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NATIONAL TRANSPORTATION SAFETY COMMITTEE

AIRCRAFT INCIDENT REPORT

PT Merpati Nusantara – Post Maintenance Test Flight

CN235 PK-MNM

Bandung, West Java

25 January 2000

NATIONAL TRANSPORTATION SAFETY COMMITTEE
DEPARTMENT OF COMMUNICATIONS
REPUBLIC OF INDONESIA
2002

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This report has been prepared based upon the investigation carried out by the National Transportation Safety Committee in accordance with Annex 13 to the Convention on International Civil Aviation, UU No.15/1992 and PP No. 3/2001.

This report was produced by the National Transportation Safety Committee (NTSC), Gd. Karsa Lt.2 Departemen Perhubungan dan Telekomunikasi, Jalan Medan Merdeka Barat 8 JKT 10110 Indonesia.

CONTENTS

GLOSSARY OF ABBREVIATIONS

AD	Airworthiness Directives
AMSL	Above Mean Sea Level
AOC	Air Operator Certificate
ATC	Air Traffic Control
ATPL	Air Transport Pilot License
BDO	Bandung
CB	Cumulonimbus clouds
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DGAC	Directorate General of Air Communication
dp	differential pressure
FDR	Flight Data Recorder
ft	feet
GE	General Electric
IPTN	Industri Pesawat Terbang Nusantara
ITB	Institut Teknologi Bandung
km	kilometer
kts	knots (nm/hr)
LT	Local Time
nm	nautical mile(s)
NTSC	National Transportation Safety Committee
^{o}C	degrees Celcius
PIC	Pilot-In-Command
psi	pounds per square-inch
QFE	Height above airport elevation (or runway threshold elevation) based on local station pressure
QNH	Altitude above mean sea level based on local station pressure
S/N	Serial number
TS/RA	thunder strom and rain
TSN	Time Since New
TT/TD	ambient temperature/dew point
USA	United States of America
UTC	Universal Time Co-ordinated

SYNOPSIS

On 25 January 2000, 03:00 LT, a CN235 aircraft owned and operated by PT Merpati Nusantara Airlines, with registration number PK-MNM, was flying a post maintenance test flight, when its ventral door detached and separated from the aircraft.

The aircraft took off from Husein Sastranegara airport, and was flying at 16,000 ft altitude, at radial 100 of VOR and 15 nm from the airport, and airspeed 150 kts, when the flight test crew heard a loud noise. The flight crew observed a depressurization with the differential pressure dropping to zero from 3.6 psi dp. Opening the cockpit door the crew found out that the ventral door had separated from the aircraft. The PIC initiated a rapid descent, returned to, and landed the aircraft safely at the airport. A ground search recovered the ventral door and other components in Majalaya, approximately 30 km south-east of Bandung.

Inspection on other CN235 aircraft was immediately performed and revealed corrosion occurring on most of the port fittings, hooks, reinforcements and their assemblies of the ventral door. Cabin pressurization test showed that cabin over-pressure did not occur, as the dump valve was working in accordance with the requirements. Metallurgical examination conducted at Institut Teknologi Bandung determined the cause of the failure of the port fittings as material weakening due to exfoliation and stress corrosion cracking. This was caused by insufficient protection coating measures for port fittings against adverse environmental condition.

Few recommendations were made as a result of this investigation, including recommendations for the DGAC, the manufacturer, and the operator.

1 FACTUAL INFORMATIONS

1.1 History of Flight

On 25 January 2000, the CN235 PK-MNM, owned by PT Merpati Nusantara, was scheduled for a post-maintenance flight test program. The aircraft has not been in service for 8 months prior to the maintenance. This test flight was performed as the aircraft was grounded for more than three months (stated in the company manual).

The crew performed a normal preflight briefing and check. There were no anomalies reported.

At 07:00 LT the crew started the engines, and after checking the propeller automatic and manual feathering systems, proceeded to take-off from Runway 29 at 07:10 LT. The aircraft was airborne at 07:15 LT, climbing to 10,000 ft heading to the planned test flight area approximately 15 nm from the Bandung Husein Sastranegara Airport. Weather was reported fine with scattered cumulonimbus formations over the airport.

The test program was initially conducted over the test area at 10,000 ft, but as the ATC transponder was not functioning properly and could not be read by Jakarta control, the flight crew requested to climb to 16,000 ft.

Five minutes after reaching 16,000 ft, while flying at a speed of 150 kts and heading of 100^{o} on radial 100 about 15 nm from Bandung, the cockpit crew heard a loud noise, followed immediately by smoke and dust particles floating into the cockpit from the cabin area.

A loss of cabin pressure was recognized, and the cabin pressure indicated zero psi. The cockpit crew requested descent to 8,500 ft. An inspection of the cabin by the mechanic on board revealed that the ventral door had separated from the airframe tail section. Continuing the descent the PIC required the landing gear lowered.

On reaching 8,500 ft altitude, the crew requested and was cleared for a further descent to 4,500 ft. A further request to fly direct to Bandung Husein Sastranegara Airport for a long final on Runway 29, which was approved, and the aircraft landed safely at 08:15 LT.

On-ground inspection in a PT IPTN hangar revealed that the ventral door had separated at its hinges. A search successfully recovered the door at a position of 105^{O} approximately 15 nm from Bandung.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	TOTAL
Fatal	-	-	-	**-**
Serious	-	-	-	**-**
Minor/ None	3	-	-	3
TOTAL	**3**	**-**	**-**	**3**

1.3 Damage to Aircraft

The aircraft was inspected in a PT IPTN hangar at the Husein Sastranegara Airport, Bandung. The separated and detached parts included the ventral door, a cargo cage, a partition panel, 10 seatbelts and a fire extinguisher. The last three items were not recovered during a land search.

The examination of the aircraft, performed by an NTSC team supported by engineers from the DGAC, the operator and the manufacturer, revealed that thirteen fittings of the ventral door side frames were broken (Figure 1 and Photograph 1 B). Most of the fractures occurred along the grain direction. Other fractures showed static overload failures.

One of 14 hooks on the ventral door was found broken with its fracture surface indicating a static failure mode. The fracture surface indicated a static mode occurrence (Figure 1 and Photograph 2). Two hinge fittings and the ventral door attachment to the actuator at the rear frame were also broken statically (Photograph 3).

Frame # 43 in the rear fuselage to which the actuator was connected, was bent and partly torn (Photograph 4).

The skin panel lips of the fuselage opening were found deformed, with the deformation on the left hand side found larger than the deformations on the right hand side (Photograph 5). (Note: left and right hand referred to an observer looking in the direction of flight)

Other damaged and broken structure parts found separated were the baggage cage, which was bolted to the ramp door, and a partition panel. The baggage cage was recovered, while the partition panel was not found (Photograph 6).

1.4 Other Damage

The two large parts, which separated from the aircraft, the ventral door and baggage cage, were found at Paseh village in Majalaya, approximately 30 km east of Bandung. The ventral door caused minor damage to the roof of a house, while the baggage cage did not cause any other damage. Both were found near each other, indicating that they had separated at about the same time.

1.5 Personnel Information

1.5.1 Cockpit Crew

1.5.1.1 Pilot-in-Command

Age	31 years
License	ATPL 3578
Validation	3 March 2000
Aircraft ratings	CN235
Instrument rating	Current
Last medical check-up	3 March 1999
Last proficiency check	25 August 1999
Last line check	None
Flying experience (hours)	DHC, CN235
Total all types	5889.47 hours
Total on type	3000 hours
Last 90 days	19.88 hours
Last 72 hours	6.00 hours
Last 24 hours	None
This flight	1.08 hours

1.5.1.2 First Officer

Age	32 years
License	ATPL 8583
Validation	17 July 2000
Aircraft ratings	CN235
Instrument rating	Current
Last medical check-up	17 January 2000
Last proficiency check	4 September 1999
Last line check	None
Flying experience	DHC, CN235
Total all types	6838.58 hours
Total on type	3000 hours
Last 90 days	31.95 hours
Last 72 hours	None
Last 24 hours	None
This flight	1.08 hours

1.5.2 Airborne Mechanic

Age	38 years
License	L 256
Validation	August 2000

1.6 Aircraft Information

The last revenue flight of PK-MNM was from Palembang to Bandung on 9 October 1998. The aircraft was then proposed for heavy maintenance program (2000 hours inspection and some additional inspections), but due to the lack of spare parts such as avionics, brake units and electronics, the aircraft was grounded.

Later on after the completion of all components required, the aircraft was scheduled for test flight on 25 January 2000, which was the procedure for aircraft after more than 30 days not in service (refer to Company Operation Manual).
Last flight of the PK-MNM before the occurrence flight was to Bandung on 29 April 1999, with the PIC of the occurrence flight as pilot flying.

1.6.1 Aircraft Data

Aircraft registration	PK-MNM
Aircraft serial number	N-012
Aircraft manufacturer	PT Industri Pesawat Terbang Nusantara
Aircraft type / model	CN235

Year of manufacture	1989
Certificate of Airworthiness valid until	22 April 2000
Certificate of Registration valid until	27 November 2002
Registration number	1436
Weighing	07 April 2002
Compass swing	08 April 2001
Radio permit	28 March 2000
Completed date up to	27 December 1999
Total airframe hours	5,914.20 hours
Total cycles	12,216 cycles
Last major inspection	C-03 / 5,912.28 hours
Next major inspection	C-04 / 7,912.28 hours
Last minor inspection	B-09 / 5,595.30 hours
Next C-check FC05 inspection	Not due yet
Last heavy maintenance	
In	MTA / BDO
At hours / cycles	5,912.28 / 12,216
Date	28 November 1998
Next heavy maintenance (hours / cycles)	7,912 / ----

1.6.2 Engine Data

Engine position	**#1**	**#2**
Engine manufacturer	GE, USA	GE, USA
Engine type	GE-CT7-7A	GE-CT7-7A
Engine serial number	384128	384107
Date of installation	02-04-1998	15-04-1998
Station	MTA BDO	MTA BDO
Installed at hours / cycles	6,150 / 9,545	7,830 / 11,414
Total TSN	6,701.12	8,358.03
Total CSN	6,741	12,503
Hours / cycles on wing	550.91 / 1,196	527.77 / 1,089
Cycle limits	17,715	17,202
Cycles remaining	6,974	4,699

1.7 Meteorological Information

	0700 UTC	0800 UTC	0900 UTC
Wind	310 / 17	300 / 12	300 / 15
Visibility	4 km	6 km	2 km
Weather	TS / RA	Haze	TS / RA
Clouds	1 CB 3 Cm 1800	1 CB 3 Cm 1800	4 CB 1800
TT / DP	24 /20	24 / 19	23 /24
QNH	1011	1010	1012
QFE	926	925	926
Remarks	TS / RA	CB over Husein S	TS / RA over Husein S

1.8 Aids to Navigation

Not relevant.

1.9 Communications

Not relevant.

1.10 Aerodrome Information

Husein Sastranegara is situated in the southern part of Bandung, used as military, civil and industrial airport, operating under the Indonesian Civil Aviation Safety Regulations.

Airport Name : Husein Sastranegara

Airport Identification : WIIB

Airport Operator : PT Angkasa Pura II

Runway Direction : 29/11

Elevation : 2500 ft

1.11 Flight Recorders

The cockpit voice recorder was Fairchild cockpit voice recorder Model A100A S/N 53139. A transcript was made under supervision of the NTSC at the facilities of the PT Industri Pesawat Terbang Nusantara.

The flight data recorder was a Fairchild Digital Flight Recorder Model F800 S/N 3682 S/N but considered not necessary to be downloaded for read-out and analysis.

The CVR was transcribed at the PT IPTN read-out facilities. The recording revealed that the crew did not immediately recognize the cause of the ventral door detachment, and had

assumed the loud noise heard in flight was caused by a dump valve failure. The crew then observed indications of depressurization, i.e. the illumination of the 'cabin altitude' warning light, and a zero reading of the differential pressure indicator.

The crew started a descent immediately, but did not perform the correct procedure for this type of emergency. The crew did not put on their oxygen masks.

An in-flight inspection to check the cabin revealed that the ventral door was detached and had separated from the aircraft. The crew lowered the landing gears for an immediate landing descending with a high rate of descent, as the crew suffered some measure of ear-pain.

No emergency and normal checklists were performed, and the aircraft landed safely on Runway 29 Bandung Husein Sastranegara Airport.

The crew did not report the emergency to ATC.

1.12 Wreckage and Impact Information

Two airframe components were separated from the aircraft, i.e. the ventral door and the baggage cage. The separation occurred in flight at an altitude of 16,000 ft. The ventral door was found at Desa Cipedes, Kecamatan Paseh, Majalaya, about 30 km east of Bandung. Both the ventral door and baggage cage hit two houses causing minor damage. They were found near to each other.

1.13 Medical and Pathological Information

No one was injured in this accident, both in the air and on the ground. The detachment of the ventral door at 16,000 ft had caused a rapid depressurization, but the flight crew experienced no injuries even though they did not wear oxygen masks.

1.14 Fire

Not relevant.

1.15 Survival Aspects

The accident was survivable.

1.16 Test and Research

1.16.1 Inspection of other CN235 aircraft

For comparison purposes, visual inspections on 10 PT Merpati Nusantara CN235 aircraft were carried out. The inspection revealed corrosion occurring on most of the port fittings, hooks, reinforcements and their assemblies, some severely, especially corrosion of the reinforcements. The worst damage found showed similar characteristics to the PK-MNM case, where all the fourteen port fittings were corroded, of which eleven were showing severe exfoliation corrosion. Cracks along the grain directions were found in several of the fittings examined.

1.16.2 Metallurgical examination

The Metallurgical Laboratory of the Mechanical Engineering Department, Institut Teknologi Bandung, conducted special tests. Utilizing a stereomicroscope the examination confirmed that the fracture was due to corrosion, more specifically of the exfoliation type, as shown by the fracture occurring along the grain direction, and revealing a fibrous wooden like surface. Corrosion that was white gray colored, were found on the fracture surfaces, and the formations of lamellar aluminum along the grain direction can be observed. These are characteristics of exfoliation and stress corrosion.

The laboratory examination could not determine the rate of corrosion crack propagation rate, or in other words, the time period in which the corrosion took place.

On several of the observed fracture surfaces reddish brown colored corrosion products from steel parts (i.e. brushing) were found, indicating penetration into the cracks or gaps formed by the exfoliation corrosion prior to the accident.

Static failure modes were found on several port fittings and the two hinge fittings at the rear of the aircraft. The static mode failures occurred after corrosion failures happened, ultimately causing a weakening the structure, until a static overload mode of failure occurred at the remaining fittings (Photographs 7 and 8).

1.16.3 Cabin depressurization test

A dump valve taken from the PK-MNM aircraft was used for the depressurization test that was performed on the ground using a sister aircraft. The differential pressure at which the dump valve worked to open was found to be 3.9 Psi dp. This differential pressure met the set or prescribed value of 3.8 ± 0.1 Psi dp.

1.17 Organizational and Management Information

1.17.1 PT Merpati Nusantara

PT Merpati Nusantara is a state owned Aviation Company operating under AOC/121-002, used for commercial and pioneer flights under CASR Part 121. The operator had 38 years of experience flying propeller aircraft and 10 years of flying gas turbine aircraft. It operates a total of 66 aircraft, including 3 B737s, 3 F100s, 16 F28s, 13 CN235s, CN212s and 8 de Havilland Otters. The company operated the CN235 since the early eighties, and has an in-house program for flight and cabin crew training. Total number of pilots is 639.

PT Merpati flies to 130 destinations in Indonesia.

The company does its own management at the Surabaya Merpati Maintenance Facilities.

1.17.2 PT Industri Pesawat Udara Nusantara

The manufacturer of the aircraft is PT Industri Pesawat Terbang Nusantara, a government owned company. Established in 1976 the company, formerly PT Industri Pesawat Terbang Nurtanio, started manufacturing under license the Messerschmit-Boelkow-Blohm NBO105 helicopter and the CASA CN212 small utility transport under license from CASA of Spain. These programs were quickly followed by the license manufacturing of the PUMA NSA-330 (manufacturer Aero-Spatiale of France) and the SUPER PUMA. The next program was the CN235 program a joint risk sharing development between CASA and PT IPTN. The CN235 first flight was in December 1983, three years after the start of the program, and the certification process was successfully ended in 1986. The aircraft sales until now are around 160 aircraft flying all over the world. In the early eighties PT IPTN manufactured components for the Boeing 767 and 737, and the General Dynamics F16, as offset production lines. It also manufactured the Bell-412 under license. The next program in the late eighties was the design and manufacturing of the N250, a turbo-propeller aircraft,

which is a pure national program. Finally the design of the N2130 has begun in the early nineties. The PT IPTN is recently renamed PT Dirgantara Indonesia.

PT IPTN conducted the heavy maintenance on PK-MNM.

1.18 Other Information

None.

2 ANALYSIS

2.1 Pressurization test

The pressurization test showed that the dump valve worked to open at 3.9 Psi dp. This value met the requirements. Therefore the possibility of cabin over-pressure can be ruled out.

2.2 Material weakening

A detailed inspection was carried out at the Metallurgical Laboratory of the Mechanical Engineering Department of the ITB. A stereomicroscope was used in the examination that confirmed that the fracture was due to corrosion, more specifically of the exfoliation type. This was concluded as it can be observed that the fracture occurred along the grain direction, and the fracture revealed a fibrous (wooden like) surface. White-gray colored corrosion products were found on the fracture surfaces, and the formations of lamellar aluminum along the grain direction were observed. This type of corrosion is known as exfoliation and stress corrosion.

The laboratory examination could not conclude on the rate of corrosion crack propagation rate, or in other words, the time period in which the corrosion took place.

On several of the observed fracture surfaces reddish brown colored corrosion products from steel parts (i.e. brushing) were found, indicating penetration into the cracks or gaps formed by the exfoliation corrosion prior to the accident.

Static failure modes were found on several port fittings, and the two hinge fittings at the rear of the aircraft. The static mode failures occurred after corrosion failures happened, ultimately causing a weakening of the structure, until a static overload mode of failure occurred at the remaining fittings (figures 7 and 8).

The examination also found that 13 of the 14 fittings of the ventral door were broken.

An analysis of the results of the metallurgical laboratory examination concluded that most of the port fittings experienced corrosion in the form of exfoliation and stress corrosion. The corrosion started when corrosive environment, e.g. moisture, was in contact with the aluminum. One of the protective methods is to separate them from having a direct contact with corrosive environment. In the case of the port fittings, the coating used was an anodized layer and primer coating. During an anodization process, a thin layer of aluminum oxide (Al_20_3) is formed on the surface. However the layer does not continuously cover the metal surface, due to micro-porosity. In order to close the porosity, the part is immediately immersed in a bath of hot water directly after the anodization process. In this immersion, the layer transforms into $Al_2O, nH_2O,$ which has a larger volume than Al_2O_3, and hence the porosity will be sealed off. On the top of the anodized layer, a coating of primer is applied to prevent the moisture from contacting the metal.

It was found that from the part drawing and manufacturing processing specifications, on these particular port fittings the anodization process was not followed by a sealing step, that is a protection especially needed in hot, humid and maritime type of environment. If there is no such protection, surface corrosion will be initiated. This is followed by exfoliation corrosion, which is typical of high strength aluminum. The grain boundaries will be severely attacked. In a rolled or extruded products, the weakening will occur along the elongated grains. In the extreme stage it will form loose layers of exfoliation.

Another form of corrosion is stress corrosion cracking. The presence of tensile stress in the parts working in corrosive environment will accelerate the corrosion progress. The cracks

will form along the weakened grain boundaries. This form of corrosion was observed in the port fittings.

These facts indicate that the protection measures were not sufficient to the particular work environment. This is also supported by the fact that a higher number of corroded fittings were observed in other aircraft, which were also grounded for longer periods of time in hot, humid or maritime environments.

2.3 Ventral door detachment sequence

The nature of fractures of the port fittings and rear hinges, and the deformation of the fuselage lips, indicated that there was a weakening of the several port fittings. The normal pressurization caused the left of the ventral door to detach, starting from the left-hand side. This was indicated by the greater deformation observed on the left side fuselage lip or edge panel.

Additional aerodynamic loads were exerted on the protruding ventral door, causing failures of the remaining fittings, included the two hinge fittings at the rear. The aerodynamic drag pulling resulted in the failure of the actuator attachment on the door, as well as bend tear fractures on fuselage frame #43. The right hand fittings were broken, starting at the corroded ones. Depressurization forces, i.e. air rushing from inside the aircraft then caused the baggage compartment and one of the partition walls to be pushed out through the ventral door opening.

3 FINDINGS AND CONCLUSIONS

1) The cause of the ventral door detachment was failure due to a weakening of port fittings caused by exfoliation corrosion and stress corrosion cracking. This was caused by insufficient protection coating measures for port fittings against adverse environmental condition.
2) There is no non-destructive-testing inspection to check for corrosion effects on the ventral door hinges, especially for hinges on the most rear position due to limited accessibility. The inspection can only be done visually, which is not enough to do a thorough check.
3) The crew did not perform a specific pre-test flight briefing.
4) The flight crew did not comply with flight procedures for descent and landing.
5) There were indications of insufficient compliance to the CRM processes and procedures by the flight crew.
6) The crew did not inform ATC of the flight emergency situation.

4 RECOMMENDATIONS

1) The Directorate General of Air Communication to issue a directive to inspect port fittings and related parts of all CN235 aircraft flying in Indonesia by means of appropriate techniques.
2) The manufacturer to perform a review on the structural significant items, especially on:
    a. Corrosion control program. An additional corrosion protection process immediately after anodization step is strongly recommended (this measure has been applied to the fittings since 1993). The application of an additional coating containing primer, top coat and corrosion inhibiting compound (CIC) is also recommended on particular parts that can potentially be attacked by corrosion.
    b. Material selection. It is recommended that Al2024, instead of Al7075, be used for the hinges.
    c. Manufacturing process. It is recommended to take into consideration the grain direction relative to the load in the manufacturing of the hinges.
3) The Directorate General of Air Communications to notify operators and air safety authorities worldwide on the incident and its cause.
4) The operator to review and enforce the high altitude emergency procedures.
5) The operator and the manufacturer to provide standard flight test procedures, including ground acceptance procedures outlining the flight test details and its specific procedures.
6) The operator to review its accident/incident notification procedure according to the company operation manual.

APPENDICES

Appendix A - FIGURES AND PHOTOGRAPHS

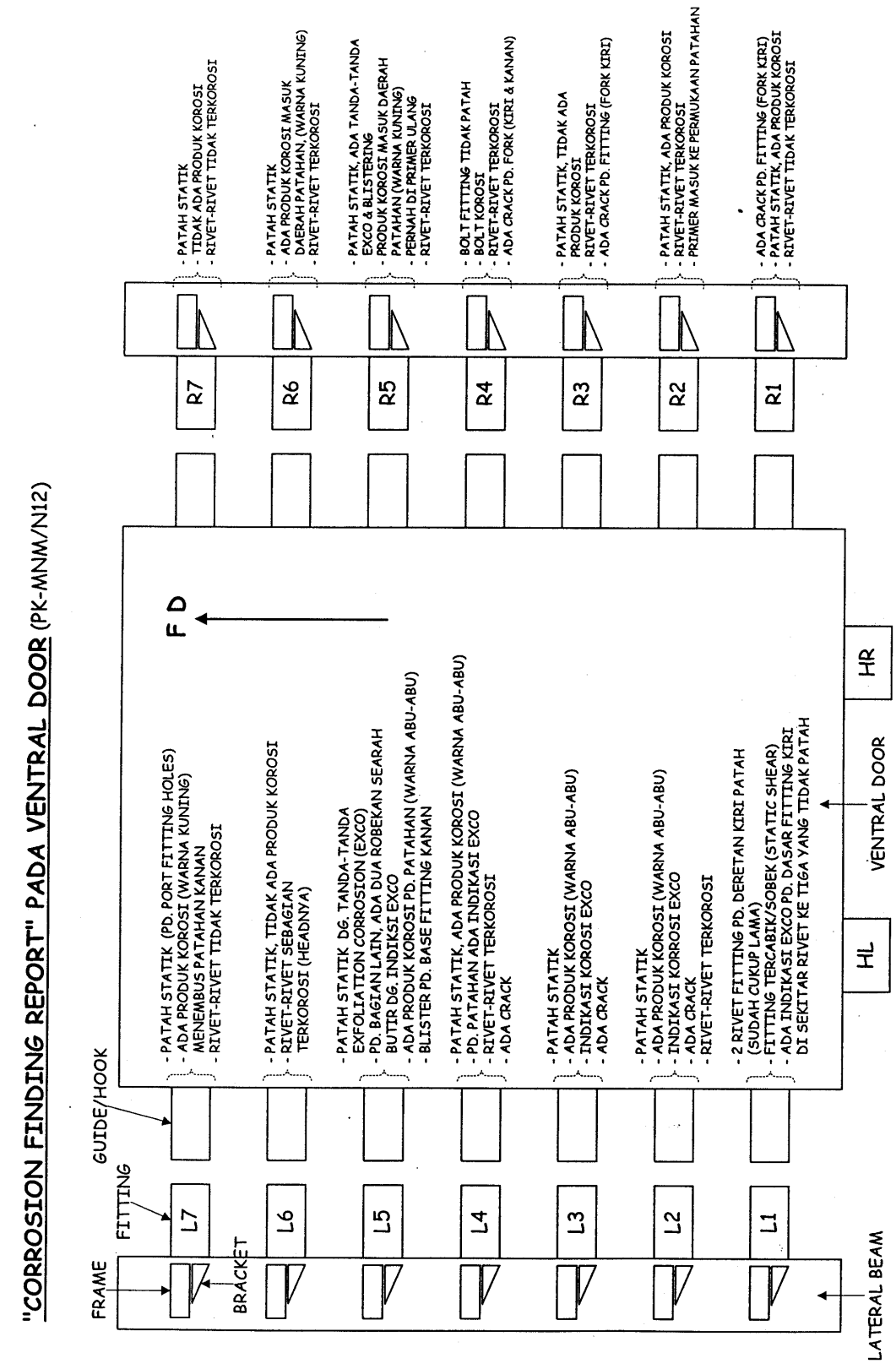


Figure 1. Corrosion Finding at Ventral Door.

Photograph 1A. One Remaining Unbroken Fitting

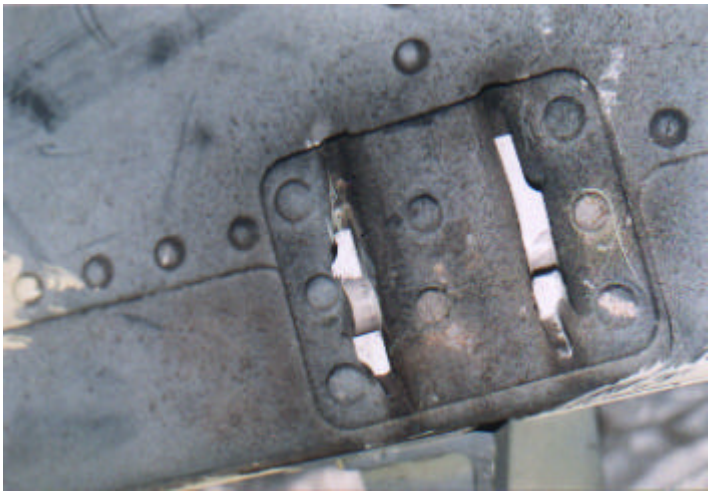
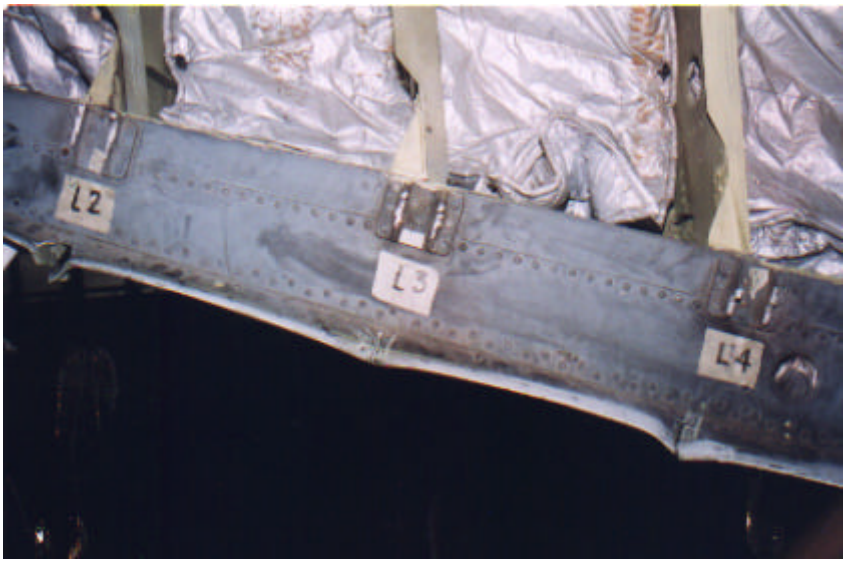


Figure 1B. Broken Fitting on Ventral Door Structure (13 fittings)

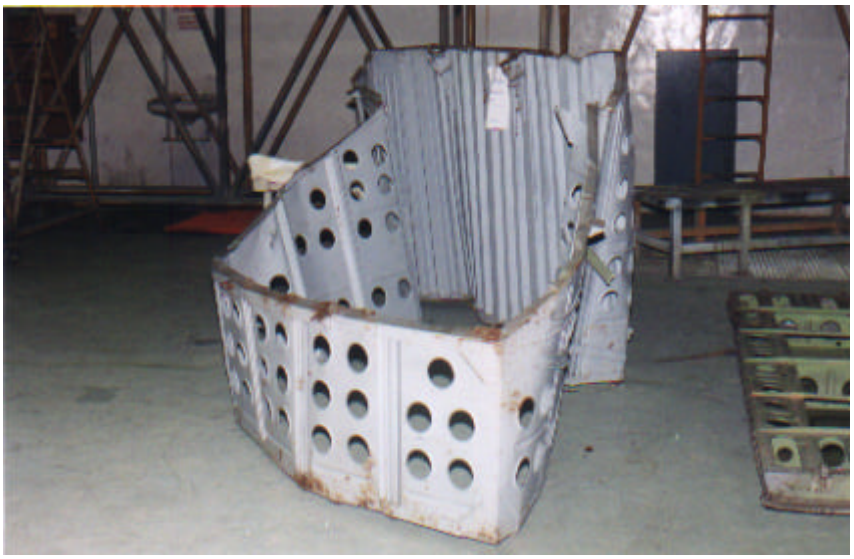
Photograph 2. Broken Guide Hook (R4)

Photograph 3. Broken Hinge and Half Hinge Assembly

Photograph 4. Bend and Tear out on Upper Frame #43

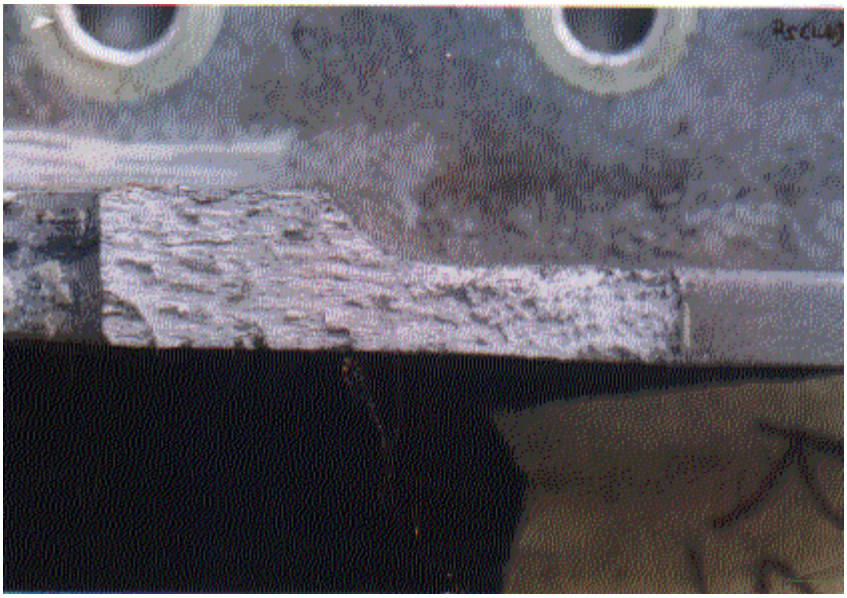


Photograph 5. Deformation on Rear Fuselage Skin Panel Lips (left-hand side)



Photograph 6. Baggage Basket (Compartment)

Photograph 7. Macroscopic Photograph on L7 Port Fitting Fracture Surface



Photograph 8. Macroscopic Photograph on R5 Port Fitting Fracture Surface