AIRCRAFT ACCIDENT REPORT

AERO/2015/06/05/F

Accident Investigation Bureau

Report on the Serious Incident involving Aero Contractors Boeing 737-500 Aircraft with Registration 5N-BLE, on Flight Level 330 en-route Kaduna Airport, which occurred on 5th June, 2015

This report was produced by the Accident Investigation Bureau, Murtala Muhammed International Airport, Ikeja, Lagos.

The report is based upon the investigation carried out by Accident Investigation Bureau, in accordance with Annex 13 to the Convention on International Civil Aviation, Nigerian Civil Aviation Act 2006, and Civil Aviation (Investigation of Air Accidents and Incidents) Regulations.

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of Aircraft Accident/Serious Incident Investigations to apportion blame or liability.

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As the Bureau believes that safety information is of great value if it is passed on for use of others, readers are encouraged to copy or reprint for further distribution, acknowledging Accident Investigation Bureau as the source.

Recommendations in this Report are addressed to the Regulatory Authority of the State (NCAA).

Printed in Nigeria for the Accident Investigation Bureau (AIB)

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AIB	Accident Investigation Bureau
AFM	Airplane Flight Manual
ATC	Air Traffic Control
CVR	Cockpit Voice Recorder
FDR	Flight Data Recorder
FL	Flight Level
IFR	Instrument Flight Rules
NCAA	Nigerian Civil Aviation Authority
Nig.CARs	Nigerian Civil Aviation Regulations
PRSOV	Pressure Relief Shut-Off Valve
QAR	Quick Access Recorder
SOP	Standard Operating Procedures
UTC	Universal Coordinated Time

Aircraft Accident Report No.:	AERO/2015/06/05/D
Registered Owner and Operator:	Aero Contractors Company of Nigeria Ltd.
Aircraft Type and Model:	Boeing 737-500
Manufacturer:	Boeing Aircraft Company, USA
Date of Manufacture:	7th August, 1992
Registration number:	5N-BLE
Serial No.:	26672
Location:	Flight Level 330 en-route Kaduna
Date and Time:	5th June, 2015 at 1857hrs
	(All the times in this report are local time, equivalent to UTC+1 unless otherwise stated)

SYNOPSIS

The Accident Investigation Bureau (AIB) was not officially notified but got to know of the serious incident the following day, 6th June, 2015 through the media. Relevant authorities and stake holders were appropriately notified thereafter.

On 5th June, 2015, Aero Contractors Company of Nigeria Ltd. scheduled commercial flight NIG181, a Boeing 737-500 aircraft with registration number 5N-BLE from Lagos to Kaduna, took off at 1828hrs with 108 passengers and 5 crew on board. The First Officer was the pilot flying. The flight operated on an Instrument Flight Rules (IFR).

The Air Traffic Control (ATC) cleared the aircraft for takeoff and to climb and maintain Flight Level (FL) 350. Normal cabin rate of climb (300ft/min) was observed during the initial climb. During climb at approximately 23 minutes, the cabin altitude warning horn sounded and the cabin altitude warning light came ON.

The Captain took control of the aircraft, passenger announcement was made and emergency descent initiated to an altitude of 10,000ft.

The flight diverted to Abuja with a distance of about 120nm to go. The aircraft made a safe landing in Abuja at 1932hrs and all passengers and crew disembarked normally and without injuries.

The incident occurred at night.

The investigation identified the following causal and contributory factors:

Causal Factor

The inadvertent failure to discover that the PRSOV was in the LOCKED CLOSED position after the engine change.

Contributory Factor

Failure to recognise that the number 2 bleed pressure was zero after engine start and subsequent failure to monitor the pressurisation system during climb.

One Safety Recommendation was made.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 5th June, 2015, Aero Contractors Company of Nigeria Ltd. scheduled commercial flight NIG181, a Boeing 737-500 aircraft with registration number 5N-BLE from Lagos to Kaduna, took off at 1828hrs with 108 passengers and 5 crew on board. The First Officer was the pilot flying. The flight operated on an Instrument Flight Rules (IFR).

ATC cleared NIG181 as follows: to climb and maintain FL350 after departure, to make a right turn on a heading of 330°, thereafter instructed to make a further right turn on a heading of 360° and cleared on course via IBA[1].

During the initial climb, the Captain observed that the cabin rate of climb was zero but later indicated normal. However, the First Officer reported that on reaching FL150, he observed that the cabin altitude was indicating about 3000ft and since this occurred at low altitude, they decided to monitor during climb.

Approximately 23 minutes after airborne and climbing through FL330, the cabin altitude warning horn came on and the Captain took control of the aircraft. The flight crew donned their oxygen masks, set the regulators to ON/100% and crew communication was established as required by the procedures of the approved Quick Reference Handbook (QRH) and Airplane Flight Manual (AFM).

According to the account of the purser, she went into the lavatory and observed that the sink was full, which she tried to drain. She got out of the lavatory and observed that her oxygen mask had dropped. She then checked the cabin area and observed that the business class passengers' oxygen masks had also dropped. She immediately took her

[1] IBA (Ibadan) is a reporting point on the UR778 airway.

seat, donned her mask and briefed the passengers. Thereafter, she called the cockpit but there was no response.

Emergency descent to an altitude of 10,000ft was initiated. The Captain briefed the purser and made an announcement to inform the passengers that the flight was being diverted to Abuja.

The aircraft landed safely in Abuja at 1932hrs, taxied to the ramp and parked. The chocks-on time was 1940hrs. Both crew and passengers disembarked without injury.

1.2 Injuries to Persons

Injuries	**Crew**	**Passengers**	**Others**
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/None	5	108	Nil

1.3 Damage to Aircraft

The aircraft was not damaged.

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 Captain

Nationality:	Nigerian
Age:	56 years
Gender:	Male
Licence No.:	ATPL 2470
Licence Validity:	8th July, 2015
Aircraft Ratings:	B737-300, 400, 500, HS-125, DC-9, BE-200, DASH-6 (Twin Otter), C-172, SHORTS 360, PA-23
Instrument Rating Validity:	13th March, 2016
Medical Validity:	8th July, 2015
Licence Proficiency Check:	13th September, 2015
Operator Proficiency Check:	13th September, 2015
Annual Line Check:	9th December, 2015
Total flying time:	5792:00hrs
Hours on Type:	3436:00hrs
Last 90 Days:	144:20hrs
Last 28 Days:	44:36hrs
Last 24 hours:	1:25hrs

1.5.2 The First Officer

Nationality:	Ivorian
Age:	57 years
Gender:	Male
Licence No.:	ATPL 5773
Licence Validity:	28th August, 2016
Aircraft Ratings:	B737-CL, B727-200
Instrument Rating Validity:	27th November, 2015
Medical Validity:	4th September, 2015
Licence Proficiency Check:	9th October, 2015
Operator Proficiency Check:	9th October, 2015
Annual Line Check:	5th December, 2015
Total flying time:	9000hrs
Hours on Type:	4000hrs
Last 90 Days:	39:40hrs
Last 28 Days:	10hrs
Last 24 hours:	1:25hrs

1.5.3 Cabin crew

The three cabin crew on-board the aircraft were qualified to carry out their duties.

Purser

Nationality:	Nigerian
Age:	34 years
Gender:	Female
Licence No.:	1072
Licence Validity:	16th February, 2019
Medical Validity (General):	17th February, 2019

1.5.4 Maintenance Engineer 1

Nationality:	Beninese
Age:	52 years
Gender:	Male
Licence No.:	2960
Licence Validity:	21st December, 2015
Ratings:	B737/300/400/500 Landplanes.
	CMF-56 Engines

This engineer released the aircraft to service after the engine replacement on 5th June 2015.

1.5.5 Maintenance Engineer 2

Nationality:	Nigerian
Gender:	Male
Licence No.:	2393
Licence Validity:	3rd January, 2016
Ratings:	Cessna 172 Landplane, Hawker 4000 Landplanes, DHC-6-300 Twin Otter Landplane, DHC-8 Landplanes, B737/300/400/500 Landplanes, Bombardier DHC-8 400 Aeroplane. Lycoming 0-320 Engines, Pratt and Whitney PT6 Engines, PW120/123 Engines, CMF-56 Engines

This engineer released the aircraft to service for a test flight on the 6th of June 2015, after the incident.

1.6 Aircraft Information

1.6.1 General Information

Type:	B737-500
Date of Manufacture:	7th August, 1992
Manufacturer:	Boeing Aircraft Company, USA
Serial No.:	26672
Total Airframe time:	49294.18hrs

Cycles:	34097
Certificate of Airworthiness:	30th January, 2016
Category:	Transport (Passenger)
Certificate of Registration:	1st August, 2008

The Boeing 737-500 aircraft is a short-to-medium-range twin engine jet airliner. It seats up to 120 passengers and is powered by two CFM-56 turbofan engines.

1.6.2 Powerplant

No. 1

Engine Type:	CFM
Manufacturer:	GE Aviation
Model:	CFM 56-3C-1
Serial No.:	726352
Hours Since New:	52048.10
Cycles Since New:	41706
Date of Manufacture:	June 1985

No. 2

Engine Type:	CFM
Manufacturer:	GE Aviation
Model:	CFM 56-3C-1
Serial No.:	725373
Hours Since New:	52556.04

Cycles Since New: 41208

Date of Manufacture: April 1987

It is pertinent to note that 5N-BLE has a history of frequent engine changes. See the table below for the summary.

ITEM	ENGINE CHANGE DATE (DD/MM/YYYY)	POSITION: PORT(#1)/ STARBOARD(#2)	ENGINE S/N OFF	ENGINE S/N ON
1	11/11/2012	#2	726447	724573
2	31/01/2015	#1	726449	724566
3	16/01/2015	#2	724573	727109
4	15/02/2015	#2	727109	721759
5	12/05/2015	#2	721759	721707
6	26/05/2015	#2	721707	858904
7	05/06/2015	#2	858904	725373

Table 1: Engine change history on 5N-BLE

On 26th May, 2015, #2 engine with serial number 721707 was replaced due to engine surge, with engine serial number 858904 at Abuja.

On the 5th of June, 2015, #2 engine with serial number 858904 was replaced due to low hours remaining, with engine serial number 725373, in Lagos at Aero Contractors facility. The incident flight was the first commercial flight with this installed engine.

Type of fuel used is Jet A1.

1.7 Meteorological Information

FORECAST ABV

Time: **1600 UTC**

Wind: 200/09

Visibility:	10km
Weather:	NIL
Cloud:	SCT 390m
Temp/Dew Point:	33°C /20°C
QNH:	1011

Time:	**1700 UTC**
Wind:	180/07
Visibility:	10km
Weather:	NIL
Cloud:	BKN 330m, FEW CB (N-NE) 600m
Temp/Dew Point:	33°C /20°C
QNH:	1011

Time:	**1800 UTC**
Wind:	200/06
Visibility:	10km
Weather:	NIL
Cloud:	FEW 330m, FEW CB (N-NE) 600m
Temp/Dew Point:	33°C /20°C
QNH:	1011

ACTUAL	**STN: KAD**
Time:	1600 UTC
Wind:	270/04
Visibility:	10km
Weather:	NIL
Cloud:	Few 300m
Temp/Dew Point:	33^{o}C /20^{o}C
QNH:	1013

1.8 Aids to Navigation

Not Applicable.

1.9 Communications

Effective communication was established between the aircraft and Abuja ATC.

1.10 Aerodrome Information

Not Applicable.

1.11 Flight Recorders

The aircraft was fitted with a solid-state Cockpit Voice Recorder (CVR) manufactured by Allied Signal and a solid–state Flight Data Recorder (FDR) manufactured by Avionica.

The flight recorders were not recovered by AIB because the aircraft had been returned to service before AIB was notified of the occurrence. The Quick Access Recorder (QAR) data was downloaded by the operator and a copy of the download was sent to AIB. See Appendix 1.

1.11.1 Flight Data Recorder (FDR)

Part Number: 980-470043

S/N: 5240

Manufacturer: Avionica

1.11.2 Cockpit Voice Recorder (CVR)

Part Number: 980-6022-001

S/N: 0765

Manufacturer: Allied Signal

1.12 Wreckage and Impact Information

There was no damage to the aircraft.

1.13 Medical and Pathological Information

Not Applicable.

1.14 Fire

There was no fire.

1.15 Survival Aspect

The crew donned their oxygen masks as required, and the passenger oxygen masks were deployed and used. The aircraft made a safe landing in Abuja at about 1932hrs; both crew and passengers disembarked normally and without injuries.

1.16 Test and Research

Not Applicable.

1.17 Organizational and Management Information

Aero Contractors Company of Nigeria Limited (ACN) was incorporated in 1959 and operates both rotary and fixed wing services. ACN provide scheduled fixed wing passenger services to various Nigerian domestic airports and international destinations in the West African sub-region.

1.17.1 Aero Contractors Standard Operating Procedure (S.O.P)

The following is an extract from the company's S.O.P:

Aero Contractors S.O.P, Section 7

System design is such that the effect of the loss or malfunction of an individual system should not, in itself, affect the safe conduct of the flight. It is of the utmost importance that a malfunction is correctly diagnosed.

Hurried action without thought must be avoided.

The crew member detecting an existing or impending emergency or abnormal condition, will immediately call out the condition. The captain, or in his absence from the flight deck, the First Officer must take the necessary action to ensure that control of the aircraft is established and maintained.

Section 3.6.2.2 – Unpressurized and partially pressurized flights

- *i.* *Stop Climb to level/altitude above 10,000ft (ALT Hold)*
- *ii.* *Ensure supply (engine bleed, packs/CBs)*
- *iii.* *Ensure control (Outflow valve is controlled in standby/manual mode)*

Complete Appropriate Non-normal checklist.

Section 2.1.10 - After Take Off Checklist

Altimeters .... SET

Set altimeters to 1013 when passing transition altitude.

Engine bleeds ....ON

Packs .... AUTO

Landing Gear .... UP and OFF

Flaps..UP, No Lights

Verify LE FLAPS TRANSIT and LE FLAPS EXT lights extinguished

1.17.2 Emergency Crew Drills and Checklist

General

The importance of one pilot monitoring the other during all abnormal and emergency procedures cannot be over-emphasized.

Warnings

Aural warnings should be silenced and the Master Caution cancelled when cause of the warning is recognized. This is normal action and is not listed in the procedures.

1.17.3 Quick Reference Handbook (QRH)

The Emergency checklist actions are contained in the QRH.

Extracts from Aero Contractors QRH

Section 2: Cabin Altitude Warning or Rapid Depressurisation

If one or more of these occur:

- *A cabin altitude exceedence.*
- *In-flight, the intermittent cabin altitude/configuration warning horn sounds or the cabin altitude light illuminates.*
  1. *Don oxygen masks and set regulator to 100%.*

2. *Establish crew communications.*
3. *Pressurization mode selector..............MAN AC*
4. *Out flow valve switch..............Hold in CLOSE until the outflow VALVE indication shows fully closed.*
5. ***If** cabin altitude is **not** controllable:*

   Passenger signs...........................ON

   ***If** the cabin altitude exceeds or is expected to exceed 14,000 feet:*

   PASS OXYGEN switch................ON

1.17.4 Aero Contractors B737-500 Approved Maintenance Manual (AMM)

Extract from Aero Contractors B737-500 AMM outlines the pressurization control system. The system description and operations were also explained. It also contains fault isolation and rectification procedures. Maintenance personnel are expected to follow the maintenance procedures as contained in this manual. See Appendix 2.

1.17.5 Engine Change Procedure

See Appendix 3 for Aero Contractors BOEING 737-300/400/500 POWER PLANT - REMOVAL/INSTALLATION CX Form.

1.18 Additional Information

1.18.1 Crew Resource Management (CRM)

CRM is a set of training procedures for use in environments where human error can have devastating effects. Used primarily for improving air safety, CRM focuses on interpersonal communication, leadership and decision-making in the cockpit, maintaining situation awareness, team building and maintenance, problem-solving, information transfer and dealing with automated systems. It is the effective use of all available resources for flight crew which makes optimum use of all available human factors, for optimal performance. It addresses the challenge of optimising the human-machine interface and accompanying interpersonal activities.

It also deals with groups routinely working with the cockpit crew, who are involved in the decisions required to conduct a flight safely, and also essential participants in an effective CRM process.

These groups include but are not limited to:

a. Aircraft Dispatchers
b. Flight attendants
c. Maintenance personnel and,
d. Air Traffic Controllers.

1.18.2 Human Factors Relating to Serious Incident involving 5N-BLE

Human factors is the discipline concerned with optimizing the relationships between people and their activities through the systematic application of the human sciences, integrated within the framework of system engineering.

Considerable advances have been made in the disciplines concerned with fitting the person to the job, and the job to the person. Flight crew and other personnel involved in the complex operations of the aviation industry must be carefully selected and trained, their equipment must match the capabilities and limitations of human performance, and they must be protected from the hazards of the environment in which they work. These matters demand the attention of the applied human sciences.

Nowhere is this more evident than in the study of aviation disasters where in more than two thirds of cases investigators are driven to conclude that human error is a major contributor. These errors are not normally due to sudden illness, suicidal tendencies, wilful neglect, or the lack of basic abilities, but typically arise from temporary breakdowns in skilled performance because; system designers, managers, and trainers have paid insufficient attention to human characteristics and skills. The discipline of human factors systematically addresses these issues, to attain the wellbeing of end users, while achieving the maximum effectiveness and efficiency of the system involved.

1.18.3 Judgment and Decision Making

Good judgment and good decision making are mental skills that are expected to be learnt by any human that relates with a complex machine such as aircraft.

There are 2 fundamental principles of good judgment and good decision making: Perception and the ability to differentiate between correct and incorrect solutions. However, it should be noted that a problem could only be solved if it is recognized and its nature is understood.

- Perception: is to; become aware, observe, detect, understand a situation and also to be able to
- Distinguish: recognize, see clearly, understand the distinction between correct and incorrect alternative to a solution.

Judgment is the cognitive process through which a decision is made. Therefore, a good decision is the correct solution based on knowledge, keen perception and the ability to recognize an appropriate course of action.

There is a common thread of pilots missing a problem altogether, pilots recognizing a problem too late or pilots not understanding the nature of the problem even after recognizing there is a problem.

Therefore, the best way a pilot could learn how to recognize that there is a problem and subsequently choose an appropriate course of action is to accurately perceive a solution and be able to distinguish between correct and incorrect alternatives to a solution.

1.19 Useful or Effective Investigation Techniques

Nil.

2.0 ANALYSIS

2.1 Conduct of the Flight

The aircraft departed Lagos at 1815hrs as flight NIG181 en-route Kaduna with 113 persons on board including 5 crew. The First Officer was the pilot flying while the Captain was monitoring.

The After Take-Off Checklist (Operations Manual Part B, Section 2.1.10) requires the crew to confirm that the engine bleeds are ON. This would have called attention to the low duct pressure from engine #2.

According to the Captain, at about twenty three minutes after airborne, the cabin warning horn sounds. The crew then accomplished the appropriate checklist (Cabin Altitude Warning) as contained in Aero Contractors QRH, Section 2, sub section 2.1.

The crew on observing that the cabin rate of climb was not normal should have followed the provisions of Aero Contractors S.O.P Section 3.6.2.2 (Unpressurized and Partially Pressurized Flights). If this procedure had been successfully carried out and the cabin altitude controlled and maintained within the prescribed schedule, the flight could have continued normally. Otherwise, an air return would have been necessary or the aircraft diverted to the nearest suitable aerodrome.

The purser observed that the passenger oxygen masks had dropped on her return from the lavatory. She immediately took her seat, donned her mask and briefed the passengers. Thereafter, she accomplished the appropriate actions. She later briefed the Captain on the situation of the cabin accordingly. These actions by the purser were in line with standard operating procedure as contained in Aero Contractors Operations Manual Part E (Cabin Crew Procedures and Instructions, Section 2.7).

2.2 Engine installation procedure

It is pertinent to note that 5N-BLE has a history of frequent engine changes. See Table 1.

On the 26th of May 2015, #2 engine with serial number 721707 was changed in Abuja due to a surge problem and replaced with engine, serial number 858904. The aircraft was then ferried to Lagos.

On 5th June, 2015; the day of the incident, #2 engine with serial number 858904 was changed due low time remaining and replaced with another engine, serial number 725373. According to evidence available to AIB, this incident occurred on the first commercial flight after this engine change.

The engine post-installation procedure requires that the PRSOV should have been checked after the engine change to confirm that it is in the OPEN position. The engine installation procedure as contained in the AMM Section 71-00-02 requires a series of post-installation tests to verify correct operation. One of these tests is the Pneumatic Leak Test (AMM Section 36-11-05-705-16). This test requires that the PRSOV be manually wrenched to the OPEN position. The PRSOV will remain open when there is pneumatic pressure upstream of the PRSOV.

There is no evidence to show that these procedures were followed by the maintenance engineers during the engine installation. Also, there was no evidence that a duplicate inspection was carried out to confirm that appropriate procedure had been followed during the engine installation. If these procedures had been followed, it would have been discovered that the PRSOV was still in the CLOSED and LOCKED position and this incident would not have occurred.

Therefore, this action contributed to the occurrence.

2.3 The Crew

The Captain and the First Officer were qualified to conduct the flight. The flight was the first flight scheduled for the crew to operate on the day of occurrence.

The Captain reported that during the initial climb, it was observed that the cabin rate of climb showed zero indication but later became normal. The First Officer also reported that on reaching FL150, he observed that the cabin altitude was indicating about 3000ft and since this occurred at low altitude, they decided to monitor during climb.

The flight crew perceived a pressurization problem during initial climb out. However, they did not recognize the nature of the problem. At different occasions, the crew observed abnormalities in the system as evident from these statements: "the cabin rate of climb showed zero indication but later became normal" and "on reaching FL150, he observed that the cabin altitude was indicating about 3000ft and since this occurred at low altitude..." but they ignored their observations and decided to monitor while the problem persisted until when the horn sounds. At FL150 when the crew observed and noticed the situation, it could have been appropriate to switch to MANUAL mode and control the cabin altitude manually.

The crew did not exhibit perception skills; they were aware of the problem but unable to detect and understand the nature of the problem. They failed to demonstrate their skills of awareness, observation, detection and understanding and therefore, were unable to recognize and solve the problem. This action by the crew contributed to the occurrence.

3.0 CONCLUSIONS

3.1 Findings

3.1.1 The aircraft had a valid Certificate of Airworthiness.

3.1.2 Flight NIG181 was cleared by ATC to climb to FL350 on take-off.

3.1.3 The pressurization warning horn sounds at FL330, 23 minutes into the flight.

3.1.4 The passenger oxygen masks deployed at FL330.

3.1.5 An attempt was made to manually control the cabin altitude but the pressure did not hold, hence emergency descent was carried out to an altitude of 10,000ft.

3.1.6 At FL100, the Purser briefed and made passenger announcement that the flight was being diverted to Abuja.

3.1.7 There were no fatalities and no injuries sustained.

3.1.8 The crew were qualified and properly certified to carry out the flight.

3.1.9 The flight crew perceived a pressurization problem during initial climb out. However, they did not recognize the nature of the problem.

3.1.10 The crew ignored their observations about the initial cabin altitude climb and decided to monitor while the problem persisted until when the horn sounds.

3.1.11 Flight NIG181 was the first flight after #2 engine was changed.

3.1.12 The aircraft was dispatched with the PRSOV in the LOCKED CLOSED position.

3.1.13 The PRSOV was found in the LOCKED CLOSED position after the engine change.

3.2 Causal Factor

The inadvertent failure to discover that the PRSOV was in the LOCKED CLOSED position after the engine change.

3.3 Contributory Factor

Failure to recognise that the number 2 bleed pressure was zero after engine start and subsequent failure to monitor the pressurisation system during climb.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendation 2017-019

NCAA should ensure that the activities of flight operations and maintenance departments of Aero Contractors Company of Nigeria Limited are carried out in compliance with the Nig.CARs.

SAFETY ACTIONS

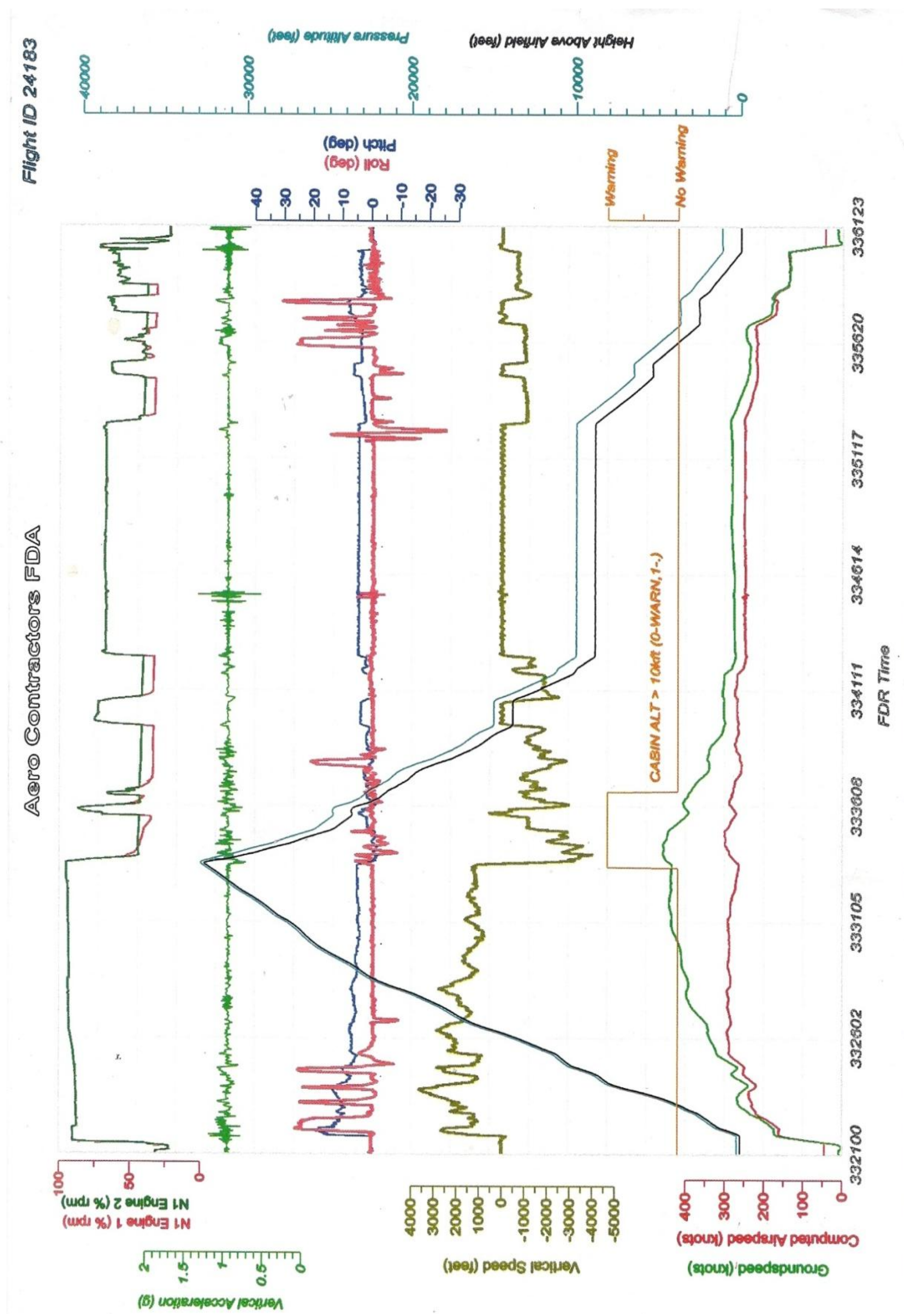
NCAA response to the investigation, Ref. No. NCAA/DG/AIB/9/16/31

FREQUENT ENGINE CHANGES

Due to the frequent engine changes detailed in Table 1, the Authority is considering issuing an All Operators' Letter (AOL), requiring operators of aircraft to mandatorily inform it of any engine changes prior to accomplishment. This will enable the Authority to monitor the processes.

APPENDICES

Appendix 1: Flight Data Analysis



Appendix 2: Pressurization Control System

BOEING

737-300/400/500
AIRCRAFT MAINTENANCE MANUAL

PRESSURIZATION CONTROL SYSTEM - DESCRIPTION AND OPERATION

1. General

A. The pressurization control system is an electrically operated and electronically controlled system, which meters the exhaust of ventilating air to supply controlled pressurization of the passenger and control cabins, the electronic compartment, the two cargo compartments, and the lower nose compartment. The pressurization control system has a pressure control panel, a pressure controller, and a cabin pressurization outflow valve (Figure 1). The pressurization control system characteristics are as follows:

(1) The system has four operating modes; automatic, standby, ac manual and dc manual. Automatic is the normal operating mode. Standby is a semiautomatic backup. The ac manual and dc manual modes are backups for automatic and standby modes. Normal operation is automatic and normally requires no adjustment by the flight crew throughout the flight except for barometric correction.

(2) The ac manual mode and the dc manual mode supply direct control to the outflow valve through separate electrical actuators. The manual modes back up the automatic and standby systems.

(3) In the automatic mode, the system accepts manual inputs of planned flight altitude and landing altitude before takeoff. It then finds the lowest possible cabin pressure that can be maintained during airplane high altitude flight and schedules any necessary change in cabin pressure during the flight without any action by the crew.

The system can also be reset if a change in planned flight altitude or landing field altitude is made.

(4) Cabin pressure rate of change is automatically controlled in AUTO. Rate of change may be manually controlled in STBY.

(5) Barometric correction for automatic and standby pressure control assures that cabin pressure and landing field pressure are approximately the same at landing.

(6) A mode selector switch on the control panel permits selection of four modes of operation plus a check position for system test.

(7) The STANDBY system automatically takes over to control cabin pressure according to cabin altitude and rate of cabin pressure change settings if certain limits are exceeded in AUTO. In addition, a manual transfer can be made from AUTO to STBY, if desired, by use of the mode selector switch.

B. Operation of the pressurization control system requires signals into the pressurization control system from direct ambient pressure sensing, barometric pressure correction and the landing gear ground safety sensor (LANDING GEAR SAFETY SENSORS - DESCRIPTION AND OPERATION, PAGEBLOCK 32-09-00/001) for the automatic mode and from the air data computer (AIR DATA SYSTEMS - DESCRIPTION AND OPERATION, PAGEBLOCK 34-12-01/001), barometric correction and the landing gear ground safety sensor in the standby mode. Electrical circuit protection for the pressurization control system is supplied by circuit breakers on the P6 circuit breaker panel.

EFFECTIVITY
UAL ALL; AIRPLANES WITH ANALOG CABIN PRESSURE CONTROLLERS

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AIRCRAFT MAINTENANCE MANUAL

PRESSURIZATION CONTROL SYSTEM - TROUBLE SHOOTING

1. **General**

A. Trouble shooting of the pressurization control system is broken down to correspond to the four operational modes. Refer to Adjustment/Test to verify that any mode is malfunctioning. The trouble shooting chart isolates the trouble to a particular system component, i.e. pressure controller, pressure control panel, cabin pressurization outflow valve, or to an input which is not part of the system i.e. air data computer or landing gear ground safety sensor. If adjustment/test shows pressurization control system is operable and a flight complaint is received, check the airplane ambient pressure sensing lines for leakage.

WARNING: OUTFLOW VALVE IS MOTOR OPERATED. DO NOT INSERT HAND OR TOOLS IN OUTLET DURING ANY GROUND OPERATION OR INJURY TO PERSONNEL MAY OCCUR.

B. Outflow valve operation may be observed from outside the airplane by looking into the valve outlet. Check the outflow valve for movement if the VALVE position indicator does not move. This would indicate a possible malfunction in the valve position indication system.

C. To simulate a flight condition with the airplane on the ground, the landing gear lights circuit breaker must be opened to de-energize the airplane landing gear ground safety sensor relay. The AUTO FAIL and STANDBY lights will remain on continuously if the circuit breakers for the 28-volt dc bus No. 1 and 2 are both open. This is normal for power input conditions. To remedy the situation, close all circuit breakers and place FLT-GRD switch to GRD.

D. The rate of cabin pressure change is shown on the CLIMB indicator in feet per minute.

E. If a rapid cabin pressure rate-of-climb (depressurization) occurs during descent and the forward and aft outflow valves are operating properly, check the entire airframe for signs of obvious air leakage such as around door seals and skin cracks. Such cracks or leaks will be well defined with a nicotine stain. If no obvious leaks are present perform cabin depressurization and excessive leak checks per Chapter 5.

2. **Fault Isolation Procedures**

A. Figure 101 Cabin Pressure Control System AUTO Mode Troubleshooting

(1) Procedure 1 OFF SCHED DESCENT Light Does Not Illuminate During Vacuum Test (PAGEBLOCK 21-31-00/501 Config 1)

(2) Procedure 2 OFF SCHED DESCENT Light Comes On But Does Not Go Out After a Short Time (approximately 3 minutes) in AUTO Mode.

(3) Procedure 3 OFF SCHED DESCENT Light Comes On Momentarily (1 to 10 seconds) Upon Touchdown.

(4) Procedure 4 Ground Pressurized or Ground Unpressurized Circuits Not Functional

(5) Procedure 5 AUTO FAIL and STANDBY Lights Do Not Come On with all Power Applied with Mode Selector in CHECK.

(6) Procedure 6 STANDBY Light Comes On when Fault is Checked with STBY Mode Inoperative

(7) Procedure 7 AUTO FAIL Light Fails to Reset or STANDBY Light Continually on Regardless of Control Panel Settings for AUTO or STBY. AC and DC MAN Normal.

(8) Procedure 8 Outflow Valve Does Not Respond to Barometric Correction. Ground Unpressurized and Ground Pressurized Checks are Normal.

(9) Procedure 9 Outflow Valve Does Not Respond Properly to Isobaric Schedule Check. Barometric Correction Check is Good and Ground Unpressurized and Ground Pressurized Checks are good.

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2. Pressure Control Panel

A. The pressure control panel includes four groupings of dials, switches, and indicators used in the operation of the pressurization control system. One grouping is for the automatic (AUTO) mode of operation, another is for the semiautomatic or standby mode, the third is for the manual mode, and the fourth is to let you choose the desired mode of control and function available.

B. For the AUTO mode there is an adjusting knob and indicator (LAND ALT) for setting destination landing field altitude and another knob and indicator (FLT ALT) for setting cruise altitude.

C. Instruments for STANDBY consist of a cabin altitude adjusting knob (CAB ALT) and indicator and a cabin rate of pressure change (CAB RATE) knob.

There is an index mark on the panel for the CAB RATE knob which marks the setting for approximately 300 feet per minute rate of change. CAB RATE range is from 50 to 2000 sea level ft/min.

D. The manual mode uses a three-position self-centering toggle switch to control the position of the outflow valve. The switch has momentary contacts to drive the outflow valve open or closed. Releasing the switch opens the contacts, stopping outflow valve movement. A position indicator is supplied for monitoring outflow valve position in all modes.

E. The fourth section of the panel includes a five-position mode selector switch, CHECK, AUTO, STBY, AC and DC MAN; and a two-position FLT-GRD toggle switch. The FLT-GRD switch is used in conjunction with the mode selector switch and landing gear sensor switch to control minimum cabin pressurization on the ground when the mode selector is in AUTO or STBY, and to check the rate limit fault detector of the auto transfer when the mode selector is in the CHECK position. When the mode selector is in MAN AC or DC position, cabin pressurization is controlled directly by the use of the manual OPEN-CLOSE switch to actuate the outflow valve under ac or dc control, depending on the position of the selector switch.

3. Pressure Controller

A. The pressure controller is an electronic unit which receives inputs from the pressurization control panel, airplane ambient pressure and cabin pressure, then positions the outflow valve to maintain proper differential pressure (Figure 2).

B. Two completely independent pressure control system networks are contained within the pressure controller. The automatic system operates as a function of destination landing field altitude and cruise altitude while the standby system operates according to the selected cabin altitude and selected rate of cabin pressure change.

C. Inputs to the pressure controller for the automatic and standby systems are shown schematically on a block diagram (Figure 2).

D. All outputs from the pressure controller operate the cabin pressurization outflow valve. The controller will operate either under the automatic system or the standby system, but never the two systems simultaneously.

The FLT-GRD switch is used to modify the two outputs for cabin pressurization control on the ground. When the switch is moved to FLT position with the mode selector in AUTO the valve will move to a position which will cause cabin pressure to rise slightly above (approximately 0.1 psi) that of the takeoff field. With the selector in STBY the valve will be positioned to control the pressure to the selected standby cabin altitude. With mode selector switch in either AUTO or STBY and FLT-GRD switch is moved to GRD (airplane on ground), the outflow valve will move to the full open position at the rate necessary to completely depressurize the airplane at rate limit.

E. On the front of the controller, there are test points under a cover which are used for trouble-shooting the pressurization control system. On the rear of the controller, the upper connection is used only for bench test.

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F. The pressure controller is installed in the electronic equipment compartment on the forward top shelf. There is a delta P module installed adjacent to the pressure controller, which supplies a maximum of 7.45 psi with the pressurization mode selector in AUTO and 28,000 ft or below selected with the FLT ALT selector. A 7.80 ª P is supplied when FLT ALT above 28,000 ft is selected with the pressurization mode selector in AUTO. STANDBY maximum pressure differential is 7.8 psi.

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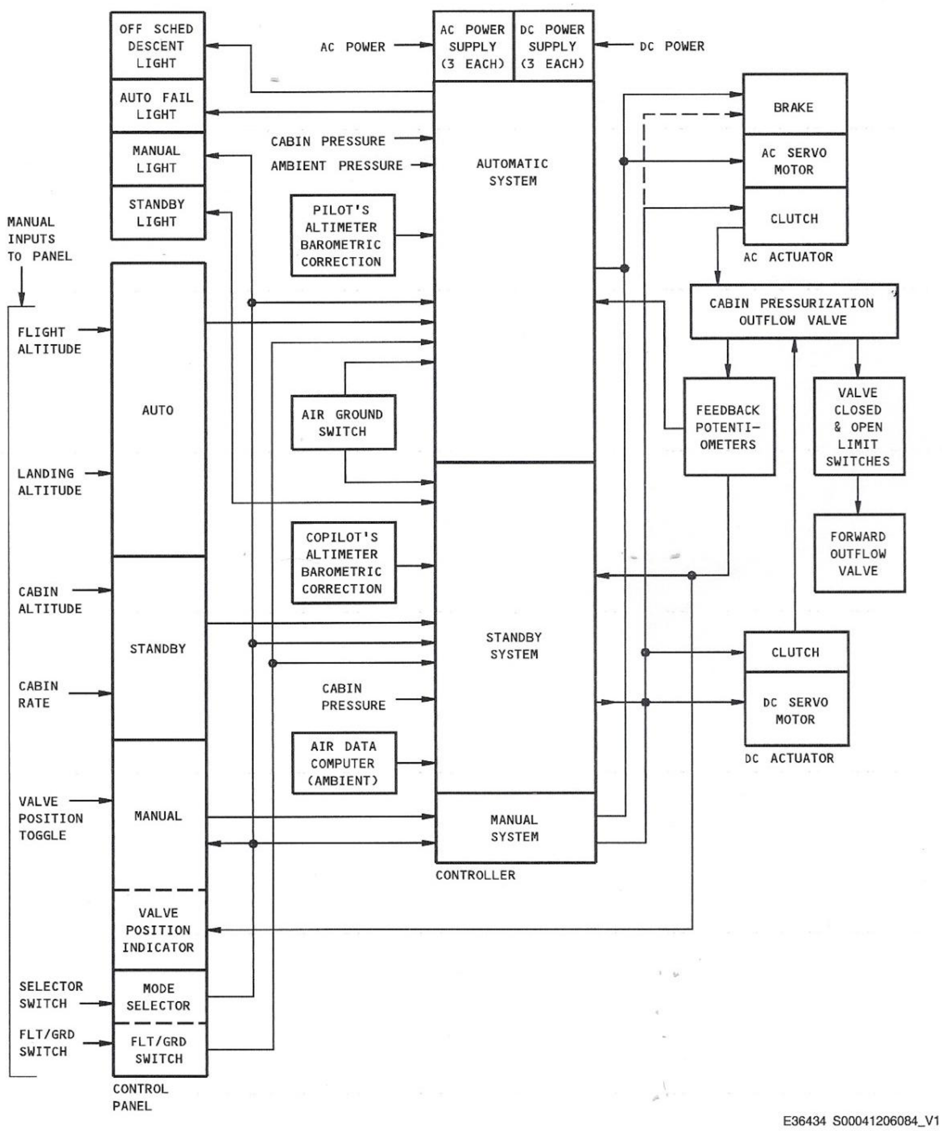

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Pressurization Control System Block Diagram
Figure 2/21-31-00-990-808-001

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4. **Cabin Pressurization Outflow Valve**

A. The outflow valve is a thrust recovery, rotating gate valve which is driven by either a rotary dc electrical actuator or a rotary ac electrical actuator. Each actuator connects to the gate shaft with an electrically operated spring-loaded clutch. AUTO and AC MANUAL modes operate the ac actuator. STANDBY and DC MANUAL modes operate the dc actuator. When either actuator is in operation the clutch to the other actuator is disengaged.

B. With no electrical power to the clutches, the dc actuator clutch is spring loaded disengaged and the ac actuator clutch is spring loaded engaged. The clutches are energized when operating from the standby system or the manual dc system. With electrical power to the clutches, the dc actuator clutch is engaged and the ac actuator clutch is disengaged.

C. There is a limit switch installed on each end of the valve gate shaft. The switches assure that the forward outflow valve (CARGO COMPARTMENT HEATING - DESCRIPTION AND OPERATION, PAGEBLOCK 21-43-00/001) does not affect the cabin pressurization control system. The forward outflow valve closes when the cabin pressurization outflow valve is within 0.5 degrees of the full-closed position. The forward outflow valve opens when the cabin pressurization outflow valve opens approximately 4.5 degrees.

WARNING: OUTFLOW VALVE IS MOTOR-OPERATED. DO NOT INSERT HAND OR TOOLS IN OUTLET DURING ANY GROUND OPERATION OR INJURY TO PERSONS CAN OCCUR.

D. The outflow valve is installed so its outlet is flush with the body skin. The valve is found to the right of the airplane centerline, at the underside of the airplane, approximately below the aft right service door.

5. **Forward Outflow Valve**

A. The forward outflow valve is located at the forward left side of the forward cargo compartment. The forward outflow valve is a component of the cargo heating system (CARGO COMPARTMENT HEATING - DESCRIPTION AND OPERATION, PAGEBLOCK 21-43-00/001) and does not affect the cabin pressurization control system. This is assured by an electrical circuit that closes the forward outflow valve whenever the cabin pressurization outflow valve is nearly closed. There is a limit switch installed in each actuator of the cabin pressurization outflow valve. The forward outflow valve will close when the cabin pressurization outflow valve is within 0.5 degrees of closed and will open when the pressurization outflow valve opens approximately 4.5 degrees. An electrical circuit also closes the forward outflow valve any time the cabin air recirculation fan is operating (Figure 3).

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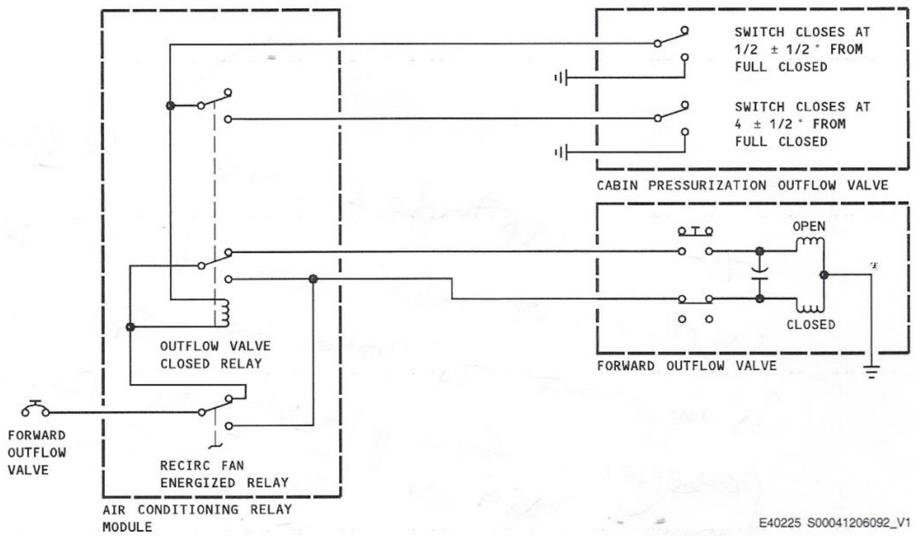

Forward Outflow Valve Control Schematic
Figure 3/21-31-00-990-811-001

6. **Operation**

A. The automatic mode is the normal operation of the pressurization control system. The destination landing field altitude and desired cruise altitude are set on the control panel, converted to voltage signals and input to the cabin pressure controller. The controller also receives signals from the air data computer, barometric correction potentiometer, outflow valve position feedback, and from the landing gear ground safety sensor. The controller also senses cabin and ambient air pressure and converts these to voltage signals. The controller provides voltage signals to the outflow valve causing the valve to modulate the flow of cabin air to maintain cabin pressure at the desired level.

B. Pressurization control is automatically transferred from automatic mode to standby if the cabin pressure rate of change exceeds 1.0 psi per minute or cabin altitude exceeds 13,895 feet. In the event of a power failure to the automatic system, control will automatically be transferred to the standby system provided power is available to that system. Upon transfer, the cabin pressure will change to the selected standby cabin altitude at the selected standby rate of change. During standby control the cabin altitude is limited to 14,625 feet by a pressure switch in the controller. This signals the dc actuator, which modulates the outflow valve closed. The AUTO FAIL and STANDBY lights come on when the automatic system has been transferred to the standby system and the mode selector is in AUTO. The automatic mode of operation may be reselected after an automatic transfer to standby. If any fault remains in the automatic mode, the system will automatically transfer back to the standby mode.

C. The standby system may be utilized, although the automatic change to standby has not occurred. By moving the selector switch to STBY after setting the cabin altitude and pressure rate of change, the standby system will control cabin pressure. The STANDBY light will come on. The possible indicator light conditions for the standby mode are:

(1) When standby mode is selected, only the STANDBY light will be on.

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(10) Procedure 10 Uncommanded cabin pressure rate of change in AUTO mode with no AUTO FAIL light during all phases of flight until STANDBY mode is selected.

B. Figure 102 Cabin Pressure Control System STANDBY Mode Troubleshooting
   (1) Procedure 1 STANDBY Light Not Illuminated.
   (2) Procedure 2 Outflow Valve Does Not Respond to Isobaric Schedule Check. Barometric Correction Check is Good and Ground Unpressurized and Ground Pressurized Checks are Good.
   (3) Procedure 3 Outflow Valve Does Not Respond at All.
   (4) Procedure 4 Outflow Valve Does Not Go Open with FLT-GRD Switch in GRD. Other Responses Normal
   (5) Procedure 5 Outflow Valve Does Not Respond to Barometric Correction Input. Ground Operation Normal.
   (6) Procedure 6 Outflow Valve Does Not Respond Properly to CAB ALT Control.

C. Figure 103 Cabin Pressure Control System DC MANUAL Mode Troubleshooting
   (1) Procedure 1 Outflow Valve Does Not Respond in Ground or Flight Operation.
   (2) Procedure 2 MANUAL Light Does Not Illuminate.
   (3) Procedure 3 Outflow Valve Responds to OPEN/CLOSE Toggle Switch in One Direction Only.

D. Figure 104 Cabin Pressure Control System AC MANUAL Mode Troubleshooting
   (1) Procedure 1 Outflow Valve Does Not Respond in Ground or Flight Operation.
   (2) Procedure 2 Outflow Valve Responds to OPEN/CLOSE Toggle Switch in One Direction Only

E. Figure 104A Cabin Pressure Controller Internal Fuse Tests
   (1) Procedure 1 AC and DC Clutch Coil Fuse Test (Fuse F2 and Fuse F1)
   (2) Procedure 2 AC Motor Winding Fuse Test (Fuse F3)

F. Figure 105 The Cabin Pressure Control System (CPCS) Cannot Maintain Cabin Pressure Due to Excessive Air Leakage or There is a Problem with the Air Supply System

G. Figure 106 System Fails in AUTO Mode, STANDBY Mode Normal

H. Figure 107 High Cabin Differential Pressure Troubleshooting

3. **Cabin Pressure Controller Internal Fuse Tests**

(Figure 104A)

A. Overcurrent protection is designed into Hamilton Standard CPC 21 and CPC 22 cabin pressure controllers. Three fuses (F1, F2 and F3) are installed internal to the controller on the output drive signals to the outflow valve clutch coils and AC motor control windings. The purpose for the fuses is to prevent thermal damage caused by excessive current draw. Should electrical resistance drop too low, as a result of aircraft wiring shorts or shorts in clutch coil or AC motor windings, the associated fuse will open. Corrective action requires not only isolation of the overcurrent failure, but removal and replacement of the faulty controller. Should the controller be replaced prior to correcting the electrical short, the newly replaced controller will experience the same open fuse failure.

B. Protective fuses are identified in controller electrical schematics as F1, F2 and F3. These fuses are associated with the DC clutch coil, AC clutch coil, and AC motor windings, respectively.

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Appendix 3: Engine Change Procedure

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POWER PLANT - REMOVAL/INSTALLATION

Work Order Number:		Date:		
Aircraft Registration:	Aircraft Hours:		Aircraft Cycles:	
Reason For Removal:			Position:	
Engine PN Off:		Engine PN On:		
Engine SN Off:		Engine SN On:		
	Engineer in Charge:			
1	Name:	Licence Number: ACN-	Stamp:	Signature:
	Engine / Airframe / Avionics Engineers:			
1	Name:	Licence Number: ACN-	Stamp:	Signature:
2	Name:	Licence Number: ACN-	Stamp:	Signature:
3	Name:	Licence Number: ACN-	Stamp:	Signature:
4	Name:	Licence Number: ACN-	Stamp:	Signature:
5	Name:	Licence Number: ACN-	Stamp:	Signature:
6	Name:	Licence Number: ACN-	Stamp:	Signature:

NO	CONTENTS:
1	Pre-Engine removal MPA Engine run and data recoring
2	365 day engine preservation
3	Prepare for the Removal
4	Power Plant (Bootstrap Method) Removal
5	Prepare for the Installation
6	Power Plant (Bootstrap Method) Installation
7	Put the Airplane Back to Its Usual Condition.
8	Post-Engine Installation MPA Engine run and data recording
9	ECM System Update

	Power Plant Removal Preparation		
	REFERENCE: AMM 71-00-02 Config 4 Page 401		
	FIGURES: 401,402,403,404,405,406,407,408,409,410,411 and 412		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
	Do these tasks to prepare for the removal of the power plant:	**Inspector**	**Engineer**
1	Do the tests listed in the Power Plant Test Reference Table (TASK 71-00-00-800-801-C00) and complete engine data and record sheet (AMM 71-00-00 Fig. 501)		
2	Preserve engine to 365 days IAW TASK 71-00-03-622-046-C00 and complete and attach ident label stating engine preserved for 365 days.		
3.1	If not already done, make the airplane level as near to a zero pitch attitude as possible (TASK 08-11-00-582-001).		
3.2	Ground the airplane (TASK 20-40-11-862-001).		
3.3	Make sure the forward thrust levers are in the idle thrust position.		
3.4	Make sure the start levers are in the CUTOFF position.		
3.5	Install DO-NOT-OPERATE tags to the start levers.		
3.6	Supply the electrical power (TASK 24-22-00-862-019).		
3.7	Remove the DO-NOT-OPERATE tag from the BAT switch.		
3.8	Make sure the FUEL VALVE CLOSED light on the pilots' overhead panel, P5, is on, dim, to show that the valve is closed.		

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NO	JOB DESCRIPTION	ACCOMPLISHED BY	
3.9	For removal of the No. 1 engine, do this step:	**Inspector**	**Engineer**
3.9.1	Open this circuit breaker and attach a DO-NOT-CLOSE tag: P6-3 Main Power Distribution Panel:		
	SHUTOFF VALVE ENG 1.		
3.9.2	Install a lockset on the open circuit breaker.		
3.1	For removal of the No. 2 engine, do this step:		
3.10.1	Open this circuit breaker and attach a DO-NOT-CLOSE tag: P6-3 Main Power Distribution Panel:		
	SHUTOFF VALVE ENG 2.		
3.10.2	Install a lockset on the open circuit breaker.		
3.11	Do the deactivation procedure for the thrust reverser for ground maintenance		
	(TASK 78-31-00-042-001-C00).		
3.12	Remove the pressure from the hydraulic system (TASK 29-09-00-862-013).		
3.12.1	Do these steps to do the deactivation of the wing leading and trailing edge devices		
	TASK 27-81-00-042-009):		
3.12.2	Retract the leading edge flaps and slats and install a DO-NOT-OPERATE tag on the flap		
	control lever.		
3.12.3	Put the ALTERNATE FLAPS switch on the pilots' overhead panel, P5, to the ARM position.		
3.12.4	Open this circuit breaker and attach a DO-NOT-CLOSE tag: P6-2 Main Power Distribution Panel		
	FLAP SHUTOFF VALVE. Install a lockset on the open circuit breaker.		
3.12.5	Put the ALTERNATE FLAPS switch to the OFF position.		
3.12.6	Put the override lever on the trailing edge bypass valve in the correct position for the engine removal:		
	Make sure the position of the override lever is in position 2.		
	If the override lever is not in position 2, manually move the lever to position 2.		
3.13	Put the HYD PUMPS ENG switch on the pilots' overhead panel, P5, in the OFF position for the		
	applicable engine. Install a DO-NOT-OPERATE tag.		
3.14	It is recommended that you do the bleed air precooler inspection for cracks		
	(TASK 36-12-25-215-049).		
3.15	Release the pressure from the pneumatic system (TASK 36-05-00-862-020).		
3.16	Remove the electrical power (TASK 24-22-00-862-025).		
3.16.1	Set the BAT switch on the Electrical Meters Battery and Galley Power Module (P5-13) to the		
	OFF position and install a DO-NOT-OPERATE tag.		
3.17	Remove the fan cowl panels (TASK 71-11-02-000-801-C00).		
3.18	Open the thrust reversers (TASK 78-31-00-020-801-C00).		
3.19	Attach the thrust reverser hold open equipment, SPL-9932 for the left and right		
	thrust reversers (Figure 401):		
3.2	Disconnect the opening actuators for the thrust reverser.		
3.21	Apply tape around the edge of the thrust reverser so that the latches are in the closed position.		

NO	JOB DESCRIPTION	ACCOMPLISHED BY

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	Engine Core Disconnects:	Inspector	Engineer
3.22	Disconnect the W1508 core wire bundle (Figure 404).		
3.23	Disconnect the PRSOV from the right side (Figure 405).		
3.24	Disconnect the PRSOV from the left side (Figure 406).		
3.25	Disconnect the throttle control cable (Figure 407).		
3.26	Disconnect the fuel shutoff cable (Figure 408).		
3.27	Remove the fuel control box (Figure 409).		
3.28	Drain the fuel supply line (Figure 410).		
3.29	Disconnect the 1-1/2-inch fitting on the fuel supply line at the service disconnect panel (Figure 411).		
3.3	Disconnect the 7/8-inch fittings on the left drain line (Figure 411).		
3.31	Disconnect the hydraulic lines.		
3.32	Disconnect the starter duct.		
3.33	Disconnect the electrical connectors D410 and D400.		
3.34	Disconnect the flexible potable water pressurization line from the No. 1 engine (Figure 412).		
3.35	Disconnect the 7/8-inch fitting on the right strut drain line.		

	Power Plant (Bootstrap Method) Removal		
	REFERENCE: AMM 71-00-02 Config 4 Page 427		
	FIGURES: 413, 414, 415, 416, 417, 418, 419, 420, 421 and 422		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
		Inspector	**Engineer**
4	Install the forward part of the engine bootstrap equipment, SPL-9909 (Figure 413).		
4.1	Install the aft part of the engine bootstrap equipment, SPL-9909 (Figure 414).		
4.2	Put the engine installation / transportation dolly, SPL-9942 and engine bootstrap cradle,		
	SPL-9941 below the power plant.		
4.3	Attach the inboard and outboard forward cradle mounts to the cradle (Figure 415).		
4.4	Attach the forward lever hoists to the forward cradle mounts.		
4.5	Attach the pulleys to the aft end of the cradle (Figure 416).		
4.6	Attach the cable to the dynamometer at the aft bootstrap location.		
4.7	Put the cable through the cradle pulleys and attach it to the lever hoist.		
4.8	Align the engine installation / transportation dolly, SPL-9942/engine bootstrap cradle, SPL-9941		
	assembly below the engine.		
4.9	Release the engine bootstrap cradle, SPL-9941 from the engine installation / transportation		
	dolly, SPL-9942.		
4.1	Set the dynamometers to the zero position.		
4.11	Raise the engine bootstrap cradle, SPL-9941 up to the engine.		
4.12	Attach the engine bootstrap cradle, SPL-9941 to the engine (Figure 417) (Figure 418).		
4.13	Apply a preload to the hoists until the two forward dynamometers read 3750 ±100 lbs (1700 ±45 kg),		
	and the aft dynamometer reads 750 ±100 lbs (340 ±45 kg).		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
4.14	To keep the thrust links attached with the strut, disconnect the	**Inspector**	**Engineer**

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	engine thrust links as follows (Figure 419).	
4.15	To keep the thrust links attached with the engine, disconnect the engine thrust links as	
	follows (Figure 419).	
4.16	Release the forward cone bolts (Figure 420).	
4.17	Release the aft cone bolts (Figure 421).	
4.18	Loosen the forward cone bolt nuts 1-1/2 to 2 turns each.	
4.19	Use the adapter wrenches (aft cone bolt wrench, SPL-9915, aft conebolt nut wrench,	
	SPL-9907, aft cone bolt nut wrench, SPL-9917) for the aft cone bolt nut to loosen the aft cone	
	bolt nut 1-1/2 to 2 turns.	
4.2	Slowly decrease the load on the lever hoists until the cone bolts are free.	
4.21	Adjust the hoists until there is a small clearance between the cone bolt nuts and their	
	mating surfaces.	
4.22	Remove the aft cone bolt nut [2] and washer [1] (Figure 421).	
4.23	Remove the forward cone bolt nuts [6] and retainers [4] (Figure 420).	
4.24	Install the cone bolts thread protector, SPL-9912 on the two forward and one aft cone bolts.	
4.25	Lower the engine.	
4.26	Carefully monitor the engine to make sure that all disconnect and separation points have been	
	made.	
4.27	As you lower the engine, adjust the attitude until all engine bootstrap cradle, SPL-9941 attach	
	pads touch the transportation base at the same time.	
4.28	Attach the engine bootstrap cradle, SPL-9941 to the engine installation / transportation dolly,	
	SPL-9942 with the attached hardware.	
4.29	Install protective caps on the ducts and the precooler to keep contamination out of the pneumatic	
	system.	
4.3	Disconnect the engine installation / transportation dolly, SPL-9942/engine	
	bootstrap cradle, SPL-9941 assembly from the bootstrap equipment.	
4.31	Remove the PRSOV from the engine.	
4.32	Remove the power plant from the work area.	

	Power Plant Installation Preparation
	REFERENCE: AMM 71-00-02 Config 4 Page 472
5	**Fuel control box compatibility**

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	Make sure the correct fuel control box agrees with the fuel control push-pull cables installed for the
	airplane model and engine type.
	NOTE: Do not modify the rack tang, the support plate dowels, or the gear fork in the fuel control box.
	The fuel control box is designed to agree with the airplane model and engine type. The table is given
	as information because of the engine intermix configurations and spare engine interchanges between
	airplanes.

Table 404/71-00-02-993-827-C04

	AIRPLANE MODEL	ENGINE TYPE	FUEL CONTROL BOX
	737-300	CFM56-3B	315A1040-4, -5, -6
	737-300	CFM56-3C	315A1040-7
	737-400	CFM56-3B	315A1040-8
	737-400	CFM56-3C	315A1040-9
	737-500	CFM56-3C	315A1040-11

	Power Plant (Bootstrap Method) Installation		
	REFERNCE: AMM 71-00-02 CONFIG 4, PAGE 474		
	FIGURE: 413, 414, 415, 416, 417, 418, 419, 420, 421 and 422		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
6	Do this task: Power Plant Installation Preparation, TASK 71-00-02-864-148-C04.	Inspector	Engineer
6.1	Examine the engine mounts and mating surfaces.		
6.2	Make an inspection of the aft engine mount.		
6.3	Make an inspection of the thrust links.		
6.4	If installed, remove the two forward and one aft thread protectors.		
6.5	Apply Never-Seez NSBT-8N compound, D00006 to the two forward and one aft cone bolt		
	threads.		
6.6	Install the cone bolts thread protector, SPL-9912 on the two forward and one aft cone bolts.		
6.7	Make sure that there is a thrust link assembly installed on the engine.		
6.8	On the new engine, do these steps to connect the PRSOV to the engine connections (Figure 405		
	and Figure 406).		
6.9	Install the engine bootstrap equipment, SPL-9909.		
6.10	Put the engine installation / transportation dolly, SPL-9942, with the engine bootstrap cradle,		
	SPL-9941 attached to the engine, below the strut.		
6.11	Attach the inboard and outboard forward cradle mounts to the engine bootstrap cradle, SPL-9941		
	(Figure 415).		
6.12	Attach the forward lever hoists to the forward cradle mounts.		
6.13	Attach the pulleys to the aft end of the engine bootstrap cradle, SPL-9941 (Figure 416).		
6.14	At the aft bootstrap location attach the cable to the dynanometer.		
6.15	Put the cable through the cradle pulleys and attach it to the lever hoist.		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
6.16	Remove the hardware that attaches the engine bootstrap cradle, SPL-9941	**Inspector**	**Engineer**
	to the engine installation / transportation dolly, SPL-9942.		
6.17	Raise the engine until it is approximately 6 inches (15 cm) below the strut and engine interfaces		

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	(Figure 431).		
6.18	Make sure all engine connections do not interfere with the strut as you raise the engine.		
6.19	Adjust the engine pitch until the forward and aft cone bolts go in their alignment holes at the		
	same time.		
6.20	Raise the power plant		
6.21	If the Thrust Links Were Kept with the Strut (preferred method): as you raise the engine,		
	align the thrust links with the fan case fitting		
6.22	Install the bolt [1] and washer [2] to each thrust link to temporarily keep the thrust link		
	attached to the fan frame fitting (Figure 419).		
6.23	If the Thrust Links Were Kept with the Engine (alternate method), align the thrust fitting on		
	the thrust link assembly with the bottom surface of the strut.		
6.24	Make sure the right cone bolt fully engages the machined slot in the cross pin.		
6.25	DO NOT APPLY MORE THAN 4000 POUNDS (1820 KG) ON THE FORWARD		
	OUTBOARD AND FORWARD INBOARD DYNAMOMETERS, AND 1000 POUNDS		
	(454 KG) ON THE AFT DYNAMOMETER. DAMAGE TO EQUIPMENT CAN OCCUR.		
6.26	Apply a load to the hoists until each cone bolt comes out of its mating receptacle enough to		
	permit the installation of a washer or retainer, and to permit each cone bolt nut to fully		
	engage the cone bolt threads.		
6.27	Increase the load to the hoists until the two forward dynamometers read 3750 ±100 lbs		
	(1700 ±45 kg), and the aft dynamometer reads 750 ±100 lbs (340 ±45 kg).		
6.28	Remove the two forward and one aft cone bolts thread protector, SPL-9912.		
6.29	Apply Never-Seez NSBT-8N compound, D00006 to the threads of the cone bolt nuts.		
6.30	Install the cone bolt nuts [13] for the forward engine mount as follows (Figure 420).		
6.31	Examine the self-locking feature of the forward cone bolt nuts.		
6.32	Apply a minimum locking torque of 32 pound-inches (3.6 Newton-meters) .		
6.33	If you cannot keep the minimum locking torque, replace the nut(s) and examine the		
	cone bolt threads for worn areas.		
6.34	Apply Never-Seez NSBT-8N compound, D00006 to the aft engine mount nut threads		
6.35	Install the cone bolt nut [2] for the aft engine mount (Figure 421).		
6.36	Install the washer [1] and the nut [2] on the aft engine mount.		
6.37	Use the aft cone bolt nut wrench, SPL-9917 to install, but not tighten, the nut on the aft		
	cone bolt.		
6.38	Install the nut [2] until it fully engages the cone bolt threads.		
6.39	Do a check of the self-locking feature of the aft cone bolt nut [2] with the aft cone bolt nut		
	wrench, SPL-9917 or aft cone bolt wrench, SPL-9915 (Figure 432).		
6.40	Apply a minimum locking torque of 50 pound-inches (5.6 Newton-meters)		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
6.41	If you cannot keep the minimum locking torque, replace the nut [2] and	**Inspector**	**Engineer**
	examine the cone bolt threads for worn areas.		
6.42	Use the aft cone bolt nut wrench, SPL-9917 or aft cone bolt wrench, SPL-9915 to tighten the aft		
	cone bolt nut [2] to 1700-2150 pound-inches (192-243 Newton-meters).		

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6.43	Calculate the torque at the torque wrench to get the necessary torque of 1700-2150 poundinches		
	(192-243 Newton-meters) (Figure 432) (TASK 70-20-02-912-002-C00).		
6.44	Tighten the nut [2] to the torque value (Y) that you calculated.		
6.45	Tighten the forward cone bolt nuts (Figure 420).		
6.46	Install the fwd engine mount cone bolt alignment guide, SPL-9916 between the cone bolt		
	and the vibration isolator.		
6.47	While you hold the fwd engine mount cone bolt alignment guide, SPL-9916 in the		
	correct position, tighten the forward cone bolt nut [6] to 1200-1400 pound-inches (136-		
	158 Newton-meters) (Figure 420).		
6.48	Make sure you can install the nut retainers [3] such that the attachment holes of the		
	nut retainer and retainer [4] are aligned.		
6.49	Tighten the other forward cone bolt nut with the above steps.		
6.50	Attach the thrust links to the fan frame as follows (Figure 419).		
6.51	If the thrust links were kept with the strut (preferred method): at each thrust link, attach the		
	washer [3] and nut [4] to the bolt [1] and washer [2] which were temporarily installed		
	earlier.		
6.51.1	Tighten the nuts [4] to 90-165 pound-inches (10-19 Newton-meters).		
6.52	If the thrust links were kept with the engine (alternate method), install the thrust link		
	assembly on the strut as follows:		
6.52.1	Get five new bolts [5] or make an inspection of the old bolts [5] that attach the thrust link		
	assembly to the strut		
6.52.2	Apply the Never-Seez NSBT-8N compound, D00006 to the wedge surfaces of the thrust		
	fitting.		
6.52.3	Apply the antiseize compound to the threads of the five bolts [5] that attach the thrust		
	link assembly to the strut.		
6.52.4	Put the thrust fitting onto the lower surface of the strut and install the bolt [5] and		
	washer [6] in the center.		
6.52.5	Tighten the bolt until the wedges of the thrust fitting and the strut engage.		
6.52.6	Install the four outer bolts [5] and washers [6] until the washers touch the thrust fitting.		
6.52.7	Do a check of the barrel nuts for self-locking torque.		
6.52.8	Tighten the five bolts [5] to 585-715 pound-inches (66-81 Newton-meters).		
6.53	Install the forward and aft nut retainers for the cone bolt nuts:		
6.53.1	Aft nut retainer for the aft cone bolt (Figure 421).		
6.53.2	Forward nut retainer for the forward cone bolt (Figure 420).		
6.54	Remove the preload from the lever hoists.		
6.55	Disconnect the engine bootstrap cradle, SPL-9941 from the power plant.		

NO	JOB DESCRIPTION	ACCOMPLISHED BY	
6.56	Lower the engine bootstrap cradle, SPL-9941 to the engine	Inspector	Engineer
	installation / transportation dolly, SPL-9942 and attach it with the attached hardware.		
6.57	Disconnect the forward part of the engine bootstrap equipment, SPL-9909 from the engine		
	bootstrap cradle, SPL-9941 as follows (Figure 415).		
6.58	Disconnect the aft part of the engine bootstrap equipment, SPL-9909 from the engine bootstrap		

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	cradle, SPL-9941 as follows (Figure 416):	
6.59	Remove the engine installation / transportation dolly, SPL-9942 from the work area.	
6.60	Remove the forward part of the engine bootstrap equipment, SPL-9909 (Figure 413).	
6.61	Remove the aft prt of the engine bootstrap equipment, SPL-9909 (Figure 414).	
6.62	If the main and nose landing gear shock struts were extended for clearance between the	
	transportation base and the thrust reverser, retract the struts to their usual service band limits	
	(TASK 08-11-00-582-001).	

	Put the Airplane Back To Its Usual Condition		
	TASK 71-00-02-844-109-C04		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
		Inspector	**Engineer**
7	Attach the PRSOV to the engine between the precooler and the 5th-stage duct.		
7.1	Attach the fire extinguishing hose and the pneumatic overtemperature sense		
	hose (Figure 405).		
7.2	Use the clamp [1], the washer [2] and the nut [3] to connect the pneumatic overtemperature		
	sense hose to the 5th-stage duct bracket (Figure 405).		
7.3	Connect the pneumatic overtemperature sense hose to the tee fitting on the right side of the		
	PRSOV (Figure 405).		
7.4	Install the pressure sense line of the precooler control valve (Figure 405).		
7.5	Connect the electrical connectors (Figure 404).		
7.6	Connect the electrical connectors (Figure 411).		
7.7	Connect the starter duct (Figure 411).		
7.8	Connect the hydraulic lines (Figure 411).		
7.9	Connect the fuel supply line (Figure 411).		
7.10	Connect the left strut drain line (Figure 411).		
7.11	Install the fuel control box (TASK 76-11-08-404-015-C00) (Figure 408 and		
	Figure 409).		
7.12	Connect the fuel shutoff cable (Figure 408).		
7.13	Connect the throttle control cable (Figure 407):		
7.14	Attach the throttle control and fuel shutoff cables to the five flip-loc clamps		
	on the engine.		
7.15	Make sure all hydraulic, electrical and pneumatic connections are tight.		
7.16	Connect the right strut drain line (Figure 412).		
NO	**JOB DESCRIPTION**	**ACCOMPLISHED BY**	
		Inspector	**Engineer**
7.17	Connect the electrical connectors (D404 and D406) (Figure 412).		
7.18	If the engine preservation procedure has been done, do the engine depreservation procedure		
	(TASK 71-00-03-622-132-C00 or TASK 71-00-03-622-071-C00).		
7.19	Do this task: 5th-Stage Bleed Air Check Valve Inspection, TASK 36-11-35-200-801.		
7.20	Do a check of the specific gravity setting and adjust if it is necessary		

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	(TASK 71-00-00-825-010-C00).		
7.21	Do the test for the engine control system rigging (TASK 76-11-00-835-001-C00).		
7.22	Do the autothrottle BITE rig check (TASK 22-31-11-825-017).		
7.23	Test the oil quantity indicating system (TASK 79-31-00-735-029-C00).		
7.24	Connect the opening actuators for the thrust reverser (Figure 402):		
7.25	Remove the thrust reverser hold open equipments, SPL-9932		
7.26	Close the thrust reversers (TASK 78-31-00-410-801-C00).		
7.27	Install the fan cowl panels (TASK 71-11-02-400-801-C00).		
7.28	If removed, install the forward fairing (TASK 54-32-01-404-005).		
7.29	Remove the circuit breaker lockset, and close this circuit breaker:		
7.30	Do the activation procedure for the leading edge flaps and slats as follows		
	(TASK 27-81-00-862-015).		
7.31	Remove the DO-NOT-0PERATE tag from the HYD PUMPS ENG switch on the pilots' overhead		
	panel, P5, for the applicable engine.		
7.32	Remove the DO-NOT-OPERATE tags from the start levers.		
7.33	Power Plant (30 to 365 Days - Serviceable Power Plant) Depreservation		
	TASK 71-00-03-622-071-C00		
8	Do the tests listed in the Power Plant Test Reference Table (TASK 71-00-00-800-801-C00) and		
	complete engine data and record sheet (AMM 71-00-00 Fig. 501)		
9	Update Engine Condition Trend Monitoring system (Planning)		

	Duplicate Inspection:			
1	Name:	Licence Number: ACN-	Stamp:	Signature:
2	Name:	Licence Number: ACN-	Stamp:	Signature: