Aircraft Incident Report

(FINAL)

One Engine Shutdown due to Overheat Warning Indication

MLTM Flight Inspection Center

CL-601, HL7577

Gimpo International Airport

Around 10:50, November 26, 2010

May 31, 2012

AVIATION AND RAILWAY ACCIDENT INVESTIGATION BOARD

MINISTRY OF LAND, TRANSPORT AND MARITIME AFFAIRS

REPUBLIC OF KOREA

According to the provisions of the Article 30 of the Aviation and Railway Accident Investigation Act of the Republic of Korea, it is stipulated;

The accident investigation shall be conducted separately from any judicial, administrative disposition or administrative lawsuit proceedings associated with civil or criminal liability.

And in the Annex 13 to the Convention on International Civil Aviation, Paragraphs 3.1 and 5.4.1, it is stipulated as follows;

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of the activity to apportion blame or liability. Any investigation conducted in accordance with the provision of this Annex shall be separate from any judicial or administrative proceedings to apportion blame or liability.

Thus, this investigation report issued as the result of the investigation on the basis of the Aviation and Railway Accident Investigation Act of the Republic of Korea and the Annex 13 to the Convention on International Civil Aviation, shall not be used for any other purpose than to improve aviation safety.

In case of divergent interpretation of this report between the Korean and English languages, the Korean text shall prevail.

Aircraft Incident Report

Aviation and Railway Accident Investigation Board. *One Engine Shutdown due to Overheat Warning Indication, MLTM, CL-601, HL7577, Gonghang-dong Gangseo-gu Seoul, November 26, 2010.* Aircraft Incident Report ARAIB/AIR1010. Seoul, Republic of Korea

The Aviation and Railway Accident Investigation Board (ARAIB), Republic of Korea, is a government organization established for independent investigation of aviation and railway accident, and the ARAIB conducts accident investigation in accordance with the provisions of the Aviation and Railway Accident Investigation Act of the Republic of Korea and Annex 13 to the Convention on International Civil Aviation.

The objective of the investigation by the ARAIB is not to apportion blame or liability but to prevent accidents and incidents.

The main office is located near Gimpo International Airport.

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Contents

One Engine Shutdown due to Overheat Warning Indication

- Operator: MLTM Flight Inspection Center
- Manufacturer: Bombardier Inc.
- Model: CL-600-2B16 (CL-601-3R)[1)]
- Registration Mark: HL7577
- Place: Gimpo International Airport, Gonghang-dong, Gangseo-gu, Seoul
- Date & Time: November 26, about 10:50 (Korea Standard Time)[2)]

Synopsis

On November 26, 2010, at 10:30, a CL601 airplane (Registration Mark HL7577, hereinafter referred to as "HL7577") affiliated with the Ministry of Land, Transport and Maritime Affairs (hereinafter referred to as the "MLTM") took off from Gimpo International Airport to inspect the signal range of the mobile TACAN facilities in Songtan at an altitude of 30,000 feet on the airway between Gimpo and Jeju. Then, about 10 minutes after the takeoff, however, when the aircraft maintained at an altitude of 4,000 feet and a speed of 250 knots, its left engine's LEFT JET PIPE/PYLON overheat (OVHT) light[3)] came on, so the flight crew shut down the engine in accordance with abnormal procedures and returned to Gimpo Airport. There was no personal injury or damage to the aircraft.

The Aviation and Railway Accident Investigation Board (hereinafter referred to as the "ARAIB") determines that the probable cause of the incident was 「the flight crew's decision to shut down one engine in accordance with abnormal procedures of the flight manual for the reason that the engine sensing element's malfunction caused the left engine's JET PIPE/PYLON OVHT light to illuminate.」

1) Engine Type: General Electric CF34-3A1 Turbo Fan Engine
2) Unless otherwise indicated, all times in this report are Korea Standard Time, based on a 24-hour clock.
3) The device to warn that temperatures in the exhaust nozzle area of the engine and in the engine pylon are overheated.

As a result of the investigation of this incident, the ARAIB makes two safety recommendations to the MLTM Flight Inspection Center.

1. Factual information

1.1 History of the Flight

On November 26, 2010, at 10:30, HL7577 took off from Gimpo Airport (with the engine N1 power of 89%) to inspect the signal range of the mobile TACAN facilities in Songtan at an altitude of 30,000 feet on the airway between Gimpo and Jeju, and when the aircraft maintained at an altitude of 4,000 feet and a speed of 250 knots in accordance with MALPA 1W Seoul departure procedures (about 10:40), the red LEFT JET PIPE/PYLON OVHT light came on.

The flight crew monitored the light if it was turned off as he slowly decreased the left engine's thrust, but the light was still on, so in accordance with the abnormal procedures of JET PIPE/PYLON OVHT, he shut down the left engine about 10:50.

About 11:00, he declared an emergency, and following the controller's guidance, he dumped 700 lbs of fuel in the fuel dumping area of the Yellow Sea. Then, about 11:13, executing "single engine approach and landing procedures," he landed on runway 32R of Gimpo Airport.

1.2 Injuries to Persons

Category	Crew	Passenger	Others
Fatal	0	0	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to Aircraft

None

1.4 Other Damage

None

1.5 Personnel Information

1.5.1 The Captain

The captain (age 52, male) held a valid transport pilot license[4], CL601 type rating, Class 1 airman medical certificate[5], radio operator license[6], and Level 4 English proficiency certificate.

The captain accumulated 6,291 total flight hours, including 3,924 hours in the same type aircraft before the day of the incident. He had flown 34 hours and 75 hours in one month and three months, respectively, before the incident flight. Also, he renewed his flight inspection pilot license issued by the director of the Seoul Regional Aviation Administration after he had completed a regular flight simulator training in July, 2010 in accordance with the Flight Inspection Center's regulations.

For the last 72 hours before the incident, the captain took a day off on November 23, went to work but did not fly on November 24, went on a business trip to the Daejeon Regional Public Procurement Service on November 25, and then returned home to relax about 19:00 on the same day.

4) Qualification No.: 1822 (Passed on Jun. 16, 2000, issued on Jun. 16, 2009)
5) Certificate No.: 049-1995 (Valid until Dec. 31, 2010)
6) Certificate No.: 98-34-1-0212

1.5.2 The First Officer

The first officer (age 63, male) held a valid transport pilot licens e[7], Class 1 airman medical certificate[8], and radio operator license[9].

The first officer accumulated 5,912 total flight hours, including 2,280 hours in the same type aircraft before the day of the incident. He had flown 19 hours and 57 hours in one month and three months, respectively, before the incident flight. Also, he renewed his flight inspection pilot license issued by the director of the Seoul Regional Aviation Administration after he had completed a regular flight simulator training in July, 2010 in accordance with the Flight Inspection Center's regulations.

For the last 72 hours before the incident, the first officer went to work and left the office as usual from November 23 to November 25, 2010, but did not fly.

1.6 Aircraft Information

1.6.1 Airworthiness and Maintenance

1.6.1.1 Aircraft General

The HL7577 aircraft, whose type is CL-600-2B16 (CL-601-3R), is a twin-engine plane manufactured by the Canadian company, Bombadier Inc., and CF34-3A1, the General Electric turbo-fan engine is installed on the aircraft. The general information on the aircraft is as shown in [Table 1].

7) Qualification No.: 2563 (Passed on Oct. 20, 1995, issued on Jun. 16, 2009)
8) Certificate No.: 049-2002 (Valid until Dec. 31, 2010)
9) Certificate No.: 98-34-1-0213

Category	Details	Category	Details
Manufacture Date	Jun. 13, 1995 (Bombardier Inc.)	Manufacture No.	5182
Delivery Date/Price	1996. 6. 22/15 billion won	Registration Date	Aug. 31, 1996
Max. Cruising Speed/Cruising Speed	869.5km/h(470knot) 800km/h	Max. Altitude	12,478m(41,000ft)
External Length/Wingspan /Height	20.85m/19.61m /6.2m	Internal Length/Wingspan /Height	6.0m/1.7m/1.7m
Takeoff Roll Distance	1,790m(5,875ft)	Landing Roll Distance	1,005m(3,300ft)
MTOW	20,460kg(45,100lbs)	MLW	16,331kg(36,000lbs)
Empty Weight	11,890kg(26,249lbs)	No. of Boarding Persons	11(including pilots)
Fuel Consumption per Hour	330.9G/L(2,234lbs)	Max. Fuel Carrying Capacity/Max. Flight Hours	2,652G/L(17,900lbs) 7 hrs. 30 min. (6,700km)
Engine Manufacturer	GE(General Electric)	Engine Output	8,729lbs

[Table 1] General Information on Aircraft

1.6.1.2 History of the Airframe and Engine

The HL7577 aircraft was manufactured by Bombardier Inc. on June 13, 1996, was delivered on June 22, 1996, and was registered on August 31, 1996. The total service times of the aircraft and engines were 4,206.08 hours, respectively, before the day of the incident.

The Flight Inspection Center entrusted Korean Air with maintenance of the HL7577 aircraft. Korean Air performed scheduled maintenance in accordance with the Maintenance Planning Document (MPD) given by the manufacturer. The scheduled maintenance performed in 2010 are as shown in [Table 2], and from November 19 until November 25, 2010, GE On-Wing Support Inc. (GEOWS) took actions in

compliance with the engine Airworthiness Directive (FAA AD 2009-07-12 Air Balance Piston Seal Replacement).

Category	Maintenance Tasks	Completion Date
100 hrs.	7 tasks including check on the anti-stall system	Feb. 8/May. 6/Nov. 1
150 hrs.	12 tasks including check on the water supply system	Mar. 4/Oct. 15
300 hrs.	95 tasks including check on sensing elements	Mar. 12
600 hrs.	88 tasks including check on voice recorders	May. 31
1800 hrs.	2 tasks including check on cockpit windows	Sep. 3
4200 hrs.	4 tasks including non-destructive inspection of wing skins	Nov. 8
APU 400 hrs. or 12 Months	Check on APU magnetic plugs	May. 31
APU 2400 hrs.	Check on APU manifold	May. 31
6 Months	4 tasks including check on the main battery	Jan. 5/May. 31/Nov. 25
12 Months	35 tasks including check on oxygen masks	Mar. 10
84 Months	2 tasks including check on the oxygen supply system	May. 31
150 hrs. or 6 Months	2 tasks including check on a water boiler	Nov. 25
300 hrs. or 6 Months	2 tasks including check on sensing elements	Nov. 1

[Table 2] Major Scheduled Maintenance in 2010

1.6.1.3 Malfunction and Action Taken List

The malfunctions occurred for two years before the airworthiness inspection on August 26, 2011 are as shown in [Table 3], and the

sections shaded are the malfunctions similar to that of this incident.

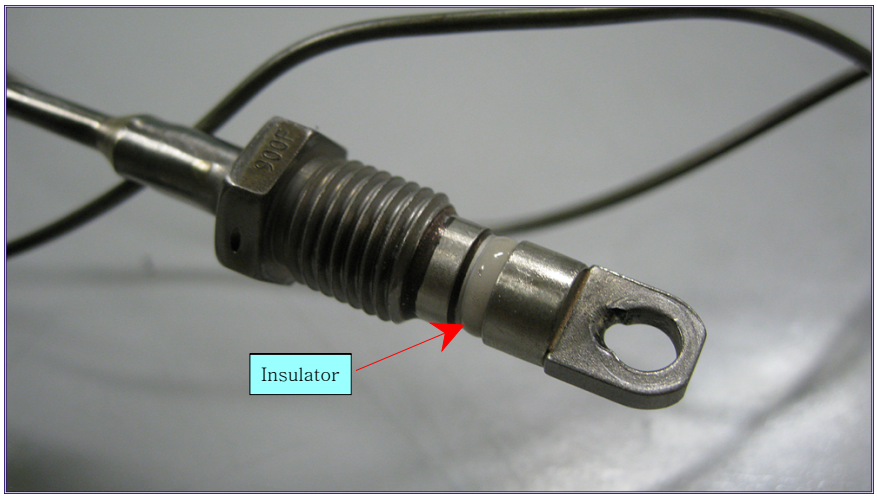
No.	Date	Malfunctions
1	09-08-20	TCAS INOP.
2	09-08-20	#1 BDHI's #2 NEEDLE INOP.
3	09-08-26	N1 RPM instrument's #2 DIGITAL number indicated non-normal depending on RPM (#2 indicated 10% less).
4	09-09-01	When AUTO FLT engaged, TRIM OVSP L'T ON (After reset, it returned to normal).
5	09-10-21	NOSE GEAR DOWN LOCK INDICATOR L'T INOP.
6	10-02-22	#3 BDHI DME not displayed.
7	10-03-10	During horizontal flight at an altitude of 1,500 ft and a speed of 160 to 180 kts (AUTO FLT), PITCH TRIM OVSP L'T ON.
8	10-03-10	After a failed approach at an altitude of 1,000 ft and a speed of 160 kts during instrument approach at an altitude of 3,000 ft and a speed of 160 kts, the fuel instrument indicated UNBALANCE between L/H 4800LBS and R/H 4100LBS, but one min. later, it returned to normal.
9	10-05-12	When L/R AFCS tripped during flight, AUTOPILOT disengaged.
10	10-08-19	#1 FLOOD LIGHT CONTROL failed.
11	10-08-19	STBY ATTITUDE WARM-UP TIME was too long (WARM-UP not done before TAXI).
12	10-08-19	#1 ENGINE PYLON/PIPE OVHT WARNING LIGHT ON (around N2 RPM 82% and over).
13	10-08-19	R/H PEDESTAL FLOOD L'T INOP.
14	10-09-20	#1 VHF transmission & reception OUT.
15	10-10-06	NO.1 RADIO INOP.
16	10-11-17	When WING & COWL ANTI-ICE operated during climbing flight, DUCT FAIL L'T ON.
17	10-11-19	When WING & COWL ANTI-ICE was operated during flight with N1 RPM 91%, DUCT FAIL L'T ON (In ST-BY MODE, ON once)
18	10-11-26	After takeoff, L/H JET PIPE/PYLON OVHT WARNING L'T ON. Even after reducing TH' to IDLE, it kept ON, so after L/H ENGINE SHUT DOWN, the aircraft landed.

19	11-02-23	When No.1 N1 RPM was 86% and over, ENGINE JET PIPE/PYLON OVHT WARNING FAIL L'T ON.
20	11-02-23	#1 FGC NAV MODE disengaged (during takeoff).
21	11-03-15	#1 PITCH TRIM failed.
22	11-03-18	When TRIM OVSP WARNING L'T ON during AUTO FLT at a speed of 200 kts, #1 PITCH TRIM INOP, which occurred three times. After reset, it returned to normal.
23	11-03-18	When MACH TRIM operated, AUTOPILOT disengaged, then YAW DAMPER disengaged, and about one min. later, MACH TRIM YAW DAMPER engaged, which occurred three times (irrelevant to PITCH TRIM OUT).
24	11-08-23	When WX RADAR ON, it was not in normal operation twice.

[Table 3] Malfunction Occurrences and Actions Taken

1.6.1.4 Sensing Element Maintenance History

When actions[10] taken in compliance with the Airworthiness Directive on November 25, 2010, a crack was found in the left engine's JET/PIPE sensing element insulator, and thus the sensing element was replaced. The insulator is a white part made of porcelain as shown in [Figure 1]. The sensing elements are not "repairable components" that can be repaired and recycled but "consumable parts."



[Figure 1] Sensing Element Insulator

10) Air Balance Piston Seal Replacement (Nov 19 - 25, 2010) conducted by GEOWS

On November 26, 2010, this incident occurred when the pilot shut down the engine of HL7577 because the left engine's JET/PIPE OVHT light came on. After landing, ground inspection was carried out, but no malfunction related to JET/PIPE OVHT was found. For troubleshooting, JET/PIPE sensing elements for both engines were swapped and given a trial run, but no malfunction was found.

On November 27, 2010, the engines were given a trial run after they were cooled off enough, but no malfunction was found, so JET/PIPE sensing elements for both engines were swapped back. However, to prevent the same malfunction from reoccurring, the left engine's JET/PIPE sensing element was replaced with a new one. The sensing element removed from HL7577 is as shown in [Figure 2]. On November 28, 2010, HL7577 was deployed to carry out flight inspection of Gwangju and Jeju airports after it conducted a test flight to verify maintenance results. So far, no malfunction has occurred.

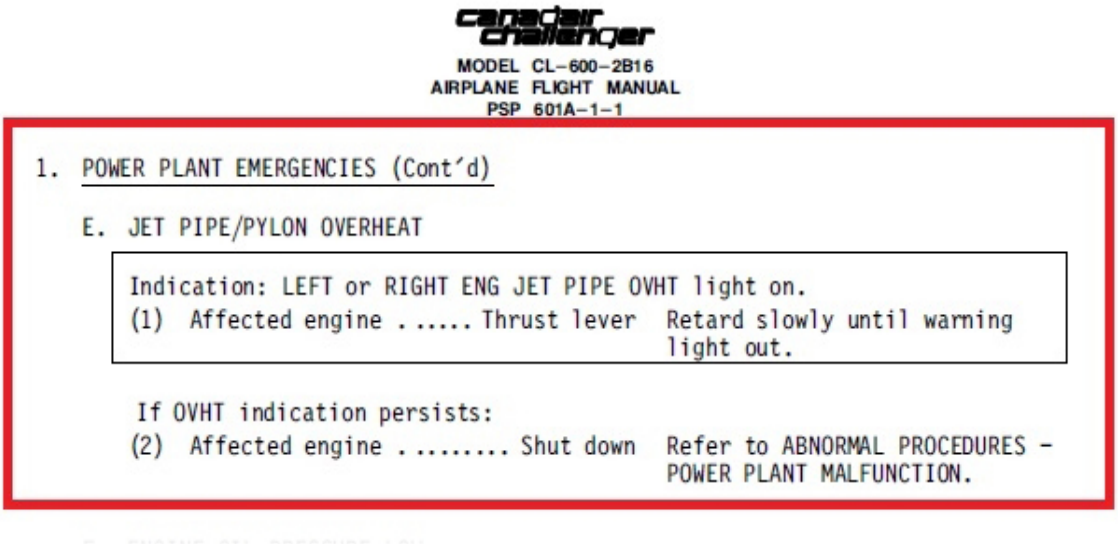
The part and serial numbers of the sensing element removed from HL7577 is 744-012047 and 103305, respectively.

[Figure 2] JET/PIPE Sensing Element Removed

1.6.1.5 Abnormal Procedures

Engine emergency procedures of CL600-2B16 airplane flight manual as shown in [Figure 3] specify that when "ENG JET PIPE OVHT light" is on, pilots shall slowly retard the affected engine's thrust until the warning light is off, but if the light is still on, they shall shut down the affected engine in accordance with abnormal procedures.

After "ENG JET PIPE OVHT" light was on, the pilots slowly retarded the left engine's thrust and monitored if the warning light was on or off, but had to shut down the affected engine since the light continued on.


MODEL CL-600-2B16
AIRPLANE FLIGHT MANUAL
PSP 601A-1-1

1. POWER PLANT EMERGENCIES (Cont'd)

E. JET PIPE/PYLON OVERHEAT

Indication: LEFT or RIGHT ENG JET PIPE OVHT light on.

(1) Affected engine	Thrust lever	Retard slowly until warning light out.

If OVHT indication persists:

(2) Affected engine	Shut down	Refer to ABNORMAL PROCEDURES - POWER PLANT MALFUNCTION.

[Figure 3] Emergency Procedures for "ENG JET PIPE OVHT" Light

1.6.1.6 Weight and Balance

The weight and balance data of HL7577 are as follows:

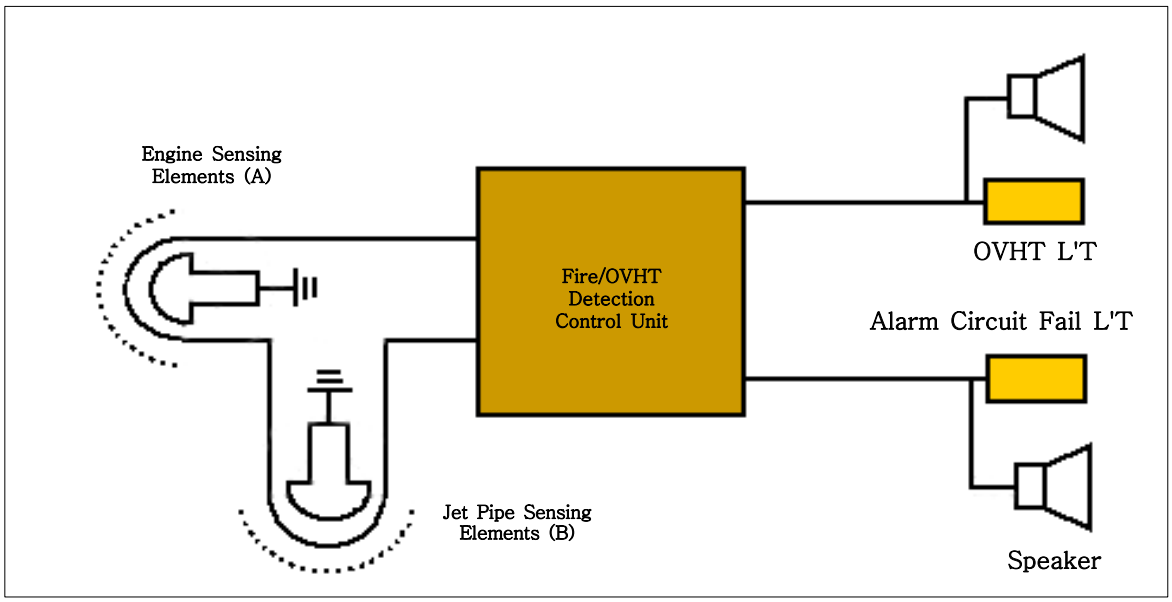
- Basic Empty Weight (BEW).....25,814 lbs
- Pilots (2 persons).....340 lbs
- Standard Operating Weight (SOW).....26.154 lbs
- Total Traffic Load (TTL).....804.9 lbs

- Zero Fuel Weight (ZFW).....26,958.9 lbs
- Takeoff Fuel (TOF).....17,000 lbs
- Takeoff Weight (TOW).....43,958.9 lbs
- Trip Fuel (TIF).....12,000 lbs
- Landing Weight (LDW).....31,958.9 lbs
- Takeoff Weight Center of Gravity (TOW C.G % MAC): 23.66% MAC (20 - 35%)

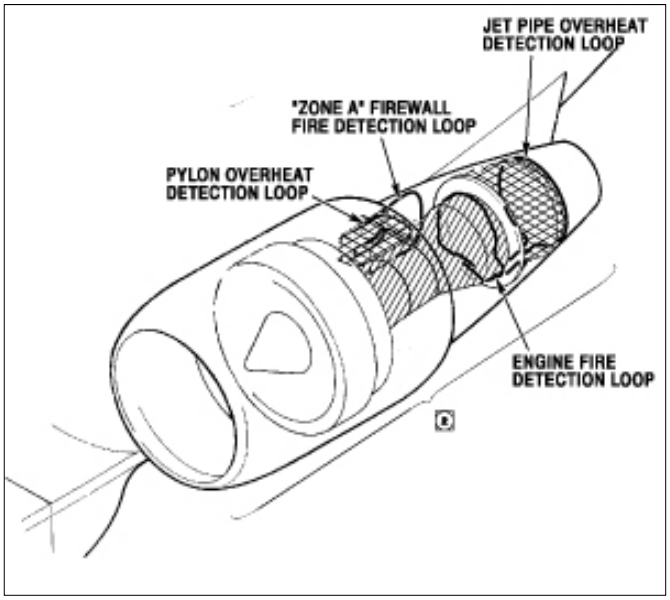
1.6.2 Fire/Overheat Detection System

1.6.2.1 General

Fire and overheat detection is provided for five areas: two for each nacelle and one for the auxiliary power unit (APU). As shown in [Figure 5], sensing elements for engines are installed in the area within the outer cowling and around the engine combustion section (Zone A), and in the jet pipe area aft of the engine firewall (Zone B). Fore of the firewall is Zone A, whereas aft of it is Zone B. The diagram of the fire/overheat detection system is as shown in [Figure 4], while installation positions of the sensing elements are as shown in [Figure 5].



[Figure 4] Diagram of Fire/Overheat Detection System



[Figure 5] Installation Positions of Sensing Elements

1.6.2.2 Sensing Elements

Each sensing element is a co-axial cable[11] with a stainless steel outer conductor grounded to the aircraft and an inner conductor connected in a closed loop to a fire and overheat detector control unit. The two conductors are separated by a semiconductor medium which decreases in electrical resistance as temperature increases. A break in an element will not impair its temperature sensing function, but if an element is broken in more than one place, any section between breaks will not function.

As for HL7577, the left and right engines each have four sensing elements: one located at the Zone A firewall, which is in series with the one routed around the engine combustion section in Zone A; and one routed around the jet pipe in Zone B, which is in series with the one routed through the pylon in Zone B.

Types of sensing elements and their alarm temperatures are as shown in [Table 4]. The alarm temperature is the temperature at which the alarm would operate if the entire length of the fire detector element

11) A cable with an inner conductor surrounded by an insulator surrounded by an outer conductor

was uniformly heated.

Zone	Location	Element Length	Alarm Temperature
A	Zone A Combustion	104.0 in	473°C (884°F)
A	Zone A Firewall	30.0 in	473°C (884°F)
B	Jet pipe	120.0 in	522°C (973°F)

[Table 4] Types of Sensing Elements & Alarm Temperatures

1.6.2.3 Fire Detection Unit

Three fire detection units, one for each engine combustion zone and one for the APU, are mounted on the first officer's console in the flight compartment. Each unit contains two separate alarm circuits to discriminate between valid fire and overheat warnings and sensing elements short circuits. The circuits compare the speed and extent of sensing element resistance change and initiate fire or detector fault warnings.

1.6.2.4 Overheat Detection Unit

Two overheat detection units, one for each jetpipe/pylon, are mounted just above the floor behind the first officer's seat. The detection units are individual circuit modules which provide overheat warnings when a decrease of the sensing element resistance occurs below a set point. The units also provide an indication of overheat warning failures when the sensing element input short circuits.

1.6.2.5 Detection and Warning

When a fire or overheat condition occurs, the resistance change of the fire sensing element is detected by the fire or overheat detection unit and interpreted as either a valid fire or overheat warning or a sensing

element fault.

If a valid fire warning is received, the detection unit powers the appropriate red ENG FIRE PUSH light on the glare shield and activates the fire warning bell. In addition, if a valid APU fire warning is received, the APU fire and overheat detection control unit energizes the APU fire shutoff relay, initiating shutdown of the APU. The fire warning light and the fire warning bell continue to operate as long as a fire or overheat condition exists. The fire warning bell is silenced when the TONE MUTED switch on the aural warning test panel is pressed.

If a fire detection unit detects a short in a sensing element, it provides a ground for the appropriate FIRE WARN FAIL light on the FIRE WARNING TEST panel, and isolates the defective fire warning circuit.

1.6.2.6 Inspection Results of Sensing Elements

The ARAIB entrusted Meggitt PLC, the manufacturer of the sensing element removed from HL7577 due to a malfunction, with inspection of the element. The inspection results from Meggitt PLC are as shown in [Table 5]. Five out of six inspection items showed "no fault," but as a result of the resistance test/inspection[12] by section, sections in the middle (sections 5 - 11) showed "fault," indicating high resistance (18.1~19.3 kΩ), but the total resistance of sensing elements indicated normal. The resistance test by section can only be carried out by manufacturers or the Original Equipment Manufacturer (OEM).

When this fault occurs, No.1 JET PIPE/PYLON OVHT light is designed to come on. The manufacturer replaced the defective sensing element with a new one since it was still under warranty, and then the old one was discarded.

12) Under the resistance test, the total length of sensing elements is divided into 16 sections, each of which resistance is measured. Normal values are 10 - 15.8 kΩ.

Inspection Items	Results
1) Visual Inspection	No Fault
2) Resistance Inspection	No Fault
3) Sand Bath Inspection	No Fault
4) Thermistor Sensing Element Inspection	No Fault
5) Helium Leakage Inspection	No Fault
6) Resistance Test/Inspection by Section	18.1～19.3 kΩ (Sections in the middle)

[Table 5] Inspection Results from Manufacturer

1.7 Meteorological Information

The weather at the time when HL7577 was operated was CAVOK (ceiling and visibility O.K.) with north-northwest wind 13.0m/sec, no rain, and temperature 10℃.

1.8 Aids to Navigation

Until HL7577 took off and returned to Gimpo Airport, there was no trouble with aids to navigation. When it landed at Gimpo Airport, it used runway 32R.

1.9 Communications

There was no trouble with communications between HL7577 and the air traffic control tower at Gimpo Airport.

1.10 Aerodrome Information

Gimpo International Airport is located west of Seoul, in Gonghang-dong, Gangseo-gu, Seoul. It has two asphalt-paved runways, 32R and 14L, which are 3,600m long and 45m wide, and 3,200m long and 60m wide, respectively.

1.11 Flight Recorders

Not related to this incident.

1.12 Wreckage and Impact Information

Not related to this incident.

1.13 Medical and Pathological Information

There was no evidence indicating that pilots' medical and pathological factors could have affected this incident.

1.14 Fire

Not related to this incident.

1.15 Survival Aspects

Not related to this incident.

1.16 Tests and Research

Not related to this incident.

1.17 Organization and Management Information

Not related to this incident.

1.18 Additional Information

Not related to this incident.

1.19 Useful or Effective Investigation Technic

Not related to this incident.

2. Analysis

2.1 General

The flight crew of HL7577 held qualification certificates proper for the applicable flight and took the required rest before flight. Also, no medical factors that could have affected the flight were found.

The aircraft held a valid airworthiness certificate, and the flight concerned was carried out within the proper limits of weight and balance.

The day before the incident, the sensing element was replaced with a new one since its insulator had cracked. The results of the trial run showed that there was no malfunction, and thus the maintenance action taken was appropriate.

On the day of the incident, as the left engine's JET PIPE/PYLON OVHT light came on, the captain shut down the affected engine and returned to Gimpo Airport. It is determined that the pilot took proper action in accordance with abnormal procedures of the airplane flight manual.

The ARAIB entrusted the manufacturer with inspection of the defective sensing element. As a result, it verified that resistance values of the sensing element in the middle exceeded permitted limits.

2.2 Fire Protection System Analysis

2.2.1 In-flight Malfunction Analysis

In-flight malfunctions that had occurred for about one year between September 1, 2010 and August 26, 2011[13], the recent airworthiness inspection date, were analyzed by system (ATA) as shown

13) Source: The 2011 regular airworthiness inspection data

in [Table 6].

Meanwhile, as a result of the analysis of in-flight malfunctions for two years before the airworthiness inspection on August 26, 2011, three out of 24 malfunctions, about 13 percent of the total, were related to fire protection. Considering that small planes have about 20 systems designated by the ATA, malfunction occurrences in the fire protection system are relatively more frequent than those in other systems.

The same system was installed on both engines, but the sensing element of the left engine alone had a malfunction.

No.	ATA	System	Occurrences	Percentage
1	22	Auto Navigation	3	27.3 %
2	23	Communications	2	18.2 %
3	26	Fire Protection	2	18.2 %
4	27	Flight Control	1	9.1 %
5	30	Protection against Ice & Rain	1	9.1 %
6	34	Navigation	1	9.1 %

[Table 6] Occurrences of In-flight Malfunctions by System
(Period: Sep. 1, 2010 - Aug. 26, 2011)

2.2.2 Cause of the Malfunction

When taking actions in compliance with the Airworthiness Directive on November 25, 2010, an aircraft mechanic found a crack in the left engine's JET/PIPE sensing element insulator and replaced a defective sensing element with a new one. On November 26 after the incident, the replaced sensing element was changed once again. The ARAIB sent the element removed to the manufacturer to carry out an inspection for the purpose of analyzing the cause.

The manufacturer conducted a resistance test on the sensing element, and the result of the resistance test by section showed that the resistance of some sections was higher than normal. Therefore, the manufacturer replaced it for free since it was still under warranty.

The cause of the malfunction was not verified whether it was a manufacturing fault or a mishandling fault, but the manufacturing fault is highly likely to have occurred in that the malfunction had occurred during the warranty period, and in that except for the resistance test by section, all the inspection results including visual inspection indicated no fault.

In case that the sensing element is bent more excessively than a certain angle, however, a malfunction may occur, and thus the mishandling fault that might have occurred when the element was installed on the aircraft might have caused the malfunction, which could not be verified nevertheless.

The manufacturer or the OEM alone can carry out the resistance test by section, whereas the operator's operation maintenance crew and the Approved Maintenance Organization (AMO) repairing the sensing element cannot.

2.2.3 Maintenance Program Analysis

Korean Air, the company entrusted with maintenance, has performed scheduled maintenance of CL-601 in accordance with the Maintenance Planning Document (MPD)[14] provided by the manufacturer. To ensure timely scheduled maintenance, the company has executed maintenance management tasks by using the CAMP[15] maintenance

14) The document given to an operator by a manufacturer after the approval of the manufacturer's aviation authorities, specifying a cycle of scheduled maintenance and maintenance tasks to be conducted every cycle.

15) CAMP established in 1947 in the US offers maintenance management services to allow commercial and private jet operators to timely conduct checks in accordance with the MPD. The company executes maintenance management for 116 models of about 3,000 planes manufactured in 17 countries.

management software.

Among the maintenance tasks of the MPD, those related to the fire and overheat protection system (ATA 26) are as shown in [Table 7]. The MPD prescribes that a visual inspection of arrangement and installation of engine fire sensing elements shall be carried out every 300 hours. However, shortening this inspection interval (Maintenance Task No.: 26-10-11-2010) needs to be considered in that yearly service hours of CL601 are about 300 hours, and in that a malfunction has occurred more than once a year.

Interval (Hrs.)	Maintenance Task No.	Titles & Description
300	26-10-11-201	Engine and APU fire sensing cables - Visual check on all visible portions of the firewires, particularly around mountings and running through bulkheads
	26-21-00-204	APU fire extinguishing - Functional test on the APU fire extinguishing system
	26-23-00-208	Engine fire extinguishing - Functional test on the engine fire extinguishing system
	26-25-00-211	Portable fire extinguishers - Check on pressure
600	26-23-21-214	Engine firex discharge lines - Visual check on any chafing with the PRSOV sensing line
1200	26-10-21-203	Main landing gear bay overheat detection system - Functional test

[Table 7] Maintenance Tasks Regarding Fire & OVHT Protection Sys.

2.2.4 Service Bulletin

Service Bulletins (SB) issued by the manufacturer to improve the fire detection system performance are four in total as shown in [Table 8]. One (SB 601-1095) out of four SBs has been performed, whereas the remaining three have not.

SBs issued between July, 2006 and July, 2007 were considered by the technical department of Korean Air for whether they could be adopted and executed or not, and then after consultation with the Flight Inspection Center, the company determined not to adopt them.

SBs, 601-0574 and 601-0584, were not adopted in that the damage and installation status of sensing elements are regularly checked every 300 hours so that a malfunction can be prevented in advance. CF34-NAC-78-032 was not adopted in that related malfunctions are less likely to occur.

The aircraft operating environment has changed as follows: 1) It has been five years since Korean Air, the company entrusted with maintenance, considered whether the SBs for sensing elements could be adopted or not; 2) The aircraft grew older; and 3) The number of malfunctions related to engine fire detection has increased as described in 2.2.1.

The results of the in-flight malfunction analysis as shown in 2.2.1 showed that malfunctions related to the engine fire protection system occurred more frequently than other systems, so it is necessary to reconsider whether the SBs for sensing elements can be adopted or not.

SB No.	Title/Issue Date	Details	Category
601-0574	Improvement in Harness Routing for Jet Pipe Sensing Element /Feb. 8, 2007	Improve the harness routing for JET PIPE sensing element to correct the false JET PIPE OVHT problem (recommended to be performed with CF34-NAC-78-032).	Recommend ation (Unadopted)
601-0584	Introduction of Fire Sensing Elements /Jul. 16, 2007	Introduce a new fire sensing element with new connectors that are less prone to damage because the fire loops are prone to breakage.	Optional (Unadopted)
601-1095	Improvement in Electric Wiring for Sensing Elements	Rewire sensing elements.	Recommend ation (Adopted)
CF34-NAC -78-032	Introduction of a New Fire Detection Mounting Cover /Jul. 24, 2006	Introduce a new Mounting Cover with enhanced support for the Fire Detection System to eliminate reports of false indications due to failure of the Fire Detector at the terminal lugs, which can be attributed to vibration-induced fatigue.	Optional (Unadopted)

[Table 8] Issuance of Service Bulletins

3. Conclusions

3.1 Findings

1. The flight crew held qualification certificates proper for the applicable flight and took the required rest before flight. Also, no medical factors that could have affected the flight were found.

2. The aircraft held a valid airworthiness certificate, and the flight concerned was carried out within the proper limits of weight and balance.

3. As the left engine's JET PIPE/PYLON OVHT light came on after takeoff, the pilot shut down the affected engine in accordance with abnormal procedures and returned to Gimpo Airport.

4. The weather at the time of landing at Gimpo Airport was good, and there was no trouble with aids to navigation.

5. One day before the incident, a crack was found in the left engine's JET/PIPE sensing element insulator, and thus the sensing element was replaced with a new one. After the incident, the replaced sensing element was replaced again.

6. The resistance test on the removed sensing element by the manufacturer resulted in a fault indication that resistance values of the middle section were higher than normal, which caused the left engine's JET PIPE/PYLON OVHT light to come on.

7. Fire protection related malfunctions accounted for 13 percent of the total in-flight malfunctions that had occurred for two years.

8. Visual inspections have been conducted since the Maintenance Planning Document prescribes that a visual inspection of

arrangement and installation of engine fire sensing elements shall be carried out every 300 hours (about one year), but a malfunction occurred more than once a year for the recent two years.

9. One out of four Service Bulletins issued by the manufacturer in 2006 to improve the fire detection system performance has been performed, whereas the remaining three have not.

10. The Service Bulletins were issued to enhance the reliability of the fire detection system by replacing the existing sensing element with the more reliable one and by adjusting arrangements of sensing elements, thereby preventing the malfunction that caused this incident.

11. In 2006, Korean Air, the company entrusted with maintenance, considered whether Service Bulletins could be adopted or not, and after consultation with the Flight Inspection Center, decided not to adopt them. However, the aircraft operating environment has changed in that about five years have passed since the decision, and in that recently, the number of related malfunctions has increased.

3.2 Causes

The ARAIB determines the cause of this incident as follows:

The flight crew shut down one engine in accordance with abnormal procedures of the flight manual for the reason that the engine sensing element's malfunction caused the left engine's JET PIPE/PYLON OVHT light to illuminate.

4. Safety Recommendations

As a result of the incident investigation of HL7577, the ARAIB issues safety recommendations as follows:

To the MLTL Flight Inspection Center

1. Introduce a measure to enhance preventive maintenance, including a review of shortening the interval of a visual inspection of engine sensing elements (AIR1010-1).

2. Reconsider three Service Bulletins that were issued by the manufacturer to improve the fire detection system but not adopted by the company entrusted with maintenance, and then perform them unless special cause is shown (AIR1010-2).