AI2015-2

AIRCRAFT SERIOUS INCIDENT
INVESTIGATION REPORT

J-AIR CORPORATION
J A 2 0 6 J

February 26, 2015

JTSB Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board (and with Annex 13 to the Convention on International Civil Aviation) is to prevent future accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

Norihiro Goto
Chairman,
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

FIRE WITHIN THE ENGINE FIRE ZONE
J-AIR CORPORATION
BOMBARDIER CL-600-2B19, JA206J
ON THE TAXIWAY A4 AT OSAKA INTERNATIONAL AIRPORT
AT AROUND 12:15 JST, MAY 6, 2013

February 13, 2015

Adopted by the Japan Transport Safety Board

Chairman	Norihiro Goto
Member	Shinsuke Endoh
Member	Toshiyuki Ishikawa
Member	Sadao Tamura
Member	Yuki Shuto
Member	Keiji Tanaka

SYNOPSIS

<Summary of the Accident>

On Monday, May 6, 2013, a Bombardier CL-600-2B19, registered JA206J, operated by J-AIR Corporation, took off from Oita Airport as the scheduled flight 2362 of Japan Airlines Corporation, a code-sharing partner, and landed on runway 32R at Osaka International Airport. While the aircraft was taxiing on the taxiway after landing, a caution message was displayed for a right engine fire detection system failure at around 12:15 Japan Standard Time (JST: UTC+9hr), and subsequently a warning message was displayed for a right engine fire. While the crew responded to the engine fire warning message, the aircraft continued to taxi and entered the parking spot. During maintenance work after the flight, evidence of fire was found within the engine fire zone.

A total of 55 persons were on board the aircraft, including the captain, two crew members, and 52 passengers. There were no injuries.

<Probable Causes>

It is highly probable that the cause of this serious incident was that the coupling nut connecting the right engine fuel manifold (fuel supply piping) and fuel injector (fuel injection nozzle) No. 14 was loose, fuel leaked from this area and was ignited by the heat of the engine, which resulted in fire in the designated fire zone.

Although it is somewhat likely that the reason why the coupling nut was loose was the insufficient tightening force of the coupling nut, resulting in gradually loosening caused by factors such as engine vibration, the Japan Transport Safety Board couldn't determine the cause of the loosening.

<Recommendations>

○ Recommendations

In view of the results of this serious incident investigation, the Japan Transport Safety Board recommends IHI Corporation and J-Air Corporation pursuant to Article 27 of the Act for Establishment of the Japan Transport Safety Board as follows:

(1) Recommendations to IHI Corporation

When conducting engine overhauls, reconfirm that the system ensures that important work for safety is surely carried out, including the tightening of the coupling nuts connecting the injector and manifold.

(2) Recommendations to J-AIR Corporation

Enhance education and training involving important system functions for safety and reconsider the contents of training in response to an outbreak of fires.

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Abbreviations used in this report are as follows.

AOM:	Aircraft Operating Manual
AMM:	Aircraft Maintenance Manual
ASDE:	Airport Surface Detection Equipment
CVR:	Cockpit Voice Recorder
DCU:	Data Concentrator Unit
DFDR:	Digital Flight Data Recorder
EICAS:	Engine Indication and Crew Alerting System
EM:	Engine Manual
ENG:	Engine
FL:	Flight Level
ITT:	Interturbine Temperature
JST:	Japan Standard Time
L:	Left
L/R:	Left or Right
L(R):	Left or Right
MAC:	Mean Aerodynamic Chord
Msg:	Message
NTT:	Nippon Telegraph and Telephone Corporation
PF:	Pilot Flying
PM:	Pilot Monitoring
R:	Right
SKC:	Sky Clear
SPM:	Standard Practices Manual
VHF:	Very High Frequency

Unit conversion table

1 psi:	0.07031 kgf/cm^2
1 inHg:	33.86 hPa
1 in:	2.540 cm
1 mil:	0.001 in
1 lb:	0.4536 kg
1 lb-in:	1.152 kg-cm
1 kg-m:	9.807 N-m
1G:	9.807 m/sec^2
1 kt:	1.852 km/h

1. PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Serious Incident

On Monday, May 6, 2013, a Bombardier CL-600-2B19, registered JA206J, operated by J-AIR Corporation, took off from Oita Airport as the scheduled flight 2362 of Japan Airlines Corporation, a code-sharing partner, and landed on runway 32R at Osaka International Airport. While the aircraft was taxiing on the taxiway after landing, a caution message was displayed for a right engine fire detection system failure at around 12:15 Japan Standard Time (JST: UTC+9hr; unless otherwise stated, all times are indicated in JST on a 24-hour clock), and subsequently a warning message was displayed for a right engine fire. While the crew responded to the engine fire warning message, the aircraft continued to taxi and entered the parking spot. During maintenance work after the flight, evidence of fire was found within the engine fire-prevention area.

A total of 55 persons were on board the aircraft, including the captain, two crew members, and 52 passengers (including three infants). There were no injuries.

1.2 Outline of the Serious Incident Investigation

This incident constitutes the "occurrence of fire within an engine fire-prevention area" as stipulated in Article 166-4 Item 10 of the Ordinance for Enforcement of the Civil Aeronautics Act, and is therefore classified as an aircraft serious incident.

1.2.1 Investigation Organization

On May 6, 2013, the Japan Transport Safety Board designated an investigator-in-charge and two other investigators to investigate this serious incident.

1.2.2 Foreign Representatives and Advisors

Representatives of Canada and the United States of America, as the States of Design and Manufacture of the aircraft and engine involved in this incident, participated in the investigation.

1.2.3 Implementation of the Investigation

May 7 to 8, 2013:	Interviews and aircraft investigation
May 14 to 15, 2013:	Engine investigation, maintenance records investigation, and interviews
May 29 to 31, 2013:	Various test surveys in the designated factory of the engine manufacturer
August 2, 2013:	Investigation on status of pilot training
August 13 to November 18, 2013:	Investigation of evidence of coupling nut looseness (requested to the Japan Aerospace Exploration Agency)
September 4, 2013:	Data gathering, on-site investigation, and interviews
September 6, 2013:	Interviews

1.2.4 Provision of Factual Information to the Japan Civil Aviation Bureau

As the factual information obtained from fact-finding investigations, information was provided on June 6, 2013 to the Japan Civil Aviation Bureau, including the facts that fuel leakage had been found near the coupling nut*1 connecting the fuel manifold*2 and fuel injector*3, that the coupling nut had been loose, and that fuel leakage had stopped by tightening at the designated torque.

1.2.5 Comments from Parties Relevant to the Cause of the Serious Incident

Comments were invited from the parties relevant to the cause of the serious incident.

1.2.6 Comments from the Relevant States

Comments on the draft Final Report were invited from the participating States.

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*1 The coupling nut is a nut that connects pipes. It is also referred to as the "B nut."
*2 The fuel manifold is multi outlet piping encircling the perimeter of the engine to supply fuel.
*3 The fuel injector is a nozzle with a check valve that injects fuel into the engine combustion chamber.

2. FACTUAL INFORMATION

2.1 History of the Flight

On May 6, 2013, a Bombardier CL-600-2B19, registered JA206J (hereinafter referred to as "the Aircraft"), operated by J-AIR Corporation (hereinafter referred to as "the Company"), took off from Oita Airport as the scheduled flight 2362 of Japan Airlines Corporation, a code-sharing partner, at 11:29 bound for Osaka International Airport and landed on runway 32R of Osaka International Airport at 12:14.

The outline of the flight plan was as follows:

Flight rules: instrument flight rules (IFR)
Departure airport: Oita Airport
Estimated off-block time: 11:25
Cruising speed: 386 kt/371 kt
Cruising altitude: FL 210/FL 190
Route: SPIDE (waypoint) -omitted-SKE (Shinoda VOR/DME)
Destination airport: Osaka International Airport
Alternate airport: Kansai International Airport
Total estimated elapsed time: 0 hours and 39 minutes
Fuel load expressed in endurance: 2 hours and 23 minutes

The taxi route following landing was as follows:

Taxi route: runway 32R-taxiway C6-taxiway A4-parking spot No.19

When the serious incident occurred, the captain sat in the left seat in the cockpit of the Aircraft as the PF (pilot mainly in charge of flying) and the copilot sat in the right seat as the PM (pilot mainly in charge of duties other than flying).

The history of the flight up to the serious incident is summarized as below, based on the digital flight data recorder (DFDR), the cockpit voice recorder (CVR), and the statements of the captain and the copilot (hereinafter referred to as the "flight crew members").

2.1.1 History of the Flight Based on the DFDR and CVR Records

12:14:36: The Aircraft landed on runway 32R at Osaka International Airport.
12:14:40: The thrust reversers were used for approximately 19 seconds.
12:15:29: A caution message was displayed for a right engine fire detection system failure, and a chime sound rang once.
12:15:30: A flight crew member made a call[*4] for the right engine fire detection system failure.
12:15:39: The flight crew members stated that this was the first time they had seen this type of message.
12:15:42: The captain instructed the copilot to respond in accordance with the checklist for response to the right engine fire detection system failure.
12:16:02: A warning message was displayed for a right engine fire, and a fire bell (fire warning sound) rang.
12:16:04: The copilot made a call for the right engine fire.
12:16:05: The fire bell was stopped.

*4 A call refers to an immediate response made by a flight crew member discovering an emergency or abnormal situation to report this in accordance with the aircraft operating manual.

12:16:09: The captain said in a low voice, "Right engine fire."

12:16:17: The captain proposed that the right engine should be shut down, and the copilot agreed.

12:16:19: The captain instructed the copilot to respond in accordance with the checklist for response to the right engine fire.

12:16:25: The copilot asked what to do with the item "the parking brake ON" in the checklist and continued to read out the engine shut down items without waiting for a response from the captain.

12:16:39: The captain instructed the copilot to shut down the right engine.

12:16:42: The copilot performed an operation to shut down the right engine.

12:16:43: The captain stated that they would continue to taxi.

12:16:44: The right engine was shut down.

12:16:48: The copilot asked whether to select the engine fire push switch*5.

12:17:14: After uttering various matters suggesting he was unsure of his decision, the captain instructed the copilot to select the switch.

12:17:23: The copilot pushed the right engine fire push switch to select it.

12:17:31: In accordance with the procedures, the copilot switched both fuel boost pumps off.

12:17:44: The captain and copilot exchanged views on holding the discharge of fire extinguishing agent.

12:17:57: The captain required time to think about the matter.

12:17:59: The captain stated that the right engine fire warning was continuing.

12:18:00: The Aircraft entered parking spot No.19 and was stopped.

12:18:02: Following this time, the left and right brake pedals were kept depressed, and the parking brake was turned on with pressure applied on the brakes.

12:18:05: The captain instructed the copilot to discharge fire-extinguishing agent.

12:18:07: The copilot reconfirmed whether fire-extinguishing agent should be discharged.

12:18:10: The captain responded that there was no other choice.

12:18:12: The copilot responded that he would discharge fire-extinguishing agent.

12:18:15: The copilot discharged fire-extinguishing agent.

12:18:16: The engine fire warning message disappeared.

12:18:36: The captain performed an operation to shut down the left engine.

12:20:14: The captain stated that he was concerned about handling after the discharge of fire-extinguishing agent.

12:20:31: The captain communicated through the ground radio station of the Company to the aircraft dispatcher to report that fire-extinguishing agent was discharged in response to a right engine fire warning message that was displayed, although it may have been a false alarm.

(See Figure 1: Estimated Taxi Route Based on DFDR, CVR, and ASDE*6 and Figure 2: DFDR Records)

2.1.2 Statements of Flight Crew Members

*5 The engine fire push switch is when this switch depressed, the system arms the selected (L/H or R/H) squib of bottles #1 and #2, the bleed air shut-off valves are CLOSED, the fuel shut-off valve is CLOSED, the hydraulics shut-off valve is CLOSED, and the generator is taken OFF-LINE..

*6 ASDE stands for airport surface detection equipment, which is a radar for monitoring the movement of aircrafts and vehicles on airport surfaces such as runways and taxiways in order to ensure safe movements.

(1) Captain

The Aircraft departed Oita Airport as flight JAL2362, and after landing on runway 32R at Osaka International Airport, it vacated the runway from taxiway C6. The state of the Aircraft was normal during this period.

The captain remembers that when the Aircraft was turned right from taxiway C6 to taxiway A4, a right engine fire detection system fail caution message (hereinafter referred to as "R fire fail caution message") was displayed on EICAS*7. The captain instructed the copilot to respond in accordance with the checklist for response to the R fire fail caution message. The captain's understanding was that the fire fail caution message is only displayed when there is a fire detection system failure.

Afterwards, because this caution message changed to a right engine fire warning message, the captain instructed the copilot to respond in accordance with the checklist for response to the warning. When the caution message changed to a right engine fire warning message, the captain believed that there was the possibility of a false alarm because neither triple chime nor fire bell sound*8 was recognized, and because the R fire fail caution message was previously displayed.

As the parking spot was nearby, the captain decided that it would be safer in case of an emergency evacuation to continue taxiing and enter the parking spot as there were personnel for assistance there.

The captain remembered that the Aircraft was a little past the halfway point on the way to parking spot No.19 after turning left from taxiway A4 when fire-extinguishing agent was discharged according to the procedures on the checklist. In addition, the captain remembered the fire warning message disappearing while the Aircraft was being parked after it entered the parking spot.

(2) Copilot

The copilot remembered that when the Aircraft entered taxiway A4 from taxiway C6, a R fire fail caution message was displayed. As later described in 2.9.1, the copilot stated that he was aware that the fire fail caution message would also be displayed if a fire is detected by only one of two sensing elements (hereinafter referred to as "elements") for each engine. When the copilot opened the checklist in accordance with the captain's instructions to commence the procedures, a right engine fire warning message was subsequently displayed. The copilot remembered that there was no fire bell sound. For this reason, the copilot felt that it was difficult to determine whether there was an engine fire or a false alarm. The copilot remembers conducting procedures in response to instructions from the captain regarding the warning message. When the warning message was displayed, the copilot had opened the checklist in response to the fire fail caution message; therefore, the copilot believed it would be better to read out the checklist rather than conduct the recall items*9 by memory as he had been trained to do, and responded by reading the engine fire checklist.

Although the checklist specified that the parking brake should be applied first, because the Aircraft continued to taxi, the copilot skipped it to move on to the subsequent

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*7 EICAS refers to the engine indicating and crew alerting system, which is an integrated system to display the condition of the engine and to visually and audibly notify the pilot of the occurrence of abnormalities.

*8 A triple chime is the sounding of three chime sounds at the same time when a warning message is displayed.

*9 Recall items are some items included in the checklist to do by memory in the event of an emergency or abnormal situation.

procedures.

After shutting down the right engine, the copilot pushed the right engine fire push switch. Subsequently, in accordance with the procedures, the copilot switched both fuel boost pumps off. Because the warning message did not disappear even after 10 seconds had passed since the fuel boost pump was turned off, the copilot discharged fire-extinguishing agent. The copilot remembered discharging fire-extinguishing agent before entering the parking spot and the warning message disappearing at the moment when the Aircraft entered the parking spot.

While the copilot did not remember that there was any fire bell sound, he remembers pressing the master warning switch light*10. The copilot did not make a report to the air traffic controller regarding the right engine fire warning message.

This aircraft serious incident occurred on the taxiway A4 at Osaka International Airport at around 12:15 JST, May 6, 2013.

2.2 Injuries to Persons

There were no injuries.

2.3 Information of Damage to the Aircraft

2.3.1 Extent of Damage

The Aircraft was slightly damaged.

2.3.2 Damage to the Aircraft Components

There were partial burn out and some soot deposits on the surface of the fuel manifold (hereinafter referred to as the "manifold") connected to the fuel injectors (hereinafter referred to as the "injectors") from No. 12 to No. 14 of the right engine. There was also soot deposits to the inside of the cowling directly above the manifold surface with burn out. In addition, there were discoloration marks suggesting that a liquid had burned on the surface of the hoses and the fuel/oil heat exchanger (the heat exchanger for fuel and oil) below injector No. 14. Below this area, there were no fire traces, nor were there any traces within the lower cowling. Moreover, there was no evidence of fire or smoke occurring outside of the engine.

(See Photo 1: Aircraft Involved in the Serious Incident, Photo 2: Evidence of Fire 1 and Photo 3: Evidence of Fire 2)

2.4 Personnel Information

(1) Captain: Male, age 55

Airline transport pilot certificate (airplane):	July 8, 1994
Type rating for Canadian CL-65:	November 7, 2012
Class 1 aviation medical certificate	
Validity:	June 30, 2013
Total flight time:	16,580 hours 43 minutes
Flight time in the last 30 days:	67 hours 08 minutes

*10 The master warning switch light is a switch that lights up when a warning message is displayed. The light on this switch goes out and the warning sound is stopped when the switch is pressed, but the warning message continues to be displayed unless the situation is improved.

Total flight time on the type of aircraft: 279 hours 01 minutes
Flight time in the last 30 days: 67 hours 08 minutes

(2) Copilot: Male, age 40
Commercial pilot certificate (airplane): March 1, 2007
Type rating for Canadian CL-65: February 16, 2010
Instrument flight certification: October 9, 2007
Class 1 aviation medical certificate
Validity: April 8, 2014
Total flight time: 4,374 hours 16 minutes
Flight time in the last 30 days: 78 hours 22 minutes
Total flight time on the type of aircraft: 2,075 hours 15 minutes
Flight time in the last 30 days: 78 hours 22 minutes

2.5 Aircraft Information

2.5.1 Aircraft

Type: Bombardier CL-600-2B19
Serial number: 7834
Date of manufacture: July 16, 2003
Certificate of airworthiness: DAI-2012-139
Validity: June 21, 2013
Category of airworthiness: Airplane Transport T
Total flight time: 23,409 hours 31 minutes
Flight time since last periodical check (3A maintenance*11 on April 21, 2013):
113 hours 05 minutes

2.5.2 Engines

(1) Left engine
Model: General Electric CF34-3B1
Serial number: GE-E-873376
Date of manufacture: February 16, 2002
Total flight time: 23,066 hours 55 minutes
Date of installation: February 11, 2010
Flight time since last overhaul (September 26, 2009): 7,458 hours 29 minutes
Total cycles: 25,998 cycles

(2) Right engine
Model: General Electric CF34-3B1
Serial number: GE-E-873377
Date of manufacture: February 16, 2002
Total use time: 23,767 hours 29 minutes
Date of installation: December 10, 2009
Flight time since last overhaul (July 17, 2009): 7,823 hours 01 minutes
Total cycles: 26,617 cycles

*11 3A maintenance refers to the third A maintenance necessary every 500 hours of operation. Note that after the C maintenance is conducted for every 5,000 hours of operation, the next category of maintenance will be the first A maintenance.

2.5.3 Weight and Balance

When the serious incident occurred, the weight of the Aircraft is estimated to have been 43,100 lb and the center of gravity (CG) is estimated to have been 13.0% MAC, both of which are estimated to have been within the allowable ranges (the maximum landing weight: 47,000 lb; the CG range for the weight at the time of the serious incident: 9.0% to 35.0% MAC).

2.5.4 Fuel and Lubricant Oil

The fuel was Jet A-1 aviation fuel and the lubricant oil was jet engine Mobil Jet Oil II.

Note that the results of the analysis of the self-ignition point*12 for the fuel and the oil remaining in the fuel filter and oil tank of the engine were 242℃ for the fuel and 417℃ for the oil.

2.5.5 Engine Fire Extinguishing System

The engine fire extinguishing system of the Aircraft is independent from the engine fire detection system. The engine fire detection system notifies crew members of events such as occurrence of fire. When there is an engine fire alarm, crew members should confirm the situation, shutdown the affected engine, and manually activate the engine fire extinguishing system.

There are two sets of engine fire push switches to prepare for extinguishing*13 and two sets of fire extinguisher bottle discharge switches to discharge fire-extinguishing agent, one set each on the right and left side of the cockpit. In addition, the Aircraft is equipped with two engine fire extinguisher bottles at the rear of the fuselage. Engine fire-extinguishing agent is discharged from one or both fire extinguisher bottles on the side of the engine for which the engine fire push switch is pushed if the fire extinguisher bottle discharge switch is pressed on that side.

One of the fire extinguisher bottles of the Aircraft was discharged.

2.6 Meteorological Information

The Aviation Selected Special Weather Report*14 at the time of the serious incident at Osaka International Airport was as follows.

12:02 Wind direction: 230°; Wind velocity: 15 kt; Gust: 25 kt
Prevailing visibility: 20 km
Clouds: Amount SKC
Temperature: 23℃; Dew point: 3℃
Altimeter setting (QNH): 29.92 inHg

2.7 Information on the DFDR and the CVR

The Aircraft is equipped with a DFDR (parts number: 2100-4043-00) and a CVR (parts number: 2100-1020-20) manufactured by L-3 Communications (USA), which kept records when the

*12 The self-ignition point refers to the minimum temperature at which fuel begins to self-ignite under atmospheric pressure.

*13 Extinguishing preparations consist of creating the electric circuit for discharging fire-extinguishing agent into the engine from the side for which the engine fire push switch is pressed.

*14 Aviation Selected Special Weather Report refers to weather reports made in cases such as there being certain significant changes in meteorological conditions outside of scheduled meteorological observations.

serious incident occurred. The DFDR time calibration was conducted by comparing the NTT time signal recorded in the air traffic control communications record with the transmission keying signals for the VHF radio recorded in the DFDR and the CVR.

2.8 Information on the Occurrence of Fires

2.8.1 Identification of the Fuel Leakage Location

When the right engine was brought into IHI, the factory designated by the engine manufacturer, for wet motoring*15 on the test cell, the leakage of small quantities of fuel was found near the coupling nut (hereinafter referred to as "B nut") connecting injector No. 14 and the manifold.

Moreover, although fuel leakage was not found near the B nuts connectors the other 17 injectors except for injector No. 14, when the B nuts breakaway torque were checked it was done in a tightening direction, it was confirmed as later described in 2.8.2 that the one location (No. 3) was tightened lower and four locations (No. 4, No. 10, No 11 and No. 12) were tightened higher than the specified value for this engine model.

They were measured by an additional tightening torque method*16.

Tightened torque values (specified torque values: 135 to 150 lb-in)						
Position (number)	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Torque value (lb-in)	140	145	**125**	**160**	140	150
Position (number)	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
Torque value (lb-in)	135	140	150	**165**	**175**	**155**
Position (number)	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18
Torque value (lb-in)	140	- - -	150	150	150	140

As the manifold can be divided into two parts, the left half includes injector No. 14 and it was removed to conduct a fuel injection test. When fuel pressure was gradually increased in this test, fuel leaked near the No. 14 injector B nut connector. Furthermore, it was confirmed that the volume of leakage increased as pressure increased.

The tightened torque value for the B nut connecting injector No. 14 was too loose to be measured with the torque wrench, and the screw could be turned by hand. By tightening the B nut connecting injector No. 14 to the minimum specified torque value of 135 lb-in, it was found to move approximately 3 mm on the circumference of the circle. When fuel was injected under pressure after re-tightening, no fuel leakage was found.

(See Photo 4: Confirmation of Fuel Leaks)

2.8.2 Tightening of B Nuts

The installation torque value for B nuts for the same engine model is specified as 135 to 150 lb-in in the engine manual (hereinafter referred to as "EM"). However, the number of tightening times is not specified.

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*15 Wet motoring refers to a test in which the starter is used to start the engine with the ignition device disabled and fuel is injected.

*16 An additional tightening torque method consists of using a torque wrench to tighten screws that have already been tightened and measuring the torque value when the screw begins to rotate. Because this method measures the torque value that overcomes the static friction of torque thread, the torque values obtained tend to be higher than the actually tightened torque value.

The installation torque value for B nuts for the General Electric CF34-8, the same series as the engine model with the same screw size specifications for B nuts, is specified as 142.6 to 167.4 lb-in. The EM instructs that B nuts should be tightened by a triple torque procedure in which the nuts are turned three times as below.

(Excerpt)

(6) Triple torque the fuel manifold injector nuts as follows:

(a) Torque each one of the fuel manifold injector nuts to 142.6-167.4 lb in. (16.1-18.9 N.m).

(b) Loosen each one of the coupling nuts one-half turn and torque each one of the coupling nuts to 142.6-167.4 lb in. (16.1-18.9 N.m).

(c) Torque each one of the coupling nuts one additional time to 142.6-167.4 lb in. (16.1-18.9 N.m).

The triple torque procedure is described in the service bulletin (technical report) for the CF34-8 engine as below.

(Excerpt)

Safety wire requirement has been eliminated from the fuel half manifolds. Safety wire holes have been eliminated from the B-nuts on the manifold and no longer require safety cable at these fuel half manifold connections to the nozzles and fuel supply line. Triple torque procedure of these connections per the Engine Manual has replaced the requirement for safety wire.

The SPM*17 issued by the engine manufacturer states as below.

(Excerpt)

(7) Tube, Manifold, and Hose (0.75 in.[19 mm] and smaller in diameter) coupling nuts triple tightening procedure.

(a) Tighten the coupling nut to applicable torque identified in Subtask 70-51-00-400-045, Standard Torque Values.

(b) Break the torque on the coupling nut and then tighten to the torque value identified above.

(c) Break the torque on the coupling nut and then tighten to the torque value identified above.

In addition, the operational regulations for the factory contracting for the last overall of the engine (hereinafter referred to as “the Factory”) stipulate that “the certified repair and modification methods shall be in accordance with the latest methods designated by the equipment designers.”

The company does not conduct tightening of B nuts unless defects such as fuel leakage are discovered during visual inspections, and such tightening had not been conducted for the engine prior the occurrence of this serious incident.

2.8.3. Manifold Mounting Procedures

The procedures outlined in EM72-00-40 for engine overhaul stipulate that after the

*17 SPM is an abbreviation for standard practice manual, which is an explanation manual issued by the engine manufacturer that states basic work procedures and methodologies regardless of the engine model.

manifold is first attached to the engine using the clamps (supporting clasps) and the brackets (supporting metals fitting), the injectors and the manifold should be tightened to the specified torque value.

Meanwhile, the procedures outlined in the aircraft maintenance manual 73-11-09 for aircraft maintenance stipulate that after the injectors and manifold are tightened to the specified torque, the manifold should be mounted to the engine using the clamps and brackets.

The mounting holes for connecting clamps to brackets are oblong so that the mounting position can be adjusted. In addition, the tightening torque for the clamps and brackets are specified as 38 to 42 lb· in.

(See Figure 5: Manifold)

2.8.4 Work at the Factory

Engine assembly work after maintenance at the Factory is conducted while confirming the EM and build record (assembly work inspection records) on the site. For the items completed, the worker signs the build record after each item of work is conducted. Tightening the B nuts for the 18 injectors to the specified torque is handled together as one item. The procedure for tightening the B nuts to the specific torque was confirmed by the statement of the worker that conducted the injector and manifold tightening work (hereinafter referred to as "the Worker") as follows: The Worker initially lubricated the B nuts for the 18 locations and then provisionally tightened them to the injectors by hand. Next, the Worker tightened them up with a torque wrench starting from injector No. 13, as the only one with a differing shape of the 18 injectors, and proceeding clockwise to injector No. 12. The Worker stated that he had tightened them in accordance with the triple torque procedure stated in the SPM.

The inspector conducts a visual and hand tight inspection of the B nuts after the tightening by workers, but does not check the tightening torque. If the results of the inspection show no problem, the inspector signs. The inspector does not conduct an attending inspection while workers are conducting tightening work. The build record describes the work of the inspector as follows:

(Excerpt)

8 Final Inspection.

(1) Visually inspect all exposed area for damages and assembly condition.

(2) Inspect that all build records necessitated in the maintenance work are corrected and all operations are completed.

Accuracy management of the torque wrench used in work is conducted based on the internal rules, and the identification of the torque wrenches used in each work is conducted with the tool management records. Accuracy management had been conducted for the torque wrench used for the engine disassembly, and the calibration conducted after the occurrence of this serious incident indicated that the accuracy of the torque wrench was within the standard values.

2.8.5 Result of Blanket Inspections by the Japan Civil Aviation Bureau

On June 6, 2013, the Japan Civil Aviation Bureau instructed the operators operating this model of aircraft to conduct an inspection covering items such as the loosening of B nuts. As a result, out of all the 13 aircrafts of this type in operation in Japan, loosening was discovered at one location each for three engines of three aircrafts. The positions of the loosened B nuts were No. 3, No. 13, and No. 18, and accordingly they were not concentrated on a specific position. Moreover, no relationship was confirmed between the flight time after the overhaul of the three engines and the loosening nuts.

Note that the four engines that loosening was discovered, including the engine involved in this serious incident, were all overhauled at the same factory.

2.8.6. Fire Detection System

While the operations of the fire detection system including the fire bell of the Aircraft were confirmed in the initial investigations following the occurrence of this serious incident, no defects were found.

In addition, according to the aircraft manufacturer, the signal sources for the engine fire warning message and the fire bell are the same. This common signal is sent to the DCU*18, divided into two signals at the DCU, and transmitted for the message and the sound. No defects were found as a result of an inspection by a repair company of the DCU the Aircraft was equipped with.

While it is possible to turn off the fire bell sound and the lighting of the master warning switch light by pressing the master warning switch light located on either the left or right side at the front of the cockpit, it is not possible to turn off the engine fire push switch lighting or the warning message displayed on the EICAS.

The DFDR recorded the activation of master warning such as fire bell sounds and the right engine fire warning displaying the right engine fire warning message at the same time, and it recorded that the master warning was turned off after approximately three seconds.
(See Figure 2: DFDR Records)

2.8.7 Engine Surface Temperature

The engine surface where there were remarkable burn marks is covered with thermal insulation blankets. According to the documentation on the engine surface temperature provided by the engine manufacturer, the surface temperature of the blankets may be higher than the fuel auto-ignition point depending on operating conditions.

There are large slots in these blankets for structural reasons near injector No. 14 where fuel leakage was discovered. For this reason, there is no heat insulation near injector No. 14.

In order to cool the engine surface, some bypass air is brought into the cowling through 31 intake vents as cooling air. After cooling the engine surface, this air naturally flows out four outlet vents.
(See Figure 4: Cooling Air Flow, Photo 4: Confirmation of Fuel Leaks and Photo 5: Thermal Insulation Blanket Slots)

2.8.8 Soot Component Analysis

The results of an analysis conducted on soot arising from the burning of fuel and engine oil and the soot deposited on the engine of the Aircraft is as below.

Only carbon was detected from the soot arising from the burning of fuel. In addition, mainly carbon was detected from the soot arising from the burning of engine oil, as well as

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*18 DCU is an abbreviation for a data concentrator unit, which is a device that collects various data and sends signals to display devices and other equipment.

phosphorous and iron.

Meanwhile, mainly carbon was detected from the soot deposited on the engine, as well as silicon and calcium. However, phosphorous, a unique element contained in engine oil, was not detected.

2.8.9 Investigation of Evidence of the B Nut Loosening

(1) There was no evidence of foreign material between the B nut and the manifold sleeve shoulder that comes into contact with the B nut.

(2) There were friction marks and damage on the inlet fitting area (entrance coupling section) of injector No. 14. There were also friction marks on the flare side (funnel-shaped coupling section) of the manifold that comes contact with the inlet fitting area. The surface roughness of the friction marks and damage was not sufficient to cause fuel leakage.

(3) While there were multiple small hit marks on the screw threads of injector No.14, because there were no marks on the nut side, it was determined that they did not occur at the time of fastening.

(4) It was determined through an X-ray examination that the manifold flare and sleeve had a sturdy structure; accordingly there was no possibility of flare deformation at the time of fastening.

(See Figure 5: Manifold)

2.9 Additional Information

2.9.1 Fire Occurrence Display

The sensing element of the engine fire detection system used in the Aircraft makes use of a property that resistance lowers when the temperature rises. The element consists of two loops of loop A and loop B encircling the engine in parallel with an interval of approximately one inch between them. In normal operations, if heat greater than a fixed value and is detected by both elements, an engine fire warning message is displayed on the EICAS. The fire fail caution message is displayed when the system fails or when there is a time difference in the fire detection of these two loops. The following is stated in the AOM Supplement.

(Excerpt)

AOM Supplement

1. FIRE DETECTION AND EXTINGUISHING

A. Engine

(Abbreviated)

If only one loop detects a fire, when both loops are selected, this is considered a False Fire and a L/R FIRE FAIL caution message will be displayed on the EICAS primary page.

Because both fire fail and engine fire messages cannot be displayed at the same time in the system, when an engine fire warning message is displayed, the fire fail caution message will disappear. When an engine fire warning message is displayed, the flight crew members must immediately respond in accordance with the AOM as a real fire regardless of whether or not a fire fail caution message appeared beforehand.

(See Figure 6: Fire Fail Checklist and Figure 7: Engine Fire Checklist (on ground))

2.9.2 Operation Procedures in Emergency or Abnormal Situations

The AOM stipulated by the Company states the operation procedures in an emergency or abnormal situations are as follows:

(Excerpt)

(Abbreviated)

- *When a crew member discovers an emergency or abnormal situation, they shall immediately make a call.*
- *The PF shall instruct the implementation of the corresponding recall items.*
  The recall items are stated within the box in the procedures.
- *The responsible crew member shall implement the recall items by memory in accordance with their area of responsibility.*

(Abbreviated)

- *The PF shall issue instructions for conducting emergency or abnormal procedures after confirming the following situation.*
  - *Confirm that the flight path is under control.*
  - *Confirm that the aircraft is not in a critical flight condition (e.g., takeoff or landing).*
  - *Confirm that all the recall items have been completed.*
- *The PM shall read out the emergency or abnormal procedure title and implement the procedure after confirming that it matches with the displayed EICAS message or status.*
  The PM shall read out each item including the response in accordance with the procedure.
  - *For the recall items, the responsible crew member shall confirm that the necessary operations have been completed, and then conduct a response.*

  (Abbreviated)

  - *Implement the items besides recall items while reading out the procedure. The PM shall read out each item including the response in accordance with the procedure. The responsible crew member shall conduct a response by conducting the required operations.*
  - *The PM shall also read out the notes, cautions, warnings, and other information. While the PF is not required to repeat these items, they should provide sufficient acknowledgment.*

  (Abbreviated)

(See Figure 7: Engine Fire Checklist (on ground))

3. ANALYSIS

3.1 Qualification of Personnel

The captain and the copilot held valid airman competence certificates and valid aviation medical certificates.

3.2 Airworthiness of the Aircraft

The Aircraft had a valid airworthiness certificate and had been maintained and inspected as prescribed.

3.3 Effects of Meteorological Conditions

As described in 2.6, the weather conditions at the time of the serious incident were a wind direction of 230°, a wind velocity of 15 kt, and a gust of 25 kt. This consisted of a wind straight from the left while on the runway and a wind from behind when on taxiway C6 and in parking spot No.19. It is probable that when the Aircraft continued to taxi and entered parking spot No.19, operations were not in accordance with the Engine Fire Checklist (on ground) caution item of attempt to face the airplane into the wind then stop in the place.

3.4 Background of the Occurrence of Fires

3.4.1 Identification of flammable fluid Source

It is highly probable that the flammable materials susceptible to ignition were fuel and oil. Because fuel leakage was found as described in 2.8.1 and because phosphorous, a unique element contained in engine oil, was not detected in the soot composition collected as described in 2.8.8, it is highly probable that the leaked fuel ignited and caused the fire to occur.

3.4.2 Occurrence of Fuel Leakage

As described in 2.8.1, it is certain that in this serious incident, there was loosening in the B nut connecting injector No. 14 and the manifold, which caused fuel leakage to occur.

As described in 2.8.9, although evidence of the B nut loosening was investigated, it was not possible to discover the evidence of the cause of fuel leakage.

Meanwhile, in regard to the insufficient tightening force of B nuts, as described in 2.8.4, the worker stated that he had tightened the B nuts in accordance with the triple torque procedure stated in the SPM. In addition, as described in 2.8.4, the worker and inspector signed the build record to indicate tightening them to the specified torque. However, the work procedures do not require the inspector to conduct an attending inspection while the worker was working or check the tightening torque. Moreover, as described in 2.8.5, the loosening of B nuts was found for multiple engines of the same model of the engine involved in this serious incident that were overhauled at the same factory. Accordingly, while it is somewhat likely that there was variation in the tightening force of each B nut at the time of the previous overhaul, the JTSB couldn't determine the cause of the loosening of the B nut of injector No. 14. Note that as described in 2.8.4, the inspector conducted a visual and hand tight inspection of B nuts after the tightening by the workers, but did not check the tightening torque. Therefore, it is highly probable that in practical, the tightening force of B nuts depended on the workers overhaul shop.

In addition, as described in 2.8.3, the EM procedures stipulate that after the manifold is first attached to the engine using the clamp and the bracket, the injector and manifold should be tightened with the B nut. Accordingly, it is somewhat likely that the manifold was pulled by the tightened length of the B nut, which caused tensile stress on the B nut, and that this was involved with the gradual loosening caused by factors such as vibrations of the engine during operations.

As described in 2.3.2, because the liquid burn marks did not reach to the lower cowling, it is somewhat likely that the quantity of leaked fuel was small. In addition, the JTSB couldn't determine the time at which the fuel began to leak.

3.4.3 Ignition of the Leaked Fuel

It is highly probable that even if fuel leaked out during the flight of the Aircraft, the flow of cooling and ventilation air possibly prevented its ignition. As described in 2.1.1, when the Aircraft was on the ground, the thrust reversers were used for approximately 19 seconds from 12:14:40, immediately after landing. It is highly probable that this caused both the engine RPM and internal temperature to increase and that the reduction in aircraft speed caused a reduction in the quantity of cooling and ventilation air.

It is highly probable that the factors mentioned above caused the engine surface temperature to increase and the leaked fuel to auto-ignite after the Aircraft landed.

3.5 Operations of the Fire Detection System

As described in 2.9.1, while the fire detection system can detect a fire as a result of the element temperature increasing and the resistance decreasing to below a fixed value. When an engine fire warning message is displayed, the flight crew members must immediately shut down the engine regardless of whether it is during the flight.

As described in 2.9.1, the Aircraft is equipped with two loops of element, and if only one loop detects a fire, a fire fail caution message will be displayed. In this case, a flight crew member shall confirm the effectiveness of the fire detection system in accordance with the checklist in Figure 6. As described in 2.1.1, after a caution message was displayed for a right fire detection system failure at 12:15:29, a warning message was displayed for a right engine fire at 12:16:02; accordingly, 33 seconds passed from the caution message display to the warning message display. As described in 2.9.1, it is highly probable that this was due to detection by only one of the two element loops and subsequent detection by both because the occurrence of fire was small scale. Although a flight crew member can determine whether the fire detection system effectively functions or not by going through the fire fail checklist, it is highly probable that it was not possible to go through this checklist due to the fact that the engine fire warning message was displayed before accomplishing the checklist as described in the statements in 2.1.2(2). In addition, while the copilot stated that he had understood the conditions for the display of the caution message as described in 2.9.1, it is somewhat likely that he did not have a sufficient understanding of the fire detection system because he exchanged views with the captain on holding the discharge of fire extinguishing agent even after the warning message was displayed following the caution message.

As described in 2.8.6, it is highly probable that the fire detection system functioned correctly. Meanwhile, as described in 2.1.2, the flight crew members stated that while a right engine fire warning message was displayed, there was no fire bell sound. As described in 2.1.1 and 2.8.6, however, both the DFDR and the CVR recorded that it was activated. In addition, because the fire bell sound and the master warning were stopped in approximately three seconds in both records, it is highly probable that at this point either the left or right master warning switch light was pressed.

Generally, pilots are instructed at engine fire training that because of the necessity to eliminate noise in the cockpit in order to maintain communication and keep a calm environment, they should first press the master warning switch light to stop the fire bell sound after confirming the situation and prepare for the display of a new warning message. Because the Company conducts this training and because the flight crew members for the Aircraft had received this training several times, it is somewhat likely that after making a call for an engine fire in this serious incident, the master warning switch was immediately pressed as in training. Accordingly, it is somewhat likely that the reason why the flight crew members did not remember but believed that there had been no fire bell sound was because it stopped after a short period of time and because the captain and the copilot were under the impression that it was a false alarm due to system failure.

3.6 Response of the Flight Crew Members

As described in 2.1.1, it is highly probable that it took 2 minutes and 13 seconds from the display of the right engine fire warning message to the discharge of fire-extinguishing agent, and that fire-extinguishing agent was discharged after the Aircraft entered the parking spot.

When a fire warning message is displayed, even if there is the possibility of it being a false alarm, safety must be prioritized and the measures stipulated in the AOM as described in 2.9.2 must be immediately implemented. However, in this serious incident, it took more than 2 minutes from the warning display to the discharge of fire-extinguishing agent. It is somewhat likely that the following factors were involved in the reasons why the measures stipulated in the AOM were not immediately conducted after the warning display.

- The flight crew members did not have a sufficient understanding of the fire detection system functions.
- Because a fire fail caution message was initially displayed, this created the perception among the flight crew members that this detection system had failed.
- Because 33 seconds passed between the fire fail caution message and fire warning message, the perception became established among the flight crew members that it was a false alarm due to the failure.
- Because the fire call and warning suspension operations in response to the warning message and warning sound had been conducted reflexively, the warning sound was not remembered by the flight crew members.
- For this reason, even after the warning message was displayed, the flight crew members continued to suspect that it was a false alarm.

It is probable that the flight crew members delayed the decision to discharge fire-extinguishing agent due to concerns of unnecessary discharge of fire-extinguishing agent in response to a false alarm while thinking the possibility of a false alarm.

It is somewhat likely that an engine fire training method that is generally conducted by other operators and is also conducted by the Company contributed to the reflexive response to the fire warning.

Moreover, as described in 2.1.1, the flight crew members made statements that suggested they wavered in their judgment, such as asking about recall items while reading out the checklist that constitutes the emergency response that should be promptly conducted. It is probable that the low risk awareness of the flight crew members underlay this behavior.

4 CONCLUSIONS

4. 1 Probable Causes

It is highly probable that the cause of this serious incident was that because the B nut connecting the right engine manifold and injector No. 14 was loose, fuel leaked from this area and was ignited by the heat of the engine, which caused fire within the engine fire zone.

Although it is somewhat likely that the reason why the B nut was loose was the insufficient tightening force of the B nut, resulting in gradually loosening caused by factors such as engine vibration, the JTSB couldn't determine the cause of the loosening.

4. 2 Other Safety Related Findings

During this serious incident, it is certain that it took time for the flight crew members to respond to the emergency of the engine fire warning message, and that they moved the Aircraft into the parking spot as is without facing it into the wind and stopping it while the engine fire warning message was being displayed.

It is probable that it took time to respond to the engine fire warning message because the flight crew members suspected that it was a false alarm. Continuing to hold doubts towards warning messages that constitute an emergency could lead to a crisis. It is probable that the flight crew members should have prioritized promptly taking measures in response to the engine fire warning message with a sense of risk in accordance with the regulations.

5. SAFETY ACTIONS

5.1 Safety Actions Taken

5.1.1 Safety Actions Taken by the Company

(1) Safety Actions for Aircraft Maintenance

The Company established work cards on June 12, 2013, indicates slip marks on the B nuts for the same engine model of all aircrafts the Company is operating, and regularly confirms conformity with these marks.

(2) Safety Actions for Flight Operation

After this serious incident, the Company has distributed to all flight crew members documents dated May 13, 2013 which describe the importance of implementing operations that constantly take into consideration the worst-case scenario and the faithful implementation of basic operations. Meetings were held from May to July 2013 with all flight crew members for the purpose of providing education and ensuring a thorough understanding of these documents. Moreover, reviews have been conducted of fire protection system in classroom training for all flight crew members based on materials established on April 1, 2014.

On May 14, 2013, education for safety awareness and risk management improvement was provided to the captain and the copilot involved with this serious incident, and their knowledge of the fire detection system was reconfirmed.

5.1.2 Safety Actions Taken by the Factory

The Factory revised the education materials for maintaining worker skills on March 17, 2014, and through the recurrent education, it has made all workers aware once more of the importance of the triple torque procedure in order to prevent loosening. The Factory also revised the build record on November 13, 2013 to add a column for entering the torque value set and torque wrench number used when tightening B nuts.

5.1.3 Safety Actions Taken by the Engine Manufacturer

The engine manufacturer revised the EM for the same engine model in order to add the following items.

(1) Use the triple torque procedure to tighten the B nuts.

(2) Add a note to confirm that each one of the B nuts matches the specified position by hand tightening without interference before tightening to the specified torque.

(3) Add a note to stipulate the use of another wrench to hold fittings when tightening the B nuts with a torque wrench.

5. 2. Safety Actions Required

Although it was not possible to determine the cause of the B nut loosening, it is somewhat likely that it was due to insufficient tightening force at the previous overhaul by the Factory, and it is highly probable that in practice, the tightening force of B nuts depended on the worker in the Factory. For this reason, based on the results of these investigations, it is necessary to review the system to ensure that important safety work is faithfully carried out when conducting engine overhauls, including B nut tightening.

In addition, considerable time was taken between the display of the right engine fire warning message and extinguishing the fire. It is somewhat likely that this was attributed to the fact that the flight crew members did not have a sufficient understanding of the fire detection system functions, which was partially due to the training system by the Company. It is probable that the low risk awareness of the flight crew members underlay this behavior. For this reason, the Company needs to enhance education and training programs and revise the contents of training in accordance with the results of this investigation.

6. RECOMMENDATIONS

6. 1. Recommendations

6.1.1 Recommendations to IHI Corporation

It is highly probable that the cause of this serious incident was because the B nut connecting the right engine manifold and injector No. 14 was loose, and because fuel leaked from this area and was ignited by the heat of the engine, which caused fire. Although it is somewhat likely that the reason why the B nut was loose was the insufficient tightening force of the B nut, resulting in gradually loosening by factors such as engine vibration, the JTSB couldn't determine the cause of the loosening. Note that among the 26 engines of the same model that were inspected in a blanket inspection after the occurrence of this serious incident, three engines were found to have looseness outside the specified value, and all of them were overhauled by IHI.

In view of the results of this serious incident investigation, the Japan Transport Safety Board recommends IHI Corporation pursuant to the provision of paragraph (1) of Article 27 of the Act for Establishment of the Japan Transport Safety Board.

When conducting engine overhauls, reconfirm that the system ensures that important work for safety is surely carried out, including the tightening of the connecting B nuts connecting the injector and the manifold.

6.1.2 Recommendations to J-AIR Corporation

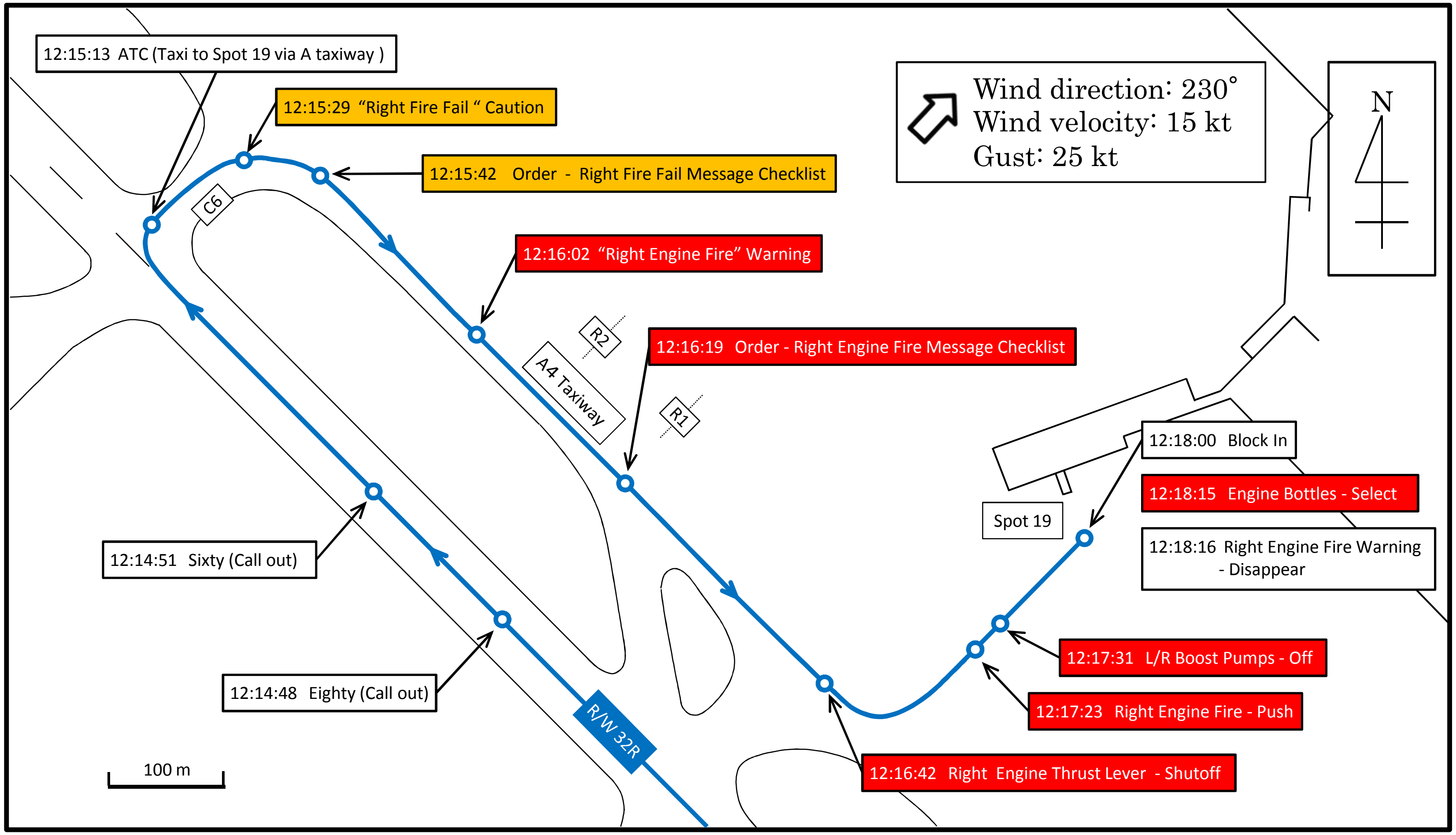
During this serious incident, it is certain that it took time for the captain and the copilot to respond to the emergency of the engine fire warning message, and that they moved the Aircraft into the parking spot as is without facing it into the wind or stopping it while the engine fire warning message was being displayed.

Although it is probable that it took time to respond to the engine fire warning message because the captain and copilot suspected that it was a false alarm, it is probable that the captain and copilot should have prioritized promptly taking measures in response to the engine fire warning message with an awareness of risk management in accordance with the regulations.

In view of the results of this serious incident investigation, the Japan Transport Safety Board recommends J-Air Corporation pursuant to Article 27 of the Act for Establishment of the Japan Transport Safety Board.

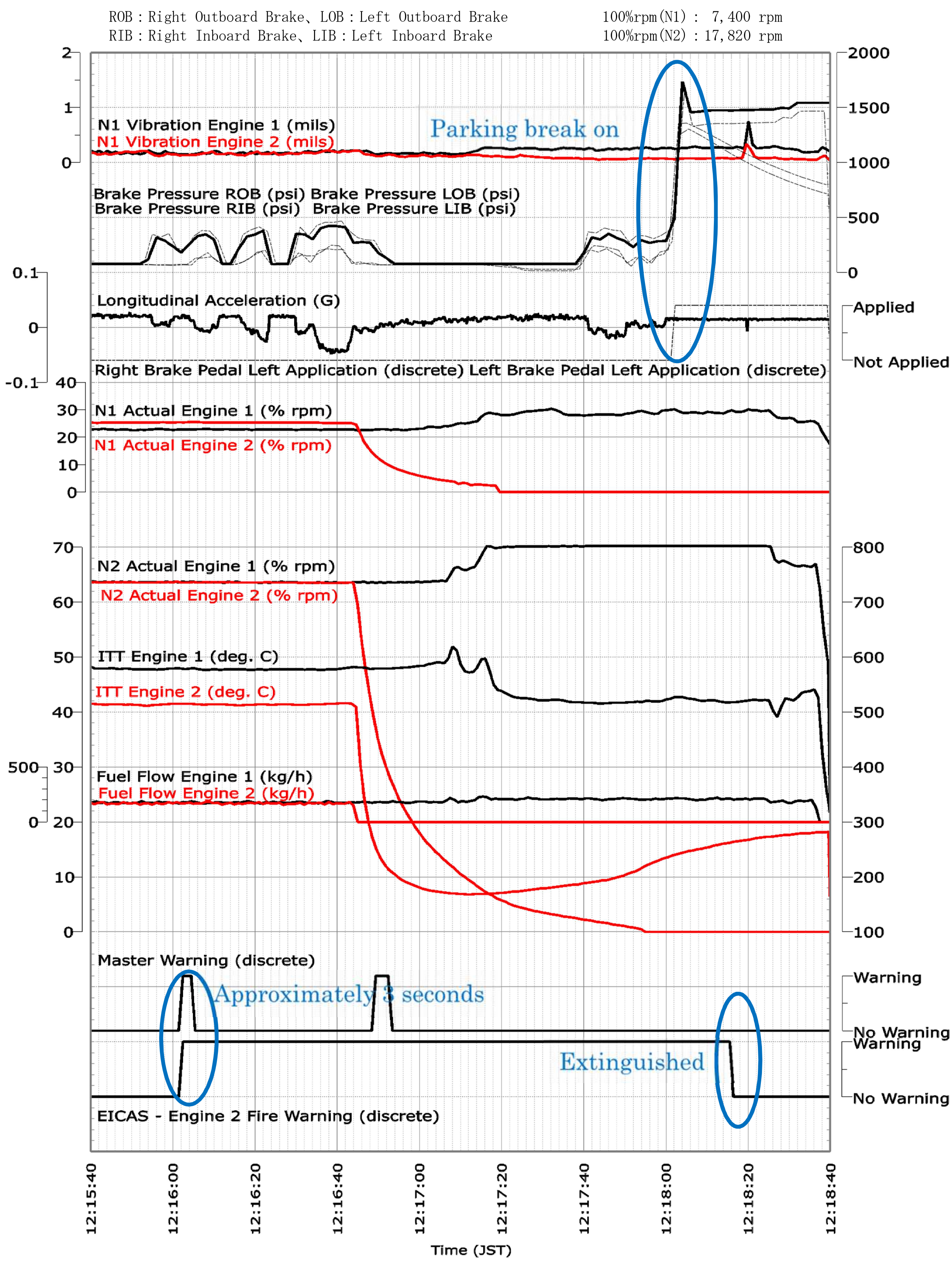
Enhance education and training involving important system functions for safety and reconsider the contents of training in response to an outbreak of fires.

Figure 1: Estimated Taxi Route Based on DFDR, CVR, and ASDE



*The north magnetic bearing for Osaka International Airport is 7° 02' east of true north.

Figure 2: DFDR Records



*Excluding "N1" and "N2", for "1" and "2" within figures, "1" indicates left and "2" indicates right

Figure 3: Three Angle View of Bombardier CL-600-2B19

Unit: m

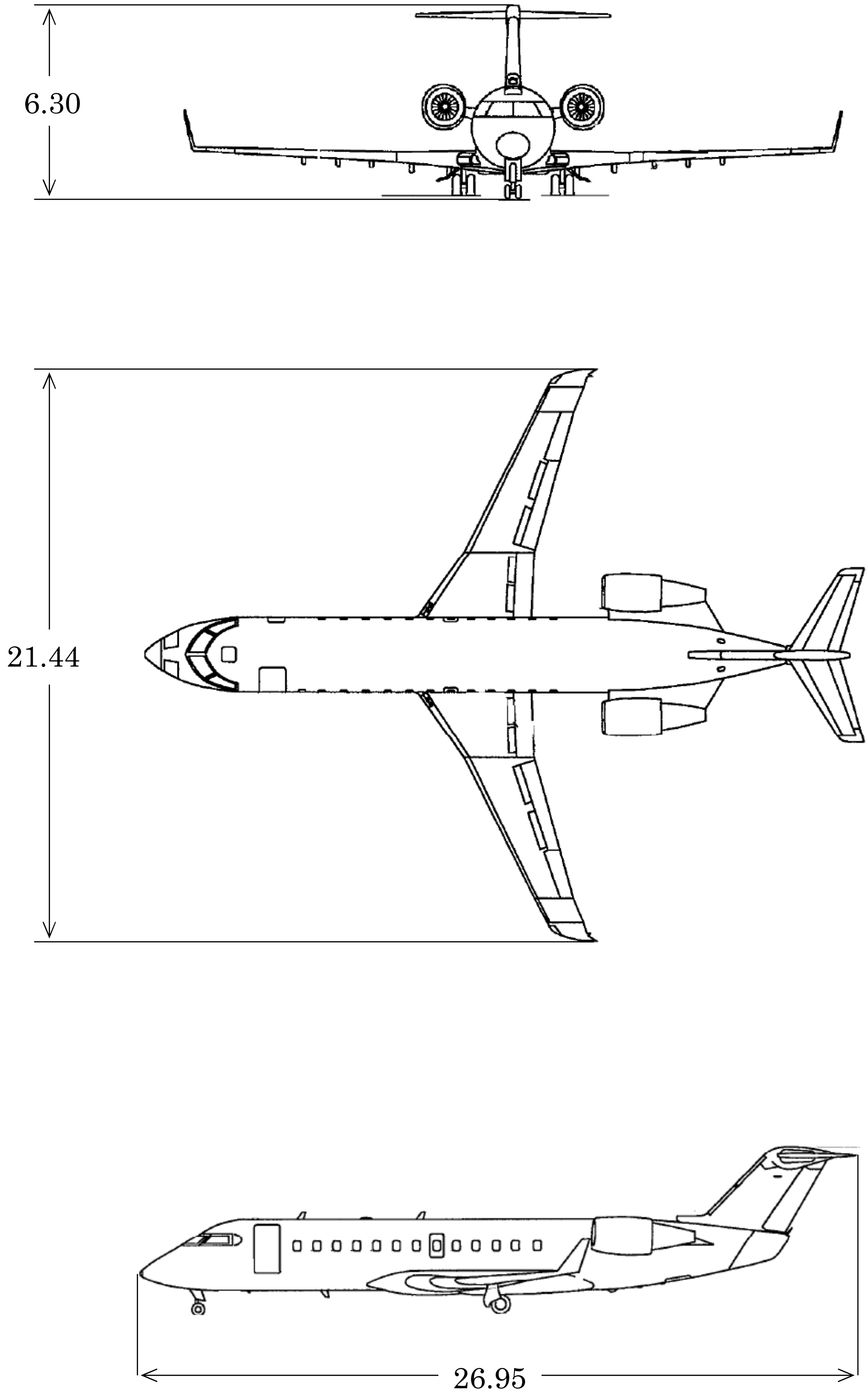
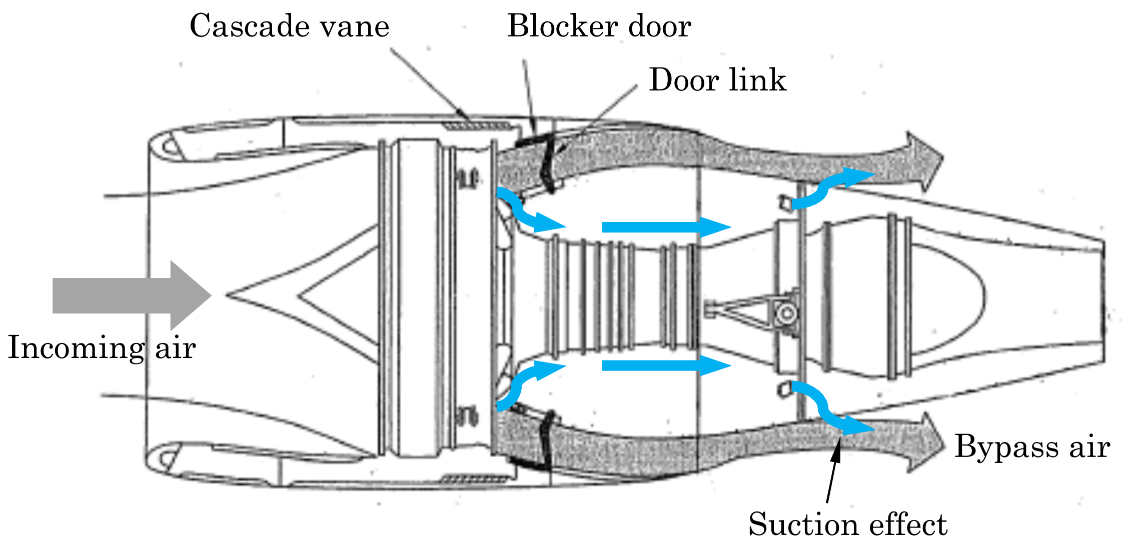


Figure 4: Cooling and Ventilation air Flow

Normal state



: Cooling and ventilation air

State at the time of using the thrust reverser

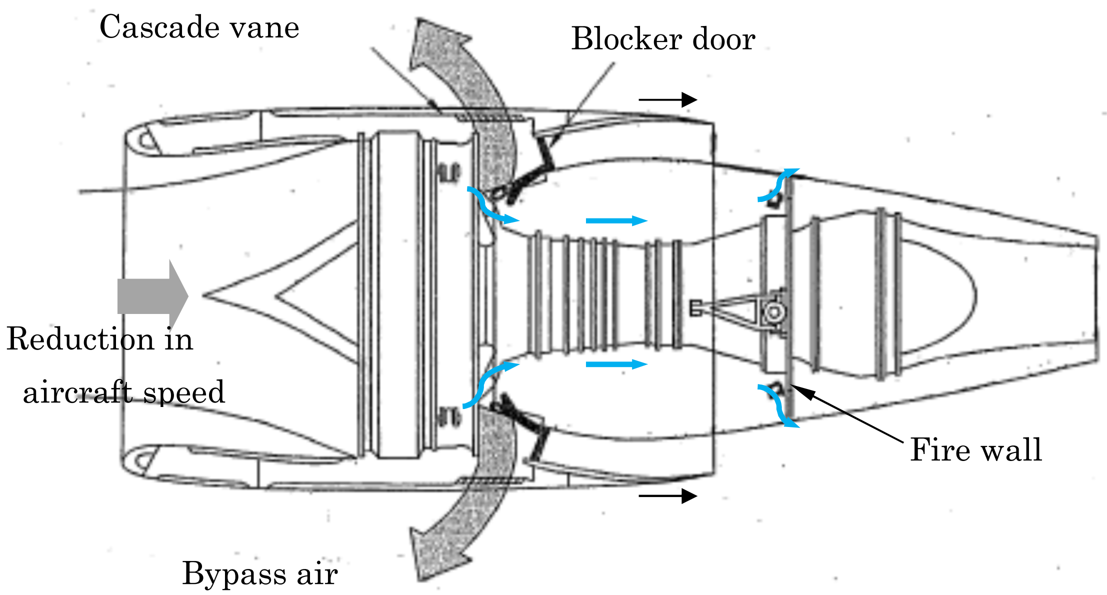


Figure 5: Manifold

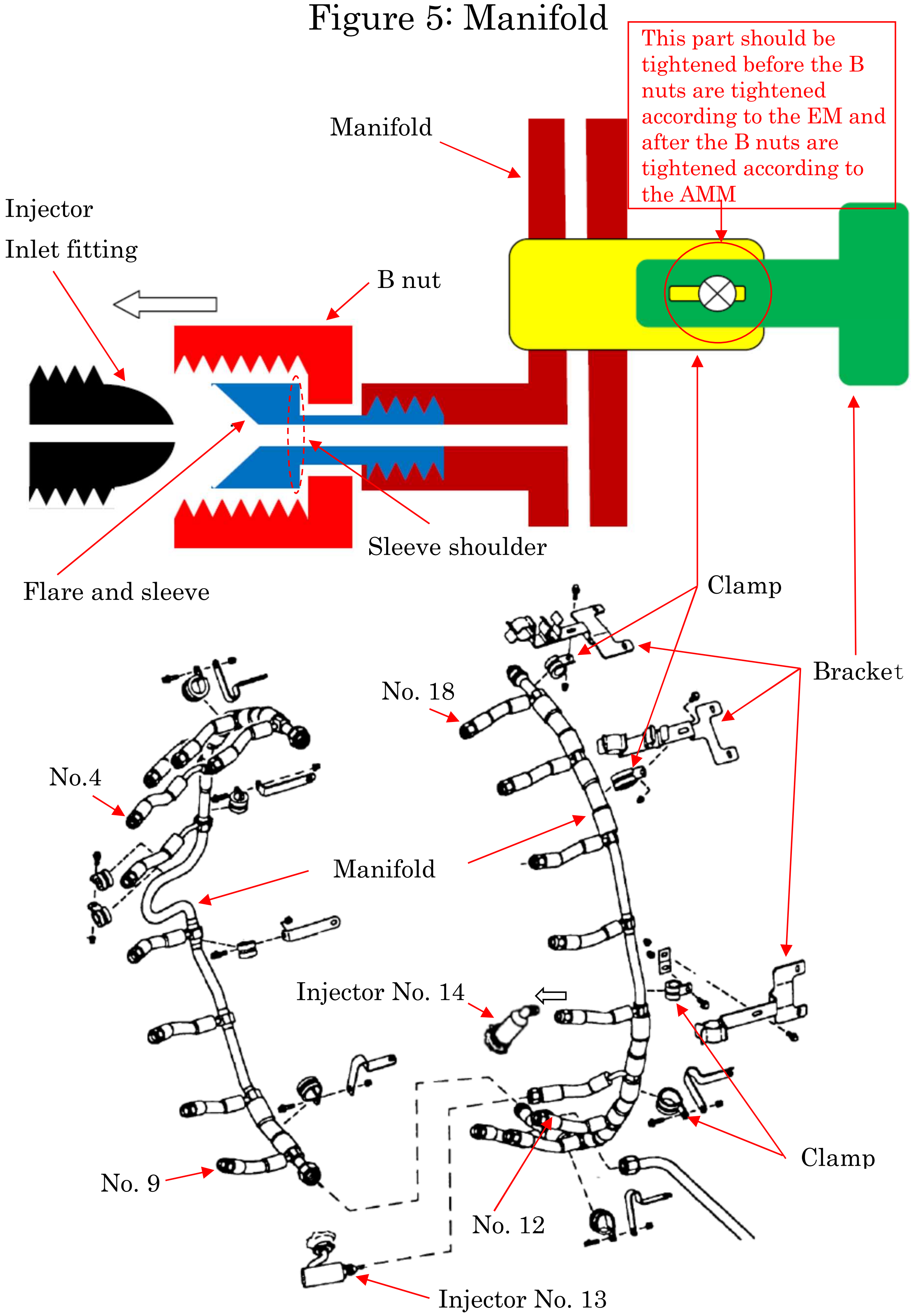


Figure 6: Fire Fail Checklist

L (R) FIRE FAIL Msg

(1) FIRE DETECTION TEST . . . . WARN

L or R ENG FIRE warning message comes on:

Yes

(2) No further action required.

NOTE

Engine fire protection is still available.

– END –

No

(3) Affected engine . . . . MONITOR

NOTE

Affected engine fire protection is not available.

– – – – – – – – – – – END – – – – – – – – – – –

Figure 7: Engine Fire Checklist (On ground)

L (R) ENG FIRE Msg or Severe Engine Damage
(On Ground)

NOTE

Attempt to face the airplane into the wind.

(1) PARKING BRAKE . . . . ON

Affected engine:

(2) Thrust lever. . . . . SHUT OFF

(3) ENG FIRE PUSH . . . . SELECT

(4) L and R FUEL BOOST PUMPs . . . . OFF

After 10 seconds and fire warning persists:

(5) Both engine BOTTLEs . . . . SELECT

(6) Passenger Evacuation
procedure . . . . AS REQUIRED
(Refer to EMER 8)

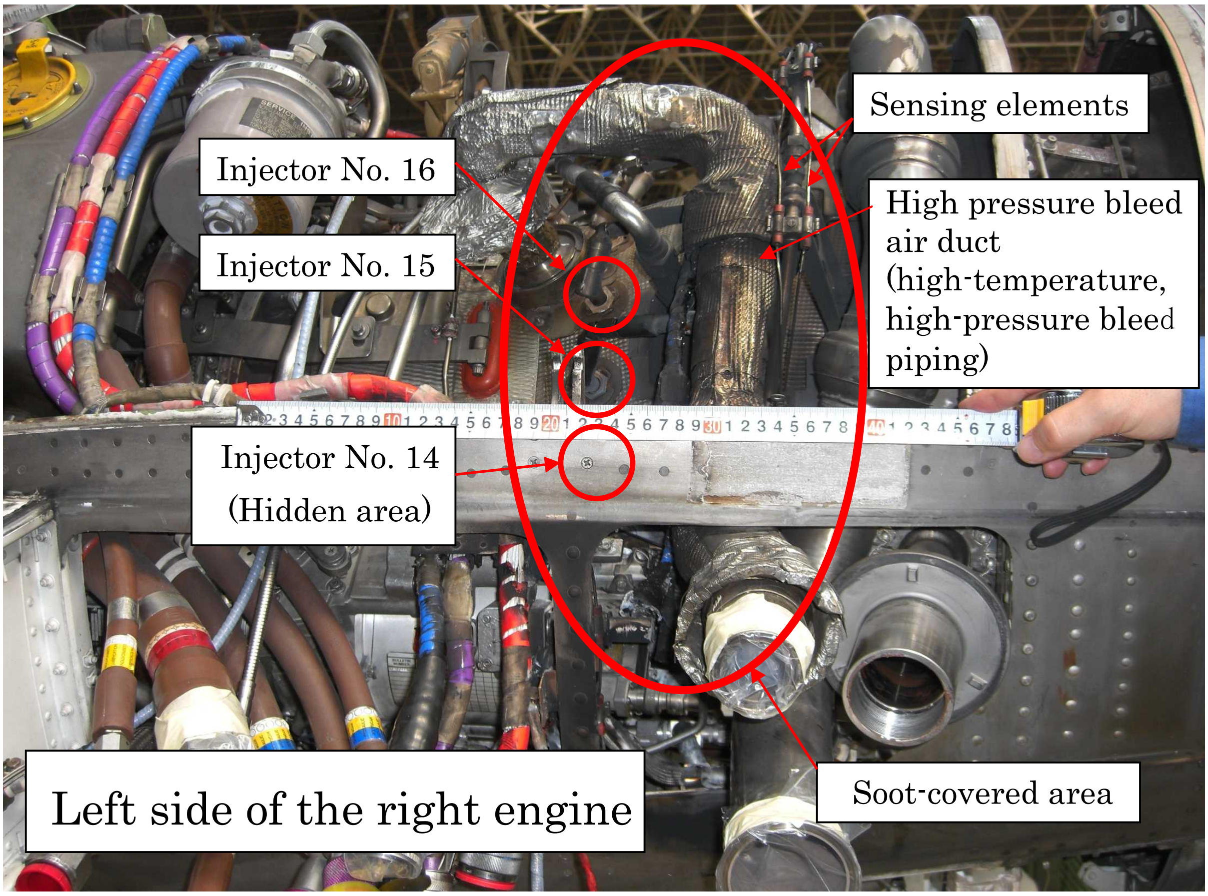
– – – – – – – – – – – END – – – – – – – – – – –

Photo 1: Aircraft Involved in the Serious Incident

Overall view

Exterior view of the right engine

Photo 2: Evidence of the Fire 1



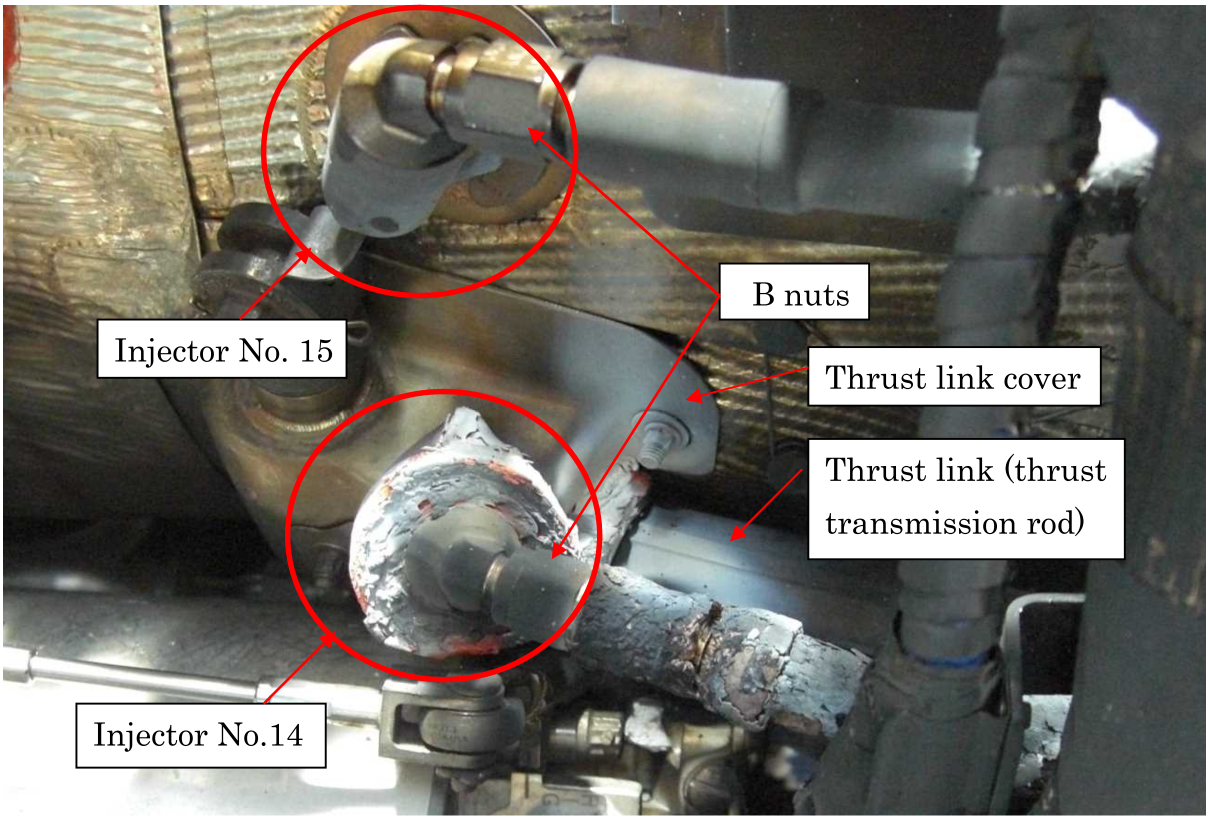
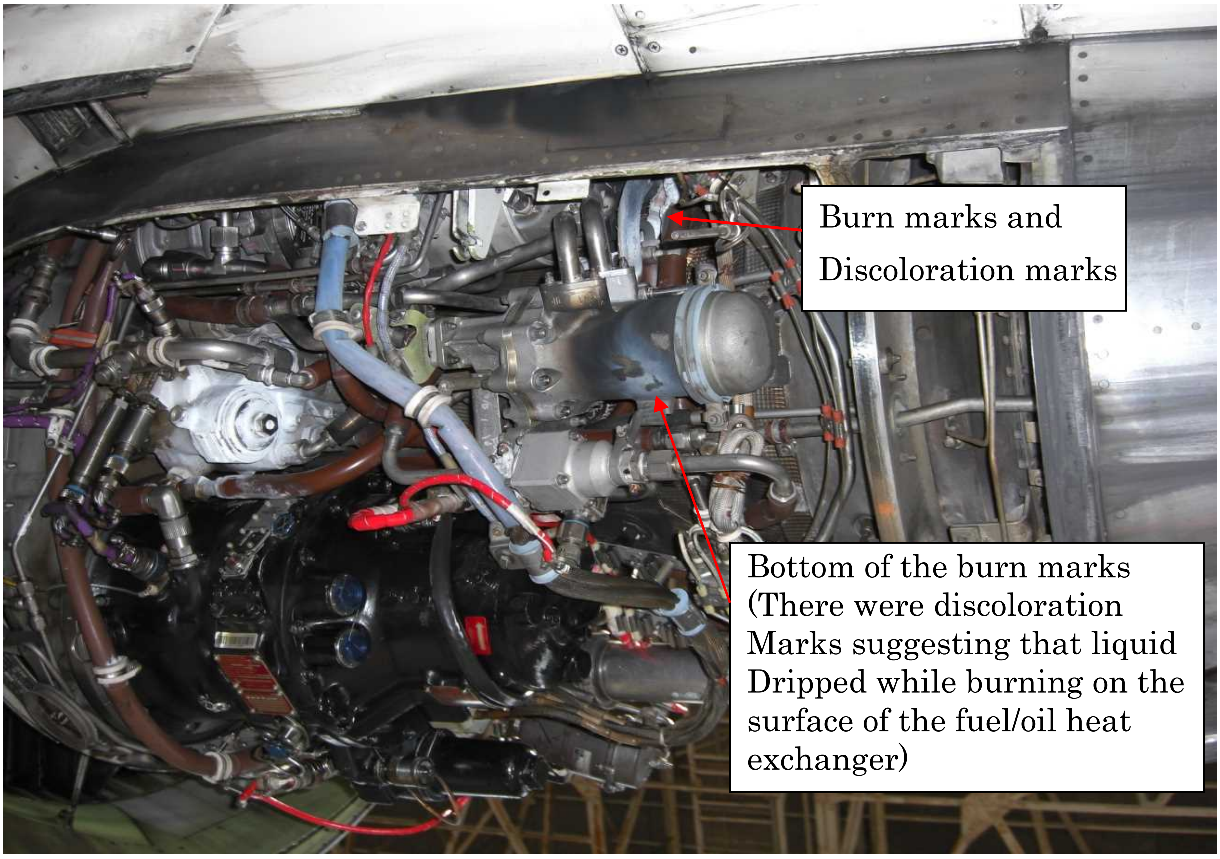


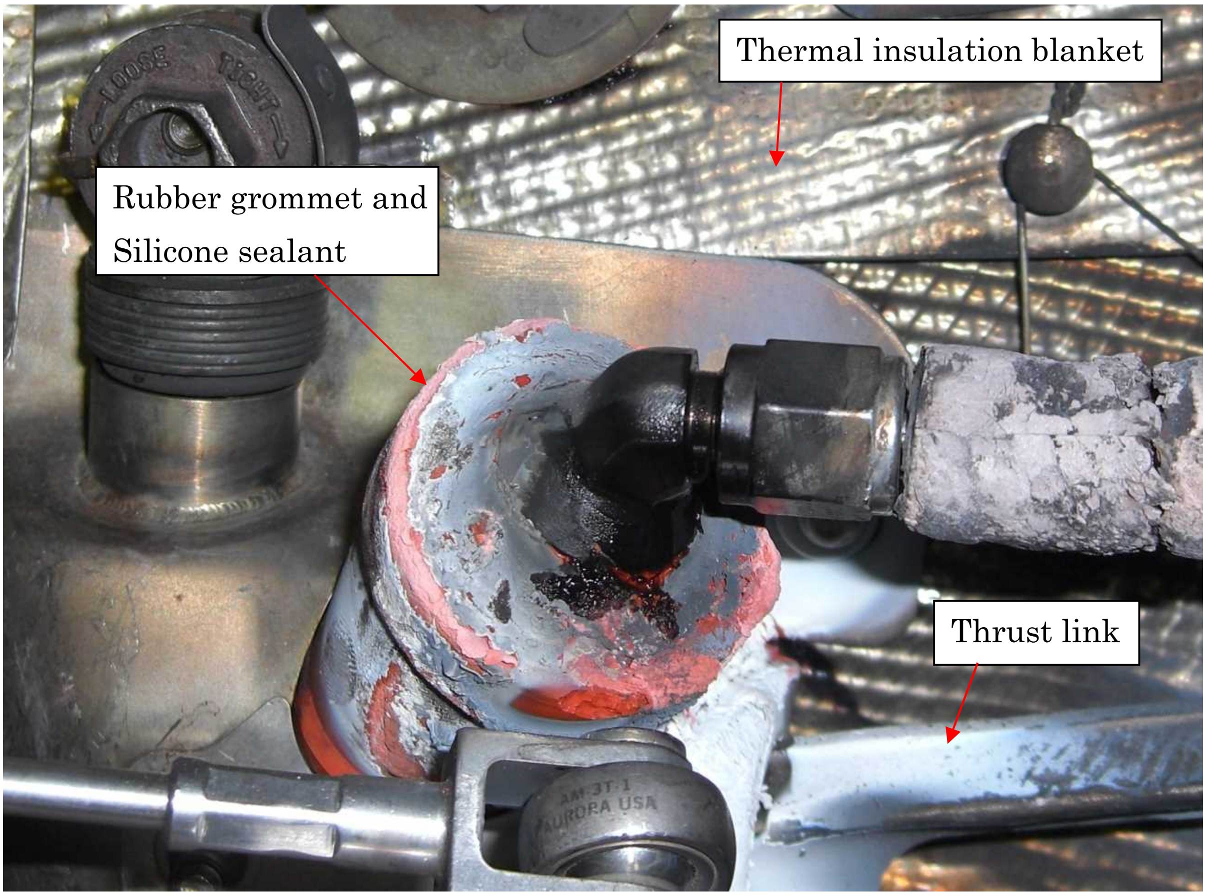
Photo 3: Evidence of the Fire 2



There was soot on the upper cowling directly above where the the fire occurred.

There were no burn marks on the lower cowling

Photo 4: Confirmation of Fuel Leaks



The wet motoring in the test cell revealed that fuel had leaked from the B nut connecting the injector No. 14 and the manifold. In addition, it was confirmed that the B nut was loose.

Because the starter is used for wet motoring, the RPM was approximately 30 % (approximately half of idle RPM), the time was approximately 30 seconds, and the fuel pressure was approximately 30 psi.

Photo 5: Thermal Insulation Blanket Slots