DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Advisory Circular 25.735–1, Brakes and Braking Systems Certification Tests and Analysis

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of issuance for advisory circular and disposition of comments.

SUMMARY: This action announces the issuance of Advisory Circular (AC) 25.735–1, Brakes and Braking Systems Certification Tests and Analysis, and documents the disposition of comments received in response to the notice of availability for the proposed AC, published in the **Federal Register** on August 10, 1999. This AC sets forth an acceptable means, but not the only means, of demonstrating compliance with the braking system requirements of Title 14, Code of Federal Regulations (14 CFR) for transport category airplanes. Like all AC's, it is not regulatory but is to provide guidance for applicants in demonstrating compliance with the objective safety standards set forth in the rule. The FAA will publish the Revision of Braking Systems Airworthiness Standards final rule and a Notice of Availability of Technical Standard Order (TSO) C135 in the **Federal Register** when they are issued.

DATES: The subject advisory circular was issued in the FAA Transport Airplane Directorate in Renton, Washington, on April 10, 2002.

FOR FURTHER INFORMATION CONTACT: Mahinder K. Wahi, FAA, Propulsion/Mechanical Systems Branch, ANM–112, Transport Airplane Directorate, 1601 Lind Avenue SW., Renton, WA 98055–4056; telephone (425) 227–2142; facsimile (425) 227–1320, e-mail *mahinder.wahi@faa.gov.*

SUPPLEMENTARY INFORMATION:

How To Obtain a Copy of the AC

Copies of this AC can be found and downloaded from the Internet at *http://www.faa.gov/certification/aircraft/air—index.htm* by taking the following steps: Under "Aircraft Certification Related Information" click on Advisory Circulars. Under "Search Help" click on Related Links. Then click on Advisory Circulars. You may also go to the Regulatory and Guidance Library web site at *http:\\www.airweb.faa.gov/rgl,* at the link titled "Advisory Circulars." Paper copies of the AC's will be available in approximately 6–8 weeks from the U.S. Department of Transportation, Subsequent Distribution Office, SVC–121.23, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

Discussion of Comments

Twenty-one commenters responded to the Notice of Proposed Rulemaking (NPRM), Proposed Advisory Circular (AC), and Notice of Availability of Proposed TSO and request for comments, published in the **Federal Register** on August 10, 1999 (64 FR 43579).

Comments were received from eight foreign and domestic airplane and brake manufacturers, nine foreign airworthiness authorities, one operator, and three foreign and domestic industry organizations. Six of the twenty-one commenters have comments on the proposed advisory circular. The majority of the six commenters agree with the proposal and recommend its adoption. However, some commenters disagree with the proposal, while providing alternative proposals that appear to merit further consideration by the Aviation Rulemaking Advisory Committee (ARAC). Therefore, the FAA tasked the ARAC Braking Systems Harmonization Working Group (HWG) by letter dated February 8, 2000, to consider the comments and provide recommendations for the disposition of the comments along with any recommendations for changes to the proposal. The disposition of the comments below is based on the agreement reached by the HWG and submitted to the FAA by letter, dated June 19, 2000. Several of the commenters address multiple issues, while many commenters address the same issue. As a result, the FAA responses to the comments are organized by paragraph number and subject.

1. *Purpose.* One commenter suggests using "14 CFR" or "Federal Aviation Regulations" instead of "FAR." Although most people in the aerospace industry understand the informal use of the acronym FAR as pertaining to the requirements of Title 14 of the Code of Federal Regulations (14 CFR), it is not correct. The acronym FAR is an abbreviation for Federal Acquisition Regulations.

FAA's Response: The FAA concurs. The FAA is to use CFR to when referring to the Code of Federal Regulations. For Title 14, it appears as 14 CFR.

2. *Related Documents.* The same commenter suggests including a statement that all section numbers, such as § 25.735, refer to regulations in 14 CFR, unless otherwise noted.

FAA's Response: As stated in the "Purpose" paragraph, this AC provides guidance material for demonstrating compliance with the braking system requirements of 14 CFR.

3. *Background.* No comments were received for this paragraph.

4. *Discussion.*

Paragraph 4a(1)(e): One commenter explains the need to clarify the statement "Combinations of any additional wheel and brake assemblies should meet applicable airworthiness requirements." In this context it is unclear what "additional" wheels and brakes mean. Also it is not recognized how meeting JAR 21.101(a) and (b) will eliminate situations that may have adverse consequence on airplane braking control and performance.

FAA's Response: The FAA concurs that a clarification is necessary. The second sentence is revised to read: "Following initial airplane certification, any additional wheel and brake assemblies should meet the applicable airworthiness requirements." The FAA has decided that reference to § 21.101 and JAR 21.101 is appropriate.

Paragraph 4a(2) and 4a(3)(b): One commenter suggests deleting "Refurbished and Overhauled Equipment" from paragraph 4a(2) as this advisory material is not applicable for showing compliance to § 25.735(a). The same commenter suggests deleting "monitoring plan" from paragraph 4a(3)(b), again because this advisory material is not applicable for showing compliance to § 25.735(a).

FAA's Response: The FAA does not agree. The FAA considers the advisory material to be relevant to the continued airworthiness of qualified equipment, reference paragraph 2.1 of the TSO–C135.

Paragraph 4b(1): One commenter states that there is a significant difference between the Advisory Material Joint (AMJ) associated with the Joint Aviation Authority (JAA) rule and the AC associated with the FAA rule. The FAA material includes the word "tire" when referring to multiple failures originating from a single cause. It is pointed out that earlier drafts of the AMJ material also referred to tire failures potentially causing multiple hydraulic failures. The commenter recommends that the proposal should be re-worded to clarify that the rule refers to multiple failures from a single source occurring within the system itself. Failures from outside the system are adequately dealt with elsewhere in the regulations. Suggested text: "Multiple failures resulting from a single cause shall be considered a single failure, for example, failure of a single component within the system leading to

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the loss of two or more hydraulic supplies."

FAA's Response: The FAA concurs and the JAA agrees to modify the AMJ text to agree with the AC text. The FAA disagrees with the suggested rewording. The wording is correct as stated. The tire is considered a part of the braking system. The tire failure example is appropriate and relevant for a single failure leading to multiple failures of hydraulic power.

Paragraph 4b(2)(c): One commenter states that if more than one fluid is allowed for the airplane hydraulic system, then the one resulting in the worst case scenario should be used for showing compliance. For example, LD–4 has a lower auto-ignition point than Skydrol 500B–4 and, if both are allowed for use on a particular airplane, the former should be used for showing compliance. A statement should be added accordingly. Note that the same comment has been made with respect to the proposed TSO–C135.

FAA's Response: The FAA concurs that if the applicant can identify one fluid that exhibits all the worst case properties, then that one fluid may be used to show compliance. However, fluids are tested and qualified for a multitude of properties and the same fluid is unlikely to possess all worst case scenario properties. Therefore, the statement "If more than one fluid is allowed for the hydraulic system, compliance should be addressed for all fluids" is added in the AC.

Paragraph 4f(1) and (2): Two commenters state that if the most severe landing stop is not added to 14 CFR 25.735(f) or included in TSO–C135, then it should not be included in the advisory material.

FAA's Response: The FAA concurs that the contents of the AC should reflect the regulation. The most severe landing stop test requirement is retained; hence no change in the AC is necessary.

Paragraph 4f(2)(a): One commenter suggests replacing the text "conservative assessments of typical ambient conditions" with "assessment of ambient conditions within the operational limits established by the applicant and the typical time the airplane will be on the ground." The commenter states that the use of a typical ambient condition is inconsistent with the general requirements for landing performance that requires horizontal distances to be determined for standard temperatures within the operational limits established by the applicant.

FAA's Response: The FAA concurs and the text is revised accordingly.

Paragraph 4f(2)(b): One commenter states that the phrase "with the airplane in a configuration that would enable such a return to be made" might seem to indicate that the analysis is not to consider an immediate return to land in cases where the airplane configuration is less than ideal. This is obviously not the intent as illustrated in the NPRM discussion for § 25.735(f). Furthermore, there is no discussion about the acceptable probability of failure conditions in such cases (*i.e.* not extremely improbable), which is an important element of the rule. Finally, it should be specified how single failure cases are to be considered since their acceptability is linked to the effect, not the probability. For example, would it be acceptable that an applicant foregoes a most severe landing stop case test on the basis that it involves an extremely improbable single failure case resulting in a hazardous failure condition (such designs have been encountered in the past)? It is suggested that the discussion in the guidance material be expanded accordingly.

FAA's Response: The FAA concurs. The following statement is added to the AC: The applicant should address effects and consequences of typical single and multiple failure conditions which are foreseeable events and can necessitate landings at abnormal speeds and weights. The critical landing weight for this condition is the Maximum Takeoff Weight, less fuel burned and jettisoned during a return to the departure airfield. A 30-minute flight should be assumed, with 15 minutes of active fuel jettisoning if equipped with a fuel jettisoning system.

Paragraph 4f(3)(b): One commenter states that the concern about not allowing a brake application speed higher than the ones used in the determination of the kinetic energy requirements to ensure that proper energy absorption rates are achieved is understood. However, it is felt that "as close as practicable" is too subjective and should be quantified. This would alleviate the certification office to have to argue with the applicant as to what a lesser but appropriate brake application speed can be for a particular project and help ensure a level playing field nation wide. Note that a similar comment has been made on the proposed TSO–C135.

FAA's Response: The FAA disagrees. Quantifying the speed tolerance may lead to more restrictive inertia plate increments that may be incompatible with dynamometer setups "As close as practicable" provides the desired flexibility.

Paragraph 4f(3)(b): The following comment is made relative to TSO–C135 paragraph 3.3.1.3, but its disposition affects the AC paragraph 4f.(3)(b) as follows: The reason stated for not exceeding the speed specified is that "for a target test deceleration," the rate of energy input will decrease as speed increases. However, for the same stop distance or torque, the deceleration must increase for a higher initial brake-on speed, which causes the rate of energy input to increase as speed increases. In general, experience has shown that for the same energy and torque requirement, higher initial brake-on speed is a more severe condition. The commenter suggests adding the following statement to the TSO paragraph 3.3.1.3, which is also included in proposed AC 25.735–lX: "However, a brake having a higher initial brakes-on speed is acceptable If the dynamometer test showed that both the energy absorbed and the energy absorption rate required by § 25.735(f) had been achieved."

Alternatively, a tolerance on initial brake application speed of ± 2 knots could be included, which is currently allowed by at least one airplane manufacturer. This will allow continuation of the current practice of matching Inertia Equivalent (IE) as close as possible and varying speed slightly to achieve the required energy, which has worked well for many years. If the specified speed cannot be exceeded, combined margins to allow for tire energy absorption (when brake energy is specified) and the inability to initiate a stop at a precise brake-on speed may drive the IE and brake-on speed farther from the specified conditions, than for the current practice.

FAA's Response: The FAA disagrees. The TSO wording for paragraph 3.3.1.3 is correct as stated. The FAA agrees that there was confusion in the text of AC 25.735–1X, and that rearrangement of some text in paragraph 4f(3)(b) is necessary. As a result, the sentence: "However, a brake having a higher initial brakes-on speed is acceptable if the dynamometer test showed that both the energy absorbed and the energy absorption rate required by § 25.735(f) had been achieved." is removed from 4f(3)(b). This sentence is relocated under a separate paragraph, 4f(3)(c), to read as follows: "(c). For certification purposes, a brake having a higher initial brakes-on speed is acceptable if the dynamometer test showed that both the energy absorbed and the energy absorption rates required by § 25.735(f) had been achieved." Existing paragraph "4f(3)(c)" is redesignated as "4f(3)(d)."

Paragraph 4f(3)(c): One commenter suggests rewording this statement to say that brake qualification tests are not intended to verify expected performance on the airplane. Brake qualification tests are intended to predict expected performance on the airplane. This is the main reason for conducting these tests.

FAA's Response: The FAA disagrees. Airplane performance is determined by airplane tests, therefore, no change in the AC text is necessary.

Paragraph 4g(3): One commenter states that keeping the brake pressure applied throughout the 5-minute post stop period would help determine whether it might contribute to a fire hazard. It would, however, be acceptable for the parking brake pressure to fail to be maintained after 3 minutes, since the tires would most likely be deflated by that time anyway, thereby holding the aircraft stationary. It is important to determine whether the parking brake design aspects of the brake assembly could be potentially deficient at the time of qualification. Consequently, a statement to the effect that parking brake should remain applied throughout a 5-minute period should be added. Note that similar comments have been made about the proposed TSO–C135.

FAA's Response: The FAA does not concur that the parking brake should remain applied for 5 minutes and reaffirms the 3-minute parking brake applied period for the dynamometer test. The FAA agrees that clarification of the parking brake set period is needed. There is no intent by the FAA to dictate that the parking brake must be released at 3 minutes, but that it must be applied at least that long. Changes are made to the TSO Figures 3–1 and 3–2 and paragraphs 3.3.3.5 and 3.3.4.5 to minimize ambiguity in this respect.

The certification test on the airplane (worn brake RTO) need not follow the procedure prescribed in the TSO. But it is important that the brake manufacturer know early in the development period what procedure will be used on the airplane (i.e. the certification basis) since it can impact the design.

The Transport Canada (representative) agrees that this is an acceptable harmonized solution allowing authorities that are not part of the harmonization process the needed flexibility. Also see the disposition of comments under NPRM proposal 13, and TSO paragraphs 3.3.3.5 and 3.3.4.5.

Paragraph 4h(4): One commenter suggests changing "A full brake application * * *" to "A full brake application cycle * * *" The term "brake application" or "brake actuation" is commonly used to mean increasing pressure from fully released to fully applied, while "brake retraction" is commonly used to define returning brake pressure from fully applied to fully released. Using the term "brake application cycle" will help avoid the possibility of confusion.

FAA's Response: The FAA concurs and the AC text is changed accordingly.

Conclusion

With the exceptions of the changes noted in paragraph 4(a)(1)(e), 4b(2)(c), 4f(2)(a), 4f(2)(b), 4f(3)(b), 4f(3)(c), and 4h(4), this AC is adopted as proposed.

Issued in Renton, Washington, on April 10, 2002.

Ali Bahrami,

Acting Manager, Transport Airplane Directorate, Aircraft Certification Service.

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