which compliance is shown with the applicable provisions of part 23 (including the provisions of special conditions SC23.55 and SC23.59 for weights, altitudes, temperatures, wind components, and runway gradients).

(4) The extremes for variable factors (such as altitude, temperature, wind, and runway gradients) are those at which compliance with the applicable provision of part 23 and these special conditions is shown.

(h) Maximum operating altitude. The maximum altitude established under § 23.1527 must be furnished.

(i) Maximum passenger seating configuration. The maximum passenger seating configuration must be furnished.

(j) Ambient temperatures. Where appropriate, maximum and minimum ambient air temperatures for operation.

(k) Allowable lateral fuel loading. The maximum allowable lateral fuel loading differential, if less than the maximum possible.

(l) Baggage and cargo loading. The following information for each baggage and cargo compartment or zone.

(1) The maximum allowable load; and

(2) The maximum intensity of loading.

(m) Systems. Any limitation on the use of airplane systems and equipment.

(n) Smoking. Any restriction on smoking in the airplane.

Issued in Kansas City, Missouri, on November 15, 1999.

**Marvin R. Nuss,**

*Acting Manager, Small Airplane Directorate, Aircraft Certification Service.*

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## DEPARTMENT OF TRANSPORTATION

## Federal Aviation Administration

## 14 CFR Part 25

**[Docket No. NM156, Special Conditions No. 25–151–SC]**

# Special Conditions: McDonnell Douglas Corporation (MDC) Model MD–17 Series Airplanes

**AGENCY:** Federal Aviation Administration, DOT.

**ACTION:** Final special conditions.

**SUMMARY:** These special conditions are issued for the McDonnell Douglas Corporation Model MD–17 airplane. This airplane incorporates novel and unusual design features, including the use of power-augmented-lift from externally blown flaps, for which the applicable airworthiness standards for transport category airplanes do not contain adequate or appropriate safety standards. These special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that provided by the existing airworthiness standards.

**EFFECTIVE DATE:** December 30, 1999.

**FOR FURTHER INFORMATION CONTACT:** Gerry Lakin, Project Officer, FAA Transport Airplane Directorate, Standardization Branch, ANM–113, 1601 Lind Avenue SW., Renton, WA 98055–4056; telephone (425) 227–1187; facsimile (425) 227–1149; Email: gerald.lakin@faa.gov.

**SUPPLEMENTARY INFORMATION:**

## Background

On July 7, 1996, McDonnell Douglas Corporation, 2401 E. Wardlow Rd., Long Beach, CA 90807–5309, a wholly owned subsidiary of The Boeing Company, submitted an application for type certification of a commercial version of the Model C–17 military airplane, designated as the MDC Model MD–17. The MD–17 is a long range, transport category airplane powered by four Pratt & Whitney F–117–PW–100 engines, which are a military version of the PW2040 engines used on other civil transport category airplane types. The airplane will be offered in a cargo configuration only and is designed for carriage of outsized cargo into short runways.

The MD–17 airplane will be certified as a part 25 transport category airplane and, as such, pilots and flight instructors who operate it will have a standard airplane multiengine rating.

## Type Certification Basis

Under the provisions of § 21.17, McDonnell Douglas must show that the MD–17 complies with the applicable provisions of 14 CFR part 25, as amended by Amendments 25–1 through 25–87. In addition, the certification basis includes part 36, as amended at the time of certification; part 34, as amended at the time of certification; any subsequent amendments to part 25 that are required for operation under part 121; and these special conditions.

If the Administrator finds that the applicable airworthiness regulations (i.e., part 25) do not contain adequate or appropriate safety standards for the MD–17 because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

In addition to the applicable airworthiness regulations and special conditions, the MD–17 must comply with the fuel vent and exhaust emission requirements of part 34 and the noise certification requirements of part 36, and the FAA must issue a finding of regulatory adequacy pursuant to § 611 of Public Law 92–574, the ''Noise Control Act of 1972.''

Special conditions, as appropriate, are issued in accordance with § 11.49 after public notice, as required by §§ 11.28 and 11.29(b), and become part of the type certification basis in accordance with § 21.17(a)(2).

Special conditions are initially applicable to the model for which they are issued. Should the type certificate for that model be amended later to include any other model that incorporates the same novel or unusual design feature, the special conditions would also apply to the other model under the provisions of § 21.101(a)(1).

## MD–17 Design Features

The MD–17 has novel and unusual design features to support the operation of a large transport category sized airplane at airports with very short runways. The MD–17 has externally blown flaps (EBF), which are fixed-vane double slotted flaps that deflect directly into the engine exhaust stream. The MD–17 integrated EBF design includes positioning the engines to provide engine exhaust blowing on the flaps, and flap slots sized to provide engine exhaust flow over both the upper and lower flap and vane surfaces. The resulting flap/exhaust stream interaction provides power-augmented-lift relative to conventional transport category airplane designs. The total lift produced by the EBF is made up of three components: (1) conventional aerodynamic lift produced by the wing and flap; (2) lift due to thrust deflection (the vertical component of the thrust force); and (3) the powered circulation lift (the additional aerodynamic lift resulting from the interaction of the engine exhaust stream on the wing flaps).

To distinguish the new and novel power-augmented-lift design feature of the MD–17 from conventional transport category airplanes, the following definition has been established: Power-augmented-lift means a heavier-than-air airplane capable of operation in regimes of short field takeoff and short field landing, and low speed flight. The airplane depends upon the propulsion system for a significant portion of lift and control during these flight regimes, but relies primarily on conventional wing lift when in the en route configuration.

The MD–17 features Direct Lift Control (DLC), which uses spoilers to provide rapid control of the flight path angle in the down direction for large flight path adjustments without throttle movement. DLC is actuated via push button switches placed on both sides of the thrust levers. Another feature of the MD–17 design that differs from conventional transport category airplanes is that the spoilers are biased to a non-flush position when the flaps are extended. When in this configuration, separate from the DLC function, the spoilers are electronically linked to the thrust levers to provide airplane response equivalent to instantaneous engine response to thrust lever movement.

The MD–17 Primary Flight Control System (PFCS) provides three-axis control and envelope protection using conventional cockpit controls and control surfaces, and a full authority fly-by-wire Electronic Flight Control System (EFCS) with single-strand mechanical backup. The PFCS provides stability and command augmentation to improve basic airplane characteristics and also integrates the trim and high lift controls.

Pitch and roll control inputs are made through a one-handed center stick controller centrally mounted to the floor in front of each pilot station. In addition to four electronic displays, the cockpit display system incorporates pilot and co-pilot full-time head up displays that can be used as primary flight displays.

The MD–17 will utilize electrical and electronic systems that perform critical functions. Examples of these systems include the electronic displays and electronic engine controls.

As the type design of the MD–17 contains novel or unusual design features not envisioned by the applicable part 25 airworthiness standards, special conditions are considered necessary in the following areas:

**Power-Augmented-Lift**

*1. Stall Speeds and Minimum Operating Speeds*

The primary purpose of the EBF design feature on the MD–17 is to reduce the takeoff and landing speeds, and hence the required takeoff and landing distances. The benefits provided by this novel design feature are not adequately addressed by the current part 25 stall speed and minimum operating speeds requirements. A special condition is needed to fully address the benefits of the MD–17 design features on stall speeds and minimum operating speeds, and to provide appropriate safety standards to ensure equivalent safety with current part 25 requirements.

The part 25 minimum allowable operating speeds are derived from power-off (i.e., zero thrust or power) stall speeds ($V_S$), except in those instances where the operating speeds are limited by some other constraint. Appropriate multiplying factors are applied to these power-off stall speeds to provide adequate safety in the one-engine-inoperative power-on condition. The beneficial effects of power-on available lift due to both circulation effects and thrust inclination were well known at the time the airworthiness requirements were developed. Evidence for this point is provided by the requirements associated with the minimum takeoff safety speed, $V_{2MIN}$, in § 25.107(b). For airplanes without ‘‘significant’’ power-augmented-lift effects in the one-engine-inoperative condition, $V_{2MIN}$ must not be less than 1.20 $V_S$, or 1.13 $V_S$ if the 1-g stall speed is used. However, for airplanes that realize a significant reduction in stall speed in the one-engine-inoperative power-on condition, the multiplying factor is reduced to 1.15. According to the explanatory information associated with this requirement that is provided in Civil Aeronautics Manual 4b, ‘‘The difference in the required factors * * * provides approximately the same margin over the actual stalling speed under the power conditions which are obtained after the loss of an engine. * * *’’

The MD–17 power-augmented-lift design, however, achieves significantly more lift from power than would be taken into account by the part 25 requirements. At the conditions applicable to the determination of the takeoff safety speed, $V_2$, the MD–17 achieves a 15 percent reduction in power-on stall speed. The four percent reduction in $V_2$ speed permitted by § 25.107(b)(2) for ‘‘turbojet powered airplanes with provisions for obtaining a significant reduction in the one-engine-inoperative power-on stalling speed’’ would therefore not provide ‘‘approximately the same margin over the actual stalling speed’’ as conventional transport category airplanes in the one-engine-inoperative power-on condition. A further reduction in $V_2$ speed could be made while maintaining the same margin over the one-engine-inoperative power-on stall speed.

At approach thrust, the MD–17 achieves over a 50 percent increase in lift due to power-augmented-lift effects. In the maximum landing flap configuration, the thrust used for a stable approach results in a stall speed reduction of approximately 20 percent relative to the zero thrust stall speed. There are no provisions in part 25, however, for allowing the landing approach speed to be reduced to account for the beneficial effects of power-augmented-lift on stall speeds. For a conventional transport category airplane, thrust or power may vary considerably during the landing approach, including reductions to idle thrust or power. During the landing flare for a conventional transport category airplane, thrust is typically reduced to idle.

The MD–17 power-augmented-lift design, however, requires a significant thrust level to be maintained during the approach to remain on the desired approach flight path. Unlike conventional transport category airplanes, only minor thrust modulation may be necessary during the approach to maintain or recover the desired flight path. The MD–17 design features and operational procedures will discourage use of thrust reductions to make flight path adjustments during approach. Adjustments in speed are obtained through changes in airplane pitch attitude during approach. In addition, the MD–17 is designed to provide very stable controllability characteristics to allow very slow approach speeds using a backside control technique, which is explained later in this preamble. With the backside control technique, airplane pitch attitude is used to control airspeed and thrust is used to control flight path angle.

As stated earlier, the MD–17 incorporates a DLC feature, which uses the spoilers to provide rapid control of the flight path angle in the down direction for large flight path adjustments without throttle movement. DLC is actuated via push button switches placed on both sides of the thrust levers. Separate from the DLC function, the spoilers are biased to a non-flush position in the flaps extended configurations. In this configuration, the spoilers are electronically linked to the thrust levers to provide an airplane response equivalent to instantaneous engine response to thrust lever movement. This feature provides a high level of control feedback and further minimizes the need for thrust adjustments. Because of the unique characteristics of the MD–17 power-augmented-lift design, thrust reduction is not used to reduce the rate of descent at touchdown. Instead, a slight thrust increase and a throttle-coupled reduction in spoiler deflection may sometimes be used to accomplish this task when desired.

To establish a level of safety equivalent to that established in the regulations, the MD–17 minimum operating speeds should provide approximately the same margin over the stall speed as conventional transport category airplanes under the power conditions that are obtained after the loss of an engine. In a power-augmented-lift airplane like the MD–17, significant increases in lift capability can be achieved not only by increasing angle of attack, but also by increasing thrust. During the takeoff phase of flight, there is no capability to add lift due to power because operation is already based on the use of the maximum thrust available. For approach and landing, however, the lift reserve due to thrust is much greater than that available on conventional transport category airplanes. A rapid lift increase due to increasing thrust is achievable on the MD–17 because it uses not only a higher approach power setting than conventional transport category airplanes, but also spoiler modulation to compensate for engine spool-up time. The higher approach power setting is necessary to compensate for the high induced drag from the power-augmented-lift effects, and to compensate for the relatively high profile drag of the approach and landing configurations, which include spoilers that are biased in the up direction. Advancing the thrust levers modulates the spoilers such that engine spool-up time is compensated for and a rapid increase in lift is achieved.

In addition, the MD–17 design incorporates a feature in which the deployed spoilers will be retracted should the airplane exceed a predetermined angle-of-attack that is less than the stall angle-of-attack. The stall speeds are defined assuming that the spoilers are flush to the wing at the point of stall. McDonnell Douglas must demonstrate to the FAA that the probability of the failure of any system that could change the calculated stall speeds by one-half knot or more is improbable.

Because there is no regulatory requirement to determine one-engine-inoperative power-on stall speeds, there is only limited data available to the FAA for assessing the margins attained under these conditions by the current fleet of conventional transport category airplanes. Based on the limited data that are available, and on the precedent established by Civil Air Regulations part 4b and part 25 for powered-lift credit, on average, conventional transport category airplanes without provisions for obtaining significant lift from power obtain approximately a 4–5 percent reduction in stall speed in the one-engine-inoperative power-on condition. This 4–5 percent reduction in stall speed applies to both the takeoff configuration at takeoff power and the landing configuration at the power for a 3-degree glideslope.

To retain equivalent safety, the MD–17 minimum operating speed in the takeoff configuration, $V_2$, should retain the additional 4–5 percent safety margin in the one-engine-inoperative power-on stall speed currently obtained on conventional transport category airplanes. To use one-engine-inoperative power-on stall speeds to determine $V_{2MIN}$ for the MD–17, the multiplying factor used to derive $V_{2MIN}$ from power-off stall speeds for conventional transport category airplanes should therefore be increased by not less than 4 percent (i.e., $V_{2MIN}$ must be 1.18 times the power-on 1-g stall speed, rather than 1.13 times the power-off 1-g stall speed). In determining the thrust effects on stall speeds for $V_{2MIN}$ determination, the thrust or power on the operating engines should be no greater than the minimum power that may exist at any point in the takeoff flight path. This means that the takeoff (or derated takeoff) power or thrust for the minimum engine would normally be determined at a height of 1500 feet above the runway surface at the appropriate takeoff power setting for the conditions existing at the time of takeoff. However, if the effect of altitude on takeoff thrust or power up to 1500 feet above the runway surface has a negligible impact on power-on stall speed used for $V_{2MIN}$ determination, thrust or power at the runway height may be used. McDonnell Douglas has provided the FAA with data which show, for the MD–17 power-augmented-lift design, that the effect of altitude on takeoff thrust up to 1500 feet above the runway surface has a negligible (less than 0.5 knots) impact on MD–17 power-on stall speeds used for $V_{2MIN}$ determination.

As noted above, the MD–17 incorporates several design features and operating characteristics that result in significant fundamental differences from the way conventional transport category airplanes are flown in the approach and landing phase of flight. During approach to landing, the MD–17's power-augmented-lift allows it to fly at speeds that are less than the speed at which total airplane drag is a minimum. Therefore, the MD–17 will be operating on the ''backside'' of the drag (or power) curve, which means that drag increases as speed is reduced and drag is reduced as speed increases. This variation of drag with speed is in the opposite sense to that normally encountered on conventional transport category airplanes operating at higher approach speeds.

A significant consequence of operating on the backside of the drag curve is that MD–17 pilots will use a different technique for controlling airspeed and flight path than is used on conventional transport category airplanes. In the MD–17, the thrust levers (including the DLC switches) are the primary means for controlling flight path for approach and landing. Thrust is increased to reduce descent angle. To increase descent angle, the MD–17 pilot will use small reductions in thrust to make small down flight path adjustments, and will use the DLC thumb switch on the thrust lever to make large down flight path corrections. In effect, the MD–17 pilot uses the throttles in a similar manner to the way a helicopter pilot uses the collective pitch lever. In contrast, the pilot of a conventional transport category airplane primarily uses the pitch control device for flight path control. For airspeed control, the MD–17 pilot uses pitch, while the pilot of a conventional transport category airplane primarily uses thrust.

Another significant characteristic of the power-augmented-lift MD–17 design is that, while operating on the backside of the drag curve, there is not much cross-coupling between pitch and thrust controls. This means that changes in thrust result primarily in changes to the flight path with very little effect on airspeed. Similarly, changes in pitch affect primarily airspeed with little change to the flight path. In combination with a full-authority three-axis fly-by-wire stability and control augmentation system, this characteristic ensures accurate airspeed control during manipulation of the thrust levers to control the flight path descent angle. On a conventional transport category airplane, manipulation of the pitch control to change the flight path will result in unwanted airspeed excursions. For example, a one-degree change in flight path takes four seconds in a conventional transport category airplane and is accompanied by a seven-knot speed change, while the same change in flight path for a powered-lift airplane takes one second and does not result in a speed change.

Analysis of C–17 flight test and piloted simulator data support a conclusion that airspeed can be controlled to a much higher degree of precision during an approach with this airplane than with a conventional transport category airplane. The analysis shows that the standard deviation in speed due to maneuvering varied from 1 to 1.3 knots, while the speed excursions due to horizontal gusts ranged from 1.6 to 5.3 knots for light to severe turbulence levels. (The 5.3 knot deviation corresponded with severe turbulence, including a 30-knot crosswind and 33-knot headwind at a height of 50 feet above the runway.) The standard deviation for the flight test approaches for reported crosswinds of 13 to 31 knots, including both steep and normal path approaches, was about 3.5 knots.

The unique MD–17 design features and operating characteristics discussed above support a reevaluation of the minimum operating speed for the approach and landing phase of flight. These design features and operating characteristics provide the capability for rapid increases in lift from thrust in the approach and landing configurations. Unlike conventional transport category airplanes, there is no need to reduce thrust to idle at any point in the approach or landing (until after touchdown) for controlling either the flight path or rate of sink at touchdown. Also, airspeed can be controlled very accurately even when flight path changes are being made. Since large thrust decreases will not be necessary nor will thrust be reduced to idle during the approach, and rapid lift increases are available through the use of the thrust levers, the FAA considers the use of one-engine-inoperative power-on stall speeds in determining the reference landing speed, $V_{REF}$, for the MD–17 to provide equivalent safety to conventional transport category airplanes. In addition, due to the capability for more accurate airspeed control during the approach, the FAA considers it appropriate to reduce the multiplying factor applied to the reference stall speed in determining $V_{REF}$. For the MD–17, $V_{REF}$ may not be less than 1.20 times the one-engine-inoperative power-on stall speed.

However, until more operational experience is gained with power-augmented-lift airplanes, the FAA will not allow an applicant to establish operating speeds for transport category airplanes lower than the power-off stall speed. To provide some margin between the operating speeds and the power-off stall speed, the MD–17's minimum operating speeds must provide at least a 3 percent speed margin above the power-off stall speed.

In addition to the speed margin obtained by applying factors to the one-engine-inoperative power-on stall speeds, other constraints on the minimum operating speeds must be considered due to the unique characteristics of power-augmented-lift airplanes. For conventional transport category airplanes, providing an airspeed margin between the operating speed and the stall speed provides an adequate angle-of-attack margin to stall. For a power-augmented-lift airplane like the MD–17, however, separate airspeed, angle-of-attack, and thrust margins must be considered. Maneuvering capability may also be more of a concern on a power-augmented-lift airplane because of the difference in thrust effects for a maneuver at a constant airspeed compared to a slowdown maneuver.

Thrust Margin

On the MD–17, variations in thrust at a constant airspeed result in variations in the stall speed margin. While this characteristic provides the capability to increase lift (and hence stall speed margin) simply by increasing thrust, there is also a potential for reductions in stall speed margin following a thrust reduction. On a conventional transport category airplane, where thrust is used primarily to control airspeed, thrust reductions to idle can and do occur. On the MD–17, thrust is used to control flight path rather than airspeed. The DLC feature removes the need for large thrust reductions, and loss of stall margin due to transient thrust reductions can be recovered quickly. Additionally, because $V_{REF}$ is based on the one-engine-inoperative power-on stall speed, additional margin is present in the normal all-engines-operating condition. For the MD–17, the $V_{REF}$ would result in a speed approximately 1.27 times the power-on stall speed with all-engines-operating at the thrust required to maintain the reference approach flight path angle. At maximum thrust, the $V_{REF}$ would be 1.30 times greater than the resulting power-on stall speed.

Another type of thrust variation would be a steady-state thrust reduction that may, for example, be caused by a steady or increasing tailwind, or a decreasing headwind. In this type of situation, attempting to maintain a steady approach path with respect to the ground would result in a steeper descent path angle, which would most likely be attained by a lower thrust setting rather than through use of the DLC. For an approach at the limiting tailwind condition, the steeper approach flight path angle relative to the air mass reduces the MD–17 airspeed margin to stall by less than one knot for normal and steep approaches.

Based on the information presented above, an additional airspeed margin to allow for thrust variation is not considered necessary. The thrust or power on the operating engines used in the stall speed determination for $V_{REF}$ should be the power or thrust used to maintain the steady-state reference flight path angle at $V_{REF}$. For the MD–17, the reference flight path angle is defined as $-3$ degrees for a normal approach, and the shallower of $-5$ degrees or the flight path angle associated with a descent rate of 1000 feet per minute for a steep approach.

Maneuvering Capability

During a banked turn, a portion of the lift generated by the wings provides a force to help turn the airplane. To remain at the same altitude, the airplane must produce additional lift. Therefore, banking the airplane (at a constant speed and altitude) reduces the stall margin, which is the difference between the lift required for the maneuver and the maximum lift capability of the wing. As the bank angle increases, the stall margin is reduced proportionately. Ignoring Mach effects, this bank angle effect on the stall margin can be determined analytically for conventional airplanes, and the multiplying factors applied to the stall speed to determine the minimum operating speeds are intended to ensure that an adequate stall margin is maintained.

For the MD–17, however, the effect of power-augmented-lift on stall speeds differs between a slowdown maneuver (i.e., a wings level deceleration) and a banked turning maneuver at a constant airspeed. The speed reduction during a slowdown maneuver results in a larger contribution of lift from thrust than is provided in a constant speed maneuver. Therefore, for a power-augmented-lift airplane like the MD–17, the stall $C_L$ would be lower in a constant speed turning maneuver than in a slowdown maneuver. To ensure an equivalent level of safety, the MD–17 minimum operating speeds should provide a maneuver margin equivalent to conventional transport category airplanes.

The existing part 25 regulations do not prescribe specific maneuvering margin requirements. However, as part of the proposed 1-g stall amendment to part 25, maneuvering margin requirements are proposed in Notice 95–17 (61 FR 1260, January 18, 1996). These proposed maneuvering margin requirements represent the minimum maneuvering margin to stall warning (or other characteristic that might interfere with normal maneuvering) expected for the current fleet of transport category airplanes. To provide equivalent maneuvering capability within the operational flight envelope, the MD–17 must comply with maneuvering margin requirements equivalent to those proposed in Notice 95–17, except that the thrust used for the maneuvering capability at $V_{REF}$ may be adjusted as necessary during the maneuver to maintain the reference approach flight path angle. This change is considered appropriate for the backside control technique that will be used on the MD–17, where thrust, rather than pitch, is used as the primary parameter to control flight path.

Angle-of-Attack Margin

Another characteristic of power-augmented-lift airplanes like the MD–17 is that the stall angle-of-attack during a slowdown maneuver can be higher than the stall angle-of-attack achieved at higher speeds. Again, this characteristic results from the variation of the effect of power on lift as speed varies. At higher airspeeds, the contribution of power-augmented-lift can be less than at lower airspeeds. From an operational standpoint, this characteristic can be critical during the approach to landing phase of flight, where a sharp-edged vertical gust could induce a large change in the angle-of-attack at approach speed. For a conventional transport category airplane, where the angle-of-attack margin is generally directly related to airspeed, vertical gust margins are assured by the speed multiples applied to stall speeds when determining the minimum allowable operating speeds. For power-augmented-lift airplanes, this may not be true; therefore, the vertical gust margin must be evaluated independently.

For conventional transport category airplanes, it has been determined that approximately 20 knots of vertical gust margin is provided at the minimum landing approach speed. (Reference: Report No. FAA–RD–76–100, ''Progress Toward Development of Civil Airworthiness Criteria for Powered-Lift Aircraft,'' May 1976, a copy of which is included in the official docket for these special conditions.) To provide equivalent safety, a vertical gust margin of 20 knots will be included as a constraint on $V_{REF}$ for the MD–17 with all engines operating. To ensure safety in the event of an engine failure, the vertical gust margin in the one-engine-inoperative condition must also be considered. Considering the short time period for operation in this failure condition, the FAA has concluded that a vertical gust margin of 15 knots will be required.

Special Condition 1 for MD–17 stall speeds and minimum operating speeds takes into account power-augmented-lift effects for configurations with flaps extended. Additionally, the FAA has determined that the MD–17 stall speeds will be based on 1-g stall criteria consistent with those proposed in Notice 95–17.

**Systems**

*2. Head Up Display (HUD) Used as Primary Flight Display (PFD)*

The MD–17 flight deck is equipped with two monochrome head up displays (HUD), one at each pilot station. They are centrally located in front of each pilot, above the glareshield at the pilot's eye level, and between the pilot and the forward window. The MD–17 dual HUD functions as the Primary Flight Display (PFD) for all regimes of normal and abnormal operation and performs the functions of certain primary flight instruments required for transport category airplanes by § 25.1303. The information is electronically projected on a transparent surface with monochrome strokes. It may be used as the only visible display, without any alternative flight instrument indications displayed at the pilot station.

Until recently, HUD certification did not require a special condition because conventional, certified primary flight instruments were also provided at each pilot station and were always visible. The MD–17 dual-HUD installation has the novel and unique feature of being used when it is the only visible display of primary flight information, which is not fully addressed by the current regulations. Therefore, special conditions are adopted for the MD–17 dual HUD installation in the following areas.

Arrangement and Visibility

Section 25.1321(b) states that the ''flight instruments required by § 25.1303 must be grouped on the instrument panel. . . .'' Section 25.1303 does not adequately address the MD–17 HUD's novel and unique location for a primary flight display, which is above the instrument panel and in the field of view of the forward window.

As described above, the HUD is not in the same visual field as the instrument displays on the instrument panel. The electronically displayed information is projected on a transparent surface and focused at a distance (i.e., optical infinity). Unlike instrument scanning between displays on the instrument panel, when scanning between the HUD and the instrument panel the pilot's eyes must substantially change viewing angle (about 15 degrees), light adaptation, and focus (from infinity to 2 feet). Furthermore, information displayed on the instrument panel cannot as easily be viewed in the pilot's peripheral vision while simultaneously viewing the HUD, when compared to viewing the suite of conventional flight instruments.

Therefore, in addition to compliance with § 25.1321(b), the special condition requires that the HUD provide all information necessary for rapid pilot evaluation of the airplane's flight state and position, during all phases of flight, for manual control of the airplane, and for pilot monitoring of the performance of the automatic flight control system. The HUD must provide equivalent situational awareness of critical information that is normally displayed near but not on the conventional PFD.

Pilot Compartment View and HUD Optical Characteristics

Section 25.1321(a) requires that ''[e]ach flight, navigation, and powerplant instrument for use by any pilot must be plainly visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking forward along the flight path.'' When the pilot is viewing conventional flight instruments, the variations of pilot seating positions are not significant in the pilot's ability to view the flight instruments. However, the optical characteristics of HUD's require that the pilot's eyes be located within a very small volume to view all of the required information, which is not adequately addressed by § 25.1321(a). There is much less tolerance for changes in eye position and viewing angles when viewing the HUD. Hence, the special condition ensures that primary flight information remains visible to the pilot without inadvertent lapses. In addition to compliance with § 25.1321(a), the special condition ensures that the HUD information is fully visible from the cockpit design eye position, at which the required angular dimensions of the external field of view, visibility of other cockpit instruments, and access to cockpit controls are simultaneously realized. Furthermore, the special condition ensures that pilot viewing of the HUD does not unduly restrict pilot head movement, cause unacceptable fatigue or discomfort, or interfere with other required pilot duties.

Also, unlike conventional flight displays, the HUD displays certain flight information symbols conformally (i.e., graphically with angular position and movement corresponding to the external view and in the same angular scale). Mispositioning of conformal symbolic information can be more hazardous than mispositioning the same information on conventional displays. There is no specific rule that addresses the use of conformal symbolic information as primary flight information. Therefore, the special condition does not permit the display of electronic or optical misalignment of conformal symbology that would be hazardously misleading.

## Compatibility With Other Cockpit Displays

The existing regulations did not anticipate and do not address the display limitations of a monochrome HUD. The HUD electronically displays information with monochrome strokes, while on conventional displays color is used to highlight and distinguish different types of information. On color displays, the warning and caution indications follow the same color scheme, red and amber, respectively, as described in § 25.1322 for warning, caution, and advisory lights. This use of red and amber is consistent across the cockpit and serves to give unmistakable meaning to the indications. A monochrome HUD must have an equivalent means to unmistakably highlight and distinguish the same information.

The monochrome HUD must also have certain display design features to make other essential flight information conspicuous, distinct, and meaningful to compensate for the lack of multiple colors. For example, the conventional primary attitude indication distinguishes angles on the pitch scale above the horizon (sky) and angles below the horizon (earth) with different colors, such as blue and brown, respectively. To perform its intended function as the primary attitude indicator, and to ensure satisfactory pilot recognition of unusual attitudes, the HUD must provide clear visual distinction between positive and negative pitch angles by means other than color.

In summary, the display format of the HUD can differ from the format of other cockpit displays of the same information due to differences in their capabilities and limitations. These differences must be regulated to ensure that one format is not so unlike the other that the pilot can misinterpret the information hazardously, or that excessive time and attention is required for the pilot to interpret the information. During critical high workload or emergency conditions, the pilot may need to quickly make a transition from the HUD to other flight instruments to continue safe flight. The existing rules do not adequately address the compatibility of different display formats. This special condition is required to avoid potentially hazardous workload and pilot confusion due to display incompatibility.

To address the above identified inadequacies in current regulations as related to the acceptability of the HUD as the primary source of flight information, Special Condition 2 is adopted as an appropriate set of requirements.

## Additional Recommendations or Supporting Data

In addition to the special condition for the HUD system, there are other regulations and advisory material that, although adequate, warrant special attention due to the unique features of the MD–17 HUD installation. The following discussion of applicable regulations is provided for information in the context of this special condition.

### *Regulations*

• Section 25.771(e): ''Vibration and noise characteristics of cockpit equipment may not interfere with safe operation of the airplane.'' Attention should be paid to the visual effects resulting from vibration of the cockpit and the optical components of the HUD, including vibration associated with engine imbalance resulting from fan blade failure.

• Section 25.773(a)(1): ''Each pilot compartment must arranged to give the pilots a sufficiently extensive, clear, and undistorted view, to enable them to safely perform any maneuvers within the operating limitations of the airplane, including taxiing, takeoff, approach, and landing.'' Special attention should be paid to this requirement because of the unique location of the HUD combiner, between the pilot's eyes and the forward windshield, compared to conventional displays. The potential of each combiner structure to obstruct the outside view of both pilots (on-side and off-side) should be considered.

• Section 25.773(a)(2): ''Each pilot compartment must be free of glare and reflection that could interfere with the normal duties of the minimum flight crew (established under § 25.1523). This must be shown in day and night flight tests under non-precipitation conditions.'' Special attention should be paid to this requirement because the unique HUD optical system and the location of the combiner, between the pilot's eyes and the forward windshield, can be especially susceptible to and be the cause of a variety of glare and reflections in the cockpit.

• Section 25.785(k): ''Each projecting object that would injure persons seated or moving about the airplane in normal flight must be padded.'' Typical installations of HUD's include components that project into the space near the pilot's head. Attention should be paid to head contact with these components during all expected operations and pilot activities, especially during turbulence.

• Section 25.1301(a): ''Each item of installed equipment must be of a kind and design appropriate to its intended function.''

Previously, HUD's for transport category airplanes have been certified with a fully certificated set of primary flight instruments/displays visible on a full-time basis; therefore, the HUD was not required to meet all of the requirements for primary flight instruments. However, the MD–17 HUD's are a primary source of flight information and must comply with those requirements, because alternate instrument flight displays that comply are not in full-time use. Therefore, consideration should be given to the functionality of the MD–17 HUD under all foreseeable operating conditions. For example, looking directly at the sun through the HUD combiner can be painful or harmful to the pilot's eyes; therefore, an alternate display of primary flight information, which complies with the applicable regulatory requirements, must be available on demand. The MD–17 is capable of displaying primary flight information on any of its four multi-function displays (MFD's). To comply with § 25.1321, the two MFD's centered in front of each pilot must be available to display instrument flight information on demand, and the other two center displays must be able to simultaneously display other essential information, such as navigation and engine indications. Selectable display functionality needs special attention in determining compliance with § 25.1301 for the MD–17 suite of displays, including HUD's and MFD's.

The installation of the HUD system must not interfere with or restrict the use of other installed equipment such as emergency oxygen masks, headsets, or microphones. HUD installations typically result in the placement of protruding equipment (e.g., projector, combiner) in the vicinity of the pilot's head and thereby provide the potential for compromising the intended function of the equipment identified above.

The HUD is capable of presenting a large amount of static and dynamic symbology, numbers, and text that can appear cluttered, difficult to interpret, and difficult to see through. Special attention should be given to the potential effects of display clutter, such as interference between moving symbols, other symbols, and alphanumeric information on display functionality, flightcrew task performance, and workload (§ 25.1523; Appendix D).

''Declutter'' modes can selectively remove certain data from the display, so special attention should be given to ensuring that essential data cannot be removed, when needed to continue safe flight and landing.

• Section 25.1381a(2)(ii): ''Instrument lights must be installed so that no objectionable reflections are visible to the pilot.'' Attention should be paid both to reflections from other sources on the HUD and those from the HUD on to windows and other displays.

## Advisory Material

Advisory Circular (AC) 25–11, ''Transport Category Airplane Electronic Display Systems,'' provides guidance and policy information regarding means to demonstrate the acceptability of electronic displays, including HUD's. All portions of AC 25–11 are applicable to demonstrate compliance for the special conditions, except for the color unique criteria of paragraph 5. However, note that the fundamental principles specified in subparagraph 5b, Color Perception vs. Workload, do apply and should be followed with non-color means such as size, shape, and location. Although the HUD does not have color, criteria for evaluation of clutter, workload, and display perception, considering distinctive symbology features such as size, shape, and location, are applicable. Also note that, for HUD's, excessive clutter affects not only the workload and readability of the presentation, but also the pilot's ability to see the outside view and visually detect operational hazards. Also, in spite of its title, the luminance criteria of subparagraph 6b, Chromaticity and Luminance, applies to evaluation of the HUD display luminance. Unique HUD requirements for HUD brightness capability and control are specified in Special Condition 2(b)(2).

*3. Protection From Unwanted Effects of High Intensity Radiated Fields (HIRF)*

The MD–17 uses electrical and electronic systems that perform critical and essential functions. These systems include electronic displays, electronic engine controls, fly-by-wire flight controls, and others. There is no specific regulation that addresses protection requirements for these systems from HIRF. Increased power levels from ground based radio transmitters and the growing use of sensitive electrical and electronic systems to command and control airplanes have made it necessary to provide adequate protection.

Changes in technology have given rise to advanced electrical and electronic airplane systems, use of composite materials in airplane structures, and higher energy levels from radio, television, and radar transmitters. The combined effect of these developments has been an increased susceptibility of electrical and electronic systems to electromagnetic fields.

Many advanced digital systems are prone to upsets and/or damage at energy levels lower than analog systems. Digital systems also allow the location of more complex functions in fewer components. These functions were previously performed manually, electromechanically, or hydraulically. The implementation of such advanced systems has found rapid acceptance since they lower cost, crew workload, and maintenance requirements, while airplane performance and fuel efficiency are enhanced.

Propelled by the need to attain higher efficiency, industry has also proceeded to adopt composite materials for use in airplane structures, thus reducing or replacing the use of aluminum. Due to their low conductivity properties, composite materials afford poor shielding effectiveness, further exposing electrical and electronic systems to the electromagnetic environment.

At this time, the FAA and other airworthiness authorities are unable to precisely define or control the HIRF energy level to which the airplane will be exposed in service. Therefore, to ensure that a level of safety is achieved equivalent to that intended by the current regulations, Special Condition 3 requires that new electrical and electronic systems that perform critical functions be designed and installed to preclude component damage and interruption of function due to both the direct and indirect effects of HIRF.

**Airframe**

*4. Interaction of Systems and Structures*

The MD–17 airplane utilizes a full-time electronic flight control system (EFCS). Pilot control commands are sent to flight control computers which condition the input signals, combine them with other sensor data indicating airplane configuration and flight condition, and apply servo position commands to the actuation systems of the control surfaces. In this way, the EFCS affects control surface actuation and therefore the airplane flight loads. Failures that occur in the EFCS may further affect flight loads, both at the time of the event and thereafter.

The current part 25 airworthiness standards were intended to account for control laws for which control surface deflection is proportional to control device deflection. They do not address any nonlinearities or other effects on control surface actuation that may be caused by the EFCS, whether fully operative or in a failure mode. Since the EFCS may affect flight loads, and therefore the structural capability of the airplane, specific regulations are needed to address these effects. Thus, Special Condition 4 is adopted.

If a failure occurs within the EFCS, the airplane may still be capable of operating within a reduced structural envelope. That is, the airplane may be able to meet the strength and flutter requirements of part 25, but at reduced factors of safety or airspeed, as applicable. This reduced structural envelope is considered acceptable provided that it is based on failure probabilities within the EFCS. Special Condition 4 provides specific structural load and aeroelastic stability requirements with reduced factors of safety and/or airspeeds based on the probability of failure. These requirements ensure that the airplane structural design safety margins will be dependent on system reliability. The requirements of Special Condition 4 also ensure that any influence of the EFCS on airplane flight loads will be accounted for when the system is fully operative.

*5. Design Maneuvering Requirements for Fly-by-Wire*

Use of the EFCS also affects the maneuvering capability of the MD–17, which is not adequately addressed by the current part 25 design maneuver requirements. Special Condition 5 differs from current requirements in that it requires that certain maneuvers be performed by actuation of the cockpit control device as opposed to the corresponding control surface. In addition, the special condition requires consideration of loads induced by the EFCS itself. These requirements ensure that any influence of the EFCS on airplane flight loads will be accounted for.

*6. Limit Engine Torque Loads for Sudden Engine Stoppage*

McDonnell Douglas proposes to treat the rare sudden engine stoppage condition resulting from structural failure as an ultimate load condition. Section 25.361(b)(1) specifically defines the seizure torque load, resulting from structural failure, as a limit load condition.

The limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming) has been a specific requirement for transport category airplanes since 1957. The size, configuration, and failure modes of jet engines has changed considerably from those envisioned by § 25.361(b) when the engine seizure requirement was first adopted. Engines are much larger and are now designed with large bypass fans capable of producing much larger torque loads if they become jammed. It is evident from service history that the frequency of occurrence of the most severe sudden engine stoppage events, resulting from structural failures, is rare.

Relative to the engine configurations that existed when the rule was developed in 1957, the present generation of engines are sufficiently different and novel to justify issuance of a special condition to establish appropriate design standards. The latest generation of jet engines are capable of producing engine seizure torque loads that are significantly higher than previous generations of engines.

The FAA is developing a new regulation and a new AC that will provide more comprehensive criteria for treating engine torque loads resulting from sudden engine stoppage. In the meantime, a special condition is needed to establish appropriate criteria for the MD–17 type design.

In order to maintain the level of safety envisioned by § 25.361(b), more comprehensive criteria are needed for the new generation of high-bypass engines. Special condition 6 would distinguish between the more common seizure events and those rare seizure events resulting from structural failures. For these more rare but severe seizure events, the criteria would allow deformation in the engine supporting structure (ultimate load design) in order to absorb the higher energy associated with the high-bypass engines, while at the same time protecting the adjacent primary structure in the wing and fuselage by providing an additional safety factor.

To provide appropriate structural design criteria for the engine torque on the MD–17, Special Condition 6 is adopted.

**Flight Characteristics**

*7. Flight Characteristics Compliance via Handling Qualities Rating Method*

The EFCS will provide an electronic interface between the pilot's flight controls and the flight control surfaces (for both normal and failure states), generating the actual surface commands that provide for stability augmentation and control about all three airplane axes. Because EFCS technology has outpaced existing regulations (written essentially for unaugmented airplanes, with provision for limited ON/OFF augmentation), a suitable special condition is needed to aid in the certification of flight characteristics.

In addition, service history and certification experience have shown that EFCS-type airplanes and others may be susceptible to airplane-pilot coupling (A–PC) tendencies. Pilot induced oscillations can be considered a subset of A–PC problems. An example of these problems are control systems that are rate or position limited during some pilot commands in which the pilot has no feedback through the controller.

The special condition provides a means by which flight characteristics (''satisfactory,'' ''safe flight and landing,'' etc.) can be evaluated and compliance found. The Handling Qualities Rating System (HQRS) was developed for airplanes with control systems having similar functions and is employed to aid in the evaluation of the following:

- For all EFCS/airplane failure states not shown to be extremely improbable, and where the envelope (task) and atmospheric disturbance probabilities are each 1.
- For all combinations of failures, atmospheric disturbance level, and flight envelope that yield flight conditions expected to occur more frequently than extremely improbable.
- For any other flight condition or characteristic where part 25 proves to be inadequate for proper assessment of unique MD–17 flight characteristics.

The HQRS provides a systematic approach to handling qualities assessment. It is not intended to dictate program size or need for a fixed number of pilots to achieve multiple opinions. The airplane design itself and success in defining critical failure combinations from the many reviewed in systems safety assessments would dictate the scope of any HQRS application.

Handling qualities terms, principles, and relationships familiar to the aviation community have been used to formulate the HQRS. For example, similarity has been established between the well-known Cooper-Harper rating scale and the FAA three-part rating system. This approach is derived, in part, from work on flying qualities of highly augmented/relaxed static stability airplanes, namely regulatory and flight test guide requirements.

In addition, experience has shown that compliance with only the qualitative, open-loop (pilot-out-of-the-loop) requirements does not guarantee that the required levels of flying qualities are achieved. There must be an evaluation by certification pilots conducting high gain (wide band width) closed-loop (pilot-in-the-loop) tasks, to ensure that the airplane demonstrates the flying qualities required by §§ 25.143(a) and (b) and to minimize the hazards associated with encountering adverse A–PC tendencies in service.

For the most part, these tasks must be performed in actual flight. For conditions that are considered too dangerous to attempt in actual flight (i.e., certain flight conditions outside of the operational flight envelope, flight in severe atmospheric disturbances, flight with certain failure states, etc.), the closed loop evaluation tasks may be performed on a validated high fidelity simulator.

Special Condition 7 is adopted for the MD–17 to aid in the certification of flight characteristics. An acceptable means of compliance with this special condition is provided in AC 25–7A, ''Flight Test Guide for the Certification of Transport Category Airplanes.''

*8. Static Longitudinal Stability*

Like other airplanes with similar highly augmented electronic flight control systems, the MD–17 does not literally comply with the requirements prescribed by § 25.173 for static longitudinal stability. In one control mode of the electronic flight control system, no control force is needed to maintain a speed change from the trimmed condition. Although this operating system mode provides quick, accurate pitch response with minimal pilot effort, it does not comply with the literal requirements for static longitudinal stability.

Static longitudinal stability has been required in accordance with part 25 for the following reasons:

- Provides additional speed change cues to the pilot through control force changes.
- Ensures that short periods of unattended operation do not result in any significant changes in attitude, airspeed, or load factor.
- Provides predictable pitch response.
- Provides acceptable level of pilot attention (workload) to attain and maintain trim speed and altitude.
- Provides gust stability.

In order to achieve an equivalent level of safety with part 25, the MD–17 should meet the intent of these principles, even though it may not comply with the literal terms of § 25.173. Special Condition 8 ensures that the MD–17 has suitable static longitudinal stability in any condition normally encountered in service. The HQRS prescribed by Special Condition 7 may be used to make this assessment.

*9. Static Lateral-Directional Stability*

Because of the MD–17 roll axis design feature in which the commanded roll rate is proportional to roll stick position, aileron control movements and forces do not comply with § 25.177 as they are not proportional to angle of sideslip. This feature is active during all flight phases and conditions, except when the flap/slat handle is at or greater than the 1/2 detent setting, or during a rudder pedal input.

Dihedral effect (as indicated by aileron forces proportional to the angle of sideslip) has been required in accordance with § 25.177 for the following reasons:

- In the event that primary lateral control is lost, roll can be produced by use of the rudder.
- In an airplane with positive dihedral effect, the bank angle and the

lateral control forces required to hold heading provide positive indication of an inadvertent sideslip.

- It can have a beneficial effect on spiral stability.
- In the event of an engine failure, the roll due to the asymmetric yawing moment contributes to the ease of identifying the failed engine.

In order to achieve an equivalent level of safety with part 25, the MD–17 should meet the intent of these principles even though it may not comply with the literal terms of § 25.177.

In lieu of showing compliance with § 25.177, Special Condition 9 is adopted to ensure that the MD–17 has suitable static lateral-directional stability in any condition normally encountered in service. The HQRS prescribed by Special Condition 7 may be used to make this assessment.

*10. Control Surface Awareness*

In airplanes with electronic flight control systems, there may not always be a direct correlation between pilot control position and the associated airplane control surface position. Under certain circumstances, a commanded maneuver that may not involve a large control input may nevertheless require a large control surface movement, possibly encroaching on a control surface or actuation system limit without the flightcrew's knowledge. This situation can arise in both manually piloted and autopilot flight, and may be further exacerbated on airplanes where the pilot controls are not back-driven during autopilot system operation. Unless the flightcrew is made aware of excessive deflection or impending control surface limiting, piloted or auto-flight system control of the airplane might be inadvertently continued in such a manner as to cause airplane loss of control or other unsafe stability or performance characteristics.

As a result of these concerns, Special Condition 10 is adopted to require that suitable flight control position annunciation be provided to the flightcrew when a flight condition exists in which near full surface authority (not crew-commanded) is being utilized. Suitability of such a display or alerting must take into account that some pilot-demanded maneuvers are necessarily associated with intended full performance, which may saturate the surface. Therefore, simple alerting systems, which would function in both intended or unexpected control-limiting situations, must be properly balanced between needed crew awareness and nuisance factors. A monitoring system that compares airplane motion, surface deflection, and pilot demand could be useful for eliminating nuisance alerting.

**Approach and Landing Limitations**

*11. Steep Approach Air Distance*

The MD–17 has a number of design features to support steep approach flight path capability with precision landing. McDonnell Douglas proposes to certify MD–17 landing performance for both conventional 3-degree approach glideslope operation and steep approach operation.

Novel and unique features on the MD–17 provide for increased touchdown dispersion accuracy during steep approach operations relative to conventional transport category airplanes. McDonnell Douglas has proposed an alternative method for defining the airborne portion of the landing distance in lieu of the demonstrated distance from a 50-foot height to touchdown. A special condition is adopted to redefine the air distance portion of the MD–17 landing distance for steep approach operations conducted under a proposed Special Federal Aviation Regulation (SFAR), ''Requirements for operational approval of special approaches to short field landings for the McDonnell Douglas Model MD–17 power-augmented-lift airplane,'' currently being developed by the FAA.

Steep approach operations are intended to minimize the air run to help achieve short field performance. Steep approach for the MD–17 is defined as an approach flight path angle no steeper than −5 degrees, with an approach rate of descent not to exceed 1,000 feet per minute. For the landing reference speeds used by the MD–17, almost all operations are limited by the 1,000 feet per minute constraint, which yields approach flight path angles predominantly in the range from 4 to 4.8 degrees.

Several design features on the MD–17 are intended to enable the airplane to safely fly steep approaches. First, the landing gear is designed to withstand touchdown rates of descent of up to 12.5 feet per second for weights up to 435,800 pounds and 11 feet per second for weights up to 502,100 pounds. Second, the high lift system with externally blown flaps allows operation at relatively low landing reference speeds which, when combined with the MD–17 lift/drag characteristics, allows this airplane to be flown using a backside control technique. Third, a spoiler function electronically linking spoilers and throttle movement provides much more precise flight path control. Fourth, the MD–17 is equipped with a HUD, which displays the airspeed and the flight path vector, and a pilot-selectable flight path marker to indicate the desired flight path. The HUD assists the pilot in precisely controlling the airplane flight path to an aim point on the runway. With no pitch flare needed, the aim point is very close to the actual touchdown point. Considered together, these MD–17 features allow pilots to fly steep approaches and accurate touchdowns near the aim point, while maintaining control over speed and the rate of descent at touchdown.

The backside control technique mentioned above uses thrust changes to primarily affect flight path angle, and pitch changes to primarily affect airspeed. As with all airplanes, there is some control coupling such that any control input will affect both flight path angle and airspeed, but the coupling is minimized for the low speed backside operation used by the MD–17. Reduced control coupling leads to greater precision in airspeed and flight path control. The backside control technique allows throttle inputs to be used to control vertical speed all the way to touchdown instead of the ''pitch flare'' maneuver used on other airplanes.

The throttle-spoiler interconnect feature of the MD–17 design allows spoiler motion to simulate the effect of immediate engine response to throttle movement. The spoilers are nominally biased in the up direction during steady-state operation. When the throttles are moved, the spoilers move in the direction necessary to provide essentially the same airplane response as an immediate thrust change. As the engine responds, the spoilers, over time, return to their original (biased) positions. This feature eliminates the lag often associated with thrust control.

Over 175 steep approach landings were performed during C–17 testing to demonstrate the precision landing characteristics. All of these runs were made using an operational technique performed by pilots with only three practice runs to gain familiarity with the technique. These approaches were conducted to establish that no exceptional piloting skill or training was required to achieve the tested performance levels. During the demonstrations, only a limited portion of the flight manual allowable wind and temperature conditions were accounted for. The purpose of the testing was to demonstrate that the precision approach accuracy could yield touchdowns with a ±2 standard deviation (σ) band of less than 500 feet relative to the mean touchdown point, while also maintaining an acceptable rate of descent at touchdown.

There are two distinct types of landing operations for the MD–17: (1) conventional landings that will be conducted in accordance with existing part 25 and 121 regulations, and applicable special conditions; and (2) special approaches to short field landings that will be conducted in accordance with existing part 25, a proposed SFAR (to be published at a later date), and applicable special conditions. The proposed SFAR would address additional equipment, training, and operating requirements associated with conducting special approaches to short field landings. McDonnell Douglas intends to provide steep approach capability (allowing operators to seek steep approach approval) for both types of landing operations.

For conventional landings, the steep approach air distance would be determined by using the existing applicable type certification and operating requirements. This special condition for steep approach air distance would only apply to special approaches to short field landings conducted in accordance with the proposed SFAR and Special Condition 12, ''Landing Distances for Special Approaches to Short Field Landings.'' It addresses only the determination of landing distance to be used in conjunction with those operations and does not imply approval to conduct steep approach operations.

For MD–17 steep approach operations conducted under the proposed SFAR, Special Condition 11 is adopted in conjunction with Special Condition 12, in lieu of § 25.125(a).

*12. Landing Distances for Special Approaches to Short Field Landings*

As noted in the discussion of Special Condition 11, McDonnell Douglas proposes two distinct types of landing operations for the MD–17: (1) conventional landings that will be conducted in accordance with existing part 25 and 121 regulations, and (2) special approaches to short field landings that will be conducted in accordance with a proposed SFAR and associated special conditions.

The operational landing distance margin provided by part 121 takes into account steady-state variables that are not included in the part 25 landing distances, differences in operational procedures and techniques from those used in determining the part 25 landing distances, non steady-state variables, and differences in the conditions forecast at dispatch and those existing at the time of landing. Examples of each of these categories include:

| Steady-state variables | Non steady-state variables | Operations vs. flight test | Actual vs. forecast conditions |
|---|---|---|---|
| Runway slope | Wind gusts/turbulence | Flare technique | Runway or direction (affecting slope). |
| Temperature | Flight path deviations | Time to activate deceleration devices. | Airplane weight. |
| Runway surface condition (dry, wet, icy, texture). | | Flight path angle | Approach speed. |
| Brake/tire condition | | Rate of descent at touchdown | Environmental conditions (e.g., temperature, wind, pressure altitude). |
| Speed additives | | Approach/touchdown speed | Engine failure. |
| Crosswinds | | Height at threshold | |
| | | Speed control. | |

**Note:** This is not intended to be an exhaustive list of variables to be considered.

In order to allow the part 121 operational landing distance margins to be reduced as proposed in the SFAR for special approaches to short field landings, additional type certification requirements are needed. In addition to what is currently required by § 25.125, the landing distances to be used under the proposed SFAR would be required to include the effects of runway slope and ambient temperature. Landing distances on a wet runway would also have to be determined in a manner acceptable to the FAA. In addition, during the flight testing to determine the landing distances, the average touchdown rate of descent and the approach flight path angle would be limited to no greater than 4 feet per second and no steeper than $-3$ degrees, respectively.

The applicant would be required to establish operating procedures for use in service that are consistent with those used to establish the performance data and can be executed by crews of average skill. The applicant would be required to include, as applicable, procedures associated with speed additives for turbulence and gusts for approaches with all engines operating and with an engine failure on final approach, and the use of thrust reversers on all operative engines during the landing rollout.

The operational landing distance margins applicable to the MD–17, and additional operational considerations associated with the use of these reduced margins (e.g., runway markings, meteorological conditions, and flightcrew procedures and training), are covered in the proposed SFAR.

Although this special condition will explicitly take into account many of the variables currently accounted for by the part 121 operational landing distance margins, some operational landing distance margin is still necessary to account for variables that remain. For example, because § 121.195(d) specifies the maximum takeoff weight for the conditions forecast at the time of landing (including environmental conditions such as temperature and pressure altitude, airport conditions such as runway and direction, and airplane conditions such as fuel burnoff and approach speed), potential differences in the forecast and actual conditions should be taken into account. Other operational issues that should be considered in the operational landing distance margins include piloting technique and time to activate deceleration means, unsteady winds and crosswinds, and airspeed and flight path deviations. Therefore, the proposed SFAR will still contain operational landing distance margins, although reduced from those margins currently required by §§ 121.195 and 121.197, that would be applied to the landing distance determined in accordance with this special condition.

Special Condition 12 provides the additional requirements noted above that the FAA considers necessary to allow operational use of the landing distance margins prescribed in the proposed SFAR. Note that the determination of landing distances in accordance with this special condition does not constitute operational approval to use landing distance margins reduced from those specified in part 121. Operational approval to use the reduced landing distance margins must be obtained in accordance with the proposed SFAR.

*13. Thrust for Landing Climb*

Section 25.119(a) states that the airplane must achieve a 3.2 percent climb gradient after initiating a thrust increase from the minimum flight idle position. The thrust allowed is that thrust attained within eight seconds of engine spool-up time from the initiation of thrust lever movement. Because of the power-augmented-lift design, the MD–17 thrust required for a stabilized approach is significantly above a conventional turbojet minimum flight idle setting, and thrust would not be reduced to idle during the approach.

Section 25.119(a) was written to assure that the flightcrew would have sufficient airplane performance to safely transition to a climb during a go-around in the landing configuration. The rule assumes that the approach power setting may be as low as the flight idle position. The MD–17 power-augmented-lift design requires a significant approach thrust level during the approach to maintain the approach flight path. Unlike conventional transport category airplanes, thrust reductions during the approach are not necessary to maintain or recover the flight path. The MD–17 operational procedures will discourage use of thrust reduction to make down flight path adjustments during approach. The direct lift control (DLC) feature provides a down path angle control for large flight path adjustments without throttle movement.

To improve the control response to throttle movement, the MD–17 uses a spoiler function where the spoilers are linked with the throttles to simulate the effect of instantaneous engine response to throttle movement. The throttle-spoiler function is a short-term response; as the engine responds to throttle movement, the spoilers return to their original positions. The approach is flown with a non-zero spoiler bias to allow spoilers to react upward or downward in response to throttle movement. This function provides instantaneous response to control input and allows throttle movement to be minimized.

During the segment from 50 feet to touchdown, the MD–17 uses a backside control technique that does not require either thrust to be reduced to an idle power setting or the use of a pitch-up flare maneuver prior to touchdown. With the backside control technique, airplane pitch attitude is used to control airspeed, and thrust is used to control flight path angle.

In lieu of compliance with § 25.119(a), Special Condition 13 is adopted. The thrust for a stabilized approach, including an appropriate margin for operational safety, will be used as a basis for determining the thrust available for the landing climb requirement. The initial thrust level at the start of the 8-second spool-up time will be the thrust for a stabilized approach at a flight path angle 2 degrees steeper than the desired flight path angle. This thrust level will account for thrust variations during the approach and conservatively represents the initial thrust level.

This special condition is applicable only when the following design features are present:

- At no time in the landing configuration should the thrust be reduced to idle.
- A backside control technique must be used such that a thrust reduction is not used to reduce the rate of descent at touchdown.
- Procedures must be provided in the Airplane Flight Manual to define the proper technique for flight path angle adjustments during approach and landing.
- The airplane must have DLC spoilers or other aerodynamic means of making down path angle adjustments without thrust reduction.
- Throttle movement should activate a short-term aerodynamic surface motion in order to provide a high level of control feedback and to avoid excessive throttle adjustments.
- The airplane and engine state (e.g., airplane weight and engine bleed configuration) and operating conditions (e.g., pressure altitude and temperature) should be the most critical combination relative to the thrust level used to show compliance with this special condition.

**Discussion of Comments**

Notice of Proposed Special Conditions 25–99–04–SC for the McDonnell Douglas Corporation Model MD–17 airplane was published in the **Federal Register** on May 18, 1999 (64 FR 26900). Two commenters, including the applicant, responded. Some of the comments were of an editorial or clarifying nature and have been incorporated where appropriate. A discussion of the remainder of the comments follows, corresponding to the special conditions as proposed in Notice 25–99–04–SC.

*General Comments*

The commenter asks what the military certification basis is for the Model MD–17 military version (the C–17), and states that it would be interesting to compare it with the civil basis.

The C–17 was designed for the U.S. Air Force in accordance with the design standards defined in the C–17 System Specification and C–17 Air Vehicle Specification documents per the contractual agreement between the company and the U.S. Air Force.

The specifications for C–17 power-augmented-lift performance speeds include: (1) criteria for power-on minimum margins from stall speeds; (2) angle-of-attack margins from stall expressed in terms of vertical gust margins; and (3) maneuvering capabilities. These C–17 criteria and the corresponding MD–17 criteria, which meet the applicable airworthiness standards of part 25 and are discussed in the MD–17 special condition for power-augmented-lift, are similar or identical in both the nature and magnitude of the required margins.

In the areas of flight controls and flying qualities, previously existing military standards were invoked as part of the overall C–17 specifications. For instance, the flying qualities specifications were a tailored revision of Mil–F–8785B. Similarly, for the MD–17, the FAA adopted previous special conditions issued for other fly-by-wire airplanes.

In summary, the MD–17 special conditions are similar to the standards used for contractual acceptance of the C–17 by the U.S. Air Force, but reflect the part 25 airworthiness standards and do not include U.S. Air Force mission specific items.

The commenter would like to know more about the assumptions made when thrust handling techniques were developed, and further states that the technique proposed for flying the approach on the ''backside of the drag curve'' is radically different than conventional airplanes, and from airplanes on which most, if not all, civil pilots will have been trained. The commenter is concerned that while such pilots may be able to demonstrate sufficient proficiency during training, there is a real risk that under certain conditions of high workload they may revert to conventional flying techniques. The commenter believes that there should be some safeguarding of the human factors aspects.

The thrust handling techniques for the backside approach for power-augmented-lift aircraft were developed from flight simulator research dating back to the 1970's. Test pilots from several regulatory agencies, including the FAA and the U.K. CAA, participated in these development tests. Test findings are summarized in FAA Report No. FAA–RD–76–100, ''Progress Toward Development of Civil Airworthiness Criteria for Powered-Lift Aircraft,'' dated May 1976, a copy of which is in the docket for this rulemaking. The results of this research indicate that the ease of flying the backside approach and the capability to accurately hold airspeed and flight path depend to a great extent on minimizing pitch and thrust coupling. Minimizing airspeed changes as a result of thrust changes and minimizing flight path angle changes as a result of pitch changes not only allows more precise speed and path control, but also provides better feedback to the pilot on the effect of the use of the throttle and pitch controls. As noted in the preamble to the proposed special conditions, the MD–17 design minimizes pitch and thrust coupling.

Notwithstanding the research results noted above, and the MD–17 adherence to the design principles resulting from that research, the FAA considered the potential for pilots to revert to the control techniques used on conventional transport category airplanes to be a major concern during the development of the special conditions. To address this concern, the FAA interviewed U.S. Air Force reserve pilots, flew simulator exercises, and reviewed the C–17 service history.

The interviews with the U.S. Air Force reserve pilots were considered to be especially valuable as many of these pilots also fly as line pilots for major airlines, flying conventional transport category airplanes ranging from older Boeing 727's to more modern Boeing MD–11's. These pilots appeared to have little difficulty in transitioning back and forth between the conventional airplanes and the MD–17 with its unique characteristics. Training was essential for introducing the backside technique, but after being exposed to the differences in techniques in the simulator, reversion has not proven to be a problem. The piloting cues and airplane response are significantly different from those of a conventional transport category airplane, which reinforces the use of the backside technique.

The simulator exercises flown by the FAA reinforced both the conclusions of the earlier research efforts and the experiences of the U.S. Air Force reserve pilots. The service history of the C–17 with the U.S. Air Force has been very good, including experience under high workload, high stress conditions. It should also be noted that the Lockheed C–130 airplane, in the short takeoff and landing mode, also flies on the backside and has had a good safety record.

1. Stall Speeds and Minimum Operating Speeds

The commenter states that credit over and above that already given in the part 25 requirements is given for a reduced factor to obtain $V_2$ as a result of increased effects of power on stalling speed, and asks if adequate stall margins will be available with the use of reduced thrust/EPR techniques.

The credit for power-augmented lift for stall speed in the takeoff phase of flight is based on the minimum power that exists at any point in the takeoff flight path. This requirement includes consideration of derated/reduced power techniques. The same speed margin will exist between the power-on stall speed and the minimum takeoff safety speed for a derated/reduced power takeoff as for a full power takeoff.

The commenter considers the justification for the reduction in $V_{REF}$ resulting from a lower factor applied to a power-on stall speed to be insufficient, at least until some operational experience is gained. For example, one of the reasons given for using the power-on stall speed is that there is no need to reduce thrust to idle at any point during the approach. The commenter further states that while this may be accurate, it is no guarantee that thrust will never be reduced to idle (unless of course a physical movement restriction is provided). The commenter asks how the probability of the airplane being operated, albeit inadvertently, outside of the certification assumptions has been considered within the special conditions.

The FAA considered inadvertent speed and flight path excursions not only due to piloting issues, but also due to environmental conditions and other reasons. The requirements address each of these concerns by providing margins for speed, angle-of-attack, thrust, and maneuverability. Also, certain design features, combined with the piloting cues and operating characteristics of the airplane, reduce the probability of inadvertent and excessive thrust reduction, as well as provide the capability for a quick recovery from both speed and flight path excursions.

Minimal coupling between pitch and thrust reinforces the proper operating techniques of using thrust to control flight path and pitch to control airspeed. Targets for pitch angle, flight path angle, and thrust level are displayed in the head-up primary flight display, along with the current values to assist the pilot in making appropriate control inputs. Large downward flight path changes are enabled through the use of the Direct Lift Control, and rapid changes in the upward direction are possible because of the separate spoiler bias design feature.

The FAA considers the proposed margins provided at the reference landing speed, $V_{REF}$, to be adequate considering the specific design features and operating characteristics of the MD–17.

Given that the probability of engine failure for part 25 airplanes is generally assumed to be 1.0, the commenter asks what the justification is for the 5-knot reduction in one-engine-inoperative vertical gust margin based solely on the short exposure time in that condition.

Although ensuring safe flight characteristics and performance capability in the event of an engine failure is a fundamental principle embodied in part 25, this does not mean that the probability of an engine failure is generally assumed to be 1.0. The FAA continues to consider a vertical gust margin of 15 knots is adequate to ensure safety in the event of engine failure. For the normal all-engines-operating condition, the FAA considers it appropriate to require a larger margin, equivalent to the vertical gust margin typical of conventional transport category airplanes operating at their minimum landing approach speed. The commenter states that it is not clear how the power is required to be set for the one-engine-inoperative power-on stall speed demonstrations, and that in any case the thrust must be set asymmetrically to simulate a realistic condition, rather than to have thrust set symmetrically.

The power-on stall speeds for the MD–17 power-augmented-lift design are influenced by which engines are operating. The distribution of the engine efflux interacting with the externally blown flaps is different for the all-engines-operating, outboard-engine-inoperative, and inboard-engine-inoperative configurations. As a result, the power-on stall speeds differ between engines-operating configurations for a given weight and total airplane thrust level. Accordingly, the one-engine-inoperative stall speeds for the C–17, the military version of the MD–17, were determined from flight testing with asymmetric thrust.

In addition to the all-engines-operating configuration, the C–17 one-engine-inoperative power-on stall speeds were determined from flight testing of both the outboard-engine-inoperative and inboard-engine-inoperative configurations. The power-on stall speeds for these different engine operating configurations were determined at airplane thrust levels ranging from idle to takeoff thrust. For test safety purposes, the one-engine-inoperative stall speeds were determined from flight testing with a majority of the one-engine-inoperative test points flown with the ''inoperative'' engine at idle thrust and the remaining engines at the thrust level desired for a particular test point. A smaller number of power-on stall test points were flown for both the outboard-engine-inoperative and inboard-engine-inoperative configurations with the ''inoperative'' engine shut down. These test points provided a basis for correcting the majority of the power-on stall speed test data, flown with the ''inoperative'' engine at idle thrust, to a power-on stall speed level for the ''inoperative'' engine shut down. This same technique will be acceptable to the FAA for showing compliance with Special Condition 1.

Another commenter points out that the last sentence of Special Condition 1, paragraph (2)(i), ''Approach,'' defines a 2.7 percent gradient of climb requirement without specifying the number of engines. The commenter states that for consistency with the takeoff requirements for gradient of climb [paragraph 1(h)], this should specify the gradient of climb required based on the number of engines.

The inconsistency identified by the commenter was not intended by the FAA when developing the special conditions. The FAA has tailored these special conditions specifically for the MD–17, which is a four-engine airplane. To correct this inconsistency, paragraph 1(h) of the special condition has been revised to limit the applicability to a four-engine airplane.

The commenter states that the preamble description of the spoiler system may imply that the throttle-to-spoiler coupling is a mechanical linkage, and believes that wording changes are needed to clarify that the linkage is not mechanical.

The FAA agrees. The general discussion of the MD–17 design features has been revised to provide clarification that the linkage is electronic. Also, the discussion of ''Stall Speeds and Minimum Operating Speeds'' has been revised to clarify that in addition to a slight thrust increase to reduce the rate of descent at touchdown, ''a throttle-coupled reduction in spoiler deflection'' may be used.

2. Head-Up Display (HUD) Used as Primary Flight Display (PFD)

One commenter considers the reliance on dual HUD's for the display of primary flight information to be radical and in need of careful attention, and further considers that better guidance is required for the unusual attitude recovery training using HUD.

The FAA agrees that the use of the HUD as a primary flight display, which includes its use by the pilots for unusual attitude recognition and recovery, is a novel design feature. This is one of the key reasons for the HUD special condition.

The FAA recognizes that unlike conventional primary attitude displays, the HUD is monochrome and ''stroke-written,'' without the contrast of color and shading found in conventional headdown attitude displays. The FAA conducted a multiple expert opinion team study of the C–17 HUD to explore this and several other factors related to its use as a primary flight display. In addition, FAA test pilots flew several unusual attitude recognition and recovery scenarios.

The special condition specifically requires that the HUD perform the function of conventional color primary flight instruments and that the flightcrew must be able to immediately recognize and perform a safe recovery from unusual attitudes. One of many factors that the FAA must evaluate is the ability of the monochrome HUD symbology to effectively distinguish positive (sky) and negative (ground) pitch attitudes. The FAA will carefully determine compliance with these requirements through the use of flight test and simulation.

The commenter states that the preamble discussion of this special condition seems to imply that the dual HUD installation is the novel feature of the MD–17, and that it should emphasize the HUD as the primary flight display (PFD) for each pilot, not just a dual HUD installation.

The FAA considers that the current preamble discussion does, in fact, adequately emphasize that these HUD's will be used as the primary flight display. The fact that this is a dual-HUD installation is also potentially significant, due to their location, depending on the information content displayed and the concurrent use of both HUD's by the flightcrew. The preamble discussion therefore remains unchanged.

The commenter requests that under the preamble discussion of the ''Arrangement and Visibility'' of the HUD, the second sentence be revised to read, ''Section 25.1303 does not adequately address the MD–17 HUD's location, and novel, unique features which allow the pilots to keep their heads up and eyes out of the cockpit while viewing primary flight data.'' The commenter states that this revision reinforces that the MD–17 HUD installation deviates from the strict location requirements of § 25.1321(b) in order to enhance crew awareness outside the cockpit.

The purpose of this discussion is to explain what is unique and novel about the design that requires the special condition, not to endorse potential advantages of the design. However, to address the commenter's concern, the sentence in question has been revised to read, ''Section 25.1303 does not adequately address the MD–17 HUD's novel and unique location for a primary flight display, which is above the instrument panel and in the field of view of the forward window.''

The commenter requests that the last sentence of the preamble discussion of the ''Arrangement and Visibility'' of the HUD be deleted, stating that it is too vague and implies, too generally, that additional data must be displayed on the HUD.

The FAA disagrees. This portion of the preamble discussion describes the scope of, and need for, the kind of requirements specified in the special condition. It is not meant to state the specific requirements of the special condition that require compliance. This discussion therefore remains unchanged.

The commenter requests that the first sentence of the preamble discussion of the ''Compatibility with Other Cockpit Displays,'' be rewritten as it implies that the MD–17 HUD has monochrome limitations that other current HUD's would not have.

The FAA agrees and has revised this discussion accordingly.

The commenter further states that because the MD–17 monochrome HUD represents current state-of-the art, it should not be made to sound as if it is less than current technology. The commenter adds that this requirement for HUD's to highlight certain information is important only if a monochrome HUD is specifically used as a PFD.

This special condition applies only to the MD–17 HUD, not generally to all HUD's. The FAA did not intend to imply that the MD–17 monochrome HUD, alone, has limitations due to the lack of color. However, to address the commenter's concern, the FAA has revised the preamble discussion referred to by the commenter to state that a ''monochrome HUD'' must have an equivalent means to unmistakably highlight and distinguish the same information.

The commenter states that the wording of the last sentence of the discussion of the ''Compatibility with Other Cockpit Displays'' which reads, ''the existing rules do not adequately address the compatibility of different display formats in the MD–17 cockpit'' implies that the MD–17 cockpit design has a display compatibility problem. The commenter asserts that the MD–17 display formats were designed using human factors design principles to be compatible with other cockpit displays, and recommends that the phrase ''in the MD–17 cockpit'' be removed to prevent potential misunderstandings of the Boeing display design philosophy.

The FAA agrees and has revised the discussion accordingly.

The commenter recommends that the discussion of the ''Additional Recommendations and Supporting Data'' be removed, stating that it provides no additional or revised requirements, but simply collects into one location part 25 requirements that the MD–17 must meet.

The FAA does not agree. The regulations and advisory material referred to by the commenter are not part of the special conditions and are not additional requirements. They are listed in the preamble discussion for information only in the context of this special condition. The FAA considers that they should be given special attention due to the uniqueness of the HUD.

Further to the above discussion, the commenter states that the discussion of § 25.1301(a) digresses into a minimum equipment list set of requirements, dictating which displays must be operative and how displays must be used. The commenter considers these to be operational issues that do not belong in this discussion.

The FAA disagrees. Unlike other transport HUD's, the MD–17 HUD's are used as PFD's. Certain environmental light conditions significantly affect the pilot's ability to use the HUD compared to headdown instruments. In some of these conditions, the HUD cannot be relied on as the PFD, so another PFD must be available. The safety objective is to ensure that the flight has functional primary flight displays in all foreseeable conditions. While it may also have MEL implications, this requirement is stated for the sake of the design and functional allocation of the display suite of the flight deck in which these HUD's are installed.

The commenter states that paragraph (a)(2) of the special condition is confusing. The first sentence allows for guidance to be displayed in ''close proximity'' to the HUD field of view, while the second sentence begins ''Likewise'' and yet implies that the information must be displayed on the HUD, not in close proximity. The commenter suggests that the second sentence be revised to read ''Likewise, other essential information and alerts that are related to displayed information and may require pilot action must be displayed for instant recognition, either on the HUD or in close proximity to the HUD field of view.''

The FAA agrees and has revised the special condition as proposed by the commenter.

The commenter requests that the wording of the third sentence of paragraph (a)(7) of the special condition be revised to state that the HUD symbology must not ''excessively'' interfere with the pilot's forward view, etc. The commenter's reason for the change is that without the word ''excessively,'' a strict FAA interpretation might require all HUD symbology to be removed so as not to interfere with the pilot's forward view at all, thus defeating the intended purpose of the HUD.

The word ''excessively'' was removed because the criteria for what is and is not excessive were undefined at the time. This is a compliance finding based on FAA flight test pilot judgement. The word ''excessively'' has been restored, as suggested by the commenter, with an explanation added that ''interference would be considered excessive if it prevents the pilot from seeing flight hazards, such as airborne traffic, terrain, and obstacles, or outside visual references required for safe operation such as approach lights, runway lights, runways, and runway markings.''

The commenter notes that the term ''slowovers'' in paragraph (a)(9)(ii) of the special condition is used when discussing autopilot failures, and points out that the unique MD–17 fly-by-wire control design is not subject to slowovers in the same way as conventional designs.

The use of the term ''slowover'' was intended only as an example of autopilot failures that may cause an upset; the emphasis is actually on the upset. However, to avoid any confusion in this regard, the reference to ''slowover'' has been removed and the words ''as applicable to the MD–17 type design'' have been added in its place.

In paragraph (b)(5), the commenter recommends that the FAA maintain the portion of the sentence that reads, ''There must be no adverse physiological effects of long term use of the HUD system, such as fatigue or eye strain'' and delete the remainder of that sentence and the sentence that follows. The commenter maintains that the design of the MD–17 is such that the pilot can always choose to use the head-down PFD instead of the HUD while seated in a reclined position, and that the HUD is not intended to be relied on as the sole PFD.

The FAA agrees with the change recommended by the commenter and has revised the special condition accordingly.

The same commenter recommends that paragraphs (c)(2)(i) through (viii) be removed, stating that these paragraphs impose a series of safety requirements interpretations for hazards associated with loss or erroneous display of parameters on the HUD and/or elsewhere in the cockpit. The commenter further states that most of these interpretations are already provided in AC 25–11, ''Transport Category Airplane Electronic Display Systems.'' The commenter questions the value of a special condition that applies criteria with which the MD–17 will comply using existing guidance.

The FAA disagrees that this information should be removed. Since direct reference to the AC cannot be included in the text of the special condition, the applicable criteria were inserted instead. This does not change the requirements that were originally agreed to by the applicant and imposes no additional burden.

The commenter states that the MD–17 HUD, by design, will not display any data unless the combiners are fully deployed and aligned, so the warning called out in paragraph (c)(4) of the special condition is of little value. The commenter suggests revising this paragraph to say that the HUD system must monitor the position of the combiner and must not display conformal data that is hazardously aligned due to combiner position. A suitable warning, alerting the crew of this condition, is also acceptable.

The FAA agrees with the intent of the comment and has revised paragraph (c)(4) accordingly.

4. Interaction of Systems and Structure

The commenter points out that a sentence appears to be missing from the special condition.

The FAA agrees. The sentence the commenter is referring to concerns the flutter clearance speeds that may be based on the speed limitation specified for the remainder of the flight. The omission of this sentence in the proposed special condition was an inadvertent oversight, which has been corrected.

7. Flight Characteristics Compliance via Handling Qualities Rating System

The commenter states that in order to determine whether the airplane has suitable stability, objective requirements are necessary against which to make the assessment. The commenter does not consider the Handling Qualities Rating System to be an acceptable alternative.

The FAA disagrees. The special conditions for flight characteristics evaluation of the MD–17 are the same as those used on other airplanes with similar fly-by-wire flight control systems. The FAA Handling Qualities Rating System has been used successfully to evaluate airplanes with fly-by-wire flight control systems since the early 1980's.

11. Steep Approach Air Distance, and 12. Landing Distances for Approaches to Short Field Landings

The commenter states that the intention to distinguish between conventional and special approaches to short field landings is noted and would be interested in reviewing the complete SFAR, which will address short field operations, when it becomes available. The commenter further states that there also needs to be a clear distinction operationally between the two and asks, ''While there is a clear upper limit on the steep approach angle (i.e., 5 degrees or 1,000 fpm), what will be the upper limit for a conventional approach?''

The commenter has misunderstood the proposals related to steep approach operations and special approaches to short field landings. There are two distinct types of landing operations for the MD–17: (1) conventional landings that will be conducted in accordance with existing part 25 and 121 regulations; and (2) special approaches to short field landings that will be conducted in accordance with a proposed SFAR (to be published at a later date) and associated special conditions. These two types of landing operations would be distinguished by the additional equipment, training, and operating requirements associated with approval to conduct special approaches to short field landings. The applicant intends to provide steep approach capability (allowing operators to seek steep approach approval) for both types of landing operations.

The Steep Approach Air Distance special condition, which provides an alternative methodology for determining the airborne part of the landing distance, would apply only to those steep approaches flown as part of a special approach to a short field landing conducted in accordance with the proposed SFAR. In general, the FAA considers a steep approach to be any approach conducted at angles steeper than 3.77 degrees. This value is derived from the normal 3 degrees approach path angle, plus the outside limit for vertical displacement from the 3 degrees glide slope on the Instrument Landing System (ILS), as established by the FAA Flight Standardization Board.

Another commenter notes that the steep approach air distance definition in paragraph (a) of Special Condition 11 does not reflect the specific distance between the runway threshold and the touchdown aim point to be used in operation.

The FAA has revised the wording of this special condition to provide the clarification requested by the commenter.

The same commenter notes that Special Conditions 11(a)(4) and 12(a)(4) refer to a ''water loop'' maneuver and questions whether this maneuver has ever been demonstrated with a land-based airplane.

The FAA has determined that there is no need to consider this maneuver for a land-based airplane such as the MD–17, and has removed the reference to the water loop maneuver from both special conditions.

This commenter points out that there are several references to approach flight path angle in both the preamble discussion of Special Conditions 11 and 12, and in the text of paragraph 12(b)(4) of Special Condition 12, that use a negative sign convention that could lead to confusion.

The FAA agrees and has revised the wording accordingly.

With the exception of the changes discussed above, the special conditions are adopted as proposed in Notice 25–99–04–SC.

## Applicability

As discussed above, these special conditions are applicable to the McDonnell Douglas Model MD–17 series airplanes. Should McDonnell Douglas apply at a later date for a change to the type certificate to include another model incorporating the same novel or unusual design features, the special conditions would apply to that model as well under the provisions of § 21.101(a)(1).

## Conclusion

This action affects only certain novel or unusual design features on one model series of airplanes. It is not a rule of general applicability and affects only the applicant who applied to the FAA for approval to use these features on the airplane.

## List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements. The authority citation for these special conditions is as follows:

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

## The Special Conditions

Accordingly, pursuant to the authority delegated to me by the Administrator, the following special conditions are issued as part of the type certification basis for McDonnell Douglas Model MD–17 series airplanes:

*1. Stall Speeds and Minimum Operating Speeds*

(a) In addition to the general definitions, abbreviations, and symbols provided in §§ 1.1 and 1.2, this special condition relies on the following additional definitions, abbreviations, and symbols:

''Reference flight path angle means -3 degrees for a normal approach, and the shallower of -5 degrees or the flight path angle resulting from a 1000 feet per minute rate of descent for a steep approach.''

''$V_{SR}$ means reference stall speed.''

''$V_{SR_{PWR}}$ means power-on reference stall speed.''

''$V_{SRO}$ means reference stall speed in the landing configuration.''

''$V_{SRO_{PWR}}$ means power-on reference stall speed in the landing configuration.''

''$V_{SR1}$ means reference stall speed in a specific configuration.''

''$V_{SR1_{PWR}}$ means power-on reference stall speed in a specific configuration.''

''$V_{REF}$ means reference landing speed.''

''$V_{FTO}$ means final takeoff speed.''

''$V_{SW}$ means speed at which onset of natural or artificial stall warning occurs.''

(b) In lieu of compliance with § 25.103, the following applies:

(1) The reference stall speed, $V_{SR}$, is a calibrated airspeed as defined in paragraph (3) below. $V_{SR}$ is determined with—

(i) Engines idling, or, if that resultant thrust causes an appreciable decrease in stalling speed, not more than zero thrust at the stall speed;

(ii) The airplane in other respects (such as flaps and landing gear) in the condition existing in the test in which $V_{SR}$ is being used;

(iii) The weight used when $V_{SR}$ is being used as a factor to determine compliance with a required performance standard;

(iv) The center of gravity position that results in the highest value of reference stall speed; and

(v) The airplane trimmed for straight flight at a speed selected by the applicant, but not less than 1.13 $V_{SR}$ and not greater than 1.30 $V_{SR}$.

(2) Starting from the stabilized trim condition, apply elevator control to decelerate the airplane so that the speed

reduction does not exceed one knot per second.

(3) The reference stall speed, $V_{SR}$, may not be less than a 1-g stall speed, which is a calibrated airspeed determined in the stalling maneuver and expressed as:

$$V_{SR} = V_{C_{L_{MAX}}} / \sqrt{n_{zw}}$$

where:

$V_{C_{LMAX}}$ = Speed occurring when lift coefficient is first a maximum; and

$n_{ZW}$ = Flight path normal load factor (not greater than 1.0) at $V_{C_{LMAX}}$.

(4) The power-on reference stall speed, $V_{SR_{PWR}}$, is a calibrated airspeed as defined in paragraph (6) below. $V_{SR_{PWR}}$ is determined with—

(i) The critical engine inoperative and the power or thrust setting on the remaining engines at the minimum power or thrust level appropriate for the flight condition used to show compliance with a required performance standard;

(ii) The airplane in other respects (such as flaps and landing gear) in the condition existing in the test in which $V_{SR_{PWR}}$ is being used;

(iii) The weight used when $V_{SR_{PWR}}$ is being used as a factor to determine compliance with a required performance standard;

(iv) The center of gravity position that results in the highest value of the power-on reference stall speed; and

(v) The airplane trimmed for straight flight at a speed selected by the applicant, but not less than 1.18 $V_{SR_{PWR}}$ and not greater than 1.36 $_{VSR_{PWR}}$.

(5) Starting from the stabilized trim condition, apply elevator control to decelerate the airplane so that the speed reduction does not exceed one knot per second.

(6) The power-on reference stall speed, $V_{SR_{PWR}}$, may not be less than a 1-g power-on stall speed, which is a calibrated airspeed determined in the stalling maneuver and expressed as:

$$V_{SR_{PWR}} = V_{C_{L_{MAX}}} / \sqrt{n_{zw}}$$

where:

$V_{C_{LMAX}}$ = Speed occurring when lift coefficient is first a maximum; and

$n_{ZW}$ = Flight path normal load factor (not greater than 1.0) at $V_{C_{LMAX}}$.

(c) In lieu of compliance with § 25.107(b), the following applies: $V_{2MIN}$, in terms of calibrated airspeed, may not be less than—

(1) 1.03 $V_{SR}$;

(2) 1.18 $V_{SR_{PWR}}$, with the operative engines at the minimum thrust or power existing at any point in the takeoff path; and

(3) 1.10 times $V_{MC}$ established under § 25.149.

(d) In addition to compliance with §§ 25.107(c)(1) and (c)(2), the following also applies: A speed that provides the maneuvering capability specified in paragraph (k) below.

(e) In addition to compliance with § 25.107(a) and §§ 25.107(c) through (f), the following also applies: $V_{FTO}$, in terms of calibrated airspeed, must be selected by the applicant to provide at least the gradient of climb required by paragraph (h) below, but may not be less than—

(1) 1.18 $V_{SR}$; and

(2) A speed that provides the maneuvering capability specified in paragraph (k) below.

(f) In lieu of compliance with § 25.111(a), the following applies: The takeoff path extends from a standing start to a point in the takeoff at which the airplane is 1,500 feet above the takeoff surface, or at which the transition from the takeoff to the en route configuration is completed and $V_{FTO}$ is reached, whichever point is higher. In addition—

(1) The takeoff path must be based on the procedures prescribed in § 25.101(f);

(2) The airplane must be accelerated on the ground to $V_{EF}$, at which point the critical engine must be made inoperative and remain inoperative for the rest of the takeoff; and

(3) After reaching $V_{EF}$, the airplane must be accelerated to $V_2$.

(g) In lieu of compliance with § 25.119 (b), the following applies: A climb speed of not more than $V_{REF}$.

(h) In lieu of compliance with § 25.121(c), the following applies:

*Final takeoff.* In the en route configuration at the end of the takeoff path determined in accordance with § 25.111, the steady gradient of climb may not be less than 1.7 percent at $V_{FTO}$ and with—

(1) The critical engine inoperative and the remaining engines at the available maximum continuous power or thrust; and

(2) The weight equal to the weight existing at the end of the takeoff path, determined under § 25.111.

(i) In lieu of compliance with § 25.121(d), the following applies:

*Approach.* In a configuration corresponding to the normal all-engines-operating procedure in which $V_{SR_{PWR}}$ for this configuration, with the operative engines at the minimum thrust or power existing at any point in the go-around, does not exceed 110 percent of the $V_{SR_{PWR}}$ for the related all-engines-operating landing configuration, with the operative engines at the power or thrust setting for approach at the reference flight path angle at $V_{REF}$, the steady gradient of climb may not be less than 2.7 percent with—

(1) The critical engine inoperative, the remaining engines at the go-around power or thrust setting;

(2) The maximum landing weight;

(3) A climb speed established in connection with normal landing procedures, but not more than 1.4 $V_{SR_{PWR}}$ with the operative engines at the minimum power or thrust setting existing at any point in the go-around; and

(4) The landing gear retracted.

(j) In lieu of compliance with § 25.125(a)(2), the following applies: A stabilized approach, with a calibrated airspeed of not less than $V_{REF}$ or $V_{MCL}$, whichever is greater, must be maintained down to the 50 foot height. $V_{REF}$ may not be less than—

(1) 1.03 $V_{SR0}$;

(2) 1.20 $V_{SR0_{PWR}}$ with the operative engines at the power or thrust setting for approach at the reference flight path angle;

(3) The airspeed that provides an angle-of-attack margin to stall for not less than a 20 knot equivalent airspeed vertical gust with all engines operating at the power or thrust setting for approach at the reference flight path angle;

(4) The airspeed that provides an angle-of-attack margin to stall for not less than a 15 knot equivalent airspeed vertical gust with the critical engine inoperative at the power or thrust setting for approach at the reference flight path angle; and

(5) A speed that provides the maneuvering capability specified in paragraph (k) below.

(k) In addition to compliance with § 25.143, the following applies: The maneuvering capabilities in a constant speed coordinated turn, as specified in the table below, must be free of stall warning or other characteristics that might interfere with normal maneuvering.

| Configuration | Speed | Maneuvering Bank Angle (degrees) | Thrust Representative of |
|---|---|---|---|
| Takeoff | $V_2$ | 30 | Asymmetric WAT-Limited.[1] |

| Configuration | Speed | Maneuvering Bank Angle (degrees) | Thrust Representative of |
|---|---|---|---|
| Takeoff | $V_2$+XX [2] | 40 | All-engines operating climb.[3] |
| En route | $V_{FTO}$ | 40 | Asymmetric WAT-Limited.[1] |
| Landing | $V_{REF}$ | 40 | Symmetric for approach at the reference approach flight path angle.[4] |

[1] A combination of Weight, Altitude and Temperature (WAT) such that the thrust or power setting produces the minimum climb gradient specified in § 25.121 for the flight condition.
[2] Airspeed approved for all-engines-operating initial climb.
[3] That thrust or power setting which, in the event of failure of the critical engine and without any crew action to adjust the thrust or power of the remaining engines, would result in the thrust or power specified for the takeoff condition at $V_2$, or any lesser thrust or power setting that is used for all-engines-operating initial climb procedures.
[4] Thrust may be adjusted during the maneuver to maintain the reference approach flight path angle.

(l) In lieu of compliance with § 25.145(a), the following applies: It must be possible at any speed between the trim speed prescribed in paragraph (b)(1)(v), or (b)(4)(v), of this special condition for flaps extended configurations, and the minimum speed obtained in conducting a stalling maneuver, to pitch the nose downward so that the acceleration to this selected trim speed is prompt with—

(1) The airplane trimmed at the speed prescribed in paragraph (b)(1)(v) of this special condition for flaps retracted configurations, or as prescribed in paragraph (b)(4)(v) of this special condition for flaps extended configurations;

(2) The landing gear extended;

(3) The wing flaps—

(i) retracted, and

(ii) extended; and

(4) Power—

(i) off with the flaps retracted and, with the flaps extended, with all engines operating at the minimum power or thrust level consistent with that used to determine the power-on reference stall speeds; and

(ii) at maximum continuous power on the engines.

(m) In lieu of compliance with § 25.145(b)(2), the following applies: Repeat paragraph (b)(1) of this section, except begin with the flaps fully extended and all engines at the minimum power or thrust level consistent with that used to determine the power-on reference stall speed for that flap position, and then retract the flaps as rapidly as possible.

(n) In lieu of compliance with § 25.145(b)(5), the following applies: Repeat paragraph (b)(4) of this section, except with the flaps extended and all engines at the minimum power or thrust level consistent with that used to determine the reference power-on stall speed.

(o) In lieu of compliance with § 25.145(b)(6), the following applies: With all engines at the minimum power or thrust level consistent with that used to determine the reference power-on stall speed, flaps extended, and the airplane trimmed at 1.3 $V_{SR1_{PWR}}$, obtain and maintain airspeeds between $V_{SW}$, and either 1.6 $V_{SR1_{PWR}}$ or $V_{FE}$, whichever is lower.

(p) In lieu of compliance with § 25.161(c)(2), the following applies: A glide with the landing gear extended, the most unfavorable center of gravity position approved for landing with the maximum landing weight, and the most unfavorable center of gravity position approved for landing, regardless of weight with the wing flaps—

(1) retracted with power off at a speed of 1.3 $V_{SR1}$, and

(2) extended with all engines at the minimum power or thrust level consistent with that used to determine the power-on reference stall speed at a speed of 1.3 $V_{SR1_{PWR}}$.

(q) In lieu of compliance with § 25.175(d)(4), the following applies: All engines at the minimum power or thrust level consistent with that used to determine the power-on reference stall speed.

(r) In lieu of compliance with § 25.175(d)(5), the following applies: The airplane trimmed at 1.3 $V_{SR0_{PWR}}$.

(s) In lieu of the speeds given in the following part 25 requirements, comply with the speeds as follows:

§§ 25.145(b)(1) and (b)(4), 1.3 $V_{SR1}$, in lieu of 1.4 $V_{S1}$.
§ 25.145(b)(1), 30 percent, in lieu of 40 percent.
§ 25.145(b)(1), power-on reference stall speed, in lieu of stalling speed.
§ 25.145(c), 1.08 $V_{SR1}$, in lieu of 1.1 $V_{S1}$.
§ 25.145(c), 1.18 $V_{SR1_{PWR}}$, in lieu of 1.2 $V_{S1}$.
§ 25.147(a), (a)(2), (c), and (d), 1.3 $V_{SR1}$, in lieu of 1.4 $V_{S1}$.
§ 25.149(c), 1.13 $V_{SR}$, in lieu of 1.2 $V_S$.
§ 25.161(b), (c)(1), and (c)(2), 1.3 $V_{SR1}$, or 1.3 $V_{SR1_{PWR}}$ for flaps extended configurations, in lieu of 1.4 $V_{S1}$.
§ 25.161(c)(3), 1.3 $V_{SR1}$, in lieu of the first instance of 1.4 $V_{S1}$, and 1.3 $V_{SR1_{PWR}}$, in lieu of the second instance of 1.4 $V_{S1}$.
§ 25.161(d), 1.3 $V_{SR1}$ in lieu of 1.4 $V_{S1}$.
§ 25.161(e)(3), 0.013 $V_{SR0}^2$, in lieu of 0.013 $V_{S0}^2$.
§ 25.175(a)(2), (b)(1), (b)(2), and (b)(3), 1.3 $V_{SR1}$, in lieu of 1.4 $V_{S1}$.
§ 25.175(b)(2)(ii), ($V_{MO}$ + 1.3 $V_{SR1}$)/2, in lieu of $V_{MO}$ + 1.4 $V_{S1}$/2.
§ 25.175(c), $V_{SW}$ and 1.7 $V_{SR1_{PWR}}$, in lieu of 1.1 $V_{S1}$ and 1.8 $V_{S1}$.
§ 25.175(c)(4), 1.3 $V_{SR1_{PWR}}$, in lieu of 1.4 $V_{S1}$.
§ 25.175(d), $V_{SW}$ and 1.7 $V_{SR0_{PWR}}$, in lieu of 1.1 $V_{S0}$ and 1.3 $V_{S0}$.
§ 25.177(c), 1.13 $V_{SR1}$, or 1.18 $V_{SR1_{PWR}}$ for flaps extended configurations, in lieu of 1.2 $V_{S1}$.
§ 25.181(a) and (b ), 1.13 $V_{SR1}$, or 1.18 $V_{SR1_{PWR}}$ for flaps extended configurations, in lieu of 1.2 $V_{S1}$.
§ 25.201(a)(2), 1.5 $V_{SR1_{PWR}}$ (where $V_{SR1_{PWR}}$ corresponds to the power-on reference stall speed with flaps in the approach position, the landing gear retracted, and maximum landing weight), in lieu of 1.6 $V_{S1}$ (where $V_{S1}$ corresponds to the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight).

(t) In addition to compliance with §§ 25.201(a)(1) and (a)(2), the following also applies: The critical engine inoperative and the power or thrust setting on the remaining engines at the minimum power or thrust level appropriate for the flight condition used to show compliance with a required performance standard.

(u) In lieu of compliance with § 25.207(b), the following applies: The warning may be furnished either through the inherent aerodynamic qualities of the airplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However, a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself. If a warning device is used, it must provide a warning in each of the airplane configurations prescribed in paragraph (a) of this section at the speed prescribed in paragraph (v)(1) and (2) below.

(v) In lieu of compliance with § 25.207(c), the following applies:

(1) In each normal configuration with the flaps retracted, when the speed is reduced at rates not exceeding one knot per second, stall warning must begin at a speed, $V_{SW}$, exceeding the speed at which the stall is identified in accordance with § 25.201(d) by not less than five knots or five percent, whichever is greater. Once initiated, stall warning must continue until the angle of attack is reduced to approximately that at which stall warning began.

(2) In addition to the requirement of paragraph (v)(1) above, when the speed is reduced at rates not exceeding one knot per second, in straight flight with engines idling and at the center of gravity position specified in paragraph (b)(1)(iv) above, $V_{SW}$, in each normal configuration with the flaps retracted, must exceed $V_{SR}$ by not less than three knots or three percent, whichever is greater.

(3) In each normal configuration with the flaps extended, when the speed is reduced at rates not exceeding one knot per second, stall warning must begin at a speed, $V_{SW}$, exceeding the speed at which the stall is identified in accordance with § 25.201(d) by not less than five knots or five percent, whichever is greater. Once initiated, stall warning must continue until the angle of attack is reduced to approximately that at which stall warning began.

(4) In addition to the requirement of paragraph (v)(3) above, when the speed is reduced at rates not exceeding one knot per second, in straight flight with the critical engine inoperative and the power or thrust setting on the remaining engines at the minimum power or thrust level appropriate for the flight condition used to show compliance with a required performance standard, and at the center of gravity position specified in paragraph (b)(4)(i) above, $V_{SW}$, in each normal configuration with the flaps extended, must exceed $V_{SR_{PWR}}$ by not less than three knots or three percent, whichever is greater.

(5) In slow-down turns with at least 1.5g load factor normal to the flight path and airspeed deceleration rates greater than 2 knots per second, with the flaps and landing gear in any normal position, the stall warning margin must be sufficient to allow the pilot to prevent stalling (as defined in § 25.201(d)) when recovery is initiated not less than one second after the onset of stall warning. Compliance with this requirement must be demonstrated with—

(i) The airplane trimmed for straight flight at a speed of 1.3 $V_{SR}$ with the flaps retracted or 1.3 $V_{SR_{PWR}}$ with the flaps extended; and

(ii) The power or thrust necessary to maintain level flight at 1.3 $V_{SR}$ with the flaps retracted or 1.3 $V_{SR_{PWR}}$ with the flaps extended.

(w) In addition to compliance with § 25.207(a) and paragraphs (u) and (v) above, the following applies: Stall warning must also be provided in each abnormal configuration of the high lift devices likely to be used in flight following system failures (including all configurations covered by Airplane Flight Manual procedures).

(x) In lieu of the speeds given in §§ 25.233(a) and 25.237(a), comply with speeds as follows: 0.2 $V_{SR0_{PWR}}$ in lieu of 0.2 $V_{S0}$.

(y) In lieu of the definition of V in § 25.735(f)(2), the following apply:

$V=V_{REF}/1.3$

$V_{REF}$=Airplane steady landing approach speed, in knots, at the maximum design landing weight and in the landing configuration at sea level.

(z) In lieu of compliance with § 25.735(g), the following applies: The minimum speed rating of each main wheel-brake assembly (that is, the initial speed used in the dynamometer tests) may not be more than the V used in the determination of kinetic energy in accordance with paragraph (f) of this section, assuming that the test procedures for wheel-brake assemblies involve a specified rate of deceleration, and, therefore, for the same amount of kinetic energy, the rate of energy absorption (the power absorbing ability of the brake) varies inversely with the initial speed.

(aa) In lieu of the speeds given in the following part 25 requirements, comply with the speeds as follows:

§ 25.773(b)(1)(i), 1.5 $V_{SR1}$, in lieu of 1.6 $V_{S1}$.
§ 25.1001(c)(1) and (c)(3), 1.3 $V_{SR1}$, in lieu of 1.4 $V_{S1}$.
§ 25.1323(c)(1), 1.23 $V_{SR1}$, in lieu of 1.3 $V_{S1}$.
§ 25.1323(c)(2), 1.20 $V_{SR0_{PWR}}$, in lieu of 1.3 $V_{S0}$.
§ 25.1325(e), 1.20 $V_{SR0_{PWR}}$, in lieu of 1.3 $V_{S0}$, and 1.7 $V_{SR1}$, in lieu of 1.8 $V_{S1}$.

*2. Head-up Display Used as a Primary Flight Display*

(a) Display Requirements.

(1) The HUD must provide information necessary to enable rapid pilot interpretation of the airplane's flight state and position during all phases of flight. This information shall enable the flightcrew to manually control the airplane and monitor the performance of the automatic flight control system. The HUD display shall enable manual airplane control including guidance, if necessary, during an engine failure during any phase of flight. The monochrome HUD must equivalently perform the intended function of conventional color primary flight instruments and utilize display features that compensate for the lack of color. Operational acceptability of the HUD system for use while manually controlling the airplane shall be demonstrated and evaluated by the FAA. This task-oriented demonstration will evaluate crew workload and pilot compensation for normal, abnormal, and emergency operations, with single and multiple failures not shown to be extremely improbable by the system safety analysis, and is extended to all HUD display formats, unless use of specific formats is prohibited for specific phases of flight.

(2) The current mode of the flight guidance/automatic flight control system shall be clearly annunciated in the HUD, unless it is displayed elsewhere in close proximity to the HUD field of view and shown to be equivalently conspicuous. Likewise, other essential information and alerts that are related to displayed information and may require immediate pilot action must be displayed for instant recognition, either on the HUD or in close proximity to the HUD field of view. Such information, depending on the phase of flight, includes malfunctions of primary data sources, guidance and control, and excessive deviations that require a go-around maneuver.

(3) If a windshear detection system or a traffic alert and collision avoidance system (TCAS) is installed, the guidance will be provided on the HUD. When the ground proximity warning system detects excessive terrain closure, appropriate annunciations are displayed on the HUD. Additional warnings and annunciations that are required to be a part of these systems, and are normally required as part of the approved design to be in the pilot's primary field of view (i.e., the line of vision when looking forward along the flight path), must remain in the pilot's primary field of view when utilizing the HUD for flight information.

(4) Symbols must appear clean-shaped, clear, and explicit. Lines must be narrow, sharp-edged, and without halo or aliasing. Symbols must be stable with no discernible flicker or jitter.

(5) The optical qualities (accommodation, luminance, vergence) of the HUD shall be uniform across the entire field of view. When viewed by both eyes from any off-center position

within the eyebox, non-uniformities shall not produce perceivable differences in binocular view.

(6) For all phases of flight, the HUD must update the positions and motions of primary control symbols with sufficient rates and latencies to support satisfactory manual control performance.

(7) The HUD display must present all information in a clear and unambiguous manner. Display clutter must be minimized. The HUD symbology must not excessively interfere with the pilots' forward view, ability to visually maneuver the airplane, acquire opposing traffic, and see the runway environment. Interference would be considered excessive if it prevents the pilot from seeing flight hazards, such as airborne traffic, terrain, and obstacles, or outside visual references required for safe operation such as approach lights, runway lights, runways, and runway markings. Critical and essential data elements of primary flight displays must not be removed by any declutter function. Changes in the display format and primary flight data arrangement should be minimized to prevent confusion and to enhance the pilots' ability to interpret vital data.

(8) The content, arrangement, and format of the information must be sufficiently compatible with the head down displays to preclude pilot confusion, misinterpretation, or excessive cognitive workload. Immediate transition between the two displays, whether required by navigation duties, failure conditions, unusual airplane attitudes, or other reasons, must not present difficulties in data interpretation or delays/ interruptions in the crew's ability to manually control the airplane or to monitor the automatic flight control system.

(9) The HUD display must enable the flightcrew to immediately recognize and perform a safe recovery from unusual airplane attitudes. This capability must be shown in a simulator and on the airplane for all foreseeable modes of upset. However, ''corner conditions'' (i.e., test conditions where more than one attitude parameter is at its extreme value) may be demonstrated in the simulator. Foreseeable modes of upset include—

(i) flightcrew mishandling;

(ii) autopilot failure, as applicable to the MD–17 type design; and

(iii) turbulence/gust encounters.

(b) *Installation Requirements.*

(1) The arrangement of HUD display controls must be visible to and within reach of the pilot from any normal seated position. The position and movement of the controls must not lead to inadvertent operation. The HUD controls must be illuminated to be visible for all normal cockpit lighting conditions, and must not create any objectionable reflections on the HUD or other flight instruments.

(2) The HUD combiner brightness must be controllable to ensure uninterrupted visibility of all displayed information in the presence of dynamically changing background (ambient) lighting conditions. If automatic control of HUD brightness is not provided, it must be shown that a single setting is satisfactory. When the HUD brightness level is changed, the relative luminance of each displayed symbol, character, or data shall vary smoothly. In no case shall any selectable brightness level allow any information to be invisible while other data remains discernible. There shall be no objectionable brightness transients when switching between manual and automatic control. The HUD data shall be visible in lighting conditions from 0 fL to 10,000 fL. If certain lighting conditions prevent the crew from seeing and interpreting HUD data (for example, flying directly toward the sun), accommodation must be provided to permit the crew to make a ready transition to the head down displays.

(3) To the greatest extent practicable, the HUD controls must be integrated with other controls, including the flight director, to minimize the crew workload associated with HUD operation and to ensure flightcrew awareness of engaged flight guidance modes.

(4) The visibility of the HUD and the primary flight information displayed is paramount to the HUD's ability to perform its intended function as a primary flight display. The fundamental requirements for instrument arrangement and visibility specified in §§ 25.1321, 25.773, and 25.777 apply to these devices.

(i) The design eyebox should be laterally and vertically centered around the respective pilot's design eye position, and should be large enough that the minimum monocular field of view is visible at the following minimum displacements from the cockpit design eye position:

*Lateral:* 1.5 inches left and right
*Vertical:* 1.0 inches up and down
*Longitudinal:* 2.0 inches fore and aft

(ii) The HUD installation must accommodate pilots from 5′2″ to 6′3″ tall, seated with seat belts fastened and positioned at the design eye position (ref. § 25.777(c)). Larger eyebox dimensions may be required for meeting operational requirements for use as a full time primary flight display. Operational suitability and compliance with the requirements of the above cited regulations must be demonstrated and evaluated by the FAA. The design eye position must comply with the above cited regulations.

(5) Notwithstanding compliance with the minimum eyebox dimensions given above, the HUD eyebox must be large enough to serve as a primary flight display without inducing adverse effects on pilot vision and fatigue. Use of the HUD system shall not place physiologically burdensome limitations on head position. There must be no adverse physiological effects of long term use of the HUD system, such as fatigue or eye strain.

(c) *System Requirements.*

(1) The HUD system must be shown to perform its intended function as a primary flight display during all phases of flight. The normal operation of the HUD system cannot adversely affect, or be adversely affected by, other airplane systems. Malfunctions of the HUD system that cause loss of all primary flight information, including that displayed on the HUD and head down instruments, shall be extremely improbable.

(2) The classification of the HUD system's failure to display flight information and navigation information, as applicable to the airplane type design, including the potential to display hazardously misleading information, must be assessed according to §§ 25.1309 and 25.1333. All alleviating flightcrew actions that are considered in the HUD safety analysis must be validated during testing for incorporation in the airplane flight manual procedures section or for inclusion in type-specific training. The failure cases discussed below, which consider the entire suite of cockpit displays of each flight parameter, hazardously misleading failures are, by definition, not associated with a suitable warning.

(i) *Attitude.* Display of attitude in the cockpit is a critical function. Loss of all attitude display, including standby attitude, is classified as a catastrophic failure and must be extremely improbable. Loss of primary attitude display for both pilots is classified as a major failure and must be improbable. Display of hazardously misleading roll or pitch attitude simultaneously on the primary attitude displays for both pilots is classified as a catastrophic failure and must be extremely improbable. Display of hazardously misleading roll or pitch attitude on any single primary attitude display is classified as a major failure and must be improbable.

(ii) *Airspeed.* Display of airspeed in the cockpit is a critical function. Loss of all airspeed display, including standby, is classified as a catastrophic failure and must be extremely improbable. Loss of primary airspeed display for both pilots is classified as a major failure and must be improbable. Displaying hazardously misleading airspeed simultaneously on both pilots' displays, coupled with the loss of stall warning or overspeed warning functions, is classified as a catastrophic failure and must be extremely improbable.

(iii) *Barometric Altitude.* Display of altitude in the cockpit is a critical function. Loss of all altitude display, including standby, is classified as a catastrophic failure and must be extremely improbable. Loss of primary altitude display for both pilots is classified as a major failure and must be improbable. Displaying hazardously misleading altitude simultaneously on both pilots' displays is classified as a catastrophic failure and must be extremely improbable.

(iv) *Vertical Speed.* Display of vertical speed in the cockpit is an essential function. Loss of vertical speed display to both pilots is classified as a major failure and must be improbable.

(v) *Slip/Skid Indication.* The slip/skid or side slip indication is an essential function. Loss of this function to both pilots is classified as a major failure and must be improbable. Simultaneously misleading slip/skid or side slip information to both pilots is classified as a major failure and must be improbable.

(vi) *Heading.* Display of stabilized heading in the cockpit is an essential function. Displaying hazardously misleading heading information on both pilots' primary displays is classified as a major failure and must be improbable. Loss of stabilized heading in the cockpit is classified as a major failure and must be improbable. Loss of all heading information in the cockpit is classified as a catastrophic failure and must be extremely improbable.

(vii) *Navigation.* Display of navigation information (excluding heading, airspeed, and clock data) in the cockpit is an essential function. Loss of all navigation information is classified as a major failure and must be improbable. Displaying hazardously misleading navigational or positional information simultaneously on both pilots' displays is classified as a major failure and must be improbable. However, the nonrestorable loss of the combination of all navigation and communication functions is classified as a catastrophic failure and must be extremely improbable.

(viii) *Crew Alerting Displays.* Loss of crew alerting for essential functions is classified as a major failure and must be improbable. Display of hazardously misleading crew alerting messages is classified as a major failure and must be improbable.

(3) The display of hazardously misleading information on more than one primary flight display is classified as a catastrophic failure and must be extremely improbable; therefore, the HUD system software which generates, displays, or affects the generation or display of primary flight information shall be developed to Level A requirements, as specified by RTCA Document DO–178B, ''Software Considerations in Airborne Systems and Equipment Certification,'' or similar processes that provide equivalent product and compliance data. Monitoring software shown to have no ability to generate, display, or affect the generation or display of primary flight information, and which has the capability to command shutdown of the HUD system, shall be developed to no less rigor than that defined for Level C, or criticality as determined by a safety assessment of the HUD system.

(4) The HUD system must monitor the position of the combiner and must not display conformal data that is hazardously aligned due to combiner position, without a warning to alert the crew of the condition.

(5) The HUD system must be shown to comply with the high intensity radiated fields certification requirements of Special Condition 3.

*3. Protection from Unwanted Effects of High Intensity Radiated Fields*

(a) Each electrical and electronic system that performs critical functions must be designed and installed to ensure that the operation and operational capability of these systems to perform critical functions are not adversely affected when the airplane is exposed to high-intensity radiated fields.

(b) For the purpose of this special condition, the following definition applies: *Critical Functions.* Functions whose failure would contribute to or cause a failure condition that would prevent the continued safe flight and landing of the airplane.

*Discussion:* With the trend toward increased power levels from ground-based transmitters, plus the advent of space and satellite communications, coupled with electronic command and control of the airplane, the immunity of critical digital avionics systems to HIRF must be established.

It is not possible to precisely define the HIRF to which the airplane will be exposed in service. There is also uncertainty concerning the effectiveness of airframe shielding for HIRF. Furthermore, coupling of electromagnetic energy to cockpit-installed equipment through the cockpit window apertures is undefined. Based on surveys and analysis of existing HIRF emitters, an adequate level of protection exists when compliance with the HIRF protection special condition is shown with either paragraph 1 OR 2 below:

1. A minimum threat of 100 volts per meter peak electric field strength from 10 KHz to 18 GHz.

1a. The threat must be applied to the system elements and their associated wiring harnesses without the benefit of airframe shielding.

b. Demonstration of this level of protection is established through system tests and analysis.

2. A threat external to the airframe of the following field strengths for the frequency ranges indicated.

| Frequency | Field strength (Volts per meter) | |
|---|---|---|
| | Peak | Average |
| 10 KHz–100 KHz | 30 | 30 |
| 100 KHz–500 KHz | 40 | 30 |
| 500 KHz–2 MHz | 30 | 30 |
| 2 MHz–30 MHz | 190 | 190 |
| 30 MHz–70 MHz | 20 | 20 |
| 70 MHz–100 MHz | 20 | 20 |
| 100 MHz–200 MHz | 30 | 30 |
| 200 MHz–400 MHz | 30 | 30 |
| 400 MHz–700 MHz | 80 | 80 |
| 700 MHz–1 GHz | 690 | 240 |
| 1 GHz–2 GHz | 970 | 70 |
| 2 GHz–4 GHz | 1570 | 350 |
| 4 GHz–6 GHz | 7200 | 300 |
| 6 GHz–8 GHz | 130 | 80 |
| 8 GHz–12 GHz | 2100 | 80 |
| 12 GHz–18 GHz | 500 | 330 |
| 18 GHz–40 GHz | 780 | 20 |

*4. Interaction of Systems and Structures*

(a) *General.* Airplanes equipped with systems that affect structural performance, either directly or as a result of a failure or malfunction, must account for the influence of these systems and their failure conditions in showing compliance with the requirements of subparts C and D of part 25. The following criteria must be used to evaluate the structural performance of airplanes equipped with flight control systems, autopilots, stability augmentation systems, load alleviation systems, flutter control systems, and fuel management systems. If these criteria are used for other systems, it may be necessary to adapt the criteria to the specific system.

(b) *System fully operative.* With the system fully operative, the following apply:

(1) Limit loads must be derived in all normal operating configurations of the systems from all the limit conditions specified in subpart C, taking into account any special behavior of such systems or associated functions or any effect on the structural performance of the airplane that may occur up to the limit loads. In particular, any significant nonlinearity (rate of displacement of control surface, thresholds, or any other system nonlinearities) must be accounted for in a realistic or conservative way when deriving limit loads from limit conditions.

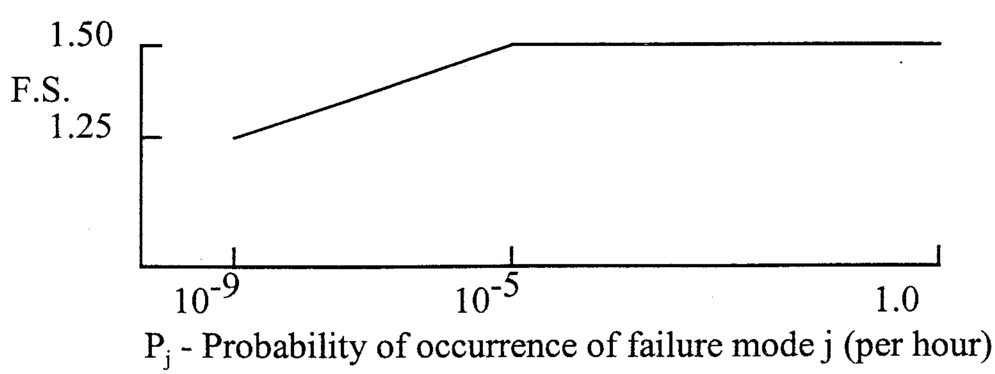
(2) The airplane must meet the strength requirements of part 25 (static strength, residual strength), using the specified factors to derive ultimate loads from the limit loads defined in paragraph (b)(1) above. The effect of nonlinearities must be investigated beyond limit conditions to ensure the behavior of the systems presents no anomaly compared to the behavior below limit conditions. However, conditions beyond limit conditions need not be considered when it can be shown that the airplane has design features that make it impossible to exceed those limit conditions.

(3) The airplane must meet the aeroelastic stability requirements of § 25.629.

(c) *System in the Failure Condition.* For any system failure condition not shown to be extremely improbable, the following apply:

(1) *At the time of occurrence.* Starting from 1–g level flight conditions, a realistic scenario, including pilot corrective actions, must be established to determine the loads occurring at the time of failure and immediately after failure. The airplane must be able to withstand these loads, multiplied by an appropriate factor of safety that is related to the probability of occurrence of the failure. The factor of safety (F.S.) is defined in Figure 1.

Figure 1
Factor of Safety at Time of Occurrence

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(i) These loads must also be used in the damage tolerance evaluation required by § 25.571(b) if the failure condition is probable.

(ii) Freedom from aeroelastic instability must be shown up to the speeds defined in § 25.629(b)(2). For failure conditions that result in speed increases beyond $V_C/M_C$, freedom from aeroelastic instability must be shown to the increased speeds, so that the margins intended by § 25.629(b)(2) are maintained.

(iii) Notwithstanding subparagraph (1) of this paragraph, failures of the system that result in forced structural vibrations (oscillatory failures) must not produce peak loads that could result in catastrophic fatigue failure or detrimental deformation of primary structure.

(2) *For the continuation of the flight.* For the airplane in the system failed state, and considering any appropriate reconfiguration and flight limitations, the following apply:

(i) Static and residual strength must be determined for loads derived from the following conditions at speeds up to $V_c$, or the speed limitation prescribed for the remainder of the flight:

(A) The limit symmetrical maneuvering conditions specified in §§ 25.331 and 25.345.

(B) The limit gust conditions specified in § 25.341, but using the gust velocities for $V_c$, and in § 25.345.

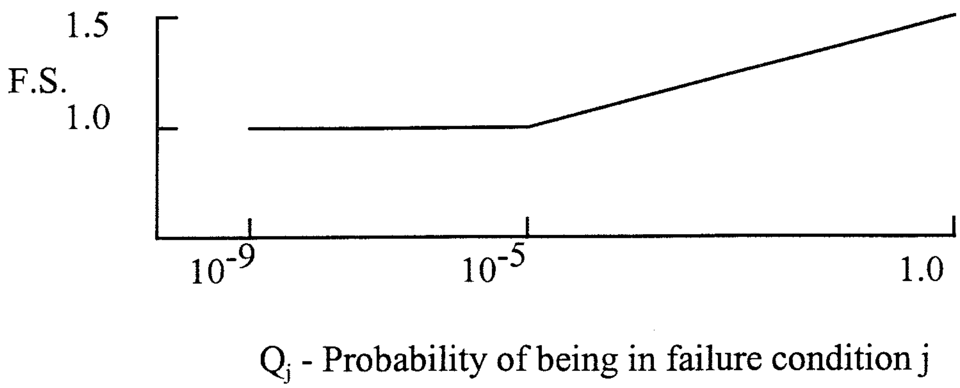
(C) The limit rolling conditions specified § 25.349 and the limit unsymmetrical conditions specified in §§ 25.367 and 25.427(b) and (c).

(D) The limit yaw maneuvering conditions specified in § 25.351.

(E) The limit ground loading conditions specified in §§ 25.473 and 25.491.

(ii) For static strength substantiation, each part of the structure must be able to withstand the loads specified in subparagraph (2)(i) of this paragraph, multiplied by a factor of safety depending on the probability of being in this failure state. The factor of safety is defined in Figure 2.

Figure 2
Factor of Safety for Continuation of Flight

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$Q_j=(T_j)(P_j)$ where:

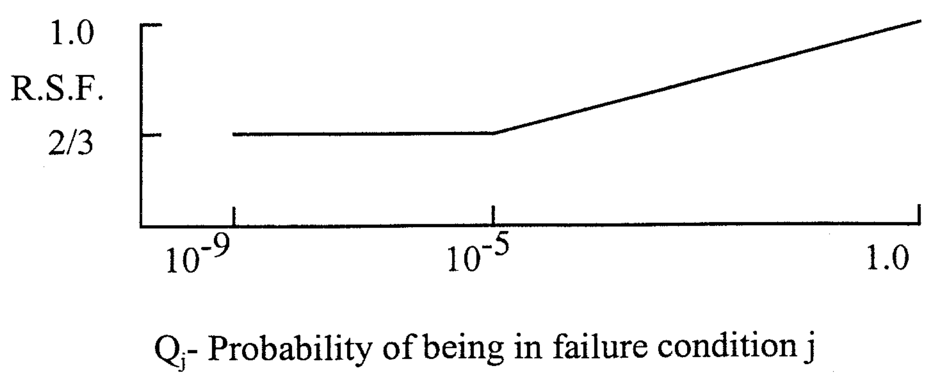
$T_j$=Average time spent in failure condition j (in hours)

$P_j$=Probability of occurrence of failure mode j (per hour)

**Note:** If $P_j$ is greater than $10^{-3}$ per flight hour, then a 1.5 factor of safety must be applied to all limit load conditions specified in subpart C.

(iii) For residual strength substantiation as defined in § 25.571(b), structures affected by failure of the system and with damage in combination with the system failure, a reduced factor may be applied to the loads of subparagraph (2)(i) of this paragraph. However, the residual strength level must not be less than the 1-g flight load, combined with the loads introduced by the failure condition, plus two-thirds of the load increments of the conditions specified in subparagraph (2)(i) of this paragraph, applied in both positive and negative directions (if appropriate). The residual strength factor (R.S.F.) is defined in Figure 3.

Figure 3
Residual Strength Factor

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$Q_j=(Tj)(Pj)$ where:

$T_j$=Average time spent in failure condition j (in hours)

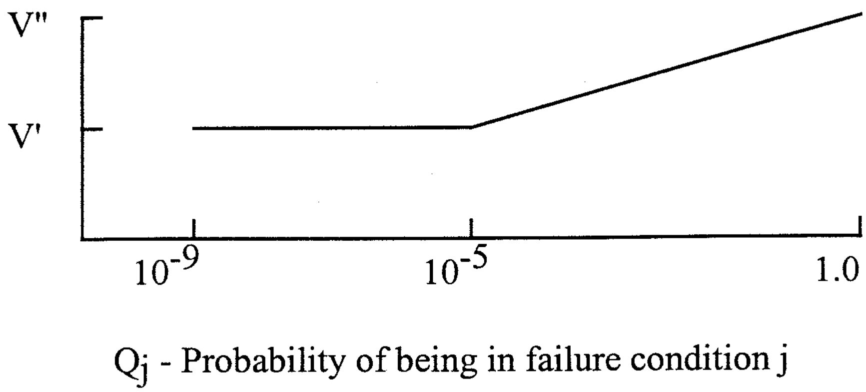
$P_j$=Probability of occurrence of failure mode j (per Hour)

**Note:** If $P_j$ is greater than $10^{-3}$ per flight hour, then a residual strength factor of 1.0 must be used.

(iv) If the loads induced by the failure condition have a significant effect on fatigue or damage tolerance, then their effects must be taken into account.

(v) Freedom from aeroelastic instability must be shown up to the speeds determined from Figure 4. Flutter clearance speeds V′ and V″ may be based on the speed limitation specified for the remainder of the flight, using the margins defined by § 25.629(b).

Figure 4
Clearance Speed

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V′=Clearance speed as defined by § 25.629(b)(2).
V″=Clearance speed as defined by § 25.629(b)(1).
$Q_j$=(Tj)(Pj) where:
$T_j$=Average time spent in failure condition j (in hours)
$P_j$=Probability of occurrence of failure mode j (per hour)

**Note:** If $P_j$ is greater than $10^{-3}$ per flight hour, then the flutter clearance speed must not be less than V″.

(vi) Freedom from aeroelastic instability must also be shown up to V′ in Figure 4 above, for any probable system failure condition combined with any damage considered in the evaluation required by § 25.571(b).

(vii) If the mission analysis method is used to account for continuous turbulence, all the systems failure conditions associated with their probability must be accounted for in a rational or conservative manner in order to ensure that the probability of exceeding the limit load is not higher than the value prescribed in appendix G to part 25.

(3) Consideration of certain failure conditions may be required by other sections of this part, regardless of calculated system reliability. Where analysis shows the probability of these failure conditions to be less than $10^{-9}$, criteria other than those specified in this paragraph may be used for structural substantiation to show continued safe flight and landing.

(d) *Warning Considerations.* For system failure detection and warning, the following apply:

(1) The system must be checked for failure conditions, not shown to be extremely improbable, that degrade the structural capability of the airplane below the level required by part 25 or significantly reduce the reliability of the remaining system. The flightcrew must be made aware of these failures before flight. Certain elements of the control system, such as mechanical and hydraulic components, may use special periodic inspections, and electronic components may use daily checks, in lieu of warning systems, to ensure failure detection. These certification maintenance requirements must be limited to components that are not readily detectable by normal warning systems and where service history shows that inspections will provide an adequate level of safety.

(2) The existence of any failure condition, not shown to be extremely improbable, during flight that could significantly affect the structural capability of the airplane, and for which the associated reduction in airworthiness can be minimized by suitable flight limitations, must be signaled to the flightcrew. For example, failure conditions that result in a factor of safety below 1.25, as determined by paragraph (c) of this special condition, or flutter clearance speeds below V'', as determined by paragraph (c) of this special condition, must be signaled to the flightcrew during flight.

(e) *Dispatch with Known Failure Conditions.* If the airplane is to be dispatched in a known system failure condition that affects structural performance, or affects the reliability of the remaining system to maintain structural performance, then the provisions of this special condition must be met for the dispatched condition and for subsequent failures. Operational and flight limitations may be taken into account.

(f) The following definitions are applicable to this special condition:

*Structural performance:* The capability of the airplane to meet the structural requirements of part 25.

*Flight limitations:* Limitations that can be applied to the airplane flight conditions following an in-flight occurrence and that are included in the flight manual (e.g., speed limitations, avoidance of severe weather conditions, etc.).

*Operational limitations:* Limitations, including flight limitations, that can be applied to the airplane operating conditions before dispatch (e.g., fuel and payload limitations).

*Probabilistic terms:* The probabilistic terms (probable, improbable, extremely improbable) used in this special condition are the same as those used in Advisory Circular (AC) 25.1309–1A.

*Failure condition:* The term failure condition is the same as that used in AC 25.1309–1A; however, this special condition applies only to system failure conditions that affect the structural performance of the airplane (e.g., failure conditions that induce loads, change the response of the airplane to inputs such as gusts or pilot actions, or lower flutter margins).

*5. Design Maneuvering Requirements for Fly-by-Wire*

(a) *Maximum elevator displacement at* $V_A$. In lieu of compliance with § 25.331(c)(1) of the FAR; the airplane is assumed to be flying in steady level flight (point $A_1$, § 25.333(b)) and, except as limited by pilot effort in accordance with § 25.397, the cockpit pitching control device is suddenly moved to obtain extreme positive pitching acceleration (nose up). In defining the tail load condition, the response of the airplane must be taken into account. Airplane loads that occur subsequent to the normal acceleration at the center of gravity exceeding the maximum positive limit maneuvering factor, n, need not be considered.

(b) *Pitch maneuver loads.* In addition to the requirements of § 25.331; it must be established that pitch maneuver loads induced by the system itself (e.g., abrupt changes in orders made possible by electrical rather than mechanical combination of different inputs) are accounted for.

(c) *Roll maneuver loads.* In lieu of compliance with § 25.349(a), the following conditions, speeds, and spoiler and aileron deflections (except as the deflections may be limited by pilot effort) must be considered in combination with an airplane load factor of zero and of two-thirds of the positive maneuvering factor used in design. In determining the required aileron and spoiler deflections, the torsional flexibility of the wing must be considered in accordance with § 25.301(b).

(1) Conditions corresponding to steady rolling velocities must be investigated. In addition, conditions corresponding to maximum angular acceleration must be investigated. For the angular acceleration conditions, zero rolling velocity may be assumed in the absence of a rational time history investigation of the maneuver.

(2) At $V_A$, sudden deflection of the cockpit roll control up to the limit is assumed.

(3) At $V_C$, the cockpit roll control must be moved suddenly and maintained so as to achieve a rate of roll not less than that obtained in paragraph (2).

(4) At $V_D$, the cockpit roll control must be moved suddenly and maintained so as to achieve a rate of roll not less than one third of that obtained in paragraph (2).

(5) It must also be established that roll maneuver loads induced by the system itself (i.e., abrupt changes in orders made possible by electrical rather than mechanical combination of different inputs) are acceptably accounted for.

(d) *Yaw maneuver loads.* In lieu of compliance with § 25.351, the airplane must be designed for loads resulting from the conditions specified in paragraph (e) below. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces. Physical limitations of the airplane from the cockpit yaw control device to the control surface deflection, such as control stop position, maximum power and displacement rate of the servo controls, or control law limiters, may be taken into account.

(e) *Maneuvering.* At speeds from $V_{MC}$ to $V_D$, the following maneuvers must be considered. In computing the tail loads, the yawing velocity may be assumed to be zero.

(1) With the airplane in unaccelerated flight at zero yaw, it is assumed that the cockpit yaw control device (pedal) is suddenly displaced (with critical rate) to the maximum deflection, as limited by the stops.

(2) With the cockpit yaw control device (pedal) deflected as specified in paragraph (1) above, it is assumed that the airplane yaws to the resulting side slip angle (beyond the static side slip angle).

(3) With the airplane yawed to the static sideslip angle with the cockpit yaw control device deflected as specified in paragraph (1) above, it is assumed that the cockpit yaw control device is returned to neutral.

### *6. Limit Engine Torque Loads for Sudden Engine Stoppage*

In lieu of showing compliance with § 25.361(b), the following apply:

(a) For turbine engine and auxiliary power unit installations, the mounts and local supporting structure must be designed to withstand each of the following:

(1) The maximum limit torque load imposed by—

(i) A sudden deceleration due to a malfunction that could result in a temporary loss of power or thrust capability, and could cause a shutdown due to vibrations; and

(ii) The maximum acceleration of the engine and auxiliary power unit.

(2) The maximum torque load, considered as ultimate, imposed by sudden engine or auxiliary power unit stoppage due to a structural failure, including fan blade failure.

(3) The load condition defined in paragraph (a)(2) of this section is also assumed to act on adjacent airframe structure, such as the wing and fuselage. This load condition is multiplied by a factor of 1.25 to obtain ultimate loads when the load is applied to the wing and fuselage structure.

### *7. Flight Characteristic Compliance Determination by Use of the Handling Qualities Rating System (HQRS) for EFCS Failure Cases*

(a) In lieu of showing compliance with § 25.672(c), a handling qualities rating system will be used for evaluation of EFCS configurations resulting from single and multiple failures not shown to be extremely improbable. The handling qualities ratings are:

(1) Satisfactory: Full performance criteria can be met with routine pilot effort and attention.

(2) Adequate: Adequate for continued safe flight and landing; full or specified reduced performance can be met, but with heightened pilot effort and attention.

(3) Controllable: Inadequate for continued safe flight and landing, but controllable for return to a safe flight condition, safe flight envelope, and/or reconfiguration so that the handling qualities are at least adequate.

(b) Handling qualities will be allowed to progressively degrade with failure state, atmospheric disturbance level, and flight envelope. Specifically, within the normal flight envelope, the pilot-rated handling qualities must be satisfactory/adequate in moderate atmospheric disturbance for probable failures, and must not be less than adequate in light atmospheric disturbance for improbable failures.

### *8. Static Longitudinal Stability*

In lieu of compliance with § 25.173, the airplane must be shown to have suitable static longitudinal stability in any condition normally encountered in service, including the effects of atmospheric disturbance. The HQRS may be used to make this assessment.

### *9. Static Lateral-Directional Stability*

In lieu of compliance with § 25.177, the following applies:

(a) The airplane must be shown to have suitable static lateral directional stability in any condition normally encountered in service, including the effects of atmospheric disturbance. The HQRS may be used to make this assessment.

(b) In straight, steady sideslips, the rudder control movements and forces must be substantially proportional to the angle of sideslip in a stable sense; and the factor of proportionality must lie between limits found necessary for safe operation throughout the range of sideslip angles appropriate to the operation of the airplane. At greater angles, up to the angle at which full rudder is used or a rudder force of 180 pounds is obtained, the rudder pedal forces may not reverse; and increased rudder deflection must be needed for increased angles of sideslip. Compliance with this paragraph must be demonstrated for all landing gear and flap positions and symmetrical power conditions at speeds from 1.13 $V_{SR1}$, or 1.18 $V_{SR1_{PWR}}$ for flaps extended configurations, to $V_{FE}$, $V_{LE}$, or $V_{FC}$/ $M_{FC}$, as appropriate.

*10. Control Surface Awareness*

In addition to compliance with §§ 25.143, 25.671, and 25.672, when a flight condition exists where, without being commanded by the crew, control surfaces are coming so close to their limits that return to the normal flight envelope and (or) continuation of safe flight requires a specific crew action, a suitable flight control position annunciation shall be provided to the crew, unless other existing indications are found adequate or sufficient to prompt that action.

**Note:** The term suitable also indicates an appropriate balance between nuisance and necessary operation.

*11. Steep Approach Air Distance*

In lieu of compliance with § 25.125(a) for steep approach landing distances, the following applies:

(a) The horizontal distance necessary to land and to come to a complete stop, including an airborne distance of no less than the greater of 500 feet or the distance resulting from the combination of an aim point on the runway offset 300 feet from the runway threshold to be used in operations plus the demonstrated 3σ touchdown dispersion distance from the touchdown aim point, must be determined (at each weight for temperature, altitude, and wind within the operational limits established by the applicant for the airplane) as follows:

(1) The airplane must be in the landing configuration.

(2) A stabilized approach, with a calibrated airspeed of not less than $V_{REF}$ or $V_{MCL}$, whichever is greater, must be maintained down to the 50 foot height. $V_{REF}$ may not be less than—

(i) 1.03 $V_{SR0}$;

(ii) 1.20 $V_{SR0_{PWR}}$ with the operative engines at the power or thrust setting for approach at the reference flight path angle;

(iii) The airspeed that provides an angle-of-attack margin to stall for not less than a 20 knot equivalent airspeed vertical gust with all engines operating at the power or thrust setting for approach at the reference flight path angle;

(iv) The airspeed that provides an angle-of-attack margin to stall for not less than a 15 knot equivalent airspeed vertical gust with the critical engine inoperative at the power or thrust setting for approach at the reference flight path angle; and

(v) A speed that provides the maneuvering capability specified in paragraph (k) of Special Condition 1.

(3) Changes in configuration, power or thrust, and speed, must be made in accordance with the established procedures for service operation.

(4) The landing must be made without excessive vertical acceleration, tendency to bounce, nose over, ground loop, or porpoise.

(5) The landings may not require exceptional piloting skill or alertness.

*12. Landing Distances for Special Approaches to Short Field Landings*

(a) In lieu of compliance with § 25.125(a), the following applies: The horizontal distance necessary to land and come to a complete stop from a point 50 feet above the landing surface must be determined (for each weight, altitude, wind, temperature, and runway slope within the operational limits established for the airplane) as follows:

(1) The airplane must be in the landing configuration.

(2) A stabilized approach, with a calibrated airspeed of not less than $V_{REF}$ or $V_{MCL}$, whichever is greater, must be maintained down to the 50 foot height. $V_{REF}$ may not be less than—

(i) 1.03 $V_{SR0}$;

(ii) 1.20 $V_{SR0_{PWR}}$ with the operative engines at the power or thrust setting for approach at the reference flight path angle;

(iii) The airspeed that provides an angle-of-attack margin to stall for not less than a 20 knot equivalent airspeed vertical gust with all engines operating at the power or thrust setting for approach at the reference flight path angle;

(iv) The airspeed that provides an angle-of-attack margin to stall for not less than a 15 knot equivalent airspeed vertical gust with the critical engine inoperative at the power or thrust setting for approach at the reference flight path angle; and

(v) A speed that provides the maneuvering capability specified in paragraph (k) of Special Condition 1.

(3) Changes in configuration, power or thrust, and speed, must be made in accordance with the established procedures for service operation.

(4) The landing must be made without excessive vertical acceleration, tendency to bounce, nose over, ground loop, or porpoise.

(5) The landings may not require exceptional piloting skill or alertness.

(b) In lieu of compliance with § 25.125(b), the following applies: For land planes, the landing distance on land must be determined on level, smooth, dry and wet, hard-surfaced runways. In addition—

(1) The pressures on the wheel braking systems may not exceed those specified by the brake manufacturer;

(2) The brakes may not be used so as to cause excessive wear of brakes or tires; and

(3) Means other than wheel brakes may be used if that means—

(i) Is safe and reliable;

(ii) Is used so that consistent results can be expected in service; and

(iii) Is such that exceptional skill is not required to control the airplane.

(4) The average touchdown rate of descent must not exceed 4 feet per second and the approach flight path angle must be no steeper than −3 degrees for a normal approach.

(c) Procedures must be established by the applicant for use in service that are consistent with those used to establish the performance data under this special condition. These procedures must be able to be consistently executed in service by crews of average skill, and must include, as applicable, speed additives for turbulence and gusts for approaches with all engines operating and with an engine failure on final approach, and the use of thrust reversers on all operative engines during the landing rollout.

(d) The procedures and performance data established under this special condition must be furnished in the Airplane Flight Manual.

*13. Thrust for Landing Climb*

In lieu of compliance with § 25.119(a), the following applies: The engines at the power or thrust that is available eight seconds after initiation of movement of the power or thrust controls to the go-around power or thrust setting from the thrust level necessary to maintain a stabilized approach at a flight path angle two degrees steeper than the desired flight path angle.

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**Vi L. Lipski,**

*Acting Manager, Transport Airplane Directorate, Aircraft Certification Service.*

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## DEPARTMENT OF TRANSPORTATION

## Federal Aviation Administration

## 14 CFR Part 39

**[Docket No. 98–CE–87–AD; Amendment 39–11434; AD 99–24–10]**

**RIN 2120–AA64**

## Airworthiness Directives; Precise Flight, Inc. Model SVS III Standby Vacuum Systems

**AGENCY:** Federal Aviation Administration, DOT.