Stall Speed Determination

Introduction

This stall speed demonstration is intended to introduce the student to the techniques for determining stall speeds. This demonstration is based on the FAR 23 and military light utility aircraft requirements (Class I).

Purpose

Stall speed determination is a fundamental performance item because many regulations pertaining to performance, handling qualities, airspeed indicator markings, and other variables are referenced to stall speeds. Consequently, stall speed testing is done early in the flight test program so that the data are available for subsequent testing. Because of the interrelationship among stall speeds and other critical performance parameters, it is essential that accurate measurement methods and careful piloting techniques be used. The standard airplane pitot-static system is generally not acceptable for stall speed determination for certification, and a separate system such as a trailing bomb, trailing cone, or nose or wing boom is required. The stall speed determinations needed for marking the airspeed indicator are in terms of indicated airspeed (IAS), corrected for instrument error. The other stall speeds are reported in terms of calibrated airspeed (CAS).

For certification, the elevator up-stop should be set to the minimum allowable deflection. Flap travels should be set to minimum allowable settings. The gross weight should be at maximum takeoff weight and the center of gravity (c.g.) should be at the forward limit.

Mission Specifics

The FARs require that V_{s0} and V_{s1} speeds be determined using specified procedures. The FARs also define when the aircraft can be considered stalled for certification purposes. Three conditions, whichever occurs first, define the stall:

i. Uncontrollable downward pitching motion, or

ii. the control reaches the stop.

iii. activation of a stall barrier (stick-pusher) system.

The phrase "uncontrollable downward pitching motion" is the point at which the pitching motion can no longer be arrested by application of nose-up elevator and not necessarily the first indication of nose-down pitch.

Mil Spec 8785C defines stall speed as the highest of:

i. speed for steady straight flight at C_{Lmax}, the first local maximum of the curve of lift coefficient vs. angle of attack which occurs as C_L is increased from zero.
ii. speed at which uncommanded pitching, rolling or yawing occurs
iii. speed at which intolerable buffet or structural vibration is encountered

For airplanes whose control reaches the stop (elevator control limited), V_s is considered to be the minimum speed obtained while the control is held against the stop. These airplanes may or may not develop a minimum steady flight speed. The time the control is held against the stop for stall speed determination should be consistent with the time against the stop for stall characteristics testing (see Section 15). For airplanes with a stall speed barrier system, speed at which the stick pusher activates is considered to be stall speed.

For reciprocating engine airplanes, the stalling speed is that obtainable with the propeller(s) in the takeoff position and the engine idling with throttles closed. Alternatively, sufficient power to produce zero propeller thrust at a speed equal to or less than 10% above the stall speed may be used. If zero propeller thrust is used, a dependable method for monitoring thrust, such as a propeller slipstream rake, should be installed or an appropriate method for calculating zero thrust should be employed. Turbo-propeller airplanes pose additional requirements.

The stalling speed should also be determined at weight and *cg* positions defining the corners of the loading envelope to define the critical conditions. The highest stall speed for each weight will be at forward *cg* in most instances. Data should be recorded so that weight and *cg* at the time of the test can be accurately determined.

The test is commenced with the airplane in the desired configuration and trimmed at approximately 1.5 V_{s1}, or at the minimum trim speed, which ever is greater. The airplane is slowed to about 10 knots above stall, then the speed should be reduced at a rate of one knot per second or less until the stall occurs or the control reaches the stop. Mil Spec 8785C requires a maximum bleed rate of 0.5 knot per second. Wings must be kept level, ball centered in its race, and control inputs should be smooth. The indicated airspeed at the stall warning and stall should be noted, using the production airspeed system. Both the indicated airspeeds and the calibrated stall speeds may then be plotted against bleed rate to determine the one knot per second values. (Where exact determination of stall speed is required, entry (bleed) rate should be varied to bracket one knot per second, and data should be recorded to allow construction of time histories.)

The adequacy of the stall warning will also be determined on this demonstration flight. At each test point, note the indicated airspeed at which both the artificial warning activates and when natural aerodynamic buffet, sufficient to serve as stall warning commences. Part 23 requires that the stall warning begin at a speed exceeding 5 knots, but not more than the greater of 10 knots or 15 percent of the stalling speed, and must continue until the stall occurs. Mil Spec 8785C specifies that the minimum speed for onset of the warning shall be the higher of $1.05V_s$ or $V_s + 5$ knots and the maximum speed for onset shall be the higher of $1.10V_s$ or $V_s + 10$ knots for approach and $1.15V_s$ or $V_s + 15$ for all other flight phases.

The stall test should be repeated sufficient times for each configuration to ensure a consistent speed. If a correction is to be made for zero thrust, then the stall speed and power at several power settings should be recorded for later extrapolation to zero thrust.

Limitations

The stall demonstration should be done so that a minimum altitude of 1500 feet AGL remains after completion of the test. Accordingly, entries should initiated at 2000 feet AGL or higher.

Stall Speed Determination

Student:	A/C:	Date:
IP:	Tiger:	Step:
Weight:	*cg*:	T/O:
Start Time:		H_p:

Event		**Flaps**	**Gear**	**Power**	**Trim Speed**	**Bleed Rate**	**Warn Speed**	**Buffet Speed**	**Stall Speed**
	Wings Level								
1		UP	UP	Idle	1.5 V_{S1}	< 1 kt/sec			
				T/O RPM					
		1/2	DN	Idle	1.5 V_{S1}				
				T/O RPM					
	c.	DN	DN	Idle	1.5 V_{S1}				
				T/O RPM					
2	a	UP	UP	Zero Thrust	1.5 V_{S1}	< 1 kt/sec			
				T/O RPM					
	b	1/2	DN	Zero Thrust	1.5 V_{S1}				
				T/O RPM					
	c.	DN	DN	Zero Thrust	1.5 V_{S1}				
				T/O RPM					

Stop Time:

STALL SPEED DETERMINATION

Student:	A/C: BOSBOK	Date:
IP:	Tiger:	Step:
Weight:	*cg*:	T/O:
Start Time:		H_p:

Event		**Flaps**	**Gear**	**Power**	**Trim Speed**	**Bleed Rate**	**Warn Speed**	**Buffet Speed**	**Stall Speed**
	Wings Level								
1	a.	UP	DN	IDLE	90	< 1 kt/sec			
				40"@3000					
	b.	33	DN	IDLE	80				
				40"@3000					
	c.	DN	DN	IDLE	75				
				40"@3000					
2	a.	UP	DN	IDLE	90	< 1 kt/sec			
				40"@3000					
	b.	33	DN	IDLE	80				
				40"@3000					
	c.	DN	DN	IDLE	75				
				40"@3000					
	30º ϕ								
3	a.	UP	DN	IDLE	90	3 - 5 kt/sec			
				40"@3000					
	b.	33	DN	IDLE	80				
				40"@3000					
	c.	DN	DN	IDLE	75				
				40"@3000					

Stop Time:

Test Hazard Analysis Worksheet

Test Title:

Stall Speed Determination

Aircraft/System:

Subjective Probability of Occurrence

Hazard	high	probable	uncertain	remote	improbable
catastrophic					
critical	High				
marginal			Medium		
negligible				Low	

Hazard:

Departure from controlled flight

Cause:
1. Improper control input
2. Unpredicted aircraft response

Effect:

Destruction of aircraft/death

Minimizing Procedures:

Minimum altitude for planning recovery is 1500 AGL

Entry altitude should be 2000 AGL or higher (B-35 4000 AGL, turboprop/jet 5000 AGL)

If bank angle exceed 15 deg during stall speed determination, abort the test.

Do not add power at stall recovery untill airspeed is 1.2 Vs.

Emergency Procedures:
If a departure occurs: Controls neutral and reduce power to idle.
If a spin develops: Apply aircraft flight manual spin recovery procedure

Risk Level (after minimizing procedures taken into account):

High ____ Medium ____ Low __X__