Docket No. SA-542

Exhibit No. 2-A

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Operational Factors Group Chairman's Factual Report

(25 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 6, 2018

Group Chairman's Factual Report

OPERATIONAL FACTORS

DCA18MA142

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A. ACCIDENT

Location: Philadelphia, Pennsylvania
Date: April 17, 2018
Time: 1103 EDT[1]
1503 UTC[2]
Airplane: Boeing 737-700, N772SW, serial no. 27880

B. OPERATIONAL FACTORS GROUP

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C. SUMMARY

On April 17, 2018, at 1103 eastern daylight time, Southwest Airlines flight 1380, a Boeing 737-7H4, N772SW, experienced a left engine failure and loss of engine inlet and cowling during climb through flight level (FL) 320[4]. Fragments from the engine inlet and cowling struck the wing, fuselage, and one cabin window, resulting in a depressurization. The flight crew conducted an emergency descent and diverted into Philadelphia International Airport (PHL), Philadelphia, PA. Of the 144 passengers and five crewmembers onboard, one passenger received fatal injuries and eight passengers received minor injuries. The airplane sustained substantial damage. The regularly scheduled domestic passenger flight was operating under 14 *Code of Federal Regulations* Part 121 from LaGuardia Airport (LGA), Queens, New York, to Dallas Love Field (DAL), Dallas, Texas.

D. DETAILS OF THE INVESTIGATION

The Operational Factors group was formed on April 18, 2018 at the Philadelphia International Airport. Interviews with the flight crew were conducted on April 18, 2018. The group documented the flight deck on April 17 and 18, 2018.

[1] Eastern daylight time. All times are EDT unless otherwise noted.
[2] Coordinated Universal Time/ Greenwich Mean Time (GMT), also known as Zulu (Z) time.
[3] Aircrew Program Designee
[4] FL320 is the height above mean sea level (msl) at standard atmospheric pressure, measured in hundreds of feet.

Flight documents, crew training records, and company manuals were obtained from Southwest Airlines. Flight crew certification records were obtained from the Federal Aviation Administration (FAA). Technical documents on the B737 were received from Boeing.

E. FACTUAL INFORMATION

1.0 History of the Flight

The crew had arrived at Nashville International Airport (BNA), Nashville, Tennessee, the night before the accident (Monday), and had ended their duty day at 2017 CDT[5] after completing a block time[6] of 7 hours and 53 minutes, and a total duty time[7] of 12 hours and 28 minutes. The following morning, (the day of the accident) they reported to BNA at 0600 CDT for their first flight to LGA. The flight to LGA was uneventful. The accident flight was the second flight of the day for the crew and was planned to go from LGA to DAL. There were 144 passengers, two flightdeck crewmembers and three cabin crewmembers aboard. The passenger count included one Southwest Airlines ramp employee who was seated on a flight attendant jumpseat. The accident flight had an on-time departure from LGA at 1030. The first officer (FO) was the pilot-flying (PF).

The crew stated nothing unusual occurred during the taxi, takeoff, and climb to their cleared cruising altitude of FL380. At 1103, and about 40.444° north latitude, 76.235° west longitude[8], and shortly after passing through FL320, the crew noted a loud bang, significant aircraft vibration, and aircraft yaw and bank to the left. The CABIN ALTITUDE warning light and horn (indicating cabin altitude of more than 10,000 ft) were activated almost immediately after the onset of the vibration.

The crew donned their oxygen masks. The PF rolled the airplane back to wings-level and began an emergency descent. About one minute later, the aircraft was descending through FL307. At 1104, the air traffic controller in communication with the flight (unaware of the situation) issued a clearance direct to VINSE waypoint. The controller reported hearing a response that contained only static. He also stated he heard an alarm in the background. In the crew interviews, (Attachment 1) they reported some initial confusion about the position of one of the switches which allowed the crew to communicate through a microphone in the oxygen masks. By 1105, the communication issue had been resolved, and the crew reported an engine fire to the controller, and that they were descending.[9] They asked for vectors to the nearest airport. The controller responded with Harrisburg International Airport (MDT), Middletown, Pennsylvania, and issued a heading of 250 degrees to that airport. The crew then requested a destination of PHL. At 1106, after coordination with another controller, the controller in contact with the flight cleared the flight to fly direct to PHL.

[5] central daylight time
[6] Block time is the total time from an aircraft leaving the departure gate until its arrival at the destination gate.
[7] Duty time is the total time on duty and includes total block time and time on the ground before and after flights.
[8] Location according to FAA form 8020-6, "Report of Aircraft Accident."
[9] Source: ATC Communications Summary

Shortly after the descent was begun, the captain, per Southwest Airlines requirement, took the airplane's controls to become the PF, and the FO assumed the duties of pilot monitoring (PM.)[10] He then began executing the *Engine Fire or Engine Severe Damage or Separation* checklist from the Southwest Airlines B737NG Quick Reference Handbook (QRH.)

The crew reported they accomplished the non-normal *Engine Fire or Engine Severe Damage or Separation* checklist. The pilots stated during their respective interviews they were very busy controlling the plane and assessing the damage and they did not execute two other appropriate non-normal checklist, *Cabin Altitude Warning or Rapid Depressurization* (indicated by the *CABIN ALTITUDE* warning light and horn), or *Emergency Descent* (required by step 5 of the *Cabin Altitude Warning or Rapid Depressurization* checklist.) The other checklist they stated they accomplished was the *Before Landing* checklist. The three non-normal checklists mentioned above are shown and discussed in section 7.2.

According to the cockpit voice recorder (CVR) transcript, about 11 minutes after the engine failure, the FO attempted to call the cabin to speak to the flight attendants. The FO stated in his interview there was no reply to his call. In separate interviews[11], a flight attendant stated she heard the interphone chime, but when she answered it, she could not hear anything. She stated it was too loud in the cabin. A few seconds later, another flight attendant was successful in reaching the flightdeck on the interphone. The CVR transcript confirms that shortly after the FO reported no reply to his first call, a chime was heard on the flightdeck, and the FO began speaking with one of the flight attendants. This was the first communication between the flightdeck and the cabin and was when the flightdeck crew first learned of the situation in the cabin, including an injured passenger.

According to information from the Flight Data Recorder, from the time of the event until reaching about 17,000 feet msl, the airplane maintained an airspeed between 280 and 300 knots. As the descent continued, the airplane gradually slowed, reaching an airspeed of about 185 knots two minutes before landing. The airplane maintained this speed through the approach until touchdown. The flight conducted a visual approach to runway 27L at PHL and landed without further incident 17 minutes after the engine failure.

The captain stated in the interview that she initially flew slower than the recommended speed for emergency descent to reduce the severity of the airframe vibration. The captain also stated she flew the final segment of the approach at a higher-than-normal airspeed of 180 knots because she was concerned about controllability problems and did not want to get too slow. The recommended landing flap configuration from the Aircraft Operating Manual for a single engine landing was flaps 15. The captain said she chose to land with flaps 5 to avoid getting too slow and because of the airplane's sluggish handling. The aircraft operating manual does not list recommended reference speeds for landing with flaps 5, so the captain decided to use the speed for flaps 15 and add 20 knots. She obtained the speed for flaps 15 landing from the referring to the approach reference page on the Flight Management Computer, then added 20 knots (to account for the flap 5 vs flaps 15 setting.) She stated this came to 180 knots.

[10] Southwest Airlines Flight Operations Manual sections 3.1.2 and 12.1.2.
[11] For flight attendant interviews, see the Survival Factors Group Chairman's Factual Report for this accident.

2.0 Flight Crew Information

The incident flight crew consisted of a Captain and an FO. The accident flight occurred on day 2 of a 4-day pairing. The first day the crew had a report time of 0730 CDT and operated three flights with their day terminating at BNA. On the day of the accident they began their day at 0600 CDT and operated a flight from BNA to LGA. The accident flight then departed LGA at 1040.

2.1 The Captain

2.1.1 The Captain's Pilot Certification Record

FAA records for the Captain indicated the following:

Commercial Pilot – Airplane Single and Multiengine Land - limited to center thrust; Instrument Airplane certificate issued May 8, 1987.

Airline Transport Pilot – Airplane Multiengine Land; B-737; Commercial Privileges Airplane Single Engine Land certificate issued July 28, 1993. (Re-issued January 13, 2009 to remove SSN.)

2.1.2 The Captain's Certificates and Ratings Held at Time of the Accident

AIRLINE TRANSPORT PILOT (issued January 13, 2009)
Airplane Multiengine Land
B-737
Commercial Privileges Airplane Single Engine Land

MEDICAL CERTIFICATE FIRST CLASS (issued December 12, 2017)
Limitation(s): Must have available glasses for near vision.

2.1.3 The Captain's Training and Proficiency Checks Completed

The information below was provided by Southwest Airlines[12].

Date Upgraded to Captain on B-737	September 11, 2000
Date of Initial Type Rating on B-737	July 28, 1993
Date of Most Recent LOE[13]	May 3, 2017
Date of Most Recent Simulator Training Event	May 2, 2017
Date of Most Recent PIC Line Check	April 21, 2017

2.1.4 The Captain's Flight Times

The captain's flight hours, based on Southwest Airlines and the captain's records:

[12] See Attachment 2
[13] Line Oriented Evaluation. This is the recurring pilot evaluation event associated with Southwest Airlines' Advanced Qualification Program (AQP) training program. For more information on LOE and AQP, see section 7.1

Total pilot flying time	11,715
Total Pilot-In-Command (PIC) time	8,518
Total B-737 flying time	10,513
Total B-737 PIC time	7,118
Total flying time last 24 hours	8
Total flying time last 30 days	43
Total flying time last 90 days	123
Total flying time last 12 months	537

2.1.5 The Captain's 72-Hour History

On Saturday, April 14, 2018, the captain stated she was off duty, and woke up about 0800 CDT, and gone to bed that night at midnight. On Sunday, she woke up at 0800 CDT and went to church. She left home early this day to commute to William P. Hobby Airport (HOU), Houston, Texas, where she was based, for her flight Monday morning. On Sunday night, she went to bed at 2045 CDT. On Monday morning, she woke up at 0500 CDT for a report time of 0730 CDT. Monday was a 12-hour duty day due to delays. She was at the crew hotel and in bed by 2130 CDT Monday night. On Tuesday, the day of the accident, she woke up at 0500 CDT, and did not feel fatigued when she reported for duty. Prior to the accident flight she operated one flight from BNA to LGA.

2.1.6 The Captain's Personal Background

The Captain was 56 years old and had been a pilot for Southwest Airlines for 24 years. She had flown as an FO on the B737 until 2000, when she upgraded to captain. She had held no other positions with Southwest Airlines.

She had entered the U.S. Navy in 1985 and had flown A-7s and F-18s. After she left the Navy, she flew forest fire support for one summer before joining Southwest Airlines.

2.2 The First Officer

2.2.1 The FO's Pilot Certification Record

FAA records for the FO indicated the following:

Commercial Pilot – Airplane Multiengine Land; B-707 B-720; Instrument Airplane certificate issued February 13, 2007.

Airline Transport Pilot – Airplane Multiengine Land; B-707 B-720 B-737 certificate issued March 17, 2007. (Re-issued July 21, 2008 to replace a lost certificate.)

2.2.2 The FO's Certificates and Ratings Held at Time of the Accident

AIRLINE TRANSPORT PILOT (issued July 21, 2008)
Airplane Multiengine Land

B-707 B-720 B-737

MEDICAL CERTIFICATE FIRST CLASS (issued January 22, 2018)
Limitation(s): none

2.2.3 The F/O's Training and Proficiency Checks Completed

The information below was provided by Southwest Airlines[14].

Date of Initial Type Rating on B-737	March 17, 2007
Date of Initial Line Check on B-737	December 14, 2008
Date of Most Recent LOE	November 8, 2017
Date of Most Recent Simulator Training Event	November 7, 2017

2.2.4 The F/O's Flight Times

The accident F/O's flight hours, based on Southwest Airlines records:

Total pilot flying time	9,508
Total PIC time	1,468
Total Second-in-Command (SIC) time	8,039
Total flying time in B-737	6,927
Total B-737 SIC time	6,927
Total flying time last 24 hours	8
Total flying time last 30 days	70
Total flying time last 90 days	202
Total flying time last 12 months	671

2.2.5 The F/O's 72-Hour History

The FO began the 4-day trip on Monday, April 16, 2018. He stated he went to bed about 2130 CDT on the previous Sunday night. He slept well and felt rested when he reported for duty at HOU (where he was based) at 0730 CDT on the 16th. On that day, he flew three flights, and ended the day in Nashville at 2017 CDT. He went to bed in his hotel room shortly after 2100 CDT on the 16th. On Tuesday, April 17th, he woke up about 0500 CDT and reported for duty at 0600 CDT. Before the accident flight, he flew one flight, from BNA to LGA.

[14] See Attachment 3

2.2.6 The FO's Personal Background

The FO was 44 years old. He had graduated from the US Air Force Academy, and had flown T-37, T-1, and E-3 AWACS aircraft in the Air Force. He had been employed at Southwest Airlines for 10 years and 2 months. He had served as a B-737 FO for all his time at Southwest Airlines.

2.3 Pathological Information

Required alcohol and drug screening tests were conducted on each crewmember following the accident. All results were negative.

3.0 Aircraft Information

The accident airplane was a Boeing 737-700, registration number N772SW, serial number 27880. It was owned by Southwest Airlines. It was equipped with two CFM56 Series engines, manufactured by CFM International. There were no deferred maintenance (MEL[15]) items listed on the dispatch release for the accident flight. There were 143 passenger seats on the airplane, four cabin-crew jumpseats (two double seats), two pilot seats, and two flightdeck observer seats[16].

3.1 Weight and Balance Information

The information in the table below was provided by Southwest Airlines in the form of the flight's weight and balance report, included as Attachment 4.

WEIGHT & BALANCE / PERFORMANCE (maximum weights in bold)	
Operating Empty Weight (OEW[17])	84,835
Cabin Crew weight, including jumpseater	840
Passenger weight	27,150
Cargo / baggage weight	4,237
Take-off Fuel weight	25,500
Takeoff Weight	142,600
Maximum Takeoff Weight	**154,500**
Planned landing weight (DAL)	125,900
Maximum Landing Weight	**128,000**
Center of Gravity (CG)	23.0
Takeoff CG limits	9.8-31.5

Weights are in pounds. Center of Gravity and Takeoff CG limits are in percent of MAC[18].

[15] *Minimum Equipment List* is a list of items on the airplane that may be inoperable while still allowing the airplane to operate, provided specified operational and/or maintenance requirements are met.
[16] Aircraft seating configuration provided by NTSB Survival Factors Group Chairman's Field Notes.
[17] According to Southwest Airlines Weight and Balance Manual, OEW includes the aircraft, oil and other fluids, galley supplies, and normal complement of flight deck crewmembers and their baggage.
[18] Mean Aerodynamic Chord

4.0 Meteorological Information[19]

The Automated Surface Observing System (ASOS) at PHL reported the following airport conditions at 1454Z (about 9 minutes before the accident) and 1554Z (about 34 minutes after the flight landed at PHL.)

At 1454Z, winds were from 290° at 18 knots, gusting to 27 knots. Visibility was 10 statute miles or greater, there was a broken ceiling at 4800 ft and broken skies at 8000 ft above the ground. The temperature was 7° C and the dewpoint temperature was -4° C. The altimeter setting was 29.75 inches of mercury.

At 1554Z, winds were from 270° at 16 knots, gusting to 21 knots. Visibility was 10 statute miles or greater, there was a broken ceiling at 4900 ft and overcast skies at 8000 ft above the ground. The temperature was 7° C and the dewpoint temperature was -4° C. The altimeter setting was 29.73 inches of mercury.

A review of pilot reports (PIREPS) within 100 miles of the accident site from about two hours prior to the accident time to about one hour after the accident time for altitudes above 10,000 ft revealed no reports of turbulence or other significant weather conditions.

The New York Center Weather Service Unit (CWSU) had issued no Center Weather Advisories (CWA) or Meteorological Impact Statements (MIS) valid for the accident site at the accident time.

There were no convective or non-convective SIGMETS valid for the accident site at the time of the accident. There was an AIRMET valid at the time of the accident and for the accident location which warned of moderate turbulence between FL240 and FL410.

5.0 Communications[20]

5.1 Crew Communications System

Each pilot was provided an audio control panel (ACP) which allowed crewmembers to select both what audio sources they were listening to and to where they were transmitting. See Figure 1, below.

[19] Source is the NTSB Meteorology Factual Report for this accident.
[20] Source: Boeing document 737-600/700/800/900 SDS SWA D633A101-SWA (Received from Boeing)

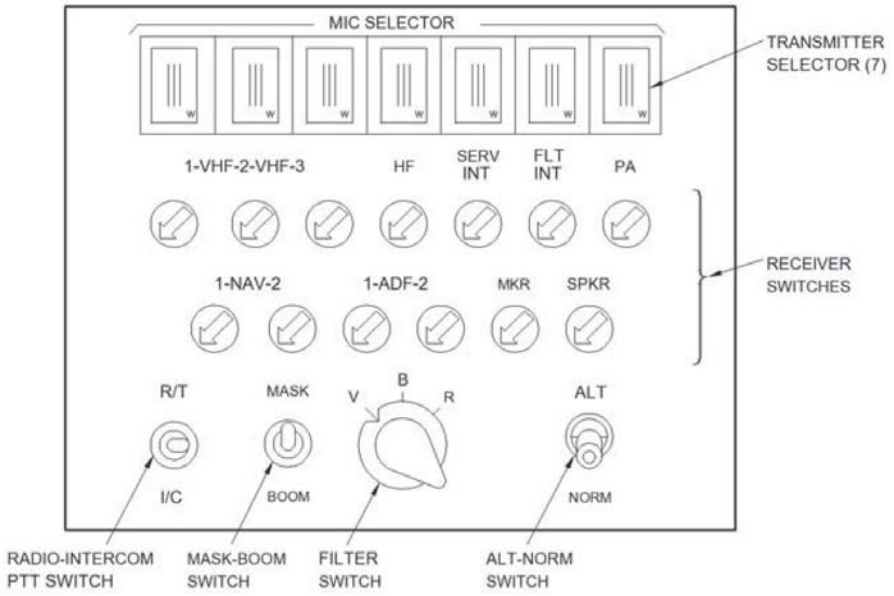


Figure 1: B737-700 Audio Control Panel

The flightdeck crew was provided with two sets of switches on the ACP. The transmitter selector switches allowed each crewmember to select where his transmission was going. To speak over the VHF radio for example, one of the three VHF transmitter switches would be selected. To speak with the cabin crew, the service interphone (SERV INT) switch would be selected, and to make an announcement to the passengers, the public address (PA) switch would be selected. Only one transmit switch could be selected at a time. The Receiver switches allowed the pilot to select one or more sources to listen to. Selecting a transmit switch also enabled the listening function for that selection; it was not necessary to select the corresponding receiver switch. After selecting a destination for the transmission, to begin transmitting, the crewmember could use either a push-to-talk (PTT) switch on the control wheel, or the R/T – I/C switch on the ACP. The R/T – I/C switch was spring loaded to the center (off) position. When held to the R/T position, the crewmember would be transmitting over the selected transmitter. The I/C position allowed the crewmember to speak over the interphone system with other crewmembers. The control-wheel mounted switch provided similar functionality but could be latched in the intercom position to facilitate continuing communication over the interphone. When this switch was latched in the I/C position, ACP transmit settings were not changed.

5.2 Oxygen Mask Microphone

Each crewmember was provided with an oxygen mask containing a microphone to allow communications while the mask was worn. The ACP (Figure 1) for each crew member had a switch which activates the microphone in the mask. The switch had two positions; “BOOM” and “MASK.”. When this switch was placed in the “MASK” position, the microphone in the crewmember’s oxygen mask would be activated, and the crewmember wearing the mask would be able to communicate through the VHF radio system, the airplane’s interphone system, or over the PA system to make announcements to the passengers. In the “BOOM” position, the crewmember would be able to speak into any other microphone connected to the system, either a

hand-held microphone, or a "BOOM" microphone attached to the crewmember's headset. According to the Preflight section of Southwest Airlines' B737NG Aircraft Operating Manual, this switch should be returned to the "BOOM" position after testing the mask microphone during the preflight checklist. The *Cabin Altitude Warning or Rapid Depressurization* checklist (section 7.2.2) shows *Establish Crew communications* as the next step after donning the oxygen mask but does not specifically direct crewmembers to move this switch to "MASK". According to Operational Factors group members from Southwest Airlines, the airline uses *Establish Crew communications* as a checklist item and trains crews specifically on the various Audio Panels installed in the aircraft. Not all Southwest aircraft had a "MASK-BOOM" switch on the panel. For example, the B737-800 Audio Panel does not have the switch, since the oxygen mask microphone is activated automatically when the mask is removed from its storage compartment.

5.3 Flightdeck-Cabin Communications[21]

An interphone system allowed communication between the flightdeck crew and the cabin crew. The system consisted of two handsets which were similar to traditional telephone handsets. They were located in the cabin, one each at the forward and aft flight attendant stations. To call the cabin, the flightdeck crew would select the attendant call button on the overhead panel. This would cause a hi/lo chime to sound in the cabin, prompting a cabin crewmember to answer using one of the handsets. To call the flightdeck from one of the flight attendant handsets, the "PILOT" button on one of the cabin handsets would be pushed twice for a routine call, or 4 times for an emergency call. This would sound either two or four sets of hi/lo chimes on the flightdeck, prompting either crewmember to answer by selecting the "SERV INT" transmit switch on their ACP.

6.0 Airport Information[22]

Philadelphia International Airport (PHL) was the main airport serving the city of Philadelphia, PA. It was the primary airport within the Philadelphia Class B airspace and had four take-off and landing surfaces allowing for eight designated runways. The runways were served by numerous instrument approaches. The airport had a control tower which operated continuously. The airport had an Airport Rescue and Firefighting (ARFF) index of E. For more information about airport classification and ARFF ratings, see section 7.3.

7.0 Company Information

7.1 Pilot Training[23]

Southwest Airlines utilized an FAA-approved Advanced Qualification Program (AQP) to train it's flightdeck crewmembers. According to Southwest's AQP Manual (AQPM), "The objective of Southwest Airlines AQP is to utilize the instructional system design (ISD) process to provide operationally relevant, systematically designed and statistically validated training to the flight deck

[21] Source: Boeing document 737-600/700/800/900 SDS SWA D633A101-SWA and Southwest Airlines Flight Attendant Manual
[22] Source: FAA Chart Supplement for PHL.
[23] Source: Southwest Airlines Advanced Qualification Program Manual (AQPM).

crewmembers, instructors, and evaluators of Southwest Airlines. The intended result of this training is improved technical and human factors skills as well as decreased operational risk."

The AQP contained three primary curriculums (Indoctrination, Qualification, and Continuing Qualification Training, or CQT) for each make, model, and series of aircraft, and for each duty position. The two pilots involved in this accident were each participating in the Continuing Qualification Training curriculum. According to the AQPM, the Continuing Qualification Curriculum consisted of classroom training, device ground training, and full-flight simulator training. The practice and evaluation of flight maneuvers and emergency procedures took place primarily in the full-flight simulator training. The two primary CQT events conducted in the full-flight simulator were the maneuvers observation (MO) and the line operational evaluation (LOE). The MO and the LOE events were administered to pilots each calendar year

MO events provided pilots with practice performing critical or infrequently used skills. Each accident crewmember's training record indicates they completed the MO one day prior to their most recent LOE. (See section 2 for most recent crewmember LOE dates.) A list of items observed during the crew's most recent MO event was obtained from Southwest Airlines. According to the list, two items relevant to this accident were observed during their 2017 MO. One item was *engine failure during takeoff/severe damage/fire.* The second item was *engine failure during approach/ILS CAT I minimums/flame out.* The Southwest Airlines AQP Manual stated the following concerning the MO portion of a recurring qualification curriculum:

> *The Pilot CQT Maneuvers Observation event is administered to eligible pilots each calendar year. Maneuvers Observations are conducted in full flight simulators. MO events provide pilots with practice performing critical or infrequently used skills. The approved ISD process produces unique MO event profiles for each calendar year to adapt the curriculum to integrated data collection and analysis. Observation rules of engagement apply to Maneuvers Observation events*[24]*.*
>
> *Any substandard event is repeated to meet the applicable performance standards.*
>
> *Only the unsatisfactory portion of an event set must be repeated to meet performance standards, so long as the complexity, difficulty, and conditions of the repeat are similar to the first attempt.*
>
> *Repeats are accomplished during the scheduled event period.*
>
> *CQT Maneuvers Observation events result in Satisfactory, Additional Training Required, or Incomplete*.

[24] According to the Southwest Airlines AQPM, the rules of engagement for observation events were:

- The observation of the first attempt of each event set shall be recorded for data collection.
- In the event the first attempt is substandard, the number of repeats is not limited, and training is not prohibited in order to provide an opportunity to demonstrate satisfactory performance.
- The I/E (instructor/evaluator) shall ensure that learner performance meets event learning objectives prior to recording the completion of the event.

LOE events evaluated flight crewmembers on those skills which may be required in daily operations. Standardized triggering events were introduced to allow evaluators to observe flight crewmembers' behaviors in normal and non-normal situations, as well as create complex or time sensitive conditions requiring RRM (risk resource management) skills which meet performance standards. LOE events were designed to allow evaluators the opportunity to evaluate a crew's RRM skills, including the identification and management of errors. Pilot LOE events may therefore be expected to create scenarios likely to led to crew errors which must then be recognized and managed by the crew.

New LOE scenarios containing different triggering events were introduced on a yearly basis. The *Southwest Airlines 2017 Pilot CQT Day 3 Evaluator Supplement* contains the LOE scenarios used in that calendar year. The accident captain and FO completed the LOE portion of the CQT curriculum in May and November of 2017, respectively. A review of the three LOE scenarios contained in the Evaluator Supplement indicated that events relevant to this accident (engine severe damage, rapid depressurization, and emergency descent) were not events evaluated during the pilots' most recent LOE events. These events also did not appear in the 2016 LOE scenarios that were contained in *Southwest Airlines 2016 Pilot CQT Day 3 Evaluator Supplement*.

Special Purpose Operational Training (SPOT) was a third AQP training event conducted in a full-flight simulator and was defined in the Southwest Airlines AQPM as "A unit of training (event set) to provide practice and instruction for a single skill set, usually contained within a maneuvers observation." The Southwest Airlines SPOT training events were contained in the two Evaluator Supplements noted in the previous paragraph. For 2016, Southwest Airlines SPOT training contained a rapid depressurization/emergency descent event. SPOT training for 2017 did not contain training on events relevant to this accident.

7.2 Relevant Company Procedures – Non-Normal Checklists

Southwest Airlines used two items on the flight deck to assist the pilot in dealing with non-normal situations in flight: The QRH and the Quick Reference Card (QRC)[25].

Non-normal checklists contained immediate action items, quick reference items, and reference items. Immediate action items were time-critical steps that must be committed to and accomplished from memory. Immediate action items were listed above a red dashed-line separator symbol both in the QRH and on the QRC. Quick reference items were time sensitive steps that were to be completed by use of the QRC, though they were also contained in the QRH. Quick reference items were listed above a black dashed-line separator symbol both on the QRC and in the QRH. Reference items are actions or steps that were to be accomplished while reading the non-normal checklist.

The QRC was a tool provided to assist the flight deck crew in the accomplishment of quick reference items during non-normal checklists. The QRC listed the steps within a non-normal

[25] Attachment 6

checklist necessary to stabilize the event. Subsequent direction was provided in the QRC to complete the remainder of the appropriate non-normal checklist within the QRH, if required.

Based on the descriptions of the checklists from the QRC/QRH, (see sections 8.2.1, 8.2.2, and 8.2.3), the three relevant non-normal checklists for this accident were: *Engine Fire or Engine Severe Damage or Separation; Cabin Altitude Warning or Rapid Depressurization; Emergency Descent*.

According to crew interviews, the crew accomplished only the *Engine Fire or Engine Severe Damage or Separation* and the *Before Landing* checklists. The *Before Landing* checklist was considered a normal checklist. According to interviews, the FO stated his hands were full trying to accomplish the first item on the Southwest Airlines non-normal procedures general guidance (contained in section 5 of the Southwest Airlines Flight Operations Manual (FOM), printed on the cover of the Southwest Airlines B737NG QRH, and excerpted below in figure 2) and the Captain stated she kept going back to the number one item in the guidance.

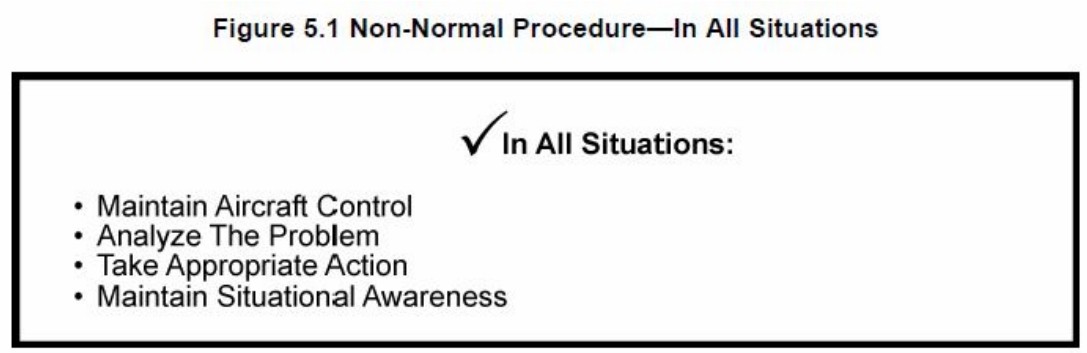


Figure 2: Excerpt from Section 5, Southwest Airlines FOM

7.2.1 Engine Fire or Engine Severe Damage or Separation Checklist

According to the SWA (Southwest Airlines) B737NG Quick Reference Handbook, this checklist should be accomplished if one or more of the following occur:

Engine fire warning;
Airframe vibrations with abnormal engine indications;
Engine separation.

The 3-page checklist is shown below in figure 3.

ENGINE FIRE or Engine Severe Damage or Separation

Condition: One or more of these occur:
- Engine fire warning
- Airframe vibrations with abnormal engine indications
- Engine separation.

1 Autothrottle (if engaged) . . . . . .Disengage

2 Thrust lever
(affected engine) . . .Confirm . . . . . Close

3 Engine start lever
(affected engine) . . .Confirm . . . . . CUTOFF

4 Engine fire switch
(affected engine) . . .Confirm . . . . . Pull

To manually unlock the engine fire switch, press the override and pull.

5 **If** the engine fire switch or ENG OVERHEAT light is illuminated:

Engine fire switch . . . . . Rotate to the stop and hold for 1 second

If after 30 seconds the engine fire switch or ENG OVERHEAT light stays illuminated:

Engine fire switch. . . . . .Rotate to the other stop and hold for 1 second

▼ Continued on next page ▼

▼ENGINE FIRE or Engine Severe Damage or Separation continued▼

6 Choose one:

◆High airframe vibration **occurs** and **continues** after the engine is shut down:

Without delay, reduce airspeed and descend to a safe altitude which results in an acceptable vibration level.

Note: If high vibration returns and further airspeed reduction and descent are not practical, increasing airspeed may reduce the vibration.

►►Go to step 7

◆High airframe vibration does **not** occur or does **not** continue after the engine is shut down:

►►Go to step 7

7 ISOLATION VALVE switch . . . . . CLOSE

8 PACK switch (affected side) . . . . . OFF

This causes the operating pack to regulate to high flow in flight with the flaps up.

9 APU BLEED air switch . . . . . OFF

10 Choose one:

◆APU is **available** for start:

APU . . . . . START

When APU is running:

APU GEN switch (affected side) . . . . . ON

►►Go to step 11

◆APU is **not** available:

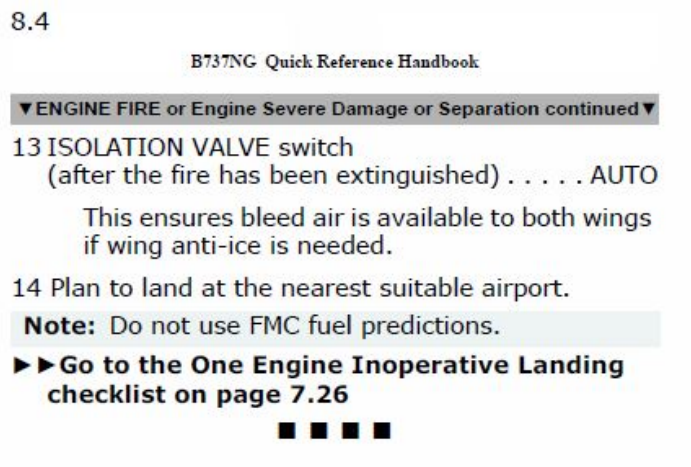
►►Go to step 11

11 Balance fuel as needed.

12 Transponder mode selector . . . . . TA

This prevents climb commands which can exceed single engine performance capability.

▼ Continued on next page ▼



8.4

B737NG Quick Reference Handbook

▼ENGINE FIRE or Engine Severe Damage or Separation continued▼

13 ISOLATION VALVE switch
(after the fire has been extinguished) . . . . . AUTO

This ensures bleed air is available to both wings if wing anti-ice is needed.

14 Plan to land at the nearest suitable airport.

Note: Do not use FMC fuel predictions.

►►**Go to the One Engine Inoperative Landing checklist on page 7.26**

■ ■ ■ ■

Figure 3: Excerpt from Southwest Airlines QRH: Engine Fire or Engine Severe Damage or Separation Checklist

7.2.2 Cabin Altitude Warning or Rapid Decompression Checklist

According to the SWA B737NG Quick Reference Handbook, this checklist should be accomplished if one or more of the following occur:

> A cabin altitude exceedance;
> In flight, the intermittent cabin altitude/configuration warning horn sounds or a CABIN ALTITUDE light (if operative) illuminates[26]

The checklist is shown in figure 4 below.

[26] The SWA B737NG Aircraft Operating Manual states the CABIN ALTITUDE warning light illuminates when the cabin altitude exceeds 10,000 feet.

CABIN ALTITUDE WARNING or Rapid Depressurization

CABIN ALTITUDE if operative

Condition: One or more of these occur:
- A cabin altitude exceedance
- In flight, the intermittent cabin altitude/configuration warning horn sounds or a CABIN ALTITUDE light (if operative) illuminates.

1 Don oxygen masks and set regulators to 100%.

2 Establish Crew communications.

3 Pressurization mode selector . . . . . MAN

4 Outflow VALVE switch . . . . . Hold in CLOSE until the outflow VALVE indication shows fully closed

5 **If** cabin altitude is **uncontrollable**:

Passenger signs . . . . . ON

PASS OXYGEN switch . . . . . ON

►►**Go to the Emergency Descent checklist on page 0.1**

■ ■ ■ ■

6 **If** cabin altitude is **controllable**:

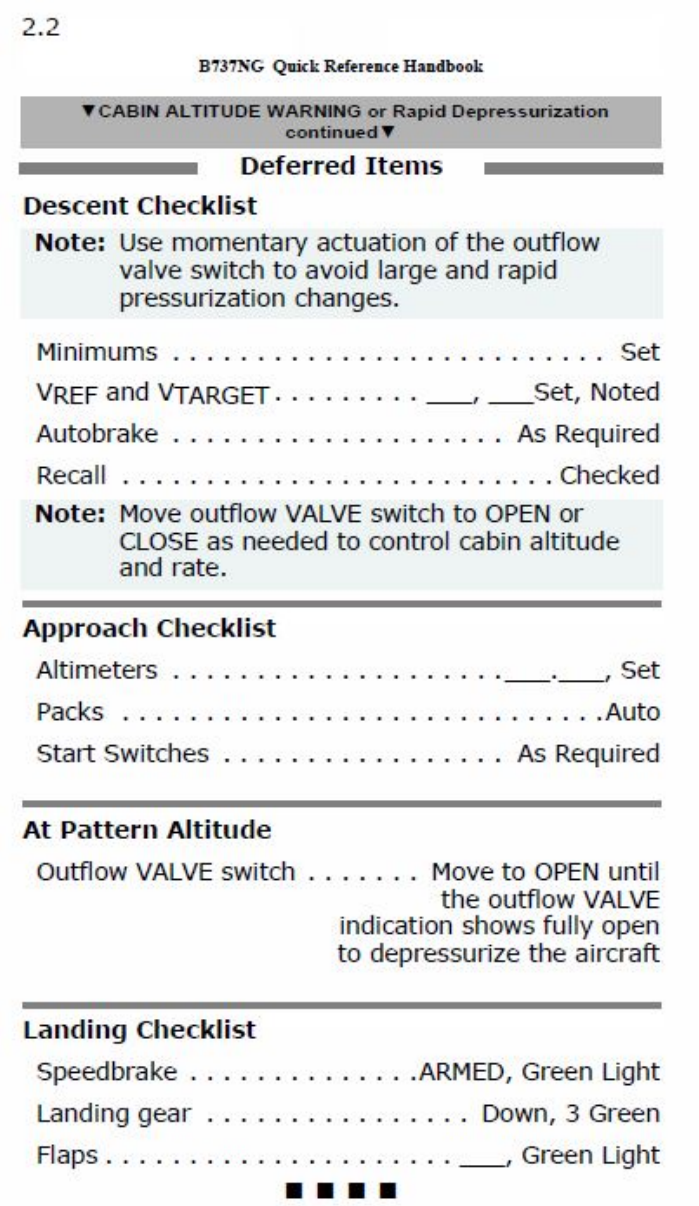
Continue manual operation to maintain correct cabin altitude.

When the cabin altitude is at or below 10,000 feet:

Oxygen masks may be removed.

7 **Checklist Complete Except Deferred Items**

▼ Continued on next page ▼



2.2

B737NG Quick Reference Handbook

▼CABIN ALTITUDE WARNING or Rapid Depressurization continued▼

Deferred Items

Descent Checklist

Note: Use momentary actuation of the outflow valve switch to avoid large and rapid pressurization changes.

Minimums . . . . . Set

VREF and VTARGET . . . . . ___, ___Set, Noted

Autobrake . . . . . As Required

Recall . . . . . Checked

Note: Move outflow VALVE switch to OPEN or CLOSE as needed to control cabin altitude and rate.

Approach Checklist

Altimeters . . . . . .___.___, Set

Packs . . . . . .Auto

Start Switches . . . . . As Required

At Pattern Altitude

Outflow VALVE switch . . . . . Move to OPEN until the outflow VALVE indication shows fully open to depressurize the aircraft

Landing Checklist

Speedbrake . . . . . .ARMED, Green Light

Landing gear . . . . . Down, 3 Green

Flaps . . . . . ___, Green Light

■ ■ ■ ■

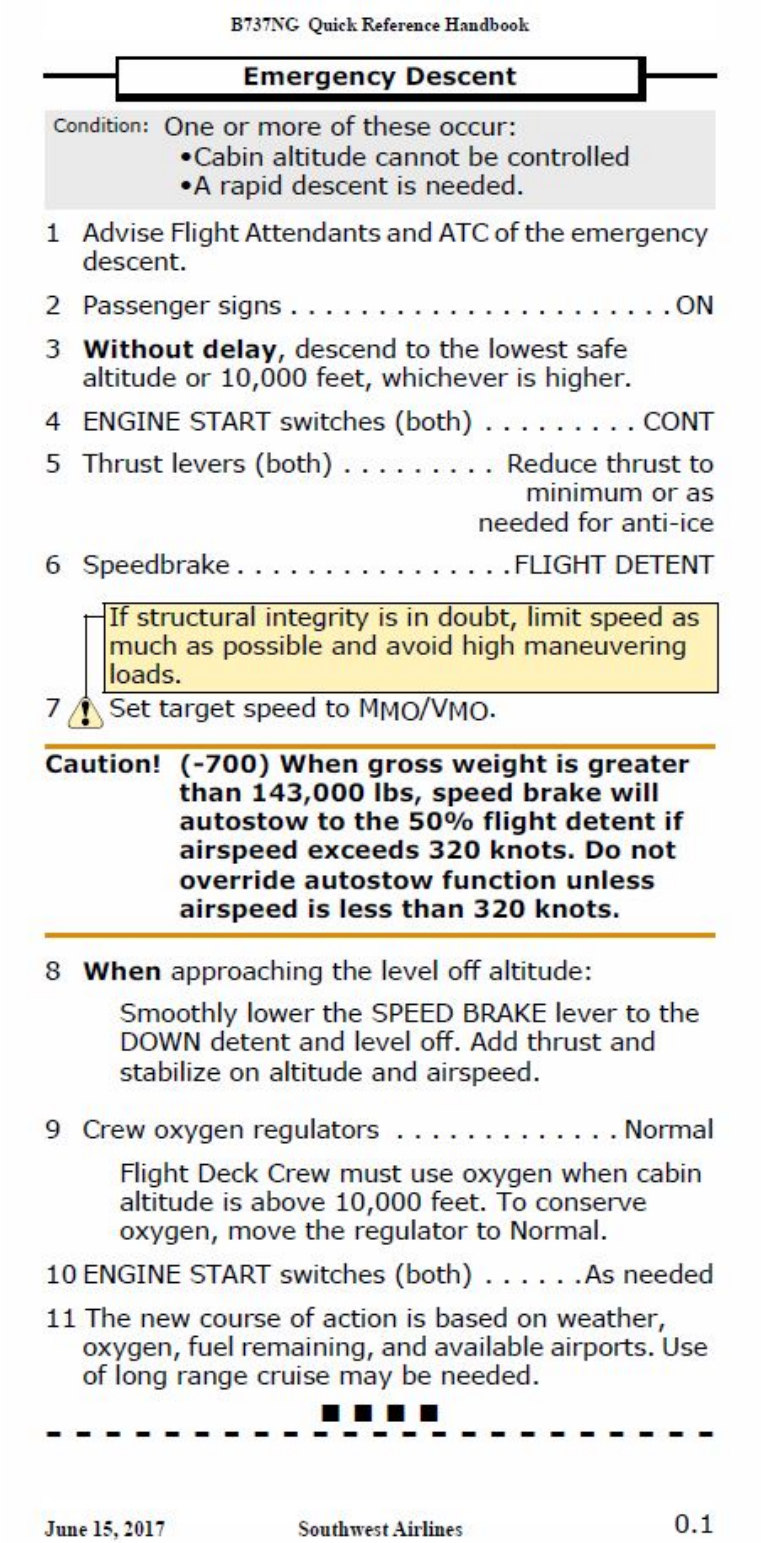
Figure 4: Southwest Airlines QRH Excerpt: Cabin Altitude Warning or Rapid Depressurization Checklist

7.2.3 Emergency Descent Checklist

According to the SWA B737NG Quick Reference Handbook, this checklist should be accomplished if one or more of the following occur:

Cabin altitude cannot be controlled
A rapid descent is needed.

The checklist is shown in figure 5 below.



B737NG Quick Reference Handbook

Emergency Descent

Condition: One or more of these occur:
- Cabin altitude cannot be controlled
- A rapid descent is needed.

1 Advise Flight Attendants and ATC of the emergency descent.

2 Passenger signs . . . . . ON

3 **Without delay**, descend to the lowest safe altitude or 10,000 feet, whichever is higher.

4 ENGINE START switches (both) . . . . . CONT

5 Thrust levers (both) . . . . . Reduce thrust to minimum or as needed for anti-ice

6 Speedbrake . . . . . FLIGHT DETENT

If structural integrity is in doubt, limit speed as much as possible and avoid high maneuvering loads.

7 Set target speed to M_{MO}/V_{MO}.

Caution! (-700) When gross weight is greater than 143,000 lbs, speed brake will autostow to the 50% flight detent if airspeed exceeds 320 knots. Do not override autostow function unless airspeed is less than 320 knots.

8 **When** approaching the level off altitude:

Smoothly lower the SPEED BRAKE lever to the DOWN detent and level off. Add thrust and stabilize on altitude and airspeed.

9 Crew oxygen regulators . . . . . Normal

Flight Deck Crew must use oxygen when cabin altitude is above 10,000 feet. To conserve oxygen, move the regulator to Normal.

10 ENGINE START switches (both) . . . . . As needed

11 The new course of action is based on weather, oxygen, fuel remaining, and available airports. Use of long range cruise may be needed.

■ ■ ■ ■

June 15, 2017 Southwest Airlines 0.1

Figure 5: Southwest Airlines QRH Excerpt: Emergency Descent Checklist

7.3 Airport Considerations for Emergency Landings

Certain checklists in the QRH directed the crew to land at the nearest suitable airport. This was the last step in the *Engine Fire or Engine Severe Damage or Separation* checklist (figure 3.)

The SWA Flight Operations Manual, section 5.1.7, provided the following information regarding the nearest suitable airport requirement:

> *Whenever an engine fails, or rotation of an engine is stopped to prevent possible damage, the Captain must land the aircraft at the nearest suitable airport, in point of time at which a safe landing can be made.*
>
> *If the Captain lands at an airport other than the nearest suitable airport, in point of time, the Captain shall submit a written report stating the reasons for determining that the selection of an airport other than the nearest suitable airport was as safe a course of Action. This report is sent to the Senior Director Regulatory Programs and Compliance/Director of Operations.*

Additionally, 14 *CFR* Part 121.565(a) stated:

> *Except as provided in paragraph (b) of this section, whenever an airplane engine fails or whenever an engine is shutdown to prevent possible damage, the pilot in command must land the airplane at the nearest suitable airport, in point of time, at which a safe landing can be made.*

Paragraph (b) in the above excerpt refers to airplanes with three or more engines.

Paragraph (d) of the regulation stated:

> *If the pilot in command lands at an airport other than the nearest suitable airport, in point of time, he or she shall (upon completing the trip) send a written report, in duplicate, to his or her director of operations stating the reasons for determining that the selection of an airport, other than the nearest airport, was as safe a course of action as landing at the nearest suitable airport. The director of operations shall, within 10 days after the pilot returns to his or her home base, send a copy of this report with the director of operation's comments to the responsible Flight Standards office.*

According to measurements made on Google Earth, at the time of the engine failure, the airplane was about 29 nautical miles from Harrisburg International Airport (MDT). Philadelphia International Airport (PHL) was about 57 nautical miles from the point of the failure.

According to an ATC Summary of Communications, the air traffic controller had originally suggested MDT when the captain had requested a vector to the closest airport. Immediately after being given a vector to MDT, the Captain requested PHL, and was cleared direct to that airport.

The definitions of *nearest airport* and *suitable airport*, for use when executing non-normal checklists, was shown on pages CI.2.2-CI.2.3 of Southwest Airlines B737NG QRH (Attachment 7.)

According to the FAA, airports were certified to service different levels and types of air carrier traffic. Two primary methods of rating airports were airport classification and ARFF index.

The FAA defined four classes of airport, I-IV, that are certified under *14 CFR* Part 139[27]. Both MDT and PHL were Class I airports, which allowed them to serve scheduled air carrier operations with aircraft having more than 30 seats[28].

The FAA also specified ARFF capability required for an airport using an ARFF index. 14 *CFR* Part 139.315 stated that an ARFF index was calculated for an airport based on the length of air carrier aircraft serviced by the airport and the average number of daily departures of air carrier aircraft at the airport. The index ranged from A to E. ARFF index E was the highest index, indicating the highest level of ARFF capability. For each index, 14 *CFR* Part 139.317 specified ARFF capabilities, including the number of vehicles and amounts of water and firefighting chemicals required for the airport. For example, airports with ARFF index E were required to have at least three vehicles and a minimum of 6,000 gallons of water available for foam production, along with additional firefighting chemical agents. Airports with an ARFF index B were required to have only one or two vehicles with a minimum of 1500 gallon of water (but with the same chemical firefighting agent requirements as index E airports.)

PHL had an ARFF index of E. MDT had an ARFF index of B[29].

The wind at MDT at the approximate time of the crew's airport decision was from 250° at 15 knots gusting to 23 knots. The visibility at the airport was 10 miles, and the ceiling was 4,900 ft above ground level.[30] There was one paved surface at MDT which provided for runways 13 and 31. These runways had a magnetic alignment of 130° and 310° respectively. The single surface was 10,001 ft in length and 200 ft wide (10,001 x 200).

As recorded in section 4.0. Meteorological Information, the wind at PHL about the time of the decision was from 290° at 18 knots, gusting to 27 knots. The visibility was 10 miles, and the ceiling was 4,800ft. There were four paved surfaces, making up eight runways; 9R/27L (12,000 x 200), 9L/27R (9,500 x 150), 17/35 (6,501 x 150), 8/26 (5,000 x 150).

There are no indications from crew interviews that the crew took these factors (airport ARFF index, runway length and magnetic alignment, winds, or visibility and ceiling) into consideration when determining what made an airport "suitable" per the requirement of the *Engine Fire or Engine*

[27] 14 CFR Part 139 requires FAA to issue airport operating certificates to airports that:

- Serve scheduled and unscheduled air carrier aircraft with more than 30 seats;
- Serve scheduled air carrier operations in aircraft with more than 9 seats but less than 31 seats, or;
- The FAA Administrator requires to have a certificate.

[28] Source: FAA Chart Supplement for MDT and PHL

[29] Source: FAA Chart Supplement for MDT and PHL

[30] Source: 1456Z METAR for MDT from Plymouth State Weather Center, Plymouth State University.

Severe Damage or Separation Checklist. As noted earlier, very little time elapsed between the engine failure, the controller's suggestion of MDT, and the crew's request for PHL.

F. LIST OF ATTACHMENTS

Attachment 1: Interview Summaries
Attachment 2: Captain's Training Record
Attachment 3: First Officer's Training Record
Attachment 4: SWA Flight 1380 Weight and Balance Report
Attachment 5: SWA Flight 1380 Flight Release
Attachment 6: SWA B737NG Non-Normal Quick Reference Card
Attachment 7: SWA B737NG Quick Reference Handbook Excerpt

Submitted by:

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