

Advisory Circulars

COMMERCIAL AND BUSINESS AVIATION ADVISORY CIRCULAR

No. 0247

2005.08.24

Training and Checking Practices for Stall Recovery

INTRODUCTION

Recent stall and upset accidents of turbojet aeroplanes has reinforced the need for appropriate training for the prevention of an aeroplane stall and for stall recovery. This *Commercial and Business Advisory Circular* (CBAAC) applies to the training and checking practices for the approach to a stall and for stall recovery for aeroplanes. This CBAAC does not apply to the phenomenon of tail-plane stall, usually associated with flight in icing conditions.

PURPOSE

The purpose of this CBAAC is to provide guidance and recommendations to operators, for stall recovery training, with the goal of ensuring flight crews recognize early indications of an approach to a stall and apply the appropriate recovery actions to prevent an aeroplane from entering a stall or upset.

REFERENCES

- Section 604.73 of the Canadian Aviation Regulations (CARs) and Section 624.73 of the *Private Operator Passenger Transportation Standards*;
- Standard 624 Schedule I - Pilot Proficiency Check (PPC) - Table of Requirements;
- Section 702.76 of the CARs and Section 722.76 of the *Commercial Air Service Standards* (CASS);
- Standard 722 Schedule I - PPC - Aeroplane;
- Section 703.98 of the CARs and Section 723.98 of the CASS;
- Standard 723 Schedule I - PPC;

- Section 704.115 of the CARs and Section 724.115 of the CASS;
- Standard 724 Schedule I - PPC - Synthetic Flight Training Device;
- Standard 724 Schedule II - PPC - Aeroplane;
- Section 705.124 of the CARs and Section 725.124 of the CASS;
- Standard 725 Schedule I - PPC - Synthetic Flight Training Device;
- Standard 725 Schedule II - PPC - Aeroplane;
- Standard 725 Schedule II - PPC - Cruise Relief Pilot;
- *Federal Aviation Administration (FAA) Advisory Circular (AC) 23-8A; Flight Test Guide for the Certification of Part 23 Airplanes, dated 2/9/89;*
- *FAA AC 25-7A; Flight Test Guide for the Certification of Transport Category Airplanes, dated 3/31/98;*
- *Flight Safety Foundation Accident Prevention; After Intentionally Stalling DC-8, Crew uses Incorrect Recovery Technique, Resulting in Uncontrolled Descent and Collision with Terrain, Vol. 54 No. 9, Sept 1997;*
- *Handling the Big Jets, D.P. Davies, Third Edition, Civil Aviation Authority (U.K.), reprinted February 1988;*
- *NASA Glenn Research Center Icing Branch; « Icing for Regional and Corporate Pilots » (Video); <http://icebox.grc.nasa.gov/>;*
- *Transport Canada Safety and Security - Approved Check Pilot Manual 7th Edition - November 2004, Revision 2 (TP 6533E).*

BACKGROUND

The CAR standards require that training for recovery from an approach to a stall be carried out, both where ground contact is imminent and where ground contact is not a factor. Many current training and checking practices typically assume that ground contact is imminent and have placed an emphasis on actions to minimize any altitude loss in a stall recovery.

For training and checking where ground contact is assumed to be imminent, a common practice is to approach a stall in level flight under prescribed conditions. Recovery is initiated by the application of maximum available engine thrust (or power) at the first indication of a stall while avoiding any altitude loss. Although a successful recovery may

be possible at low altitudes, this technique may result in a stall at high altitude, during manoeuvring flight or during flight with icing contamination.

Wing Aerodynamic Stall

The wing stalls when it reaches an angle of attack, where increasing airflow separation results in a large loss of lift and an increase in drag. Airflow separation is often indicated by airframe buffeting and a reduction in controllability of the aircraft. However for some aircraft, the loss in lift is sudden and without any preceding buffet.

The stall angle of attack is normally constant for a given configuration, but for swept wing turbojet aeroplanes generally reduces as altitude increases, because of Mach effects. The stall angle of attack for all aeroplanes significantly reduces when the wing, particularly the leading edge, is contaminated with ice or other contaminants. The speed at which an aeroplane stalls is not constant, but is a function of weight and the maneuvering load factor. Increased weight and load factors will increase stall speeds for a given stall angle of attack.

Certification Requirements

Certification testing of aeroplanes attempts to ensure that there is stall warning with sufficient margin to prevent inadvertent stalling. For many aeroplanes this warning is provided by a system such as a stick shaker. Inherent in the certification requirements is the assumption that the pilot will take the correct action to prevent the stall.

Certification also requires that the stall characteristics be satisfactory. Where the natural aerodynamic stall characteristics do not meet the certification requirements, systems are required to either prevent the aerodynamic stall or to ensure satisfactory characteristics. Hence for some aeroplanes stick pushers have been introduced to abruptly pitch the aircraft nose down and reduce the angle of attack.

Stall Recovery

Effective stall recovery requires a deliberate and smooth reduction in wing angle of attack. The primary pitch control (elevator) is the most effective control for recovery from high angle of attack flight under all flight conditions. In some circumstances, an increase in engine thrust (or power) can be used at low altitude to accelerate an aircraft from a low speed condition without losing altitude. However, at the angle of attack associated with stall warning the aerodynamic drag is high and engine acceleration may be slow, especially if the initial thrust is at idle, thus extending the recovery. At higher altitude where available thrust is lower, acceleration without losing altitude may be impossible.

Failure to promptly reduce the wing angle of attack at stall warning can result in a continuing increase in wing angle of attack and a stall. Turbojet engines may experience surging or compressor stalls at high angles of attack because of inlet flow interruptions. Asymmetric lift associated with wing airflow separation or loss of thrust associated with engine inlet flow interruptions may result in a lateral-directional upset or possibly a spin. If a stall is allowed to develop, full nose down pitch inputs may be necessary to ensure a stall recovery. Recovery from a fully developed stall will likely result in a significant altitude loss.

The following are specific flight conditions where the current training practices may fail to achieve a recovery from an approach to a stall approach and result in a stall or upset:

- Engine thrust may be insufficient for effective recovery at high altitudes, during flight with an engine inoperative, or when thrust is at idle. Turbojet engines normally require eight seconds to achieve go-around thrust from idle thrust at low altitudes. These values increase significantly at high altitudes;
- If engines are already developing maximum thrust, such as during a take-off, a go-around or an engine inoperative climb, there will not be any additional thrust available to initiate a stall recovery using thrust;
- Ice contamination can result in stall onset at lower angles of attack and an increase in stall speeds. Increased drag as a result of ice contamination may exceed the thrust (or power) available to maintain level flight. Failure to correctly operate ice protection systems in icing conditions, can result in an aerodynamic stall, which may precede the stall warning provided by a stick shaker and precede the protection provided by a stick pusher;
- Stall entry during manoeuvring flight results in higher stall speeds due to load factor and higher deceleration rate than demonstrated during training.

During high altitude flight the stall angle of attack and associated level flight pitch attitude will be significantly lower than experienced at lower altitudes. Low speed Mach buffet may precede the indications of an approach to a stall. These indications are not normally experienced at the altitudes that stall training is typically conducted.

In all of the preceding cases, a prompt reduction in wing angle of attack is necessary to prevent the angle of attack from increasing and an aerodynamic stall from occurring. **This requires that the primary pitch control (elevator) be used to initiate a stall recovery. The goal of minimizing altitude loss should be a secondary consideration, until a positive stall recovery has been assured.**

Training for Fully Developed Stalls

Many current training practices do not demonstrate a full stall and associated handling characteristics. This may leave flight crews insufficiently prepared to recognize and recover from an aerodynamic stall, should the recovery actions from the approach to a stall, not be successful.

POLICY DEVELOPMENT/ACTION

This CBAAC provides recommendations for training and checking associated with approaches to a stall that are consistent with the *Private Operator Passenger Transportation Standards*, CASS and the *Approved Check Pilot Manual*. The primary goal of the following recommendations is to provide appropriate training so that flight crews can recognize the early indications of stall or low speed buffet and take appropriate action to avoid a stall or upset. The following training recommendations are not intended to be prescriptive, but are intended as a guide for the development of an operator's stall recovery training program.

Training organizations should review and amend their ground and flight training curriculum for stall recognition and recovery to ensure that the training is appropriate to the particular aeroplane type for foreseeable flight conditions and configurations.

It is recommended the following ground, simulator, and where applicable, aeroplane training be undertaken for the initial type rating. The same training should also be conducted on the next recurrent, for those pilot's who have not been exposed to this training and recorded in the pilot's training records. Subsequent training, as required by the CARs should be conducted in accordance with these guidelines:

Recommended Ground Training

- Stall and low speed buffet characteristics peculiar to the aeroplane type;
- Operation and function of stall protection systems;
- The hazards of overriding or ignoring stall protection system indications and/or operation;
- Effects of icing and other contamination on stall characteristics and stall protection systems;
- Operation and function of ice protection systems and any effects on stall protection systems;
- Recommended recovery actions to apply at first indication of a stall (stall warning) and in the event of a stall;
- The effects of various control inputs on stall recovery to include:
 - o Primary pitch control and associated altitude loss that may be expected with the necessary nose down inputs;
 - o Thrust (or power) control;
 - o Aileron and rudder inputs for lateral/directional control;
 - o Effect of speed brakes;
 - o Requirement for disconnecting autopilots.
- For aeroplanes equipped with a stick pusher, recommended recovery actions in response to stick pusher activation, including activation when in close proximity to the ground;
- Avoidance of a secondary stall with particular emphasis on minimizing load factors during recovery;
- Consideration of proximity to terrain and expected altitude loss during stall recoveries;
- The necessity for smooth, deliberate and positive control inputs to avoid increasing load factors and secondary stalls. The need to avoid cyclical or oscillatory control

inputs to prevent exceeding the structural limits of the aircraft should be emphasized.

Recommended Simulator and Aircraft Training

The following are recommended basic recovery inputs to first indications of a stall, **with due considerations of aeroplane manufacturer's recommendations and for characteristics peculiar to specific aeroplane types:**

Simultaneously:

- Autopilot - disconnect (if not automatically disconnected at stall warning);
- Pitch Control - positive pitch reduction as necessary to reduce wing angle of attack, and to accelerate the aircraft (increase airspeed);
- Thrust (or Power) - apply maximum available;
- Rudder - control yaw with care.

After the initial actions have been taken:

- Speed brakes - ensure stowed;
- Roll attitude - roll to wings level;
- Pitch Control - as necessary to avoid recurrence of stall warning and to minimize the altitude loss, with due consideration of proximity to terrain;
- Configuration - check appropriate. Some actions such as gear retraction increase drag during the gear retraction sequence and delay stall recovery;
- Air Traffic Control (ATC) - advise ATC of any deviations **after** successful stall recovery is confirmed.

At all times handling of aircraft should be in a smooth, deliberate and positive manner. Avoid increasing load factors until a minimum manoeuvring speed has been achieved.

Recommended Simulator Training for recovery from an approach to a stall

Many current training practices typically complete stall training in three basic configurations of cruise, take-off and landing, while under one specific flight condition - eg. Level flight at 15,000 ft. It is recommended that training be conducted in the three existing configurations, but at appropriate flight conditions as follows:

1. Cruise - Entry in level flight should be conducted from an idle thrust setting and at least at 75% of the maximum certified altitude of the aircraft and at a weight appropriate

to initial cruise following a maximum weight take-off. Emphasis for recovery should be on immediate angle of attack reduction using primary pitch control. Response of engines to thrust application should be observed.

2. Take-off - Entry should be made during a turning climb with an engine inoperative in a configuration, airspeed and thrust appropriate for a second segment climb. Aircraft weight should be at least 75% of maximum take-off weight. Emphasis should be on use of pitch control for recovery (since thrust is at (or near) maximum available), and avoidance of lateral/directional loss of control.
3. Landing - Approach to stall at 500 ft above ground level or representative Minimum Descent Altitude over a runway at idle thrust and in landing configuration. Emphasis should be on prompt stall recovery and allowing any altitude loss as necessary to affect a stall recovery while avoiding any contact with terrain.

Note: The above training can be integrated into the simulator training program over various sessions, when the configuration is appropriate, rather than completing the training in one single session.

Recommended Simulator Training for recovery from full stall

Many flight training devices (simulators) have a limited ability to model high angle of attack flight conditions, associated with the stall angles of attack. However where a simulator is capable, a full stall should be entered to demonstrate the function of stall protection systems on aeroplanes, (such as stick pushers), the appropriate recovery actions to be applied, and the altitude loss associated with entry into a full stall.

Recovery inputs should be the same for a recovery from an approach to a stall with emphasis on the need for increased and sustained pitch control (elevator) inputs until the airspeed is increasing rapidly. The training should also emphasize the control inputs necessary for the prevention of a secondary stall.

Aeroplane-Only Training for Various Phases of Flight - Recommendations

Because of potential hazards associated with a stall, it is recommended that full aerodynamic stalls or stall entries causing the activation of the stick pusher be avoided during training. However, for recovery from approaches to stalls, the training should encourage a nose down pitch input as necessary, to promptly reduce the angle of attack, with due consideration for any associated altitude loss and terrain clearance. At no time should a goal of zero altitude loss be a criteria for successful demonstration of recovery from the initial indications of a stall. Should a stall be inadvertently entered, the recovery inputs from a full stall as specified above should be applied.

Any aeroplane only stall training should be conducted with due consideration to clearance from terrain and cloud. Aeroplane weight and balance should be within required limits, and a forward center of gravity position is recommended. Aircraft weight should be limited to ensure adequate performance for recovery from initial indications of a stall.

Recommended Checking Practices for stall recovery

Checking for stall training should be consistent with the preceding guidance. The primary goals of checking should be to ensure that appropriate pilot actions have been taken at the first indications of a stall. These goals should take precedence over the current emphasis placed for minimizing any altitude loss, when demonstrating approaches to a stall in level flight.

Some of the referenced CASS schedules for PPC have criteria, to provide relief from checking the approach to check for recoveries from an approach to a stall if successfully demonstrated during training. Use of the relief provisions should be encouraged to promote effective training and understanding of stall recoveries, and avoid prescriptive recovery actions for which the current checking practices may inadvertently encourage.

FUTURE DISPOSITION

This CBAAC will remain in effect until further notice.

Michel Gaudreau
Director
Commercial and Business Aviation

Commercial & Business Aviation Advisory Circulars (CBAAC) are intended to provide information and guidance regarding operational matters. A CBAAC may describe an acceptable, but not the only, means of demonstrating compliance with existing regulations. CBAACs in and of themselves do not change, create any additional, authorize changes in, or permit deviations from regulatory requirements. CBAACs are available electronically on the TC Web site, at:
<http://www.tc.gc.ca/CivilAviation/commerce/circulars/menu.htm>
