26 January 1999

COMMENTS AND RESPONSES

ON

NPA 25B-215 STALL AND STALL WARNING SPEEDS AND MANOEUVRE CAPABILITY

1. Introduction

NPA 25B-215 was circulated for consultation by JAA on 15 February 1996. The NPA proposed that the stall speed used as a datum speed in many other requirements should be re-defined as a reference stall speed, V_{SR}, which was not less than the 1-g stall speed. Proposals were also made for more extensive demonstrations of manoeuvre capabilities at scheduled operating speeds without encountering stall warning. Consequential amendments were proposed to other requirements throughout JAR 25 (except for sub-part C, which is being addressed separately) where stall speeds are referred to. Proposals were also made to introduce appropriate definitions into JAR 1.

JAA received significant comments from :-

AECMA
AIA
ALPA
Australian Flight Test Services (AFTS)
Bombardier (Canadair)
DGAC-France

Douglas Aircraft Company
LBA
Raytheon
Transport Canada

In addition, IFALPA endorsed the ALPA comments. CAA (UK) made an observation related to the NPA and the proposals were endorsed without comments by Airtours International and the regulatory authorities of Denmark, Hungary and Monaco.

The proposals had been fully harmonised with the FAA who published an equivalent NPRM (Notice 95-17) proposing amendments to FAR 25 and FAR 1. The comments received by the FAA closely matched those received by JAA, but included some additional comments. To satisfy the desire that the finally adopted changes are fully harmonised between JAA and FAA, all comments received were jointly addressed.

The vast majority of the proposals, dealing solely with consequential adjustments to the factors applied to datum stall speeds in other requirements, attracted no comments at all. No commentators commented adversely on the principle of re-defining the datum stall speed as the 1-g speed, although comments were received on the detail of how the new datum speed (the reference stall speed) was defined. The principle of adjusting factored stall speeds by roughly 94% to determine minimum operating speeds, in consequence to the shift in the datum speed, was also endorsed, except to the extent that views were expressed on extending this to aeroplanes with stick pushers.

The vast majority of the comments received were related to :-

25.103	stall speed definitions
25.143	manoeuvre demonstrations free of stall warning
25.207	stall warning

This document summarises all the significant comments received and JAA's responses to them.

2. Adoption of Proposals that Received no Comments

The proposals related to the regulatory and guidance paragraphs listed below attracted no comments and are adopted without further change :-

JAR 1.2	Definitions
ACJ 25.21(d)	Flight test tolerances
JAR 25.107	Take-off speeds
JAR 25.111	Take-off path
JAR 25.119	Landing climbs : all-engines-operating
JAR 25.121	Climb : one-engine-inoperative
JAR 25.125	Landing
ACJ 25.145(d)	Longitudinal control-take-off climb
JAR 25.147	Directional and lateral control
JAR 25.149	Minimum control speed
JAR 25.161	Trim
JAR 25.175	Demonstration of static longitudinal stability
JAR 25.181	Dynamic stability
JAR 25.201	Stall demonstration (except that the proposed change to the ACJ cross-reference in JAR 25.201(c)(1) is further amended to read "ACJ 25.103(c)" due to editorial changes elsewhere).
ACJ 25.201(a)(2)	Stall demonstration
ACJ 25.203	Stall characteristics
JAR 25.231	Longitudinal stability and control (ground handling)
JAR 25.233	Directional stability and control (ground handling)
JAR 25.237	Wind velocities
JAR 25.773	Pilot compartment view
JAR 25.1001	Fuel jettisoning system
JAR 25.1323	Airspeed indicating system
ACJ 25.1323(c)(2)	Airspeed indicating system
JAR 25.1325	Static pressure systems
ACJ 25.1329	Automatic pilot
JAR 25.1533	Additional operating limitations

3. Discussion of Comments Received

3.1 JAR 25.103 and associated guidance material. Stall speed.

In a covering letter to the NPA, JAA particularly sought comments on the question of whether aeroplanes fitted with a stick pusher, or similar device, should be treated differently, compared to aeroplanes with acceptable natural stalling characteristics. For such aeroplanes, the NPA proposed that the reference stall speed, V_{SR}, should be limited by the greater of the 1-g stall speed and the speed at which the device operated in 1-g flight. Thus, there would have been no penalty in terms of V_{SR}, compared to aeroplanes without such a device, where the device was set to operate at or beyond the C_{LMAX} point. Where the device operated before reaching the C_{LMAX} point, there would be a penalty but only to the extent that the device limited the C_L that could be demonstrated.

Even amongst the specialist study group that sponsored the NPA, there were divided views, with some believing strongly that a distinction should be made, for the reasons expressed in JAA's covering letter. A recent example of a turbojet aeroplane with a stick pusher and certificated in accordance with the 1-g stall speed concept, has been cited. In this case, the (non-JAA) domestic certificating authority required that the reference stall speed be declared as not less than 2 knots or 2% above the speed at which the stick pusher would operate in 1-g flight.

Two commentators responded in detail on this point. There was the manufacturer and the domestic certificating authority involved with the turbojet aeroplane cited above. The manufacturer supported the NPA proposals in making no distinction between pusher-equipped aeroplanes and those certificated on the basis of natural stalling characteristics. They believed that this provided similar safety in each case such that no safety case existed for applying higher margins between the pusher speed and operating speeds. This commentator also cited a European turbopropeller aeroplane with a stick pusher that had been widely certificated and validated (including by their own domestic authority) without the additional speed margins that had been imposed on their aeroplane.

The original certificating authority involved in this turbojet aeroplane commented that the proposals would probably have little effect on the minimum operating speeds for conventionally stalling aeroplanes, but could result in significant reductions, compared to existing requirements, for stick pusher aeroplanes. This would introduce a reduced level of safety compared to existing requirements and service experience related to pusher aeroplanes. They agreed that additional margins were not required for equivalence in lift margins, but argued that they were required to ensure equivalence with conventionally stalling aeroplanes in terms of protection provided by a pusher system, flight characteristics and system reliability and safety. It was these concerns that led this authority to set additional margins of 2% on minimum operating speeds on the turbojet aeroplane they had certificated; i.e. V_2 not less than 1.15 times the pusher speed and V_{REF} not less than 1.25 times the pusher speed, compared to factors of 1.13 and 1.23, respectively, that would be permissible in accordance with the NPA. It was pointed out that both JAA and FAA had subsequently validated this aeroplane without changing the original authority's certification standard in this respect. The commentator also suggested that there was a similarity between their standard and the additional stall warning criterion proposed in the NPA for stick pusher aeroplanes (proposed JAR 25.207(d)).

This authority commentator also referred to the turbopropeller aeroplane with a stick pusher which they had evaluated and accepted without these additional margins. They reported that the aeroplane in question had excellent pusher and aircraft response characteristics, and that there was a significant, beneficial, effect of power on stall reference speed and manoeuvre capability at scheduled operating speeds, even in the asymmetric power case. This combination of factors had satisfied them that the relevant parts of the NPA could be applied without change in that case.

To account for their views, this commentator proposed an additional sub-paragraph to JAR 25.103, as amended by the NPA, to read :-

"In addition to the requirements of (sub-paragraph (c) of this paragraph), when devices that abruptly push the nose down at a selected angle of attack (e.g. stick pushers) are installed, the reference stall speed, V_{SR}, may not be less than 2 knots or 2 per cent, whichever is greater, above the speed at which the device operates. This requirement is not applicable for turbopropeller powered aircraft which demonstrate a significant reduction in the stall speed in the one engine inoperative, power on condition."

JAA concurs with the proposal of the foreign authority commentator quoted above, that requiring the reference stall speed to be not less than 2 knots or 2 per cent, whichever is the greater above the speed at which the device operates, would provide a suitable criterion for such aeroplanes. JAA concurs with the commentator's analysis and fundamental principle that in terms of the protection from stall provided by such a device, the characteristics resulting from its operation, and its reliability and safety result in significant differences from a conventionally stalling airplane. Also, the difference between the 1-g stall speed and the minimum speed obtained in the stalling maneuver for this class of airplanes is more like 0 to 3 percent, rather than the 6 percent average for conventionally stalling airplanes upon which the reduction in operating speed factors was based. Permitting a significant reduction in the operating speeds for this class of airplanes could potentially result in a reduction in safety that is not justified by existing operational experience. The commentator's suggested additional constraint on V_{SR} represents a reasonable means to retain approximately equivalent safety without penalizing airplanes for which the device trigger point is at an angle-of-attack well beyond $C_{L_{MAX}}$. Therefore, as adopted, JAR 25.103(d) requires, for airplanes equipped with a device that abruptly pushes the nose down at a selected angle-of-attack, that V_{SR} not be less than 2 percent or 2 knots, whichever is greater, above the speed at which the device operates.

The same commentator had proposed that this additional criterion for aeroplanes with a stall identification device should not apply to "turbopropeller powered aircraft which demonstrate a significant reduction in the stall speed in the one engine inoperative power on condition". JAA recognises that this qualification to the "2 knots/2 per cent" criterion would avoid establishing an anomaly for one turbopropeller design that has been certificated with a stick pusher and without this criterion. However, JAA believes it would introduce a number of other concerns and anomalies. JAR 25 contains no requirements related to stalling with asymmetric power; indeed, such requirements were deleted from both FAR and JAR 25 some while ago. The beneficial effect of power on stall speeds applies to all aeroplanes, particularly those which are propeller-driven. It would be anomalous to give credit for this effect on the datum stall speeds only in the case of aeroplanes with stick pushers or similar devices. The reference stall speed is intended to provide a datum applicable to the critical loading and power conditions. Where the beneficial effects of power are significant under scheduled operating conditions, JAR 25 will continue to permit credit for this in the related operating speeds (see JAR 25.107(b)(2) and 25.119(b)(1)). This aspect of the commentator's proposal is not accepted and the criterion that V_{SR} shall not be less than 2 knots or 2 per cent, whichever is greater, above the speed at which a device such as a stick pusher operates, is adopted for all aeroplanes fitted with such devices.

Two other commentators responded on this aspect of how aeroplanes with pushers, or similar devices, should be treated. One advocated no distinction, but called for urgent work to define design requirements for stick pushers. The other recommended additional speed margins, such as 2%, for pushers aeroplanes that had "severe lateral problems at higher angles of attack (catastrophic roll off)". No guidance was offered on what might be considered "severe" or "catastrophic roll off" in this context, but the proposal referred to the certification of the turbojet aeroplane discussed previously.

The manoeuvre criteria contained in proposed new JAR 25.143(g) will ensure that all aeroplanes, whether or not they are equipped with a stick pushers or similar device, will satisfy minimum acceptable margins in terms of lift capability at scheduled operating speeds. However, JAA has concluded that some recognition of the characteristics and implications of using an artificial stall identification system, and the history to date of their use, should continue to be made. JAA does not agree with the comment that distinctions should be limited to aeroplanes fitted with stick pushers due to "severe lateral problems at higher angles of attack (catastrophic roll off)". It is considered that the stall characteristics requirements of JAR 25.201 are sufficient and that it would not be appropriate to require subjective judgements of the degree of unacceptability against these requirements, as would be the effect of this commentators proposal.

Two other commentators proposed editorial changes to the proposed text of JAR 25.103 to aid clarity without altering the technical intent. JAA concurs and the final amendment to be adopted has been revised editorially, substantially as these commentators suggested.

One other commentator proposed that the reference stall speed be based on C_{NMAX}, rather than C_{LMAX}, where C_N refers to the aerodynamic force coefficient normal to the aeroplane's body axis. The commentator argued that this change would simplify the analysis required, with consequential accuracy and/or cost benefits for applicants, as the analysis would relate to fixed body axes, rather than to flight path axes (as in the case with C_L) which vary throughout the stalling manoeuvre. Furthermore, the commentator considered that this change would be slightly conservative (i.e. result in slightly higher values of V_{SR}) for any practical transport aeroplane design. The commentator did not quantify the sensitivity in the determination of V_{SR} (based on C_{LMAX}) due to likely errors in assumed flight path angle or the degree of conservatism that would be introduced for typical aeroplanes. This latter point would offset any economic benefits to operators of the suggested simplification of flight test instrumentation and analysis.

These concerns over the analysis required, and any possible benefit of basing V_{SR} on aeroplane body axes, were not raised by any aircraft manufacturer. JAA does not consider that those certifications carried out so far using the 1g stall speed concept, based on C_{LMAX}, have revealed any significant problems with determining the required speeds to sufficient accuracy. The amendment to be adopted has not been changed due to this comment.

One commentator questions the reason for the new wording in JAR 25.103(a)(1) to describe the option of idle or zero thrust. The commentator does not see the new wording as an improvement in clarity. The current rule states that zero thrust must be used in determining the stalling speed, except that idle thrust may be used when it does not appreciably affect the stalling speed. Stated in this manner, the rule permits the use of zero thrust when idle thrust causes an increase in the stalling speed. On some turboprop airplanes, where flight idle thrust may be negative, a lower stall speed may be demonstrated using zero thrust than would occur with idle thrust.

The JAA considers such a loss of stall speed margin in a normal flight condition to be unacceptable. In NPA, the JAA proposed a change such that the reference stall speed must be determined with idle thrust, except in cases where that thrust level causes an appreciable decrease in the stall speed, not more than zero thrust must be used. There were no comments regarding the substance of the proposed change; therefore, this section is adopted as proposed.

A commentator suggests that it is technically more accurate in JAR 25.103(c) to refer to the lift coefficient in the definition of $V_{C_{L_{MAX}}}$ as the load factor-corrected lift coefficient. The commentator also considers the proposed definition of $V_{C_{L_{MAX}}}$ to be ambiguous and lacking in guidance material that would provide clarification. Other commentators made various editorial and formatting suggestions to further improve the clarity of JAR 25.103. The JAA agrees with these suggestions and has modified the proposal accordingly

3.2 JAR 25.143 Controllability and Manoeuvrability : General

The JAA received several comments regarding the proposed addition of maneuvering requirements as a new JAR 25.143(g). One commentator suggests that the JAA should perform a rigorous study before including a specific gust margin in airplane maneuvering requirements. The commentator points out that the same atmospheric gust would have different effects at different airspeeds, and that using the same gust margin throughout causes the proposed after takeoff maneuvering requirement at V_2 speed to be unduly restrictive. In a similar vein, another commentator believes that the need for a 15-degree overshoot capability should first be justified by authorities. This commentator suggests that a 5-degree overshoot, as specified as an objective for accomplishing steep turns in the "Airplane Transport Pilot and Type Rating Practical Test Standards," would be more reasonable.

Several commentators claim that the proposed maneuvering requirements, particularly the one associated with the final takeoff speed (V_{FTO}), are excessive and would be difficult to meet without increasing the operating speeds. One commentator notes that for an airplane equipped with a stick pusher that activates near $C_{L_{MAX}}$, due to design tolerances for the stick pusher and stall warning systems, V_2 and V_{FTO} would most likely be set by the proposed maneuvering requirements rather than the 1.13 and 1.18 factors applied to V_{SR}, respectively. Another commentator notes that the maneuvering requirement associated with V_{FTO} relates to a one-engine-inoperative condition of short duration, after which the airplane is accelerated to the en route climb speed. This commentator suggests that a maneuvering bank angle of 30 degrees, the same as specified for the takeoff safety speed (V_2) one-engine-inoperative condition, would be more appropriate for this condition.

This commentator goes on to say that for many existing large transport category airplanes, an early onset of natural stall warning results in a larger stall warning margin than the minimum margin required by the regulations. At V_{FTO} , these airplanes would have a maneuvering capability to stall warning of less than the proposed 40 degrees of bank, possibly as low as 27 degrees. Requiring 40 degrees of bank capability would necessitate an increase in V_{FTO}, which could affect the net takeoff flight path used for clearance of distant obstacles. Either a different departure path may be necessary in the event of an engine failure, or takeoff weight may have to be reduced. The commentator considers the existing rule to be adequate, and the potential penalties associated with the JAA's proposal to be unjustifiable.

This commentator also questions whether the proposed 40 degree bank angle requirement at V_{FTO} was based on a 25 degree bank angle limit used by many current flight guidance systems. If so, this commentator considers such reasoning to be flawed in that not all flight guidance systems use 25 degrees as their bank angle limit. In some cases, flight guidance systems are limited to a 15 degree bank angle at the final takeoff speed.

As a final comment on this section, this commentator suggests that if the JAA believes that increased bank angles are appropriate for the en route flight paths, which are of longer time duration, this need should be addressed separately from the takeoff flight path requirements. However, the commentator does not consider it necessary to do so as this commentator is unaware of any associated safety issues.

The JAA disagrees that the maneuvering requirements specified in the proposed JAR 25.143(g) are excessive, including the proposed 40 degree bank angle requirement at V_{FTO}. These maneuvering requirements are comparable to the maneuvering capability implied by the current regulations assuming the stall warning margin is near the regulatory minimum. Safety records and operating practices indicate that low speed maneuvering capability is a genuine concern.

Some airports necessitate close-in maneuvering on a regular or contingency basis. Accidents and incidents have occurred due to windshear, icing, and high-lift device anomalies. The ability to tolerate such operational conditions can depend on the maneuvering capability at the designated minimum operating speeds.

The proposed maneuvering requirements consist of the minimum bank angle capability the JAA deems adequate for the specified regimes of flight combined with a further 15 degrees of bank angle to provide a safety margin for various operational factors. These operational factors include both potential environmental conditions (e.g., turbulence, wind gusts) and an allowance for piloting imprecision (e.g., inadvertent overshoots). Because this safety margin does not represent either a specific gust margin or expected piloting precision alone, the JAA does not consider it necessary to either perform a rigorous study of the effect of atmospheric gusts nor to restrict the size of the margin to a piloting test standards objective as suggested by the commentators. The allowance and magnitude of the proposed bank angle margin is also consistent with typical industry practice.

The maneuvering requirement at V_2 speed with one engine inoperative is derived from the 15 degree bank angle allowed after takeoff plus the specified 15 degree safety margin. At the higher speed of V_{FTO}, after the airplane has transitioned to the en route configuration and is farther along in the flight path, it is reasonable to require additional maneuvering capability appropriate to that phase of flight. The JAA considers an additional 10 degrees of maneuvering capability to be a reasonable expectation for a minimum capability after transitioning to the en route configuration and accelerating to the final takeoff climb speed. This same level of maneuvering capability exists on most transport category airplanes currently in service, and the JAA does not see a compelling reason to set a lower minimum standard. The JAA considers this same maneuvering capability (25 degrees of bank plus a 15 degree safety margin) to also be appropriate for the normal all-engines-operating takeoff case as well as for the landing approach.

In addition to receiving comments on the minimum bank angles proposed for the new JAR 25.143(g), the JAA received comments on the footnotes accompanying the table of conditions to be demonstrated. A commentator notes that because the trigger point of an artificial stall warning device may vary with thrust or power setting, the proposed wording of footnote 1 may not cover the most critical condition for determining the airplane's maneuver margin. This commentator suggests adding the phrase "or any greater thrust or power if more critical" to the thrust/ power setting references in footnotes 1 and 3 to the table in JAR 25.143(g).

Although the JAA agrees with the intent of this comment, the JAA believes that the comment may stem from a misinterpretation of the proposed requirement. The condition specified in the proposed footnote 1 to JAR 25.143(g) represents the highest thrust or power setting for the applicable conditions of weight, altitude, and temperature. If system design features or other relevant characteristics result in any condition of weight, altitude, or temperature being more critical than another,

compliance with this requirement must be demonstrated for the most critical condition of weight, altitude, and temperature. This point is addressed in the proposed ACJ 25.143(g)(3).

The commentator further suggests simplifying the text of footnote 3 by replacing the JAA proposed text with, "The critical thrust or power for all engines operating should be that which in the event of an engine failure would result in the minimum climb gradient specified in 25.121, or any greater thrust or power if more critical." Although the JAA agrees with the intent of simplifying this footnote, the wording proposed in NPA is needed to address all-engines-operating climb procedures, such as those used for noise abatement, that may use a thrust or power setting less than that used during the takeoff. The suggestion regarding greater thrusts or power settings is addressed in the preceding paragraph.

JAR 25.143(g) is adopted as proposed.

3.3 JAR 25.145 Longitudinal control

One commentator suggests that the NPA25B-215 proposal to replace "V_S" with "the stall" in JAR25.145(a) is misleading and inaccurate relative to the NPA 25B-215 supporting discussion. The commentator believes that changing "V_S" to "the stall" is unsatisfactory for two reasons: (1) "The stall" is a vague terminology that might generally be defined by JAR 25.201(d), but without defining the configuration (i.e., flaps, center-of-gravity position, power, etc.); and (2) The ACJ 25.145(a) of NPA 25B-215 states that the demonstration should only have to be conducted down to stall warning speed plus one second, which is less demanding than the proposed new JAR25.145(a). Therefore, the commentator suggests adding the words "In a deceleration" at the beginning of JAR25.145(a) and replacing the proposed reference to "the stall" with "one second after stall warning."

JAA does not intend for the change in the reference stall speed to alter the basic requirement of JAR25.145(a), namely that the capability exist on transport category airplanes, at the specified configurations and power settings, to pitch the nose down from any point in the stalling maneuver and regain the trim speed. The commentator's suggested change would reduce the stringency of the regulatory requirement, while depending on non-regulatory guidance material to provided assurances that equivalent capability is retained.

Because the JAA cannot rely on non-regulatory material to establish a capability required of the airplane, the JAA has not adopted the commentator's suggested change. However, to improve clarity, the words "the stall," proposed in NPA 25B-215 have been replaced by "stall identification (as defined in JAR 25.201(d))" in the adopted JAR 25.145(a). In addition, ACJ 25.145(a) addresses techniques to show compliance with this requirement..

3.4 JAR 25.177

Two comments were received regarding the flight test demonstrations to show compliance with JAR 25.177. Both comments were relative to the safety aspects of conducting full rudder sideslips at low airspeeds, as required by the current rule, although both commentators also noted that this situation may be exacerbated by the lower speeds that can result from the proposed change. The proposed change is not intended to result in overall lower speeds. Because these comments raise an issue on not only speed but also on rudder deflection that is beyond the scope of the NPA25B-215 proposals, JAR 25.177 has been adopted as proposed. These comments will be retained for consideration of potential future rulemaking to address the concerns expressed by the commentators.

3.5 JAR 25.207 Stall warning

There were many comments on the proposed changes to the stall warning requirements of JAR 25.207. One commentator requests explicit criteria to address whether or not a stick shaker is required to provide stall warning, or if a visual or aural warning is sufficient. The issue of what constitutes an acceptable artificial stall warning is beyond the scope of this rulemaking. However, as stated in the current JAR 25.207(b) (and unchanged by this rulemaking), "a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself."

Several commentators took issue with the proposed three percent or three knots stall warning margin of JAR 25.207(c). One commentator believes that the proposal represents an unjustified increase in the severity of this requirement relative to the current rules. This commentator notes that a requirement for stall warning to begin one percent above the 1-g stall speed would be equivalent to the current requirement of a seven percent margin from the minimum speed obtained in the stalling maneuver. As a compromise, this commentator suggests a two percent or two knot stall warning margin relative to the redefined reference stall speed. Another commentator has a concern over possible difficulties in showing compliance with the proposed arbitrary numerical margin for airplanes with a gradual loss of lift as the angle-of-attack for maximum lift is exceeded. Both of these commentators request that any increase in the severity of this requirement: (1) be tempered such that inappropriate design changes are not imposed for small shortfalls in meeting the strict numerical criteria; and (2) be taken into account in the Aviation Rulemaking Advisory Committee (ARAC) discussions of stall warning margin when operating in icing conditions.

Another commentator has concerns that the change in stall warning margin requirements will reduce the margin that is currently required and therefore would not retain the existing level of safety. This commentator believes that the proposed margin would not represent a reasonable balance between providing the pilot with enough warning to avert an impending stall and providing adequate maneuvering capability at the minimum operating speeds. This commentator suggests retaining the current FAA standard of seven knot stall warning margin from the reference

stall speed, even though the reference stall speed would be redefined as the 1-g stall speed, in order to retain the existing level of safety.

Another commentator considers the proposed JAR 25.207(c) to represent an unjustified increase in the currently required minimum stall warning margin that would inhibit use of part of the airplane flight envelope within which the airplane is controllable without risk of structural damage. The commentator remarks that in windshear avoidance maneuvers, the likelihood of escape is maximized by flying at the minimum controllable airspeed. The commentator also disagrees with the statement made in NPA 25B-215 that a speed lower than the 1-g stall speed represents a transient flight condition. The commentator notes that in steady climbing flight, the lift force needed to sustain steady flight is less than the airplane weight, and for larger climb angles, steady flight is sustainable at speeds lower than the 1-g stall speed. This commentator suggests revising the proposed JAR 25.207(c) to require the stall warning to begin at the greater of: (1) a speed higher than either one knot or one percent higher than the reference stall speed; or (2) seven knots or seven percent higher than the speed at the occurrence of a stall (as defined in JAR 25.201(d)).

Other comments were received on the proposed JAR 25.207(c) relative to the engine thrust or power setting associated with the proposed three percent or three knot stall warning margin. Two commentators support removing the reference to "engines idling and throttles closed" so that the same stall warning margin would apply to all power and thrust settings. One commentator suggests that to be consistent with the proposed JAR 25.103(a)(1) it is unnecessary to refer to throttles. This commentator also questions why the proposal states that "JAR 25.103(a)(5) does not apply" when defining the reference stall speed to be used in connection with this requirement.

In combination with adopting the 1-g stall speed as the appropriate benchmark for the low speed end of an airplane's limit flight envelope, the JAA considers a warning three knots or three percent prior to reaching this speed to be the minimum margin needed to prevent the crew from inadvertently slowing beyond this speed. A categorical statement regarding the severity of this requirement relative to the current requirement cannot be made since the effect of the change in the reference stall speed will vary with airplane type (and with the high lift device configuration on a given type).

The JAA does not consider the proposed stall warning margin to unduly restrict access to useable parts of the airplane flight envelope. Relative to windshear escape, the dynamic nature of windshear warrants, if anything, a larger speed margin to the stalled condition. Using current windshear escape procedures, frequent and irregular penetrations of the stall warning margin are more likely to occur. This type of trained maneuver was not envisioned when the current stall warning requirements were promulgated. Regarding the comment that for climbing flight the lift force will be less than the airplane's weight, this condition is irrelevant

for establishing the reference stall speed or defining a reasonable stall warning margin. The JAA believes that the intent of the proposal is sufficiently clear in this respect.

The JAA agrees that the stall warning margin for other than idle thrust or power settings should be addressed. The JAA did not intend to restrict consideration of the adequacy of the stall warning margin to only the idle thrust or power condition. The general requirement for a stall warning with sufficient margin to prevent inadvertently stalling prescribed by JAR 25.207(a) applies to all normal configurations and flight conditions. The three knot or three percent warning margin reference in the proposed JAR 25.207(c) would specifically quantify this requirement for the conditions under which V_{SR} is determined. At other conditions, the JAA would have expected an equivalent margin to that prescribed by JAR 25.207(c). However, there is an inherent difficulty in either specifying an appropriate warning margin or determining an equivalent warning margin to that specified in the proposed JAR 25.207(c) for conditions other than idle thrust or power, straight flight, and the center-of-gravity position defined in the proposed JAR 25.103(a)(5), because V_{SR} is undefined for those other conditions.

In response to the comments, and to clarify the situation regarding the acceptable stall warning margin for conditions other than those under which V_{SR} is defined, the JAA has decided to revise the proposed JAR 25.207(c) by retaining the criteria of the current JAR 25.207 (c) which specifies that stall warning must begin at least five knots or five percent, whichever is greater, prior to the speed at which the airplane is considered stalled (as defined in JAR 25.201(d)). This criteria is not limited to specific conditions of thrust or power, throttle position, or center-of-gravity position, and moreover it insures a clear equivalent safety with the current rule.

The proposed three knot or three percent (whichever is greater) stall warning margin requirement relative to V_{SR} is retained in JAR 25.207(d) as an additional criterion applicable to that specific flight condition. The reference to throttles has been removed, as has the statement that the proposed JAR 25.103(a)(5) should not apply when defining the reference stall speed to be used in connection with this requirement. In response to the commentator's question, the reference to JAR 25.103(a)(5) had been proposed because the proposed definition of the reference stall speed would have required that the center-of-gravity position for determining the reference stall speed would be that which results in the highest value of the reference stall speed. Since the center-of-gravity position at which the proposed three knot or three percent stall warning requirement would apply was not specified, it presumably would apply to all center-of-gravity positions. Therefore, without the proposed statement, a literal interpretation of the proposed requirement would have required the stall warning speed at any center-of-gravity position to be three knots or three percent above the stall speed evaluated at the most adverse center-of-gravity position. This was not the intention. Any evaluation of the effect

of center-of-gravity position on the stall warning margin should be based on the same center-of-gravity position for both the stall speed and the stall warning speed.

The proposed wording, along with additional explanatory material provided in ACJ 25.207(c) and (d) was intended to clarify that for center-of-gravity positions other than that specified in the proposed JAR 25.103(a)(5), the same center-of-gravity position should be used for both the stall speed and the stall warning speed. However, due to the potential for confusion over the proposed wording, and because the explicit stall warning speed margin prescribed by the proposed JAR 25.207(c) only applies to the conditions under which V_{SR} is determined, the proposed wording regarding center-of-gravity position has been removed. Instead, the center-of-gravity position specified in JAR 25.103(b)(5) (re-numbered from the proposed JAR 25.103(a)(5)) has been included in the list of conditions for which the specific three knot or three percent stall warning margin of the adopted JAR 25.207(d) applies. For other center-of-gravity positions, the acceptable stall warning margin is now addressed in the adopted JAR 25.207(c).

Because of the differences between naturally stalling airplanes and those that employ a device to abruptly push the nose down at a selected angle of attack to identify the stall, the JAA proposed that the stall warning margin for airplanes that employ these devices would be required to be five knots or five percent prior to the speed at which the device activates. The application of JAR 25.207(d), as adopted, in combination with the adopted new requirement of JAR 25.103(d) will ensure that there must be a 5 knot or 5 percent stall warning margin relative to V_{SR} for these airplanes. Therefore, the proposed JAR 25.207(d) is removed.

The stall speed margins required by the adopted JAR 25.207(c) and (d) must be available in terms of calibrated airspeed. Normally, test demonstrations at the conditions specified in JAR 25.201 (Stall demonstration) will be sufficient to show compliance with these requirements. However, if the stall warning margin for a particular airplane type varies significantly with power or thrust, center-of-gravity position, bank angle, of some other characteristic, additional test conditions may be necessary.

As with other JAR 25 requirements, shortfalls in demonstrating compliance with the literal terms of the stall warning margin requirements would necessitate either a design change, an exemption, or features that would provide equivalent safety using an alternate means of compliance. Other rulemaking projects in which the stall warning margin is an issue (e.g., discussions of flight in icing conditions by the Flight Test Harmonisation Working group) will be considered on their own merits.

Several commentators objected to the accelerated stall warning margin requirement proposed as a new JAR 25.207(e). Some of the commentators claim that, in some cases, attempts to demonstrate compliance with this proposed requirement during flight testing resulted in maneuvers that the commentators

consider inappropriate for a transport category airplane. These commentators provided several examples of the maneuvers they described as inappropriate. Other commentators noted that the phrase "to prevent stalling" needs further clarification. One commentator questioned the lack of a bank angle stipulation in the proposed requirement and provided an analysis indicating that bank angles of about 45 degrees have the greatest effect on aerodynamics. This commentator also claims that a prescribed load factor and deceleration rate are not simultaneously achievable at $C_{L_{MAX}}$. The commentator suggests revising the proposed JAR 25.207(e) to specify 30 degree banked turns (for consistency with the turning flight stall characteristics demonstration required by JAR 25.201(a)) with accelerated rates of entry into the stall, up to the greater of 1.5g load factor and 3 knots per second speed reduction. This suggestion was made by other commentators as well.

The JAA acknowledges that detailed guidance material is needed to ensure an appropriate and consistent demonstration of compliance with the proposed accelerated stall warning requirement

The purpose of the proposed requirement is to ensure that adequate stall warning exists to prevent an inadvertent stall under the most demanding conditions likely to occur in normal flight. The proposed conditions of 1.5g and a three kt/sec entry rate (i.e., airspeed deceleration rate) correspond to the steep turn maneuver prescribed in FAR regulation part 121, Appendices E and F for pilot initial and proficiency training, respectively, plus some margin for error (three degrees more bank and a decreasing airspeed). The elevated load factor will emphasize any adverse stall characteristics, such as wing drop or asymmetric wing flow breakdown, while also investigating Mach and potential aeroelastic effects on available lift. The proposed three kt/sec deceleration rate is intended to result in a reasonable penetration beyond the onset of stall warning. A 30-degree banked turn maneuver, as proposed by several of the commentators, produces a load factor of only 1.15g, which the JAA does not consider high enough to evaluate the effect of elevated load factor on the capability to prevent an inadvertent stall.

As noted by one of the commentators, the bank angle used during the maneuver to demonstrate compliance with this proposed requirement may affect the airplane's stall characteristics. However, this aspect is considered secondary to the primary effect of an elevated load factor on the stall warning margin. For this reason, as adopted, JAR 25.207(e) prescribes a load factor rather than a bank angle. An acceptable means of producing this load factor would be a 48-degree banked turn in level flight.

As adopted, JAR 25.207(e) requires an airspeed deceleration rate of at least two knots per second instead of rates up to three knots per second. This change clarifies the intent of achieving a reasonable deceleration rate rather than one specific value and will result in the intended penetration beyond the onset of stall warning. It is anticipated that with typical test techniques, requiring a deceleration rate of greater than two knots per second will result in deceleration rates close to

three knots per second. The power and trim conditions are now specified in the rule in order to ensure consistent application of this requirement.

To clarify the meaning of the phrase "to prevent stalling," the parenthetical expression, "(as defined in JAR 25.201(d))," has been added in the adopted JAR 25.207(e). Therefore, any of the acceptable indications of a stall applicable to stall demonstration testing is also considered an indication that the airplane has stalled during the accelerated stall warning demonstration. If any of these indications of a stall occur during the accelerated stall warning demonstration, compliance with JAR 25.207(e) will not have been demonstrated.

3.6 Miscellaneous

Two respondents offered comments relative to subpart C (Structure) of JAR 25. One of these commentators suggested that the interpretation of the stall speed used in subpart C be undertaken urgently as part of the Harmonization Work Program. The other commentator suggested that either subpart C should be reworked to reflect the introduction of V_{SR} or JAR 25.103 should introduce definitions of V_{S0} and V_{S1} in terms of V_{SR}.

These comments regarding subpart C of JAR 25 are beyond the scope of this rulemaking, which is confined to the definition of the stall speed used for airplane performance determination and handling characteristics. This amendment does not affect the stall speeds used in subpart C for structural analysis.