

AI2006-4

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

ALL NIPPON AIRWAYS FLIGHT 198
AIRBUS INDUSTRIE A321 – 131, JA102A
AIR ABOVE APPROXIMATELY 90 KILOMETERS EAST-SOUTHEAST OF
CHUBU INTERNATIONAL AIRPORT
SEPTEMBER 29, 2005

July 28, 2006

Aircraft and Railway Accidents Investigation Commission
Ministry of Land, Infrastructure and Transport

The investigation for this report was conducted by Aircraft and Railway Accidents Investigation Commission, ARAIC, about the aircraft serious incident of All Nippon Airways flight 198 Airbus Industrie A321 – 131, JA102A in accordance with Aircraft and Railway Accidents Investigation Commission Establishment Law and Annex 13 to the Convention of International Civil Aviation for the purpose of determining cause of the aircraft accident and contributing to the prevention of accidents and not for the purpose of blaming responsibility of the accident.

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

Junzo Sato,
Chairman,
Aircraft and Railway Accidents Investigation Commission

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

**ALL NIPPON AIRWAYS FLIGHT 198
AIRBUS INDUSTRIE A321 - 131, JA102A
AIR ABOVE APPROXIMATELY 90 KILOMETERS EAST-SOUTHEAST OF
CHUBU INTERNATIONAL AIRPORT
AT ABOUT 18:56 JST, SEPTEMBER 29, 2005**

June 21, 2006

**Decision by the Aircraft and Railway Accidents Investigation Commission
(Air Sub-committee Meeting)**

Chairman	Junzo Sato
Member	Yukio Kusuki
Member	Susumu Kato
Member	Noboru Toyooka
Member	Yukiko Kakimoto
Member	Akiko Matsuo

1. PROCESS AND PROGRESS OF THE SERIOUS INCIDENT INVESTIGATION

1.1 Summary of the Serious Incident

The event covered by this report falls under the category of “multiple failures of one or more systems with which the aircraft is equipped, that hinders safety in flight of the aircraft” as stipulated in Clause 8, Article 166 - 4 of the Civil Aeronautics Regulations of Japan and, as such, is classified as a serious aircraft incident.

Designated as Flight 198, the Airbus Industrie A321-131 airplane, JA102A, operated by All Nippon Airways Co., Ltd., took off from Oita Airport on September 29 (Thursday), 2005 for Tokyo International Airport on scheduled service. About 18:56 Japanese Standard Time (JST), when flying approx. 90 km east-southeast of Chubu International Airport, the aircraft’s both air-conditioning packs became inoperative. The airplane then began an emergency descent, and the passenger oxygen masks were deployed manually by the crew. At 19:33, the aircraft landed at Tokyo International Airport.

A total of 172 people were on board, consisting of the pilot-in-command, five other crewmembers, and 166 passengers (one of whom was an infant). No one was injured.

1.2 Outline of the Serious Incident Investigation

1.2.1 Investigative Organization

On September 29, 2005, The Aircraft and Railway Accidents Investigation Commission appointed an investigator-in-charge and two investigators for the serious incident.

1.2.2 Accredited Representative Participating in the Investigation

An accredited representative of the French Republic, the state of design and manufacture of the aircraft involved in the serious incident, participated in the investigation.

1.2.3 Implementation of Investigation

September 30, 2005	Investigation of aircraft and interviews
October 3, 2005	Inspection of air-conditioning packs
October 4 and 5, 2005	Investigation of air-conditioning pack components
October 12, 2005	Investigation of air-conditioning pack components
October 13 and 14, 2005	Investigation of air-conditioning pack components

1.2.4 Interviews with Relevant Organization Personnel

Interviews were conducted with personnel of the organization relevant to the cause of the serious incident.

1.2.5 Comment from the State of Design and Manufacture

Comment was invited from the state of design and manufacture of the aircraft involved in the serious incident.

2. FACTUAL INFORMATION

2.1 History of the Flight

On September 29, 2005, the Airbus Industrie A321-131 airplane, JA102A (hereafter called “the aircraft”), operated by All Nippon Airways, Co., Ltd. (hereafter called “the company”) and designated as Flight 198 on the company’s scheduled service, took off from Oita Airport for Tokyo International Airport.

The aircraft flight plan submitted to the Oita Airport Office is outlined below.

Flight rules: Instrument flight rules (IFR)

Departure aerodrome: Oita Airport

Estimated off-block time: 18:10

Cruising speed: 460 knots

Cruising altitude: FL370

Route: MPE (Matsuyama VOR) – V40 (Airway) – KTE (Kagawa VOR) – V17 (Airway) – XMC (Kowa VORTAC) – G597 (Airway) – XAC (Oshima VORTAC) – Y211 (Airway) – WESTN (Reporting point)

Destination aerodrome: Tokyo International Airport

Total estimated elapsed time (EET): 1 hr and 9 min

Alternate aerodrome: Narita International Airport

Endurance: 2 hrs and 40 min

The aircraft took off from Oita airport at 18:16 with 172 people on board, including the pilot-in-command, five other crewmembers, and 166 passengers. In the cockpit, the pilot-in-command sat in the left seat as pilot flying (primarily responsible for aircraft maneuvering) while the first officer sat in the right seat as pilot not flying (primarily responsible for non-maneuvering tasks).

The subsequent flight history of the aircraft, as summarized below, was determined based on statements from the crew and records of the digital flight data recorder (hereafter called “DFDR”), cockpit voice recorder (hereafter called “CVR”), quick access recorder (hereafter called “QAR”), ATC communications, etc.

At about 18:49, when the aircraft was flying at a pressure altitude (hereafter called “altitude”) of 37,000 ft (approx. 7,400 ft in cabin altitude), the “AIR PACK1 OVHT”^{*1} and then “AIR PACK1 FAULT”^{*2} messages were displayed on the electronic centralized aircraft monitor (hereafter called “ECAM”) and the “FAULT” light on the

^{*1} The “AIR PACK1 OVHT” message indicates that the compressor outlet temperature of PACK1 has reached the specific temperature stated in 2.9.1. This also applies to PACK2.

^{*2} The “AIR PACK1 FAULT” message indicates that a fault has occurred that requires PACK1 to be shut off. This also applies to PACK 2.

cockpit control panel came on. The pilot-in-command took ECAM Action^{*3}, setting the PACK1 switch on the control panel to OFF to shut off PACK1. Approximately 30 seconds later, he observed that the “FAULT” light on the control panel went off. After confirming on the ECAM that the compressor outlet temperature of PACK1’s air cycle machine (ACM) had dropped to approx. 180°C, almost the same level as that of PACK2’s ACM, the pilot-in-command set the PACK1 switch on the control panel to ON in order to reset PACK1. A few seconds later, the “AIR PACK1 OVHT” message appeared again on the ECAM and PACK1 reverted to the FAULT condition. As soon as this occurred, the pilot-in-command set the PACK1 switch to OFF again and shut off PACK1 at around 18:50.

As the aircraft was approaching the scheduled point for starting a descent from the cruising altitude, the pilot-in-command told the first officer that the aircraft would promptly start a descent upon clearance from the Tokyo Area Control Center (hereafter called “Tokyo Control”). The aircraft continued to maintain the cruising altitude of 37,000 ft. At about 18:56, the “AIR PACK2 OVHT” message appeared on the ECAM followed by “AIR PACK2 FAULT.” Placed in a situation in which both PACKs had failed and maintaining appropriate cabin altitude was impossible, the pilot-in-command started an emergency descent. At about 18:57, the crew notified Tokyo Control that the aircraft was in an emergency descent^{*4} to 13,000 ft and received permission. At the onset of the emergency descent, the pilot-in-command and the first officer donned their oxygen masks and performed a series of necessary actions including the “emergency descent checklist.” When the pilot-in-command turned the “Cabin Sign” ON to prompt the passengers to fasten their seat belts, he informed the cabin attendant (hereafter “CA”) who was acting for the chief purser (hereafter called “CP”) that the aircraft was in an emergency descent due to an air-conditioning system failure and was told by the CP that there were no abnormalities with the cabin or the passengers. At about 18:58, the pilot-in-command performed ECAM Action, setting the PACK2 switch on the control panel to OFF in order to shut off PACK2. While the cabin altitude rose at a moderate rate of 500 ft per minute, at about 19:02 when the aircraft was descending, passing an altitude of approx. 17,700 ft, the cabin altitude rose to approx. 8,140 ft, a level higher than the maximum level of 8,000 ft for normal flight. In response to this, the pilot-in-command

^{*3} “ECAM Action” is a set of steps displayed on the ECAM screen and the actions taken by the pilot following the steps.

^{*4} The prescription concerning ECAM Action in an emergency-descent situation specifies that the aircraft shall descend to an altitude of flight level (FL) 100, minimum en-route IFR altitude (MEA), or altitude with sufficient separation from obstacles, whichever is highest. With the aircraft involved in this serious incident, the pilot-in-command chose 13,000 ft as an initially descending altitude limit considering safe distance from mountains under poor visibility conditions due to evening darkness.

had the first officer deploy the oxygen masks in the cabin. At about 19:04, when the aircraft descended to 10,000 ft, the pilot-in-command and the first officer took off their oxygen masks. The cabin altitude of the aircraft had then reached approx. 8,750 ft, the highest level since the aircraft had started its emergency descent. At about 19:07, when the aircraft was about 30 nautical miles west-southwest of Oshima VORTAC at an altitude of approx. 8,000 ft, the pilot-in-command opened the “ram air valve^{*5}” through ECAM Action. At about 19:08, the pilot-in-command announced over the public address system, “The aircraft had to make an emergency descent because of an air-conditioning system failure, but now the aircraft has reached a safe altitude and so you may take off your oxygen masks,” and confirmed with the CP that the passengers were still in a normal state. At 19:33, the aircraft landed at Tokyo International Airport.

This serious incident occurred about 18:56, in air approximately 90 kilometers east-southeast of Chubu International Airport.

(See Figures 1 and 2.)

2.2 Injuries

None

2.3 Damage to the Aircraft

None

2.4 Pilot Information

(1)	Pilot-in-command	Male, 48 years old	
	Airline transport pilot certificate (Airplane)		February 28, 1996
	Type rating for Airbus Industries A320		April 19, 2000
	1st class aviation medical certificate		
	Validity		Until February 9, 2006
	Total flight time		10,045 hrs and 19 min
	Flight time in the last 30 days		49 hrs and 4 min
	Flight time on the aircraft type		2,246 hrs and 37 min
	Flight time in the last 30 days		49 hrs and 4 min
(2)	First officer	Male, 34 years old	
	Commercial pilot certificate (Airplane)		November 18, 1997
	Type rating for Airbus Industries A320		October 19, 2000
	1st class aviation medical certificate		

^{*5} The purpose of the ram air valve is to bring outside air (ram air) into the air-conditioning system.

Validity	Until October 1, 2005
Total flight time	3,011 hrs and 0 min
Flight time in the last 30 days	47 hrs and 30 min
Flight time on the aircraft type	2,755 hrs and 40 min
Flight time in the last 30 days	47 hrs and 30 min

2.5 Aircraft Information

2.5.1 Aircraft

Type	Airbus Industries A321-131
Aircraft serial number	811
Date of manufacture	April 21, 1998
Certificate of airworthiness	DAI 98-005
Validity	Period during which the maintenance manual (All Nippon Airways Co., Ltd.) is effective since April 21, 1998.
Categories	Airplane, Transport category
Total flight hours	17,069 hrs and 53 min
Flight time since last A01C inspection (August 6, 2005)	373 hrs and 12 min

2.5.2 Engine

Type	International Aero Engines V2530-A5	
	No.1	No.2
Engine serial number	V10326	V10563
Date of manufacture	January 29, 1998	April 8, 1999
Total time in service	12,874 hrs and 52 min	13,826 hrs and 14 min

2.6 Meteorological Information

The synoptic weather report at around the time of the serious incident was as follows:

A high belt prevailed across Japan, from the Sea of Japan to the eastern part of Hokkaido, which was slowly moving east. Typhoon No. 15, at the time far southeast of Okinawa, was slowly moving north. Cloudy skies extended from the Chubu to Kanto areas, with moderate northeasterly winds.

2.7 Information on DFDR and CVR

The aircraft was equipped with a DFDR (P/N 980-4700-003) and a CVR (P/N 980-6022-001), both made by AlliedSignal Inc. (now Honeywell Inc.) of the United States of America.

Both the DFDR and CVR retained a record of the aircraft's operation during the

period from takeoff at Oita Airport to landing at Tokyo International Airport.

For the purpose of time collation, the VHF transmitter keying signals recorded in the DFDR during communications between the flight crew and ATC were correlated with the NTT-broadcast time signals that were recorded in the ATC communications record.

The aircraft's QAR data was used for analysis the operation of the air-conditioning systems.

2.8 History of Air-Conditioning System Related Events as Derived from DFDR and Other Data

18:15:31	The aircraft took off from Oita Airport.
18:43:12	The aircraft reached a cruising altitude of 37,000 ft (cabin altitude at 7,400 ft).
About 18:49	PACK1's compressor outlet temperature reached approx. 230°C four times.
18:49:22	"AIR PACK1 OVHT" warning was displayed on ECAM.* ⁶
18:49:22	"AIR PACK1 FAULT" warning was displayed on ECAM.
18:49:38	PACK1 was switched OFF.
18:49:38	Flow rate of the flow control valve (hereafter called "FCV") 1 began decreasing.
18:49:40	FCV1 was fully closed.
18:50:10	PACK1 was switched ON.
18:50:10	Flow rate of FCV1 began increasing.
18:50:14	"AIR PACK1 OVHT" warning was displayed on ECAM.
18:50:14	"AIR PACK1 FAULT" warning was displayed on ECAM.
18:50:24	PACK1 was switched OFF.
18:50:24	Flow rate of FCV1 began decreasing.
18:50:26	FCV1 was fully closed.
18:55:58	PACK2's compressor outlet temperature reached approx. 260°C.
18:55:58	"AIR PACK2 OVHT" warning was displayed on ECAM.
18:55:58	"AIR PACK2 FAULT" warning was displayed on ECAM.
18:56:07	The aircraft started an emergency descent from altitude of 37,000 ft.
18:57:19	"Descending to 13,000 ft" was radioed to Tokyo Control.
18:58:05	PACK2 was switched OFF.
18:58:05	Flow rate of FCV2 began decreasing.
18:58:06	FCV2 was fully closed; cabin altitude began increasing.

*⁶ While no specific DFDR and QAR records were available on the PACK "OVHT" and "FAULT" display timing and PACK switch operation timing, occurrence of such events and their timing are described referring to other relevant records and data.

18:59:29 Clearance for descent to 10,000 ft was requested to Tokyo Control.

19:01:50 The aircraft passed an altitude of 17,700 ft (cabin altitude at 8,140 ft).

19:01:50 Cabin oxygen masks were dropped.

19:04:39 The aircraft reached an altitude of 10,000 ft (cabin altitude at 8,750 ft).

19:05:33 Clearance for descent to 8,000 ft was requested to Tokyo Control.

19:07:43 Ram air valve was opened.

19:08:05 Permission to take off oxygen masks was announced to passengers.

19:08:07 The aircraft leveled off at 8,000 ft.

19:33:13 The aircraft landed at Tokyo International Airport.

(See Figure 3.)

2.9 Fact-Finding Tests and Research

2.9.1 Outline of the Air-Conditioning Systems

(1) The air-conditioning system installed on the aircraft incorporates a PACK temperature controller (hereafter called “PTC”) and zone temperature controller, which automatically keep the aircraft interior air-conditioned to the settings made on the air-conditioning control panel in the cockpit. Bleed air from both engines flows through the corresponding FCVs and PACKs and is led to the mixing unit before being distributed to three zones, i.e. the cockpit, forward cabin, and aft cabin.

(2) Each FCV regulates the flow rate by changing the position of the butterfly valve in it.

(3) Three FCV flow modes are available: ECON, NORMAL and HIGH. Among these, the ECON and NORMAL flow modes can be selected from the cockpit control panel.

ECON flow mode (80%) This mode is used for economic operation when 100% flow is not required.

NORMAL flow mode (100%) This mode is for normal operation in which the two PACKs are used.

HIGH flow mode (120%) This mode is for when one of the two PACKs is inoperative. If one PACK becomes inoperative, the other PACK is automatically set to the 120% flow rate.

(4) In an emergency, the ram air valve can be opened to let outside air (ram air) into the mixing unit.

(5) The PACK OVHT warning comes on when either of the following conditions is met concerning the compressor outlet temperature:

① A 230°C temperature is reached four times (once after resetting has been made).

② A 260°C temperature is reached once.

(6) The air-conditioning system is provided with an overheat protection feature that

operates as follows depending on the compressor outlet temperature:

- ① When the compressor outlet temperature reaches 205°C, the PTC prevents the ram air door (hereafter called “RAD”) from closing further.
- ② When the compressor outlet temperature reaches 210°C, the PTC causes the RAD to fully open.
- ③ When the compressor outlet temperature reaches 230 °C , the compressor pneumatic overheat sensor (hereafter called “CPNOH”) opens the vent and releases the pressure, which moves the FCV in the closing direction.
- ④ When the compressor outlet temperature reaches 260°C, the CPNOH releases the pressure, which moves the FCV to the fully closed position.

(7) When one of the PACKs fails during flight, the maximum operating altitude is 39,000 ft, the same altitude as when both PACKs are in operation.

If the aircraft flies with only one PACK initially operated and continues to fly without using the other PACK, then the maximum operating altitude is 31,500 ft.

(See Figure 4.)

2.9.2 Maintenance Program and Procedure for the Air-Conditioning System

The company applies a reliability monitoring method^{*7} to the maintenance related to the FCVs and CPNOHs as specified in the applicable maintenance manual. FCVs are classified as those components for which technical actions should be taken as necessary considering past removal history. The filter in the P1 probe had been cleaned every time the FCV was removed, and there were no overheating events experienced prior to the last FCV removal. CPNOHs are classified as other category components that are controlled through monitoring of the air-conditioning system; they had almost no past removal experience.

2.9.3 Inspection of the Air-Conditioning System Components

The FCV1, FCV2, PACK1 and PACK2 were all removed from the air-conditioning systems on the aircraft and subjected to functional inspection and teardown inspection in accordance with the methods specified by the manufacturer. Of the removed components, those having a connection to this serious incident are listed below.

Component	No.1 P/N	No.1 S/N	No.1 TSCO ^{*8}	No.1 TT ^{*9}
	No.2 P/N	No.2 S/N	No.2 TSCO	No.2 TT

^{*7} With the “reliability monitoring method”, optimum maintenance timing and menus are determined either through monitoring in which in-flight equipment conditions are assessed from collected data or through sampling in which predetermined components are removed from the aircraft for assessment.

^{*8} Time since conditional overhaul

^{*9} Total time

FCV	751B0000-02	10307	4,532 hrs	10,194 hrs
	751B0000-02	10261	4,159 hrs	9,642 hrs

Component	No.1 P/N	No.1 S/N	TT (No. 1 and No. 2)
	No.2 P/N	No.2 S/N	
CPNOH	766A0000-01	02174	17,069 hrs
	766A0000-01	02205	

The defects found as a result of the above inspections are as tabled below.

In the table, the discharge values (rates and pressures) indicated are only those measured under a 100% flow-rate condition. Similar tendencies were observed under other flow-rate conditions.

		FCV1	FCV2
Functional inspection	Under dynamic pressure ^{*10}	121.3 pounds/min (ppm) (Standard value: 86.9 – 93.4 ppm)	102.8 ppm (Standard value: 86.9 – 93.4 ppm)
	Under static pressure ^{*11}	192 mbar (Standard value: 105 – 115 mbar)	128 mbar (Standard value: 105 – 115 mbar)
		122 mbar after installing a new filter in P1 probe. ^{*12}	114 mbar after installing a new filter in P1 probe.
Teardown inspection	Blocked filter in P1 probe	5.63 psig (Upper limit: 0.87psig)	2.06 psig (Upper limit: 0.87 psig)
	Contamination	Contamination on inner sliding/contact surfaces Traces of black soot-like substance present near G11 jet located downstream of P1 probe filter	
		Large contamination	Small contamination

	CPNOH1	CPNOH2
Functional inspection	Failed to fall within the standard ranges in both leak and functional checks.	
Teardown inspection	Large contamination (adhesion of foreign matter and blockage)	

(See Figures 4 and 5.)

^{*10} Inspection was conducted while letting air equivalent to actual bleed-air flow through the FCV. The indicated discharge value is a flow-rate value.

^{*11} Inspection was conducted only applying the same static pressure as the actual working pressure. The indicated discharge value is a pressure value.

^{*12} The filter is installed in the P1 probe, which picks up the pressure in the FCV, in order to remove foreign matter from bleed air.

3. ANALYSIS

3.1 The pilot-in-command of the aircraft possessed proper airman competency certification and a valid aviation medical certificate.

3.2 The aircraft had been certified for airworthiness and had been maintained/inspected in accordance with the specified program.

3.3 It is estimated that the serious incident was not influenced by weather conditions prevailing at the time of its occurrence.

3.4 Analytical Description

3.4.1 Primary Cause for the Air-Conditioning System Failure

Based on the results of the inspections described in 2.9.3, it is estimated that the factors primarily contributing to the failure of the air-conditioning system on the serious incident aircraft are the following.

(1) FCV

The filter in the P1 probe having become blocked impaired the normal flow-rate control function of the FCV, which resulted in 130% or more bleed-air flow, as measured at FCV1, to PACK1 and 110% or more bleed-air flow, as measured at FCV2, to PACK2, both exceeding the demanded level (100%) set by the flight crew.

On the other hand, when PACK1 was switched OFF and an automatic shift to the HIGH flow mode then took place, bleed air at flow rate of 130%, rather than 120% as designed, flowed through the FCV2 to the PACK2.

(2) CPNOH

Having been affected by contamination, the CPNOH lost its function to properly release pressure depending on temperature change. This functional deterioration of the CPNOH resulted in the FCV failing to move in the closing direction when the compressor outlet temperature exceeded 230°C.

In other words, the threshold at which the overheat protection function should start working had high-shifted^{*13}, causing a delay in pressure releasing.

(3) Contamination source

It is estimated that the events described in (1) and (2) above may have been caused by contaminants contained in bleed air supplied through the components located upstream of the air-conditioning system, such as the engine compressors. However, it was not possible to clarify the mechanism whereby the bleed air might have been contaminated.

^{*13} “High-shift” means that the pressure release start temperature becomes higher than the preset threshold.

Anticipating the unavoidability of aircraft air-conditioning systems using bleed air, including that from APU while the aircraft is on the ground, which is usually contaminated to a certain degree, air-conditioning system manufacturers provide various measures to prevent contaminants from negatively affecting the system. In fact, for the P1 filter mentioned in (1) above, a new improved type is now available and the company (All Nippon Airways Co., Ltd.) will be modifying their fleet's FCVs by installing the new type of filters according to a schedule. The filters used in the aircraft involved in the serious incident were of the current type.

3.4.2 Process Leading to PACK Fault

When estimated mainly based on the factors discussed in 3.4.1, the process in which the series of events described in 2.1 and 2.8 concerning with the air conditioning system took place would have been as follows. The small alphabets at the end of each process step correspond to those in Figure 3.

(1) PACK1

- ① As the FCV flow control thresholds had high-shifted on both PACKs, a greater-than-normal flow of air entered the ACMs. This caused the compressors to run faster, resulting in higher-than-normal temperatures at the compressor outlets. At the same time, the speed of the ACM turbines increased, causing the temperatures at the PACK outlets to drop below the normal level. …… a
- ② In order to achieve PACK outlet temperatures corresponding to the temperature settings for each zone, the two PTCs caused the RADs to move towards the closing direction. …… b
- ③ As the PTC had reached its capability limit for controlling the temperature (through moving the RADs and bypass valves according to change in compressor outlet temperature), the compressor outlet temperature rose, while the PACK outlet temperature dropped again. …… c
- ④ The compressor outlet temperature continued to rise until the compressor outlet temperature sensor (hereafter called “CDS”) in PACK1 sensed a temperature of 205°C, upon which the PACK1 PTC initiated its control to prevent the RAD from moving further in the closing direction. …… d
- ⑤ The PACK1 compressor outlet temperature still continued to rise until the CDS sensed 210°C, in response to which the PACK1 PTC operated so as to drive the RAD to the fully-open position. …… e
- ⑥ Although subsequent PTC control successfully stabilized the PACK1 compressor outlet temperature at around 230°C, four instances occurred in which 230°C was exceeded, which triggered ECAM warnings. Even at this time, the overheat protection had not yet been initiated due to a contaminated CPNOH. In other words, pressure release from the FCV1 pneumatic chamber was not started, preventing

FCV1 from closing.f

⑦ The flight crew turned OFF the PACK1 control switch, which caused FCV1 to close, the compressor outlet temperature to drop in turn, and the warning to extinguish. The flight crew switched ON PACK1 again.g

⑧ Approximately 4 seconds after the above flight crew's action, the PACK1 compressor outlet temperature reached 205°C, which triggered the ECAM warning again. The flight crew then switched OFF PACK1, so there was no bleed air flowing to PACK1.h

(2) PACK2

⑨ Switching off the PACK1 caused the PACK2 to automatically shift into the HIGH flow mode. However, due to a high-shift of the pressure release threshold temperature in FCV2, air entered the ACM at an abnormally high flow rate (130% of normal flow) rather than at the designed HIGH flow rate (120% of normal flow rate), causing the compressor outlet temperature to rise rapidly.i

⑩ The PACK2 CDS sensed a compressor outlet temperature of 205°C and then 210°C, with resultant PTC operation to fully open the RAD. This helped to slightly slow down the rise in the compressor outlet temperature, but was not enough to lower the temperature. The temperature continued to rise.j

⑪ The compressor outlet temperature reached 260°C, triggering ECAM warning, and simultaneously, the flow rate of air to PACK2 started to decrease. This means that contamination delayed the CPNOH overheat protection start timing, which should have been at 230°C, until a temperature around 260°C was reached.k

⑫ The flow rate of air to PACK2, which had decreased once, started to increase again. This was caused by FCV2 moving in the closing direction, with a consequent drop in the compressor outlet temperature and resetting of the CPNOH overheat protection.l

⑬ Momentarily after a rise in the PACK2 air flow rate following the opening of FCV2, the flight crew switched OFF PACK2 on the control panel; air flow to PACK2 was stopped.m

(See Figure 3.)

3.5 Air-Conditioning System Maintenance

As described in 2.9.3, 3.4.1, and 3.4.2, this serious incident inflicted a situation on the aircraft where both PACKs had to be shut off under the effect of the FCVs and CPNOHs in which degradation in performance was detected. It is considered that the company employed the maintenance method described in 2.9.2 on the assumption that chances of both PACKs becoming simultaneously inoperative during a flight, as in the serious incident, would be extremely low. However, concurrent shut off of both PACKs would cause a serious threat to

flight safety. Considering this, improvement efforts towards appropriate repair, replacement, etc. need to be put in place by adopting such measures as monitoring of the air-conditioning system operation.

4. PROBABLE CAUSE

It is estimated that this serious incident was caused by contamination and resultant performance degradation of air-conditioning system components (FCVs and CPNOHs), which prevented the air-conditioning system from operating normally and made continuous use of the system impossible.

5. REFERENTIAL MATTERS

5.1 Measures taken by the company

The company has taken the following actions to prevent recurrence of similar events.

- (1) Modification of FCVs (installation of new-type filters in P1 probes - Permanent measure)
- (2) Periodical replacement of current-type FCV P1 probe filters (temporary measure until completion of the modification)
- (3) Replacement of CPNOHs with those for which prescribed maintenance has been accomplished
- (4) Establishment of a system for in-flight monitoring of the PACKs on each aircraft

5.2 Technical Information distributed by Airbus

The items concerning the air conditioning system in the Technical Information that Airbus Industrie distributed before occurrence of this serious incident are as follows.

The company (All Nippon Airways Co., Ltd.) had addressed this information before occurrence of the serious incident.

- (1) Pressure Probes and Filter for FCV 751xx(TFU REF:21.51.51.008)
- (2) Flow Control Valve-Installation of an Air Filter(SIL Number:21-101)
- (3) Hot Day-Cabin Cooling Capabilities(SIL Number:21-094)

Figure 1 Estimated Flight Path

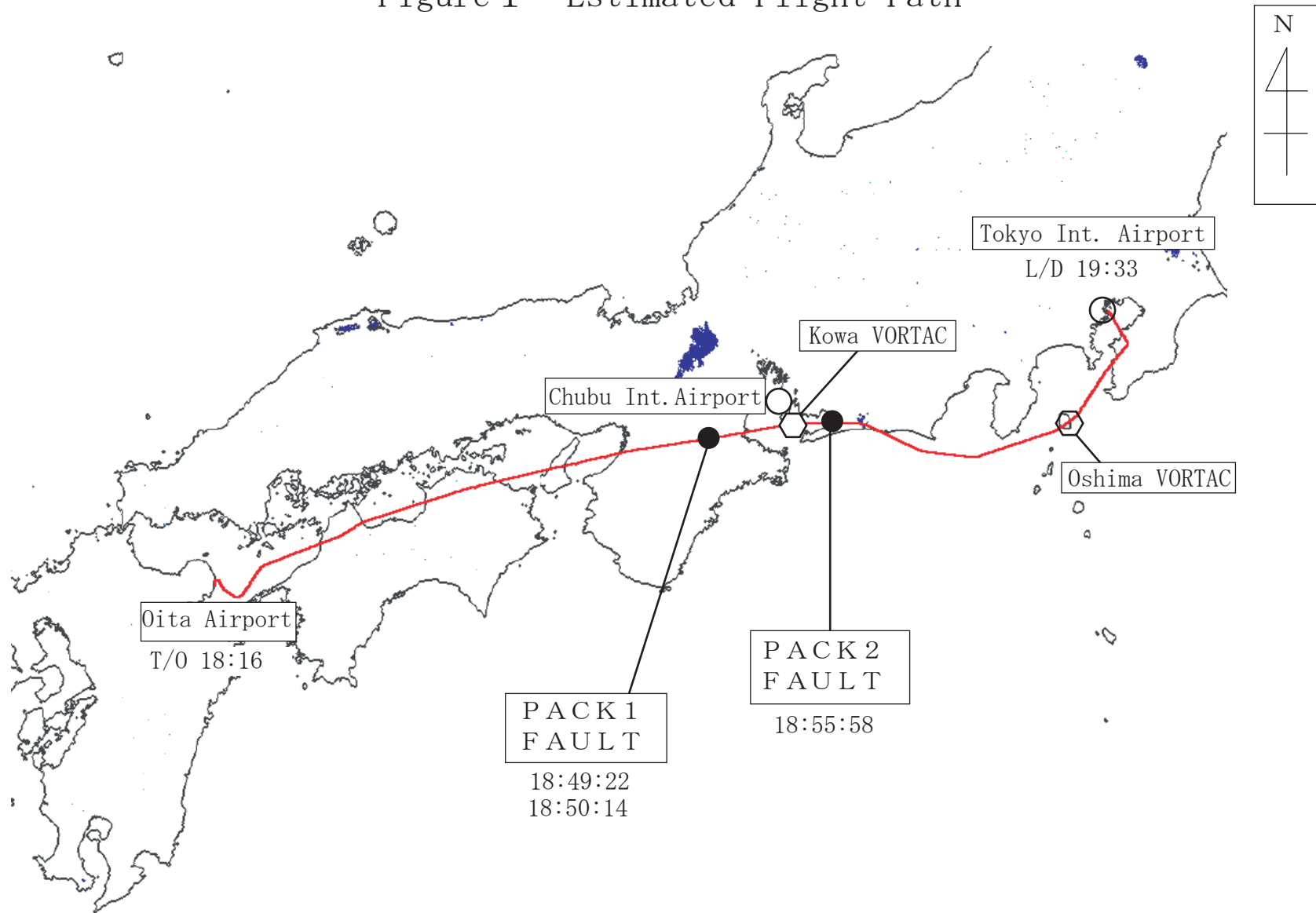


Figure2 Three Views AIRBUS Industry A321-131

Unit : m

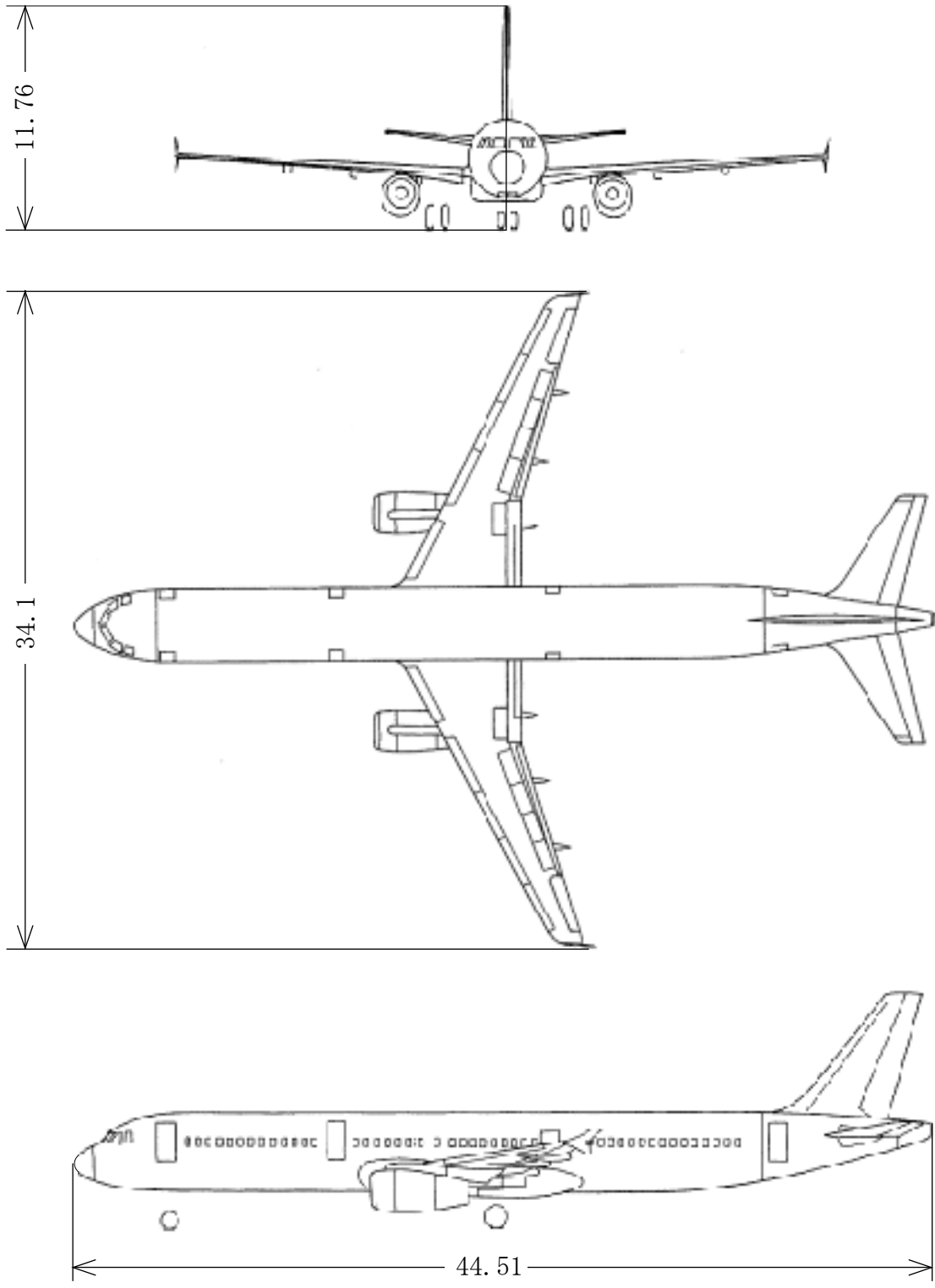
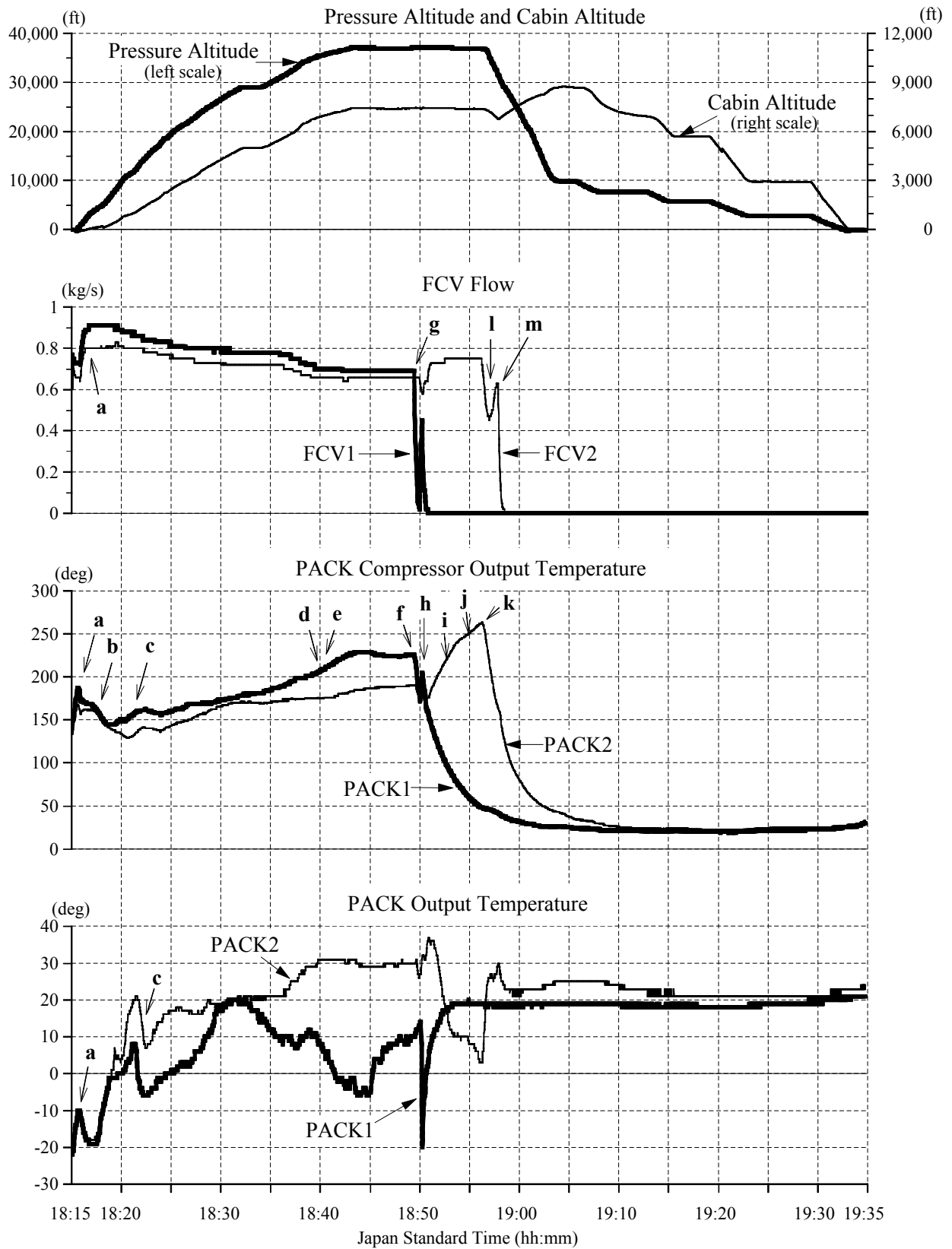
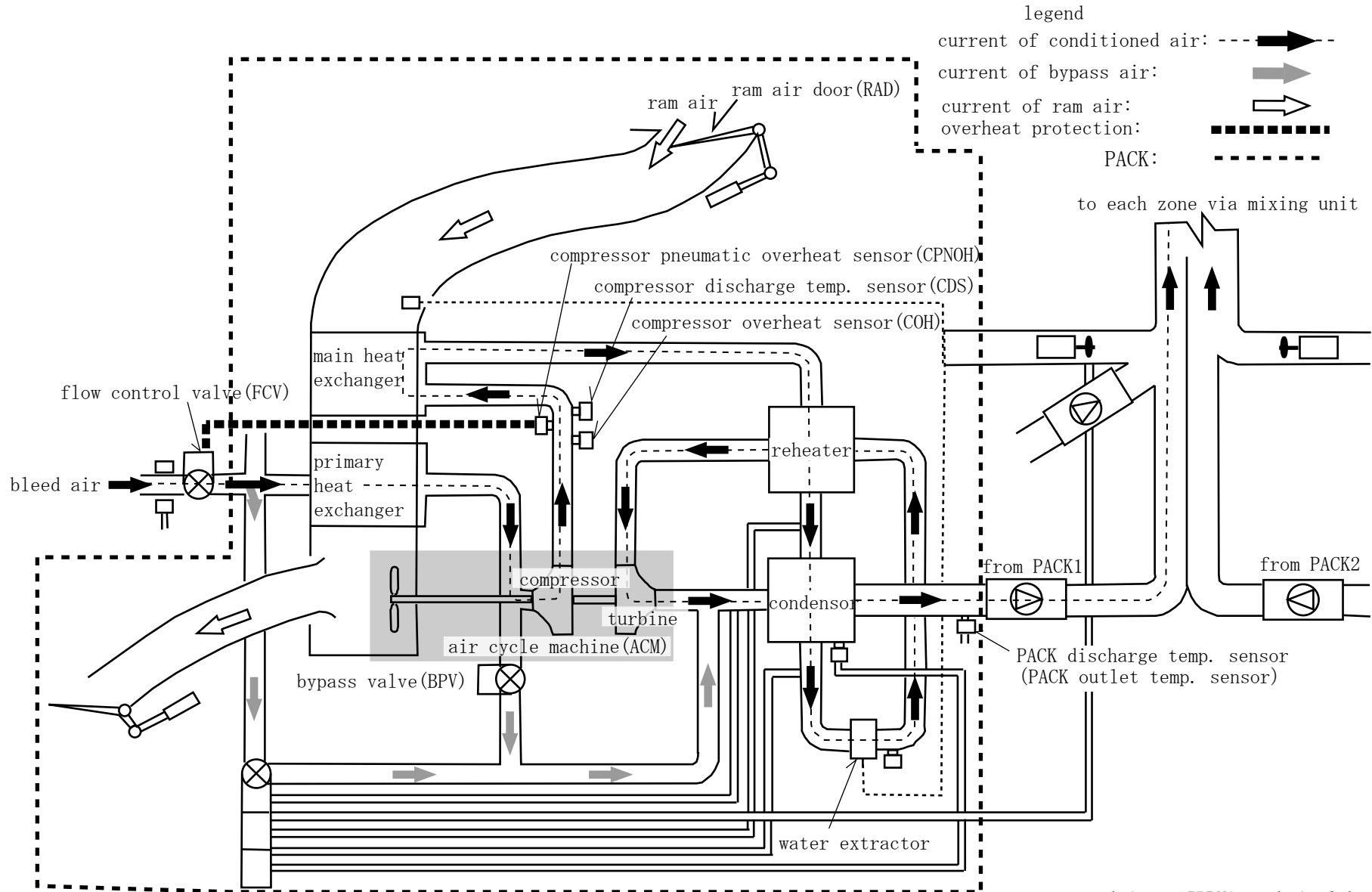


Figure 3 Relevant Parameters for Air Conditioning System



The signs of a – m correspond to the description of 3.4.2

Figure4 air-conditioning system chart



quoted from AIRBUS technical book

Figure5 F C V structure

⊗ : means vent port

