U.S. Department
of Transportation

**Federal Aviation
Administration**

Advisory Circular

Subject: HIGH LIFT AND DRAG DEVICES **Date:** 5/4/88 **AC No:** AC 25-14
Initiated by: ANM-110 **Change:**

1. PURPOSE. This advisory circular (AC) sets forth an acceptable means of compliance with the provisions of Part 25 of the Federal Aviation Regulations (FAR) dealing with the certification requirements for high lift and drag devices. Guidance information is provided for showing compliance with structural and functional safety standards for high lift and drag devices and their operating systems. The intent of the requirements and some acceptable means of compliance are discussed. Other means are acceptable if they meet the intent of the regulations.

2. RELATED FAR SECTIONS. The contents of this AC are considered by the FAA in determining compliance of flaps, slats and drag devices with Part 25. Related sections are 25.301, 25.303, 25.333(e), 25.345, 25.457, 25.571, 25.671, 25.672 25.697, 25.699, 25.701, 25.703, and 25.1309.

3. BACKGROUND. For several years, special consideration has been given to high lift and drag devices to ensure that malfunction or failure will not result in an unsafe condition. These considerations are consolidated and incorporated in this AC.

4. STRUCTURAL REQUIREMENTS. The structure of high lift and drag devices must be designed to comply with the damage tolerance requirements of § 25.571, Amendment 25-45, of the FAR. The design should incorporate features which would provide a high probability of detection of any damage before the damage causes loss of the surface from the airplane. High lift and drag components to be evaluated under the requirements of § 25.571 typically include all structure which contributes significantly in reacting applied flight and actuation loads. Examples of such structure are the flap or slat surfaces, support linkages or tracks, hinges, fittings and attachments.

5. CONTROL SYSTEM REQUIREMENTS. The control system for high lift and drag devices must be designed to comply with the requirements of § 25.671. For the purpose of compliance with § 25.671, the control system ends where the control surface attaches to fixed structure such as the wing or fuselage. Examples of elements to be evaluated under the requirements of § 25.671 are linkages, hinges, cables, pulleys, quadrants, valves, actuator components, track rollers, movable tracks, bearings, and hydraulic or electrical systems. In accordance with § 25.671, the airplane must be shown to be capable of continued safe flight and landing without requiring exceptional pilot skill or strength following the failure of any single mechanical element or any

combination of failures not shown to be extremely improbable, excluding jamming. Following this failure or combination of failures, the remaining structure must be able to withstand the loads defined by §§ 25.333 and 25.345. These are considered ultimate loads for this condition. If the surfaces are automatically or power operated, the control system must also be designed to meet the requirements of § 25.672.

6. DETAIL DESIGN CONSIDERATIONS.

a. Unless the airplane has safe flight characteristics with the functionally related high lift or drag devices retracted on one side and extended on the other, the motion of the devices on opposite sides of the plane of symmetry must be synchronized by a mechanical interconnection or approved equivalent means as required by § 25.701. The criteria of § 25.701 are considered equally applicable to high lift and drag devices.

(1) The surface interconnection must be designed for the loads resulting when the surfaces on one side of the plane of symmetry are jammed and immovable while the surfaces on the other side are free to move and the full power of the surface actuating system is applied. The flight loads from § 25.345 acting on the surface must be considered in combination with the actuating system loads (including system inertia loads). This is considered a limit load condition.

(2) In showing compliance with the interconnection requirements of § 25.701, all possible jam locations in the drive and support system should be considered. The surface mechanical interconnection must be able to withstand the jam condition and preclude any unsafe asymmetrical condition. The interconnection system is comprised of all elements which react the drive output from the actuator source to the jam point. These elements may include structures, interconnection linkages, and drive system components. When the interconnection is the only means to prevent an unsafe asymmetrical condition, the loads associated with the jam conditions are considered limit loads and require a 1.5 factor of safety. A factor of safety less than 1.5 may be used when a reliable (i.e., a probability of failure of 10^{-3} or less) and independent means is used, in addition to the mechanical interconnection, to prevent unsafe asymmetry of a high lift system. The alternate system should detect the jam and shut down the drive system before the loads from any jam condition are reacted by the mechanical interconnection. The factor of safety may be as low as 1.25 if the probability of failure of the alternate system is 10^{-5} or less; however, it should not be less than 1.25 unless the alternate system is found to be equivalent to a mechanical interconnection. When a torque limiter is used, the torque tolerance limit should be used to react the required load rather than the nominal or set torque. A torque limiter should not be located in the drive system in a position where the limiter itself would allow an unsymmetrical configuration if a jam occurred.

(3) An equivalent means of compliance with the requirements for a mechanical interconnection system may be substantiated using a systems safety analysis. Guidelines for performing a systems safety analysis are given in AC 25.1309-1, System Design Analysis.

b. Where failures in the drive system can result in uncommanded extensions or retractions of the high lift or drag devices, a positive means should be provided to limit the movement of the affected surfaces. This may be accomplished through irreversible drive actuators, no-back devices, redundancy in the drive system, or other equivalent means.

c. In determining loads on high lift devices during actuation, it may be necessary to consider friction loads in the actuating system which may be reasonably expected to occur in service. Flap tracks and rollers for instance, are often subjected to ice and slush which may offer high resistance to flap actuation. Each design should be evaluated to determine its susceptibility to friction in the mechanism and any loads associated with such resistance should be accounted for and applied in combination with normal operating loads.

d. In evaluating the effects of failures or jamming of high lift surfaces, the effects of skewed surfaces on the operation of adjacent surfaces should be evaluated. Damage to adjacent structures and systems due to skewing of the surface should also be evaluated.

7. INDICATING AND WARNING SYSTEMS.

a. Indicating systems for high lift and drag devices must provide visual indication to the pilot of the surface positions for the takeoff, enroute, approach, and landing conditions. The position sensors should be located such that they show a direct indication of failure conditions. There should be independent monitoring of each functionally related set of surfaces (i.e., a set of surfaces on each side of the plane of symmetry that is driven by a common actuator, or is synchronized by some other means to ensure symmetric actuation) for which a failure will require an action or procedural change by the flightcrew. For instance, a functionally related flap set which is in an unsymmetrical configuration about the fuselage centerline would require an indication to the pilot of the unsymmetrical condition before takeoff. The indication to the flightcrew need not indicate the specific surface which has failed, but must clearly reflect the abnormal configuration (§ 25.699). The cockpit surface position display must also clearly distinguish a fault which was caused by a high lift "asymmetrical" deployment from a high lift "disagree" condition. A "disagree" condition exists when the high lift surface is stopped at a position different than the position commanded by the pilot through the flap selection switch or handle. This distinction will aid the pilot in using proper procedures to further deploy, retract, or leave the high lift or drag devices for continued flight.

b. The takeoff warning system required by § 25.703 should sense the position of each functionally related set of high lift devices (symmetric about the airplane centerline) and provide aural warning during the initial portion of the takeoff roll if any set is not in an approved takeoff position.

8. <u>FLIGHT LOADS MEASUREMENT</u>. Notwithstanding the advancements in analytical methods used in predicting loads on airplane structures, accurate prediction of loads on wing leading edge and trailing edge high lift devices continues to be a problem. It is, therefore, advisable to verify the loads on these surfaces by conducting flight loads surveys regardless of the level of confidence in the overall loads program.

9. <u>AIRPLANE CONTROLLABILITY</u>. It should be shown by analysis, and where necessary by ground, simulation or flight tests, that the airplane has adequate stall margins and controllability to sustain the failure conditions addressed in paragraphs 4, 5, and 6 of this AC without requiring exceptional flightcrew skill or strength. It should also be demonstrated that no hazardous change in altitude or attitude will develop during transition to the unsymmetric condition considering likely transition rates.

Darrell M Pederson

DARRELL M. PEDERSON
Acting Manager, Aircraft Certification Division