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Stick shaker

A **stick shaker** is a mechanical device designed to rapidly and noisily vibrate the control yoke (the "stick") of an aircraft, warning the flight crew that an imminent aerodynamic stall has been detected. It is typically present on the majority of large civil jet aircraft, as well as most large military planes.

The stick shaker comprises a key component of an aircraft's stall protection system. Accidents, such as the 1963 BAC One-Eleven test crash, were attributable to aerodynamic stalls and motivated aviation regulatory bodies to establish requirements for certain aircraft to be outfitted with stall protection measures, such as the stick shaker and stick pusher, to reduce such occurrences. While the stick shaker has become relatively prevalent amongst airliners and large transport aircraft, such devices are not infallible and require flight crews to be appropriately trained on their functionality and how to respond to their activation. Several instances of aircraft entering stalls have occurred even with properly functioning stick shakers, largely due to pilots reacting improperly.



The BAC-111 cockpit includes a stick shaker/pusher following its 1963 crash

History

Stick shakers were being developed as early as 1949.^[1]

During 1963, a BAC One-Eleven airliner was lost after having crashed during a stall test. The pilots pushed the T-tailed plane past the limits of stall recovery and entered a deep stall state, in which the disturbed air from the stalled wing had rendered the elevator ineffective, directly leading to a loss of control and crash.^[2] As a consequence of the crash, a combined stick shaker/pusher system was installed in all production BAC One-Eleven airliners. A wider consequence of the incident was the instatement of a new requirement related to the pilot's ability to identify and overcome stall conditions; a design of Transport category aircraft that fails to comply with the specifics of this requirement may be acceptable if the aircraft is equipped with a stick pusher.^{[3][4]}

Following the crash of American Airlines Flight 191 on 25 May 1979, the Federal Aviation Administration (FAA) issued an airworthiness directive, which mandated the installation and operation of stick shakers on both sets of flight controls on most models of the McDonnell Douglas DC-10, a trijet airliner. (Previously, only the captain's controls were equipped with a stick shaker on the DC-10; in the case of Flight 191, this single stick shaker had been disabled by a partial electrical power failure early in the accident sequence.)^[5] In addition to regulatory pressure, various aircraft manufacturers have endeavoured to devise their own improved stall protection systems, many of which have included the stick shaker.^[6] The American aerospace company Boeing had designed and integrated stall warning systems into numerous aircraft that it has produced.^{[7][8]}

A wide range of aircraft have incorporated stick shakers into their cockpits.^[8] Textron Aviation's Citation Longitude business jet is one such example,^[8] as is the Pilatus PC-24 light business jet,^[9] and Bombardier Aviation's Challenger 600 family of business jets.^[10] Commercial airliners such as the newer models of the Boeing 737, the Boeing 767, and the Embraer E-Jet E2 family have also included stick shakers in the aircraft's stall protection systems.^{[11][12][13]}

Function in stall protection systems

The stick shaker is a major element of an aircraft's stall protection system. The system is composed of fuselage or wing-mounted angle of attack (AOA) sensors that are connected to an avionics computer, which receives inputs from the AOA sensors along with a variety of other flight systems. When this data indicates an imminent stall condition, the computer actuates both the stick shaker and an auditory alert.^[8] The shaker itself is composed of an electric motor connected to a deliberately unbalanced flywheel. When actuated, the shaker induces a forceful, noisy, and entirely unmistakable

Valve Exhibit 1110
Valve v. Immersion

shaking of the control yoke. This shaking of the control yoke matches the frequency and amplitude of the stick shaking that occurs due to airflow separation in low-speed aircraft as they approach the stall. The stick shaking is intended to act as a backup to the auditory stall alert, in cases where the flight crew may be distracted.^[8]

Stick pusher

Other stall protection systems include the stick pusher, a device that automatically pushes forward on the control yoke, commanding a reduction in the aircraft's angle of attack and thus preventing the aircraft from entering a full stall. In the majority of circumstances, the stick pusher will not activate until shortly after the stick shaker has given its warning of near-stall conditions being detected, and will not activate if the flight crew have performed appropriate actions to reduce the likelihood of stalling by lowering the angle of attack.^{[4][8]} Under most regulatory regimes, an aircraft's stall protection systems must be tested and armed prior to takeoff, as well as remain armed throughout the flight; for this reason, startup checklists normally include performing such tests as a matter of routine.^[8]

Audio

The vibration of the stick shaker is loud enough that it can be commonly heard on cockpit voice recorder (CVR) recordings of aircraft that have encountered stall conditions. This level of vigorous movement is intentional, the stick shaker having been designed to be impossible to ignore.^[8] To unfamiliar flight crews, the stall warning system can be viewed as aggressive and impatient, hence why it has become commonplace for the system to be introduced to trainee pilots via a flight simulator rather than a live aircraft. To fly without them would increase the likelihood of the aircraft encountering, and improperly responding to, a stall event.^[8]

Flight crew factor

During the 2000s, there was a series of accidents that were attributed, at least in part, to their flight crews having made improper responses to the activation of the stall warning systems.^{[4][14]} During the early 2010s, in response to this wave of accidents, the FAA issued guidance urging operators to ensure that flight crews are properly training on the correct use of these aids.^{[15][16]}

See also

- 1963 BAC One-Eleven test crash
- Dual control (aviation)

References

- "Pilot Warning Device" (http://archive.org/details/Aviation_Week_1949-10-17/page/n10). *Aviation Week*. Vol. 51, no. 16. McGraw-Hill Publishing Company. 17 October 1949. p. 21. Retrieved 8 June 2021.
- Report on the Accident to B.A.C. One-Eleven G-ASHG at Cratt Hill, near Chicklade, Wiltshire on 22nd October 1963*, Ministry of Aviation C.A.P. 219, 1965.
- "Bjorn's Corner: Pitch stability, Part 6" (<https://leehamnews.com/2019/01/18/bjorns-corner-pitch-stability-part-5-2/>). *Leeham News*. 18 January 2019.
- "Stick Pusher" (https://www.skybrary.aero/index.php/Stick_Pusher). skybrary.aero. Retrieved 21 July 2020.
- "MCDONNELL DOUGLAS DC-10, -10F, -30, -30F, -40 Series" (http://rgl.faa.gov/Regulatory_and_Guidance_Library%5CrgAD.nsf/0/83D4FF29A77B501C862569F200686555). *rgl.faa.gov*. Retrieved 24 May 2019.
- "US5803408A: Autopilot/flight director stall protection system" (<http://www.google.com/patents/US5803408>). Retrieved 22 July 2020.
- Dominic Gates; Mike Baker (22 June 2019). "The inside story of MCAS: How Boeing's 737 MAX system gained power and lost safeguards" (<https://www.seattletimes.com/seattle-news/times-watchdog/the-inside-story-of-mcas-how-boeings-737-max-system-gained-power-and-lost-safeguards/>). *Seattle Times*.
- Mark, Rob (14 August 2017). "How it Works: Stick Shaker/Pusher" (<https://www.flyingmag.com/how-it-works-stick-shaker-pusher/>). *Flying*.
- Gerzanics, Mike (10 May 2019). "We fly the Pilatus PC-24" (<https://www.flightglobal.com/in-depth/we-fly-the-pilatus-pc-24/132416.article>). *Flight International*.

10. Learmount, David (18 October 2019). "How business aviation safety is stuck in a rut" (<https://www.flightglobal.com/in-depth/how-business-aviation-safety-is-stuck-in-a-rut/134681.article>). Flight International.
11. Hemmerdinger, Jon (23 December 2019). "Intense scrutiny on Boeing overshadows unaddressed lessons from 737 Max crashes" (<https://www.flightglobal.com/air-transport/intense-scrutiny-on-boeing-overshadows-unaddressed-lessons-from-737-max-crashes/135907.article>). Flight International.
12. Hemmerdinger, Jon (12 March 2019). "Crashed Atlas 767 dove after turbulence, elevator movement: NTSB" (<https://www.flightglobal.com/airframers/crashed-atlas-767-dove-after-turbulence-elevator-movement-ntsb/131814.article>). Flight International.
13. Gerzanics, Mike (17 July 2018). "ANALYSIS: With E2 series, Embraer closes the loop" (<https://www.flightglobal.com/analysis/analysis-with-e2-series-embraer-closes-the-loop/128584.article>). Flight International.
14. Learmount, David (7 December 2009). "Many airline pilots do not understand aerodynamics, conference learns" (<https://www.flightglobal.com/many-airline-pilots-do-not-understand-aerodynamics-conference-learns/90735.article>). Flight International.
15. Mark, Robert P. (4 February 2013). "Training: Enhanced Stall and Stick Pusher Update" (<https://www.ainonline.com/aviation-news/2013-02-04/training-enhanced-stall-and-stick-pusher-update>). AIN Online.
16. "NTSB Makes ATR-42 Stick-Pusher Recommendations To FAA, EASA" (<http://www.aero-news.net/index.cfm?do=main.textpost&id=ebbd5f80-c8e0-4a2d-8630-c0290297ad83>). aero-news.net. 28 June 2012.

External links

- [FAA Advisory Circular 120-109, Stall and Stick Pusher Training](http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%20120-109.pdf) (http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%20120-109.pdf)
 - [Manual on Aeroplane Upset Prevention and Recovery Training via icao.int](https://www.icao.int/Meetings/LOCI/Documents/10011_draft_en.pdf) (https://www.icao.int/Meetings/LOCI/Documents/10011_draft_en.pdf)
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