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AIRCRAFT INCIDENT REPORT

Report by the US National Transportation Safety Board into the incident to Boeing 757-200, TF-FII near Baltimore, USA on October 20, 2002

M-08602/AIG-34

FACTUAL INFORMATION

NTSB Identification: DCA03IA005

Scheduled 14 CFR Part 129

Foreign operation of ICELANDAIR - FLUGLEIDIR HF

Incident occurred Sunday, October 20, 2002 in Baltimore, MD

Probable Cause Approval Date: 7/15/2005

Aircraft: Boeing 757-200, registration: TF-FII

Injuries: 196 Uninjured

HISTORY OF FLIGHT

On October 19, 2002, about 2000 eastern daylight time (EDT) [or 0000 coordinated universal time (UTC)], a Boeing 757-200, TF-FII, operating as Icelandair flight 662, experienced a stall while climbing from flight level (FL) 330 (i.e., 33,000 feet) to FL 370. The flight lost about 7,000 feet during the recovery and then diverted to Baltimore-Washington International Airport (BWI), Baltimore, Maryland. There were no injuries to the 191 passengers or 7 crewmembers and no damage to the airplane. The airplane was being operated under the provisions of 14 Code of Federal Regulations Part 129 as a scheduled international passenger flight from Orlando International Airport (MCO), Orlando, Florida, to Keflavik International Airport, Keflavik, Iceland (KEF).

The incident flight departed MCO about 1900 EDT; the first officer was the pilot flying (PF). According to Icelandair's Standard Operating Procedures (SOPs) and Boeing's 757/767 Flight Crew Training Manual, the captain (as the non-flying pilot) was responsible for calling out 80 knots during the takeoff roll. The captain indicated that about the time he was going to call out 80 knots, the first officer called out 100 knots. The captain indicated that he was going to abort the takeoff until he noticed that the first officer and the standby airspeed indicators were indicating the same airspeed (at this point, about 110 knots). He decided to allow the FO to continue with the takeoff, with the option of returning to MCO. The first officer indicated that during the takeoff, all of the parameters on his side were normal; therefore, he continued the takeoff.

The pilots indicated that shortly after takeoff, the lateral and vertical flight director (FD) bars on the captain's display and lateral FD bar on the first officer's display disappeared. The first officer switched his flight director source from "right" to "center", but the problem remained and the first officer returned the switch to "right".

In addition, after passing through about 1,000 feet, the advisory messages MACH/SPD TRIM and RUDDER RATIO appeared on the Engine Indication and Crew Alerting System (EICAS) display. The status message ELEV ASYM also displayed. (EICAS information includes systems alerts, maintenance information, and status messages.)

The captain told the first officer to continue the climb and to deal with the messages later. After trimming the airplane and retracting the flaps, the first officer asked the captain for the After-Takeoff checklist and the Quick Reference Handbook (QRH) to address the EICAS messages. Subsequently, the EICAS messages disappeared, the FD bars returned, and the airspeed indications showed consistent readings.

After climbing through about 10,000 feet, the same advisory and status messages again appeared on the EICAS, and the captain airspeed indication showed 10 knots lower than the first officer and the standby airspeed indications. A few minutes later, the EICAS messages disappeared, and the captain's airspeed indication again agreed with the first officer and the standby airspeed indications. The first officer indicated that the messages disappeared without any action by the flight crew. When the flight reached FL 330, the same messages and airspeed sequences once again occurred, and then everything returned to normal about two minutes later. The pilots indicated that they suspected that failure in the left Air Data Computer might have caused the captain's airspeed anomalies. However, they indicated that because no failure flags appeared on the captain's airspeed indicator, they decided not to switch captain's air data source to alternate.

After a little over an hour into the flight, air traffic control (ATC) authorized a climb to FL 370. The climb from FL 330 was made at normal climb power, with the autothrottle and the autopilot engaged.

During the climb the captain's indicated airspeed began increasing, and the overspeed warning occurred as the airplane neared FL 350. The first officer indicated that he did not remember what his airspeed indication was at that time. The pilots indicated that because of the previous airspeed anomalies, they felt that the overspeed warning was erroneous and they decided to pull circuit breakers to silence the aural overspeed warning. The captain stated that his airspeed indication reached a maximum of between 320 and 350 knots during the climb.

The first officer indicated that during the climb his airspeed indication and the standby airspeed indication both decreased from about 250 to 220 knots. The first officer told the captain that he did not think that his airspeed indication was reliable and asked him to take control of the airplane. He stated that the captain promptly took control of the airplane. The first officer indicated that he did not remember the pitch attitude at this time but thought that it was less than 10 degrees.

When asked why control was transferred from the first officer to the captain, despite their acknowledgement of anomalies with the captain's airspeed indicator and agreement between the first officer and standby airspeed indicators, the first officer indicated that he noticed that the airplane's pitch was unusually high and the airspeed had decreased substantially. Because he became unconvinced whether his instruments were correct, he asked the captain to assume control of the airplane. The captain indicated that he had a better view of the standby instruments, in case the first officer's airspeed indicator had become unreliable.

Soon after the captain assumed control, the flight experienced activation of the stick shaker and then heavy stall buffet. The captain indicated that he then disconnected the autopilot and autothrottle. The captain indicated that he initiated the stall recovery by reducing the power to idle and lowering the nose about 5 degrees below the horizon. He indicated that he looked at the first officer and standby airspeed indications and that they were the same. The captain stated that "there was a lot of vibration" during the stall encounter, and both pilots acknowledged that they had never experienced anything like it before. The first officer indicated that the stall buffet felt a little bit different than what he had experienced during simulator training but that it felt the same in strength. Subsequent FDR analysis revealed that the stick-shaker continued for about 45 seconds.

During the loss of altitude, the first officer radioed the urgency message PAN PAN, advising that they were unable to maintain altitude and were descending out of their cleared flight level. The flight crew received immediate clearance to descend FL 300 and then subsequently to FL 290. The captain then decided to divert to BWI.

The pilots stated that they monitored their instruments during the descent to BWI. The captain indicated that his airspeed indication was 40 to 70 knots lower than the first officer and standby airspeed indications at times during the descent. After descending to FL 250, the pilots verified that the first officer and standby airspeed indications were the same (about 250 knots), and the first officer took control of the airplane and reengaged the autopilot. The captain indicated that at this time, his airspeed indication was 180 knots. The pilots further checked the captain's airspeed indication against ground speed values provided by ATC to determine the erroneous nature of the airspeed indication.

The flight landed at BWI about 2100 EDT.

PERSONNEL INFORMATION

Captain

The captain has been employed by Icelandair since 1986. His total flight time prior to the incident was around 8,500 hours, including about 1,020 hours as B-757 pilot-in-command (PIC). He previously served as captain with Icelandair on the Fokker 50 and as first officer on the B-757.

The captain completed training (as a captain) for his B-757 type rating in May 2001. During his training, he demonstrated approaches to stall in the clean configuration (with terrain not a factor) and in the landing configuration (with terrain a factor) and also conducted a recovery from a full stall. The captain demonstrated these maneuvers in his most recent company proficiency check in April 2002.

The captain held a first-class medical certificate, dated May 7, 2002, with no waivers.

The first officer stated that he had flown with the captain on three previous occasions. He characterized the captain as having very good situational awareness. He stated that the captain was calm, practiced crew resource management (CRM), and was a good commander.

On October 16, 2002, the captain flew a round trip from KEF to London and was off-duty on the following day. On October 18th, the captain flew from KEF to MCO and arrived about 2100. He stated that he had a good night's sleep in Orlando and that he awoke about 0700 on October 19th. He added that he later took a 2-hour nap and departed the hotel at 1730. The flight departed MCO for KEF about 1900.

During interviews with Safety Board personnel following the incident, the captain indicated that the stall recovery procedure he used was the procedure taught to him during simulator training. He stated that he was taught that if there was enough altitude, the pilot should reduce power and lower the nose. He was taught that at lower altitudes, the pilot should use full thrust with 5 degrees nose-up pitch. He stated that he received stall training during his proficiency check in April 2002. He stated that there were no procedures in company manuals for pulling the circuit breaker on the cockpit voice recorder (CVR) following an incident. He added that he was not trained on postincident landing procedures.

The captain further indicated that he did not initially increase thrust during the stall recovery because high thrust can increase nose-up tendencies and make it more difficult to decrease the airplane's angle of attack.

First Officer

The first officer has been employed by Icelandair since 1997. His total flight time prior to the incident was about 4,100 hours. His flight time on the B-757 was about 1,800 hours and was all as first officer. During company proficiency checks in April 2000 and May 2002, the first officer demonstrated approaches to stall in the clean configuration (with terrain not a factor) and in the landing configuration (with terrain a factor).

The first officer's attended recurrent ground school training in October 2002. He had three days off prior to the trip to MCO. The first officer held a first-class medical certificate, dated May 7, 2002, with no waivers.

The captain stated that he thought he had flown with the first officer on two previous occasions, the last time being on August 31, 2002. He characterized the first officer as very professional and as someone who always tried to do his best.

The first officer stated that he always followed the checklists. He stated that he was taught stall recovery for incidents in which terrain is not a factor during simulator training. He stated that for an overspeed warning, pilots are taught to disengage the autopilot, autothrottle, and flight director; check all possible sources of airspeed; and then attempt to maintain normal attitude, pitch, speed, and thrust settings.

The first officer stated that he performed approaches to stall in the clean and landing configurations, with and without terrain as a factor, during his May 2002 training. The first officer stated that the recovery procedures for an approach to stall called for applying maximum thrust, maintaining configuration, then pitching up to the eyebrow on the primary attitude display and allowing speed and altitude to increase.

AIRPLANE INFORMATION

General

The incident airplane, serial number 24760, was manufactured on March 5, 1990 and delivered to Icelandair on May 3, 1990. It was powered by two Rolls Royce RB211-535E4 turbofan engines.

Daily and ETOPS checks were carried out by maintenance at MCO. No open discrepancies and no entries related to erroneous airspeed indications were noted in the maintenance log before the incident flight. A check of the maintenance records revealed no sign of erroneous airspeed indications prior to the incident.

Icelandair indicated that pitot covers were most likely not used while the incident airplane was parked at MCO and that this might have allowed insects to enter the captain's pitot tube.

Air Data System

The B-757 air data system consists of a pitot-static system (the pitot static system consists of one left [captain] and one right [first officer] pitot tube, one right auxiliary and one left auxiliary pitot tube, and six static ports); one temperature probe; two angle-of-attack probes; two air data computers (ADC); and electric flight instruments. The system provides pitot and/or static pressure information to various flight instruments and airplane systems. The two ADCs use sensed air data to provide input signals to certain flight instruments, including the mach/airspeed and standby airspeed indicators and the altimeter and standby altimeter indicators. The left ADC provides information to the captain's instruments, and the right ADC provides information to the first officer's instruments, although the opposite ADCs are available as alternate air data sources. If the ADC detects a fault or stops transmitting valid air data signals, warning flags appear on the air data instruments.

The left and right ADC data buses can be switched by the air data source select switches in the cockpit. Crew statements and FDR data indicate that the switches remained in their normal positions throughout the flight. With the switches in the normal positions, the data recorded on the FDR are from the same ADC supplying the captain's instruments.

Each mach/airspeed indicator displays airspeed, mach, and Vmo (maximum operating airspeed) from the selected ADC. The standby airspeed indicator is installed along the left side of the center control panel. The instrument is connected directly to the right auxiliary pitot and the alternate static ports.

ADC Inputs to Flight Control and Flight Management Computers

Each of the B-757's three flight control computers (FCCs) receives air data from both the left and right ADCs. The source of air data utilized by the FCCs is dependent upon the autopilot or flight director engagement configuration. The FCCs will utilize air data from the right ADC if the right FCC is engaged first or if only the first officer's flight director is switched on. Otherwise, the FCCs will utilize data from the left ADC.

During the altitude hold, flight level change, and vertical speed autopilot pitch modes, the FCCs generate pitch commands using ADC information. For VNAV modes, the FCCs receive VNAV steering commands directly from the Flight Management Computer (FMC). The FMC receives air data from both ADCs and selects the left ADC as the primary source.

During a VNAV climb, the FMC generates pitch steering commands to control the airspeed to the FMC target speed. With the autothrottle engaged, the FMC requests the autothrottle to control thrust to the target thrust setting (climb thrust). VNAV will command an increase of the pitch attitude to manage excess airspeed until the FMC target airspeed is reached or a 15 degree pitch attitude limit is reached. During VNAV PATH mode the FMC generates pitch steering commands to control the airplane to the FMC target altitude, while the autothrottle manages the thrust to control airspeed to the FMC target speed.

When the flight directors are engaged, the pitch commands for the engaged mode are presented to the pilot via the flight director bars. The flight director bars provide commands to lead the pilot to the desired path.

After the flight had leveled at FL330, the crew switched from the center autopilot system to the right autopilot system; this was maintained until the autopilot was disconnected during the stall encounter at FL370. The crew indicated that they made the switch to the right autopilot system because they had thought it would use data from the right ADC and FMC instead of possible erroneous data from the left ADC and FMC.

B-757 Engine Indication and Crew Alerting System (EICAS)

The EICAS consolidates engine and subsystem indications and provides a centrally located crew alerting message display. EICAS provides system alerts, maintenance information, status messages, and communications alerts. System alert messages are normally associated with system failures or faults that may require performance of a specific nonnormal procedure or affect the way the flight crew operates the airplane. System alert messages not directly caused by system failures or faults include altitude alerts and stall warnings.

The following information was contained in the incident airplane's QRH for responding to EICAS messages for RUDDER RATIO and MACH/SPD TRIM. Neither provided reference to a possible airspeed anomaly.

The RUDDER RATIO light illuminated indicates the rudder ratio system has failed.

Above 160 knots, avoid large or abrupt rudder inputs.
If normal left hydraulic system pressure is available:
Crosswind limit is 15 knots.
Do not attempt autoland.

The MACH SPD TRIM light illuminated indicates the mach/speed trim system is inoperative.

On B-757 airplanes modified with Boeing Service Bulletin (SB) 757-34A0222 (discussed later in this report), dated March 28, 2002, EICAS messages "ALT DISAGREE" and "IAS DISAGREE" display when the captain and first officer airspeed indicators disagree by more than 5 knots. The incident airplane had not received this modification at the time of the incident.

B-757 Stall and Overspeed Warnings

Stall warnings are provided by left and right stick shakers, which are designed to independently vibrate the left and right control columns just prior to and during a stall. An overspeed warning occurs if the Vmo limits are exceeded. The overspeed warning consists of master WARNING lights that illuminate; an OVSPD light that illuminates; the EICAS warning message, "OVERSPEED," that displays; and an aural warning that sounds. All warning indications remain activated until the airspeed is reduced below Vmo. The aural warning can be silenced by pulling the respective circuit breaker.

FLIGHT RECORDERS

The airplane was equipped with a flight data recorder (FDR) and a CVR. Both recorders were removed from the airplane and transported to the Safety Board's headquarters for readout and evaluation. The captain had requested maintenance personnel at BWI to secure the CVR; however, this was not accomplished, and the recording only contained sounds and conversations made by airport maintenance personnel working on the airplane after the incident.

Flight Data Study

Because of the reported airspeed anomalies, the airplane's airspeed was derived using Boeing 757-200 aerodynamic data as well as FDR parameters not related to the air data system (including airplane weight, FDR normal load factor, FDR vane angle of attack, and FDR ground speed). The airspeed recorded on the FDR represents the airspeed displayed on the captain's primary flight display. A study of the data revealed the following.

A manual takeoff was performed with the autothrottle engaged and both flight directors on. During the takeoff roll the FDR ground speed was 20 to 25 knots higher than the FDR airspeed, which is consistent with comments by the captain. Immediately after takeoff as the airplane was gaining altitude, the FDR airspeed became higher than the derived airspeed. At an altitude of 1000 feet VNAV climb was engaged, which would result in steering commands on the flight directors. At an altitude of 6000 feet, the center autopilot was engaged to fly the VNAV steering commands.

During the climb from 10,000 feet to FL 330 and during the initial portion of the cruise at FL 330, the FDR airspeed and the derived airspeed were similar. Several minutes after reaching FL 330 and while in level flight (and in VNAV PATH mode), the autothrottle increased the thrust and the derived airspeed began increasing, while the FDR airspeed remained constant. The autothrottle increased thrust in response to erroneous airspeed from the left ADC. Soon afterward, the autothrottle was disengaged and then reengaged, and the right autopilot was selected. As a result of the right autopilot engagement, the autothrottle began targeting the air data from the right ADC; however, the autopilot in VNAV PATH mode continued to receive FMC steering commands based on air data from the left ADC. FDR and derived airspeeds then began to align again.

With the right autopilot engaged, the FDR and derived airspeeds were consistent (280 knots and Mach 0.80) as a VNAV climb from FL 330 to FL 370 was initiated. However, as the climb continued the FDR airspeed began to increase. During the climb, the FMC provided VNAV steering commands to the autopilot to target airspeed. Because the FMC uses the captain's (left) air data, it provided continuous airplane-nose-up (ANU) commands sensing that the airplane was flying faster than the target airspeed. FDR data show ANU movements of the elevators and horizontal stabilizer as the FDR airspeed increased during the airplane's climb, and the derived airspeed decreased. As the FDR airspeed increased above Mach 0.86, the overspeed warning activated. When the airplane reached FL 370 the FDR airspeed had risen to about 320 knots (Mach 0.96), while the derived airspeed had decreased to about 210 knots (Mach 0.66). After reaching an altitude of 37,000 feet and transitioning to VNAV PATH, the autopilot continued to command ANU stabilizer and elevator in an effort to maintain the selected altitude, and derived airspeed continued to decay. The FDR airspeed began decreasing as well, and the overspeed warning stopped as the FDR airspeed decreased below Mach 0.86. According to the FDR data, the overspeed warning was active for approximately 70 seconds. Fifteen seconds after the overspeed warning had ceased and 15 seconds before the stick shaker activated, the thrust was retarded. Several seconds later, at a derived airspeed of about 195 knots, the autothrottle was disconnected. At a derived airspeed of about 175 knots, the stick shaker activated (and continued for approximately 45 seconds). Soon after activation of the stick shaker, the airplane began pitching down despite aft movement of the control column. (The elevator inputs associated with the aft control column inputs at this time were in excess of the autopilot's command authority.) FDR data reveal that the autopilot was disengaged and thrust reduced to idle about 20 seconds after the stick shaker began. The control column was maintained aft of the neutral position for approximately 20 seconds after the autopilot was disengaged. Nose-down control column commands were then begun, and the airplane's angle of attack and pitch attitude began decreasing while airspeed began increasing. Engine thrust, which had been reduced following autopilot disengagement, was increased about 40 seconds after autopilot disengagement.

The derived airspeed reached 175 knots or Mach 0.55 at its lowest point. During the incident, the FDR vane angle of attack reached a maximum of 12.5 degrees and the corresponding calculated body angle of attack reached a maximum of 16 degrees. After recovery from the stall, the airplane was leveled off at an altitude of 30,000 feet.

TESTS AND RESEARCH

Postincident Testing of the Incident Air Data Computers

After the airplane landed at BWI, maintenance personnel under contract to Icelandair removed the left pitot probe from the airplane. The pitot probe and pressure lines were flushed, and the maintenance personnel reported that dusty particles came out. The material was not captured. Maintenance personnel then performed a pitot-static test on the captain's airspeed indicator and noticed during some of the testing that the airspeed was still not indicating correctly. The left ADC was replaced, after which all of the system parameters tested normal.

The ADC was sent to the vendor's facility and examined under Federal Aviation Administration (FAA) oversight. Upon initial power up, the unit contained no recorded failures. No evidence of residue in the pitot tubes or static ports was found. When tested, several of the ADC's static pressure measurements were outside acceptable test limits. The greatest static deviation at 45,000 feet was 38 feet below the minimum passing tolerance, and the greatest pitot deviation at 360 knots was 0.5 knots below the minimum passing tolerance. The unit passed all other test points.

The unit was partially disassembled to isolate and remove the internal tubing that connects the sensors to the connectors on the front panel of the unit. No residue was found at the tube or sensor entrances.

ORGANIZATIONAL AND MANAGEMENT INFORMATION

Icelandair operates scheduled flights between Europe and North America, using Iceland as a hub. Icelandair also operates charter and cargo flights. It operates a fleet of 12 Boeing 757-200, one 757-300 and one Boeing 737-300F. Icelandair holds an Air Operators Certificate (AOC) issued by the CAA of Iceland.

ICELANDAIR PROCEDURES/TRAINING

Airspeed Disagree and Unreliable Airspeed Indications

Procedures contained in the Non-Normal Maneuvers portion of Icelandair B-757 Operations Manual (effective September 3, 2002) indicate that in the event of an airspeed disagree, takeoff should be rejected at or before 80 knots. Above 80 knots, the takeoff should be rejected for engine failure, fire, predictive windshear warning, and if the airplane is considered unsafe or unable to fly.

The captain indicated that instead of rejecting the takeoff after noting the low reading of his airspeed indicator (as the airspeed was increasing through 110 knots), he considered it safer to continue the takeoff with the option of returning if the problem persisted.

Although Icelandair made no procedural changes regarding the issue of airspeed anomalies during takeoff, it indicated that it did address the issue of unreliable airspeed and go/no-go takeoff decisions during simulator sessions for its B-757 pilots. Details of the incident flight were also reviewed during annual incident reviews conducted with its pilots.

Unreliable Airspeed Procedures

Icelandair indicated that unreliable airspeed scenarios (during takeoff and in flight) are covered during initial training. Emphasis is placed on locating the instrument error(s) and conducting the unreliable airspeed checklist.

It is also repeated at least every three years in a simulator and was covered in simulator recurrent training approximately one year prior to the incident (including for both pilots from the incident flight). Icelandair indicated that after the incident involving TF-FII, unreliable airspeed scenarios were further emphasized in simulator recurrent training programs.

Procedures contained in the Non-Normal Checklist section of Icelandair's B-757 Operations Manual (dated November 16, 2001, and current at the time of the incident) for a suspected unreliable airspeed include the following.

One or more of the following may be evidence of unreliable airspeed/Mach indication:
- speed/altitude information not consistent with pitch attitude and thrust setting
- speed/Airspeed/Mach failure flags
- blank or fluctuating airspeed displays
- variation between Captain and First Officer airspeed displays
- amber line through one or more ADI flight mode annunciations
- overspeed indications
- radome damage or loss
- simultaneous overspeed and stall warnings
- display of one or more of the following EICAS messages:

ALT DISAGREE MACH/SPEED TRIM
CAPT PITOT OVERSPEED
F/O PITOT PROBE HEAT
IAS DISAGREE R AUX PITOT
L AUX PITOT RUDDER RATIO

(The "ALT DISAGREE" and "IAS DISAGREE" messages would not have applied for the incident airplane, since it had not been modified at the time of the incident with Boeing SB 757-34A0222.)

The checklist stated the following "outlined" procedures (signifying procedures that should be performed from memory):

PITCH ATTITUDE AND THRUST-----CHECK

If pitch attitude or thrust is not normal for phase of flight:
AUTOPILOT............................DISENGAGE
AUTOTHROTTLE............................DISCONNECT
FLIGHT DIRECTORS............................OFF
ATTITUDE AND THRUST............................ADJUST

Establish normal pitch attitude and thrust setting for phase of flight.

[end of recall items]

Note: Normal pitch attitude and thrust settings are available in the "Flight with Unreliable Airspeed" table in the Performance-Inflight chapter.

Altitude information, vertical speed information, limit EPR, Reference EPR, and EPR bug may be unreliable.

SPEED INDICATIONS...........................CROSS CHECK

Cross check captain and first officer airspeed indications and standby airspeed indicator. An airspeed display differing by more than 15 knots from the standby indicator should be considered unreliable.

If the reliable airspeed data source can be determined:

AIR DATA SOURCE SWITCH
(Unreliable side)............................SELECT RELIABLE SOURCE

Invalid overspeed warning and invalid input to AFDS and autothrottle may occur or continue.

If the reliable airspeed data source cannot be determined:

ATTITUDE AND THRUST...........................ADJUST

Maintain normal pitch attitude and thrust setting for phase of flight. Refer to the FLIGHT WITH UNRELIABLE AIRSPEED table in the Performance-Inflight chapter.

The Non-Normal Operations section of Boeing's Flight Crew Training Manual (dated December 1, 1999, and effective at the time of the incident), which Icelandair uses for its training, includes the following information on flight with unreliable airspeed.

Unreliable airspeed indications can result from blocking or freezing of the pitot system. When the ram air inlet to the pitot head is blocked, pressure in the probe is released through the drain holes and the airspeed will slowly drop to zero. If the ram air inlet and the probe drain holes are both blocked, trapped pressure within the system reacts unpredictably. The pressure may increase through expansion, decrease through contraction, or remain constant. In each case the airspeed indications would be abnormal. This could mean increasing indicated airspeed in
climb, decreasing indicated speeds in descent or unpredictable indicated speeds in cruise.

If the flight crew is aware of the problem, flight without the benefit of valid airspeed information can be safely conducted and should present little difficulty. Early recognition of erroneous airspeed indications require familiarity with the interrelationship of attitude, thrust setting and airspeed. A delay in recognition could result in loss of aircraft control.

The flight crew should be familiar with the approximate body attitude for each flight maneuver. For example, climb performance is based on maintaining a particular airspeed or Mach number. This results in a specific body attitude that varies slightly with gross weight and altitude. Any significant change from this body attitude required to maintain a desired airspeed should alert the flight crew to a potential problem.

When the abnormal airspeed is recognized, immediately return the airplane to the target attitude and thrust setting for the flight regime. If continued flight without valid airspeed indications is necessary, consult the Unreliable Airspeed table in the Performance Inflight section of the QRH for the correct attitude and thrust settings for actual airplane gross weight and altitude.

Ground speed information is available from the FMC and on the instrument displays. These indications can be used as a cross check. Many air traffic control radars can also measure ground speed.

Icelandair Stall Recovery Training

Icelandair indicated that its B-757 stall recovery training (from onset of stick shaker) is included during initial training, and that it is conducted during simulator training in both "clean" and approach/landing configurations and with and without terrain contact being a factor. Approach to stick shaker with autopilot engaged is also covered during initial training, A fully developed stall is also covered during initial training, as long as the simulator used can accommodate this type of maneuver. Icelandair indicated that approach to stall recovery training in "clean" and approach/landing configurations and with and without terrain contact being a factor is covered at least every three years but typically more frequently.

Icelandair's stall recovery training utilizes procedures contained in the Boeing 757 Flight Crew Training Manual. Procedures for recovering from an approach to stall and from a fully developed stall include the following.

Approach-to-Stall Recovery ---

If terrain contact not a factor:
At buffet or stick shaker,
- apply maximum thrust
- smoothly decrease pitch attitude to approximately 5 degrees above the horizon (as the engines accelerate, counteract the nose-up pitch tendency with positive forward control column pressure and nose-down trim)
- level wings
- accelerate to maneuvering speed for flap configuration
- stop descent and return to target altitude
- at altitudes above 20,000 feet, pitch attitudes less than 5 degrees may be necessary to achieve acceptable acceleration

Recovery from a Fully-Developed Stall ---

An airplane may be stalled in any attitude (nose high, nose low, high angle of bank) or any airspeed (turning, accelerated stall). It is not always intuitively obvious that the airplane is stalled.

An airplane stall is characterized by any one (or a combination) of the following conditions:
- buffeting, which could be heavy
- lack of pitch authority
- lack of roll control
- inability to arrest descent rate

These conditions are usually accompanied by a continuous stall warning. A stall must not be confused with the stall warning that alerts the pilot to an approaching stall. Recovery from an approach to a stall is not the same as recovery from an actual stall. An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable condition.

Note: Anytime the airplane enters a fully developed stall, the autopilot and autothrottle should be disconnected.

To recover from a stall, angle of attack must be reduced below the stalling angle. Nose down pitch control must be applied and maintained until the wings are unstalled. Application of up to full nose-down elevator and the use of some nose-down stabilizer should provide sufficient elevator control power to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Pilots should not fly the airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen. Under certain conditions, on airplanes with underwing-mounted engines, it may be necessary to reduce thrust in order to prevent the angle of attack from continuing to increase. Once the wing is unstalled, upset recovery actions may be taken and thrust reapplied as necessary.

PREVIOUS B-757 ERRONEOUS AIRSPEED ACCIDENT

In 1996, a B-757 crashed after takeoff from the Dominican Republic. After climbing through 7,300 feet, the airplane started a right descending turn, and it continued to descend until it crashed into the Atlantic Ocean.

FDR and CVR data from the airplane indicate that the airspeeds displayed to the captain during the takeoff roll were erroneous and that the captain was aware of this during the takeoff roll. However, the captain decided to continue the takeoff. Shortly after takeoff, the captain commented that his airspeed indicator had begun to operate even though it indicated unrealistic airspeeds. The climbout was normal, and the captain engaged the center autopilot. During the climb at about 4,700 feet, the advisory messages, "RUDDER RATIO" and "MACH/SPEED TRIM," displayed on the EICAS. The CVR recorded the flight crew discussing the significance of the messages. About 7,000 feet, the captain's airspeed indicator showed 350 knots, and an overspeed warning activated, followed by activation of the stick shaker. The airplane stalled, descended, and then crashed. The investigation determined that the captain's erroneous airspeed indications were consistent with a blocked pitot tube.

NTSB Safety Recommendations

In response to issues identified during the accident investigation, the Safety Board issued Safety Recommendations A-96-15 through -20. Safety Recommendation A-96-15 asked the FAA to issue an airworthiness directive to require that Boeing's 757/767 Airplane Flight Manual be revised to notify pilots that the simultaneous activation of the "MACH/SPEED TRIM" and "RUDDER RATIO" advisories indicates an airspeed discrepancy. On November 15, 1996, Boeing issued a revision to the Boeing 757/767 Operations Manual that included detailed information addressing flightcrew response to a suspected airspeed error. The revision included additional information for recognizing an unreliable airspeed/Mach indication and guidelines for responding to the condition.

Safety Recommendation A-96-16 asked the FAA to require that Boeing modify the 757/767 EICAS to include a caution alert when an erroneous airspeed indication is detected. On May 18, 2004, the FAA issued AD 2004-10-05, effective June 22, 2004. This AD required (1) a modification of the air data computer on certain Boeing 747, 757, and 767 aircraft, and (2) that work performed in response to the AD be in accordance with Boeing SBs referenced in the AD. Among the SBs referenced were instructions to include on Boeing 757 and 767 aircraft a "caution" alert when an erroneous airspeed indication is detected.

Safety Recommendation A-96-17 asked the FAA to require that Boeing modify its 757/767 Operations Manual to include a detailed emergency procedure addressing the identification and elimination of an erroneous airspeed indication. Boeing's revision to the B-757/B-767 Operations Manual issued November 15, 1996, also addressed this recommendation.

Safety Recommendation A-96-18 asked the FAA to issue a flight standards information bulletin (FSIB) to direct principal operations inspectors (POI) to ensure that the operating manuals of their Boeing 757/767 operators include a detailed emergency procedure addressing the identification and elimination of an erroneous airspeed indication. Safety Recommendation A-96-19 asked the FAA to issue an FSIB to notify POIs of the circumstances of this accident and to have them ensure that training providers emphasize the importance of recognizing an airspeed indication malfunction during the takeoff roll. On September 26, 1996, the FAA responded to these recommendations by issuing FSIB 96-15, "Boeing 757/767 Aircraft Airspeed Indicator Malfunction Procedures and Training."

Safety Recommendation A-96-20 asked the FAA to ensure that all 757/767 training providers include an effective scenario in the flight simulator during which the student is trained to appropriately respond to the effects of blocked pitot tubes. On February 25, 1997, the FAA issued a change to Advisory Circular (AC) 120-51B, "Crew Resource Management," to incorporate appropriate crew resource management (CRM) training topics, including those that address the effects of a blocked pitot tube.

Boeing Service Letters 747-SL-34-110, 757-SL-34-140, 767-SL-34-136, and 777-SL-34-022

On June 20, 2001, Boeing issued Service Letters (SL) 747-SL-34-110, 757-SL-34-140, 767-SL-34-136, and 777-SL-34-022, all of which were titled, "Persistent Erroneous

Overspeed Warning," applicable to all 747-400, 757-200, 767-200, and 777 series airplanes. The SLs address a condition with ADCs on these model airplanes in which selection of an alternate air data source does not silence the aural portion of an erroneous airspeed warning. The SL also discusses a resettable overspeed aural feature and the "IAS DISAGREE" and "ALT DISAGREE" EICAS caution messages. According to the SL, Boeing SB 757-34A0222 was scheduled for release on February 28, 2002.

Boeing Alert Service Bulletin 757-34A0222

On March 28, 2002, Boeing issued Alert SB 757-34A0222, which gives instructions to operators of 757 airplanes that provide their flight crews the ability to switch away from a failed ADC that generates an erroneous overspeed or stall warning. The changes also result in generation of the caution EICAS messages, "IAS DISAGREE" or "ALT DISAGREE," when the airspeeds from the left and right ADCs differ more than 5 knots or when the altitudes from the left and right ADCs differ more than 200 feet. (As previously noted, AD 2004-10-05 mandated compliance with SB 757-34A0222.)

After receiving the SB, Icelandair's engineering department recommended its incorporation. At the time of the incident, the company had not made a decision whether to incorporate the SB on its airplanes. Following the incident, Icelandair decided to incorporate the SB. As of Spring 2005, all but two of Icelandair's B-757 airplanes had been modified with the SB. The remaining two airplanes were scheduled for modification later in 2005.

ADDITIONAL INFORMATION

Postincident Company Safety Recommendations and Actions

Icelandair indicated that it incorporated changes since the incident involving the following issues.

Issue:
Review the stall recovery training relating to stall characteristics at cruise altitudes. Training could be accomplished by evaluating information from other airlines or organizations.

Action:
Stall recovery procedures at cruise altitudes were included in Icelandair's flight training syllabus for the B-757-200/300.

Issue:
Emphasize during flight crew training the importance of early detection and analysis of erroneous airspeed.

Action:
The proficiency checks and ground school training for Icelandair B-757 pilots in 2003 included specific emphasis in unreliable airspeed scenarios. In addition, rejected-takeoff procedures were covered.

Issue:
Incorporate Boeing SB 757-34A0222 on applicable 757 airplanes. Prepare and disseminate material to its B-757 flight crews that highlights system changes involving this incorporation.

Action:
After the incident, Icelandair decided to incorporate SB 757-34A-0222 on all applicable aircraft. Icelandair expects to have disseminated the relevant info to all B-757 flight crews once the SB has been fully incorporated.

Issue:
Prepare and disseminate in-depth material to 757 flight crews on the interface between Air Data Computers, Flight Management Computers, and autopilots on its B-757 airplanes.

Action:
Icelandair indicated that work in this area remains ongoing.

Issue:
Evaluate procedures regarding the use of pitot covers, especially those procedures that relate to situations in which the risk of insects or dust penetrating the pitot system is considered likely.

Action:
Icelandair indicated that prior to the incident, the need to use pitot covers was evaluated separately for each destination and would be determined after consulting its contractors carrying out inspections at the various locations. According to the maintenance provider at MCO, it was not standard practice to use pitot covers on aircraft it operated and serviced there.

Following the incident, Icelandair reviewed its procedures pertaining to the use of pitot covers. The new procedures state that when aircraft are parked in a tropical climate or on ground for more than 12 hours, pitot covers are to be installed.

Issue:
Establish and disseminate more detailed procedures on how to preserve CVR data in the event of an accident or serious incident.

Action:
During annual incident reviews with Icelandair pilots in 2003, pilots were briefed on requirements and duties for securing CVRs in case of accidents or serious incidents. Additional language regarding CVR preservation procedures was also inserted into Icelandair's Flight Operations Manual.

ANALYSIS/CONCLUSIONS

During the takeoff roll as the captain was about to call "eighty" knots, the first officer called "hundred." The captain noted that the standby airspeed indicator agreed with the first officer's and decided to continue the takeoff and address the anomaly of his airspeed indicator after takeoff. The pilots indicated that EICAS messages appeared and disappeared several times after takeoff and during the climb, including the messages MACH/SPD TRIM and RUDDER RATIO. Checklists for MACH/SPD TRIM and RUDDER RATIO messages did not mention an unreliable airspeed as a possible condition. The modifications associated with Boeing Alert Service Bulletin 757-34A0222 (and mandated by FAA Airworthiness Directive 2004-10-15 after the incident), which had not been incorporated on the incident airplane, would have provided a more direct indication of the airspeed anomaly. According to information in the Icelandair Operations Manual, these EICAS messages (in conjunction with disagreements between the captain and first officer airspeed indicators) may indicate an unreliable airspeed. Overspeed indications and simultaneous overspeed and stall warnings (both of which occurred during the airplane's climb from FL330 to FL370) are also cited as further indications of a possible unreliable airspeed. The crew did take actions in an attempt to isolate the anomalies (such as switching from the center autopilot to the right autopilot at one point during the flight). However, this did not affect the flight management computer's use of data from the left (captain's) air data system, and the erroneous high airspeeds subsequently contributed to airplane-nose-up autopilot commands during and after the airplane's climb to FL370. During the climb the captain's indicated airspeed began to increase, and the overspeed warning occurred. The first officer indicated that at this time his airspeed indication and the standby airspeed indication both decreased to about 220 knots and his pitch attitude felt high. Despite agreement between the first officer and standby airspeed indications and the pilots' belief that the captain's airspeed indicator was inaccurate, control was transferred from the first officer to the captain. Pitch attitude continued to climb and airspeed continued to decay after the captain assumed control. The airplane's pitch attitude became excessively high until the airplane's stick shaker activated and the airplane stalled. Although stall recovery was eventually effected and the airplane was leveled at FL300, the lack of appropriate thrust and control column inputs following the stall delayed the recovery. Evidence from the investigation indicates that anomalies of the captain's airspeed indicator were caused by a partial and intermittent blockage of the captain's pitot tube. The reason for the blockage was not determined.

The National Transportation Safety Board determines the probable cause(s) of this incident as follows:

The captain's improper procedures regarding stall avoidance and recovery. Contributing to the incident were the partial blockage of the pitot static system, and the flight crew's improper decisions regarding their use of inaccurate airspeed indications. Contributing to the flight crew's confusion during the flight were the indistinct alerts generated by the airplane's crew alerting system.