U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Rudder Control Reversal Conditions **Date:** 11/28/22 **AC No:** 25.353-1
Initiated By: AIR-600

1 PURPOSE.

This AC describes acceptable means for showing compliance with the requirements of Title 14, Code of Federal Regulations (14 CFR) 25.353, *Rudder control reversal conditions*, at amendment 25-147. Section 25.353 requires that transport category airplanes be designed to withstand the structural load conditions that result from at least three cyclic, full rudder pedal reversals, if those airplanes have a powered rudder control surface or surfaces.

The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.

2 APPLICABILITY.

2.1 The guidance provided in this AC is for airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport airplane type certification engineers and the Administrator's designees. This guidance applies to airplanes certified under 14 CFR part 25 at amendment 25-147 or later.

2.2 This guidance is not legally binding in its own right and will not be relied upon by the FAA as a separate basis for affirmative enforcement actions or other administrative penalty. Conformity with the guidance is voluntary only and nonconformity will not affect rights and obligations under existing statues and regulations. The FAA will consider other methods of demonstrating compliance that an applicant may elect to present. Terms such as "should," "shall," "may," and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance in this document is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. On the other hand, if the FAA becomes aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation as the basis for finding compliance.

2.3 This material does not change, create any additional, authorize changes in, or permit deviations from existing regulatory requirements.

3 RELATED REGULATIONS.

The following part 25 regulations are related to this AC. You can download the full text of these regulations at the e-CFR website. You can order a paper copy by sending a request to the U.S. Superintendent of Documents, U.S. Government Publishing Office, Washington, D.C. 20401; by calling telephone number (202) 512-1800; or by sending a fax to (202) 512-2250.

- Section 25.305, *Strength and deformation*.
- Section 25.321, *Flight Loads—General*.
- Section 25.351, *Yaw maneuver conditions*.
- Section 25.353, *Rudder control reversal conditions*.

4 BACKGROUND.

4.1 Requirements for Addressing Pilot-Commanded Rudder Control Inputs.

Sections 25.351 and 25.353 specify structural design load conditions that result from rudder control inputs. Rudder control inputs include pilot commands through the flightdeck rudder control, which may be combined with commands from automated systems such as yaw damper, rudder ratio changer, and other flight control augmentation logic. For purposes of the guidance in this AC, "flightdeck rudder control" is assumed to be a traditional rudder pedal mechanism. The conditions in §§ 25.351 and 25.353 are intended to encompass all the maneuver loads expected to occur in flight that arise from flightdeck rudder control commands.

4.2 Section 25.351, Yaw Maneuver Conditions.

The FAA established § 25.351 when part 25 was adopted in 1965 and has amended it several times since then. The design load conditions specified in § 25.351 are considered limit load conditions as defined by § 25.301, and a factor of safety of 1.5 is applied to obtain ultimate loads, as defined by § 25.303.

4.3 Section 25.353, Rudder Control Reversal Conditions.

4.3.1 The FAA established § 25.353, effective on January 23, 2023, at amendment 25-147 (87 FR 71203). The design load conditions in § 25.353 include a full flightdeck rudder control displacement (as limited by control stops or a rudder pedal force of 200 pounds) followed by three full-displacement control reversals and return to neutral position. A flightdeck rudder control "reversal" is defined as a continuous, pilot-commanded control (i.e., rudder pedal) movement starting from control displacement in one direction followed by control displacement in the opposite direction. The design load conditions specified in § 25.353 include those arising from multiple control reversals and may result in higher loads than those in § 25.351. These conditions are anticipated to occur rarely, so they are considered ultimate load conditions, and no additional safety factor is applied.

4.3.2 Section 25.353 applies only to airplanes that have a powered rudder control surface or surfaces. A powered rudder control surface is one in which the force required to deflect the surface against the airstream is generated or augmented by non-mechanical means, such as hydraulic or electric systems. Powered rudder control systems include fly-by-wire and hydro-mechanical systems. An unpowered rudder control surface is one for which the force required to deflect the surface is transmitted from the pilot's rudder pedal directly through mechanical means, without any augmentation from hydraulic or electric systems. Unpowered rudder control systems are also referred to as mechanical systems. Incorporation of a powered yaw damper into an otherwise unpowered rudder control system does not constitute a powered rudder control system. Additionally, other powered systems, such as electrical, hydraulic, or pneumatic systems, may aid in the reduction of pedal forces for single engine--out operations or to trim out pedal force to maintain steady heading. However, if such systems do not contribute to hinge moment generation during maneuvering of a fully operational airplane, they do not constitute a powered rudder control system.

5 APPLICATION OF THE REQUIREMENTS.

5.1 General.

5.1.1 Design Criteria.

Section 25.353 requires that airplanes with a powered rudder control surface or surfaces be designed for the rudder control reversal load conditions specified in that regulation. The regulation specifies these as ultimate load conditions; therefore, no additional safety factor is applied. However, any permanent deformation resulting from these ultimate load conditions must not prevent continued safe flight and landing.

5.1.2 Load Conditions.

The regulation further states that applicants must consider the design load conditions at all airspeeds ranging from the minimum control speed with the critical engine inoperative (V_{MC}) to the design cruising speed (V_C/M_C). Further, the applicant must assume a pilot-commanded control force of at least 200 pounds is applied to the rudder pedals for all conditions, and must consider these conditions with the landing gear retracted and speed brakes (or spoilers when used as speed brakes) retracted. The applicant must also evaluate the effects of flaps, flaperons, or any other aerodynamic devices when used as flaps, and slats--extended configurations, if they are used in en route conditions. By "en route conditions," the FAA means the conditions occurring during any phase of flight after initial climb and before the approach and landing phase.

5.1.3 Means of Compliance.

The applicant should use standard design loads analysis methods or simulation to determine loads on the airplane, as specified in § 25.321 for design loads and as specified in § 25.301 for flight loads analysis and validation.

5.1.4 System Effects.

The applicant’s evaluation of the maneuver prescribed by § 25.353 should take into account normal systems operation and functionality. For example, analysis of fly-by-wire airplanes should assume the airplane is in the normal control law mode. Similarly, analysis of airplanes equipped with yaw damper systems should assume the systems are operational. Any system function used to demonstrate compliance with the regulation should meet the following criteria:

5.1.4.1 The system is normally active during flight in accordance with the Airplane Flight Manual (AFM) procedures. Limited dispatch with the system inoperative could be allowed under minimum equipment list provisions.

5.1.4.2 Flightcrew procedures should be provided in the appropriate document (e.g., AFM or similar) in the event of loss of function to ensure safe operation. If loss of system function would not be detected by the flightcrew, the probability of loss of function (failure rate multiplied by maximum exposure period) should be less than 1/1000.

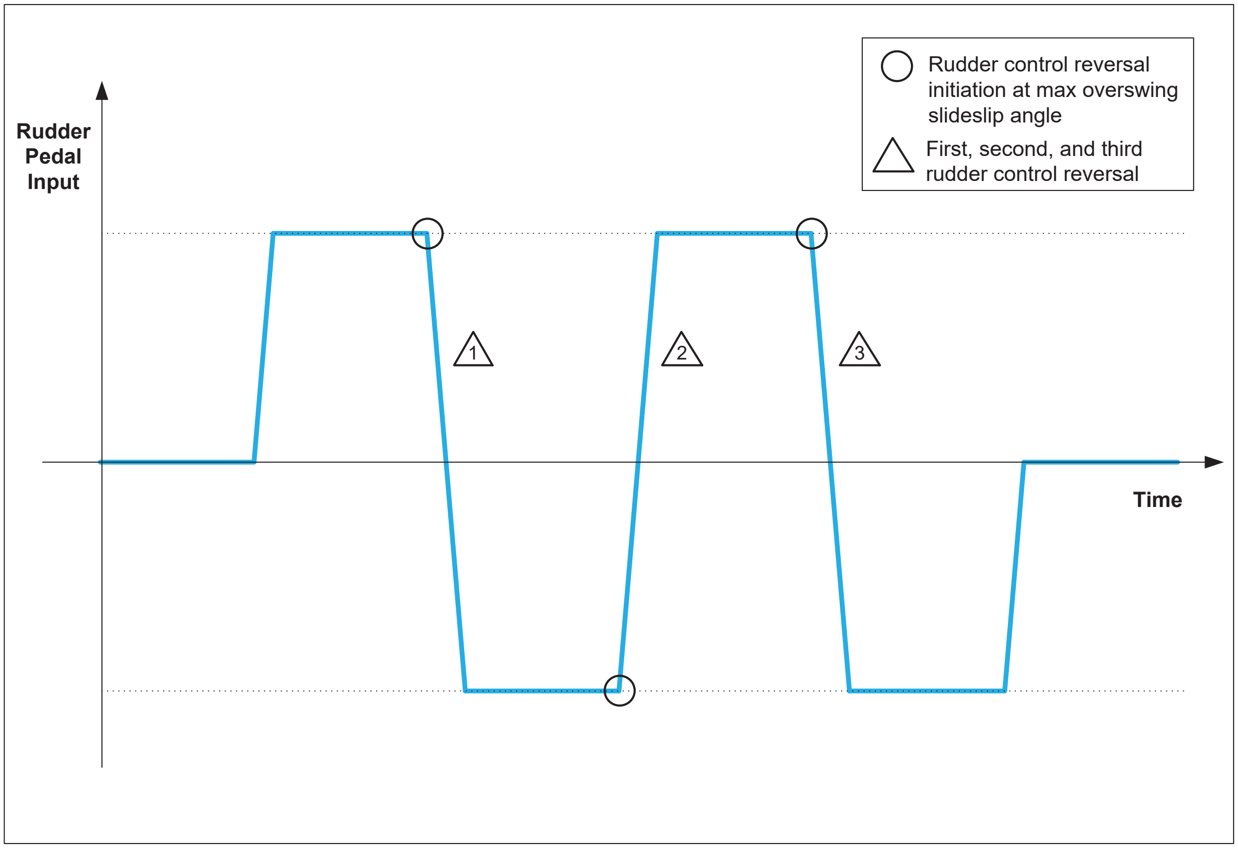
5.1.5 Failure Conditions.

Due to the low probability of flightdeck rudder control reversal events, applicants need not include failure scenarios in combination with the flightdeck rudder control reversal conditions specified in § 25.353.

5.2 Compliance with § 25.353.

5.2.1 The design load conditions in § 25.353 include a full rudder pedal displacement (as limited by control stops or a flightdeck rudder control force of 200 pounds) followed by three full-displacement flightdeck rudder control reversals and return to neutral position. See figure 1 below. Airspeed should remain reasonably constant throughout the maneuver using pitch control. Investigation of the design load conditions should assume rational or conservative roll control input (pilot or system induced).

Figure 1. Illustration of Rudder Control Inputs



5.2.2 With the airplane in unaccelerated flight at zero yaw (i.e., flying with zero sideslip angle), assume that the flightdeck rudder control is suddenly displaced to achieve the resulting rudder deflection. In the context of this regulation, "suddenly" means as fast as possible within human and system limitations. In the absence of an analysis substantiating other values, the applicant should assume initial flightdeck rudder control displacement is achieved in no more than 0.2 seconds, and full rudder control reversal displacement is achieved in 0.4 seconds. Alternatively, the applicant may assume the flightdeck rudder control is displaced instantaneously.

5.2.3 The resulting rudder displacement should take into account any additional rudder displacement resulting from aerodynamic load relief caused by increasing sideslip, and the applicant should include the effects of airframe (structural) flexibility or control system flexibility, if these effects substantially increase the baseline loads (i.e., loads that arise absent flexibility effects). The FAA would typically consider an increase of more than 2 percent to be substantial.

5.2.4 As soon as the maximum "overswing sideslip angle" is achieved, assume full opposite flightdeck rudder control input is applied. The overswing sideslip angle is the maximum sideslip angle that occurs following full flightdeck rudder control input and includes the overshoot that may occur beyond the steady state sideslip angle. The achieved rudder deflection may be limited by control laws in flight control systems, system architecture, or air loads. This deflection might not be the same magnitude as the initial rudder deflection prior to the control reversal. For critically damped airplane response, maximum overswing sideslip angle may be assumed to occur when the sideslip angle is substantially stabilized.

5.2.5 Assume two additional control reversals are performed as defined in paragraph 5.2.4 above. After the final control reversal, as soon as the airplane yaws to the opposite overswing sideslip angle, assume the flightdeck rudder control is suddenly returned to neutral. This ends the maneuver.

6 SUGGESTIONS FOR IMPROVING THIS AC.

If you have suggestions for improving this AC, you may use the Advisory Circular feedback form at the end of this AC.

Digitally signed by
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Advisory Circular Feedback Form

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Subject:____________________________ Date: ____________________

Please mark all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph___________________on page__________________________.

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Submitted by:__________________________________Date: ________________________