Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Braking Systems Harmonization Working Group

Task 1 – Brakes Installed on Transport Category Airplanes

Task Assignment

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Issues

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of establishment of the Braking Systems Harmonization Working Group.

SUMMARY: Notice is given of the establishment of the Braking Systems Harmonization Working Group by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of the ARAC.

FOR FURTHER INFORMATION CONTACT: Michael H. Borfitz, Assistant Executive Director, Aviation Rulemaking Advisory Committee, Transport Airplane and Engine Issues, FAA Engine & Propeller Directorate, 12 New England Executive Park, Burlington, Massachusetts 01803; telephone (617) 238-7110, fax (617) 238-7199.

SUPPLEMENTARY INFORMATION: On January 22, 1991 (56 FR 2190), the Federal Aviation Administration (FAA) established the Aviation Rulemaking Advisory Committee (ARAC). The committee provides advice and recommendations to the FAA Administrator, through the Associate Administrator for Regulation and Certification, on the full range of the FAA's rulemaking activities with respect to aviation-related issues.

In order to develop such advice and recommendations, the ARAC may choose to establish working groups to which specific tasks are assigned. Such working groups are comprised of experts from those organizations having an interest in the assigned tasks. A working group member need not be a representative of the full committee. Recently the ARAC established the Braking Systems Harmonization Working Group.

The FAA announced at the Joint Aviation Authorities (JAA)-Federal Aviation Administration (FAA) Harmonization Conference in Toronto, Canada June 2-5, 1992 that it would consolidate within the ARAC structure an ongoing objective to "harmonize" the Joint Aviation Requirements (JAR) and the Federal Aviation Regulations (FAR).

Tasks

The Braking Systems Harmonization Working Group is charged with recommending to the ARAC new or revised requirements for approval of brakes installed on transport category airplanes. The product of this exercise is intended to be a harmonized standard, acceptable to both the FAA and the Joint Aviation Authorities (JAA).

Reports

The Braking Systems Harmonization Working Group should develop and present to the ARAC:

1. A recommended work plan for completion of the task, including the rationale supporting such plan, for consideration at the meeting of the ARAC to consider transport airplane and engine issues held following publication of this notice;

2. A detailed conceptual presentation on the proposed recommendation(s), prior to proceeding with the work stated in item 3. below;

3. A draft Notice of Proposed Rulemaking (NPRM), with supporting economic and other required analyses, and/or any other related guidance material or collateral documents the working group determines to be appropriate; or, if new or revised requirements or compliance methods are not recommended, a draft report stating the rationale for not making such recommendations; and

4. A status report at each meeting of the ARAC held to consider transport airplane and engine issues.

Participation in Working Group Task

An individual who has expertise in the subject matter and wishes to become a member of the working group should write to the person listed under the caption **FOR FURTHER INFORMATION CONTACT** expressing that desire, describing his or her interest in the task and stating the expertise he or she would bring to the working group. The request will be reviewed with the assistant chairman and working group leader, and the individual will be advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the information and use of the Aviation Rulemaking Advisory Committee are necessary in the public interest in connection with the performance of duties imposed on the FAA by law. Meetings of the Aviation Rulemaking Advisory Committee will be open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the working group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on June 3, 1994.

Chris A. Christie,

Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 94-14146 Filed 6-9-94; 8:45 am]

BILLING CODE 4910-13-M

Recommendation Letter

400 Main Street
East Hartford, Connecticut 06108

Pratt & Whitney
A United Technologies Company

May 1, 1998

Action: AIR 100

Department of Transportation
Federal Aviation Administration
800 Independence Avenue
Washington, DC 20591

Attn: Mr. Guy S. Gardner, Associate Administrator for Regulation and Certification

Subject: ARAC Rulemaking Package

Dear Guy:

The ARAC Transport Airplane and Engine Issues Group (TAEIG) is pleased to forward the attached rulemaking package and associated advisory material to the FAA for further action. This package has been approved by the TAEIG and contains proposals for the revision of FAR sections 25.731 and 25.735 (Standards for Brake Certification) and sections 25.613 (Material Strength Properties and Design Values), proposed Advisory Circulars and a proposed Technical Standard Order (TSO-C 135).

TAEIG requests that the FAA consider tasking the disposition any substantive comments relating to sections 25.731 and 25.735 to the Brake System Harmonization Working Group and comments relating to section 25.613 to the General Structures Harmonization Working Group. Please feel free to contact us if we can be of assistance in any way.

Sincerely,

Craig R. Bolt

Craig R. Bolt
Assistant Chair, ARAC TAEIG
boltcr@pweh.com
(Ph: 860-565-9348/Fax: 860-565-5794)

CRB/amr

Attachment (to addressee only)

cc: Bob Amberg
Bob Benjamin
Jean Casciano
Brenda Courtney
Herb Lancaster
Stu Miller

Acknowledgement Letter

JUN 3 1998

Mr. Craig R. Bolt
Aviation Rulemaking Advisory Committee
Pratt & Whitney
400 Main Street
East Hartford, CT 06106

Dear Craig:

Thank you for your May 1 letter transmitting recommendations of the Aviation Rulemaking Advisory Committee (ARAC). You provided proposed rulemakings for the revision of sections 25.613, 25.731, and 25.735 of the Federal Aviation Regulations, proposed advisory circulars to the associated rule proposals, and a proposed technical standard order (TSO-C-135). The Federal Aviation Administration (FAA) accepts these recommendations provided there are no legal or other reasons why we cannot adopt them.

The complete rulemaking package will be reviewed and coordinated within the FAA and the Offices of the Secretary of Transportation and Management and Budget, if appropriate. The FAA will publish the Notice of Proposed Rulemaking for public comment as soon as the coordination process is complete. The proposed advisory circulars and TSO will also be made available for public comment when the coordination process is complete. We will make every effort to handle these recommendations expeditiously. Although no decision will be made at this time, the FAA will look at tasking the disposition of comments to the working groups at the end of the comment periods.

I would like to thank the ARAC, and particularly the Braking Systems Harmonization Working Group and the General Structures Harmonization Working Group for their actions on these tasks.

Sincerely,

Original Signed By
Margaret Gilligan

Guy S. Gardner
Associate Administrator for
Regulation and Certification

Recommendation

[4910-13] DRAFT

DEPARTMENT OF TRANSPORTATION 12/12/97

Federal Aviation Administration

[14 CFR Part 25]

[Docket No. ; Notice No.]

RIN 2120-

Revision of Braking Systems Airworthiness Standards to Harmonize with European Airworthiness Standards for Transport Category Airplanes.

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of proposed rulemaking.

SUMMARY: The Federal Aviation Administration proposes to revise the airworthiness standards for transport category airplanes to harmonize braking systems design and test requirements with standards proposed for the European Joint Aviation Requirements (JAR). These proposals were developed in cooperation with the Joint Aviation Authorities (JAA) of Europe and the U.S. and European aviation industry through the Aviation Rulemaking Advisory Committee (ARAC), and are intended to benefit the public interest by standardizing certain requirements, concepts, and procedures contained in the airworthiness standards without reducing, but potentially enhancing, the current level of safety.

DATES: Comments must be received on or before [insert date 90 days after date of publication in the Federal Register].

ADDRESSES: Comments on this notice may be mailed in triplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attention: Rules Docket (AGC-200), Docket No. , 800 Independence Avenue SW., Washington, DC 20591; or delivered in triplicate to: Room 915G, 800 Independence Avenue SW., Washington, DC 20591. Comments delivered must be marked Docket No. . Comments may also be sent electronically to the following internet address: 9-NPRM-CMTS@faa.dot.gov.

Comments may be examined in Room 915G weekdays, except Federal holidays, between 8:30 a.m. and 5:00 p.m. In addition, the FAA is maintaining an information docket of comments in the Transport Airplane Directorate (ANM-100), Federal Aviation Administration, Northwest Mountain Region, 1601 Lind Avenue SW., Renton, WA 98055-4056. Comments in the information docket may be examined weekdays, except Federal holidays, between 7:30 a.m. and 4:00 p.m.

FOR FURTHER INFORMATION CONTACT: Mahinder K. Wahi, FAA, Propulsion/Mechanical/Cabin Safety Branch, ANM-112, Transport Airplane Directorate, 1601 Lind Avenue SW., Renton, WA 98055-4056; telephone (425) 227-2142; facsimile (425) 227-1320.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in this proposed rulemaking by submitting such written data, views, or arguments as they may desire. Comments relating to any environmental, energy, or economic impact that might result from adopting the proposals contained in this notice are invited. Substantive comments should be accompanied by cost estimates. Commenters should identify the regulatory docket or notice number and submit comments in triplicate to the Rules Docket address above. All comments received on or before the closing date for comments will be considered by the Administrator before taking action on this proposed rulemaking. The proposals contained in this notice may be changed in light of comments received. All comments received will be available in the Rules Docket, both before and after the comment period closing date, for examination by interested persons. A report summarizing each substantive public contact with FAA personnel concerning this rulemaking will be filed in the docket. Persons wishing the FAA to acknowledge receipt of their comments must submit with those comments a self-addressed, stamped postcard on which is stated:

"Comments to Docket No. ." The postcard will be date stamped and returned to the commenter.

Availability of the NPRM

An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the Fedworld electronic bulletin board service (telephone: 703-321-3339), the Federal Register's electronic bulletin board service (telephone: 202-512-1661), or the FAA's Aviation Rulemaking Advisory Committee Bulletin Board service (telephone: 202-267-5948).

Internet users may reach the FAA's web page at http://www.faa.gov or the Federal Register's web page at http://www.access.gpo.gov/su_docs for access to recently published rulemaking documents.

Any person may obtain a copy of this notice by submitting a request to the Federal Aviation Administration (FAA), Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591; or by calling (202) 267-9680. Communications must identify the notice number or docket number of this notice. Persons interested in being placed on a mailing list for future rulemaking documents should also request a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure.

Background

The airworthiness standards for transport category airplanes are contained in 14 CFR part 25. Manufacturers of transport category airplanes must show that each airplane they produce of a different type design complies with the relevant standards of part 25. These standards apply to airplanes manufactured within the U.S. for use by U.S.-registered operators and to airplanes manufactured in other countries and imported under a bilateral airworthiness agreement.

In Europe, the Joint Aviation Requirements (JAR) were developed by the Joint Aviation Authorities (JAA) to provide a common set of airworthiness standards for use within the European aviation community. The airworthiness standards for European type certification of transport category airplanes, JAR-25, are based on part 25 of Title 14. Airplanes certificated to the JAR-25 standards, including airplanes manufactured in the U.S. for export to Europe, receive type certificates that are accepted by the aircraft certification authorities of 23 European countries.

Although part 25 and JAR-25 are very similar, they are not identical. Differences between the FAR and the JAR can result in substantial additional costs when airplanes are type certificated to both standards. These additional costs, however, frequently do not bring about an increase in safety. For example, part 25 and JAR-25 may use different means to accomplish the same safety intent. In this case, the manufacturer is usually burdened with meeting both requirements, although the level of safety is not increased correspondingly. Recognizing that a common set of standards would not only economically benefit the aviation industry, but would also maintain the necessary high level of safety, the FAA and JAA consider harmonization to be a high priority.

In 1988, the FAA, in cooperation with the JAA and other organizations representing the American and European aerospace industries, began a process to harmonize the airworthiness requirements of the United States and the airworthiness requirements of Europe, especially in the areas of Flight Test and Structures.

The Aviation Rulemaking Advisory Committee

The Aviation Rulemaking Advisory Committee (ARAC) was formally established by the FAA on January 22, 1991 (56 FR 2190) to provide advice and recommendations concerning the full range of the FAA's safety-related rulemaking activity. This advice was sought to develop better rules in less overall time using fewer FAA resources than are currently needed. The committee provides the opportunity for the FAA to obtain firsthand information and insight from interested parties regarding proposed new rules or revisions of existing rules.

There are 64 member organizations on the committee, representing a wide range of interests within the aviation community. Meetings of the committee are open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act.

The ARAC establishes working groups to develop proposals to recommend to the FAA for resolving specific issues. Tasks assigned to working groups are published in the Federal Register. Although working group meetings are not generally open to the public, all interested parties are invited to participate as working group members. Working groups report directly to the ARAC, and the ARAC must accept a working group proposal before that proposal can be presented to the FAA as an advisory committee recommendation.

The activities of the ARAC will not, however, circumvent the public rulemaking procedures. After an ARAC recommendation is received and found acceptable by the FAA, the agency proceeds with the normal public rulemaking procedures. Any ARAC participation in a rulemaking package will be fully disclosed in the public docket.

Starting in 1992, the FAA harmonization effort for various systems related airworthiness requirements was undertaken by the ARAC. A working group of industry and government braking systems specialists of Europe, the United States, and Canada was chartered by notice in the Federal Register (59 FR 30080, June 10, 1994). The working group was tasked to develop a harmonized standard, such as a Technical Standard Order (TSO), for approval of wheels and brakes to be installed on transport category airplanes and to develop a draft notice of proposed rulemaking (NPRM), with supporting economic and other required analyses, and/or any other related guidance material or collateral documents, such as advisory circulars, concerning new or revised requirements and the associated test conditions for wheels, brakes and braking systems, installed in transport category airplanes (§§ 25.731 and 25.735). The JAA is to develop a similar proposal to amend JAR-25, as necessary, to achieve harmonization.

The rulemaking proposal contained in this notice is based on a recommendation developed by the Braking Systems Harmonization Working Group, and presented to the FAA by the ARAC as a recommendation.

Discussion of the Proposals

The FAA proposes to amend 14 CFR §§ 25.731 and 25.735 to harmonize these sections with JAR-25. The JAA intends to publish a Notice of Proposed Amendment (NPA), also developed by the Braking Systems Harmonization Working Group, to revise JAR-25 as necessary to ensure harmonization in those areas for which the proposed amendments differ from the current JAR-25, Change 14. When published, the NPA will be placed in the docket for this rulemaking.

Generally, the FAA proposes to: (1) add appropriate existing JAR requirements to achieve harmonization; (2) move some of the existing regulatory text, considered to be of an advisory nature, to an advisory circular; (3) add regulations addressing automatic brake systems, brake wear indicators, pressure release devices, and system compatibility; and (4) consolidate and/or separate requirement subparagraphs for clarity.

A new proposed Advisory Circular (AC) 25.735-1X, Brakes and Braking Systems Certification Tests and Analysis, has been developed by the ARAC Harmonization Working Group to ensure consistent application of these proposed revised standards. Public comments concerning AC 25.735-1X are invited by separate notice published elsewhere in this issue of the Federal Register. The JAA intends to publish an Advisory Material Joint (AMJ), also developed by the Harmonization Working Group, to accompany their NPA. The proposed AC and the proposed AMJ contain harmonized advisory information.

A new proposed TSO-C135 has also been developed by the Harmonization Working Group as a harmonized standard for approval of transport airplane wheels and wheel and brake assemblies to replace applicable parts of the existing TSO-C26c, Aircraft Wheels and Wheel-Brakes Assemblies, dated May 18, 1984. Public comments concerning TSO-C135 are invited by separate notice published elsewhere in this issue of the Federal Register. The JAA intends to adopt TSO-C135 as Joint Technical Standard Order (JTSO)-C135 and publish it to accompany their NPA.

Discussion of Proposals in this NPRM

Proposal 1. The FAA proposes to revise the current heading of § 25.735, "Brakes," to read, "§ 25.735 Brakes and braking systems."

Discussion: This section covers not only the brakes and their performance requirements and safety considerations, but also provides requirements for the systems and equipment associated with the brakes. As examples, the proposed additional paragraph (b)(2) refers to the brake hydraulic system and the hydraulic fluid supplying the brakes, and the proposed paragraph (e) refers to the antiskid system. The proposed change is of an editorial nature only, and consequently would have no impact on the current level of safety.

Proposal 2. The FAA proposes to add a heading to and revise the text of § 25.735(a) to read, "(a) Approval. Each assembly consisting of a wheel(s) and brake(s) must be approved."

Discussion. The current § 25.735(a), which states that each brake must be approved, is considered incomplete. Although a wheel not associated with a brake (non-braked) may be approved on its own per the applicable TSO, a brake approval is always considered in combination with its associated wheel(s) (i.e., for a combined wheel(s) and brake(s) assembly). The proposed change is of an editorial nature only and therefore would have no impact on the current level of safety. Applicable advisory information would be included in proposed AC 25.735-1X.

Proposal 3. The FAA proposes to add the heading "Brake system capability" to § 25.735(b), to separate and revise the current text of the first sentence of § 25.735(b) into §§ 25.735(b) and (b)(1), and to delete the current text of the entire second sentence to read, "(b) Brake system capability. The brake system, associated systems and components must be designed and constructed so that: (1) if any electrical, pneumatic, hydraulic or mechanical connecting or transmitting element fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest with a braked roll stopping distance of not more than two times that obtained in determining the landing distance as prescribed in § 25.125."

Discussion: The current text of the first sentence of § 25.735(b) reads, "The brake systems and associated systems must be designed and constructed so that if any electrical, pneumatic, hydraulic, or mechanical connecting or transmitting element (excluding the operating pedal or handle) fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest under conditions specified in § 25.125 with a mean deceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance as prescribed in that section."

Under this proposal, the term "components" would be added to the terms "brake system and associated systems" to make it more comprehensive. The parenthetical phrase "(excluding the operating pedal or handle)" would be deleted because no justification could be found for such an exclusion. The words "braked roll stopping distance" would be inserted in place of "landing roll" to clarify that the requirement refers only to the distance covered while the brakes are applied. The change from "at least 50 percent mean deceleration" to "not more than two times the landing distance" is intended to eliminate any possible confusion between "mean" and "average" deceleration, and to state the requirement more clearly in terms of its real intent. The other changes in text are editorial and are made for clarity.

The current second sentence reads "Subcomponents within the brake assembly, such as brake drum, shoes, and actuators (or their equivalents), shall be considered as connecting or transmitting elements, unless it is shown that leakage of hydraulic fluid resulting from failure of the sealing elements in these subcomponents within the brake assembly would not reduce the braking effectiveness below that specified in this paragraph." The current second sentence would be removed and, due to its advisory content, included as guidance material in proposed AC 25.735-1X.

The proposed changes are clarifications of current regulations and the associated terminology and therefore would have no impact on the current level of safety. Applicable advisory information would be included in proposed AC 25.735-1X.

Proposal 4. The FAA proposes to add a new § 25.735(b)(2) that would contain the intent and content of the ACJ 25.735(b) of JAR-25 regarding protection against fire resulting from hydraulic fluid leakage, spillage, or spraying on hot brakes. The proposal would state that, "(2) Fluid lost from a brake hydraulic system, following a failure in, or in the vicinity of, the brakes, is insufficient to cause or support a hazardous fire on the ground or in flight."

Discussion. Although the proposed requirement was previously included in ACJ 25.735(b) as acceptable means of compliance and interpretative material, it is now thought more appropriate that these practices should be considered as requirements as they have generally been treated as such in the past by both airplane manufacturers and regulatory authorities. The current level of safety would not be affected by this proposed change as it would adopt an existing industry practice. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 5. The FAA proposes to add the heading "Brake controls" to § 25.735(c), and to separate and revise the current text of § 25.735(c) into §§ 25.735(c) and (c)(1) to read, "(c) Brake Controls. The brake controls must be designed and constructed so that: (1) Excessive control force is not required for their operation."

Discussion: The current text reads, "Brake controls may not require excessive control force in their operation." The proposed changes are clarifications of current regulations and the associated terminology and therefore the current level of safety would not be impacted. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 6. The FAA proposes to add a new § 25.735(c)(2) to read, "(2) If an automatic braking system is installed, means are provided to (i) arm and disarm the system, and (ii) allow the pilot(s) to override the system by use of manual braking."

Discussion. The intent and content of the proposed changes have generally been adopted in the design of current automatic braking systems and are currently included in FAA Order 8110.8, "Engineering Flight Test Guide for Transport Category Airplanes," as interpretative and acceptable means of compliance. Consequently, both the airplane manufacturers and the regulatory authorities have generally considered them as standard practices; therefore, they would not impact the current level of safety. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 7. The FAA proposes to amend § 25.735(d) by adding the heading, "Parking brake," and by modifying the current text from, "The airplane must have a parking control that, when set by the pilot, will without further attention, prevent the airplane from rolling on a paved, level runway with takeoff power on the critical engine," to"(d) Parking brake. The airplane must have a parking brake control that, when selected on, will, without further attention, prevent the airplane from rolling on a dry and level paved runway when the most adverse combination of maximum thrust on one engine and up to maximum ground idle thrust on any, or all, other engine(s) is applied. The control must be suitably located or be adequately protected to prevent inadvertent operation. There must be indication in the cockpit when the parking brake is not fully released."

Discussion: Introduction of the word "brake" before "control" clarifies that the paragraph refers to the means provided to the flightcrew for the application of the wheel brakes in the airplane parking mode. By revising the text, as proposed, the requirement would be enhanced to cover not only the case of a single engine takeoff thrust check with all other engines stopped, but would also cover an equally if not more probable case where any or all other engines are operating and producing up to a maximum ground idle thrust. The proposal also clarifies the extent of the takeoff thrust to be considered for the "critical" engine as the maximum that can be achieved, and by implication also requires the relevant thrust cases for remaining engine(s) according to the environmental circumstances that are dictated for the achievement of the maximum takeoff thrust on the critical engine. The word "dry" is added solely for clarification of the current understanding of this requirement.

The requirement for suitable location or protection against inadvertent operation of the parking brake control is derived from the current ACJ 25.735(d) of JAR-25 and is introduced because it is believed that such considerations should be regarded as requirements, and have generally been treated as such in the past by both airplane manufacturers and regulatory authorities. The additional requirement for cockpit indication when the parking brake is "not fully released" is to caution the pilot against a takeoff with the parking brake set. The proposed changes potentially enhance the current level of safety by clarifying intent and addressing some critical cases. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 8. The FAA proposes to add the heading "Antiskid system" to § 25.735(e), to delete the current text "no single probable malfunction will result in a hazardous loss of braking ability or directional control of the airplane" as being superfluous, and in order to facilitate the introduction of the new proposed §§ 25.735(e)(1) and (e)(2) under proposals 9 and 10 respectively, revise the remaining current text to read,

"(e) Antiskid system. If an antiskid system is installed:"

Discussion: The current § 25.735(e) reads: "If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction will result in a hazardous loss of braking ability or directional control of the airplane." The reference to antiskid devices and associated systems would be changed to "antiskid system," this being more appropriate to the paragraph's intent. The term "probable" was incompatible with the terminology of § 25.1309 because a "probable" malfunction cannot be associated with either major or hazardous effects and, if used in the "§ 25.1309" sense, could lead to a requirement that could be seen as less severe than § 25.1309 for that specific failure condition, with no obvious technical/state of the art reasons. It appears that the terminology (probable and hazardous) used was probably not "§ 25.1309 related" when the requirement was first introduced. Rather than trying to define the words, it is considered that the requirement is adequately covered by § 25.1309 and the current § 25.735(e) is superfluous. The proposed changes are of a clarifying and an editorial nature only and therefore would have no impact on the current level of safety. Appropriate advisory material would be included in proposed AC 25.735-1X.

Proposal 9. The FAA proposes to add a new § 25.735(e)(1) to read, " (1) It must operate satisfactorily over the range of expected runway conditions, without external adjustment".

Discussion: The intent and content of the proposed changes are currently included in FAA Order 8110.8, "Engineering Flight Test Guide for Transport Category Airplanes," as interpretative material and acceptable means of compliance and are deemed appropriate to be adopted as requirements. Both the airplane manufacturers and the regulatory authorities have, in the past, considered them as standard practices; therefore, they would not impact the current level of safety. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 10. The FAA proposes to add a new § 25.735(e)(2) to read, "(2) It must, at all times, have priority over the automatic braking system, if installed."

Discussion: The intent and content of the proposed change is currently included in FAA Order 8110.8, "Engineering Flight Test Guide for Transport Category Airplanes," as interpretative material and acceptable means of compliance and is deemed appropriate to be adopted as a requirement. Both the airplane manufacturers and the regulatory authorities have, in the past, considered it as a standard practice; therefore, it would not impact the current level of safety. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 11. **(Note: This item proposes changes to amendments proposed in NPRM 93-8, Improved Standards for Determining Rejected Takeoff and Landing Performance. Publication of that amendment is expected soon. In the event that this rulemaking should proceed to publication before the RTO amendment, this proposal will be rewritten to address the current FAR/JAR.)**

The FAA proposes to amend § 25.735(f) by adding the heading "Kinetic energy capacity," by consolidating the requirements of current paragraphs (f) and (h), by adding similar requirements for a high energy landing condition, by removing paragraphs (f)(1) and (2), and paragraphs (h)(1), and (2), and by revising the text to read:

"(f) Kinetic energy capacity. The design landing stop, the maximum kinetic energy accelerate-stop, and the most severe landing stop brake kinetic energy absorption requirements of each wheel and brake assembly must be determined. It must be substantiated by dynamometer testing that, at the declared fully worn limit(s) of the brake heat sink, the wheel and brake assemblies are capable of absorbing not less than these levels of kinetic energy. Energy absorption rates defined by the airplane manufacturer must be achieved. These rates must be equivalent to mean decelerations not less than 10 fps^2 for the design landing stop and 6 fps^2 for the maximum kinetic energy accelerate stop. The most severe landing stop need not be considered for extremely improbable failure conditions or if the maximum kinetic energy accelerate-stop energy is more severe. Design landing stop is an operational landing stop at maximum landing weight. Maximum kinetic energy accelerate-stop is a rejected takeoff for the most critical combination of airplane takeoff weight and speed. Most severe landing stop is a stop at the most critical combination of airplane landing weight and speed.

Discussion: The current paragraphs (f) and (h) state that the brake kinetic energy capacity ratings may not be less than the determined energy absorption requirements. The proposed paragraph (f) would require the calculation of the necessary energy absorption capacity, and require dynamometer test substantiation of the capability of the wheel and brake assemblies to absorb the energy at not less than specified rates. Usually, brakes are sized to exceed the calculated energy absorption requirements (i.e., their capacity exceeds the requirements, hence the heading "Kinetic energy capacity"). The term "rating" would be deleted because it is more relevant to the TSO than to the regulation. The proposed change would encompass the requirements of current paragraph (h) without the need for complete duplication of text.

The term "rejected takeoff" used under current paragraph (h) would be replaced with "accelerate-stop" for compatibility with § 25.109 terminology; and the term "most severe landing stop" would be added to address cases such as emergency return to land after takeoff, where the brake energy for a flaps up landing may exceed that corresponding to the accelerate-stop energy. For the accelerate-stop and the most severe landing stop, it is intended that the initial brake temperature resulting from previous brake use must be accounted for as specified in paragraphs 3.3.3.3 and 3.3.4.3 in the proposed

TSO-C135. It should be noted that the consideration for the initial temperature (in terms of residual energy) reflects an existing British Civil Aviation authority (CAA) Specification 17 requirement. Changing the term "main wheel-brake assemblies" to "wheel and brake assemblies," ensures the paragraph's applicability to any wheels fitted with brakes (i.e., includes the possibility of nose wheel brakes, etc.) and further ensures the understanding that the absorption requirements apply to the wheel and brake assembly. The substantiation statement requires that the wheel and brake assemblies be capable of absorbing the calculated levels of kinetic energy at the fully worn limit and that the energy absorption capability substantiation testing be conducted on the dynamometer.

The current §§ 25.735(f)(1) and (h)(1) would be incorporated in proposed AC 25.735-1X, because their content is not strictly part of the requirement, but provides advice on the primary features that should be conservatively included in a rational analysis.

The current §§ 25.735(f)(2) and (h)(2) are not strictly the requirement, but advice on the method of energy calculation to be used. Consequently, these would be incorporated in proposed AC 25.735-1X.

Because the required energy capacity of each wheel and brake assembly must be determined, the need to refer to "designed unequal braking distributions" is no longer necessary and would be deleted.

The current level of safety would be retained and possibly enhanced by addressing the most severe landing stop condition. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 12. The FAA proposes to remove the current § 25.735(g) requirement.

Discussion: The current § 25.735(g) requirement states that when setting up the dynamometer test inertia, an increase in the initial brake application speed is not a permissible method of accounting for a reduced (i.e., lower than ideal) dynamometer mass. This method is not permissible because, for a target test deceleration, a reduction in the energy absorption rate would result, and could produce a performance different from that which would be achieved with the correct brake application speed. Such a situation is recognized and is similarly stated in the proposed new TSO-C135, which would provide an acceptable means for wheel and brake assembly approval under § 25.735(a), thus making current § 25.735(g) unnecessary. The proposed change consolidates existing requirements and deletes redundant wording, and therefore would not impact the current level of safety.

Proposal 13. The FAA proposes to add a new § 25.735(g), "Brake condition after high kinetic energy dynamometer stop(s)," to read, "Following the high kinetic energy stop demonstration(s) required by paragraph (f) of this section, with the parking brake promptly and fully applied for at least three (3) minutes, it must be demonstrated that for at least five (5) minutes from application of the parking brake, no condition occurs (or has occurred during the stop), including fire associated with the tire or wheel and brake assembly, that could prejudice the safe and complete evacuation of the airplane."

Discussion: Paragraph (g) would require that the parking brake be applied for a minimum of three minutes, which is considered to be the minimum period of time required to cover the brake's ability to maintain the airplane in a stationary condition to allow a safe evacuation.

The requirement also gives consideration to the fact that the flightcrew may not be aware of the condition of the brake assemblies at the commencement of the flight, nor of the condition of the brake and wheel assemblies following the braking maneuver. Furthermore, the reason for the severe braking could encompass both airplane system and engine failures or fires. It would therefore appear sensible that it should be demonstrated that neither during the stop, nor for a reasonable period of time after its completion, no condition(s) shall occur as a result of these maneuvers that could further prejudice the safe and complete evacuation of the airplane. On the basis that an evacuation may be determined as prudent or necessary, and that such an evacuation must be capable of completion, irrespective of the timely response of the emergency services, five minutes would appear to be a reasonable period of time for the associated brake systems and equipment to remain free from conditions that might prejudice or jeopardize the evacuation. It is proposed that this period should commence at the time of initial application of the parking brake, this being a time during which the possible need for evacuation and airport emergency services occurs following an accelerate-stop. The proposed changes provide for the additional demonstration of a safe condition following high energy absorption by the wheels and brakes, which was not previously required. Although previously approved brakes may have been able to comply with the requirement, approval could not have been refused had this not been the case. It is therefore believed that the proposed changes would provide a potential enhancement of the current level of safety. Applicable advisory material would be included in proposed AC 25.735-1X.

Proposal 14. The FAA proposes to add a modified version of the current JAR 25.735 (i) as new 14 CFR § 25.735(h), "Stored energy systems," to read as follows:

"(h) Stored energy systems. An indication to the flightcrew of usable stored energy must be provided if a stored energy system is used to show compliance with paragraph (b)(1) of this section. The available stored energy must be sufficient for:

(1) At least six (6) full applications of the brakes when an antiskid system is not operating; and,

(2) Bringing the airplane to a complete stop when an antiskid system is operating, under all runway surface conditions for which the airplane is certificated."

Discussion: A full brake application is defined as an application from brakes fully released to brakes fully applied, and back to fully released. For those airplanes that may provide a number of independent braking systems, which are not "reliant" on a stored energy system for the demonstration of compliance with paragraph (b)(1) of this section, but which perhaps incorporate a stored energy device, this requirement is not applicable. It would be unreasonable that the requirement for a minimum energy capacity and the provision of means to indicate the level of stored energy to the flightcrew should be maintained, particularly if its failure would have a minimal consequence on airplane or passenger safety.

In the event that an hydraulic accumulator is used for energy storage and the gas pressurization depletes, a pressure indication alone as currently required in JAR 25.735(i) would be inadequate because it would not provide indication of such faults to the flightcrew. In fact, the current typical flight deck presentation could give a false sense of security to the crew because it would almost inevitably indicate a satisfactory pressure, regardless of the real situation. Consequently, the proposed rule would require a measure of the stored energy, rather than pressure, to be presented to the flightcrew.

The minimum level of stored energy required for the emergency/standby braking means would be presented as a requirement rather than as advisory material. In the majority of cases, this material has been used as a virtual requirement in the past by airplane manufacturers and regulatory authorities. The proposed change would potentially enhance the current level of safety because the FAA is proposing to adopt a common but not universal industry practice and an improvement over the existing JAR rule. Applicable advisory material would be included in the proposed new AC 25.735-1X.

Proposal 15. The FAA proposes to add a new § 25.735(i), "Brake wear indicators," to read as follows:

"(i) Brake wear indicators. Means must be provided for each brake assembly to indicate when the heat sink is worn to the permissible limit. The means must be reliable and readily visible."

Discussion: In order to ensure, as far as is practicable, that the brake heat sink is not worn beyond its allowable wear limits throughout its operational life, it is considered necessary to provide some device that can readily identify the fully worn limit of the heat sink. The proposal reflects a requirement included in a series of airworthiness directives issued between 1989 and 1994 to require establishment of brake wear limits and to provide means to indicate the same. The British Civil Aviation Authority (CAA) Specification No. 17 also specifies the provision of such an indicator, and the majority of wheel and brake assembly designs include such a device. The proposed rule would have no impact on the current level of safety, because the FAA is proposing to adopt an existing industry practice. Appropriate advisory information would be included in proposed AC 25.735-1X.

Proposal 16. The FAA proposes to add a new § 25.735(j), "Overtemperature burst prevention," a new § 25.731(d), "Overpressure burst prevention," and a new § 25.731(e), "Braked wheels," to read as follows:

"§ 25.735(j) Overtemperature burst prevention. Means must be provided in each braked wheel to prevent wheel failure and tire burst that may result from elevated brake temperatures. Additionally, all wheels must meet the requirements of § 25.731(d)."

"§ 25.731(d) Overpressure burst prevention. Means must be provided in each wheel to prevent wheel failure and tire burst that may result from excessive pressurization of the wheel and tire assembly."

"§ 25.731(e) Braked wheels. Each braked wheel must meet the applicable requirements of § 25.735."

Discussion - § 25.735(j): There is an existing requirement (§ 25.729(f)) related to the protection of equipment in wheel wells against the effects of bursting tires and a similar requirement is stated in TSO-C26c, Wheels and Wheel-Brake Assemblies. JAR 25.729(f) requires protection of equipment on the landing gear and in wheel wells against tire burst and elevated brake temperatures, and a similar requirement is stated in the "Minimum Operational Performance Specification for Wheels and Brakes on JAR Part 25 Civil Aeroplanes" (document ED-69). However, there is no direct requirement in either part 25 or JAR-25 that means must be provided to prevent wheel failure and tire burst that could result from elevated brake temperatures. As a result, it has become an industry practice to incorporate pressure release device(s) that function as a result of elevated wheel temperatures to deflate the tires. Nevertheless, it is believed to be both reasonable and prudent that such a requirement should be clearly stated in the paragraph related to airplane brakes and braking systems. The proposed requirement for temperature activated devices would not impact the current level of safety. Applicable advisory information would be included in proposed AC 25.735-1X.

Discussion - § 25.731(d): Wheel failure and tire burst due to overinflation presents a hazard to ground personnel and the airplane. Certain airplane manufacturers require wheel pressure release devices that reduce this hazard. This is considered a safety issue requiring the incorporation of these devices. Incorporation of pressure release devices in tire inflation equipment is not considered adequate due to a history of misuse resulting in serious injuries or fatalities. Installation in the wheel reduces the potential for tampering or misuse and insures proper levels of protection. The proposed change would retain and potentially enhance the current level of safety. Applicable advisory information would be included in proposed AC 25.735-1X.

Discussion - § 25.731(e): § 25.731 contains regulations applicable to all airplane wheels. If the wheel is braked, additional regulations apply which are contained in § 25.735. Section 25.731(e) is added to provide a cross-reference to those additional requirements. The proposed change would retain and potentially enhance the current level of safety.

Proposal 17. The FAA proposes to add a new § 25.735(k), "Compatibility," to read as follows:

"(k) Compatibility. Compatibility of the wheel and brake assemblies with the airplane and its systems must be substantiated."

Discussion: Reliable and consistent brake system performance can be adversely affected by incompatibilities within the system and with the landing gear and the airplane. As part of the overall substantiation of safe and anomaly free operation, it is necessary to show that no unsafe conditions arise from incompatibilities between the brakes and brake system with other airplane systems and structures. Areas such as antiskid tuning, landing gear dynamics, tire type and size, brake combinations, brake characteristics, brake and landing gear vibrations, etc., need to be explored and corrected if necessary. Therefore, this requirement is introduced to address these issues which are normally covered by airplane manufacturers during development of the airplane and must be addressed by modifiers of the equipment. Incorporation of this requirement would potentially enhance the current level of safety. Appropriate advisory information would be included in proposed AC 25.735-1X.

Regulatory Evaluation, Regulatory Flexibility Determination, and Trade Impact Assessment

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Finally, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these assessments, the FAA has determined that this proposed rule: (1) would generate benefits exceeding its costs and is not "significant" as defined in Executive Order 12866; (2) is not "significant" as defined in DOT's Policies and Procedures; (3) would not have a significant impact on a substantial number of small entities; and (4) would lessen restraints on international trade. These analyses, available in the docket, are summarized below.

Regulatory Evaluation Summary

Although numerous revisions would be made to FAR § 25.735, only one would impose additional quantified costs for both part 25 large and small airplane manufacturers (see proposal 11). One ARAC member, a manufacturer of part 25 small airplanes, asserted that proposals 7, 14, and 16 would also impose incremental costs, but provided no specific estimates. Essentially all of the changes codify current industry practice or conform FAR § 25.735 to corresponding sections of the JAR. Adoption of the proposed changes would increase harmonization and commonality between American and European airworthiness standards. Harmonization would eliminate unnecessary duplication of airworthiness requirements, thus reducing manufacturers' certification costs (6 substantive proposals out of 17 total in the subject NPRM would essentially mirror the proposed European standards; the 11 others would not differ significantly). The FAA believes the harmonization cost savings would exceed the relatively low incremental costs of the proposed rule (see Summary of Costs and Benefits section below).

Proposal 7. Changes regarding parking brake control and cockpit indication of the brake essentially reflect current industry practice for the majority of part 25 manufacturers; consequently, there are no expected incremental costs. As noted above, one manufacturer of part 25 small airplanes, however, indicated that its current designs do not meet this requirement and that costs for cockpit indication in future designs would, in fact, be incremental. The manufacturer, however, did not provide such costs to the FAA. The FAA invites that manufacturer (and/or other interested parties) to provide detailed cost estimates during the public comment period.

Proposal 11. One ARAC member, a manufacturer of part 25 large airplanes, notes that the average impact of the 10% residual RTO energy requirement would be a two to three percent increase in the brake's energy absorption requirements. Notwithstanding, this increase is smaller than the tolerances on its ability to define brake requirements and the brake manufacturer's conformance to the specifications. Also, higher residual energies would enable the manufacturer to raise its recommended brake temperatures for dispatch, so any potential higher brake costs would be offset by more efficient aircraft operation (shorter turnaround times, less time at gate waiting for brakes to cool).

The term "most severe landing stop" ("MSL") would be added to address cases such as immediate return to land after takeoff, where the brake energy for a flaps up landing may exceed that corresponding to the accelerate-stop energy. The MSL requirement, while a new FAA requirement, has been in effect in Europe (per British CAA); consequently, many large part 25 airplane manufacturers currently meet this standard. Notwithstanding, large part 25 airframe and brake manufacturers note that in almost all cases either the MSL stop energy would not exceed the maximum kinetic energy accelerate-stop energy or, the MSL stop condition is extremely improbable. One part 25 large airplane manufacturer, however, noted that demonstrating adherence to this requirement for its typical airplane model would add the equivalent of two additional high energy dynamometer tests in which the test brake would be destroyed; estimated incremental one-time costs for this equal approximately $60,000 per type certification. Another manufacturer, however, estimates only one test in the $20,000 - $40,000 range. Manufacturers of small part 25 airplanes would experience some incremental one-time testing costs totalling approximately $20,000 per type certification.

The aforementioned nonrecurring costs for either the part 25 large or small airplane type certification would easily be offset by the harmonization cost savings cited earlier. Any potential safety benefits from avoiding even one minor accident would add to such benefits. The FAA, therefore, finds proposal 11 to be cost beneficial.

Proposal 14. As the stored energy requirement reflects current industry practice for most part 25 manufacturers, there would be no expected incremental costs associated with it. However, the same manufacturer (of part 25 small airplanes) that reported potential costs for proposal 7 also indicated that its current designs do not include usable stored energy indication, and compliance with this requirement in future designs would impose incremental costs; detailed cost estimates, however, were not provided. The FAA requests that the manufacturer (or others) provide detailed cost estimates during the public comment period.

Proposal 16. In the last several years, many wheel manufacturers have included pressure release devices in most new production wheels in order to avoid potential liability. Codification of existing industry practice would ensure that the enhanced level of safety is retained. There are no expected incremental costs associated with this proposal since it does reflect current industry practice. However, the same manufacturer (of part 25 small airplanes) that, in contrast to other manufacturers, reported potential costs for proposals 7 and 14 indicated that the requirement for wheel pressure release devices would also impose incremental costs in future designs. Again, the FAA invites that manufacturer (or others) to provide detailed cost estimates during the public comment period.

Summary of Costs and Benefits

As delineated above, and barring more detailed information for proposals 7, 14, and 16, the FAA concludes that only proposal 11 would result in incremental costs attributable to the subject NPRM. Demonstrating adherence to the MSL requirement would increase nonrecurring testing costs from $20,000 - $60,000 for a part 25 large airplane type certification; the amount for a part 25 small airplane type certification is estimated to be $20,000. According to one manufacturer, cost savings from harmonization, in terms of avoiding added costs of coordination and documentation, with the JAA and involving, for example, additional travel overseas, reports, etc., would be equal to or greater than the maximum incremental cost of $60,000. The FAA believes that potential safety benefits resulting from specification of minimum accepted standards would supplement these cost-savings. Although there were numerous (approx. 170) accidents involving brake failures during landings in the period 1982-1995, none were determined to have been directly preventable by the subject provisions. Different designs in future type certifications, however, could present unexpected problems and raise future accident rates. This proposed rule is expected to reduce the chances of future accidents by codifying in the FAR (and therefore making mandatory) what was prevailing, but not necessarily universal, industry practice.

For the reasons specified, the FAA finds the proposed rule to be cost-beneficial.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by government regulations. The RFA requires a Regulatory Flexibility Analysis if a proposed or final rule would have a significant economic impact, either detrimental or beneficial, on a substantial number of small entities. FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, prescribes standards for complying with RFA review requirements in FAA rulemaking actions. The Order defines "small entities" in terms of size thresholds, "significant economic impact" in terms of annualized cost threshold, and "substantial number" as a number that is not less than eleven and that is more than one-third of the small entities subject to the proposed or final rule.

The proposed rule would affect manufacturers of transport category airplanes produced under future new airplane type certifications. For manufacturers, Order 2100.14A specifies a size threshold for classification as a small entity as 75 or fewer employees. Since no part 25 airplane manufacturer has 75 or fewer employees, the proposed rule would not have a significant economic impact on a substantial number of small manufacturers.

International Trade Impact Assessment

Consistent with the Administration's belief in the general superiority, desirability, and efficacy of free trade, it is the policy of the Administrator to remove or diminish, to the extent feasible, barriers to international trade, including both barriers affecting the export of American goods and services to foreign countries and those affecting the import of foreign goods and services into the United States.

In accordance with that policy, the FAA is committed to develop as much as possible its aviation standards and practices in harmony with its trading partners. Significant cost savings can result from this, both to United States companies doing business in foreign markets, and foreign companies doing business in the United States.

This proposed rule is a direct action to respond to this policy by increasing the harmonization of the U.S. Federal Aviation Regulations with the European Joint Aviation

Requirements. The result would be a positive step toward removing impediments to international trade.

Federalism Implications

The amended regulations proposed in this rulemaking would not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this proposal would not have sufficient federalism implications to warrant preparing a Federalism Assessment.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) standards and recommended practices to the maximum extent practicable. The FAA has determined that this proposed rule would not conflict with any international agreement of the United States.

Paperwork Reduction Act

There are no new requirements for information collection associated with this proposed rule that would require approval from the Office of Management and Budget pursuant to the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)).

Regulations Affecting Intrastate Aviation in Alaska.

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying regulations in Title 14 of the CFR in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish such regulatory distinctions as he or she considers appropriate. Because this proposed rule would apply to the certification of future designs of transport category airplanes and their subsequent operation, it could, if adopted, affect intrastate aviation in Alaska. The FAA therefore specifically requests comments on whether there is justification for applying the proposed rule differently to intrastate operations in Alaska.

INFORMATION CONTACT.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements

The Proposed Amendments

Accordingly, the Federal Aviation Administration proposes to amend 14 CFR part 25 of the Federal Aviation Regulations (FAR) as follows:

PART 25 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

2. Section 25.731 would be amended by adding new paragraphs (d) and (e) to read as follows:

§ 25.731 Wheels

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(d) Overpressure burst prevention. Means must be provided in each wheel to prevent wheel failure and tire burst that may result from excessive pressurization of the wheel and tire assembly.

(e) Braked Wheels. Each braked wheel must meet the applicable requirements of § 25.735.

3. Section 25.735 would be revised to read as follows:

§ 25.735 Brakes and braking systems

(a) Approval. Each assembly consisting of a wheel(s) and brake(s) must be approved.

(b) Brake system capability. The brake system, associated systems and components must be designed and constructed so that:

(1) If any electrical, pneumatic, hydraulic, or mechanical connecting or transmitting element fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest with a braked roll stopping distance of not more than two times that obtained in determining the landing distance as prescribed in § 25.125.

(2) Fluid lost from a brake hydraulic system, following a failure in, or in the vicinity of, the brakes, is insufficient to cause or support a hazardous fire on the ground or in flight.

(c) Brake controls. The brake controls must be designed and constructed so that:

(1) Excessive control force is not required for their operation.

(2) If an automatic braking system is installed, means are provided to:

(i) arm and disarm the system, and

(ii) allow the pilot(s) to override the system by use of manual braking.

(d) Parking brake. The airplane must have a parking brake control that, when selected on, will, without further attention, prevent the airplane from rolling on a dry and level paved runway when the most adverse combination of maximum thrust on one engine and up to maximum ground idle thrust on any, or all, other engine(s) is applied. The control must be suitably located or be adequately protected to prevent inadvertent operation. There must be indication in the cockpit when the parking brake is not fully released.

(e) Antiskid system. If an antiskid system is installed:

(1) It must operate satisfactorily over the range of expected runway conditions, without external adjustment.

(2) It must, at all times, have priority over the automatic braking system, if installed.

(f) Kinetic energy capacity. The design landing stop, the maximum kinetic energy accelerate-stop, and the most severe landing stop brake kinetic energy absorption requirements of each wheel and brake assembly must be determined. It must be substantiated by dynamometer testing that, at the declared fully worn limit(s) of the brake heat sink, the wheel and brake assemblies are capable of absorbing not less than these levels of kinetic energy. Energy absorption rates defined by the airplane manufacturer must be achieved. These rates must be equivalent to mean decelerations not less than 10 fps^2 for the design landing stop and 6 fps^2 for the maximum kinetic energy accelerate stop. The most severe landing stop need not be considered for extremely improbable failure conditions or if the maximum kinetic energy accelerate-stop energy is more severe.Design landing stop is an operational landing stop at maximum landing weight. Maximum kinetic energy accelerate-stop is a rejected takeoff for the most critical combination of airplane takeoff weight and speed. Most severe landing stop is a stop at the most critical combination of airplane landing weight and speed.

(g) Brake condition after high kinetic energy dynamometer stop(s). Following the high kinetic energy stop demonstration(s) required by paragraph (f) of this section, with the parking brake promptly and fully applied for at least three (3) minutes, it must be demonstrated that for at least five (5) minutes from application of the parking brake, no condition occurs (or has occurred during the stop), including fire associated with the tire or wheel and brake assembly, that could prejudice the safe and complete evacuation of the airplane.

(h) Stored energy systems. An indication to the flightcrew of the usable stored energy must be provided if a stored energy system is used to show compliance with paragraph (b)(1) of this section. The available stored energy must be sufficient for:

(1) At least six (6) full applications of the brakes when an antiskid system is not operating; and

(2) Bringing the airplane to a complete stop when an antiskid system is operating, under all runway surface conditions for which the airplane is certificated.

(i) Brake wear indicators. Means must be provided for each brake assembly to indicate when the heat sink is worn to the permissible limit. The means must be reliable and readily visible.

(j) Overtemperature burst prevention. Means must be provided in each braked wheel to prevent wheel failure and tire burst that may result from elevated brake temperatures. Additionally, all wheels must meet the requirements of § 25.731(d).

(k) Compatibility. Compatibility of the wheel and brake assemblies with the airplane and its systems must be substantiated.

Issued in Washington, DC, on

BRAKES AND BRAKING SYSTEMS CERTIFICATION TESTS, AND ANALYSIS ANM-110

1. PURPOSE. This Advisory Circular (AC) provides guidance material for use as an acceptable means of demonstrating compliance with the braking system requirements of the Federal Aviation Regulations (FAR) for transport category airplanes. Like all AC material, this AC is not, in itself, mandatory and does not constitute a regulation. It is issued to provide an acceptable means, although not the only means, of compliance with the rules. Terms used in this AC, such as "shall" and "must," are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the pertinent FAR. This advisory circular does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

2. RELATED DOCUMENTS

a. Related Federal Aviation Regulations. Sections 25.731 and 25.735 of the FAR, as amended through Amendment 25-xx, and other sections relating to brakes and braking system installations. Sections which prescribe requirements for the design, substantiation, and certification of braking systems include:

§ 21.303	Replacement and modification parts
§ 25.101	General
§ 25.109	Accelerate-stop distance
§ 25.125	Landing
§ 25.301	Loads
§ 25.303	Factor of safety
§ 25.729	Retracting mechanism
§ 25.733	Tires
§ 25.1301	Function and installation.
§ 25.1309	Equipment, systems and installations.
§ 25.1322	Warning, caution and advisory lights.
§ 25.1501	General: Systems and equipment limitations (JAR25x1524)
§ 25.1541	Markings and Placards

Additional sections (and their associated advisory circulars where applicable) that prescribe requirements which can have a significant impact on the overall design and configuration of braking systems include, but are not limited to:

§ 21.101	Designation of applicable regulations
§ 25.863	Flammable fluid fire protection
§ 25.943	Negative acceleration (JAR 25x1315)
§ 25.1001	Fuel jettisoning system
§ 25.1183	Flammable fluid-carrying components
§ 25.1185	Flammable fluids

b. Advisory Circulars (AC's).

AC 25.1309-1A	System Design and Analysis
AC 25-7	Flight Test Guide for Certification of Transport Category Airplanes (under revision)
AC 21-29A	Detecting and Reporting Suspected Unapproved Parts
AC 91-6A	Water, Slush, and Snow on the Runway (AMJ 25x1591 Supplementary Performance Information for Takeoff from Wet Runways and for Operation on Runways Contaminated by Standing Water, Slush, Loose Snow, Compacted Snow, or Ice)

c. Technical Standard Orders (TSO's).

TSO-C26c	Aircraft Wheels and Wheel-Brake Assemblies with Addendum I
TSO-C135	Transport Airplane Wheel and Wheel and Brake Assemblies
TSO-C62d	Tires
TSO-C75	Hydraulic Hose Assemblies

d. Federal Aviation Administration Orders.

Order 8110.4A	Type Certification Process
Order 8110.8	Engineering Flight Test Guide For Transport Category Airplanes

Advisory Circulars, TSOs, and FAA Orders can be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, SVC-121.23, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

e. Society of Automotive Engineers (SAE) Documents.

ARP 597C	Wheels and Brakes, Supplementary Criteria for Design Endurance - Civil Transport Aircraft
ARP 813A	Maintainability Recommendations for Aircraft Wheels and Brakes
AIR 1064B	Brake Dynamics
ARP 1070B	Design and Testing of Antiskid Brake Control Systems for Total Aircraft Compatibility
AS 1145A	Aircraft Brake Temperature Monitor System (BTMS)
ARP 1619	Replacement and Modified Brakes and Wheels
AIR 1739	Information on Antiskid Systems
ARP 1907	Automatic Braking System Requirements
AIR 1934	Use of Carbon Heat Sink Brakes on Aircraft
ARP 4102/2	Automatic Braking System (ABS)
ISO 7137	Environmental Conditions and Test Procedures for Airborne Equipment (not an SAE document but is available from the SAE)

These documents can be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania, 15096.

f. RTCA Documents.

RTCA/DO-160D	Conditions and Test Procedures for Airborne equipment, Issued July 12, 1996.
RTCA/DO-178B	Software Considerations in Airborne Systems and Equipment Certification, Issued December 1, 1992

Copies of RTCA documents may be purchased from the RTCA Inc., 1140 Connecticut Avenue NW, Suite 1020, Washington, D.C. 20036.

g. Military Documents.

MIL-STD-810	Environmental Test Methods and Engineering Guidelines

This document can be obtained from the Department of Defense, DODSSP, Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.

3. BACKGROUND.

a. Effective February 1, 1965, part 25 was added to the FAR to replace Part 4b of the Civil Air Regulations (CAR). For wheels, CAR 4b.335(a) and (b), respectively, became §§ 25.731(a) and (b) of the FAR. For brakes/braking systems, CAR 4b.337 (a)(1), 4b.337(a)(2) and (a)(3), 4b.337(b), 4b.337(c), 4b.337(d), 4b.335(c), and 4b.335(d),respectively, became §§ 25.735(a), 735(b), 735(c), 735(d), 735(e), 735(f), and 735(g) of the FAR. Since then, § 25.735 has been revised by Amendment 25-23 (1970), Amendment 25-48 (1979), Amendment 25-52 (1980), Amendment 25-72 (1990), Amendment 25-XX **[insert amendment number when final rule resulting from Notice 93-8 is published]**, Improved Standards for Determining Rejected Takeoff and Landing Performance, and Amendment 25-XX **[insert amendment number when published]**, Revision of Braking Systems Airworthiness Standards to Harmonize with European Airworthiness Standards for Transport Category Airplanes, to make the regulations more comprehensive and to delete redundancies.

(1) Amendment 25-23 deleted reference to military specification (MIL-B-8075) to show compliance for antiskid devices under § 25.735(e), to allow any other acceptable means of compliance. In addition, proper units of "knots" were added to stall speed under § 25.735(f)(2).

(2) Amendment 25-48 revised the technical standard order TSO-C26b for aircraft wheels and wheel-brake assemblies and related type certification requirements for airplane brakes (§ 25.735). The revised standard TSO-C26c incorporated updated and improved minimum performance standards for the design and construction of aircraft wheels and brakes. The amendment also changed § 25.735 as follows: Under § 25.735(b), the incorrect reference to § 25.75 was replaced by a correct reference to § 25.125. Under § 25.735(f)(2), the numerical constant 0.0442 was corrected as 0.0443, and the letter "N" was appropriately redefined as the Number of main wheels with brakes. Under § 25.735(f)(2), the term V_{SO} in the formula was replaced with "V" such that V must not be less than V_{SO} under definition. Under § 25.735(g), the term V_{SO} was replaced by V to be consistent with terminology used under § 25.735(f)(2).

(3) Under Amendment 25-52, § 37.172, Aircraft wheels and brakes, TSO-C26c was removed from the regulations, previously published as Subpart B of 14 CFR part 37, and made available to the public through the FAA Office of Airworthiness, Aircraft Engineering Division, Systems Branch (AWS-130) at FAA Headquarters in Washington, D.C., and at all regional Flight Standards Engineering and Manufacturing Offices. Subpart A of 14 CFR part 37 was included in Subpart O of 14 CFR part 21. Part 37 was revoked.

(4) Under Amendment 25-72, the text of the last sentence in existing § 25.735(b) was changed to clarify the intent. In addition, § 25.731 was amended to become compatible with § 25.25, which had been amended to provide for weights that are in excess of takeoff weight, such as ramp weights, provided that compliance with the applicable structural requirements, including wheel strength, is demonstrated at the higher weights.

(5) Under Amendment 25-XX **[insert amendment number, when published, of the rule resulting from Notice 93-8, Improved Standards for Determining Rejected Takeoff and Landing Performance]**, the regulations were updated to add the brake wear limits determination requirements. On May 21, 1988, an American Airlines DC-10 experienced an 86% maximum kinetic energy (KE) rejected takeoff (RTO) in a dispatch configuration in which eight of the ten brakes were worn close to the maintenance limits. The eight brakes failed in the early portion of the braking run and the airplane overran the runway. As a result, the FAA reviewed the methodology used in the determination of allowable brake wear limits for transport category airplanes. It was determined that brake wear limits should be established during certification to ensure that fully worn brakes will function properly during a maximum KE RTO. The FAA issued a series of airplane specific airworthiness directives between 1989 and 1994 to establish brake wear limits using the new criteria.

(6) Although part 25 and JAR-25 are very similar, they are not identical. Differences between the FAR and the JAR can result in substantial additional costs when airplanes are type certificated to both standards. Starting In 1992, the harmonization effort for various systems-related airworthiness requirements was undertaken by the Aviation Rulemaking Advisory Committee (ARAC). A working group of industry and government braking systems specialists from Europe , the United States, and Canada was chartered by notice in the Federal Register (59 FR 30080, June 10, 1994). The working group was tasked to develop harmonized standards and any collateral documents, such as advisory circulars, concerning new or revised requirements for braking systems, and the associated test conditions for braking systems, installed in transport category airplanes (§§ 25.731 and 25.735). The advisory material contained in this AC was developed by the Braking Systems Harmonization Working Group to ensure consistent application of the standards revised under Amendment 25-XX **[insert amendment number when published]**, Revision of Braking Systems Airworthiness Standards to Harmonize with European Airworthiness Standards for Transport Category Airplanes, and the corresponding new TSO-C135.

4. DISCUSSION.

a. Approval.

(1) (Ref. § 25.735(a)). Each wheel and brake assembly fitted with each designated and approved tire type and size, where appropriate, should be shown to be capable of meeting the minimum standards and capabilities detailed in the applicable TSO, in combination with the type certification procedures for the airplane; or by any other means approved by the Administrator. This applies equally to replacement, modified, and refurbished wheel and brake assemblies or components, whether the changes are made by the Original Equipment Manufacturer (OEM) or others. Additionally, the components of the wheels, brakes, and braking systems should be designed to:

(a) Withstand all pressures and loads, applied separately and in conjunction, to which they may be subjected in all operating conditions for which the airplane is certificated.

(b) Withstand simultaneous applications of normal and emergency braking functions, unless adequate design measures have been taken to prevent such a contingency..

(c) Meet the energy absorption requirements without auxiliary cooling devices (such as cooling fans)

(d) Not induce unacceptable vibrations at any likely ground speed and condition or any operating condition (such as retraction or extension).

(e) Protect against the ingress or effects of foreign bodies or materials (water, mud, oil, and other products) that may adversely affect their satisfactory performance. Combinations of any additional wheel and brake assemblies should meet the applicable airworthiness requirements specified in §§ 21.101(a) and (b) to eliminate situations that may have adverse consequences on airplane braking control and performance. This includes the possibility of the use of modified brakes either alone (i.e., as a shipset) or alongside the OEM's brakes and the mixing of separately approved assemblies.

(2) Refurbished and Overhauled Equipment. Refurbished and overhauled equipment is equipment overhauled and maintained by the applicable OEM or its designee in accordance with the OEM's Component Maintenance Manual (CMM) and associated documents. It is necessary to demonstrate compliance of all refurbished configurations with the applicable TSO and airplane manufacturer's specifications. It is also necessary to verify that performances are compatible for any combination of mixed brake configurations, including refurbished/overhauled and new brakes. It is essential to assure that Airplane Flight Manual braking performance and landing gear and airplane structural integrity are not adversely altered.

(3) Replacement and Modified Equipment. Replacement and modified equipment includes changes to any approved wheel and brake assemblies not addressed under paragraph 4a(2) of this AC. Consultation with the airplane manufacturer on the extent of

testing is recommended. Particular attention should be paid to potential differences in the primary brake system parameters (e.g., brake torque, energy capacity, vibration, brake sensitivity, dynamic response, structural strength, wear state, etc.). If comparisons are made to previously approved equipment, the test articles (other than the proposed parts to be changed) and conditions should be comparable, as well as the test procedures and equipment on which comparative tests are to be conducted. For wheel and brake assembly tests, the tire size, manufacturer, and ply rating used for the test should be the same and the tire condition should be comparable. For changes of any heat sink component parts, structural parts (including the wheel), friction elements, etc., it is necessary for the applicant to provide evidence of acceptable performance and compatibility with the airplane and its systems.

(a) Changes to a brake might be considered as a minor change, as long as the changes are not to the friction elements, and the proposed change cannot affect the airplane stopping performance, brake energy absorption characteristics, and/or continued airworthiness of the airplane or wheel and brake assembly (e.g., vibration and/or thermal control, brake retraction integrity, etc.). It is incumbent on the applicant to provide technical evidence justifying a minor change. Changes to a wheel assembly outside the limits allowed by the OEM's CMM should be considered a major change due to potential airworthiness issues.

(b) Past history with friction elements has indicated the necessity of on-going monitoring (by dynamometer test) of frictional and energy absorption capabilities to assure that they are maintained over the life of the airplane program. These monitoring plans have complemented the detection and correction of unacceptable deviations. The applicant should demonstrate that frictional and energy absorption capabilities of the friction elements are maintained over time.

(c) Intermixing of wheel and brake assemblies from different suppliers is generally not acceptable due to complexities experienced with different friction elements, specific brake control tuning, and other factors.

b. Brake system capability.

(1) (Ref. § 25.735(b)(1)). The system should be designed so that no single failure of the system degrades the airplane stopping performance beyond doubling the braked roll stopping distance. Failures are considered to be fracture, leakage, or jamming of a component in the system or loss of an energy source. Components of the system include all parts that contribute to transmitting the pilot's braking command to the actual generation of braking force. Multiple failures resulting from a single cause should be considered a single failure (e.g., fracture of two or more hydraulic lines as a result of a single tire failure). Sub-components within the brake assembly, such as brake discs and actuators (or their equivalents), should be considered as connecting or transmitting elements, unless it is shown that leakage of hydraulic fluid resulting from failure of the sealing elements in these sub-components within the brake assembly would not reduce the braking effectiveness below that specified in § 25.735(b)(1).

(a) In order to meet the stopping distance requirements of § 25.735(b)(1) in the event of failure of the normal brake system, it is common practice to provide an alternate brake system. The normal and alternate braking systems should be independent, being supplied by separate power sources. Following a failure of the normal system, the changeover to a second system (whether manually or by automatic means) and the functioning of a secondary power source should be effected rapidly and safely and should not involve risk of wheel locking, whether the brakes are applied or not at the time of changeover.

(b) The brake systems and components should be separated or appropriately shielded so that complete failure of the braking system(s) as a result of a single cause is minimized.

(2) (Ref. § 25.735(b)(2)). Compliance may be achieved by:

(a) showing that fluid released would not impinge on the brake, or any part of the assembly that might cause the fluid to ignite;

(b) showing that the fluid will not ignite; or

(c) showing that the maximum amount of fluid released is not sufficient to sustain a fire.

Additionally, in the case of a fire, the applicant may show that the fire is not hazardous, taking into consideration such factors as landing gear geometry, location of fire sensitive (susceptibility) equipment and installations, system status, flight mode, etc.

c. <u>Brake controls</u>.

(1) (Ref. § 25.735(c)(1)). The braking force should increase or decrease progressively as the force or movement applied to the brake control is increased or decreased and should respond to the control as quickly as is necessary for safe and satisfactory operation. A brake control intended only for parking need not operate progressively. There should be no requirement to select the parking brake "off" in order to achieve a higher braking force with manual braking.

(2) (Ref. § 25.735(c)(2)). When an automatic braking system is installed such that various levels of braking (e.g., low, medium, high) may be preselected to occur automatically following a touchdown, the pilot(s) should be provided with a means that is separate from other brake controls to arm and/or disarm the system prior to the touchdown.

The automatic braking system design should be evaluated for integrity and non-hazard, including the probability and consequence of insidious failure of critical components, and noninterference with the non-automatic braking system. Single failures in the automatic braking system should not compromise non-automatic braking of the airplane. Automatic braking systems that are to be approved for use in the event of a rejected takeoff should have a single selector position, set prior to takeoff, enabling this operating mode.

d. Parking brake. (Ref. § 25.735(d)). It should be demonstrated that the parking brake has sufficient capability in all allowable operating conditions (Master Minimum Equipment List (MMEL) conditions) to be able to prevent the rotation of braked wheels, with the stated engine power settings, and with the airplane configuration (i.e., ground weight, c.g. position and nosewheel (or tailwheel) angle) least likely to result in skidding on a dry, level runway surface. Where reliable test data are available, substantiation by means other than airplane testing may be acceptable.

(1) For compliance with the requirement for indication that the parking brake is not fully released, the indication means should be associated, as closely as is practical, with actual application of the brake rather than the selector (control). The intent is to minimize the possibility of false indication due to failures between the point used to indicate that the parking brake is set and the brake. This requirement is separate from and in addition to the parking brake requirements associated with JAR 25.703(a)(3), Take-off warning systems.

(2) The parking brake control, whether or not it is independent of the emergency brake control, should be marked with the words "Parking Brake" and should be constructed in such a way that, once operated, it can remain in the selected position without further flightcrew attention. It should be located where inadvertent operation is unlikely or be protected, by suitable means, against inadvertent operation.

e. Antiskid system.

(1) (Ref. § 25.735(e)). No single failure in the antiskid system should result in the brakes being applied, unless braking is being commanded by the pilot. In the event of a failure, an automatic or pilot controlled, or both, means should be available to allow continued braking without antiskid.

(2) (Ref. §§ 25.735(e)(1) and (e)(2)).

(a) Failures which render the system ineffective should not prevent manual braking control by the pilot(s) and should normally be indicated. Failure of wheels, brakes, or tires should not inhibit the function of the antiskid system for unaffected wheel, brake, and tire assemblies.

(b) The antiskid system should be capable of giving a satisfactory braking performance over the full range of tire to runway friction coefficients and surface conditions, without the need for pre-flight or pre-landing adjustments or selections. The range of friction coefficients should encompass those appropriate to dry, wet, and contaminated surfaces and for both grooved and ungrooved runways.

(c) The use of the phrase "without external adjustment" is intended to imply that once the antiskid system has been optimized for operation over the full range of expected conditions for which the airplane is to be type certificated, pre-flight or pre-landing adjustments made to the equipment to enable the expected capabilities to be achieved are not acceptable. For example, a specific pre-landing selection for a landing on a contaminated, low μ runway, following a takeoff from a dry, high μ surface, should not be necessary for satisfactory braking performance to be achieved.

(d) It should be shown that the brake cycling frequency imposed by the antiskid installation will not result in excessive loads on the landing gear. Antiskid installations should not cause surge pressures in the brake hydraulic system that would be detrimental to either the normal or emergency brake system and components.

(e) The system should be compatible with all tire sizes and type combinations permitted and for all allowable wear states of the brakes and tires. Where brakes of different types or manufacture are permitted, compatibility should be demonstrated or appropriate means should be employed to ensure that undesirable combinations are precluded.

f. Kinetic energy capacity (Ref. § 25.735(f)). The kinetic energy capacity of each tire, wheel, and brake assembly should be at least equal to that part of the total airplane energy that the assembly will absorb during a stop, with the heat sink at a defined condition at the commencement of the stop.

(1) Calculation of Stop Kinetic Energy.

(a) The design landing stop, the maximum kinetic energy accelerate-stop, and the most severe landing stop brake kinetic energy absorption requirements of each wheel and brake assembly should be determined using either of the following methods:

(1) A conservative rational analysis of the sequence of events expected during the braking maneuver; or

(2) A direct calculation based on the airplane kinetic energy at the commencement of the braking maneuver.

(b) When determining the tire, wheel, and brake assembly kinetic energy absorption requirement using the rational analysis method, the analysis should use conservative values of the airplane speed at which the brakes are first applied, the range of the expected coefficient of friction between the tires and runway, aerodynamic and propeller drag, powerplant forward thrust, and, if more critical, the most adverse single engine or propeller malfunction.

(c) When determining the tire, wheel, and brake assembly energy absorption requirement using the direct calculation method, the following formula, which needs to be modified in cases of designed unequal braking distribution, should be used:

$$KE = 0.0443\ WV^2/N \text{ (ft-lb.)}$$

where KE = Kinetic Energy per wheel (ft-lb.)
N = Number of main wheels with brakes
W = Airplane Weight (lb.)
V = Airplane Speed (knots)

or if SI (Metric) units are used:

$$KE = 1/2\ mV^2/N \text{ (Joule)}$$

where KE = Kinetic Energy per wheel (J)
N = Number of main wheels with brakes
m = Airplane Mass (kg.)
V = Airplane Speed (m/s)

For all cases, V is the ground speed and takes into account the prevailing operational conditions. All approved landing flap conditions should be considered when determining the design landing stop energy.

These calculations should account for cases of designed unequal braking distributions. "Designed unequal braking distribution" refers to unequal braking loads between wheels that result directly from the design of the airplane. An example would be the use of both mainwheel and nosewheel brakes, or the use of brakes on a centerline landing gear supporting lower vertical loads per braked wheel than the main landing gear braked wheels. It is intended that this term should account for effects such as runway crown. Crosswind effects need not be considered.

For the design landing case, the airplane speed should not be less than $V_{REF}/1.3$, where V_{REF} is the airplane steady landing approach speed at the maximum design landing weight and in the landing configuration at sea level. Alternatively, the airplane speed should not be less than V_{SO}, the poweroff stall speed of the airplane at sea level, at the design landing weight, and in the landing configuration.

(2) Heat Sink Condition at Commencement of the Stop.

(a) For the maximum kinetic energy accelerate-stop case, the calculation should account for the brake temperature following a previous typical landing, the effects of braking during taxi-in, the temperature change while parked, the effects of braking during taxi-out, and the additional temperature change during the takeoff acceleration phase, up to the time of brake application. The analysis may not take account of auxiliary cooling devices. Conservative assessments of typical ambient conditions and the time the airplane will be on the ground should be used.

(b) For the most severe landing stop case, the same temperature conditions and changes used for the maximum kinetic energy accelerate-stop case should be assumed, except that further temperature change during the additional flight phase may be considered. The duration of this additional flight phase should be determined as the minimum practical between the takeoff and landing on the same runway, with the airplane in a configuration that would enable such a return to be made. However, should it be determined that the most severe landing stop can only reasonably occur after a more extended flight phase, this may also influence (reduce) the determined heat sink temperature.

(c) The brake temperature at the commencement of the braking maneuver should be determined using the rational analysis method. However, in the absence of such analysis, an arbitrary heat sink temperature should be used equal to the normal ambient temperature, increased by the amount that would result from a 10% maximum kinetic energy accelerate-stop for the accelerate-stop case and from a 5% maximum kinetic energy accelerate-stop for landing cases.

(3) Substantiation.

(a) Substantiation is required that the wheel and brake assembly is capable of absorbing the determined levels of kinetic energy at all permitted wear states up to and including the declared fully worn limits. The term wear "state" is used to clarify that consideration should be given to possible inconsistencies or irregularities in brake wear in some circumstances, such as greater wear at one end of the heat sink than the other. Qualification related to equally distributed heat sink wear may not be considered adequate. If in-service wear distribution is significantly different from wear distribution used during qualification testing, additional substantiation and/or corrective action may be necessary.

(b) The minimum initial brakes-on speed used in the dynamometer tests should not be more than the velocity (V) used in the determination of the kinetic energy requirements of § 25.735(f). This assumes that the test procedure involved a specific rate of deceleration and, therefore, for the same amount of kinetic energy, a higher initial brakes-on speed would result in a lower rate of energy absorption. 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. Such a situation is recognized and is similarly stated in TSO-C135, which provides an acceptable means for brake approval under § 25.735(a).

(c) Brake qualification tests are not intended as a means of determining expected airplane stopping performance, but may be used as an indicator for the most critical brake wear state for airplane braking performance measurements.

g. Brake condition after high kinetic energy dynamometer stop(s). (Ref. § 25.735(g)).

(1) Following the high kinetic energy stop(s), the parking brake should be capable of restraining further movement of the airplane and should maintain this capability for the period during which the need for an evacuation of the airplane can be determined and then fully accomplished. It should be demonstrated that, with a parking brake application within a period not exceeding 20 seconds of achieving a full stop, or within 20 seconds from the time that the speed is retarded to 20 knots (or lower), in the event that the brakes are released prior to achieving a full stop (as permitted by TSO-C135), the parking brake can be applied normally and that it remains functional for at least 3 minutes.

(2) Practical difficulties associated with dynamometer design may preclude directly demonstrating the effectiveness of the parking brake in the period immediately following the high energy dynamometer stop(s). Where such difficulties prevail, it should be shown that, for the 3-minute period, no structural failure or other condition of the brake components occurs that would significantly impair the parking brake function.

(3) Regarding the initiation of a fire, it should be demonstrated that no continuous or sustained fire, extending above the level of the highest point of the tire, occurs before the 5-minute period has elapsed. Neither should any other condition arise during this same period or during the stop, either separately or in conjunction with a fire, that could be reasonably judged to prejudice the safe and complete airplane evacuation. Fire of a limited extent and of a temporary nature (e.g., those involving wheel bearing lubricant or minor oil spillage) is acceptable. For this demonstration, neither firefighting means nor coolants may be applied.

h. Stored energy systems. (Ref. § 25.735(h))

(1) Stored energy systems use a self-contained source of power, such as a pressurized hydraulic accumulator or a charged battery. This requirement is not applicable for those airplanes that provide a number of independent braking systems, including a stored energy system, but are not "reliant" on the stored energy system for the demonstration of compliance with § 25.735(b).

(2) The indication of usable stored energy should show:

(a) The minimum energy level necessary to meet the requirements of §§ 25.735 (b)(1) and (h) (i.e., the acceptable level for dispatch of the airplane);

(b) The remaining energy level; and

(c) The energy level below which further brake application may not be possible.

(3) If a gas pressurized hydraulic accumulator is to be used as the energy storage means, indication of accumulator pressure alone is not considered adequate means to indicate available stored energy, unless verification can be made of the correct precharge

pressure with the hydraulic system pressure off and the correct fluid volume with the hydraulic system pressure on. Furthermore, additional safeguards may be necessary to ensure that sufficient energy will be available at the end of the flight. Similar considerations should be made if other stored energy systems are used.

(4) A full brake application is defined as an application from brakes fully released to brakes fully applied, and back to fully released.

i. Brake wear indicators. (Ref. § 25.735(i)). The indication means should be located such that no special tool or illumination (except in darkness) is required. Expert interpretation of the indication should not be necessary.

j. Overtemperature and overpressure burst prevention. (Ref. §§ 25.735(j) and 25.731(d)). Generally, two separate types of protection should be provided: one specifically to release the tire pressure should the wheel temperature increase to an unacceptable level, and the other to release the tire pressure should the pressure become unacceptably high, particularly during the inflation process. The temperature sensitive devices are required in braked wheels only, but the pressure sensitive devices are required in all wheels.

(1) The temperature sensitive devices (e.g., fuse or fusible plugs) should be sufficient in number and appropriately located to reduce the tire pressure to a safe level before any part of the wheel becomes unacceptably hot, irrespective of the wheel orientation. The devices should be designed and installed so that once operated (or triggered) their continued operation is not impaired by the releasing gas. The effectiveness of these devices in preventing hazardous tire blowout or wheel failure should be demonstrated. It should also be demonstrated that the devices will not release the tire pressure prematurely during takeoff and landing, including during "quick turnaround" types of operation.

(2) It should be shown that the overpressurization devices, or the devices in conjunction with the tire inflation means permanently installed in the wheel, would not permit the tire pressure to reach an unsafe level regardless of the capacity of the inflation source.

(3) Both types of devices should normally be located within the structure of the wheel in positions which minimize the risk of damage or tampering during normal maintenance.

k. Compatibility. (Ref. § 25.735(k).

(1) As part of the overall substantiation of safe and anomaly free operation, it is necessary to show that no unsafe conditions arise from incompatibilities between the brakes and brake system with other airplane systems and structures. Areas that should be explored include antiskid tuning, landing gear dynamics, tire type and size, brake combinations, brake characteristics, brake and landing gear vibrations, etc. Similarly, wheel and tire compatibility should be addressed. These issues should be readdressed when the equipment is modified.

(2) During brake qualification testing, sufficient dynamometer testing over the ranges of permissible brake wear states, energy levels, brake pressures, brake temperatures, and speeds should be undertaken to provide information necessary for systems integration.

Revised 12/12/97 per legal review
Revised 12/17/97 per additional cmnts from Mahinder.

Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C135

Proposed
Technical Standard Order

Subject: **Transport Airplane Wheels and Wheel and Brake Assemblies**

1. PURPOSE. This Technical Standard Order (TSO) prescribes the minimum performance standards (MPS) that transport category airplane wheels, and wheel and brake assemblies must meet to be identified with the applicable TSO marking.

2. APPLICABILITY.

a. This TSO is effective for new applications submitted after the effective date of this TSO.

b. Previously Approved Equipment. Wheels and wheel-brake assemblies approved prior to the effective date of this TSO may continue to be manufactured under the provisions of their original approval.

3. REQUIREMENTS. Wheels, and wheel and brake assemblies, that are to be so identified and that are manufactured on or after the effective date of this TSO must meet the MPS qualification and documentation requirements set forth in appendix 1 of this TSO titled "Minimum Performance Specification for Transport Airplane Wheels, Brakes, and Wheel and Brake Assemblies." Brakes and associated wheels are to be considered as an assembly for TSO authorization purposes.

4. MARKING.

a. In addition to the marking specified in 14 CFR 21.607(d), the following information shall be legibly and permanently marked on the major equipment components:

(1) Size (this marking applies to wheels only)

(2) Hydraulic fluid type (this marking applies to brakes only)

(3) Serial Number

b. The manufacturer's address required by § 21.607(d)(1) may be omitted from the markings. All stamped, etched, or embossed markings must be located in non-critical areas.

5. DATA REQUIREMENTS.

a. Application Data. In addition to the data specified in § 21.605, the manufacturer must furnish one copy each of the following to the Manager of the FAA Aircraft Certification Office (ACO) having geographical purview of the manufacturer's facilities:

(1) The applicable limitations pertaining to installation of wheels or wheel and brake assemblies on airplane(s), including the data requirements of paragraph 4.1 of appendix 1 of this TSO.

(2) The manufacturer's TSO qualification test report.

b. Data to be Furnished with Manufactured Articles.

(1) Prior to entry into service use, the manufacturer must make available the applicable maintenance instructions and data necessary for continued airworthiness to the ACO specified in paragraph (c) above.

(2) The manufacturer must provide the applicable maintenance instructions and data necessary for continued airworthiness to each organization or person receiving one or more articles manufactured under this TSO. In addition, a note with the following statement must be included:

> The existence of TSO approval of the article displaying required marking does not automatically constitute the authority to install and use the article on an airplane. The conditions and tests required for TSO approval of this article are minimum performance standards. It is the responsibility of those desiring to install this article either on or within a specific type or class of airplane to determine that the airplane operating conditions are within the TSO standards. The article may be installed only if further evaluation by the user/installer documents an acceptable installation and the installation is approved by the Administrator.
>
> Additional requirements may be imposed based on airplane specifications, wheel and brake design, and quality control specifications. In-service maintenance, modifications, and use of replacement components must be in compliance with the performance standards of this TSO, as well as any additional specific airplane requirements.

6. AVAILABILITY OF REFERENCED DOCUMENTS.

a. Part 21 of Title 14 CFR may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325.

b. Advisory Circular No. 20-110, " Index of Aviation Technical Standard Orders," and this TSO, which includes the "Minimum Performance Specification for Transport Airplane Wheel and Wheel and Brake Assemblies" may be obtained from the U.S. Department of Transportation, Subsequent

Distribution Office, SVC-121.23, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

James C. Jones
Manager, Aircraft Engineering Division
Aircraft Certification Service

APPENDIX 1:MINIMUM PERFORMANCE SPECIFICATION FOR TRANSPORT AIRPLANE WHEELS, BRAKES, AND WHEEL AND BRAKE ASSEMBLIES

CHAPTER 1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This Minimum Performance Specification defines the minimum performance standards for wheels, brakes, and wheel and brake assemblies to be used on airplanes certified under 14 Code of Federal Regulations (CFR) part 25 . Compliance with this specification is not considered approval for installation on any transport airplane.

1.2 APPLICATION

Compliance with this minimum specification by manufacturers, installers and users is required as a means of assuring that the equipment will have the capability to satisfactorily perform its intended function(s).

Note: Certain performance capabilities may be affected by airplane operational characteristics and other external influences. Consequently, anticipated airplane braking performance should be verified by airplane testing.

1.3 COMPOSITION OF EQUIPMENT

The words "equipment" or "brake assembly" or "wheel assembly," as used in this document, include all components that form part of the particular unit.

For example, a wheel assembly typically includes a hub or hubs, bearings, flanges, drive bars, heat shields, and fuse plugs. A brake assembly typically includes a backing plate, torque tube, cylinder assemblies, pressure plate, heat sink, and temperature sensor.

It should not be inferred from these examples that each wheel assembly and brake assembly will necessarily include either all or any of the above example components; the actual assembly will depend on the specific design chosen by the manufacturer.

1.4 DEFINITIONS AND ABBREVIATIONS

1.4.1 Wheel Rated Static Load (S)

S = Maximum Static Load (Reference § 25.731(b)).

1.4.2 Wheel Rated Inflation Pressure (WRP)

WRP = Wheel Rated Inflation Pressure (wheel unloaded).

1.4.3 Wheel Rated Tire Loaded Radius (R)

R = Static Radius at load "S" for the Wheel Rated Tire Size at WRP. The static radius is defined as the minimum distance from the axle centerline to the tire/ground contact interface.

1.4.4 Wheel Rated Radial Limit Load (L)

L = Radial Limit Load. L is the Wheel Rated Maximum Radial Limit Load (paragraph 3.2.1).

1.4.5 Wheel Rated Tire Type(s) and Size(s) (TS_{WR})

TS_{WR} = Wheel Rated Tire Type(s) and Size(s) defined for use and approved by the airplane manufacturer for installation on the wheel.

1.4.6 Suitable Tire for Wheel Test (TT_{WT})

TT_{WT} = Wheel Rated Tire Type and Size for Wheel Test.

TT_{WT} is the tire type and size determined as being the most appropriate to introduce loads and/or pressure that would induce the most severe stresses in the wheel and must be a tire type and size approved for installation on the wheel (TS_{WR}). The suitable tire may be different for different tests.

1.4.7 Wheel/Brake Rated Structural Torque (ST_R)

ST_R = Wheel/Brake Rated Structural Torque.

ST_R is the maximum structural torque demonstrated (paragraph 3.3.5).

1.4.8 Wheel/Brake Rated Design Landing Stop Energy (KE_{DL})

KE_{DL} = Wheel/Brake Rated Design Landing Stop Energy.

KE_{DL} is the minimum energy absorbed by the wheel/brake/tire assembly during each stop of the 100 stop Design Landing Stop Test. (paragraph 3.3.2).

1.4.9 Wheel/Brake Design Landing Stop Speed (V_{DL})

V_{DL} = Wheel/Brake Design Landing Stop Speed.

V_{DL} is the initial brakes-on speed for a Design Landing Stop (paragraph 3.3.2).

1.4.10 Wheel/Brake Rated Accelerate-Stop Energy (KE_{RT})

KE_{RT} = Wheel/Brake Rated Accelerate-Stop Energy.

KE_{RT} is the energy absorbed by the wheel/brake/tire assembly demonstrated in accordance with the Accelerate-Stop test in paragraph 3.3.3.

1.4.11 Wheel/Brake Accelerate-Stop Speed (V_{RT})

V_{RT} = Wheel/Brake Accelerate-Stop Speed.

V_{RT} is the initial brakes-on speed used to demonstrate KE_{RT} (paragraph 3.3.3).

1.4.12 Wheel/Brake Rated Most Severe Landing Stop Energy (KE_{SS})

KE_{SS} = Wheel/Brake Rated Most Severe Landing Stop Energy.

KE_{SS} is the energy absorbed by the wheel/brake/tire assembly demonstrated in accordance with paragraph 3.3.4.

1.4.13 Wheel/Brake Most Severe Landing Stop Speed (V_{SS}).

V_{SS} = Wheel/Brake Most Severe Landing Stop Speed.

V_{SS} is the initial brakes-on speed used to demonstrate KE_{SS} (paragraph 3.3.4).

1.4.14 Brake Rated Wear Limit (BRWL)

BRWL = Brake maximum wear limit to ensure compliance with paragraph 3.3.3, and, if applicable, paragraph 3.3.4.

1.4.15 Airplane Maximum Rotation Speed (V_R).

V_R = Airplane Maximum Rotation Speed.

1.4.16 Brake Rated Maximum Operating Pressure ($BROP_{MAX}$)

$BROP_{MAX}$ = Brake Rated Maximum Operating Pressure.

$BROP_{MAX}$ is the maximum design metered pressure which is available to the brake to meet airplane stopping performance requirements.

1.4.17 Brake Rated Maximum Pressure (BRP_{MAX})

BRP_{MAX} = Brake Rated Maximum Pressure

BRP_{MAX} is the maximum pressure to which the brake is designed to be subjected (typically airplane nominal maximum system pressure).

1.4.~~18~~4 Brake Rated Maximum Parking Pressure ($BRPP_{MAX}$).

$BRPP_{MAX}$ = Brake Rated Maximum Parking Pressure.

$BRPP_{MAX}$ is the maximum parking pressure available to the brake.

1.4.~~19~~3 Brake Rated Retraction Pressure (BRP_{RET})

BRP_{RET} = Brake Rated Retraction Pressure.

BRP_{RET} is the highest pressure at which piston retraction to the unpressurized position is assured.

1.4.~~20~~6 Distance Averaged Deceleration (D)

D = ((Initial brakes-on speed)^2 - (Final brakes-on speed)^2)/(2 (braked flywheel distance))

D is the distance averaged deceleration to be used in all deceleration calculations.

1.4.~~21~~7 Rated Design Landing Deceleration (D_{DL}).

D_{DL} = Rated Design Landing Deceleration.

D_{DL} is the minimum of the distance averaged deceleration values demonstrated during the 100 KE_{DL} stops of paragraph 3.3.2.

1.4.~~22~~8 Rated Accelerate-Stop Deceleration (D_{RT}).

D_{RT} = Rated Accelerate -Stop Deceleration.

D_{RT} is the distance averaged deceleration which the wheel/brake/tire assembly will produce when absorbing KE_{RT}.

1.4.~~23~~9 Rated Most Severe Landing Stop Deceleration (D_{SS}).

D_{SS} = Rated Most Severe Landing Stop Deceleration.

D_{SS} is the distance averaged deceleration which the wheel/brake /tire assembly will produce when absorbing KE_{SS}.

1.4.~~24~~17 Brake Rated Tire Type(s) and Size(s) (TS_{BR}).

TS_{BR} = Brake Rated Tire Type(s) and Size(s).

TS_{BR} is the tire type(s) and size(s) used to achieve the KE_{DL}, KE_{RT}, and KE_{SS} brake ratings.

1.4.25 Suitable Tire for Brake Tests (TT_{BT}).

TT_{BT} = Rated Tire Type and Size.

TT_{BT} is the tire type and size that has been determined as being the most critical for brake performance and/or energy absorption tests, and must be a tire type and size approved for installation on the wheel. The suitable tire may be different for different tests.

1.4.26 Brake Lining.

Brake lining is individual blocks of wearable material, discs that have wearable material integrally bonded to them, or discs in which the wearable material is an integral part of the disc structure.

1.4.27 Heat Sink

The heat sink is the mass of the brake that is primarily responsible for absorbing energy during a stop. For a typical brake, this would consist of the stationary and rotating disc assemblies.

CHAPTER 2
GENERAL DESIGN SPECIFICATION

2.1 AIRWORTHINESS.

The airworthiness of the airplane on which the equipment is to be installed must be considered. (See the paragraph titled "Data to be Furnished with Manufactured Articles.")

2.2 FIRE PROTECTION.

Except for small parts (such as fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, all solid materials used must be self-extinguishing. See also paragraphs 3.3.3.5 and 3.3.4.5.

2.3 DESIGN.

Unless shown to be unnecessary by test or analysis, the equipment must comply with the following:

2.3.1 Wheel Bearing Lubricant Retainers.

Wheel bearing lubricant retainers must retain the lubricant under all operating conditions, prevent the lubricant from reaching braking surfaces, and prevent foreign matter from entering the bearings.

2.3.2 Removable Flanges.

All removable flanges must be assembled onto the wheel in a manner that will prevent the removable flanges and retaining devices from leaving the wheel if a tire deflates while the wheel is rolling.

2.3.3 Adjustment.

The brake mechanism must be equipped with suitable adjustment devices to maintain appropriate running clearance when subjected to BRP_{RET}.

2.3.4 Water Seal.

Wheels intended for use on amphibious aircraft must be sealed to prevent entrance of water into the wheel bearings or other portions of the wheel or brake, unless the design is such that brake action and service life will not be impaired by the presence of sea water or fresh water.

2.3.5 Burst Prevention.

Means must be provided to prevent wheel failure and tire burst that might otherwise result from overpressurization or from elevated brake temperatures. The means must take into account the pressure and the temperature gradients over the full operating range.

2.3.6 Wheel Rim and Inflation Valve.

Tire and Rim Association (Reference: Aircraft Year Book-Tire and Rim Association Inc.) or, alternatively, The European Tyre and Rim Technical Organization (Reference: Aircraft Tyre and Rim Data Book) approval of the rim dimensions and inflation valve is encouraged.

2.3.7 Brake Piston Retention.

The brake must incorporate means to ensure that the actuation system does not allow hydraulic fluid to escape if the limits of piston travel are reached.

2.3.8 Wear Indicator.

A reliable method must be provided for determining when the heat sink is worn to its permissible limit.

2.3.9 Wheel Bearings.

Means should be incorporated to avoid misassembly of wheel bearings.

2.3.10 Fatigue.

The design of the wheel must incorporate techniques to improve fatigue resistance of critical areas of the wheel and minimize the effects of the expected corrosion and temperature environment. The wheel must include design provisions to minimize the probability of fatigue failures that could lead to flange separation or other wheel burst failures.

2.3.11 Dissimilar Metals.

Adequate protection must be provided to prevent electrolytic action when dissimilar metals are used. In addition, differential thermal expansion must not unduly affect the load capability and fatigue life.

2.4 CONSTRUCTION.

2.4.1 Castings.

Castings must be of high quality, clean, sound, and free from blowholes, porosity, or surface defects caused by inclusions, except that loose sand or entrapped gases may be allowed when serviceability is not impaired.

2.4.2 Forgings.

Forgings must be of uniform condition, free from blisters, fins, folds, seams, laps, cracks, segregation, and other defects. Imperfections may be removed if strength and serviceability would not be impaired as a result..

2.4.3 Bolts and Studs.

When bolts or studs are used for fastening together sections of a wheel or brake, the length of the threads must be sufficient to fully engage the nut, including its locking feature, and there must be sufficient unthreaded bearing area to carry the required load.

2.4.4 Corrosion Protection.

Corrosion protection means, where used, must be compatible with the expected environment. This protection must include protection for all holes and passages exposed to potentially corrosive environments.

2.4.5 Magnesium Parts.

Magnesium parts must not be used on brakes or braked wheels.

2.4.6 Bearing and Braking Surface.

Surface and protective finishes must not be applied to bearings and braking surfaces..

CHAPTER 3
MINIMUM PERFORMANCE UNDER STANDARD TEST CONDITIONS

3.1 INTRODUCTION.

The test conditions and performance criteria described in this Chapter provide a laboratory means of demonstrating compliance with this TSO minimum performance standard. The airplane manufacturer must define all relevant test parameter values.

3.2 WHEEL TESTS.

To establish the ratings for a wheel, it must be substantiated that standard production wheel samples will meet the following radial load, combined load, roll load, roll-on-rim (if applicable) and overpressure test requirements.

For all tests, except the roll-on-rim test of paragraph 3.2.4, the wheel must be fitted with a suitable tire, TT_{WT}, and wheel loads must be applied through the tire. The ultimate load tests of paragraphs 3.2.1.3 and 3.2.2.3 provide for an alternative method of loading if it is not possible to conduct these tests with the tire mounted.

3.2.1 Radial Load Test.

If the radial limit load of paragraph 3.2.2 is equal to or greater than the radial limit load of this paragraph, the test specified in this paragraph may be omitted.

Test the wheel for yield and ultimate loads as follow:

3.2.1.1 Test method.

With a suitable tire, TT_{WT}, installed, mount the wheel on its axle, and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an airplane and is under the maximum radial limit load, L. Inflate the tire to the pressure recommended for the Wheel Rated Static Load, S, with gas and/or liquid.

If liquid inflation is used, liquid must be bled off to obtain the same tire deflection that would result if gas inflation were used.

Liquid pressure must not exceed the pressure that would develop if gas inflation were used and the tire were deflected to its maximum extent. Load the wheel through its axle with the load applied perpendicular to the flat, non-deflecting surface. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

3.2.1.2 Yield Load.

Apply to the wheel and tire assembly a load not less than 1.15 times the maximum radial limit load, L, as determined under 14 CFR 25.471 through 25.511, as appropriate.

Determine the most critical wheel orientation with respect to the non-deflecting surface. Apply the load with the tire loaded against the non-deflecting surface, and with the wheel rotated 90 degrees with respect to the most critical orientation . Repeat the loading with the wheel 180, 270, and 0 degrees from the most critical orientation. The bearing cups, cones, and rollers used in operation must be used for these loadings.

Three successive loadings at the 0 degree position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading or .005 inches (.125mm), whichever is greater. There must be no yielding of the wheel such as would result in loose bearing cups, liquid or gas leakage through the wheel or past the wheel seal. There must be no interference in any critical areas between the wheel and brake assembly, or between the most critical deflected tire and brake (with fittings) up to limit load conditions, taking into account the axle flexibility. Lack of interference can be established by analyses and/or tests.

3.2.1.3 Ultimate Load.

Apply to the wheel used in the yield test of paragraph 3.2.1.2, and the tire assembly, a load not less than 2 times the maximum radial limit load, L, for castings, and 1.5 times the maximum radial limit load, L, for forgings, as determined under 14 CFR 25.471 through 25.511, as appropriate.

Apply the load with the tire and wheel against the non-deflecting surface and the wheel positioned at 0 degree orientation (paragraph 3.2.1.2). The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tire will not successfully maintain pressure or if bottoming of the tire occurs, the tire pressure may be increased. If bottoming of the tire continues to occur with increased pressure, a loading block that fits between the rim flanges and simulates the load transfer of the inflated tire may be used. The arc of the wheel supported by the loading block must be no greater than 60 degrees.

The wheel must support the load without failure for at least 3 seconds. Abrupt loss of load-carrying capability or fragmentation during the test constitutes failure.

3.2.2 Combined Radial and Side Load Test.

Test the wheel for the yield and ultimate loads as follows:

3.2.2.1 Test Method.

With a suitable tire, TT_{WT}, installed, mount the wheel on its axle and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an airplane and is under the combined radial and side limit loads. Inflate the tire to the pressure recommended for the maximum static load with gas and/or liquid.

If liquid inflation is used, liquid must be bled off to obtain the same tire deflection that would result if gas inflation were used.

Liquid pressure must not exceed the pressure that would develop if gas inflation were used and the tire were deflected to its maximum extent. For the radial load component, load the wheel through its axle with load applied perpendicular to the flat non-deflecting surface. Apply the two loads simultaneously, increasing them either continuously or in increments no greater than 10 percent of the total loads to be applied.

If it is impossible to generate the side load because of friction limitations, the radial load may be increased, or a portion of the side load may be applied directly to the tire/wheel. In such circumstances it must be demonstrated that the moment resulting from the side load is no less severe than would otherwise have occurred.

Alternatively, the vector resultant of the radial and side loads may be applied to the axle. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

3.2.2.2 Combined Yield Load.

Apply to the wheel and tire assembly radial and side loads not less than 1.15 times the respective ground limit loads, as determined under 14 CFR 25.485, 25.495, 25.497, and 25.499 as appropriate.

Determine the most critical wheel orientation with respect to the non-deflected surface.

Apply the load with the tire loaded against the non-deflecting surface, and with the wheel rotated 90 degrees with respect to the most critical orientation. Repeat the loading with the wheel 180, 270, and 0 degrees from the most critical orientation.

The bearing cups, cones, and rollers used in operation must be used in this test.

A tube may be used in a tubeless tire only when it has been demonstrated that pressure will be lost due to the inability of a tire bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.

Three successive loadings at the 0 degree position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loadings at the 0 degree position must not exceed 5 percent of the deflection caused by the loading, or .005 inches (.125mm), whichever is greater. There must be no yielding of the wheel such as would result in loose bearing cups, gas or liquid leakage through the wheel or past the wheel seal. There must be no interference in any critical areas between the wheel and brake assembly, or between the most critical deflected tire and brake (with fittings) up to limit load conditions, taking into account the axle flexibility. Lack of interference can be established by analyses and/or tests.

3.2.2.3 Combined Ultimate Load.

Apply to the wheel, used in the yield test of paragraph 3.2.2.2, radial and side loads not less than 2 times for castings and 1.5 times for forgings, the respective ground limit loads as determined under 14 CFR 25.485, 25.495, 25.497, and 25.499, as appropriate.

Apply these loads with a tire and wheel against the non-deflecting surface and the wheel oriented at the 0 degree position (paragraph 3.2.2.2). The bearing cones may be replaced with conical bushings; however, the cups used in operation must be used for this loading.

If, at any point of loading during the test, it is shown that the tire will not successfully maintain pressure, or if bottoming of the tire on the non-deflecting surface occurs, the tire pressure may be increased. If bottoming of the tire continues to occur with this increased pressure, a loading block that fits between the rim flanges and simulates the load transfer of the inflated tire may be used. The arc of wheel supported by the loading block must be no greater than 60 degrees.

The wheel must support the loads without failure for at least 3 seconds. Abrupt loss of load-carrying capability or fragmentation during the test constitutes failure.

3.2.3 Wheel Roll Test.

3.2.3.1 Test Method.

With a suitable tire, TT_{WT}, installed, mount the wheel on its axle and position it against a flat non-deflecting surface or a flywheel. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an airplane and is under the Wheel Rated Static Load, S. During the roll test, the tire pressure must not be less than 1.14 times the Wheel Rated Inflation Pressure, WRP, (0.10 to account for temperature rise and 0.04 to account for loaded tire pressure). For side load conditions, the wheel axle must be yawed to the angle that will produce a wheel side load component equal to 0.15 S while the wheel is being roll tested.

3.2.3.2 Roll Test.

The wheel must be tested under the loads and for the distances shown in Table 3-1.

TABLE 3-1 Load Conditions and Roll Distances for Roll Test

Load Conditions	Roll Distance Miles (km)
Wheel Rated Static Load, S	2000 (3220)
Wheel Rated Static Load, S plus 0.15 S side load applied in the outboard direction	100 (161)
Wheel Rated Static Load, S plus 0.15 S side load applied in the inboard direction	100 (161)

At the end of the test, the wheel must not be cracked, there must be no leakage through the wheel or past the wheel seal(s), and the bearing cups must not be loose.

3.2.4 Roll-on-Rim Test (not applicable to nose wheels).

The wheel assembly without a tire must be tested at a speed of no less than 9 knots under a load equal to the Wheel Rated Static Load, S. The test roll distance (in feet) must be determined as $0.5V_R^2$ but need not exceed 15,000 feet (4572 meters). The test axle angular orientation with the load surface must represent that of the airplane axle to the runway under the static load S.

The wheel assembly must support the load for the distance defined above. During the test, no fragmentation of the wheel is permitted; cracks are allowed.

3.2.5 Overpressure Test.

The wheel assembly, with a suitable tire, TT_{WT}, installed, must be tested to demonstrate that it can withstand the application of 4.0 times the wheel rated inflation pressure, WRP. The wheel must retain the pressure for at least 3 seconds. Abrupt loss of pressure containment capability or fragmentation during the test constitutes failure. Plugs may be used in place of overpressurization protection device(s) to conduct this test.

3.2.6 Diffusion Test.

A tubeless tire and wheel assembly must hold its rated inflation pressure, WRP, for 24 hours with a pressure drop no greater than 5 percent. This test must be performed after the tire growth has stabilized.

3.3 WHEEL AND BRAKE ASSEMBLY TESTS.

3.3.1 General.

3.3.1.1 The wheel and brake assembly, with a suitable tire, TT_{BT}, installed, must be tested on a testing machine in accordance with the following, as well as paragraphs 3.3.2, 3.3.3, 3.3.5 and, if applicable, 3.3.4.

3.3.1.2 For tests detailed in paragraphs 3.3.2 , 3.3.3 and 3.3.4, the test energies KE_{DL}, KE_{RT}, and KE_{SS} and brake application speeds V_{DL}, V_{RT}, and V_{SS} are as defined by the airplane manufacturer.

3.3.1.3 For tests detailed in paragraphs 3.3.2, 3.3.3 and 3.3.4, the initial brake application speed must be as close as practicable to, but not greater than, the speed established in accordance with paragraph 3.3.1.2, with the exception that marginal speed increases are allowed to compensate for brake pressure release permitted under paragraphs 3.3.3.4 and 3.3.4.4. An increase in the initial brake application speed is not a permissible method of accounting for a reduced (i.e. lower than ideal) dynamometer mass. This method is not permissible because, for a target test deceleration, a reduction in the energy absorption rate would result, and could produce performance different from that which would be achieved with the correct brake application speed. The energy to be absorbed during any stop must not be less than that established in accordance with paragraph 3.3.1.2. Additionally, forced air or other artificial cooling means are not permitted during these stops.

3.3.1.4 The brake assembly must be tested using the fluid (or other actuating means) specified for use with the brake on the airplane.

3.3.2 <u>Design Landing Stop Test.</u>

3.3.2.1 The wheel and brake assembly under test must complete 100 stops at the KE_{DL} energy, each at the mean deceleration, D, defined by the airplane manufacturer, but not less than 10 ft/s^2 (3.05 m/s^2).

3.3.2.2 During the design landing stop test, the disc support structure must not be changed if it is intended for reuse, or if the wearable material is integral to the structure of the disc. One change of individual blocks or integrally bonded wearable material is permitted. For discs using integrally bonded wearable material, one change is permitted, provided that the disc support structure is not intended for reuse. The remainder of the wheel/brake assembly parts must withstand the 100 KE_{DL} stops without failure or impairment of operation.

3.3.3 <u>Accelerate -Stop Test.</u>

3.3.3.1 The wheel and brake assembly under test must complete the Accelerate-Stop test at the mean deceleration, D, defined by the airplane manufacturer, but not less than 6 ft/s^2 (1.83 m/s^2).

This test establishes the maximum takeoff energy rating, KE_{RT}, of the wheel and brake assembly using:

a. The Brake Rated Maximum Operating Pressure, $BROP_{MAX}$; or

b. The maximum brake pressure consistent with the airplane's braking pressure limitations (e.g., tire/runway drag capability based on substantiated data).

3.3.3.2 For the accelerate-stop test, the tire, wheel, and brake assembly must be capable of absorbing the test energy, KE_{RT}, using a brake on which the usable wear range of the heat sink BRWL has already been fully consumed.

The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience or wear test data of an equivalent or similar brake. Either operationally worn or mechanically worn brake components may be used. If mechanically worn components are used, it must be shown that they can be expected to provide similar results to operationally worn components. The test brake must be subjected to a sufficient number and type of stops to ensure that the brake's performance is representative of in-service use; at least one of these stops, with the brake near the fully worn condition, must be a Design Landing Stop.

3.3.3.3 At the time of brake application, the temperatures of the tire, wheel, and brake, particularly the heat sink, must, as closely as practicable, be representative of a typical in-service condition. Preheating by a taxi stop(s) is an acceptable means.

These temperatures must be based on a rational analysis of a braking cycle, taking into account a typical brake temperature at which an airplane may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during subsequent taxiing, and takeoff acceleration, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink temperature must be that resulting from the application of 10 percent KE_{RT} to the tire, wheel and brake assembly initially at not less than normal ambient temperature (59°F/15°C).

3.3.3.4 A full stop demonstration is not required for the worn brake accelerate-stop test. The test brake pressure may be released at a test speed of up to 20 knots. In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tire, wheel and brake assembly during the test is not less than the energy absorbed if the test had commenced at the specified speed and continued to zero ground speed.

3.3.3.5 Within 20 seconds of completion of the stop, or of the brake pressure release in accordance with paragraph 3.3.3.4, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure $BRPP_{MAX}$ and maintained for 3 minutes.

No sustained fire that extends above the level of the highest point of the tire is allowed before 5 minutes have elapsed after application of parking brake pressure; until this time has elapsed, neither fire fighting means nor coolants may be applied.

The time of initiation of tire pressure release (e.g., by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.3.4 and 3.3.3.5 is illustrated in figure 3-1.

3.3.4 <u>Most Severe Landing Stop Test</u>

3.3.4.1 The wheel and brake assembly under test must complete the most severe landing braking condition expected on the airplane as defined by the airplane manufacturer. This test is not required if the testing required by paragraph 3.3.3 is more severe or the condition is shown to be extremely improbable by the airplane manufacturer.

This test establishes, if required, the maximum energy rating, KE_{SS}, of the wheel/brake assembly for landings under abnormal conditions using:

a. The Brake Rated Maximum Operating Pressure, $BROP_{MAX}$; or

b. The maximum brake pressure consistent with an airplane's braking pressure limitations (e.g., tire/runway drag capability based on substantiated data).

3.3.4.2 For the Most Severe Landing Stop test, the tire, wheel and brake assembly must be capable of absorbing the test energy, KE_{SS}, with a brake on which the usable wear range of the heat sink BRWL has already been fully consumed.

The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience or wear test data of an equivalent or similar brake. Either operationally worn or mechanically worn brake components may be used. If mechanically worn components are used, it must be shown that they can be expected to provide similar results to operationally worn components. The test brake must be subjected to a sufficient number and type of stops to ensure that the brake's performance is representative of in-service use; at least one of these stops, with the brake near the fully worn condition, must be a Design Landing Stop.

3.3.4.3 At the time of brake application, the temperatures of the tire, wheel, and brake, particularly the heat sink, must, as closely as practicable, be representative of a typical in-service condition. Preheating by a taxi stop(s) is an acceptable means.

These temperatures must be based on a rational analysis of a braking cycle, taking into account a typical brake temperature at which the airplane may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during taxi, takeoff, and flight, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink temperature must be that resulting from the application of 5 percent KE_{RT} to the tire, wheel and brake assembly initially at not less than normal ambient temperature (59°F/15°C).

3.3.4.4 A full stop demonstration is not required for the most severe landing-stop test. The test brake pressure may be released at a test speed of up to 20 knots. In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tire, wheel, and brake assembly during the test is not less than the energy absorbed if the test had commenced at the specified speed and continued to zero ground speed.

3.3.4.5 Within 20 seconds of completion of the stop, or of the brake pressure release in accordance with paragraph 3.3.4.4, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure, $BRPP_{MAX}$, and maintained for 3 minutes.

No sustained fire that extends above the level of the highest point of the tire is allowed before 5 minutes have elapsed after application of parking brake pressure; until this time has elapsed, neither fire fighting means nor coolants may be applied.

The time of initiation of tire pressure release (e.g., by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.4.4 and 3.3.4.5 is illustrated in Figure 3-2.

3.3.5 Structural Torque Test

3.3.5.1 Apply to the wheel, brake and tire assembly, the radial load S and the drag load corresponding to the torque specified in paragraph 3.3.5.2 or 3.3.5.3 , as applicable, for at least 3 seconds. Rotation of the wheel must be resisted by a reaction force transmitted through the brake, or brakes, by the application of at least Brake Rated Maximum Operating Pressure, $BROP_{MAX}$, or equivalent. If such pressure or its equivalent is insufficient to prevent rotation, the friction surface may be clamped, bolted, or otherwise restrained while applying the pressure. A fully worn brake configuration, BRWL, must be used for this test. The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience of an equivalent or similar brake or test machine wear test data. Either operationally worn or mechanically worn brake components may be used. The wheel/brake rated structural torque (ST_R) is equal to the torque demonstrated in the test defined in 3.3.5.1.

3.3.5.2 For landing gear with one wheel per landing gear strut, the torque is 1.2 (SxR).

3.3.5.3 For landing gear with more than one wheel per landing gear strut, the torque is 1.44 (SxR).

3.3.5.4 The wheel and brake assembly must support the loads without failure for at least 3 seconds.

3.4 BRAKE TESTS.

It must be substantiated that standard production samples of the brake will pass the following tests:

3.4.1 Yield & Overpressure Test.

The brake must withstand a pressure equal to 1.5 times BRP_{MAX} for 5 minutes without permanent deformation of the structural components under test.

The brake, with actuator piston(s) extended to simulate a maximum worn condition, must, for at least 3 seconds, withstand hydraulic pressure equal to two times the brake rated maximum pressure, BRP_{MAX}, available to the brakes. If necessary, piston extension must be adjusted to prevent contact with retention devices during this test.

3.4.2 Endurance Test.

A brake assembly must be subjected to an endurance test during which structural failure or malfunction must not occur. If desired, the heat sink components may be replaced by a reasonably representative dummy mass for this test.

The test must be conducted by subjecting the brake assembly to 100,000 cycles of an application of the average of the peak brake pressures needed in the Design Landing Stop Test (paragraph 3.3.2) and release to a pressure not exceeding the brake rated return pressure, BRP_{RET}. The pistons must be adjusted so that 25,000 cycles are performed at each of the four positions where the pistons would be at rest when adjusted to nominally 25, 50, 75 and 100 percent of the wear limit, BRWL. The brake must then be subjected to 5000 cycles of application of pressure to BRP_{MAX} and release to BRP_{RET} at the 100 percent wear limit.

Hydraulic brakes must meet the leakage requirements of paragraph 3.4.5 at the completion of the test.

3.4.3 Piston Retention.

The hydraulic pistons must be positively retained without leakage at 1.5 times BRP_{MAX} for ten seconds with the heat sink removed.

3.4.4 Extreme Temperature Soak Test

The brake actuation system must comply with the dynamic leakage limits of paragraph 3.4.5.2 for the following tests.

Subject the brake to a 24-hour hot soak at the maximum piston housing fluid temperature experienced during the Design Landing Stop Test (paragraph 3.3.2), conducted without forced air cooling. While at the hot soak temperature, the brake must be subjected to the application of the average of the peak brake pressures required during the 100 design landing stops and release to a pressure not exceeding BRP_{RET} for 1000 cycles, followed by 25 cycles of $BROP_{MAX}$ and release to a pressure not exceeding BRP_{RET}.

The brake must then be cooled from the hot soak temperature to a cold soak temperature of -40°F (-40°C) and maintained at this temperature for 24 hours. While at the cold soak temperature, the brake must be subjected to the application of the average of the peak brake pressures required during the KE_{DL} stops and release to a pressure not exceeding BRP_{RET}, for 25 cycles, followed by 5 cycles of $BROP_{MAX}$ and release to a pressure not exceeding BRP_{RET}.

3.4.5 Leakage Tests (Hydraulic Brakes).

3.4.5.1 Static Leakage Test.

The brake must be subjected to a pressure equal to 1.5 times BRP_{MAX} for 5 minutes. The brake pressure must then be adjusted to an operating pressure of 5 psig (35 kPa) for 5 minutes. There must be no measurable leakage (less than one drop) during this test.

3.4.5.2 Dynamic Leakage Test.

The brake must be subjected to 25 applications of BRP_{MAX}, each followed by the release to a pressure not exceeding BRP_{RET}. Leakage at static seals must not exceed a trace. Leakage at moving seals must not exceed one drop of fluid per each 3 inches (76mm) of peripheral seal length.

CHAPTER 4

DATA REQUIREMENTS.

4.1 The manufacturer must provide the following data with any application for approval of equipment.

4.1.1 The following wheel and brake assembly ratings:

a. Wheel Ratings.

Wheel Rated Static Load, S
Wheel Rated Inflation Pressure, WRP
Wheel Rated Tire Loaded Radius, R
Wheel Rated Maximum Limit Load, L
Wheel Rated Tire Size, TS_{WR}

b. Wheel/Brake and Brake Ratings.

Wheel/Brake Rated Design Landing Energy, KE_{DL}, and associated brakes-on-speed, V_{DL}
Wheel/Brake Rated Accelerate-Stop Energy, KE_{RT}, and associated brakes-on-speed, V_{RT}.
Wheel/Brake Rated Most Severe Landing Stop Energy, KE_{SS}, and associated brakes on-speed, V_{SS} (if applicable).
Brake Rated Maximum Operating Pressure, $BROP_{MAX}$.
Brake Rated Maximum Pressure, BRP_{MAX}.
Brake Rated Retraction Pressure, BRP_{RET}
Wheel/Brake Rated Structural Torque, ST_R.
Rated Design Landing Deceleration, D_{DL}.
Rated Accelerate-Stop Deceleration, D_{RT}.
Rated Most Severe Landing Stop Deceleration, D_{SS} (if applicable).
Brake Rated Tire Size, TS_{BR}.
Brake Rated Wear Limit, BRWL

4.1.2 The weight of the wheel or brake, as applicable.

4.1.3 Type of hydraulic fluid used, as applicable.

4.1.4 One copy of the test report showing compliance with the test requirements.

NOTE: When test results are being recorded for incorporation in the compliance test report, it is not sufficient to note merely that the specified performance was achieved. The actual numerical values obtained for each of the parameters tested must be recorded, except where tests are pass/fail in character.

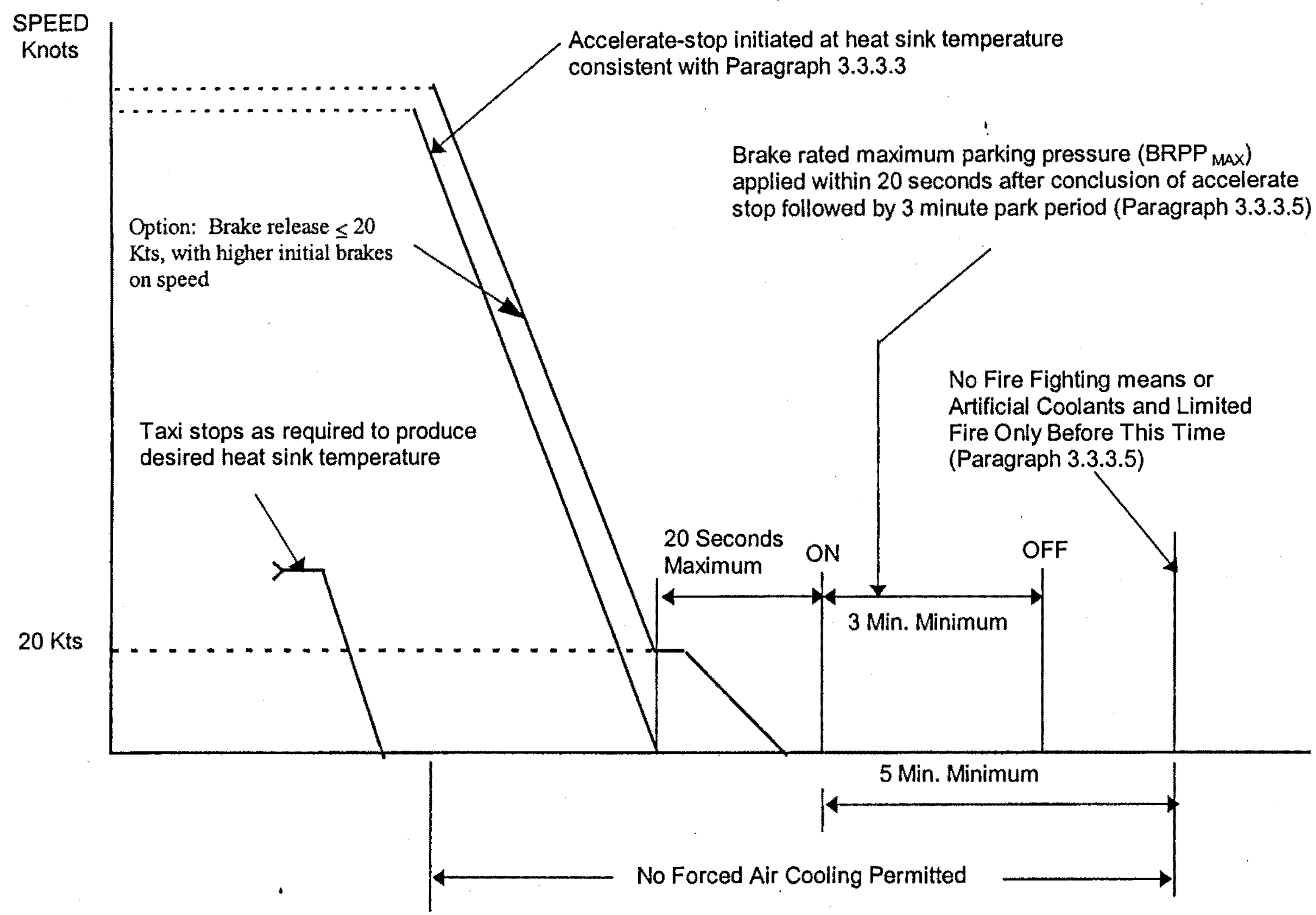

Figure 3-1. Taxi, Accelerate-Stop, Park Test Sequence

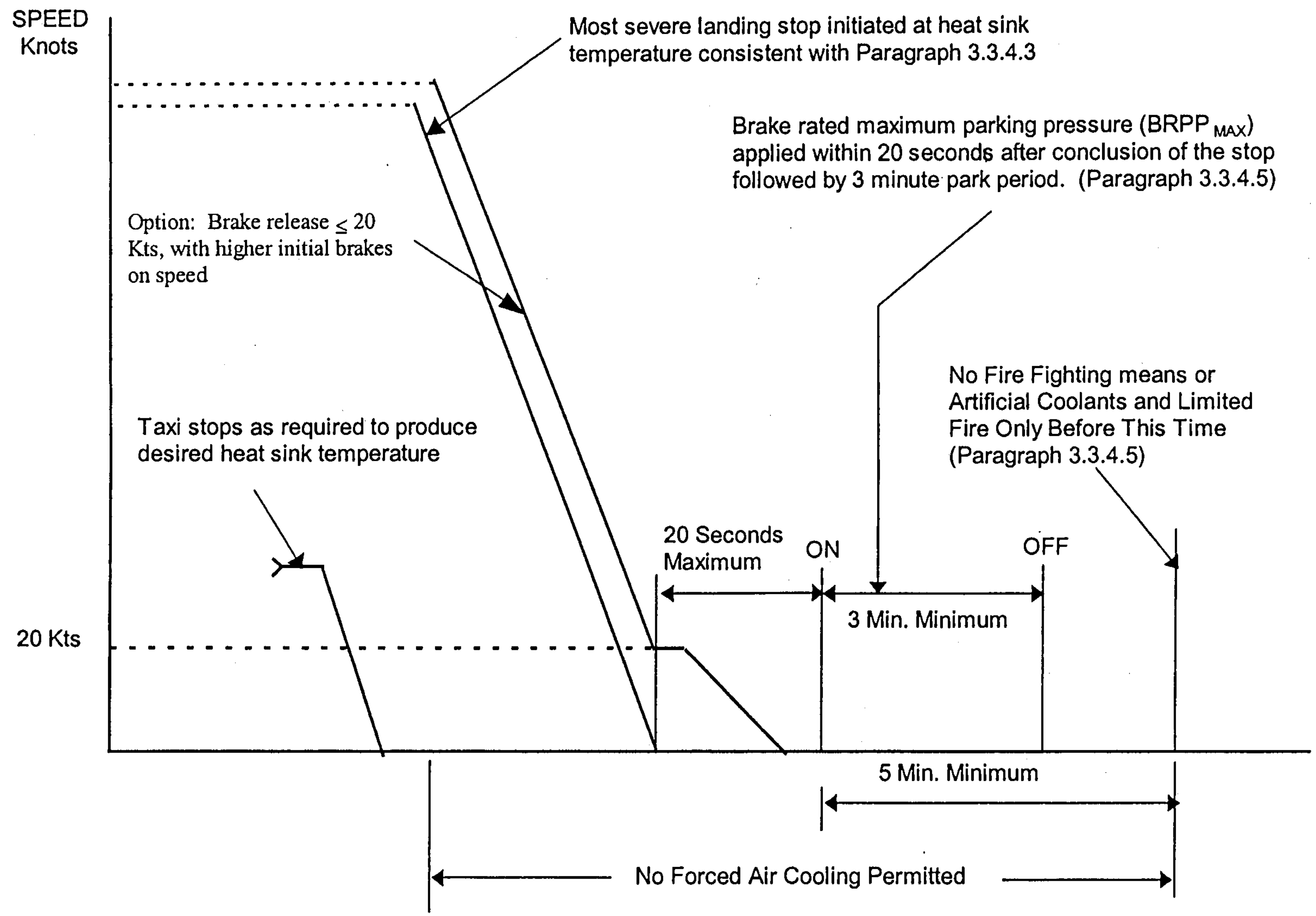

Figure 3-2. Most Severe Landing-Stop, Park Test Sequence

Federal Register

Wednesday,

April 24, 2002

Part VI

Department of Transportation

Federal Aviation Administration

14 CFR Part 25

Revision of Braking Systems Airworthiness Standards to Harmonize With European Airworthiness Standards for Transport Category Airplanes; Final Rule and Notice

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[14 CFR Part 25]

[Docket No. FAA–1999–6063; Amendment No. 25–107]

RIN 2120–AG80

Revision of Braking Systems Airworthiness Standards to Harmonize With European Airworthiness Standards for Transport Category Airplanes

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This amendment revises the braking systems design and test requirements of the airworthiness standards for transport category airplanes. The amendment moves some of the existing regulatory text, considered to be of an advisory nature, to an advisory circular and adds regulations addressing automatic brake systems, brake wear indicators, pressure release devices, and system compatibility. These revisions were developed in cooperation with the Joint Aviation Authorities (JAA) of Europe, Transport Canada, and the U.S. and European aviation industry through the Aviation Rulemaking Advisory Committee (ARAC). These changes benefit the public interest by standardizing certain requirements, concepts, and procedures contained in the airworthiness standards without reducing, but potentially enhancing, the current level of safety.

DATES: Effective May 24, 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:

Availability of Rulemaking Documents

You can get an electronic copy using the Internet by taking the following steps:

(1) Go to the search function of the Department of Transportation's electronic Docket Management System (DMS) Web page (*http://dms.dot.gov/search*).

(2) On the search page type in the last four digits of the Docket number shown at the beginning of this notice. Click on "search."

(3) On the next page, which contains the Docket summary information for the Docket you selected, click on the document number for the item you wish to view.

You can also get an electronic copy using the Internet through the Office of Rulemaking's web page at *http://www.faa.gov/avr/armhome.htm* or the **Federal Register's** web page at *http://www.access.gpo.gov/su_docs/aces/aces140.html*.

You can also get a copy by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680. Make sure to identify the amendment number or docket number of this rulemaking.

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires FAA to comply with small entities' requests for information or advice about compliance with statutes and regulations within its jurisdiction. Therefore, any small entity that has a question regarding this document may contact their local FAA official, or the person listed under **FOR FURTHER INFORMATION CONTACT.** You can find out more about SBREFA on the internet at our site, *http://www.faa.gov/avr/arm/sbrefa.htm.* For more information on SBREFA, e-mail us *9-AWA-SBREFA@faa.gov.*

Background

This amendment is based on Notice of Proposed Rulemaking (NPRM) No. 99–16, which was published in the **Federal Register** on August 10, 1999 (64 FR 43570) and Supplemental Notice of Proposed Rulemaking (SNPRM) No. 99–16A, which was published in the **Federal Register** on December 18, 2000 (65 FR 79298). The related background leading to NPRM No. 99–16, and SNPRM No. 99–16A is discussed below.

In 1988, the FAA, in cooperation with the Joint Aviation Authority (JAA) and other organizations representing the American and European aerospace industries, began a process to harmonize the airworthiness requirements of the United States and the airworthiness requirements of Europe, especially in the areas of Flight Test and Structures. Starting in 1992, the FAA harmonization effort for various systems related airworthiness requirements was undertaken by the ARAC. An ARAC working group of industry and government braking systems specialists of Europe, the United States, and Canada was chartered and named as the Braking System Harmonization Working Group (HWG) by notice in the **Federal Register** (59 FR 30080, June 10, 1994).

Statement of the Problem

The ARAC working group was tasked to develop a harmonized standard, such as a Technical Standard Order (TSO), for approval of wheels and brakes to be installed on transport category airplanes and to develop a draft notice of proposed rulemaking (NPRM), with supporting economic and other required analyses, and/or any other related guidance material or collateral documents, such as advisory circulars (AC), concerning new or revised requirements and the associated test conditions for wheels, brakes and braking systems, installed in transport category airplanes (§§ 25.731 and 25.735). The harmonization task was completed by the ARAC working group and recommendations were submitted to the FAA by letter dated May 1, 1998. The FAA concurred with the recommendations and proposed them in NPRM No. 99–16. A Notice of Availability of proposed AC 25.735–1X and request for comments, and a Notice of Availability of proposed TSO–C135 and request for comments, were also published in the **Federal Register** on August 10, 1999 (64 FR 43579). On August 25, 1999, the JAA issued a Notice of Proposed Amendment (NPA) 25D–291 and NPA TSO–7: "Brakes and Braking Systems," which included the proposed advisory material joint (AMJ) 25.735. The amendments proposed in NPA 25D–291 and the advisory material proposed in AMJ 25.735 were substantively the same as the amendments proposed by the FAA in Notice No. 99–16 and the advisory material in proposed AC 25.735–1X. The NPA TSO–7 was substantively the same as proposed in FAA TSO–C135.

As a result, the FAA received comments from the public in response to the proposed rule (Notice No. 99–16), as well as comments on the proposed AC and the proposed TSO. The JAA received comments from the public in response to NPA 25D–291 and NPA TSO–7 (which includes the AMJ 25.735). The comments received on the FAA and the JAA notices are interlinked and addressed jointly. Therefore, the FAA has considered both sets of comments in preparing the final rule contained herein, the new AC, and the new TSO. The FAA will publish a Notice of Availability in the **Federal Register** when the final version of AC 25.735–1 and TSO–C135 are issued. Interested persons have been given an opportunity to participate in this rulemaking, and due consideration has been given to all matters presented.

The FAA determined that an incremental cost identified by commenters to Notice No. 99–16 must be subject to public scrutiny. Therefore, this resulted in a supplemental notice of proposed rulemaking (SNPRM), No. 99–16A, being published for public comment on December 18, 2000 (65 FR 79278).

Comments received on Notice No. 99–16 are discussed first, followed by comments received on Notice No. 99–16A.

Discussion of Comments: Notice No. 99–16

Twenty-one commenters responded to the request for comments contained in Notice No. 99–16, the notices of availability of proposed AC 25.735–1, and TSO–C135, and the corresponding JAA documents NPA 25D–291, NPA TSO–7, and AMJ 25.735.

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. The majority of the 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 ARAC. Therefore, the FAA tasked the ARAC on Transport Airplane and Engine (TAE) issues area 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 Braking Systems HWG and submitted by ARAC on TAE issues area 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 individual comment under each proposal, i.e., proposals 1 through 17.

Proposals 1, 2, 4, 5, 6, 8, 9, 12, 15, and 17: §§ 25.735(a), (b), (c), (c)(2), (e), (e)(1), (g), (i) and (k)

No comments were received for these proposals. Sections 25.735(a), (c), (c)(2), (e), (e)(1), (g), (i), and (k) are therefore adopted as proposed.

Proposal 3, § 25.735(b)

One commenter questions the justification of deleting the parenthetical phrase ''(excluding the operating pedal or handle)'' from the current § 25.735(b). The commenter states that excluding the operating pedal or handle is justified to allow use of maximum asymmetric braking capability, use of auto-brakes, and/or thrust reversers in stopping scenarios involving a jammed pedal or high rudder deflection.

FAA's Response: The FAA disagrees with the commenter. Currently, certified airplanes can meet this requirement using rudder and nosewheel steering while providing full braking on one side of the airplane without reverse thrust or autobrakes. The regulations do not require consideration of adverse crosswinds.

Proposal 7, § 25.735(d)

One commenter recommends deleting the idle thrust requirement as use of idle thrust may result in nose gear sliding on high thrust twin engine aircraft. The commenter's suggested text is ''Thrust on any, or all, other engine(s) is to be determined by the applicant.''

FAA's Response: The FAA disagrees with the commenter. The rule, as stated, does not preclude the use of thrust in excess of idle on other engines. The advisory material is expanded to state that compliance is not limited to ground idle thrust; therefore, the applicant may choose what is critical.

Proposal 10, § 25.735(e)(2)

One commenter states that the intent of the rule could probably be better expressed by changing the text from ''(2) It must, at all times, have priority over the automatic braking system, if installed'' to ''If both Anti-Skid and Auto-Brake systems are fitted to the aircraft, then the anti-skid system shall always work independently of the auto-brake and irrespective of the auto-brake configuration/status.''

FAA's Response: The FAA does not concur with the comment. The intent of the rule is to make sure the antiskid function releases a wheel which is going into a skid regardless if the braking is commanded by the pilot or the autobrake function. An explanation to this effect is added in the AC.

Proposal 11, § 25.735(f)

For the comments and response that follow, the heat sink is the mass of the brake that is primarily responsible for absorbing energy during a stop. For a typical brake, this would consist of the stationary and rotating disc assemblies. One commenter states: ''It does not appear that the proposed § 25.735(f) requires the brake with fully worn heat sink to complete 100 cycles of the design landing stop. A brake assembly with fully worn heat sink will not be capable of completing these 100 landing stops. If the proposed § 25.735(f) requires the wheel and brake assembly with fully worn heat sink to complete ONE design landing stop dynamometer test, this test would be unnecessary since the maximum kinetic energy accelerate-stop test will be much more severe. The energy capacity of the accelerate-stop is generally three times the energy capacity of the design landing stop.''

FAA's Response: The FAA concurs; the proposed TSO–C135 does not require the brake with fully worn heat sink to complete 100 cycles of the design landing stop. However, the FAA disagrees that one design landing stop with fully worn brakes is unnecessary; it is required because the one design landing stop requirement cannot be met by the worn brake accelerate-stop test due to differing deceleration requirements.

The same commenter also states that ''the most severe landing stop should not be added until this new regulation is harmonized with other part 25 sections, especially subpart B-Flight (Performance) and § 25.1001, Fuel jettisoning system.''

FAA's Response: The FAA does not agree. The § 25.775(f)(3) requirement is for brake qualification via a dynamometer test per TSO–C135 standard, and not a flight performance test on the aircraft. Compliance with the current § 25.1001 may also result in similar design requirements, especially for aircraft without fuel jettisoning systems.

A second commenter, while supporting the general intent of harmonizing, expresses a concern

> with some aspects of the proposed rule that create significant additional constraints on braking system design and other systems architecture, and on compliance demonstration, without any clear safety benefit. In particular, the Summary of Costs and Benefits in the NPRM preamble, indicates a type certification testing cost increase from $20,000–$60,000, resulting from proposal 11 on ''most severe landing stop'' that would be balanced by the savings expected from rule harmonization. Then this summary adds considerations on potential safety benefits: ''Although there were numerous (approximately 170) accidents involving brake failures during landings in the period 1982–1995, none were determined to have been directly preventable by the subject provisions. Different designs in future type certifications, however, could present other problems (unexpected) and raise future accident rates.''

The commenter concludes ''that, in fact, the expected safety benefit is so vague that it is hard to justify the additional certification expenses, even if balanced by administrative simplifications, especially for a technically questionable requirement.''

FAA's Response: The FAA does not agree with this commenter. The requirement is conditional in that ''it need not be considered for extremely improbable failure conditions or if the maximum kinetic energy accelerate-stop energy is more severe.'' Without specifying it in the regulations, the applicant may not consider such a situation, however likely.

The second commenter continues, adding: ''Contrary to what is indicated in the Regulatory Evaluation Summary, the Most Severe Landing Stop (MSL) requirement has not been in effect in Europe per British Civilian Aviation Authority (CAA), and there is no evidence that 'many large part 25 airplane manufacturers currently meet this standard.' '' The JAR–25 does not contain this concept. Before JAR–25 adoption, British Civil Airworthiness Requirments (BCAR) Section D was the U.K. Certification code for large airplanes. The brake energy absorption capacity was based on different concepts, namely Certified Normal Brake Energy Capacity and Certified Emergency Brake Energy Capacity (BCAR chapter D–4–5, § 3.8). It is meaningless to determine a ''most severe landing stop'' case for the sole purpose of brake system certification, without considering the global use of return to land capability that will take into account such other parameters as controllability, other retardation means, landing distances, and operational procedures. The commenter therefore suggests withdrawal of the MSL concept, and proposes modifying paragraph (f) in § 25.735 as follows:

(1) Replace the first sentence with: ''Kinetic energy absorption requirements of each wheel and brake assembly must be determined for the design landing stop and the maximum kinetic energy accelerate-stop.''

(2) Delete the last sentence: ''The most severe landing stop need not be considered for extremely improbable failure conditions or if the maximum kinetic energy accelerate-stop energy is more severe.''

(3) Replace the last sentence with: ''In addition to the design landing stop and maximum kinetic energy accelerate-stop, the brake energies associated with forseeable cases of immediate return to land must also be considered. For these cases, operational procedures, possible fuel jettisoning for a maximum of 15 minutes, use of retardation means, and landing distances must be taken into account.''

The same recommendations, (1), (2), and (3) above, are made by a third commenter who states that ''the concept of an MSL is inter-related to an FAA document regarding Return Landing Capability (Issue Paper F–7), and a recent recommendation No. 99–23 from the UK Air Accidents Investigation Branch (AAIB).'' A fourth commenter, the UKCAA, states that the AAIB recommendation is a result of a serious incident at London Heathrow airport in July 1998. An aircraft, following illumination of a caution light during climb and shutdown of one engine, returned for an overweight landing in a crosswind. During this landing, the brakes overheated, the tires deflated, and the aircraft went off the runway. The third commenter continues, stating that the problem of aircraft retardation in foreseeable abnormal operating conditions cannot be adequately addressed by looking at the brakes and brake system alone. The third commenter recommends (1) that this proposal should be reassessed in view of the other current regulatory activity (Issue Paper F–7 and AAIB recommendation No. 99–23); and (2) rewording the regulation per recommendations (1), (2), and (3), above.

FAA's Response: The FAA does not agree. The FAA has reviewed the recommendation and determined that prior to the formation of the ARAC Braking Systems HWG, the requirement for the most severe landing stop condition was included in the European JAA-industry harmonized document ED–69, published in December 1992. In addition, as pointed out by two other commenters, an existing FAA issue paper (FAA Issue Paper F–7) has required applicants to address a return landing capability condition for compliance with § 25.1001. This means the applicant should address the effects and consequences of typical single and multiple failure conditions which are foreseeable events and can necessitate landings at abnormal speeds and weights. The most severe landing stop requirement is therefore retained.

The AAIB recommendation specifically states that the FAA, CAA, and JAA review the requirements for aircraft brake system certification to cover the need to consider overweight landing situations, together with the effects of crosswind and asymmetric engine thrust during ground roll.

The commenter references the existing FAA Issue Paper F–7 on this subject that indicates that the FAA too see the need to expand the scope of the requirement. The commenter continues stating that the FAA position seems to indicate that this incident would be regarded as a ''foreseeable operating condition'' when considering compliance with § 25.1309(a).

In accordance with the AAIB Safety Recommendation, the fourth commenter (UKCAA) proposes that JAR 25.735(f) be further amended to include consideration of crosswind and asymmetric engine thrust, in combination with the severe landing stop condition maximum weight.

FAA's Response: The FAA does not concur with this comment. The FAA has reviewed the UKCAA recommendation and considers that there is sufficient conservatism in the proposed requirements. This conservatism, while not provided specifically to accommodate the possible crosswind effects in an overweight return to land case, is nevertheless available as follows:

(a) The capability to stop the aircraft with only half the brakes functioning;

(b) Dynamometer testing to demonstrate the capability to complete the maximum kinetic energy rejected takeoff (RTO) stop with all brakes worn to the limit;

(c) Dynamometer testing to demonstrate the capability to complete the most severe landing stop with all brakes worn to the limit, should this be more severe than the maximum kinetic energy RTO stop, and not shown to be extremely improbable;

(d) No allowance being given for the reverse thrust capabilities for the demonstration of (b) and (c) above.

The FAA has added appropriate advisory material to the AC 25.735–1, Brakes and Braking Systems Certification Tests and Analysis.

A fifth commenter suggests changing the wording of the second sentence of § 25.735(f) from ''* * * most severe landing stop brake kinetic energy absorption requirements of each wheel and brake assembly * * *'' to ''* * * most severe landing stop kinetic energy absorption requirements of each brake-wheel-tire assembly * * *'' The commenter suggests the same change in terminology for the third sentence.

FAA's Response: The FAA concurs with the commenter. The final rule text is revised accordingly.

A sixth commenter states that, as proposed, § 25.735(f) is difficult to read and contains too many separate requirements, which could create undue difficulties during the finding of compliance. The commenter suggests that the paragraph be rearranged such that:

(1) There is a distinct sub-paragraph that can be identified for the requirement for the determination of the levels of kinetic energy and the energy absorption rates. This should indicate that three cases are to be considered (design landing stop, accelerate-stop and most severe landing stop). This sub-paragraph could also mention the caveats about the need to consider, or not consider, during testing the most severe landing stop.

(2) There is a distinct sub-paragraph for the requirement for the wheel and brake assembly to meet the levels of kinetic energy.

(3) There is a distinct sub-paragraph for the requirement for the wheel and brake assembly to meet the energy absorption rates.

(4) The definitions of the three stop cases (the last nine lines of the currently proposed paragraph, starting with: ''* * * Design landing stop is an operational * * *'') are taken out of the requirement and placed in the proposed AC 25.735–1X.

FAA's Response: The FAA concurs with the commenter that rearranging § 25.735(f) into three distinct sub-paragraphs clarifies the requirement. The FAA, however, has decided that it is more appropriate to retain the definitions as part of the regulatory text since this is the only place where these terms are identified. The text of this paragraph is divided into three subparagraphs (f)(1), (f)(2), and (f)(3) with appropriate headings. The subparagraphs cover each of the three tests and include the definitions.

Two of the commenters suggest adding a requirement that the accelerate-stop test, reference: paragraph 3.3.3.2 of the proposed TSO–C135 and § 25.735(f) of Notice No. 99–16 must be completed on both a new brake and a fully worn brake. The fully worn brake is the worst case condition for energy absorption capability; however, the new brake condition is the worst case condition for performance for some heat sink materials.

FAA's Response: The FAA concurs with these commenters. Applicable text in the final TSO–C135 paragraph 3.3.3.2, and the final rule new subparagraph § 25.735(f)(2) add a new brake accelerate-stop test requirement with the new brake defined as a brake worn no more than 5 percent of its usable wear range. The accelerate-stop applicable portion of § 25.735(f) text, NPRM No. 99–16, is revised from: ''It must be substantiated by dynamometer testing that at the declared fully worn limit(s) of the brake heat sink, the wheel and brake assemblies are capable of absorbing not less than these levels of kinetic energy'' to ''(f)(2): It must be substantiated by dynamometer testing that the wheel, brake, and tire assembly is capable of absorbing not less than this level of kinetic energy throughout the defined wear range of the brake.'' Although not a part of the TSO, large airplane manufacturers currently require a new brake RTO test as part of brake qualification. Small airplane manufacturers may experience a cost increase of $20,000 per certification.

Proposal 13, § 25.735(g)

The first commenter wonders whether the case specified in the rule (immediate application of the parking brake after the RTO for at least 3 minutes, with no fire allowed for at least 5 minutes) is indeed the worst case. The commenter opines that a more severe case, representing a likely in-service scenario, would be for the aircraft to taxi off the runway before the parking brake is applied, and that it should be allowable for the aircraft manufacturer to incorporate this scenario into the test if so desired. However, this is specifically precluded due to the current wording of the rule.

FAA's Response: The FAA does not concur. The regulation does not preclude the applicant from considering such a scenario and addressing it in their brake specification.

A second commenter states that as proposed under § 25.735(g), it must be demonstrated that with the parking brake applied for three minutes after the high kinetic energy stop demonstration of § 25.735(f), no condition (including fire) that could prejudice the safe and complete evacuation of the airplane shall occur for at least five minutes.

The commenter continues, stating: ''In recent aircraft certification programs, Transport Canada (TC) has required that the parking brake be applied for a minimum of five minutes. This is a more stringent requirement that impacts the design, testing and certification of the braking system that is currently only being applied to Canadian certifications and is violating the premise of harmonization.''

The commenter adds that ''the ARAC sub committee does not recommend the increased parking brake period, however, the significant issue is that all National Airworthiness Authorities must accept the same standard to realize the benefits of harmonization.''

FAA's Response: The FAA agrees with the second commenter that clarification of the parking brake set period is needed. The FAA has reaffirmed the 3-minute parking brake applied period for the dynamometer test. 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. Figures 3–1 and 3–2 and paragraphs 3.3.3.5 and 3.3.4.5 in the TSO will be changed 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. This approach allows authorities that are not part of the harmonization process the needed flexibility.

A third commenter adds that the new JAR 25.735(g) requires the parking brake to be promptly and fully applied for at least 3 minutes; in addition, it must be demonstrated that for at least 5 minutes no condition occurs that could prejudice the safe and complete evacuation of the airplane (a similar requirement is also included in JTSO–C135 paragraph 3.3.3.5). Both the 3- and 5-minute timeframes, according to the proposals, are related to a safe evacuation of the airplane, however, there are no data to support the use of those figures. The commenter states that advice is needed from the Cabin Safety Study Group (CSSG) on the use of three and five minutes in conjunction to a safe evacuation.

FAA's Response: The FAA does not agree that the CSSG advice is needed. The criteria are based on regulations for 90-second cabin evacuation; pilot recognition time; time to deploy slides; and time for fire trucks to arrive at the scene of the fire, as well as previous certification tests experience. If the CSSG changes the criteria (3 minutes versus 5 minutes), then a change to § 25.735(g) should be evaluated.

Proposal 14, § 25.735(h)

One commenter states that ''although this rule is only invoked if the aircraft relies on accumulators to provide back-up brake pressure, and this is generally not the case with AIRBUS aircraft, [the commenter] is not aware of an existing system that would satisfy this requirement. The display of available brake energy is a complex task, and a system would need to be devised to allow this information to be obtained.'' The commenter suggests that overall safety would probably be better enhanced by placing a reliability requirement on the accumulator system, rather than demanding a new monitoring system be developed which could degrade the system safety.

FAA's Response: The FAA disagrees with this comment. Alternate means of compliance will be discussed in AC 25–735–1. As explained in the preamble and advisory circular material, the intent is to ensure proper indication of available accumulator energy, not just pressure which has been determined to be insufficient indication. Unless available energy is displayed, there is no assurance that a backup system is available.

Proposal 16, § 25.735(j)

One commenter recommends that the proposed § 25.735(j), Overtemperature burst prevention, should be moved to § 25.731.

FAA's Response: The FAA does not concur with this comment. The overtemperature condition is caused by brake heat and, therefore, needs to be addressed in the brake section. Cross references are provided in both §§ 25.735 and 25.731.

Another commenter suggests that the intent would be better expressed by changing the words ''* * * wheel failure or tire burst * * * '' to '' * * * wheel failure and/or tire burst * * *''

FAA's Response: The FAA concurs that clarification is necessary. The final rule text is revised to read ''* * * a wheel failure, a tire burst, or both * * *''

Discussion of Comments: Notice No. 99–16A

Five commenters responded to the request for comments contained in Notice No. 99–16A. Three commenters fully support the proposal and recommend its adoption. Two other commenters made recommendations as follows.

The first commenter states ''Airplane braking systems differ between airplane models. Consideration must be given to the additional braking equipment, which is installed on certain model airplanes. When that additional equipment fails or has been rendered inoperative, a more critical condition can exist with the three proposed testing conditions for kinetic energy capacity, i.e., design landing stop, accelerate-stop, and most severe landing stop. This SNPRM does not account for model specific test qualifications for airplanes equipped with additional braking equipment such as brake fan systems. For example, the brake fan system on an airplane may be rendered inoperative due to system failure or by deactivation in accordance with the airplane minimum equipment list (AMEL). The lack of additional brake cooling, coupled with the additional mass (heat sink) of the brake fan, will further deteriorate conditions at the brake installation. Consequently, braking performance is reduced.'' Recognition of such abnormal conditions must be part of the qualification testing for kinetic energy capacity in all three proposed conditions.

FAA's Response: The FAA does not concur with this comment. While the revised regulations do not specifically address items such as brake cooling fans, they provide the basic requirements that must be met. The final AC, once it is published, will provide information on how the regulations are applied. In the case of brake cooling fans, two paragraphs are appropriate. Paragraph 4a(1)(c) of the AC will state that the brake must meet the energy requirements without the use of auxiliary cooling devices. Paragraph 4f(2)(a) states that, in calculating the energy requirements for the accelerate-stop, use of cooling fans may not be considered in determining the heat sink state at the beginning of the stop. No change in the rule text is necessary.

The second commenter recommends the following changes to §§ 25.735(f)(2) and (f)(3) for consistency with § 25.735(f)(1):

''(1) In § 25.735(f)(2) remove the words 'defined by the airplane manufacturer must be achieved,' and add the words, 'derived from the airplane manufacturer's braking requirements must be achieved.' ''

''(2) In § 25.735(f)(3), add the sentence 'The energy absorption rate derived from the airplane manufacturer's braking requirements must be achieved.' ''

FAA's Response: The FAA concurs with (1) and the final rule text has been revised accordingly. The FAA does not concur with (2) because the HWG specifically decided not to put a deceleration requirement on the most severe landing. Addition of the proposed sentence to § 25.735(f)(3) is not necessary and doing so would not have any any impact on brake design.

With the exceptions of the changes noted in §§ 25.735(f) and (j), this final rule is adopted as proposed in Notice No. 99–16 and Notice No. 99–16A.

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), the FAA has determined that there are no new requirements for information collection associated with this amendment.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has determined that there are no ICAO Standards and Recommended Practices that correspond to these regulations.

Regulatory Evaluation Summary, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

Changes to Federal Regulations must undergo several economic analyses. First, Executive Order 12866 directs that each federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. 2531–2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards, and, where appropriate, to use those standards as the basis of U.S. standards. Fourth, Title II of the Unfunded Mandates Reform Act of 1995 requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million in any one year. In conducting these analyses, the FAA has determined that this rule: (1) Will generate benefits that justify its costs and is not ''a significant regulatory action(as defined in Executive Order 12866 or in the Department of Transportation's Regulatory Policies and Procedures; (2) will not have a significant impact on a substantial number of small entities; (3) will not constitute a barrier to international trade, and (4) does not contain a Federal intergovernmental or private sector mandate that exceeds $100 million in any one year.

These analyses, available in the docket, are summarized below. All estimates are expressed in year 2000 dollars.

Regulatory Evaluation Summary

None of the commenters to Notice No. 99–16 disputed FAA's estimates of specific incremental certification costs. One commenter, however, questioned FAA's contention that costs would be balanced by the savings expected from rule harmonization.

In answer to that commenter's concerns, and based on industry experience with recent type certifications, the FAA re-calculated both the harmonization cost savings and the costs attributable to the ''proposed'' amendments (in the original NPRM), and estimated the costs associated with the proposed new requirement in Notice No. 99–16A. These cost estimates are delineated in the next several paragraphs.

Based on the previous analyses in the economic evaluations for both notices, the FAA has determined that only two changes in § 25.735(f) *Kinetic energy capacity*, will result in any incremental cost increases; those are the dynamometer testing requirements in (f)(2) and (f)(3), pertaining to the ''Maximum kinetic energy accelerate-stop'' and the ''Most severe landing stop (MSL),'' respectively.

The dynamometer test, also called a new brake rejected takeoff test, is currently conducted by brake manufacturers as specified by large airplane manufacturers in the brake qualification specification and is an industry practice as such. For some small airplane manufacturers, however, the new ''accelerate-stop'' test will result in a cost increase of $20,000 per certification. This incremental, but nonrecurring, cost for some manufacturers of part 25 small airplanes will easily be offset by the harmonization cost savings cited below. Any potential safety benefits from avoiding even one minor accident would add to such benefits.

The MSL requirement, while a new FAA requirement, has been in effect in Europe (per British CAA); consequently, many large part 25 airplane manufacturers currently meet this standard. Notwithstanding, large part 25 airframe and brake manufacturers note that in almost all cases either the MSL stop energy would not exceed the maximum kinetic energy accelerate-stop energy, or the MSL stop condition is extremely improbable. One part 25 large airplane manufacturer, however, estimates one additional dynamometer test in the $20,000–$40,000 range. Manufacturers of small part 25 airplanes will experience incremental one-time testing costs totaling approximately $20,000 per type certification.

These incremental, but nonrecurring, costs for some manufacturers of part 25 (large and small) airplanes will easily be offset by the estimated harmonization cost savings. Any potential safety benefits from avoiding even one minor accident would add to such benefits.

In summary, the incremental costs for the aforementioned new dynamometer tests will total between $20,000 and $40,000 per type certification for one manufacturer of part 25 large airplanes. Similar costs for some manufacturers of part 25 small airplanes are estimated at $40,000 per type certification.

As stated in the Regulatory Evaluation Summary in Notice No. 99–16A, the FAA had contacted industry sources to obtain estimated harmonization cost savings attributable to the revisions originally proposed in Notice No. 99–16. These cost savings are estimated to be, at a minimum, between $50,000 and $75,000 for a part 25 small airplane type certification and $100,000 to $300,000 for a part 25 large airplane type certification. These harmonization benefits exceeded the incremental costs of all the revisions specified in the NPRM as well as the costs attributable to the SNPRM change. Since there were no public comments to the SNPRM disputing these estimates, the FAA includes these same benefits in this final rule economic assessment. Given that the rule's incremental benefits exceed the incremental costs for both part 25 large and small airplane manufacturers, the FAA finds the final rule cost-beneficial.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) establishes ''as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation.'' To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The Act covers a wide-range of small entities, including small businesses, not-for-profit organizations, and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have a significant economic impact on a substantial number of small entities. If the determination is that it will, the agency must prepare a regulatory flexibility analysis as described in the Act. However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 1980 act provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

The subject rule will affect manufacturers of part 25 transport category airplanes produced under future new airplane type certifications. For manufacturers, a small entity is one with 1,500 or fewer employees. No part 25 airplane manufacturer has 1,500 or fewer employees. Notwithstanding, the relatively low annualized incremental certification costs are not considered significant. Consequently, the FAA certifies that the final rule will not have a ''significant economic impact on a substantial number of small entities'' (manufacturers).

International Trade Impact Assessment

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards or related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. In accordance with the above statute, the FAA has assessed the potential effect of this final rule and has determined that it will eliminate regulatory differences between the airworthiness standards of the U.S. and the Joint Aviation Requirements of Europe, without affecting current industry practice. This is consistent with the Trade Agreement Act.

Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Public Law 104–4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed ''significant intergovernmental mandate.'' A ''significant intergovernmental mandate'' under the Act is any provision in a Federal agency regulation that will impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals. The FAA determines that this final rule does not contain a significant intergovernmental or private sector mandate as defined by the Act.

Executive Order 3132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action will not have a substantial direct effect on the States, or the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, we determined that this final rule does not have federalism implications.

Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying regulations in Title 14 of the CFR in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish such regulatory distinctions as he or she considers appropriate. Because this final rule applies to the certification of future designs of transport category airplanes and their subsequent operation, it could affect intrastate aviation in Alaska. The Administrator has considered the extent to which Alaska is not served by transportation modes other than aviation, and how the final rule could have been applied differently to intrastate operations in Alaska. However, the Administrator has determined that airplanes operated solely in Alaska would present the same safety concerns as all other affected airplanes; therefore, it would be inappropriate to establish a regulatory distinction for the intrastate operation of affected airplanes in Alaska.

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental impact statement. In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), this rulemaking action qualifies for a categorical exclusion.

Energy Impact

The energy impact of the final rule has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) Public Law 94–163, as amended (42 U.S.C. 6362) and FAA Order 1053.1. It has been determined that the final rule is not a major regulatory action under the provisions of the EPCA.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends Chapter I of Title 14, Code of Federal Regulations as follows:

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702 and 44704.

2. Amend § 25.731 by adding paragraphs (d) and (e) to read as follows:

§ 25.731 Wheels.

* * * * *

(d) *Overpressure burst prevention.* Means must be provided in each wheel to prevent wheel failure and tire burst that may result from excessive pressurization of the wheel and tire assembly.

(e) *Braked wheels.* Each braked wheel must meet the applicable requirements of § 25.735.

3. Revise § 25.735 to read as follows:

§ 25.735 Brakes and braking systems.

(a) *Approval.* Each assembly consisting of a wheel(s) and brake(s) must be approved.

(b) *Brake system capability.* The brake system, associated systems and components must be designed and constructed so that:

(1) If any electrical, pneumatic, hydraulic, or mechanical connecting or transmitting element fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest with a braked roll stopping distance of not more than two times that obtained in determining the landing distance as prescribed in § 25.125.

(2) Fluid lost from a brake hydraulic system following a failure in, or in the vicinity of, the brakes is insufficient to cause or support a hazardous fire on the ground or in flight.

(c) *Brake controls.* The brake controls must be designed and constructed so that:

(1) Excessive control force is not required for their operation.

(2) If an automatic braking system is installed, means are provided to:

(i) Arm and disarm the system, and

(ii) Allow the pilot(s) to override the system by use of manual braking.

(d) *Parking brake.* The airplane must have a parking brake control that, when selected on, will, without further attention, prevent the airplane from rolling on a dry and level paved runway when the most adverse combination of maximum thrust on one engine and up to maximum ground idle thrust on any, or all, other engine(s) is applied. The control must be suitably located or be adequately protected to prevent inadvertent operation. There must be indication in the cockpit when the parking brake is not fully released.

(e) *Antiskid system.* If an antiskid system is installed:

(1) It must operate satisfactorily over the range of expected runway conditions, without external adjustment.

(2) It must, at all times, have priority over the automatic braking system, if installed.

(f) *Kinetic energy capacity*—(1) *Design landing stop.* The design landing stop is an operational landing stop at maximum landing weight. The design landing stop brake kinetic energy absorption requirement of each wheel, brake, and tire assembly must be determined. It must be substantiated by dynamometer testing that the wheel, brake and tire assembly is capable of absorbing not less than this level of kinetic energy throughout the defined wear range of the brake. The energy absorption rate derived from the airplane manufacturer's braking requirements must be achieved. The mean deceleration must not be less than 10 fps^2.

(2) *Maximum kinetic energy accelerate-stop.* The maximum kinetic energy accelerate-stop is a rejected takeoff for the most critical combination of airplane takeoff weight and speed. The accelerate-stop brake kinetic energy absorption requirement of each wheel, brake, and tire assembly must be determined. It must be substantiated by dynamometer testing that the wheel, brake, and tire assembly is capable of absorbing not less than this level of kinetic energy throughout the defined wear range of the brake. The energy absorption rate derived from the

airplane manufacturer's braking requirements must be achieved. The mean deceleration must not be less than 6 fps ^{2}.

(3) *Most severe landing stop.* The most severe landing stop is a stop at the most critical combination of airplane landing weight and speed. The most severe landing stop brake kinetic energy absorption requirement of each wheel, brake, and tire assembly must be determined. It must be substantiated by dynamometer testing that, at the declared fully worn limit(s) of the brake heat sink, the wheel, brake and tire assembly is capable of absorbing not less than this level of kinetic energy. The most severe landing stop need not be considered for extremely improbable failure conditions or if the maximum kinetic energy accelerate-stop energy is more severe.

(g) *Brake condition after high kinetic energy dynamometer stop(s).* Following the high kinetic energy stop demonstration(s) required by paragraph (f) of this section, with the parking brake promptly and fully applied for at least 3 minutes, it must be demonstrated that for at least 5 minutes from application of the parking brake, no condition occurs (or has occurred during the stop), including fire associated with the tire or wheel and brake assembly, that could prejudice the safe and complete evacuation of the airplane.

(h) *Stored energy systems.* An indication to the flightcrew of the usable stored energy must be provided if a stored energy system is used to show compliance with paragraph (b)(1) of this section. The available stored energy must be sufficient for:

(1) At least 6 full applications of the brakes when an antiskid system is not operating; and

(2) Bringing the airplane to a complete stop when an antiskid system is operating, under all runway surface conditions for which the airplane is certificated.

(i) *Brake wear indicators.* Means must be provided for each brake assembly to indicate when the heat sink is worn to the permissible limit. The means must be reliable and readily visible.

(j) *Overtemperature burst prevention.* Means must be provided in each braked wheel to prevent a wheel failure, a tire burst, or both, that may result from elevated brake temperatures. Additionally, all wheels must meet the requirements of § 25.731(d).

(k) *Compatibility.* Compatibility of the wheel and brake assemblies with the airplane and its systems must be substantiated.

Issued in Renton, Washington on April 10, 2002.

Vi L. Lipski,

Manager, Transport Airplane Directorate, Aircraft Certification Service.

[FR Doc. 02–9845 Filed 4–23–02; 8:45 am]

BILLING CODE 4910–13–P