane roll rate of 60 degrees per second, continues the existing standard of many years which has been found reasonable based on all available test data. Moreover, manufacturers have never indicated a problem with respect to obtaining suitable fluids. With respect to the low temperature damping characteristics, the FAA agrees with other comments pointing up the incompleteness of the standard as proposed. As proposed, section 3 requires that with the slip indicator exposed to a temperature of −30° C., the time for the slip indicator to move from the zero position to the rest position must not exceed 4 seconds. It was suggested that a more valid test would result if the regulation required that the instrument be exposed without operating to a temperature of −30° C. for 3 hours. The FAA is aware that the temperature of the instrument must be −30° C. in order to obtain the test data desired and this is what was intended by the proposal. Therefore, rather than establish a time limit for cold soaking, the FAA considers it appropriate to clarify the requirement by specifying that the test must be conducted with the temperature stablized at −30° C. The FAA does not agree with a final comment that soak temperatures depend on instrument location since the purpose of the requirement is to ensure proper operation in an aircraft immediately following lengthy parking during low temperature conditions.

One of the comments concerning the turn indicator characteristics set forth in proposed section 3.3(f) [now section 3.3(e)], pointed out that the proposal would tend to restrict development of new and different presentations that may prove better than existing displays. It was this commentator's suggestion that actual deflection dimensions be left open but that the tolerances for the deflection at specific turn rates should apply. In this connection it was earlier noted in the discussion of section 3.2(a) that the intent was to encourage development of devices other than conventional pointer-ball arrangements. Accordingly, section 3.3(f)(1) [now section 3.3(e)(1)] has been amended to delete the restrictive words "pointer" and "needle", and to add a provision for instruments that may have new display features.

The FAA has rejected a recommendation that proposed section 3.3(f)(1) include a requirement that the instrument have the inscription "2 min turn" or "4 min turn", as appropriate, placed on the dial face. Such a requirement is not necessary in the interest of safety and would result in dial clutter which could be distracting during emergency situations. Likewise, no action has been taken on a suggestion that bank angle be included as part of the turn indicator sensitivity requirement since it is not justified by any safety considerations. If there is a bank angle limitation on a particular instrument calibration, that limitation would appear in the information furnished by the manufacturer under § 37.113(c)(2)

Two commentators took exception to the proposed damping requirements of section 3.3(f)(2) [now section 3.3(e)(2)]. One expressed the thought that the standard should not give specific numbers in order that future instruments could have the damping or time constants tailored to fit specific aircraft types. The other simply said that "most pilots" prefer a 4- to 10-second time period, instead of the 2 to 4 seconds as proposed. The FAA agrees with neither of these views. The values proposed permit a sufficiently wide range of instrument damping to accommodate all current and foreseeable aircraft using this type instrument. Limits of some finite value are needed to ensure that safe and usable indications are displayed to the pilot under a variety of operational conditions. Heavy damping up to 10 seconds could make the instrument so sluggish that it would be virtually useless to the pilot of a modern airplane. The 2- to 4-second range has proven satisfactory in

FAA type certification testing and operational experience of all kinds, and we have been furnished no data to substantiate the longer times.

We agree with one comment to the effect that proposed section 3.3(f)(3)(i) and (ii) [now section 3.3(e)(3)(i) and (ii)] are ambiguous as to their requirement for an adequate indication when the instrument is started under reduced power. Therefore, to clarify this matter, the note following these two subparagraphs has been amended to correlate the reduced power conditions stated in section 3.3(e)(3) specifically with the sensitivity and damping requirements of section 3.3(e)(1) and (2).

It was noted earlier in connection with slip indicator low temperature damping characteristics that instrument location has no bearing on the required soak temperature which is set at −30° C. For consistency, and since there is no sound reason for distinguishing pressurized and unpressurized areas insofar as environmental temperature conditions are concerned, section 4.1(a) has been further amended to provide a uniform −30° C. functioning limit applicable to all instruments qualified under this TSO.

Several commentators noted the typographical error in the value of maximum acceleration for turbine engine powered aircraft in section 4.1(c) which has been corrected to read 0.25g.

The FAA does not agree with the recommendation that section 5 be rewritten to delete the requirement for demonstration of conformity with all the performance standards of section 3. No reason was given for this recommendation. However, in response to a further comment, proposed section 5 has been amended to clarify the relation between compliance testing and the environmental conditions specified in section 4.

After further consideration of section 6, Individual Performance Tests, the FAA believes it unnecessary to require that each instrument off a production line be tested for compliance with visibility requirements and with slip indicator and turn indicator characteristics requirements where a system of quality control would assure such compliance. Accordingly, section 6 has been relaxed to require tests or checks as necessary to assure that individual instruments function properly and meet the minimum performance requirements.

Other minor changes of an editorial or clarifying nature have been made to the TSO as it was proposed. They are not substantive, however, 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 and all relevant material submitted has been fully considered.

This amendment is made under the authority of sections 313(a) and 601 of the Federal Aviation Act of 1958 (49 U.S.C. 1354(a), and 1421).

In consideration of the foregoing, and pursuant to the authority delegated to me by the Administrator (25 F.R. 6489), § 37.113 of Part 37 of the Federal Aviation Regulations is amended to read as hereinafter set forth, effective September 22, 1967.

Issued in Washington, D.C., on August 16, 1967.

JAMES F. RUDOLPH,
Director,
Flight Standards Service.

§ 37.113 Turn-and-slip indicator (TSO–C3b).

(a) *Applicability.* This TSO prescribes the minimum performance standards that instruments measuring rate-of-turn and slip (formerly turn-and-bank indicators) must meet in order to be identified with the applicable TSO marking. New models of equipment that are to be so identified and that are manufactured on or after the effective date of this section, must meet the minimum performance standards set forth at the end of this section.

(b) *Marking.* In addition to the markings required by § 37.7, the equipment must also be marked with the instrument's operational power rating (electrical voltage and frequency, air pressure).

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

(1) Seven copies of the manufacturer's operating instructions, equipment limitations, installation procedures (including applicable instrument mounting angle restrictions).

(2) Information regarding specialized procedures employed in the calibration of the instrument, such as the instrument slip angle.

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

(d) *Previously approved equipment.* Turn-and-slip indicators (formerly identified as turn-and-bank indicators), approved prior to the effective date of this section may continue to be manufactured under the provisions of the original approval.

FEDERAL AVIATION ADMINISTRATION STANDARD

TURN-AND-SLIP INDICATOR

1. *Purpose.* This document provides minimum performance standards and test procedures for turn-and-slip indicators which are to be approved under this TSO.

2. *Scope.* This standard covers instruments incorporating or utilizing components that can sense aircraft angular motions and lateral accelerations to indicate aircraft flight path information in regard to rate-of-turn and slip motions. It provides for three basic type of turn-and-slip indicators as follows:

Type I—Driven by air pressure;

Type II—Driven electrically by Direct Current; and

Type III—Driven electrically by Alternating Current.

3. *Performance requirements.*

3.1 *General.*

(a) *Materials.* Materials must be of a quality demonstrated to be suitable and dependable for use in aircraft instruments.

(b) *Environmental conditions.* The instrument must be capable of performing its intended function and not be adversely affected during or following prolonged exposure to the environmental conditions as stated under § 4. Where optional environmental conditions are set forth in the condition selected must be declared as an equipment limitation.

3.2 *Detail requirements.*

(a) *Indicating means.* Rate-of-turn may be indicated by means of a pointer, deflecting in the direction of turn, or by any other means conforming to the standards of this TSO. Slip may be indicated by means of a ball, free to move in a curved transparent tube, or any other means conforming to the standards of this TSO.

(b) *Power variation.* The instrument must provide reasonably reliable and useful indications of aircraft turning and slip motions when operating under rated power conditions with variation of—

(1) Plus or minus 30 percent of rated differential air pressure;

(2) Plus or minus 15 percent of rated DC voltage; or

(3) Plus or minus 10 percent of rated AC voltage and ±5 percent of rated frequency.

(c) *Power malfunction indication.* For Types II and III indicators, means must be incorporated in the instrument to indicate when the electrical power being supplied is outside the lower limit of power variations specified in paragraph (b) of this section. Power malfunction must be indicated in a positive manner.

3.3 *Design requirements.*

(a) *Fire hazard.* The instrument must be designed to safeguard against fire hazards to the aircraft in the event of malfunction or failure. Under normal conditions, the maximum operating temperature of external surfaces of the instrument must not exceed 200° C. due to self-heating.

(b) *Magnetic effect.* The instrument must not generate an electromagnetic field which will introduce a magnetic course error corresponding to a maximum of 5 degrees deflection of a free magnet approximately 1½ inches long, in a magnetic field with a horizontal intensity of 0.18±0.01 gauss when the instrument is held in various positions on an east-west line with its nearest part 12 inches from the center of the magnet.

(c) *Visibility.* Turn-and-slip indications must be visible from any point within the frustum of a cone, the side of which makes an angle of at least 30 degrees with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass must be a practical minimum. At the extreme positions of the slip indicator, at least ½ of the indicator must be visible from a point 12 inches directly in front of the zero position.

(d) *Slip indicator characteristics.* The slip indicator must operate freely when the instrument is rotated about its longitudinal axis with the dial vertical. The range of slip angle indications must be at least 8 degrees either side of vertical. With the instrument in its normal position for mounting, the position of the indicator must be zero ±1/32 inch.

(1) *Damping.* While operating at room temperature, the time for the slip indicator to move from the zero position of the slip indication to the rest position must not be less than 0.2 seconds following a sudden rotation of the instrument from a position of 12 degrees bank through the vertical to 12 degrees opposite bank. With the temperature of the instrument stabilized at −30° C. this time must not exceed 4 seconds.

(2) *Slip indicator filling.* Instruments using a liquid as a damping medium for the slip indicator must be so designed and filled

that no part of an air bubble will be visible from a point 12 inches directly in front of the instrument when the instrument is rotated to an angle of roll of 45°.

(e) *Turn indicator characteristics.*

(1) *Sensitivity.*

(i) When the instrument is operating at room temperature under rated power and subjected to the turning rates specified in Column A, the turn indicator deflection, in inches, must be within the limits of either Column B or C. The indicator movement must be smooth.

Column A	Column B	Column C
Rate of turn (degrees per minute)	Deflection of indicator (inches)	
0	0±0.015	0±0.015
36	1/32±1/64	1/16±1/64
90	5/64±1/32	5/32±1/32
180	5/32±1/32	5/16±1/16
360	5/16±1/16	9/16±1/8

NOTE.—Column B values pertain to instruments set to indicate a standard rate of turn (180° per minute) with one indicator unit deflection. Column C provides double this displacement for instruments providing increased sensitivity.

(ii) For instruments possessing display features such that the dimensional characteristics prescribed by Columns B and C of subparagraph (1) do not apply, the applicant may demonstrate that the instrument can reliably indicate the prescribed rates of turn (Column A) with clarity and accuracy equivalent to that specified in Column B or C.

(2) *Damping.* The time for the turn indicator or index to return to the zero mark without crossing the zero mark must be at least 2, but not more than 4 seconds, when the instrument is—

(i) Suddenly stopped after being rotated about its vertical axis at a rate that causes full-scale pointer or index deflection; and

(ii) Operated at room temperature under rated power in a normal attitude position.

(3) *Turn indicator starting.* When started by the application of the instrument's rated power, rated performance must be reached in 3 minutes or less. When started under reduced power—

(i) For Type I indicators, the gyro must start to rotate and continue to run on a pressure differential not to exceed 50 percent of rated value. After no more than 5 minutes operation at this reduced power, the instrument must be able to provide an adequate indication of aircraft turning motions.

(ii) For Types II and III indicators, the gyro must start to rotate and continue to run on an applied power not to exceed 80 percent of the rated voltage and at rated frequency. After no more than 5 minutes' operation at this reduced power, the instrument must be able to provide an adequate indication of aircraft turning motions.

NOTE.—When the instrument is operated under the reduced power conditions of § 3.3(e)(3), the sensitivity and damping requirements of § 3.3(e) (1) and (2) do not apply.

4. *Environmental conditions.* The following ranges of environmental conditions are appropriate:

(a) *Temperature.* The instrument must provide reasonably reliable and useful indications of aircraft turn-and-slip motions over the range of ambient temperature of −30° C. to 50° C. and must not be adversely affected by exposure to temperatures of −65° C. to 70° C.

(b) *Altitude.* The instrument must provide reasonably reliable and useful indications of aircraft turn-and-slip motions from −1,000 feet standard altitude up to the maximum declared operating altitude. It must not be adversely affected following exposure to extremes in ambient pressure of 50 and 3 inches of mercury absolute.

(c) *Vibration.* The instrument must provide reasonably reliable and useful indications of aircraft turn-and-slip motions and must not be adversely affected when subjected to vibrations as follows:

Instrument panel mounted (vibration isolated)	Frequency cycles per second	Maximum double amplitude (inches)	Maximum acceleration
Reciprocating engine-powered aircraft.	5–50	0.020	1.5g
Turbine engine-powered aircraft.	5–55 55–1,000	0.020	0.25g

(d) *Humidity.* The instrument must provide reasonably reliable and useful indications of aircraft turn-and-slip motions and must not be adversely affected following exposure to any relative humidity in the range of 0 to 95 percent at a temperature of approximately 70° C.

5. *Compliance testing.* As evidence of compliance with this standard, the manufacturer must perform evaluation tests on prototype instruments to demonstrate proper design, reliability in performance of its intended functions, and conformity with all of the performance standards of section 3. Tests must be performed to demonstrate compliance with the environmental conditions specified in § 4.

6. *Individual performance tests.* The manufacturer must conduct tests or checks of each instrument as may be necessary to assure that it will function properly and will individually meet the minimum performance requirements of section 3.3(c), 3.3(d), and 3.3(e) (1) and (2) of this TSO.