# Aircraft Serious Incident Report

**Emergency Landing due to Engine Shut-down in Flight**

**Asiana Airlines**

**B777-200, HL7500**

**900 NM west of Anchorage, Altitude about 36,000 feet**

**26 December 2009**


**16 November 2011**

**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 and recommended as follows;**

*The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents, and it is not the purpose of the activity to apportion blame or liability. Any judicial or administrative proceedings to apportion blame or liability should be separate from any investigation conducted under the provisions of this Annex.*

Thus, this incident 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 Serious Incident Report

Aviation and Railway Accident Investigation Board. In-flight Engine shut down, Asiana Airlines, B777-200, HL7500, 900NM West of Anchorage, 26 December 2009. Aircraft Incident Report ARAIB/AIR-0910. Seoul, Republic of Korea

Korea Aviation and Railway Accident Investigation Board (ARAIB) is a government organization for independent investigation of aviation and railway accident, and the accident investigation shall be carried out based on the Aviation and Railway Accident Investigation Law of the Republic of Korea and Annex 13 of the Convention on International Civil Aviation.

The objective of accident or incident investigation of the Korea Aviation and Railway Accident Investigation Board is not to apportion blame or liability but to prevent accidents and incidents.

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**Asiana Airlines, Ltd. Republic of Korea**
**Emergency Landing due to Engine Shut-down in Flight**
**B777-200, HL7500**
**900 NM west of Anchorage, Altitude about 36,000 feet**
**26 December 2009, about 23:46 (Korea time)**

## Synopsis

On 26 December 2009, Asiana Airlines Flight 203, B777-200ER, HL7500 aircraft (below referred to as "HL7500") took off from Los Angeles Airport of United States and was flying 5 hours 40 minutes at about 36,000 feet, when its left engine shut down 900NM west of Anchorage, so it made an emergency landing at Anchorage Airport.

On board of HL7500 at the time were the captain, first officer and 14 flight attendants and 302 passengers, but there were no injuries to persons due to this incident.

The Aviation and Railway Accident Investigation Board (below to be referred to as "ARAIB" demounted the left engine and took it to the engine manufacturer Pratt & Whitney Company for precision disassembly investigation.

The ARAIB derived conclusions in three categories of findings related to probable causes, findings related to risk and other findings based on the findings from the investigation and issued one safety recommendation to Asiana Airlines and two to the engine manufacturer on the basis of the findings,

# 1. Factual Information

## 1.1 History of Flight

On 12 December 2009, HL7500 took off from Los Angeles Airport of United States and was flying for the Incheon International Airport for 5 hours and 40 minutes at an altitude of about 36,000 feet when the N1[1)] and N2[2)] of the left engine indicated zero and the EGT[3)] dropped abruptly before the engine shut down.

After the engine stopped the aircraft tilted to left and the master caution light came on while the "ENG Fail L" message was displayed on the cockpit instrument panel.

The pilot checked the relevant electric circuit and tried to restart the left engine, but since the N1 RPM was indicating zero, he gave up engine start-up.

The captain decided to return to the Anchorage Airport (ANC) nearby and declaring an emergency, he landed the aircraft on runway 07R of Anchorage Airport.

On-ground check showed no abnormalities at the inlet port and the exhaust port of the left engine and the fan blade, but a large quantity of metal chip was detected from the master and angle gearbox chips in the process of checking the magnetic chip detector (MCD) of the main gearbox.

## 1.2 Injuries to Persons

1) Low-pressure compressor (N1)
2) High-pressure compressor (N2)
3) Exhaust Gas Temperature

| Injury | Crew | Passenger | Total | Other |
|---|---|---|---|---|
| **Fatal** | 0 | 0 | 0 | 0 |
| **Serious** | 0 | 0 | 0 | 0 |
| **Light** | 0 | 0 | 0 | 0 |
| **No injury** | 16 | 302 | 318 | 0 |
| **Total** | **16** | **302** | **318** | **0** |

### 1.3 Damage to Aircraft

There was no external damage to the aircraft due to this incident, but the portions of the left engine main gearbox and angle gearbox were damaged.

### 1.4 Other Damage

There was no other damage.

### 1.5 Personal Information

#### 1.5.1 The Captain

The captain (age 40, male) held a valid airline transport pilot license[4], type ratings of A320, B747-400 and B747, First Class Airman Medical Certificate[5], and radio communication qualification certificate.

The captain's total flying time was 6,701 hours, including 2,342 hours on the relevant type of aircraft, 250 hours for the latest three months and 66 hours for the latest one month.

The captain took a rest for 72 hours without flight prior to the flight.

4) Qualification number: 2491

5) Certificate number: 062-6641(Valid until 30 April, 2010)

### 1.5.2 The First Officer

The first officer (age 38, male) held a valid commercial aircraft pilot license[6], A 330 type rating[7], First-Class Airman Medical Certificate, and radio communication qualification certificate.

The first officer's total flying time was 2,901 hours, including 641 hours on the relevant type of aircraft, 173 hours for the latest three months, and 56 hours for the latest one month.

The first officer took a rest for 72 hours without flight prior to the flight.

## 1.6 Aircraft Information

### 1.6.1 Aircraft History

The HL7500 was manufactured by Boeing Company of United States on 18 April 2002 before Asiana Airlines introduced and registered[8] it on 29 April 2002. It held a valid airworthiness certificate, and its total service time was 37,010 and the number of takeoffs and landings was 5,886 cycles.

### 1.6.2 Engine History

The left engine related to this incident was PW4090 engine manufactured by Pratt & Whitney of America. It was mounted on HL7500 on 9 December 2009 for operation. The TSN after manufacture was 17,272 hours and the CSN after manufacture was 2,751 cycles.

The TSO after engine overhaul was 242 hours and the number of cycles was 34.

In this country there has never been a case of PW4090 engine stop in flight until now.

6) Qualification number: 6444(Passed on 5 April 2007, issued on 26 May 2008)
7) Date obtained: 23 May 2008
8) Registration number: 2002-189

There has been no repair for the main gearbox or angle gearbox after the engine was manufactured. MCD check was done on 15 December 2009, but nothing unusual was found.

### 1.6.2 Weight and Balance

Not applied.

## 1.7 Meteorological Information

Not applied.

## 1.8 Aids to Navigation

Not applied.

## 1.9 Communications

Not applied.

## 1.10 Aerodrome Information

Not applied.

## 1.11 Flight Recorders

### 1.11.1 Cockpit Voice Recorder

The data recorded in the cockpit voice recorder mounted on HL7500 had nothing recorded that could affect this incident.

### 1.11.2 Flight Data Recorder

The data recorded in the solid-state flight data recorder mounted on HL7500 were checked to find that what the pilots perceived at the time of the incident was recorded as it was and there was no sign of the defect beforehand.

There were no N1 and N2 vibrations during flight, and no unusual sign of defect in engine operation appeared before IFSD occurred.

The indications of N2, fuel flow and oil pressure dropped rapidly to zero simultaneously.

### 1.12 Wreckage and Impact Information

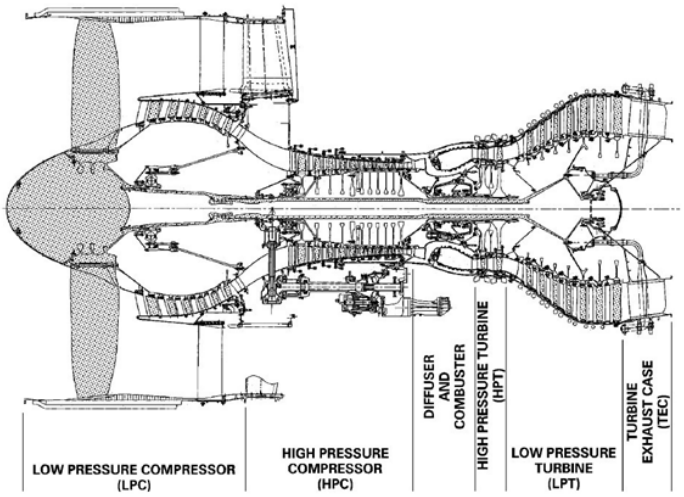
The engine had no external damage, and the metal chip detector of engine gearbox was demounted to check and a large quantity of metal chip was found as shown in Photo 1.


[Photo 1] Metal chip found in the main gearbox and angle gearbox.

Fan blade fixation did not occur.

### 1.12.1 PW4090 Engine Information

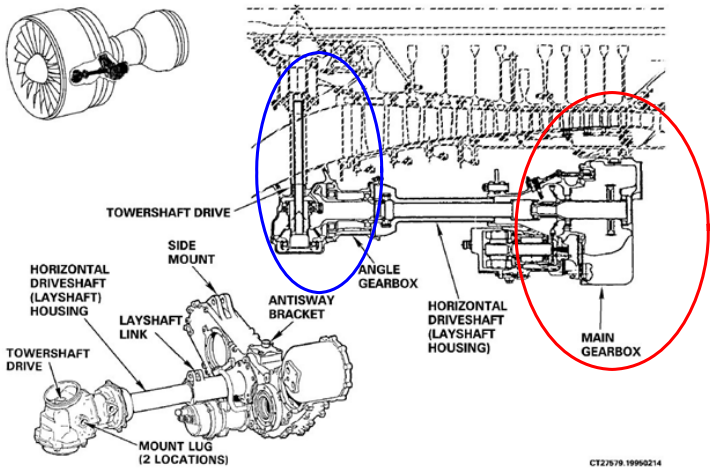
As shown in Fig. 1, the PW4090 engine is a turbofan engine developed by Pratt & Whitney Company of America to be used for B777 aircraft. Its 7-step low-pressure compressor including the first-step fan composed of 22 blades and the 11-step high-pressure compressor compress air at a ratio of about 39:1.




[Fig. 1] Basic composition of PW4090 engine

The compressed air that has passed the compressors is burned and expanded in an annular combustion chamber together with the fuel that has passed 24 fuel nozzles, and drives a two-step high-pressure turbine that is connected with the high-pressure compressor and a seven-step low-pressure turbine that drives the low-pressure compressor before it is emitted into the atmosphere.

As shown in Fig. 2, the accessory parts such as the fuel pump and the fuel regulator that get power from engine compressor are mounted on the main gearbox to be operated and the angle gearbox is mounted for operation and connection with the main gearbox.




[Fig. 2] Angle gearbox and main gearbox

The angle gearbox is operated by driving the internal gear through the towershaft connected from the high-pressure compressor, and the main gearbox is driven through the horizontal driveshaft connected from the angle gearbox.

### 1.13 Medical and Pathological Information

The flight crew members of HL7500 held valid First-Class Medical Certificates, and stated that they had not taken unusual medication or alcoholic beverage.

### 1.14 Fire

Not applied.

### 1.15 Survival Aspects

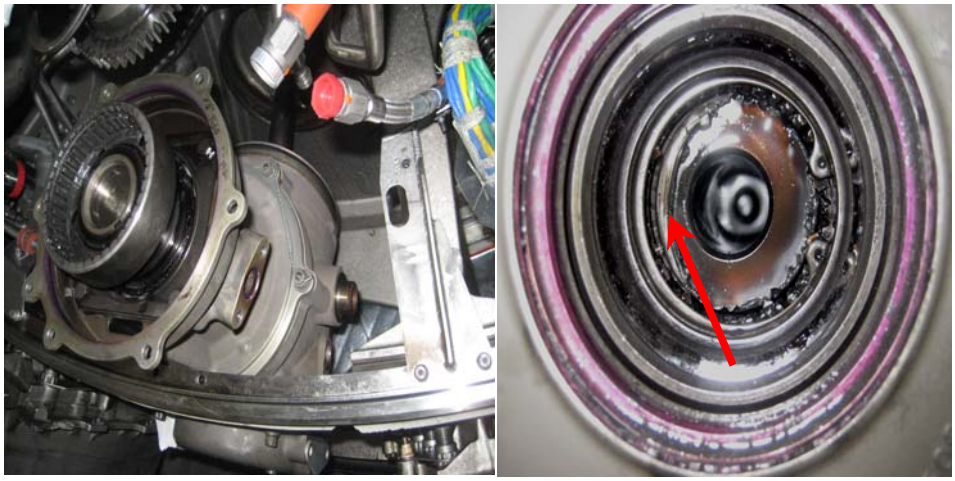
Not applied.

### 1.16 Test and Research

After the incident occurred, the ARAIB demounted the engine and took it to the engine manufacturer Pratt & Whitney Company to conduct precision disassembly investigation on the main gearbox and angle gearbox from 31 January to February 7

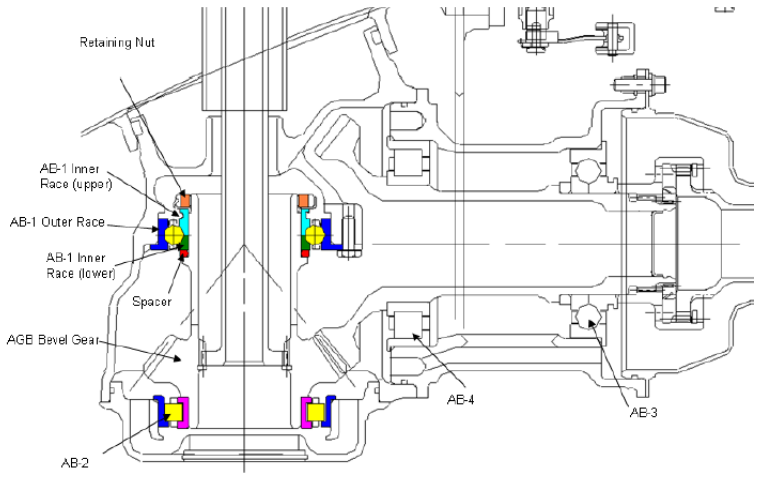
2010.

The external check on the gearboxes confirmed that the engine stopped in flight because the towershaft in the angle gearbox was separated to shut down the power of the main gearbox so that the engine accessories could not operate as shown in Photo 2.



[Photo 2] Damage to angle gearbox towershaft

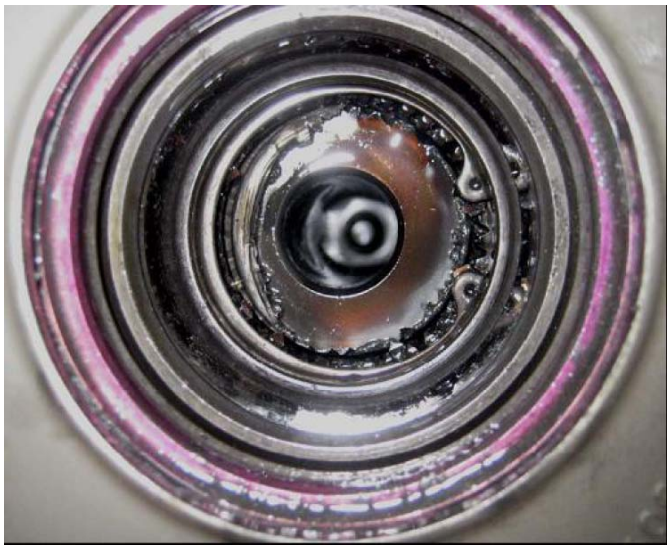
As shown in Fig. 3, the towershaft top in the angle gearbox is connected with the high-pressure compressor shaft and the bottom is connected with the horizontal driveshaft gear of the main gear box.




[Fig. 3] Towershaft support bearing

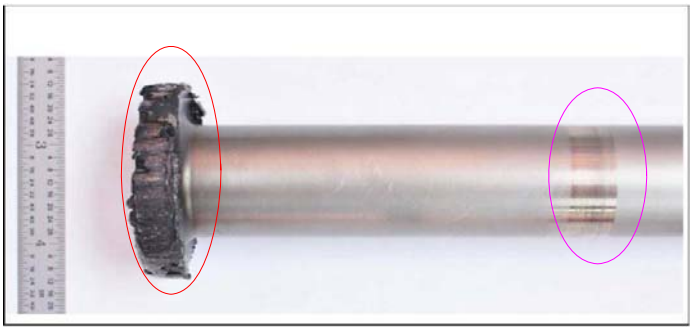
In the angle gearbox are mounted ball bearing AB-1 and roller bearing AB-2.

As shown in Photo 3, the towershaft bottom splines had severe rotational damage to make metal crumble.



[Photo 3] Damage to towershaft bottom splines

As shown in Photo 4 and Photo 5, the towershaft shank had rotational damage by contact with the loosened retaining nut of AB-1 bearing.



[Photo 4] Damage to towershaft

[Photo 5] Damage to towershaft splines

As shown in Photo 6, the AB-1 bearing bottom inner race was broken into six pieces, the top inner race was abraded by friction with the ball bearing.

[Photo 6] Damage to AB-1 bearing inner race

As shown in Photo 7, the cage was damaged to crumble, and part of it was fused with the ball bearing.

[Photo 7] Damage to ball bearing cage

As shown in Photo 8 and Photo 9, the AB-1 ball bearing inner race retaining nut lock washer was damaged and separated, and the retaining nut was loosened from the screw thread of the angle gearbox bevel gear.

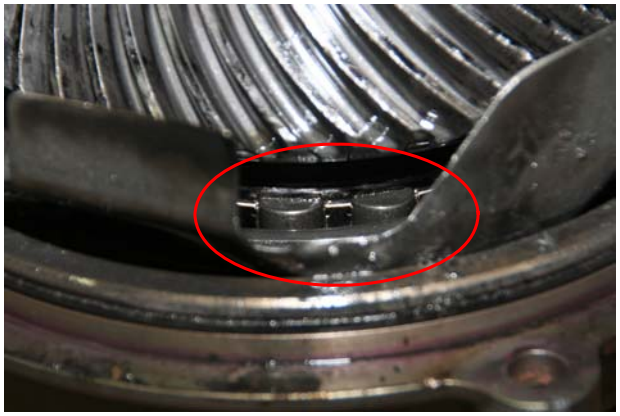
[Photo 8] Loosened AB-1 bearing inner race retaining nut

[Photo 9] Damaged retaining nut lock washer

As shown in Photo 10, 18 AB-1 bearing balls in all were found with the damaged shape different each other. Especially two balls had its size reduced significantly smaller than other balls. Some of the balls were fused with the cage and bearing race metal.

[Photo 10] Damaged bearing balls

As shown in Photo 11, there was no damage to the AB-2 roller bearings, but there were scratches by AB-1 ball bearing wreckage on the surface of both ends of some bearings.



[Photo 11] AB-2 roller bearing

As shown in Photo 2, the angle gearbox bevel gear was nicked or pressed by metal.

[Photo 12] Damage to bevel gear

Rotation of AB-3 bearing and AB-4 bearing was not smooth due to metal debris of AB-1 bearing, but there was no trace of damage to the bearing.

The components of the main gear and accessories operated functionally normally.

We looked into the work record of the gearbox made at the time of the initial engine assembly, but there was nothing unusual on the portion where the defect was discovered.

### 1.16.1 Engine Manufacturer's Recommendation and Modification

The manufacturer reviewed the history of the bearing retaining lock washer (P/N:449185) to find no problems, but they decided to revise the future maintenance manual to limit the number of usage of lock washer and add a specific service method about the use of the tool.

We consulted with Boeing Company for revision of the maintenance manual so that the master chip detector is checked every 150 hours according to the Service Bulletin (PW4G-112-79-29) and Maintenance Manual (AMM 79 -22 -00 -200 -802 -N00).

The metal contained in the oil system is to be stuck to the magnet portion of the master chip detector primarily, but if it is stuck together with oil of dark color an error can be made in reading it, so Boeing Company additionally specified in the maintenance manual on May 5, 2010 a technical method of removing the oil smeared to the chip by using alcohol or absorbing it into cloth.

## 1.17 Organization and Management Information

Not applied.

## 1.18 Additional Information

Not applied.

## 2. Analysis

### 2.1 General

The flight crew members of HL7500 held qualification certificates proper to the flight, took the specified rest before flight, and any medical factors that could impede flight were not found.

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

Any flight factors that are judged to contribute directly to the incident were not found.

### 2.2 Results of Manufacturer Test

Precision inspection to confirm the causes of damage to the angle gearbox was conducted under the control of the ARAIB.

The AB-1 bearing retaining lock washer in the angle gearbox was damaged initially by a factor with unknowable cause, and it is judged that the metal fragments got jammed between bearing balls that were rotating at high velocity to cause resistance to loosen the retaining nut.

An excessive heat was produced by friction force generated by rotation as the retaining nut was loosened and the inner race and bearing cage were separated.

The temperatures of both the bearing and cage reached almost the fusion point, so that two metals were fused, and irregular rotation continued in softened condition to make the size of bearing smaller.

The metal fragments of the damaged retaining lock washer damaged the bearing cage and the successive secondary damage is judged to have compounded the damage.

## 3. Conclusions

On the basis of the factual information and analysis of the HL7500 incident, the ARAIB developed findings[9] in three categories of findings related to probable causes[10], findings related to risk[11] and other findings.[12]

### 3.1 Findings Related to Probable Causes

The crumbling of the towershaft bottom splines in the engine angle gearbox caused the power to the main gearbox to shut off, which caused the accessory parts that drive the engine to lose their proper functions, so that the engine was shut down.

### 3.2 Findings Related to Risk

None.

### 3.3 Other Findings

1. The HL7500 flight crew members held qualification certificates proper to the

9) **Findings** are a key part of this report and are published solely to identify safety deficiencies and risk for the prevention of future accidents. Any use of the findings to assign blame or liability would be a violation of international aviation law and international best practices, including those contained in Annex 13, Chapter 3, Paragraph 3.1, and Chapter 5, Paragraph 5.4.1, to the Convention on International Civil Aviation.

10) **Findings related to probable causes** identify elements that have been shown to have operated in the incident, or almost certainly operated in this incident. These findings are associated with unsafe acts, unsafe conditions or safety deficiencies associated with safety significant event that played a major role in the circumstances leading to this incident.

11) **Findings related to risk** identify elements of risk that have the potential to degrade aviation safety. Some of the findings in this category identify unsafe acts, unsafe conditions, and safety deficiencies, including organizational and systematic risks that have the potential to degrade aviation safety; however, they cannot be clearly shown to have operated in the incident. Further, some of the findings in this category identify risks that are unrelated to this incident, but nonetheless were safety deficiencies that may warrant future safety actions.

12) **Other findings** identify elements that have the potential to enhance aviation safety, resolve an issue of controversy, or clarify an issue of unresolved ambiguity. Some of these findings are of general interest and are not necessary analytical, but are often included in the ICAO format of accident reports for informational, safety awareness, education, and improvement purposes.

flight and took the specified rest before flight. And any medical problems that could impede the flight were not found.

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

3. Any flight factors that could directly contribute to this incident were not found.

## 4. Safety Recommendations

Based on the findings from investigation of the incident in which an emergency landing was made in the Anchorage Airport because engine stopped in flight on 26 December 2009, the ARAIB issuses safety recommendations as follows.

**To Pratt & Whitney**

1. Add to the maintenance manual the contents about the method of using the angle gearbox retaining nut lock washer and the limit to the number of use. (AIR0910-1)

2. Revise maintenance manual to check the master chip detector periodically(every 150 hours) for the relevant engine angle gearbox. (AIR0910-2) - Already carried out.