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AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

VIETNAM AIRLINES

V N – A 1 4 6

April 23, 2010

Japan Transport Safety Board

The investigation for this report was conducted by the Japan Transport Safety Board, JTSB, about the aircraft serious incident of Vietnam Airlines, Boeing 777-200 registration VN-A146 in accordance with the Act for the Establishment of the Japan Transport Safety Board and Annex 13 to the Convention on the International Civil Aviation for the purpose of determining causes of the aircraft serious incident and contributing to the prevention of accidents/incidents and not for the purpose of blaming responsibility of the serious incident.

This English version of this report has been published and translated by the JTSB to make its reading easier for English speaking people who are not familiar with Japanese. Although efforts are made to translate as accurately as possible, only the Japanese version is authentic. If there is any difference in the meaning of the texts between the Japanese and English versions, the text in the Japanese version prevails.

Norihiro Goto
Chairman,
Japan Transport Safety Board

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

**VIETNAM AIRLINES
BOEING 777-200, VN-A146 (VIET NAM)
ON B TAXIWAY AT NARITA INTERNATIONAL AIRPORT
AT ABOUT 07:44 JST, JULY 30, 2008**

April 9, 2010

Adopted by the Japan Transport Safety Board (Aircraft Sub-committee)

Chairman	Norihiro Goto
Member	Shinsuke Endo
Member	Toshiyuki Ishikawa
Member	Noboru Toyooka
Member	Yuki Shuto
Member	Toshiaki Shinagawa

1. PROCESS AND PROGRESS OF THE AIRCRAFT SERIOUS INCIDENT INVESTIGATION

1.1 Summary of the Serious Incident

The occurrence covered by this report falls under the category of “Flames in the designated fire zone of an engine” as prescribed in Clause 10, Article 166-4 of the Civil Aeronautics Regulations of Japan, and is classified as a serious incident.

On July 30 (Wednesday), 2008, at 07:41 Japan Standard Time (JST: UTC+9hr, unless otherwise stated all times are indicated in JST), a Boeing 777-200, registered VN-A146, operated by Vietnam Airlines as scheduled Flight HVN950, landed at Narita International Airport. At about 07:44, while taxiing, the right engine fire warning alarm went off. The crew shut down the engine and then triggered the fire-extinguishing system, following which the fire warning alarm stopped.

Subsequently, after the aircraft arrived at the ramp and all passengers and crewmembers had disembarked, the right engine caught fire; the fire was extinguished by the firefighting squad that had been waiting there ready for operation.

There were 277 people on board, consisting of the Pilot in Command, the First Officer, 11 other crewmembers and 264 passengers. There were no injuries. The aircraft sustained minor damage.

1.2 Outline of the Serious Incident Investigation

1.2.1 Investigation Organization

On July 30, 2008, the Aircraft and Railway Accidents Investigation Commission (ARAIC) designated an investigator-in-charge and two other investigators to investigate this serious incident.

1.2.2 Representatives from Foreign Authorities

An accredited representative of the Socialist Republic of Viet Nam, as the State of Registry and the Operator of the aircraft involved in this serious incident, and an accredited representative of the United States of America, as the State of Design and Manufacture of the aircraft involved in this serious incident, participated in the investigation.

1.2.3 Implementation of the Investigation

July 30, 2008 – August 7, 2008	Airframe examination and interviews
July 31, 2008 – October 27, 2008	Analysis of data recorded by digital flight data recorder and cockpit voice recorder
September 8, 2008 – March 5, 2009	Inspection of right engine components and other things at the plants of the manufacturer of the aircraft and the like in the United States of America in the presence of the representatives from the National Transportation Safety Board (NTSB).

1.2.4 Provision of Factual Information to the Civil Aviation Bureau

On February 4, 2009, the following information obtained from the fact-finding investigation was provided to the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism.

“The engine examination found that the O-ring on a hose connection in the engine fuel line junction box was broken.”

1.2.5 Interim Report

On August 28, 2009, the Japan Transport Safety Board (JTSB) submitted an interim report to the Minister of Land, Infrastructure, Transport and Tourism based on the facts found up to that date, and the report was made available to the public.

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

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

1.2.7 Comments from the Participating States

Comments were invited from the participating States.

2. FACTUAL INFORMATION

2.1 History of the Flight

On July 30, 2008, a Boeing 777-200, registered VN-A146 (hereinafter referred to as “the Aircraft”), operated by Vietnam Airlines (hereinafter referred to as “the Company”) as scheduled Flight HVN950, flew from Ho Chi Minh Airport to Narita International Airport.

At the time of the occurrence of the serious incident, the Pilot in Command (hereinafter referred to as “the PIC”) sat in the left seat in the cockpit as the PF (pilot flying: pilot mainly in charge of flying) and the First Officer sat in the right seat as the PM (pilot monitoring: pilot mainly in charge of duties other than flying).

The flight plan for the Aircraft is outlined below:

Flight rules: Instrument flight rules (IFR), Departure aerodrome: Ho Chi Minh Airport, Estimated off-block time: 02:05, Cruising speed: 490 kt, Cruising altitude: FL370, Route: ANL1C – (skipped) – VENUS (position reporting point), Destination aerodrome: Narita International Airport, Total estimated elapsed time: 5 h 40 min, Fuel load expressed in endurance: 6 h 58 min, Persons on board: 277

The flight history of the Aircraft from the time when it took off from Ho Chi Minh Airport up to the time when the serious incident occurred after it landed at Narita International Airport is as outlined below according to the records of the digital flight data recorder (hereinafter referred to as “the DFDR”), the records of the cockpit voice recorder (hereinafter referred to as “the CVR”), the

records of the AIMS ^{*1}, the ATC communications records, the Ramp Control records, and the statements from the Aircraft's crewmembers and the maintenance engineering staff members. Parts of the statements of the PIC and the First Officer were made in Vietnamese in the CVR records, and were then translated into English by the Civil Aviation Administration of Vietnam. (These statements are underlined in the following section.)

2.1.1 History of the Flight Based on the Records of the DFDR, CVR and AIMS and the ATC Communications Records

02:11:42	The Aircraft took off from Ho Chi Minh Airport.
03:58	The first "FIRE LOOP 2 ENG R" ^{*2} and "OVERHEAT CIRCUIT R2" ^{*3} messages were recorded by the AIMS.
07:41:00	The Aircraft landed at Narita International Airport.
07:43:56	An "R ENG OVHT CAUT" message was displayed.
07:43:58	The PIC: " <u>What is it?</u> "
07:43:59	The First Officer: " <u>Overheat Engine Right.</u> "
07:44:04	The PIC: " <u>OK. Slow.</u> "
07:44:08	The PIC: " <u>Let's do check list.</u> "
07:44:29	The PIC: " <u>The problems complicated.</u> "
07:44:35	The PIC: " <u>Let's idle immediately.</u> " An "R ENG FIRE WARN" message was displayed.
07:44:38	The PIC: " <u>Let's extinguish, extinguish, extinguish.</u> "
07:44:40	A "FUEL SPAR VALVE R CLOSE" message was displayed.
07:44:41	An "R ENG FIRE BOTTLE 2 DISCHARGE" message was displayed.
07:44:42	The PIC: " <u>Turn OK.</u> "
07:44:45	The PIC: " <u>Turn OK. Declare emergency.</u> "
	The Aircraft: "HVN950 ah MAYDAY MAYDAY, we have a problem with the right engine."
07:44:55	The Tower: "HVN950 taxi to B Hold line."
07:45:04	The PIC: " <u>To inform to them that the fire right engine.</u> "
07:45:10	The First Officer: " <u>(To the chief purser) Do not you find fire, yes?</u> "
	The Aircraft: "HVN950 we got fire on the right engine."
07:45:15	The Tower: "Confirm ah fire from right engine?"
07:45:20	The Aircraft: "Affirm, HVN950."
07:45:22	The Tower: "Roger."
07:45:23	The First Officer: " <u>Completed extinguishing.</u> "
07:45:25	The "Hydraulic Oil Quantity System 2" value rose.

^{*1} The AIMS (Airplane Information Management System) is installed on Boeing 777 aircraft to perform various management functions including navigation and performance control and monitoring using computer information processing technologies.

^{*2} "FIRE LOOP 2 ENG R" is a message that indicates a failure detected in Loop 2 of the right engine fire detection circuit.

^{*3} "OVERHEAT CIRCUIT R2" is a message that indicates a failure detected in Circuit 2 of the right engine overheat detection circuit.

The Aircraft: "HVN950, we continue taxi to B Hold Line? Request fire trucks."

07:45:31 The Tower: "Ah Roger."

07:45:39 The Tower: "HVN950, now hold position please."

07:45:43 The Aircraft: "Roger, HVN950."

07:45:49 The First Officer: "Now to inform to them that the fire under control."

07:45:50 The Aircraft: "HVN950, the fire is under control, request continue taxi and request service."

07:45:52 The PIC: "OK. Fire under control."

07:46:01 The Tower: "HVN950 roger, taxi to B Hold Line."

07:46:04 The Aircraft: "We taxi to B Hold line, HVN950."

07:46:31 The Tower: "HVN950 confirm do you need fire trucks?"

07:46:41 The Tower: "HVN950 still you need fire trucks?"

07:46:45 The Aircraft: "HVN950 the fire is under control, and we ... ground service is available."

07:46:55 The Tower: "Ah roger, under control is understand, but say again the last."

07:47:02 The Aircraft: "OK, we don't need the fire trucks now and we continue taxi to B Hold Line."

07:47:08 The Tower: "Roger."

07:47:33 The PIC: "The right engine was shut down."

07:47:38 The PIC: "The engine. Let's stop the engine, all right?"

07:47:39 The First Officer: "All right."

07:47:46 The First Officer: "Checks completed."

07:47:52 The PIC: "No problem. It is normally."

07:47:54 The PIC: "The right engine was fired clearly."

07:48:01 A "FUEL CUTOFF LEVER R CUTOFF" message was displayed.

07:49:05 The First Officer: "ATC cleared to Bravo Hold Line."

07:49:31 The Tower: "HVN950 contact ramp control, 12175."

07:52:32 Parking brake was turned on.

07:52:57 The DFDR recording stopped.

07:57:34 The CVR recording stopped.

2.1.2 Statements of the Aircraft's Crewmembers

(1) The PIC

While flying over the vicinity of Taipei at an altitude of 37,000 ft about three hours after we took off from Ho Chi Minh Airport, two status messages^{*4}, "FIRE LOOP 2 ENG R" and "OVERHEAT CIRCUIT R2," were displayed in white. I then checked the

^{*4} "Status messages" are displayed on the cockpit instrument panel for the purpose of alerting the flight crew to a certain status to be acknowledged and monitored but not requiring the flight crew to take action against the indicated status while flying.

engine parameters and found them normal. For an emergency warning displayed in red, the response procedure to follow is specified in the manual. However, the messages issued then were just status messages, which do not require any special action by the flight crew other than acknowledging the indicated status, so I cleared them immediately after checking.

The subsequent flight was normal, without any warnings issued. After landing on Runway 34R at Narita International Airport, a red “FIRE ENGINE RIGHT” warning came on accompanied by an audible alarm when we entered the taxiway. I did not feel any special vibration on the Aircraft. Up to that point, we had no problems with braking, or with the hydraulic system, while taxiing.

I looked at the engine through the cockpit window. Although I saw no apparent smoke or flames, we immediately followed the “ENGINE FIRE PROCEDURE” by pulling up the right engine fire switch handle (hereinafter referred to as “the Fire Handle”) to cut off the engine and turning the Fire Handle clockwise; all warning messages then went out, confirming that the fire was extinguished. We used just one of the two fire extinguisher bottles. These actions were determined by me and performed by the First Officer.

We then contacted the Tower and requested clearance to continue taxiing.

We shut down the engines after arriving at our spot. About 10 minutes later, a maintenance engineer came to the cockpit, at which time I told him that fire extinguishing agent had been discharged following a fire alarm issued for the right engine. I did not tell the maintenance engineer about the status messages that were displayed while we were airborne.

(2) The First Officer

There was no problem with the Aircraft when we received it at Ho Chi Minh Airport. After takeoff, while flying at 37,000 ft, the “FIRE LOOP 2 ENG R” and “OVERHEAT CIRCUIT R2” status messages were displayed. I told the PIC that these messages were displayed and we agreed to keep the indicated status in mind. As there were no engine fire warnings, etc., I thought, “Something is wrong with the sensor system.”

We made our approach to Narita International Airport, and after successfully landing there, we were instructed by the Tower to taxi up to the North Hold Line. After we entered the parallel taxiway, an “OVERHEAT ENGINE RIGHT” warning was issued first. After I told the PIC about the warning, a “FIRE ENGINE RIGHT” warning was issued. With these messages displayed, we temporarily stopped the Aircraft. The red lamp on the right Fire Handle came on, the “MASTER WARNING” light came on, and the fire alarm sounded. As part of the engine fire procedure, I pulled the Fire Handle. Accordingly, I believe the fire alarm stopped, but since the red lamp on the Fire Handle was still on, I turned the Fire Handle clockwise. The “MASTER WARNING” light then went off and the red lamp on the Fire Handle went off. To me, this meant that the fire was extinguished.

I contacted the Tower and said, “MAYDAY MAYDAY . Fire on the right engine. We request fire trucks.” Subsequently, I contacted the Tower again and said, “The fire is under control. We request clearance to continue taxiing.” The Tower asked, “Do you need fire trucks?” We responded by saying, “No,” as the fire was already extinguished. Since all the Aircraft’s statuses had returned to normal, we continued taxiing to Spot 84.

At about 07:52, after the Aircraft arrived at its spot, we performed the normal procedures to stop all systems including the engines.

(3) The Chief Purser

We did not have any problems during the flight, but when we entered the taxiway after landing, I was called to the cockpit by the PIC, who then gave me instructions, saying, “The right engine caught on fire, but the necessary actions have already been taken, so the Aircraft is now in a problem-free state. However, I cannot predict what might happen later. We could possibly experience emergency conditions, so be prepared.” I returned to the cabin and, over the interphone, briefed the other cabin attendants about the situation and instructed them to be prepared for emergency conditions. Afterwards, I heard that one of the cabin attendants visually checked the right engine but saw neither fire nor smoke. I then went to the cockpit again and reported this to the PIC. A couple of minutes after I returned to the cabin, I received a message from the PIC, saying, “As there is no fire or smoke, we will follow the normal spot-in procedure.” I then conveyed the message to the other cabin attendants.

After the Aircraft arrived at its spot, the PIC came to me and said, “There is no problem, but you should let the passengers disembark as soon as possible.” I then followed his instructions. About 10 or 15 minutes after the Aircraft came to a complete stop, the last passenger had disembarked, while saying, “There is a thin trail of white smoke coming from the right engine.” I then saw thin white smoke exactly as the passenger had described.

There were two or three fire engines present when the last passenger had disembarked, but about 10 minutes later, as I waited in the cabin for the PIC, I saw more and more smoke coming out and more than 10 fire engines had gathered. The passengers had disembarked normally since they had not been informed anything about the situation.

2.1.3 Statements of the Maintenance Engineers

(1) The chief maintenance engineer of the Company’s operations support contractor at Narita International Airport

There was a call to my office from the Company, saying, “The Aircraft has an engine fire and is at a stop on the taxiway.” Just when I was about to radio this information to our maintenance engineer who was waiting at the gate for the Aircraft, he contacted me, saying, “The Aircraft is about to enter the gate.” I then made a request to him, saying,

“Call me when the Aircraft has entered the gate.” Soon afterwards, he called me and said, “Smoke is coming out and fire engines have arrived.” I then hurried to the site. It was around 8 a.m. when I arrived at the site and saw smoke coming from the engine. There were about 10 fire engines at that time. Before doing anything else, I went to the cockpit. The maintenance engineer was then on the ground beneath the Aircraft.

I saw the flight crew in the cockpit; the PIC was sitting in the pilot’s seat making entries in the flight logbook. I learned about the engine fire mainly from the PIC, who said, “The fire is already under control.” I told him that smoke was still visible. At that time, I saw the amber lamp on the right Fire Handle was on, indicating that the fire extinguishing agent in the No. 2 system had been completely discharged.

I then went down to the ground, where I found that smoke was still coming out as before. Since there was only smoke but no flames, the fire engines did not start discharging water and we stayed there for about 15 minutes monitoring the conditions. Firefighters were worried about a bad outcome, and I, too, felt it necessary to take some action, including water discharge as a fairly unavoidable measure.

Subsequently, I talked with the firefighters about how to overcome this situation. One possible solution was a method called “motoring,” whereby smoke is dispelled by rotating the engine without supplying fuel and without causing combustion. This method requires prior arrangements to cut out fuel and prevent catching fire, so I had the maintenance engineer go to the cockpit to make these preparations. During this time, I stayed on the ground and maintained contact with him through a headset.

It was, I think, between 08:30 and 08:40 that some fluid leaked out from the cowl and spilled right beneath the right engine following a maintenance engineer’s operation of turning the Fire Handle back to the center position and then pushing it in, without which motoring is impossible. I then gave the maintenance engineer instructions, saying, “Turn back the Fire Handle right now.” So I believe he would have done this immediately. Then, while I was instructing him to discharge fire extinguishing agent from the No. 1 system if a “FIRE” message appeared on the display, a display of the message actually occurred and he then discharged the No. 1 system agent. I heard that someone towards the aft saw flames on the engine, although I did not see this myself. I immediately had the fire extinguished by the firefighters using fire foam.

(2) The maintenance engineer

I did not see the Aircraft at the time that it landed, and I did not receive any information about the Aircraft’s fire during taxiing either. When the Aircraft was entering the gate, I saw fire engines behind the Aircraft, which set me to wondering, “What’s happening?” I looked at the Aircraft and noticed that the right engine was not rotating. I think the Aircraft at that time was still taxiing slowly but I did not see any smoke. When I gave instructions to chock the wheels after the Aircraft had come to a stop, I saw smoke coming from the right engine that rapidly grew into a cloud. The cloud of smoke soon stopped growing. The smoke was whitish, not black. It gathered into a

mass at one time while dispersing and becoming invisible at another time depending on the wind conditions. The smoke was coming from the engine in a manner that was different from what I have ever seen, that is, it was coming out even through the gaps in the cowl, so I felt that this was “something wrong.”

After the Aircraft was parked, I contacted the cockpit through the headset and said, “Smoke is coming from the right engine. No fire is visible. Have the passengers disembark as soon as possible.” The PIC responded, saying, “After landing, an engine fire warning was issued while taxiing, so we discharged fire extinguishing agent. The fire warning has not repeated since then.”

Our chief maintenance engineer then arrived. The passengers had already disembarked; the chief engineer went to the cockpit to learn about the situation, and then came back. Smoke continued to come out for a fairly long time, probably about 30 to 40 minutes. A person from the Narita International Airport Corporation (hereinafter referred to as “the NAA”) or the firefighting squad, who had something like a special heat detector, told me that it was likely that the engine had caught fire, so I relayed this information to the chief engineer when he returned from the cockpit. Considering that the safety was already assured with all passengers having disembarked, the chief maintenance engineer and I stayed there for a while, watching the conditions.

Around the time when the communication with the cockpit crewmember was finished, a firefighter came to me and asked, “Shall we do a chemical discharge?” I responded by saying, “Fire is not visible as yet and it was a little while ago that fire was extinguished using the engine fire extinguishing agent, so we’d like to watch the conditions a bit longer. However, if you see fire, extinguish it immediately without waiting for my instructions.”

A person, possibly from the NAA or the firefighting squad, asked me to perform motoring, which is necessary for spraying water. According to this person, spraying water into an engine is a common practice to forcibly cool it down. We had no knowledge or experience related to water spraying and we were not certain about whether doing this was acceptable or not; I assumed it to be something similar to water rinsing. The person showed me the specific amount of water to be sprayed in liters. When I asked the chief maintenance engineer, “What’s your decision?” he said, “Let’s do it as suggested.”

I then went to the cockpit. After confirming with the chief maintenance engineer by asking, “May I pressurize the hydraulics?” I believe I put both No. 1 and No. 2 systems under pressure. As fuel can be dangerous, I checked that the booster pump was turned off. I confirmed that the brake pressure was above 3,000 psi. The amber warning light above the brake pressure indicator, the BRAKE SOURCE light it should be, was not illuminated.

I then told the chief engineer that everything was ready for motoring. The APU had been kept running. The chief maintenance engineer instructed me to start motoring the engine whenever I was ready. I expressed my view to the chief maintenance engineer,

saying, “Air will not be available unless the Fire Handle is moved back.” The chief maintenance engineer responded, “Then let’s move back the Fire Handle.” The right Fire Handle was in its pulled-up position and turned to the right. I began by returning the start switch to its original position and then set the Fire Handle back to the central position. I then pushed the Fire Handle in. Prior to going ahead with my decision to start the motoring, I contacted the chief maintenance engineer over the radio, saying, “I completed moving back the Fire Handle.” The chief maintenance engineer responded to my report, saying, “Looks like something came out. Put the Fire Handle back.” I then pulled out the Fire Handle. In addition, to make sure, I turned it to the right to restore the original position even though I knew that there was no fire extinguishing agent in the right system.

After a while, the fire alarm began sounding. In response to my report to the chief maintenance engineer on the ground, saying, “The fire alarm has started ringing,” the chief maintenance engineer said, “We started spraying water.” Initially, the fire alarm sounded intermittently, each lasting about one minute. After feeling that the situation was becoming increasingly busy down there, I asked, “Shall I discharge the fire extinguishing agent in the No. 1 system?” the chief maintenance engineer said, “If you can, please.” I then discharged the agent.

Subsequently, following the chief maintenance engineer’s instructions, “As the fire appears to be out, come down and open the cowlings,” I went down and saw that the Aircraft was covered with foam all over.

After setting a stand, I opened the two forward cowlings, and found no abnormal conditions.

When I started opening the aft cowlings next, the heat shield fell down in shatters. It was so heavily burned that I was relieved that no one had been injured.

2.1.4 Information on Ramp Control

According to the Operations Management Department, Airport Operations Headquarters of the NAA, the Ramp Control records at around the time of the serious incident are as summarized below. All times are as written in the NAA Ramp Control records.

- 07:41 The Aircraft landed on Runway B.
- 07:46 The runway was closed.
- 07:47 A call from the Tower to Ramp Control, saying, “Smoke is coming from an engine of the Aircraft that landed on Runway B. Please check.”
 - Ramp Control instructed Operations No. 7 (an airside safety management vehicle) to check the Aircraft.
 - The vehicle identified the Aircraft that was between the north and south hold lines with its No. 2 engine releasing a thin, small amount of smoke. (The vehicle entered the apron from the peripheral road and drove following the Aircraft up to the spot.)

- 07:49 At a point short of the B Hold Line, the Tower transferred control of the Aircraft to Ramp Control. Ramp Control cleared the Aircraft to taxi to Spot #84.
- 07:53 The Aircraft arrived at Spot #84.
- 08:00 Runway check found no abnormal conditions.
 - All passengers and crewmembers disembarked.
 - Statement from the maintenance engineer: “The flight crew turned the fire extinguishing switch upon illumination of the engine fire warning indication after landing.”

The serious incident occurred at about 07:44 on Taxiway B near Runway B at Narita International Airport (Latitude 35°47'58"N, Longitude 140° 22'47"E).

(See Figure 1 – Sketch of the Incident Scene, Figure 2 – Three Angle Views of Boeing 777-200, Figure 3 – The Records of the DFDR, Photo 1 – Serious Incident Aircraft, Photo 2 – Aircraft Fire Fighting)

2.2 Injuries to Persons

No one was injured associated with this serious incident.

2.3 Damage to the Aircraft

The airframe examination revealed burn damage (including damage caused by the fire that started after the Aircraft came to a stop, and after all passengers and crewmembers disembarked.) to the following components.

- (1) Inside the engine cowl
 - ① Burn damage was found on the hydraulic pressure hose, hydraulic supply hose and case drain tube.
 - ② The fuel supply hose was burned. Disconnecting the quick disconnect coupling, the O-ring *⁵ was found severed with the ends showing sharply cut surfaces and 25% of its length was missing.
 - ③ Conducting a hardness test on the structural members inside the pylon, reduced hardness was found in almost all of the members.
 - ④ The electrical wiring harnesses were burned.
- (2) The outer surface of the engine case was burned and covered with soot.

(See Figure 4 – Fuel Supply Hose Coupling, Figure 7 – The Examination Results of Burning Temperature, etc., Photo 3 – Engine Cowling Interior, Photo 4 – Junction Box, – Fuel Supply Hose Coupling (Receiving), Photo 6 – Fuel Supply Hose Coupling (Inserting))

2.4 Other Damage

*⁵ This O-ring works in the fuel supply hose connecting as an element to prevent fuel leakage.

There was no damage to other objects than the Aircraft.

2.5 Personnel Information

(1) The PIC Male, Age 52	
Airline Transport Pilot Certificate (Airplane)	October 30, 2006
Type rating for Boeing 777	October 30, 2006
Class 1 Aviation Medical Certificate	
Validity	Until October 31, 2008
Total flight time	17,929 h 00 min
Flight time in the last 30 days	66 h 07 min
Total flight time on the type of aircraft	3,834 h 00 min
Flight time in the last 30 days	66 h 07 min
(2) The First Officer Male, Age 33	
Airline Transport Pilot Certificate (Airplane)	May 27, 2007
Type rating for Boeing 777	May 27, 2007
Class 1 Aviation Medical Certificate	
Validity	Until May 31, 2009
Total flight time	7,067 h 09 min
Flight time in the last 30 days	40 h 36 min
Total flight time on the type of aircraft	2,311 h 06 min
Flight time in the last 30 days	40 h 36 min

2.6 Aircraft Information

2.6.1 Aircraft

Type	Boeing 777-200
Serial number	33505
Date of manufacture	July 20, 2004
Certificate of airworthiness	No. 0404-A
Validity	Until January 28, 2009
Total flight time	17,305 h 45 min
Flight time since last periodical check (C check on July 23, 2008)	70 h 15 min
(See Figure 2 – Three Angle Views of Boeing 777-200)	

2.6.2 Engines

(1) Left engine	
Type	Pratt & Whitney PW4084D
Serial number	P222214
Date of manufacture	July 20, 2004

Total time in service	17,305 h 45 min
Total cycles * ⁶	4,277 cycles
(2) Right engine	
Type	Pratt & Whitney PW4084D
Serial number	P222215
Date of manufacture	July 20, 2004
Total time in service	17,305 h 45 min
Total cycles	4,277 cycles

2.6.3 Maintenance History of the Right Engine

There are no records of removal of the Aircraft's engines since the time of their installation during the manufacture of the Aircraft.

According to the Company's maintenance records, the Aircraft underwent major maintenance and other maintenance operations (1C+3C+S4C, etc.) during the period between July 2 and 23, 2008, including removal and reinstallation of the fuel supply hose as part of the fuel supply line inspection, and on July 8, 2008, the O-ring in the fuel supply hose was replaced during the fuel system inspection.

2.6.4 Information on the O-Ring

According to the parts REQUEST LOG as kept at the time of replacement of the O-ring, the O-ring then delivered was one that was previously listed on the Aircraft's parts catalogue (P/N: M25988-1-134 (hereinafter referred to as "the M134")).

The Aircraft's parts catalogue (dated January 5, 2008) that was current at that time listed a different O-ring (P/N: M25988-1-135 (hereinafter referred to as "the M135")), which was adopted in place of the M134 in March 1998 as a result of the investigation conducted by the aircraft manufacturer in response to reports the manufacturer had received from multiple airlines complaining of M134 loosening during its use, whereby it turned out that the M134 had been "incorrectly specified." As a consequence of this change, the parts catalogue lists the M135, which is about 1.60 mm larger in inside diameter than the M134, as the recommended part while the M134 was specified as "M25988-1-135 IS PREFERRED O-RING PACKING REPLACEMENT. DO NOT USE M25988-1-134 FOR SPARES."

Meanwhile, after the serious incident, the Company addressed an inquiry to the manufacturer of the Aircraft asking if the M134 it had thus far been using was usable. In response to this query, the manufacturer informed the Company that the part could be used provided it was lubricated.

While the manufacturer of the Aircraft gave that answer considering, among other things, the slight difference in size between the M134 and the M135, further technical study and review with the fuel tube supplier found that the M134 was likely to become loose or pinched during installation,

*⁶ The term "cycle" refers to the unit of aircraft operation that includes one time of start and one time of shutdown.

whereupon the manufacturer concluded that the use of the M134 should not be continued.

The Company's work order applied to the removal and installation of the fuel supply hose requires the use of lubricant, whereas the aircraft maintenance manual that was established by the manufacturer of the Aircraft for reference by the Company during the major maintenance in question does not mention the use of lubricant. It was thus uncertain whether or not the O-ring that ended up breaking had been coated with lubricant during installation. On the other hand, the operation procedure manual established by the manufacturer of the Aircraft for reference by the Company during the engine replacement operation, which also involves removal and installation of the fuel supply hose, states that lubricant should be applied, although the manual is not to be used for the major maintenance mentioned above.

The specifications of the two types of O-rings are as follows. The inside diameters differ by 1.60 mm between them.

(Material: silicon fluoride)

O-ring	Inside diameter (nominal)	Thickness
M134	47.30mm	2.62mm
M135	48.90mm	2.62mm

2.6.5 Records of Status Messages in the Log Book and AIMS

The Aircraft's AIMS records included many "FIRE LOOP 2 ENG R" and "OVERHEAT CIRCUIT R2" status messages, which had never been recorded prior to the major maintenance that was completed on July 23, 2008. The two messages were recorded as a pair every time they occurred. The AIMS records indicated "NOT ACTIVE"^{*7} for these messages.

The log book had an entry for the following part of the AIMS records, in conjunction with the notes indicating the application of MEL^{*8} and the need for monitoring.

LEG	Date	Times recorded
- 0	July 30	4
- 3	July 29	2
- 4	July 29	5
- 5	July 28	4
- 6	July 28	1
- 9	July 27	1
- 11	July 27	1
- 12	July 27	9

^{*7} According to the fault isolation manual, a fault record accompanied by "NOT ACTIVE" indicates an intermittent fault that does not require maintenance action, while a fault record accompanied by "ACTIVE" requires maintenance action in accordance with the procedures specified in the manual.

^{*8} MEL, which stands for Minimum Equipment List, is the limit of the permissible deferred repair period during which the aircraft is allowed to continue flying without repairing or replacing faulty or inoperative on-board equipment.

- 13	July 26	2
- 14	July 26	5
- 16	July 25	1
Total times recorded		35

NOTE: “-0” in the LEG column refers to the flight during which the serious incident occurred. The first “FIRE LOOP 2 ENG R” and “OVERHEAT CIRCUIT R2” messages were recorded at 03:58 during this flight. Each figure in the LEG column indicates the ordinal number of a flight retrospectively counted from the most recent flight, so “- 16” indicates the oldest flight of all flights listed in this table.

According to the MEL of the Company concerning maintenance actions upon the occurrence of ACTIVE status messages, the permissible repair deferment limit for a condition of “Both overheat detection systems inoperative” or “One fire detection system inoperative” for each engine is defined as “Restoration period should be within 10 days” (Class C).

2.6.6 Fuel, Lubricating Oil and Hydraulic Fluid

The Aircraft used Jet A-1 aviation fuel, Mobil Jet Oil II lubricating oil, and SKYDROL LD4 hydraulic fluid.

Jet A-1 fuel has a spontaneous ignition temperature of about 237°C and a flash point ^{*9} of about 49°C at minimum.

SKYDROL LD4 hydraulic fluid has a spontaneous ignition temperature of about 398°C and a flash point of about 160°C at minimum.

2.7 Meteorological Information

The aviation routine weather report for Narita International Airport around the time of the serious incident was as follows:

07:30

Wind direction 040° (Variable 350°–070°); Wind velocity 9 kt

Visibility 20 km

Cloud: Amount 2/8, Type Cumulus, Ceiling 1,000 ft

Amount 4/8, Type Stratocumulus, Ceiling 5,000 ft

Temperature 24°C; Dew point 20°C

Altimeter setting (QNH) 29.84 inHg

2.8 Information on the DFDR and the CVR

^{*9} Flash point is the minimum temperature at which the vapor of a fuel is ignited by a flame of a specified size brought close to the vapor when the fuel is heated to that temperature.

The Aircraft was equipped with a DFDR (P/N: 980-4700-042) and CVR (P/N: 980-6022-001), both of which were manufactured by Honeywell International Inc. of the United States of America.

The records retained by the DFDR and the CVR cover the events that took place at the time of occurrence of the serious incident.

2.9 Progress of Fire and Firefighting Operations

According to the Security Department, Airport Operations Headquarters of the NAA, the progress of fire and firefighting operations around the time of occurrence of the serious incident was as follows. The times are based on the records kept by the NAA Fire Center.

- 07:46 A message from the Tower requesting the dispatch of the airport firefighting squad: "Smoke from an aircraft upon landing on Runway B. Request fire engines on stand-by." Airport Fire Department made a report to Narita City Fire Department Headquarters.
- 07:49 A vehicle from the East Unit started entering Runway B.
- 07:51 The vehicle from the East Unit moved following the Aircraft.
- 07:52 The Aircraft entered the Spot #84.
- 08:05 A squad from Narita City Fire Department (Sanrizuka) arrived at the site and stood ready on alert.
A squad from Narita City Fire Department (Headquarters) arrived at the site and stood ready on alert.
- 08:12 Reception of a report over the fire radio: "No injuries; 13 crewmembers and 264 passengers, 277 persons in total, already disembarked."
- 08:32 Smoke came from an engine, against which fire extinguishing powder was discharged (Handline: the NAA Chemical Fire Engine No. 1).
- 08:37 Liquid flowed out in a large amount, against which fire extinguishing foam was discharged (Handline: the NAA Chemical Fire Engine No. 2).
- 08:39 Reception of a report over the fire radio: "A mechanic operated controls on the Aircraft after the spot-in, which caused liquid to flow into the engine and be ignited; smoke is coming out."
- 08:44 Black smoke came out, against which fire extinguishing foam was discharged (Handline: the NAA Chemical Fire Engine No. 4).
- 08:47 Fire extinguishing foam was discharged (Handline: the NAA Chemical Fire Engine No. 1).
- 08:54 Fire squads stopped discharging fire extinguishing foam and stood ready on alert. (Fire is under control, but white smoke is still coming out; the firefighting operations are intermittently continued against the smoke.)
- 09:27 Engine cooling operation by means of water discharge was carried out.
- 09:30 Due to the conditions involved small smoke generation, water was discharged again.
- 10:28 The fire was extinguished. The fire squads kept standing ready.

10:46 All fire squads left the site.

The following vehicles and personnel were mobilized.

Airport Fire Department	4 fire engines; 2 water trucks; 2 ambulances (including large one); 2 other vehicles (commander and rescuer)
	Total: 10 vehicles and 21 persons
Narita City Fire Department	4 fire engines; 3 ambulances
	Total: 7 vehicles and 24 persons

(See Photo 2 – Aircraft Fire Fighting)

2.10 Tests and Research for Fact-Finding

As part of the investigation into the cause of the serious incident, inspection was conducted during the period between September 2008 and March 2009, at the plants of the manufacturer of the Aircraft and the like in the United States of America in the presence of the investigators from the National Transportation Safety Board (NTSB), on the engine's fire and overheat detection system as well as the hoses and other components concerned. The results are as described below.

(1) Engine fire and overheat detection system

The engine fire and overheat detection system consists of engine fire and overheat detector elements (hereinafter referred to as "Fire/Overheat Detector(s)") and an engine fire detection card.

An electrical resistance test was conducted on each of the Fire/Overheat Detectors that were located in three places in designated fire zone of the engine (upper, lower and lower-forward portions of the engine) and the related wires connected to them. The test results showed that the wiring resistance at ambient temperature and the insulation resistance were at normal levels for all the wires, while their wiring resistance at high temperatures deviated from the permissible range. As the status messages in the Aircraft's AIMS records were accompanied by "NOT ACTIVE" indications, as described in 2.6.5, the manufacturer of the Aircraft determined the following: the messages having occurred during the said flight were of a temporary nature and that, since normal records were subsequently recovered, the damage to the detection system was due to exposure to the flames and the system had been in normal condition before the occurrence of flames.

In addition to the above, a function and performance test was conducted on the engine fire detection card that was installed in the main electrical components compartment, which did not find any problems having relevance to the serious incident.

(See Figure 5 – Engine Fire and Overheat Detection System)

(2) Soot Analysis

Soot samples from the outer surfaces of the engine case were analyzed. The analysis detected the fuel, hydraulic fluid, fire extinguishing agent and others, but did not detect any foreign substances having no relevance to the engine.

- (3) Hoses and other components near the junction box for the right engine of the Aircraft
The extent of burn damage suggested that the temperatures prevailing around the right engine junction box had been between 450°C and 1,450°C.

- ① Hydraulic hoses: Burned (hydraulic pressure hose <1,450°C and hydraulic supply hose 700–1,450°C); fuel components were detected on the surface of these hoses.
- ② Fuel supply hose: Burned (<700°C)
- ③ Other hoses: Burned (case drain tube 522–1,450°C)
- ④ Engine fire and overheat detection system: Partially burned
- ⑤ Engine fire detection card: In good condition

(See Figure 4 – Fuel Supply Hose Coupling, Figure 7 – The Examination Results of Burning Temperature, etc., Photo 3 – Engine Cowling Interior, Photo 4 – Junction Box, Photo 5 – Fuel Supply Hose Coupling (Receiving), Photo 6 – Fuel Supply Hose Coupling (Inserting))

- (4) Fuel leak test

Using a fuel system tester, a fuel pressurization leak test was conducted using the O-ring removed from the Aircraft. Fuel leakage from the fuel supply hose coupling was detected.

(See Figure 6 – Fuel Leak Rate with the Damaged O-Ring)

2.11 Additional Relevant Information

2.11.1 Engine Fire and Overheat Detection System of the Aircraft

Each of the engines of the Aircraft has Fire/Overheat Detectors in three locations, i.e., the upper, lower and lower-forward portions of the engine for early detection of fire or overheat. These detectors are connected in series to make a loop. To improve detection reliability, each detector consists of two loops called Loop 1 and Loop 2, forming a redundant system.

Each detector element consists of two Terminal Lug Sensing Element (TLSE) supported by a metal tube. The Fire Overheat Detection Card is connected to the fire detectors by aircraft wiring. As the thermal sensing element is exposed to increased temperatures the resistance of the element decreases.

The engine fire detection card on the electrical components rack in the lower portion of the fuselage constantly monitors the resistance of each loop. When the temperature rises and causes the loop resistance to drop below the preset level, the card recognizes the loop to be in an overheated condition. If the loop resistance drops to a further lower level due to a further rise in temperature, the card recognizes this as a fire condition. The temperature settings for detection of overheat and fire conditions at each detector location are as follows:

Detector location	Overheat detection temperature	Fire detection temperature
Upper	840°F (449°C)	937°F (503°C)
Lower	783°F (417°C)	881°F (472°C)
Lower-forward	580°F (304°C)	669°F (354°C)

The engine fire detection card is programmed to judge an actual occurrence of overheat or fire and to issue the corresponding warning only when both loops (Loop 1 and Loop 2) simultaneously identify the condition as overheat or fire in order to improve the reliability of warning.

When only one loop identifies the condition as overheat or fire, the detection system automatically tests the other loop that has not identified the same condition as overheat or fire. If the loop shows no problem as a result of the test, the detection system judges the loop that output a warning condition to be defective and isolates the loop from the system. The system then continues monitoring using only one loop.

If a sudden drop in resistance occurs with a Fire/Overheat Detector, the system judges it as a short circuit. As the resistance of a Fire/Overheat Detector also drops in the event of actual fire, the system discriminates between a short circuit and a fire based on the rate of change in resistance. If a short circuit occurs in one loop, a status message indicating a fault in the loop is displayed in the cockpit, and the event is recorded in the AIMS. If the short circuit condition disappears soon after, the condition is recorded in the AIMS as “NOT ACTIVE.”

The loop in question then performs a self-test (built-in test) every five minutes. If the test is completed without detecting any problems, no message is issued for this effect.

(See Figure 5 – Engine Fire and Overheat Detection System)

2.11.2 Procedures in Case of Engine Fire

If an engine fire occurs, the procedure to follow is to set the thrust lever to idle, set the fuel control switch to CUTOFF, and pull up the Fire Handle for the associated engine. This results in shutting off the fuel, pneumatic air *¹⁰ and hydraulic lines. If the procedure causes the warning to stop, no further action, including turning the Fire Handle, is needed. However, if the warning continues as in this serious incident, immediate turning of the Fire Handle is necessary to discharge the fire extinguishing agent. The Aircraft is equipped with two extinguisher tanks to allow using the second tank if the fire extinguishing agent in one tank is not enough to extinguish the fire.

*¹⁰ Pneumatic air is pressurized air, which is used for air conditioning, cabin pressurization, anti-/de-icing and other purposes.

3. ANALYSIS

3.1 Flight Crew Qualifications

The PIC and the First Officer each held a valid airman competence certificate and a valid aviation medical certificate.

3.2 Aircraft Airworthiness Certificate

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

3.3 Meteorological Conditions

It is considered highly probable that the meteorological conditions prevailing at the time of the serious incident did not have any relevance to the occurrence of the serious incident.

3.4 Damage to the O-ring

- (1) As described in 2.6.3 and 2.6.4, during the most recent major maintenance carried out on July 8, 2008, the Company replaced the O-ring M134 in the fuel supply hose coupling for the right engine of the Aircraft. The Parts Catalogue was revised in March, 1998, M134 was specified as “M25988-1-135 IS PREFERRED O-RING PACKING REPLACEMENT. DO NOT USE M25988-1-134 FOR SPARES” Also, in response to the Company’s inquiry made to the manufacturer of the Aircraft after the serious incident, asking if the M134 was usable, the manufacturer answered that it was permissible to use the part provided that lubricant was applied; however, following further technical studies, the manufacturer concluded that the use of the M134 should be discontinued.
- (2) As to the installation of the O-ring, while the Company’s work order for fuel supply hose removal and installation required the use of lubricant, what was referred to at the time of the major maintenance in question was the aircraft maintenance manual prescribed by the manufacturer of the Aircraft, which included no description about the use of lubricant, as described in 2.6.4. It is therefore considered possible that the O-ring having ended up breaking was installed on the fuel supply hose without lubricant applied.
- (3) The fractured surfaces of the damaged O-ring showed a sharply cut surface. It is therefore considered probable that the O-ring was pinched and became damaged when the fuel supply hose was connected.

It is considered possible that the use of the M134, which was smaller in size and easily loosened, as well as the non-use of lubricant, contributed to the pinching.

3.5 Occurrence of the Flames

- (1) Flames during taxiing

After the Aircraft had landed, a fire warning was issued during subsequent taxiing.

As a result of the fuel test conducted at the aircraft manufacturer's plant, fuel leaked from the fuel supply hose coupling, as described in 2.10 (4), and fuel components were detected on the surface of the hydraulic hoses, as described in 2.10 (3). It is therefore considered highly probable that the leaking fuel would have spread in the area of the junction box during taxiing, which then would have ignited, eventually flames burnt. The timing at which the fuel started to leak out could not be clarified.

It is considered highly probable that the flow of air made it difficult for the leaking fuel to ignite while the Aircraft was airborne. However, it is considered possible that, around the time when the Aircraft moved in a tailwind on the taxiway after landing, the flow of air inside the engine became slower and this would have contributed to the occurrence of flames.

(2) Fire after the Aircraft came to a stop

It is considered highly probable that after the Aircraft entered the spot and come to a stop, and after all passengers and crewmembers disembarked, the fire broke out through the following process:

- ① As indicated by the statements of the persons concerned and other information, the fuel and hydraulic fluid shutoff valves were opened when the maintenance engineer moved the Fire Handle back to the original position in preparation for the motoring to stop the white smoke, which allowed fuel or hydraulic fluid to leak out.
- ② The leaking fuel or hydraulic fluid ignited or caught fire due to the heat from hot spots on the engine, which caused a fire.

The fire was extinguished through the use of the onboard fire extinguishing agent by the maintenance engineer and the discharge of the fire foam from the fire engines.

With regard to the white smoke that continued to come out despite the pulled-up Fire Handle, it is considered possible that this resulted from the hydraulic fluid leaking from the hydraulic hoses that had been burned as described in 2.10 (3).

3.6 Engine Fire and Overheat Detection

(1) Fire and overheat detection function

As described in 2.10 (1), the electrical resistance tests conducted on the Engine Fire/Overheat Detectors removed from the three locations of the engine and on the related wires showed that their resistance values had deviated from the permissible range.

In addition, the exterior surfaces of the detectors had the signs that suggest damage resulting from exposure to high-temperature flames.

It is therefore considered possible that the said detectors were exposed to flames having generated in the designated fire zone of the engine during taxiing after landing of the Aircraft and after parking and, as a result, the electrical performance of the detectors had

deteriorated.

(2) Status messages displayed in the cockpit while airborne

As described in 2.1.1, at 03:58, about one and a half hours after the Aircraft took off from Ho Chi Minh Airport, the “FIRE LOOP 2 ENG R” and “OVERHEAT CIRCUIT R2” status messages were displayed in the cockpit, which indicated loss of electric power, short circuit or other problems in Loop 2 of the right engine fire and overheat detection system. The Aircraft’s AIMS recorded these two status messages four times. As described in 2.10 (1), the manufacturer of the Aircraft regarded these as temporary fault conditions.

(3) Maintenance actions against the status messages

As described in 2.6.5, the AIMS recorded “FIRE LOOP 2 ENG R” and “OVERHEAT CIRCUIT R2” status messages a total of 35 times after the major maintenance. As these messages were all “NOT ACTIVE,” no maintenance actions were taken.

3.7 Firefighting

After receiving an emergency message on the Aircraft, the NAA Fire Department immediately dispatched three fire engines to the side of the runway. After the Aircraft had landed, the firefighters moved following the Aircraft on fire engines prepared for firefighting operation whenever needed. After the Aircraft entered its spot, and after all passengers and crewmembers disembarked, the firefighters stood ready on alert since smoke continued to come out. As a result, the fire that broke out on the Aircraft at the spot was swiftly extinguished. The series of actions that were taken are considered appropriate.

3.8 Emergency Evacuation

It is considered appropriate that PIC stopped the fire warning after having fire extinguishing agent was discharged while taxiing and did not initiate emergency evacuation, because no subsequent problems emerged.

4. PROBABLE CAUSE

It is considered highly probable that fuel leaked from the fuel supply hose of the right engine while the Aircraft was taxiing after landing, and that the leaking fuel caught fire, resulting in this serious incident.

It is considered possible that fuel leaked due to a gap in the O-ring that was created when the O-ring was pinched and severed during installation of the fuel supply hose.

It is considered possible that the installation of the O-ring which was smaller in size and easily loosened, as well as the non-use of lubricant, contributed to the pinching.

5. REFERENTIAL MATTERS

Preventive Measures

Since the aircraft maintenance manual (AMM 73-11-08-400-801) for the installation of the fuel supply hose on the Boeing 777-200 had not included a description regarding application of lubricant to the O-ring during its installation, the manufacturer of the Aircraft issued a temporary revision to the manual, dated May 6, 2009.

Permanent measures to be taken by the manufacturer of the Aircraft against the recurrence of similar serious incidents are expected to be decided after completion of this investigation by the JTSB.

FIGURES and PHOTOS

Figure 1 Sketch of the Incident Scene

Figure 2 Three Angle Views of Boeing 777-200

Figure 3 The Records of the DFDR

Figure 4 Fuel Supply Hose Coupling

Figure 5 Engine Fire and Overheat Detection System

Figure 6 Fuel Leak Rate with the Damaged O-Ring

Figure 7 The Examination Results of Burning Temperature, etc.

Photo 1 The Serious Incident Aircraft

Photo 2 Aircraft Fire Fighting

Photo 3 Engine Cowling Interior

Photo 4 Junction Box

Photo 5 Fuel Supply Hose Coupling (Receiving)

Photo 6 Fuel Supply Hose Coupling (Inserting)

Figure 1 Sketch of the Incident Scene

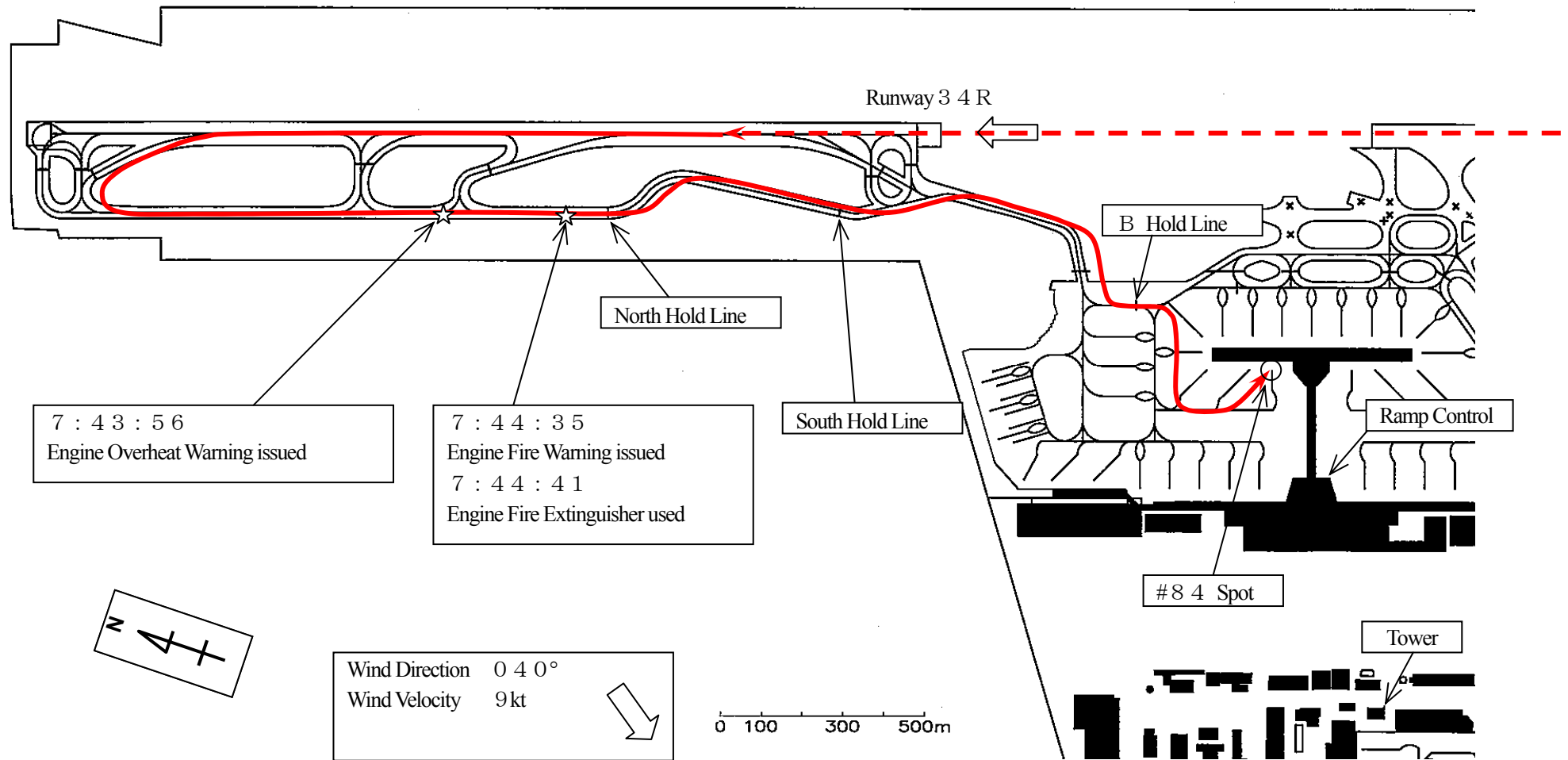


Figure 2 Three Angle Views of Boeing 777-200

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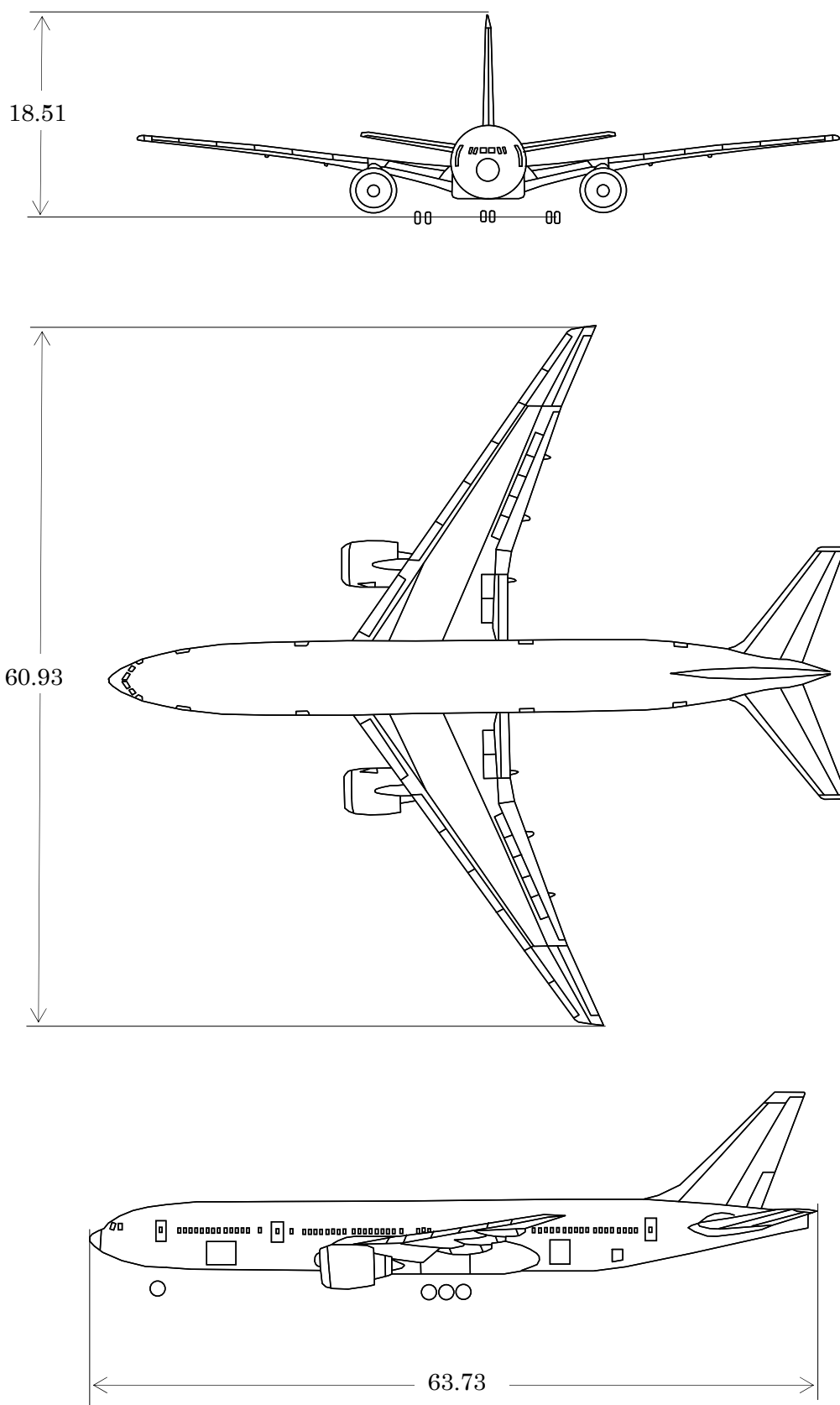


Figure 3 The Records of the DFDR

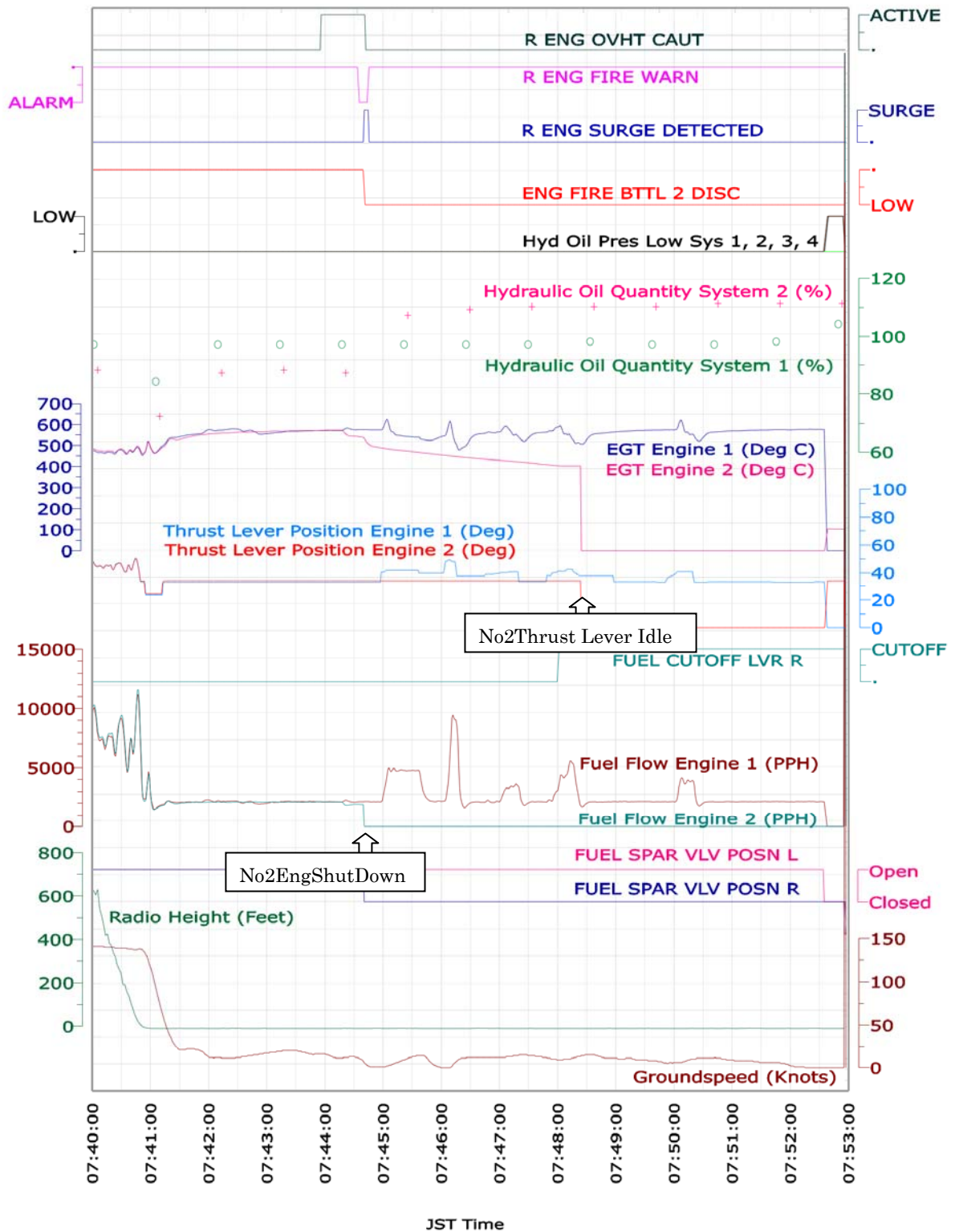


Figure 4 Fuel Supply Hose Coupling

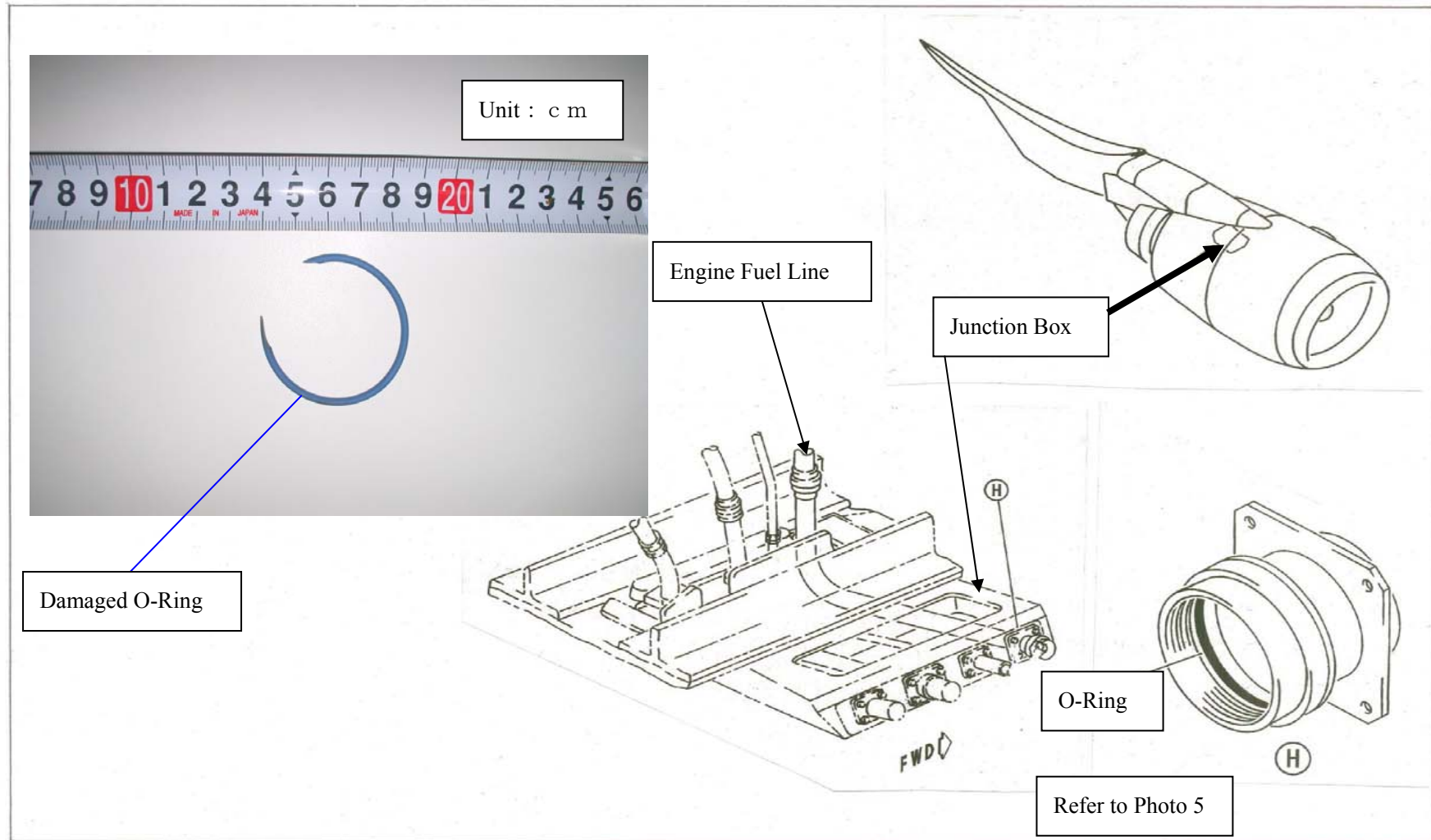
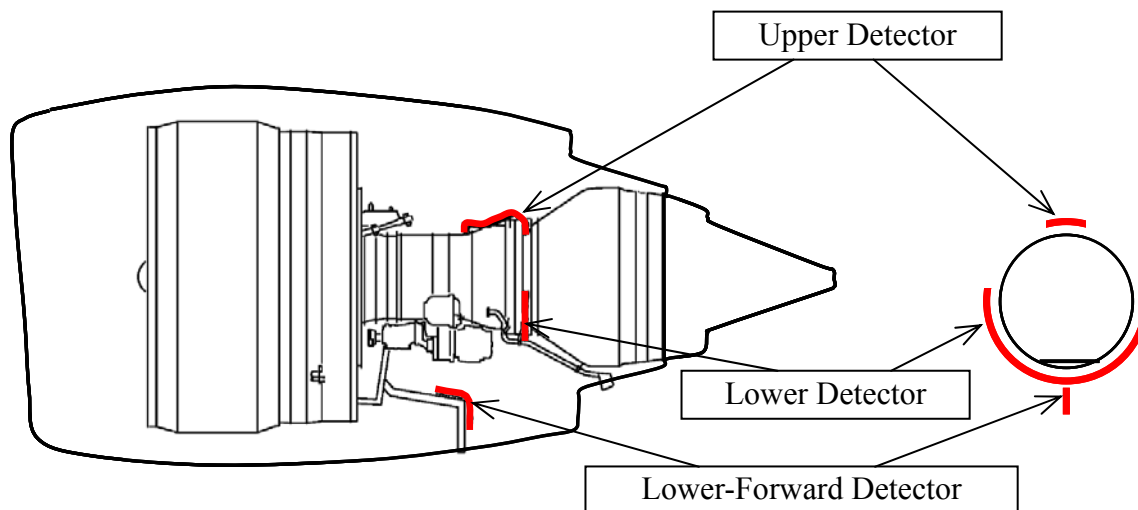
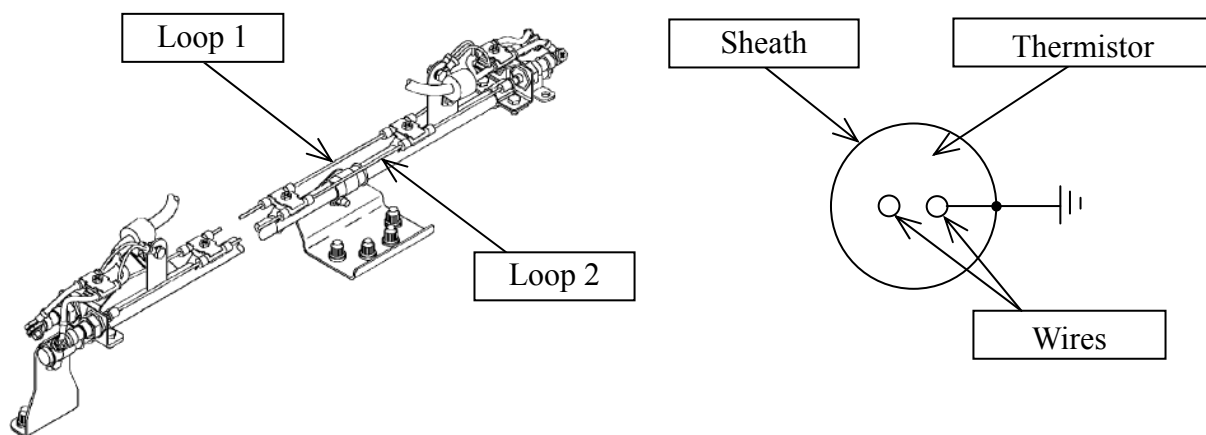


Figure 5 Engine Fire and Overheat Detection System

Detectors Installation Situation



Detector Example and Cross Section



Notion Figure of Loop Composition

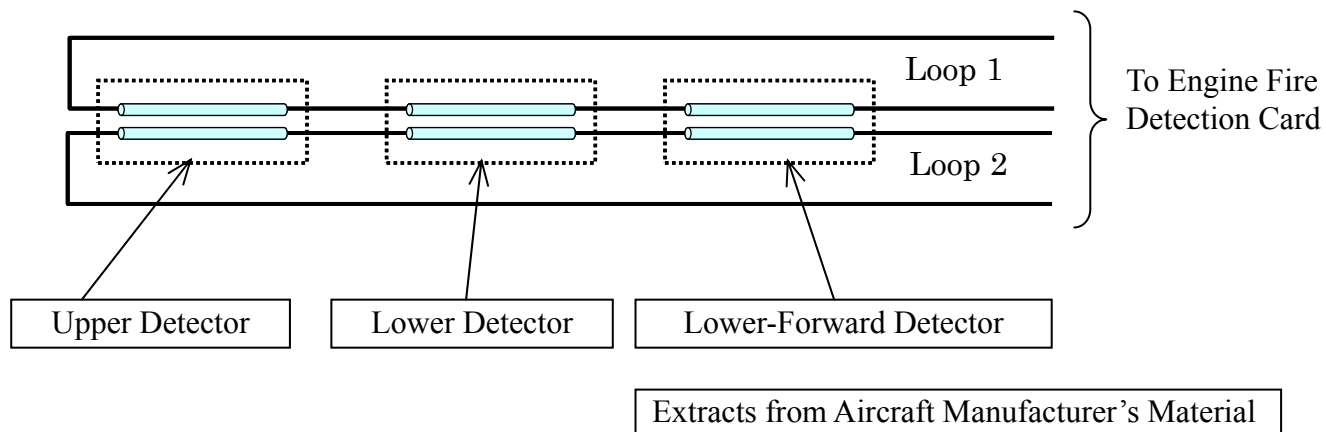


Figure 6 Fuel Leak Rate with the Damaged O-Ring

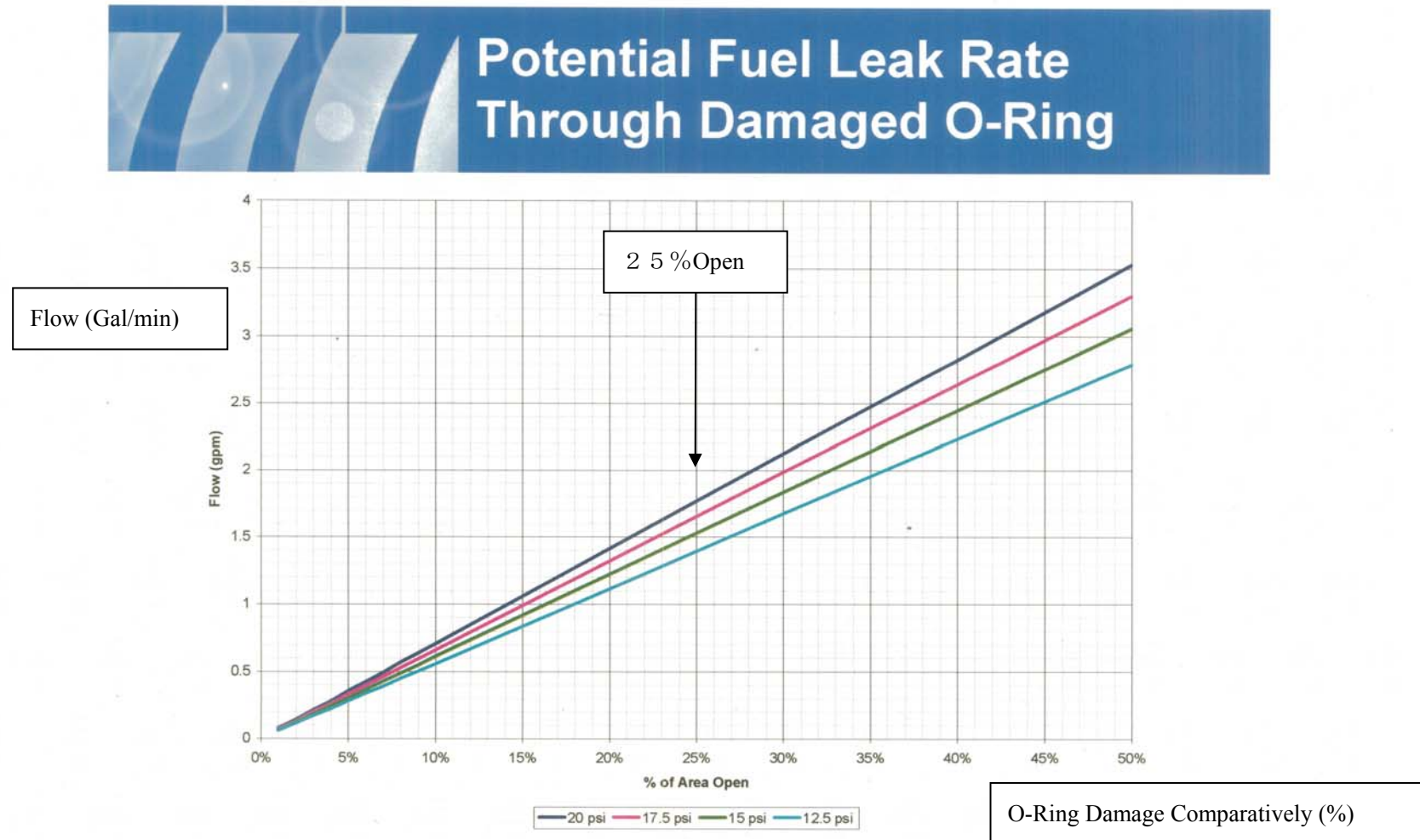


Figure 7 The Examination Results of Burning Temperature, etc.



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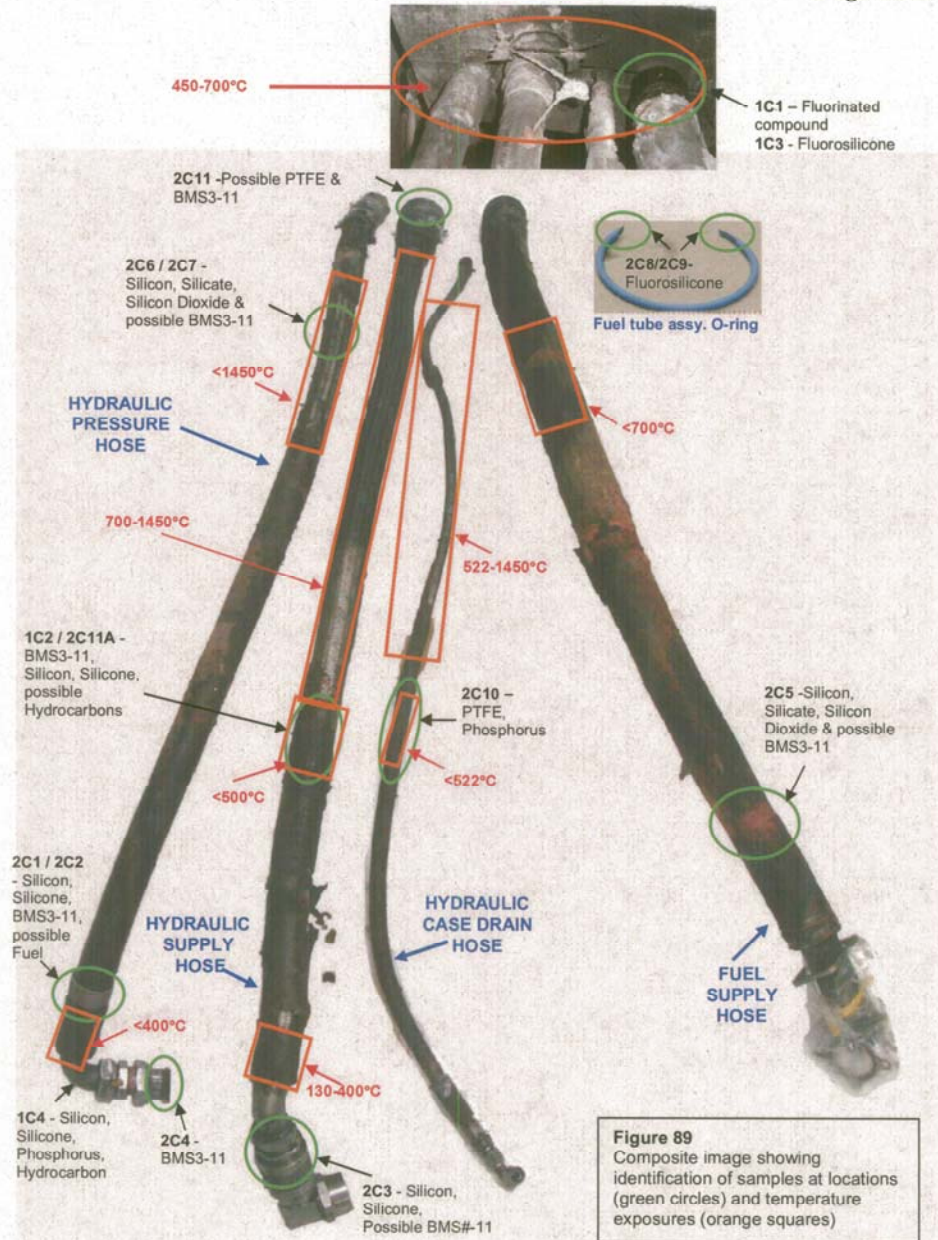


Photo 1 The Serious Incident Aircraft



Photo 2 Aircraft Fire Fighting



Photo 3 Engine Cowling Interior

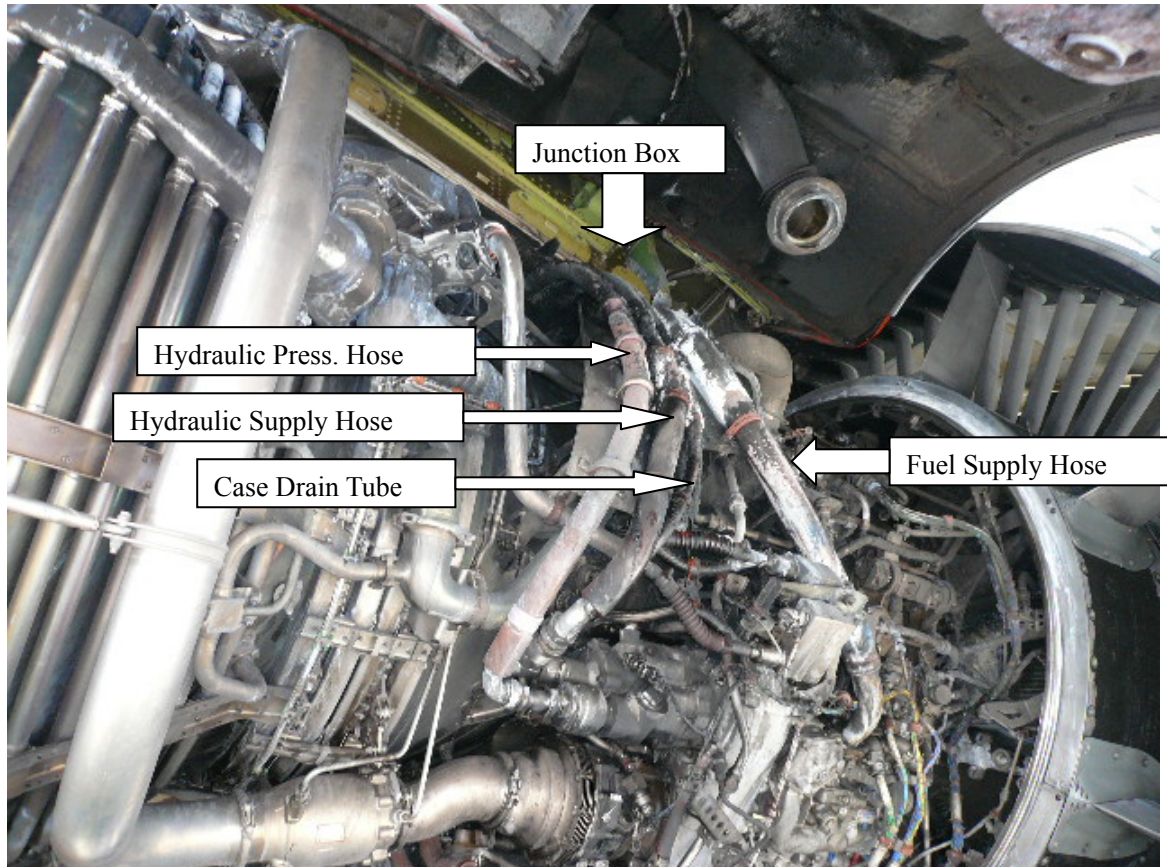


Photo 4 Junction Box

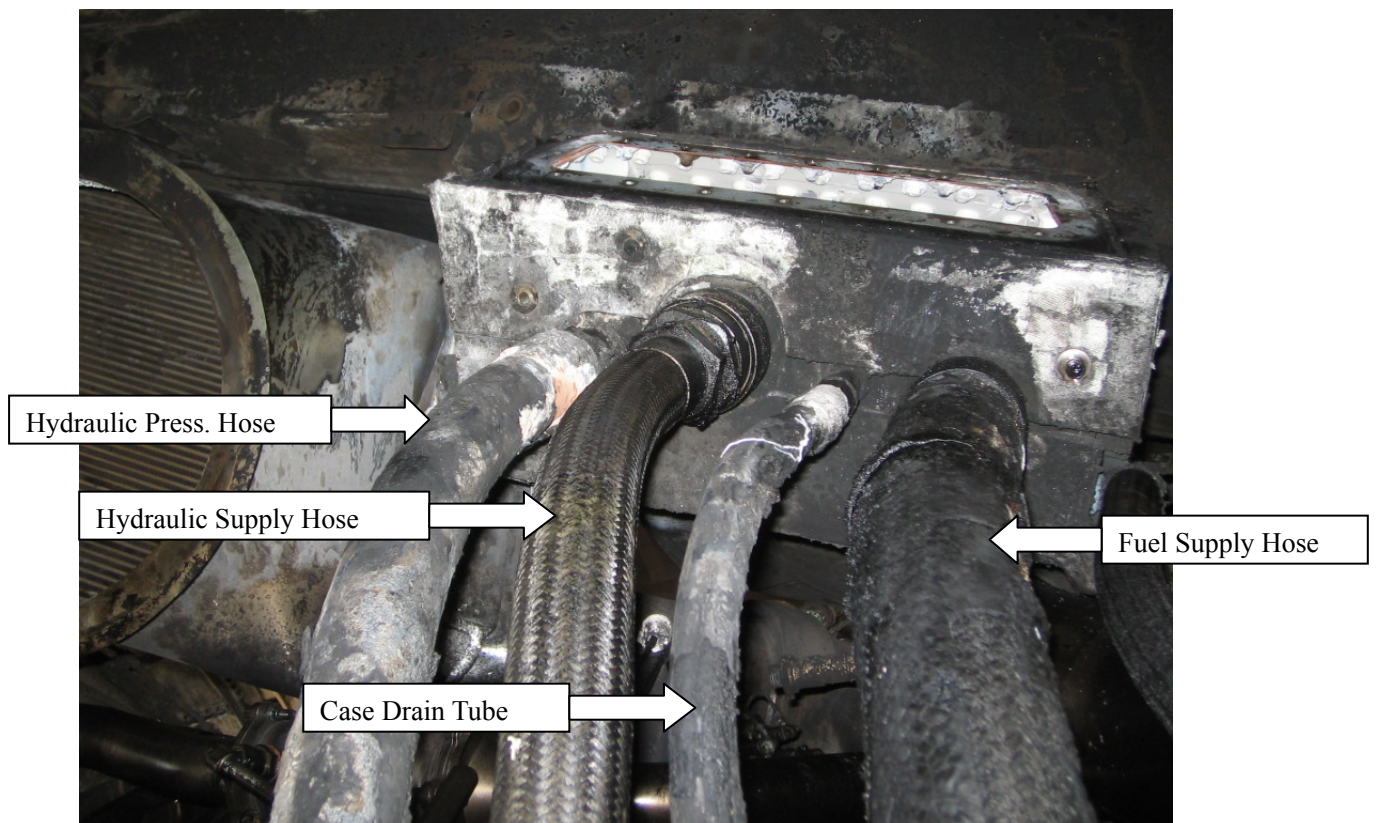


Photo 5 Fuel Supply Hose Coupling (Receiving)



Photo 6 Fuel Supply Hose Coupling (Inserting)

