U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: SHOCK ABSORPTION TESTS **Date:** 5/25/01 **AC No.** 25.723-1
Initiated by: ANM-110 **Change:**

1. PURPOSE. This advisory circular (AC) sets forth an acceptable means, but not the only means, of demonstrating compliance with the provisions of part 25 of the Federal Aviation Regulations (FAR) related to the use of landing gear shock absorption tests and analyses to determine landing loads for transport category airplanes.

2. RELATED FAR SECTIONS. Part 25, Section 25.723 "Shock absorption tests" and Section 25.473 "Ground load conditions and assumptions."

3. BACKGROUND. The requirement concerning energy absorption tests for landing gear units existed in the earliest versions of the Civil Aeronautics Regulations (CAR) 04. Questions concerning the need for the tests and the use of analyses in lieu of tests have existed since CAR 04, and have resulted in revisions to the successor regulations, CAR 4b, which replaced CAR 04, and later in the Federal Aviation Regulations (FAR), Part 25, which replaced CAR 4b.

a. Section 04.34 of CAR 04 (July 1944) allowed analyses in lieu of tests when the landing gear structure conformed to conventional types for which reliable analytical methods were available. With the advancing complexity of landing gear units, the rule was revised (CAR 4b, Section 4b.332) to require energy absorption tests to determine the landing load factors both at design landing weight and design takeoff weight. Although this rule did not specifically provide for analyses in lieu of tests, it was common practice to allow later changes in design weights to be substantiated by analytical methods which were validated by the results of the earlier tests.

b. Recognizing the need to provide for subsequent growth in the design weights, the Federal Aviation Administration (FAA) revised § 25.723 (Amendment 25-46) to clarify that analyses could be used to substantiate changes in the design takeoff and design landing weights provided these analyses were validated by the results of tests conducted on identical landing gear units.

c. Although the rule referred to tests on the "identical" landing gear units, subsequent changes in the design weights often are accompanied by minor changes in other parameters affecting the landing gear energy absorption characteristics. These included changes in the shock absorber orifice size and metering pins shape, and changes in tire inflation limits. The FAA revised § 25.723 (Amendment 25-72) to further clarify that the analyses could be based on tests performed on the same basic landing gear system with similar energy absorption characteristics.

d. In the mean time, other requirements have resulted in changes in the way the test and analytical data are used. The shock absorption tests are no longer used just to determine the landing load factors. It is now necessary to account for dynamic landing conditions in which the dynamic characteristics of the airplane and landing gear acting together are used to determine the landing loads. As a practical matter, the analytical modeling of the landing gear dynamic characteristics are indispensable in determining that landing loads and the shock absorption tests are needed in order to validate the mathematical modeling of the landing gear units.

4. SHOCK ABSORPTION TESTS.

a. Validation of the landing gear characteristics. Shock absorption tests are necessary to validate the analytical representation of the dynamic characteristics of the landing gear unit that will be used to determine the landing loads. A range of tests should be conducted to ensure that the analytical model is valid for all design conditions. In addition, consideration should be given to ensuring that the range of test configurations is sufficient for justifying the use of the analytical model for foreseeable future growth versions of the airplane.

b. Recommended test conditions for new landing gear units. The design takeoff weight and the design landing weight conditions should both be included as configurations subjected to energy absorption tests. However, in cases where the manufacturer has supporting data from previous experience in validating the analytical model using landing gear units of similar design concept, it may be sufficient to conduct tests of the new landing gear at only the condition associated with maximum energy. The landing gear used to provide the supporting data may be from another model aircraft but should be of approximately the same size with similar components.

c. Changes to type designs. Section 25.723(c) allows changes in previously approved design weights and minor changes in design to be substantiated by analyses based on tests of the same basic landing gear unit with similar energy absorption characteristics. A landing gear unit would be considered to be of "the same basic landing gear system" when the design concept has not been changed. "Similar energy absorption characteristics" means that the changes to the landing gear unit, either taken individually or as a whole, would not have a significant effect on the validation of the analytical results for the modified airplane. Changes that may be acceptable without further energy absorption tests include minor changes and adjustments incorporated in the landing gear unit to maintain similar energy absorption characteristics with changes in design weight and landing speeds. For example, the following changes may be acceptable without further tests:

(1) Minor changes in shock absorber details including pre-load, compression ratio, orifice sizes, metering pin profiles.

(2) Minor changes in tire characteristics.

(3) Minor changes in unsprung mass (e.g. brakes).

(4) Local strengthening or minor sizing changes to the landing gear.

To allow justification by analysis for the reserve energy requirement, neither the shock strut nor the tires should bottom during the reserve energy analysis or the tests upon which the analysis is correlated.

5. LIMIT FREE DROP TESTS.

a. Compliance with § 25.723(a) may be shown by free drop tests, provided they are made on the complete airplane, or on units consisting of a wheel, tire, and shock absorber, in their proper positions, from free drop heights not less than--

(1) 18.7 inches for the design landing weight conditions; and

(2) 6.7 inches for the design takeoff weight conditions.

b. If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by a reduced weight, the landing gear must be dropped with an effective weight equal to

$$W_e = W\left[\frac{h+(1-L)d}{h+d}\right]$$

where—

W_e = the effective weight to be used in the drop test (lbs.);
h = specified free drop height (inches);
d = deflection under impact of the tire (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop weight (inches);
W = W_M for main gear units (lbs.), equal to the static weight on that unit with the airplane in the level attitude (with the nose wheel clear in the case of nose wheel type airplanes);
W = W_T for tail gear units (lbs.), equal to the static weight on the tail unit with the airplane in the tail-down attitude;
W = W_N for nose wheel units (lbs.), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0 g downward and 0.25 g forward; and
L = ratio of the assumed airplane lift to the airplane weight, but not more than 1.0.

c. The drop test attitude of the landing gear unit and the application of appropriate drag loads during the test must simulate the airplane landing conditions in a manner consistent with the development of rational or conservative limit loads.

d. The value of *d* used in the computation of W_e in paragraph 5b. of this AC may not exceed the value actually obtained in the drop test.

6. RESERVE ENERGY FREE DROP TESTS.

a. Compliance with the reserve energy absorption condition specified in § 25.723(b) may be shown by free drop tests provided the drop height is not less than 27 inches.

b. If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by an equivalent reduced weight, the landing gear must be dropped with an effective weight,

$$W_e = \frac{Wh}{h + d}$$

where the symbols and other details are the same as in paragraph 5. of this AC.

/s/

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