NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

March 1, 2017

Group Chairman's Factual Report

OPERATIONAL FACTORS/ HUMAN PERFORMANCE

DCA17FA021

Contents

A. ACCIDENT

Operator:	American Airlines (AA)
Location:	Chicago, Illinois
Date:	October 28, 2016
Time:	1430 Central Daylight Time (CDT)[1]
Airplane:	Boeing 767-300 (U.S. registration N345AN)

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C. SUMMARY

On October 28, 2016, at about 1432 CDT, American Airlines flight number 383, a Boeing B767-300, N345AN, powered by two General Electric CF6-80C2B6 turbofan engines, experienced a right engine uncontained failure and subsequent fire during the takeoff ground roll on runway 28R at the Chicago O'Hare International Airport (ORD), Chicago, Illinois. The flightcrew aborted the takeoff and stopped the aircraft on runway 28R and an emergency evacuation was conducted. Of the 161 passengers and 9 crew members onboard, one passenger received serious injuries during the evacuation and the airplane was substantially damaged as a result of the fire. The flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 as a domestic scheduled passenger flight to Miami International Airport (MIA), Miami, Florida.

[1] All times in the report will be in central daylight time, also known as Local Time, except as noted.

D. DETAILS OF THE INVESTIGATION

The Operations/Human Performance Group was formed on November 15, 2016. Interviews with the accident flight crew were conducted on November 4, 2016, via teleconference.

Flight documents, company manuals, and pilot training information were obtained and reviewed, and manufacturer guidance was obtained from The Boeing Company. Pilot certification information was received from the FAA and American Airlines.

On January 9, 2017, the Operational Factors and Human Performance group reconvened at the American Airlines Training Center in Fort Worth, Texas. The group conducted four interviews, which included the fleet captain, the Miami base chief pilot, and two check airmen.

On January 10, 2017, the group conducted simulator evaluations of various scenarios, conducted five interviews, which included a first officer that had flown with the accident captain prior to the accident, two captains that had flown with the accident first officer prior to the accident, and two check airmen. The group then reconvened, along with the Survival Factors group, at American Airlines maintenance hangar 4 to conduct an evaluation of various systems on an exemplar aircraft.

E. FACTUAL INFORMATION

1.0 History of the flight

The crew consisted of a captain, first officer (FO), and seven flight attendants. The flight crew departed the hotel and began their duty day at 1235 with a proposed departure time of 1420. The crew stated that when they arrived at the airplane, maintenance was on board working on a broken passenger seat; however, there was nothing else mechanically wrong with the airplane. According to the flight plan, the flight time to MIA was projected for 3 hours and 2 minutes. The captain stated that he had flown with the accident first officer on previous occasions, with the most recent occurring at the beginning of the month.

According to interviews, the preflight and boarding activities were "normal." The flight taxied out to runway 28R for a takeoff from intersection N5. Visual meteorological conditions were present at the time and the reported ambient temperature was about 16°C (61°F). Both crew members noted that the taxi out was quick and there were no delays for departure.

About 1431 the captain lined up for takeoff, advanced the engines to takeoff power, and the engines achieved full takeoff command 10 seconds later. The crew had a calculated takeoff decision speed (V1) of 134 knots for the takeoff. The captain was the pilot flying (PF) and the FO was the pilot monitoring (PM). According to the captain and first officer, about 2 to 3 seconds after the FO's 80 knot call, they both heard a "ka-boom" or "bang" sound and the airplane veered to the right. The captain estimated that they were about 110 knots when he initiated the rejected takeoff. Flight Data Recorder information indicated that the airplane reached a maximum recorded airspeed of 136 knots. The airplane was equipped with a rejected takeoff braking system and the captain described the performance of the system as an "aggressive stop." During the rejected takeoff the first officer

announced to air traffic control (ATC) that they were stopping, at which time the controller acknowledged and reported there was a fire.

After the airplane came to a stop, the crew received the first indication of a fire in the right engine when the fire light illuminated with the fire bell. The captain commanded the engine fire checklist, which included five memory items. During the operation of the checklist, the captain shut off the fuel switch for the right engine and the first officer pulled the right fire T-handle and then rotated the handle in order to discharge one of the fire bottles into the right engine. Subsequently, they began the evacuation checklist. The first officer went through each item of the evacuation checklist and the captain accomplished the items. The captain further stated that a large portion of the evacuation checklist was to depressurize the airplane; and he felt that it took a long time to depressurize. During that time, the left engine remained at idle power and he could audibly observe a commotion in the cabin. Once they were at the point in the checklist to shut down the left engine, he secured the left engine, made an announcement over the public address system to the cabin to evacuate, activated the evacuation alarm switch, completed the evacuation checklist, and exited the cockpit, at which time they observed "a lot of smoke."

During the time from the airplane coming to a stop and the right engine being shutdown the flight attendants had begun the evacuation. Flight data recorder (FDR) information showed that between 8 and 12 seconds after the airplane came to a stop the left overwing exit door opened, followed approximately 17 seconds later by the forward left door and then approximately 4 seconds later by the forward right door. The FDR stopped recording approximately 58 seconds after the airplane came to a stop.

After exiting the cockpit, the pilots were met by the lead flight attendant who informed them that the airplane had been evacuated and that everyone was off the airplane. The first officer exited via the 1L slide, followed by the flight attendant, and then the captain. Once they were on the ground the flight crew stated that the flight attendants were moving the passengers away from the airplane. Once the airport rescue and firefighting (ARFF) personnel arrived the captain contacted their dispatcher and requested a total number of souls on board.

All of the occupants and crew evacuated the airplane through various exits and slides. During the evacuation, one passenger received serious injuries and 19 passengers received minor injuries.

2.0 Flight Crew Information

2.1 The Captain

The captain was 61 years old and had been employed at Trans World Airlines[2] since January 1986, and subsequently American Airlines since 2001. He had been a captain on the B767 for about 2 years prior to the accident. He had not held a check airman or management position and he had no other duties at American Airlines. He estimated he had 17,400 hours of total flight time, of which

[2] Trans World Airlines was acquired by AMR Corp., which is the parent company of American Airlines, in April 2001.

approximately 4,000 hours were on the B767, and of those, approximately 1,500 hours were as pilot in command.

The captain held a FAA first-class medical certificate dated May 4, 2016, with no limitations; he had no issues with color vision. He stated he had the "normal" amount of hearing loss for flying jets but it did not require use of a hearing aid.

According to the captain and FAA records, he had no prior accidents or incidents. The captain stated he had not had an engine fire or rejected takeoff (RTO) previously in his career, except during simulator training. He had never had to conduct an evacuation on an actual flight before and that the checklist was "cumbersome." He further stated that it took at least one minute to go through the checklist and that he had to confirm that the airplane was depressurized.

The captain stated that the accident trip was a regular bid trip. Also, he had previously flown with the first officer.

2.1.1 The Captain's Certification Record

FAA Records of the captain indicated the following:

Private Pilot – Airplane Single-Engine Land certificate issued February 18, 1974.

Private Pilot – Airplane Single-Engine Land; Glider Aero Tow Only certificate issued July 28, 1974.

Commercial Pilot – Airplane Multiengine Land – Limited to Center Thrust; Instrument – Airplane; Private Privileges – Airplane Single-Engine Land, Glider – Aero Tow Only certificate issued April 30, 1979.

Commercial Pilot – Airplane Multiengine Land; Instrument - Airplane; B707/720; Private Privileges – Airplane Single-Engine Land; glider – Aero Tow Only certificate issued February 6, 1984.

Airline Transport Pilot – Airplane Multiengine Land; N-265; Commercial Privileges B707, B727; Private Privileges Airplane Single-Engine Land; Glider – Aero Tow Only certificate issued September 24, 1984.

Flight Engineer – Turbojet Powered certificate issued March 26, 1986.

Airline Transport Pilot – Airplane Multiengine Land; N-265, B707, B720, B757, B767; Private Pilot Privileges – Airplane Single-Engine Land; Glider – Aero Tow Only certificate issued March 31, 1995.

Airline Transport Pilot – Airplane Multiengine Land; N265, B707, B720, B757, B767, DC-9; Private Privileges – Airplane Single-Engine Land; Glider – Aero Tow Only certificate issued July 13, 1998.

2.1.2 The Captain's Pilot Certificate and Ratings Held at the Time of the Accident[3]

AIRLINE TRANSPORT PILOT (issued July 13, 1998)
Airplane Multiengine Land
N265 B707 B720 B757 B767 DC-9
Private Pilot Privileges Airplane Single-Engine Land
Glider Aero Tow Only

FLIGHT ENGINEER (issued March 26, 1986)
Turbojet Powered

MEDICAL CERTIFICATION FIRST CLASS (Issued May 4, 2016)
Limitations: none

2.1.3 The Captain's Training and Proficiency Checks[4]

A summary of the captain's recent training events at American Airlines was as follows:

American Airlines Seniority Date	January 31, 1986
Date Upgraded to Captain on B767[5]	January 7, 2014
Date of Initial Type Rating on B767	March 31, 1995
Date of Most Recent Proficiency Check (RLE[6])	March 22, 2016
Date of Most Recent Maneuvers Training (RTS/R9[7])	March 21, 2016
Date of Most Recent RTS/R18[8]	September 20, 2015
Date of Most Recent PIC Line Check	October 21, 2015
Date of Most Recent Quarterly Home Study	October 24, 2016
Date of Most Recent Recurrent Ground	March 20, 2016

According to American Airlines' pilot training records the accident captain met or exceeded the standard that had been set by American Airlines and approved by the FAA.

[3] Source: FAA
[4] Source: American Airlines
[5] The captain reported he upgraded to captain on the B767 for a few months in 2000; however, subsequently returned to captain on the MD-80 until his most recent upgrade. Source: Attachment 1 – Flight Crew Interview Summaries pg. 3
[6] Line Operational Evaluation
[7] No more than nine calendar months (plus one month) have elapsed since the crewmember completed R18 continuing qualification training to qualify or requalify for the bid position currently held. Source American Airlines AQP B757/767 section 116.5.2
[8] No more than nine calendar months (plus one month) have elapsed since the crewmember completed R9 continuing qualification training. Source: American Airlines AQP B757/767 section 116.5.2

2.1.4 The Captain's Flight Times and Currency

According to American Airlines records and interview summaries, the following information was provided on the captain's flight times and currency:

Flight Time, previous 24 hours[9]	3:37 hours
Flight Time, previous 7 days	12:46 hours
Flight Time, previous 30 days	59:44 hours
Flight Time, previous 90 days	157:18 hours
Total Pilot Flight Experience[10]	17,400 hours
Total Flight Experience – B767[11]	4,000 hours
Total Pilot-In-Command (PIC) time B767[12]	1,500 hours

2.1.5 The Captain's Recent Activities

The captain's pre-accident activities are summarized below as documented through interviews and company records.

He flew a 3-day trip, October 24-26, 2016, prior to starting the pairing that included the accident flight. On October 24, he went on duty at 1726 EDT[13] and flew from MIA to JFK, arriving at 2021, and then deadheaded to Boston, arriving at 2346 EDT. He went to bed about 0100-0130 EDT.

On October 25, he awoke about 0900-1000 EDT and left the hotel about 1330 EDT for his duty day scheduled to start at 1400 EDT. He departed BOS at 1502 EDT and arrived in PHL at 1703 EDT, then deadheaded to CLT arriving at 2043 EDT. He flew from CLT to JFK, arriving at 2338 EDT. He went to bed about 0100 EDT.

On October 26, his wake up time was unknown but he thought he got 7-8 hours of sleep each night. He left the hotel between 1400-1430 EDT and began his duty day at 1440 EDT. He flew from JFK to MIA arriving at 1829 EDT. He characterized it as an "easy day" with only one leg flown. He stayed that night at his condo, which was about a 25-minute ride from MIA. The time he went to bed was unknown. He was off duty about 21 hours.

He started the accident pairing on October 27. He awoke about 0900 EDT and his duty day began at 1550 EDT. He departed MIA at 1706 EDT, arriving in ORD at 1943 CDT. He arrived at his hotel by 2000 CDT, got something to eat and then used his computer until about midnight before going to bed.

On October 28, the morning of the accident, he awoke between 0800 and 0900 CDT and departed

[9] Flight Time does not include the accident time.
[10] Source: Attachment 1 – Flight Crew Interview Summaries pg. 2. Total Flight time was approximated.
[11] Source: Attachment 1 – Flight Crew Interview Summaries pg. 2. Time was approximated.
[12] Source: Attachment 1 – Flight Crew Interview Summaries pg. 2. Total PIC time was approximated.
[13] Eastern Daylight Time

the hotel about 1235 CDT. His duty day began at 1320 CDT and the accident flight was scheduled to depart ORD at 1420 CDT.

He reported no problems falling asleep or staying asleep in the days preceding the accident. He woke up each day feeling rested, including the morning of the accident flight. He described the crew as being "in good shape that day." His normal sleep pattern when off duty was to get in bed between 2300 and midnight and to wake up about 0700 and he had never been diagnosed with a sleep disorder.

He did not take any medication, prescription or nonprescription in the 72 hours before the accident that might have affected his performance on the day of the accident. He did not use tobacco products or illicit drugs and had a couple of beers with dinner on October 27. He considered his health as "pretty good." He had no changes in his health, financial or personal life (good or bad) in the last 12 months that would have affected his performance the day of the accident.

2.2 The First Officer

The first officer was 57 years old, and had been employed at Trans World Airlines[14] since December 15, 1995, and subsequently American Airlines in 2001 until being furloughed in July of 2003. He was subsequently recalled from furlough in March of 2008. He was furloughed a second time in February of 2010 and was recalled from that furlough in December of 2010. He had been a first officer on the B767 for the preceding approximate 2 ½ years. He had not held a check airman or management position and he had no other duties at American Airlines; however, he had been a check airman at a previous airline. He estimated he had 22,000 hours of total flight time, of which approximately 1,600 hours were on the B767.[15] According to the first officer and FAA records, he had no prior accidents or incidents.

His most recent FAA medical prior to the accident, dated May 13, 2016, listed the limitation "holder shall possess glasses for near/intermediate vision;" he had no issues with color vision or hearing.

2.2.1 The First Officer's Certification Record

FAA records for the first officer indicated the following:

Private Pilot – Airplane Single-Engine Land certificate issued May 7, 1981.

Notice of Disapproval – Private Pilot Airplane Multiengine Land was issued on November 1, 1982. Unsatisfactory items: II Airport and Traffic Pattern Operations, D. Traffic Patterns and E. Collision Avoidance Precautions.

[14] Trans World Airlines which was acquired by AMR Corp., which is the parent company of American Airlines, in April 2001.

[15] According to records provided by American Airlines as of December 22, 2016, the first officer had accrued 1,965.31 hours of flight experience in the B767

Private Pilot – Airplane Single-Engine and Multiengine Land certificate issued November 12, 1982.

Commercial Pilot – Airplane Multiengine Land; Private Pilot Privileges – Airplane Single-Engine Land, Restrictions Carrying passenger in airplanes for hire is prohibited at night and on cross country flight of more than 50 nautical miles certificate was issued on August 3, 1983.

Commercial Pilot – Airplane Multiengine Land, Instrument Airplane; Private Pilot Privileges – Airplane Single-Engine Land certificate was issued on August 5, 1983.

Flight Engineer – Turbojet certificated was issued on July 27, 1984.

Commercial Pilot – Airplane Multiengine Land, Instrument Airplane; Gliders (Aero Tow Only); Private Pilot Privileges – Airplane Single-Engine Land certificate was issued on October 4, 1984.

Commercial Pilot – Airplane Single-Engine and Multiengine Land, Instrument – Airplane; Glider – Aero Tow Only certificate was issued on February 11, 1985.

Flight Instructor – Airplane Single-Engine certificate issued October 1, 1985.

Airline Transport Pilot – Airplane Multiengine Land, DHC-7; Commercial Privileges – Airplane Single-Engine Land; Glider – Aero Tow Only certificate issued February 2, 1989.

Airline Transport Pilot – Airplane Multiengine Land, DHC-7, ATR-42, ATR-72; Commercial Privileges – Airplane Single-Engine Land; Glider Aero Tow certificate issued February 20, 1991.

Airline Transport Pilot – Airplane Multiengine Land, CL-65, ATR-42, ATR-72, DHC-7; Commercial Pilot – Airplane Single-engine Land; Glider; Limitations – CL-65 SIC Privileges Only; CL-65 Circling Approach – VMC[16] Only certificate issued March 28, 2006.

Airline Transport Pilot – Airplane Multiengine Land, CL-65, ATR-42, ATR-72, DHC-7; Commercial Privileges – Airplane Single-Engine Land; Glider; Limitations CL-65 Circling Approach – VMC Only certificate issued August 2, 2007.

Airline Transport Pilot – Airplane Multiengine Land, ATR-42, ATR-72, CL-65, DHC-7, DC-9; Commercial Privileges – Airplane Single-Engine Land; Glider; Limitations DC-9 CL-65 Circling Approach – VMC Only, English Proficient certificate issued June 11, 2008.

Airline Transport Pilot – Airplane Multiengine Land, ATR-42, ATR-72, B757, B767, CL-65, DC-9, DHC-7; Commercial Pilot Privileges – Airplane Single-Engine Land; Glider; Limitations: English Proficient; CL-65, DC-9, B757, B767 Circling Approach – VMC Only certificate issued June 14, 2014.

[16] Visual Meteorological Conditions

2.2.2 The First Officer's Pilot Certificates and Ratings Held at the Time of the Accident[17]

AIRLINE TRANSPORT PILOT (issued June 14, 2014)
Airplane Multiengine Land
ATR-42 ATR-72 B757 B767 CL-65 DC-9
Commercial Pilot Privileges Airplane Single-Engine Land
Glider

FLIGHT ENGINEER (issued July 27, 1984)
Turbojet

MEDICAL CERTIFICATION FIRST CLASS (Issued May 3, 2016)
Limitations: Holder shall possess glasses for near and intermediate vision.

2.2.3 The First Officer's Training and Proficiency Checks

A summary of the first officer's recent training events at American Airlines was as follows:

American Airlines Seniority Date	December 15, 1995
Date of Initial Type Rating on B767	June 14, 2014
Date of Most Recent Proficiency Check (RLE)	September 7, 2016
Date of Most Recent Maneuvers Training (RTS/R9)	September 7, 2016
Date of Most Recent Advanced Maneuvers Training	September 7, 2016
Date of Most Recent RT/R18	January 4, 2016
Date of Most Recent Line Check/Observation	February 15, 2015
Date of Most Recent Quarterly Home Study	August 23, 2016
Date of Most Recent Recurrent Ground	September 5, 2016

According to American Airlines' pilot training records, the accident first officer met or exceeded the standard that had been set by American Airlines and approved by the FAA.

2.2.4 The First Officer's Flight Times and Currency[18]

According to American Airlines records and interview summaries the following information was provided on the FO's flight currency:

Flight Time, previous 24 hours[19]	3:37 hours
Flight Time, previous 7 days	12:59 hours
Flight Time, previous 30 days	77:59 hours
Flight Time, previous 90 days	116:13 hours

[17] Source: FAA
[18] Source: American Airlines.
[19] Flight Time does not include the accident flight.

Total Flight Experience[20]	22,000 hours
Total Flight Experience – B767	1,965:31 hours

2.2.5 The First Officer's Recent Activities

The first officer's pre-accident activities are summarized below as documented through interviews and company records.

The first officer could not recall his sleep/wake times for the 3 days prior to the accident flight. According to company records, he had a scheduled trip from October 20-23, 2016, and was off duty until October 27.

On October 27, he commuted about an hour from his home in Tampa, Florida, to MIA. He went on duty at 1550 EDT and flew from MIA to ORD with the accident captain, arriving at 1943 CDT. He did not think he stayed up long after arriving at the hotel before going to bed. He did not recall having any trouble going to or staying asleep. He felt rested when he awoke on October 28, the morning of the accident, following a long overnight. He went on duty at 1320 and was scheduled to depart on the accident flight at 1420. He stated there was no traffic going to the airport so the crew arrived early and were not rushed; he felt ok prior to the flight.

He said he usually slept about 7 hours per night and it was his habit to go to bed early and wake up early. He had never been diagnosed with a sleep disorder.

He did not take any medication, prescription or nonprescription in the 72 hours before the accident that might have affected his performance on the day of the accident. He did not use tobacco products or illicit drugs and thought his last alcoholic beverage was about a week prior to the accident flight. He considered his health as a "ten out of ten." He had no changes in his health, financial or personal life (good or bad) in the last 12 months that would have affected his performance the day of the accident.

3.0 Medical and Pathological Information

The accident flight crew was tested for drugs and alcohol following the accident. The results of the post-accident drug and alcohol screening for both flight crewmembers were negative for drug and alcohol.

[20] Source: Attachment 1 – Flight Crew Interview Summaries, pg. 10. Total Flight Experience was approximated.

4.0 Airplane Information

Photo 1: Accident Airplane. Courtesy of Planespotters.net website

The accident airplane was a Boeing 767-323, U.S. Registration N345AN, serial number 33084. It was manufactured in 2003 and was registered to American Airlines Inc. as a transport category aircraft. The airplane was powered by two General Electric CF6-80 series engines. The airplane had the following MEL (Minimum Equipment List) deferred maintenance item:

0483DC.SEATS PREMIUM SEAT RECLINE/LEGREST/SWIVEL….25 06A

5.0 Weight and Balance

The following weight and balance information was taken from the flight release and load sheet. Limitations were taken from the American Airlines 757/767 Operating Manual, Volume 1, Chapter 10.5 "Limitations," dated October 1, 2016.

Empty Operating Weight[21]	209,177 lb.
Total Payload	48,962 lb.
161 passengers[22]	30,281 lb.

[21] Empty Operating Weight is the Basic Empty Weight plus; drainable fuel and oil, passenger water, toilet chemicals, crew and crew baggage, catering equipment, food and beverages and cabin items (e.g. pillows, blanket and magazines), and other operational items as may be applicable to operate the aircraft. Source: American Airlines Weight and Balance Control Manual, Revision 34 dated September 1, 2016, pg. 07-1

[22] The number represented 158 adults and 3 children and 0 lap children.

Baggage/Cargo	18,681 lb.
Zero Fuel Weight	258,139 lb.
Maximum Zero Fuel Weight	**291,300 lb.**
Fuel	42,000 lb.
Ramp weight	300,139 lb.
Maximum Ramp Weight	**409,000 lb.**
Taxi Fuel	640 lb.
Takeoff Weight	299,499 lb.
Maximum Takeoff Weight	**408,000 lb.**
Planned fuel burn	24,994 lb.
Planned landing weight	273,865 lbs.
Maximum Landing Weight	**310,000 lb.**
Takeoff center of gravity (CG)	19.9% MAC[23]

For the takeoff, the forward CG limit was approximately 7.0% MAC[24] and the aft CG limit was approximately 37.0% MAC, based on the Boeing 767 Airplane Flight Manual.

6.0 Takeoff Performance

According to the flight's TPS (Takeoff Performance System) message, the maximum allowable structural weight limit from runway 28R intersection N5 was 408,000 pounds. The limiting weight for takeoff was the maximum landing weight. Using an assumed temperature of 61°C, the performance data showed the aircraft could lift 335,000 pounds. The V speeds were V1 of 134 kts., VR of 137 kts., and V2 of 142 kts.

7.0 Relevant Systems

The following information has been obtained from American Airlines and Boeing B767 Flight Crew Operations Manual (FCOM).

7.1 Engines

The airplane was powered by two General Electric CF6-80C2B6 turbofan engines. The engines were rated at 60,070 pounds of takeoff thrust each. Thrust was set by positioning the thrust levers either automatically by the autothrottle system, or manually by the flight crew. Engine indications were displayed on the EICAS[25] display and any selected LCD[26]. N1[27] and EGT[28] were the primary engine indications. The EICAS was on the upper center display unit. If that unit failed, the EICAS display automatically moved to the lower center display unit.

[23] Mean Aerodynamic Chord is the average distance between the leading and trailing edge of the wing as measured parallel to the normal airflow over the wind on a swept wing aircraft.
[24] Mean Aerodynamic Chord
[25] Engine Indicating and Crew Alerting System.
[26] Liquid Crystal Display.
[27] Low Pressure Compressor.
[28] Exhaust gas temperature.

7.1.1 Electronic Engine Controls (EEC)

Each EEC had full authority over engine operation. The EEC used thrust lever inputs to automatically control forward thrust and reverse thrust. The EEC had two control modes: normal and alternate. In both normal and alternate modes, the EEC used N1 fan speed as the parameter for setting thrust.

7.2 Fire Detection and Protection[29]

There were fire detection and extinguishing systems for the following:

- APU
- cargo compartments
- engines
- lavatories.

There was a fire detection system for the following:

- wheel wells

7.2.1 Engine Fire Warning[30]

There were two detector loops in each engine nacelle. Each detector loop provided both fire and overheat detection. Normally, both loops must detect a fire or overheat condition to cause an engine fire warning or overheat caution.

The indications of an engine fire were:

- the fire bell sounded
- the master WARNING and master CAUTION lights illuminated
- the EICAS warning message FIRE ENG (L or R) was displayed
- the engine fire switch LEFT or RIGHT fire warning light illuminated
- the engine fire switch unlocked
- the engine FUEL CONTROL (L or R) switch fire warning light illuminated.

7.2.2 Engine Fire Extinguishing

There were two engine fire extinguisher bottles. Either or both bottles could be discharged into either engine. When the engine fire switch was pulled up, or extended, rotating the fire switch in either direction discharged a single extinguisher bottle into the associated engine. Rotating the

[29] Source: American Airlines B767 Operations Manual, QRH, "Fire Protection."
[30] Source: American Airlines 757/767 Operating Manual, "Systems" pgs. 50.1 and 50.2

engine fire switch in the other direction discharged the remaining extinguisher bottle into the same engine.

If an extinguisher bottle was discharged or had low pressure:

- the ENG BTL (1 or 2) DISCH light illuminated
- the EICAS advisory message BOTTLE (1 or 2) DISCH ENG was displayed.

7.3 Audio Control Panels

The audio control panels were used to manage the radio and interphone communication systems. Navigation receiver audio could also be monitored. The captain and first officer audio control panels were installed on the aft aisle stand and the First Observer audio panel was installed on the side panel of the cockpit (Figure 1). Microphones were keyed by pushing the desired audio control panel transmitter select switch and using the MIC (microphone)_ position on the control wheel or audio control panel microphone/interphone switch, or a hand microphone push–to–talk switch.

Figure 1: B767 Audio Control Panel. [31]

7.4 Interphone Communication System

The interphone communication system included the flight interphone, the cabin interphone, the service interphone, and the passenger address (PA) system.

The flight interphone system provided communications between flight deck crew members. The cabin interphone system provided voice communications between the flight deck and the flight attendant stations. The PA system was used by the flight crew to make cabin announcements. The

[31] Source: Boeing Company.

service interphone system provided voice communications between ground crew stations at various locations around the airplane.

7.5 Communication Crew Alerting System

The communication crew alerting system provided aural and visual alerts for normal operations requiring crew awareness that may require crew action. Visual alerts were presented as EICAS messages. The aural alert was a high–low chime.

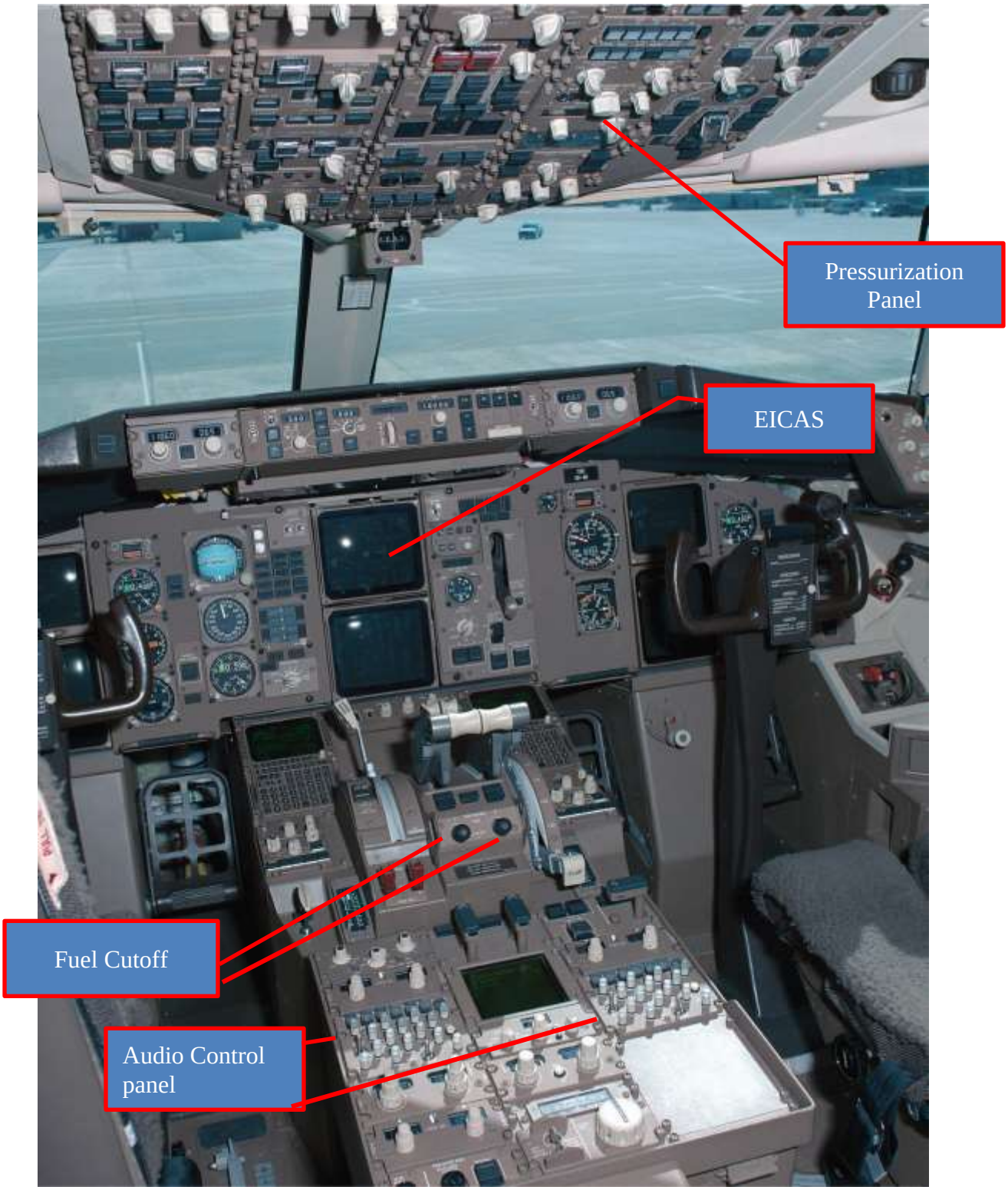

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Photo 2: B767 Cockpit Layout – Source: Boeing Company.

7.6 Pressurization

The Boeing 767 Flight Crew Operations Manual, Chapter 2, Section 30 provided the following excerpts:

> *"Cabin pressurization is controlled by adjusting the discharge of conditioned cabin air through the outflow valve.*
>
> *Positive pressure relief valves and negative pressure relief doors protect the fuselage against excessive pressure differential.*
>
> *The pressurization system has automatic and manual operating modes.*
>
> ***Pressurization System Automatic Operation***
>
> *The pressurization system is in the automatic mode when the cabin altitude mode selector is set to AUTO 1 or AUTO 2. If the selected auto mode fails controls is automatically switched to the other auto mode.*
>
> *In the automatic mode, the pressurization system uses ambient pressure data from the air data system in conjunction with the selected cabin auto rate, the takeoff altitude and the indicated landing altitude to calculate the cabin pressurization schedule.*
>
> ***Takeoff***
>
> *For takeoff, the system supplies a small positive pressurization to cause a smooth cabin altitude transition."*
>
> *"to operate the pressurization system manually:*
> - *set the cabin altitude MODE SELECT to MAN*
> - *hold the cabin altitude MANUAL control to CLIMB to move the outflow valve toward open and cause the cabin altitude to climb*
> - *hold the cabin altitude MANUAL control to DESCEND to move the outflow valve toward closed and cause the cabin altitude to descend."*

Photo 3: B-767 Pressurization Panel.[32]

7.7 Emergency Evacuation Signal System

The emergency evacuation signal system was designed to alert the flight attendants to evacuate the passenger cabin. Placing the flight deck evacuation signal COMMAND switch to ON activated the evacuation signal on the flight deck and on the flight attendant panels. With the flight deck evacuation signal COMMAND switch in the OFF (guard down) position, pressing an EVAC COMMAND switch on a flight attendant panel would activate the evacuation signals on the flight deck and on the flight attendant panels.

[32] See Attachment 4 – Simulator and Cockpit Evaluation.

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Figure 2: Emergency Evacuation Command Panel[33]

8.0 Airport Information

Chicago O'Hare International Airport was one of two commercial airports for the city of Chicago, Illinois, and was located about 13 miles northwest of downtown Chicago. It had eight runways.

8.1 Airport Diagram and Notes

According to the FAA Chart Supplement, runway 28R was 13,000 feet in length and 150 feet in width. The surface was asphalt/porous friction course, in good condition. The runway was equipped with high intensity runway lights, centerline lights, and a 4-light precision approach path indicator installed on the left side of the runway. The runway length available from N5 intersection was 9,750 feet. At the time of the accident, American Airlines was utilizing Jeppesen charts (Figure 3)

[33] Source: Boeing Company.

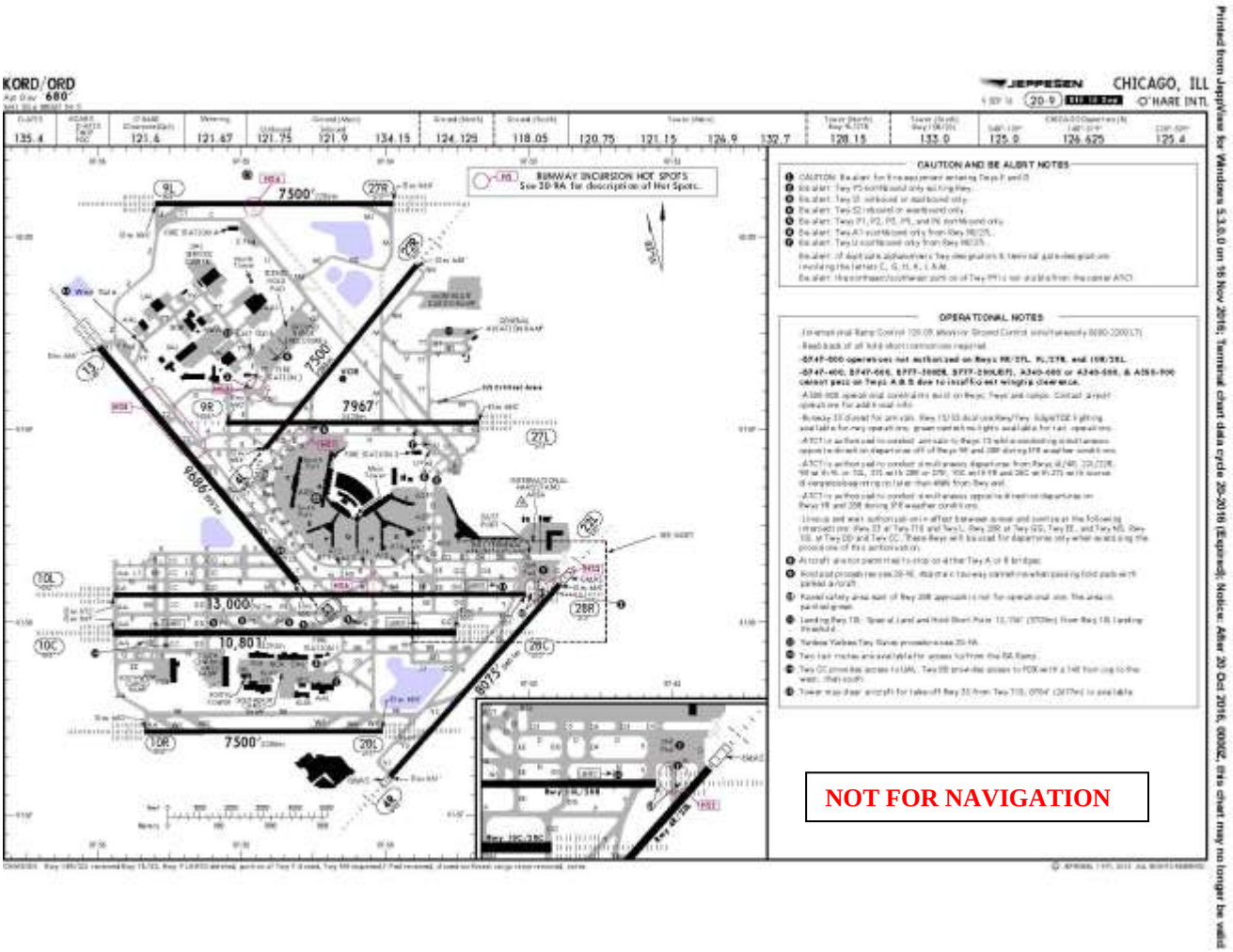

Figure 3: ORD Airport Diagram Chart[34]

9.0 American Airlines Procedures

9.1 Company Procedural Guidance

American Airlines procedural guidance to flight crews was located in several manuals. The American Airlines Flight Manual Part I provided operational information of a general nature pertaining to all aircraft. American Airlines Flight Manual Part II provided guidance when operating at the various hubs within the American Airlines system. The American Airlines 757/767 Operating Manual, Volume I, which provided procedural information for the operation of the B757/B767. The American Airlines 757/767 Operating Manual II, which was divided into 2 books – one for the 757 and one for the 767, contained system information for the respective aircraft. The B757 Operations Manual, QRH (Quick Reference Handbook), in paper form, was to be carried by the captain and the B767 Operations Manual, QRH, in paper form, was to be carried by the first officer. The American Airlines B767 Operations Manual, QRH contained specific aircraft

[34] Source: FAA.

information including all non-normal checklists. All manuals were available to both pilots in electronic form on a company provided iPad.

9.2 Cabin Crew Briefing

The American Airlines Flight Manual, Part I, Section 7.1.10 "Flight Attendant/Purser Briefing," dated October 1, 2016, stated the following:

A. The FA 1/A-FA/Purser will be the primary liaison between the Captain and the flight attendants and will promptly inform the Captain of all on-board cabin emergencies, irregular issues, passenger concerns and cabin discrepancies.

B. Prior to gate departure, the Captain will give the FA 1/A-FA/Purser the flight plan F/A briefing message and personally discuss the following items as applicable:

1. *number of flight attendants on board*
2. *any anticipated enroute delays*
3. *short-taxi situations and safety demo considerations (if applicable)*
4. *preflight turbulence briefing:*
   a) *include weather and turbulence forecast along the route of flight, the expected intensity and duration of forecast turbulence, plus notification procedures and required action in the event of a significant unexpected turbulence encounter.*
   b) *Brief service may be suspended at the flight attendants' discretion if the conditions in the cabin warrant.*
   c) *If possible, a call should be made to the flightdeck to report the cabin situation, including any injuries.*
   d) *If not seated at a jumpseat with an interphone, remain seated to avoid injury until instructed to resume duties by the Captain.*
   e) *Once cleared to resume duties, call the flightdeck to report any injuries or abnormalities.*
5. *appropriate security items (see 15.1.7 Crew Security Briefing).*
6. *brief flightdeck access procedures and codes*
7. *cabin or galley write-ups or deferrals in the AML (logbook).*
8. *A life vest or floating seat cushion demonstration is required on all flights. If the onboard video monitors are inop or not installed, a manual demonstration must be accomplished.*

Note

Allow adequate time for the manual briefing along with the complete safety demo briefing.

9. *Gen. Decs/Customs Immigration forms (if required)*
10. *coordination of flightdeck crew meal service, if applicable*
11. *address the importance of minimizing noise and activity around the crew rest areas*
12. *on North Atlantic flights routed north of 66° north over Greenland, request the FA 1/A-FA/Purser review the FA Safety Manual information concerning "66N Supplemental O2 Unit"*

13. any other unusual or pertinent issues relevant to the flight

9.3 Flight Crew Takeoff Briefing

The American Airlines, 757/767 Operating Manual, Starting 10.3, "Takeoff Briefing," dated October 1, 2016, stated the following:

TAKEOFF BRIEFING .....COMPLETED
General

The briefing is completed at the gate, to the extent possible, to allow both pilots to focus on taxi operations after gate departure. Last minute clearance changes from ATC (taxi or departure) will be verbalized by the F/O and verified by the Captain. Checklist items covering the departure procedure need not be briefed unless some contingency or exception exists. When required, the Captain will conduct whatever briefing is appropriate to the situation (e.g. poor weather, inexperienced crew member, etc.) The Captain, at his/her discretion, may delegate the briefing to the F/O (Pilot-Flying), with the understanding the Captain will take the aircraft in the event of an RTO in compliance with current policy.

Briefing

The takeoff briefing will include as a minimum:

- *Designate the pilot-flying*
- *Rejected takeoff considerations.*

Contingencies, if appropriate:

- *Departure procedure (required only if not covered previously by checklist completion or if revised by ATC)*
- *Airport/runway specific engine failure profile*
- *Takeoff alternate*
- *Takeoff weather considerations*
- *Runway surface conditions*
- *Terrain considerations*

Any other variables associated with the taxi and takeoff.

9.4 Crew Duties

9.4.1 Captain

American Airlines Flight Manual Volume 1, Chapter 3, provided the following guidance as it pertained to the captain's duties:

Captain's Responsibility for Operational Control Domestic, Flag, and Supplemental Operations

A. *The terms Captain and pilot in command are interchangeable. The designated PIC is the pilot listed first in the crew list on the Flight Plan / Dispatch Release. In the case of two Captains being assigned the same flight segment, whether for training or operational reasons, the Captain who is designated pilot in command will clearly identify that status to the cabin crew. The PIC will sign the Flight Release and the Aircraft Maintenance Logbook (AML).*

B. *Compliance with 14 CFR 121.533 and 121.535 requires that the Captain operate in accordance with FARs, Ops Specs and American Airlines procedures and policies except under circumstances provided for in 14 CFR 121.557 (Emergencies).*

C. *For the purposes of 14 CFR 121.533 and 121.535, American Airlines policy is to expand the definition of flight time to include the time from when the entry door is closed for the purpose of flight or aircraft movement and ends when the door is opened at the conclusion of the flight or movement, and at any time the engine is running and the Captain is on the flightdeck at the controls.*

D. *In addition to the provisions of 14 CFR 121.533 and 121.535, American Airlines policy is that the Captain is in complete command of the aircraft and has authority over all assigned crew members from the time they report for duty until termination of the flight. This includes transportation to and from the layover facility. The Captain's operational instructions will receive prompt compliance from all crewmembers while under his / her command. Differences from written procedures or other instructions should be brought to the Captain's attention. If the order still stands, it is to be followed.*

E. *The Captain is responsible for ensuring that the flightdeck and cabin crew is ready to depart on time and will advise ground personnel, as soon as possible, of any known delay and assist to minimize any such delay.*

F. *The Captain is in command of the aircraft, cargo, passengers and all crewmembers during an air interruption or diversion, until relieved by appropriate American Airlines personnel or other designated personnel.*

G. *The Captain will ensure compliance, provide guidance, training and facilitate the professional development of the First Officer under his or her command.*

H. *The Captain will ensure the timely completion and accurate adherence to checklist procedures.*

I. *Pre-flight: planning*

    1. *The Captain and Dispatcher will independently analyze the latest pilot reports, NOTAMS, weather reports and weather forecasts along the route and at the origination, destination and alternate airports as appropriate and available.*
    2. *The Captain and Dispatcher will jointly evaluate the Flight Plan / Dispatch Release for:*
        - *Fuel requirements and alternate airports to satisfy FARs and American Airlines policies.*
        - *Cruise altitude and mach, route, station dispatched to and alternate(s).*

- *Conditions, known and contemplated, that will affect safe operation of the flight in accordance with AA and FAA regulations and policies.*

3. *For the Dispatch Release to be valid, both the Dispatcher and Captain must sign the Dispatch Release either electronically or on a physical copy.*
   - *Normally the Flight Dispatcher will use an electronic signature and it will be shown on the Flight Plan /Dispatch Release.*
   - *Normally the Captain will convey acceptance of the Dispatch Release with an electronic signature. A physical signature on a paper copy filed at the station is acceptable during periods of computer outage.*
   - *For the 757/767, the Captain's signature also indicates that all flightdeck crewmembers meet the recency of experience requirements set forth in this Chapter of this manual.*
   - *An electronic signature is the preferred method of Captain concurrence and will have the same force and effect as a signature affixed by hand.*

9.4.2 First Officer

American Airlines Flight Manual Volume 1, Chapter 3, provided the following guidance as it pertained to the first officer's duties:

> ***First Officer Responsibility***
> *The First Officer is required to immediately advise the Captain of any deviation from applicable regulations, policies or procedures, or any unsafe condition which may place the aircraft, passengers or crewmembers in jeopardy. The Captain may choose to disregard this advice, but regardless of the degree or frequency with which advice may go unheeded, flight crewmembers will be held responsible for continuing to offer advice for the Captain's consideration.*
>
> ***EXCEPTION***
>
> *On final approach, if the pilot-monitoring directs a go around, the directed go around will be executed unless an emergency situation overrides this requirement.*

9.5 American Airlines B767 Operations Manual, QRH

The American Airlines B767 Operations Manual, QRH was a manual containing normal and non-normal ground and flight procedures. The manual was to be carried by the first officer and was to be accessible to both crewmembers during flight.[35]

[35] Source: Attachment 3 - American Airlines Personnel Interview Summaries

9.5.1 Non-Normal Checklist Operation

The American Airlines B767 QRH provided guidance on non-normal checklist operation in the "General Information" section located on pages 1.1 through 1.10.[36] Following are excerpts from this section:

> *"Most checklists correspond to a light, alert, or EICAS alert message. In some cases, the master WARNING or master CAUTION, and miscellaneous lights also illuminate to indicate the non-normal condition. These lights, alerts, and EICAS alert messages indicate a non-normal condition and are the cues to select and do the associated checklist."*
>
> *"All checklists have condition statements. The condition statement briefly describes the situation that caused the light, alert, or EICAS alert message."*
>
> *"Checklists can have both memory and reference items. Memory items are critical steps that must be done before reading the checklist. In the printed non-normal checklists, the last memory item is followed by a dashed horizontal line. In the electronic checklists, memory items are not identified. Reference items are actions to be done while reading the checklist"*
>
> "*In some multiple failure situations, the flight crew may need to combine the elements of more than one checklist. In all situations, the Captain must assess the situation and use good judgment to determine the safest course of action"*
>
> *"It must be stressed that for smoke that continues or a fire that cannot be positively confirmed to be completely extinguished, the earliest possible descent, landing, and evacuation must be done."*
>
> *"When a non–normal situation occurs, at the direction of the pilot flying, both crewmembers do all memory items without delay"*
>
> *"The pilot flying calls for the checklist when:*
>
> - *the flight path is under control*
> - *the airplane is not in a critical phase of flight (such as takeoff or landing)*
> - *all memory items are complete.*
>
> *The pilot monitoring reads aloud:*
>
> - *the checklist title*
> - *as much of the objective statement (if applicable) as needed to understand the expected result of doing the checklist*

[36] See Attachment 14 – American Airlines Non-Normal Checklist Instructions.

The pilot flying does not need to repeat this information but must acknowledge that the information was heard and understood"

"The word "Confirm" is added to checklist items when both crewmembers must verbally agree before action is taken. During an inflight non-normal situation, verbal confirmation is required for:

- *an engine thrust lever*
- *a fuel control switch*
- *an engine or APU fire switch, or a cargo fire arm switch*
- *a generator drive disconnect switch.*

"With the airplane stationary on the ground:

- *the captain and the first officer take action based on preflight and postflight areas of responsibility.*

After moving the control, the crewmember taking the action also states the checklist response."

"The flight crew must be aware that checklists cannot be created for all conceivable situations and are not intended to replace good judgment. In some situations, at the captain's discretion, deviation from a checklist may be needed."

9.5.2 Rejected Takeoff Procedure

The RTO procedure, dated March 11, 2015, was located within the Maneuvers section beginning at page MANEUVERS.1.9 of the QRH and was considered a "Non-Normal Maneuver." Flight crews were expected to do non-normal maneuvers from memory. The procedure was divided into two distinct responsibilities: Captain and First Officer. The guidance provided by the QRH included the following:

Rejected Takeoff

Captain	*First Officer*
Without delay: *Simultaneously close the thrust levers, disengage the autothrottle, and apply maximum manual wheel brakes or verify operation of RTO autobrakes.* *If RTO autobrakes is selected, monitor system performance and apply manual wheel brakes if the AUTOBRAKES disarm light illuminates or deceleration is not adequate.*	*Verify actions as follows:* *Thrust levers closed.* *Autothrottle disengaged.* *Maximum brakes applied.* *Call out "Autobrakes Off" if EICAS advisory message AUTOBRAKES displays during rollout.*
Manually deploy SPEEDBRAKES	*Verify speedbrake lever full aft and call "Deployed."* *If speedbrake lever is not deployed (or fails to remain deployed), call "No Speedbrakes."*
Apply reverse thrust up to the maximum amount consistent with conditions. *Continue maximum braking until certain the airplane will stop on the runway.*	*If there is no REV indication(s) or the indication(s) stays amber, call "No Reverser Left Engine", or "No Reverser Right Engine", or "No Reversers".* *Call out any omitted action items.*
Field length permitting: *Initiate movement of the reverse thrust levers to reach the reverse idle detent by taxi speed.*	*Call out "60 knots".* *Communicate the reject decision to the control tower and appropriate crew members as soon as practical.*

Captain	First Officer
When the airplane is stopped, perform procedures as required. Review Brake Cooling Schedule for brake cooling time and precautions. Consider the following: • The possibility of wheel fuse plugs melting • The need to clear the runway • The requirement for remote parking • Wind direction in case of fire • Alerting fire equipment • Not setting the parking brake unless passenger evacuation is necessary • Advising the ground crew of the hot brake hazard • Advising passengers of the need to remain seated or evacuate • Completion of Non–Normal checklist (if appropriate) for conditions which caused the RTO	

Note: *Following any rejected takeoff above 80 knots, heavy weight reject, or if maximum braking was used, the tires, wheels, brakes, etc., must be inspected by maintenance prior to any subsequent takeoff.*

Supplemental Information

Rejected Takeoff

The captain has the sole responsibility for the decision to reject the takeoff. The decision must be made in time to start the rejected takeoff maneuver by V1. If the decision is to reject the takeoff, the captain must clearly announce "REJECT," immediately start the rejected takeoff maneuver, and assume control of the airplane. If the first officer is making the takeoff, the first officer must maintain control of the airplane until the captain makes a positive input to the controls.

Prior to 80 knots the takeoff should be rejected for any of the following:

- *activation of the master caution*
- *system failure(s)*
- *unusual noise or vibration*
- *tire failure*
- *abnormally slow acceleration*
- *takeoff configuration warning*
- *fire or fire warning*
- *engine failure*
- *predictive windshear alert (as installed)*
- *if a side window opens*
- *if the airplane is unsafe or unable to fly.*

Above 80 knots and prior to V1, the takeoff should be rejected for any of the following:

- *fire or fire warning*
- *engine failure*
- *predictive windshear alert (as installed)*
- *if the airplane is unsafe or unable to fly.*

During the takeoff, the crew member observing the non-normal situation will immediately call it out as clearly as possible.

9.5.3 Engine Fire and Engine Severe Damage Procedures

The B767 engine fire or severe damage procedure was provided in the American Airlines B767 Operations Manual, QRH. The title of the procedure was ENGINE FIRE or Engine Severe Damage or Separation**.**[37] The first five items of the checklist pertained to the affected engine and were to be performed from memory and the checklist containing those items was located in the "Memory Items" section of the QRH as well as in Section 8 – "FIRE PROTECTION." The QRH, Section 8 also contained items 6 through 16, which were to be performed by reference to the checklist:

Messages: L ENGINE FIRE *R ENGINE FIRE*

Conditions: One or more of these occur:

- *Engine fire warning*
- *Airframe vibrations with abnormal engine indications*

[37] See Attachment 11 – American Airlines Engine Fire/Severe Damage Checklist.

- *Engine Separation*

1 *A/T ARM switch…… OFF*
2 *Thrust lever*
(affected side)…… confirm……Idle
3 *FUEL CONTROL switch*
(affected side)……confirm……..CUTOFF
4 *Engine fire switch*
(affected side)……confirm…… Pull
5 ***If*** *the engine fire warning light is illuminated:*

Engine fire switch
(affected side)……Rotate to the stop and hold for 1 second
If *after 30 seconds the engine fire warning light stays illuminated:*
Engine fire switch
(affected side)…… Rotate to the other stop and hold for 1 second

6 ***If*** *high airframe vibration occurs and continues after engine shutdown:*
Without delay, reduce airspeed and descend to a safe altitude which results in an acceptable vibration level.

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

7 *Chose one:*
APU is ***available:***
Go to step 8

APU is ***not*** *available:*
Go to step 9

8 *APU selector……START, then ON*
9 *Transponder mode selector……TA*
10 *Plan to land at the nearest suitable airport.*
11 ***If*** *wing anti-ice required:*
PACK control selector (affected side)……OFF
ISLN switch (affected side)……ON

***When** wing anti-ice no longer required:*
L and R ISLN switches……OFF

12 *GND PROX FLAP OVRD switch……OVRD*
***Note:** Do **NOT** use Flaps 15 during approach.*

13 *Use flaps 20 and VREF 20 for landing.*

14 *Use flaps 5 for go-around.*

15 *Check the Non-Normal Landing Configurations Advisory Landing Distances in the Performance Inflight-QRH chapter.*

16 *Do **not** accomplish the following checklist:*
ENGINE BOTTLE
ENGINE SHUTDOWN
PACK OFF

9.5.4 Emergency Evacuation Decision

The American Airlines B767 Operations Manual, QRH, page 2.5 – General Information," dated April 7, 2016 stated the following:

In a non-normal situation, the Captain must decide whether or not to conduct a passenger evacuation. The Captain must balance the hazard of passenger evacuation against the hazard of remaining on board. It is not feasible to establish a rigid set of rules regarding evacuation since there are many situational variables.

The Captain must evaluate a specific situation, apply good judgment, and reach the best decision given the information available. The emergency evacuation is a powerful tool. Use it cautiously.

The Captain should consider the following:

- *The decision to evacuate should be deliberate after carefully weighing the risks in evacuating against the risks of remaining on board*
- *The most hazardous event is fire or smoke within the pressurized area of the airplane (cabin or cargo compartment)*
- *Smoke or flames in the engines, APU, or wheel assembly areas, will normally burn out quickly and not endanger the cabin. Request ARFF equipment, pull the Fire Switch, discharge fire suppression agent as appropriate, carefully monitor the area and communicate with crash vehicle crews and tower. Time and conditions permitting, clear the active runway. Evacuate the passengers if the fire does not extinguish in a reasonable time or appears to be spreading.*

Whatever the decision, be specific and unambiguous in conveying your intent to the Flight Attendants.

9.5.5 Emergency Evacuation Procedure

The American Airlines B767 Operations Manual, QRH, page 2.6, dated April 7, 2016, stated the following:

> *The purpose of an evacuation is to deplane everybody on board as rapidly as possible through all usable exits after the airplane stops. Evacuations fall into two categories: planned, and unplanned. In either case, the actual evacuation is the same.*
>
> *After an airplane has landed following a significant in-flight event, the potential exists for a passenger or Flight Attendant initiated evacuation. If an immediate evacuation is not required, it is important to assure the passengers and Flight Attendants that the situation is under control. Make an immediate PA commanding:*
>
> ***"This is the Captain. Remain Seated. Remain Seated. Remain Seated."***
>
> *If an evacuation might be required after further assessment, consideration should be given to configuring the aircraft for a potential evacuation. (Steps such as shutting down the engines, should be considered to avoid the potential passenger injuries which might occur if the aircraft is not configured and the situation deteriorates or an inadvertent passenger or Flight Attendant evacuation takes place.)*
>
> *Flight Attendants receive extensive training in methods, procedures, and the evaluation of usable exits in order to perform a rapid and safe evacuation. The NTSB has conducted significant and thorough studies involving actual evacuations, required testing, and evacuation guidance provided to flight crews from their respective airlines and the FAA. As a result of their studies, the NTSB determined that "limiting the number of exits during an evacuation can have a dramatic effect on evacuation times." Throughout their evaluation of actual evacuations, the NTSB discovered there "was no evidence or data to suggest that fewer injuries occur or that panic was minimized when a limited number of exits are used". Therefore, unless there is definitive and credible evidence to the pilots indicating a potential exit is unusable and a hazard, assessing the usability of an emergency exit for evacuation should be left to the Flight Attendants. Pilots should alert the Flight Attendants to any potential hazards they may expect involving an emergency exit during the T-E-S-T briefing[38].*
>
> *The Evacuation checklist is normally read by the First Officer (F/O reads – Challenge and Response) and each checklist item is accomplished by the Captain.*
>
> *After confirming each checklist item has been accomplished, the Captain states appropriate checklist response.*
>
> *The two signals used to initiate an evacuation are:*

[38] Type, Evacuation, Signal, Time. Source: American Airlines, Inc. Flight Manual Part I, pg. 19.2-1

*• Primary evacuation signal – the words, "**This is the Captain. Evacuate. Evacuate. Evacuate.**" over the PA system.*

• Alternate evacuation signal - in addition to PA - use the Evacuation Command Switch (as installed).

9.5.6 Unplanned Evacuation

The American Airlines B767 Operations Manual – QRH, page 2.8, dated March 11, 2015, stated the following:

Since most accidents occur on takeoff and landing, the Flight Attendants are instructed to be alert to clues of an emergency situation, such as unusual impact forces, noises, smoke, fire, or abnormal airplane attitudes. After the airplane stops, the Flight Attendants will assess the situation and, if the need for an evacuation is obvious, will initiate the evacuation without waiting for instructions from the cockpit. A DOOR EICAS message indicates that the evacuation has started.

If an evacuation has commenced, it is usually best not to attempt to stop the evacuation already in progress. If an evacuation has not commenced and it is determined that an evacuation is not needed, make an immediate PA commanding:

"This is the Captain. Remain Seated. Remain Seated. Remain Seated."

9.6 Emergency Evacuation

The American Airlines, Flight Manual Part I, Chapter 19, "Non-normal and Emergency," dated October 1, 2016 stated the following:

Emergency Evacuation General Guidance

A. In an emergency evacuation, it is likely that certain passengers and crewmembers will suffer injury. The Captain should consider the relative risks of remaining aboard the aircraft against the risks of evacuation.

B. Although indications of fire must be regarded with the utmost seriousness, in some cases such as a fire warning light, torching, or external smoke, the Captain should seek further information or confirmation from other sources such as the tower, other aircraft, or emergency response crews.

C. If an irregularity or emergency develops during ground operations and it is not feasible to return or continue to the terminal / gate area, the Captain should consider the use of emergency exits and evacuation slides to deplane passengers

and crew only if their safety is in question. Otherwise internal or remote stairs or an eventual return to the terminal / gate should be used for deplaning.

Flight Attendant Initiated Evacuations

When an aircraft has come to a stop in an obvious life-threatening situation (fire, dense smoke in the cabin, crash), Flight Attendants are authorized to initiate an evacuation without awaiting instructions from the flightdeck. Flight Attendants will attempt to communicate with the flightdeck if at all possible. If contact with the flightdeck is not possible, or if life threatening conditions still exist, Flight Attendants will make an independent decision and operate all usable exits.

Planned Evacuation

Communication between the flightdeck and cabin crew is especially important, both to verify the cabin situation and communicate the evacuation plan. Using the acronym "TEST", advise the Flight Attendants of the "Type" of emergency, whether an "Evacuation" is required (to include any special considerations that may affect the use of any exits), the evacuation "Signal" to be used ("This is the Captain, evacuate, evacuate, evacuate" PA and the electronic evacuation signaling system, if applicable) and the "Time" remaining before landing. If an evacuation is planned and later determined unnecessary, or a condition where an evacuation is not desired, advise the Flight Attendants via the PA "This is the Captain, remain seated, remain seated, remain seated." If the PA is inoperative, an alternative means of communication may be coordinated.

It is always the Captain's decision to use slides or air stairs. If air stairs are to be used, tell the FA 1/A-FA/Purser how many air stairs and which door(s) will be used. Flight Attendants are instructed to disarm and open the appropriate doors as the air stairs approach. All other doors will remain armed in case conditions change.

9.7 Evacuation Duties

The American Airlines, B767 Operations Manual, QRH, page 2.8, dated March 11, 2015, contained the following excerpts:

Cockpit crewmembers will assist in the evacuation after completing required cockpit duties and should wear their hats to identify themselves as authorities to the passengers.

<u>Captain – Assist in cabin</u>

- *After checklist is complete, immediately proceed to forward cabin and assess conditions.*
- *Assist and direct evacuation. Pay attention to utilization of slides; use megaphone, if required, to maintain orderly and rapid passenger evacuation. Instruct Flight Attendants to leave airplane when their areas are clear.*

- *Check entire cabin to ensure that all passengers have evacuated. Exit via any usable rear entry door.*
- *Assemble passengers away from airplane.*
- *Ensure that one or more crewmembers remain with the passengers until relieved by station personnel.*

First Officer – Assist outside airplane

- *After checklist is complete, immediately proceed to forward cabin and assess conditions.*
- *Take Halon fire extinguisher (if possible).*
- *Exit via first usable door and assist outside as necessary.*
- *Assemble passengers away from airplane.*

Concurrent Flight Attendant Duties

- *Flight Attendants will prepare and man assigned exits and direct evacuation.*
- *When all passengers are out, they will make a quick check of their cabin areas and then leave the airplane.*
- *After leaving the airplane they will assemble passengers away from the airplane, make a count, and report to Captain.*

9.8 Evacuation Checklist

The American Airlines, B767 Evacuation procedure, dated April 7, 2016, was provided on the back cover of the American Airlines QRH. The checklist was to be read by the first officer, performed by the captain, and verified performed by the first officer. The accident captain had not been through recurrent training since the removal of the duty column, specifying which crewmember was to conduct the specific task; to the current model which required the first officer to read the checklist task, the captain accomplished the task, and the first officer verified the task was accomplished. There were no other changes to the checklist, in regards to the order or the steps that were required by the crewmembers to accomplish the checklist. All crewmembers would have been notified via company communication to all B757/767 pilots of the change, as well as having been issued the new checklist. The evacuation checklist was as follows[39]:

Note: *Light override is available.*

1. *PARKING BRAKE……Set*
2. *Cabin altitude MODE SELECT……MAN*
3. *CABIN ALTITUDE MANUAL control……Hold in CLIMB*

Note: *Hold in CLIMB until the outflow valve indication shows fully open to depressurize the airplane.*

4. *FUEL CONTROL switches (both)……CUTOFF*
5. *PA…….* ***"This is the Captain.***

[39] See Attachment 12 - American Airlines Evacuation Checklist.

Evacuate, Evacuate, Evacuate."

6. *Evacuation COMMAND Switch*
   (as installed)……ON
7. *ATC……Notify*

8. *Engine and APU*
   fire switches (all)…… Override and pull

9. *If an engine or APU fire warning occurs:*
   Related fire switch……..Rotate to the stop and hold for 1 second

Supplemental Information

If time permits, additional information is available in General Information page 2.8.

9.9 American Airlines Pilot Training

According to the American Airlines – Flight Training B757/767 Instructor Guide – Qualification Training, training was divided into 12 days of ground school followed by 10 days of simulator training. Simulator training was divided into simulator sessions and further subdivided into various numbers of SPOTs[40], concluding with a MV[41], a LOFT[42] and a LOE. During the Captain – First Officer Simulator Sessions 4, 6, 7, and 8, and First Officer – First Officer Simulator Sessions 3 and 4, rejected takeoffs were conducted[43]. The scenarios for rejected takeoffs included windshear with speed stagnation and an engine fire or cargo fire, about 110 knots; all rejected takeoffs, with the exception of the windshear scenario, included an evacuation following the simulated cabin crew reporting smoke in the cabin.

According to the American Airlines – AQP, Volume 3, Continuing Qualification Training manual, Maneuvers Training (RTS) module consisted of distance learning modules, one day of ground school, and two days of simulator training which was divided into 48 graded events. Simulator Day 1 (RTS) consisted of a two hour brief, four hour simulator and a debrief period. Simulator Day 2 (R9/R18) consisted of a two hour brief, four hour simulator and a debrief period. Day one of the simulator training included nine SPOTs. The manual provided the following statement when it came to the RTS session:

> *It is important to note that the RTS is a training session designed to allow the individual crewmember to gain proficiency in all required areas**. However, pilots are required to have a working knowledge of all items and maneuvers listed as they arrive for***

[40] Special Purpose Operational Training
[41] Maneuvers Validation
[42] Line Oriented Flight Training
[43] The FO-FO simulator sessions 3 and 4 each contained two RTO/evacuation SPOTs.

training. *Pilot performance must meet the Qualification Standards proficiency guidelines before progressing to the RLE (R9) or RVA (R18).*

SPOT Five "Rejected Takeoff (First Look), Evacuation, (FO)" comprised of the following maneuvers:

- *Takeoff*

  — Contingencies: Rejected Takeoff

- *Takeoff*

  — Contingencies: Engine Fire

- *Takeoff*

— Contingencies: Evacuation

According to the American Airlines – Flight Training B757/767 Instructor Guide, dated July 1, 2015[44], "First Look Maneuvers" were defined as:

> *…maneuvers which are NOT briefed during the RTS briefing period but are flown by each pilot in the simulator and are defined to give some indication of whether the interval between training sessions may be too long to maintain proficiency in rarely exercised critical tasks. These maneuvers are:*
>
> *Rejected Takeoff*
> *Engine Out Approach*
> *Go Around/Missed Approach*

According to the B757/767 Instructor Guide – Continuing Qualification Edition 5, dated March 29, 2016[45], defined "First Look Maneuvers" the same as the previous manual. The maneuvers were:

> *Go Around/Missed Approach*

The Instructor Guide further defined the objective and scope of SPOT 5: Rejected Takeoff (**First Look**), Evacuation (FO) as follows:

> *Objectives:*
> *The purpose of this SPOT is to demonstrate to standard:*
> *RTO (First Look)*
> *Evacuation*
>
> *Scope*
> *RTO starts at the application of takeoff thrust thru the aircraft stopped*

[44] Both crewmembers would have accomplished the RT9; this would have been the captain's most recent RTS, the first officer would have accomplished one other RTS which began April 1, 2016.

[45] This manual was in effect at the time of the accident and the First Officer had accomplished this training, the captain was scheduled for this training after the accident.

- *Evacuation starts with the CA call for evacuation thru "Checklist Complete"*

It further provided guidance to the instructor to set an "Engine Fire" indication at V1 minus 20 knots and then to further provide cues from the simulated flight attendant to the simulated air traffic control tower. The external cues required the crew to determine if an evacuation was warranted, and if it was, to complete the "Evacuation Checklist" and the crew would also explain what their additional duties were.

9.9.1 Crew Resource Management/Threat and Error Management Training

According to the Manager of Flight Training & Standards, American Airlines trained threat and error management (TEM) which incorporated all elements of crew resource management (CRM) into a broader package. He stated TEM was incorporated into every aspect of training – ground school, RTS, R9 and R18.

According to the American Airlines – Flight Training B757/767 Instructor Guide Edition 5, dated March 29, 2016, day 1 ground training included a module on human factors. The manual stated "Human Factors (RHF) training is a stand-alone class that covers Threat and Error Management, safety concerns, high threat level ASAP events, FOQA events and hot items." A letter within this guide addressed to instructors from the Managing Director of Flight Training & Standards stated, "Used effectively, the TEM model provides a common reference point for us to enhance our situational awareness and communication skills and is envisioned as a tool that will permeate our flight training and line flying practices."

According to the American Airlines Flight Operations Training Manual (FOTM), chapter 1 Threat & Error Management, section 1.1 General[46], dated January 11, 2016:

> *Threat & error management (TEM) is intended to fully integrate technical and crew resource management (CRM) skills. TEM uses both an acronym, ABCs, and a simple graphic (see Figure 1.1 Threat & Error Management Target) to provide crews with a method to visualize and remember threat and error management concepts.*
>
> ***• Note •***
> *Crews will follow CRM principles during line operations.*
>
> *According to the American Airlines – AQP, Volume 3, Continuing Qualification Training manual, section 116.5 B757/767 Aircraft Specific Continuing Qualification Training, subsection 116.5.1 Objective of Training, dated October 11, 2015:*
>
> *This course has been designed to review and validate aircraft specific task management skills and CRM. In accordance with the AQP Continuing Qualification, selected systems will be covered in adequate depth each year.*

[46] See Attachment 7 – American Airlines Flight Operations Training Manual (Excerpt)

According to the American Airlines – Flight Training B757/767 Instructor Guide, Edition 1, dated July 1, 2015[47], day 3 of CQ training included a TEM SPOT:

> ***SPOT Four: TEM SPOT - OPD Arrival, RNAV Visual Approach, Go-Around/Missed Approach, (CA), SET GPWS, (Both)***
> *Descent*
> *—Contingencies: Automation Level 3*
> *RNAV Visual Approach*
> *Go Around/Missed Approach*
> *Climb*
> *—Contingencies: SET GPWS*
> *Climb*
> *—Contingencies: SET GPWS*

F. ATTACHMENTS

Attachment 1 – Flight Crew Interview Summaries
Attachment 2 – Flight Crew Written Statements
Attachment 3 – American Airlines Personnel Interview Summaries
Attachment 4 – Simulator and Cockpit Evaluation
Attachment 5 – O'Hare Airport Diagram – Jeppesen
Attachment 6 – Flight Crew Previous 90-Day Schedule
Attachment 7 – American Airlines Flight Operations Training Manual (Excerpts)
Attachment 8 – American Airlines Flight Attendant Briefing
Attachment 9 – American Airlines Takeoff Briefing
Attachment 10 – American Airlines Rejected Takeoff Procedures
Attachment 11 – American Airlines Engine Fire/Severe Damage Checklist
Attachment 12 – American Airlines Evacuation Checklist
Attachment 13 – American Airlines Evacuation Decision Making and Duties
Attachment 14 – American Airlines Non-Normal Checklist Instructions
Attachment 15 – American Airlines Crew Authority
Attachment 16 – Boeing Rejected Takeoff Decision Making
Attachment 17 – Boeing Rejected Takeoff Maneuver
Attachment 18 – Boeing Airplane Flight Manual Engine Fire Checklist
Attachment 19 – Boeing QRH Engine Fire/Severe Damage Checklist
Attachment 20 – Boeing Evacuation Checklist
Attachment 21 – Boeing Non-Normal Checklist Instructions
Attachment 22 – American Airlines Airbus 319/320/321 Engine (1 or 2) Fire (On Ground)
Attachment 23 – American Airlines Embraer E190 Engine Fire on the Ground Checklist

[47] The American Airlines B757/767 Instructor Guide, Edition 1, dated July 1, 2015, was applicable during the accident captain's CQ training completed on March 21, 2016. The TEM SPOT Four was not included in the subsequent American Airlines B757/767 Instructor Guide, Edition 5, dated March 29, 2016, which was applicable during the accident first officer's CQ training completed on September 7, 2016.

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