AIRCRAFT INCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/3/2/1282		
Aircraft Registration	ZS-JRM	**Date of Incident**	16 September 2019		**Time of Incident**	0743Z	
Type of Aircraft	Boeing 737-400		**Type of Operation**	Commercial (Part 121)			
Pilot-in-command Licence Type	Airline Transport Pilot Licence		**Age**	50	**Licence Valid**	Yes	
Pilot-in-command Flying Experience	Total Flying Hours	17 673		Hours on Type	709:05		
First Officer Licence Type	Airline Transport Pilot Licence		**Age**	38	Licence Valid	Yes	
First Officer Flying Experience	Total Flying Hours	7 266.02		Hours on Type	137.05		
Last Point of Departure	O.R. Tambo International Aerodrome (FAOR)						
Next Point of Intended Landing	Cape Town International Aerodrome (FACT)						
Location of the incident site with reference to easily defined geographical points (GPS readings if possible)							
FAOR Runway 03L, at GPS co-ordinates S26º07'32.72" E28º16'00.42"							
Meteorological Information	Wind: Variable/4kt; Visibility: 10km, Temperature: 24°C and Due point: 4°C						
Number of People On-board	2+4+130	**No. of People Injured**	0	**No. of People Killed**	0		
Synopsis							

On 16 September 2019 at approximately 0743Z, a Boeing 737-400 aircraft with registration marks ZS-JRM departed O.R. Tambo International Aerodrome (FAOR) on a scheduled domestic flight to Cape Town International Aerodrome (FACT) with the First Officer (FO) as pilot flying. During pre-flight, start-up, taxi and take-off roll, all systems operated normally. However, during rotation on Runway 03L, the master caution lights illuminated, showing multiple system failures. Also, the auto pilot (AP) 1 and 2 did not engage.

The crew retracted the landing gears and flaps before reading the after-take-off checklist. Thereafter, they advised air traffic control (ATC) that they were experiencing a problem and requested to maintain 8000 feet (ft), which the ATC approved. Shortly thereafter, the ATC offered a climb to flight level (FL) 110, which the crew accepted to clear low-level turbulence. To diagnose the problem, the crew consulted the Quick Reference Handbook (QRH) to follow and action its recommendations. The crew then checked all circuit breakers to see if they had popped, but they were all in order. They checked the auxiliary power unit (APU) generator and found that it was not latching onto the left alternating current (AC) bus. The crew's diagnosis of the problem revealed that the number 1 engine generator failure and the transfer bus failure are the ones that had caused multiple system failures. The crew decided to use the systems still available to them to fly back to FAOR. The ATC cleared the aircraft for landing on Runway 03L. Emergency services were not dispatched as the crew felt that the aircraft was flying normally. The landing was uneventful until the landing roll when the captain's flight instruments and communications 1 (COMM 1) failed. After shutdown, it was discovered that the lever latch of the generator control unit (GCU) of the No.1 engine was broken, and that the unit had moved out of its position. The damage during the incident was only limited to the lever latch of the GCU of the No.1 engine; and none of the passengers were injured.

The investigation revealed that during rotation, the GCU of the No.1 engine had moved out of its rack, causing its electrical connectors to disconnect, resulting in multiple electrical system failures because of the broken lever latch of the GCU of the No.1 engine.

SRP Date	14 July 2020	Publication Date	22 July 2020

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ABBREVIATION	DESCRIPTION
AAIB	Air Accidents Investigation Branch
AC	Alternating Current
AIID	Accident and Incident Investigations Division
AMO	Aircraft Maintenance Organisation
AMM	Aircraft Maintenance Manual
AMSL	Above Mean Sea Level
AOC	Air Operating Certificate
ATC	Air Traffic Control
ATIS	Aerodrome Traffic Information Service
AP	Auto Pilot
APU	Auxiliary Power Unit
°C	Degrees Celsius
CAR	Civil Aviation Regulations
COMM 1	Communication 1
C of R	Certificate of Registration
CVR	Cockpit Voice Recorder
DVOR	VOR (VHF Omnidirectional Radio Range)
FDR	Flight Data Recorder
FACT	Cape Town International Aerodrome
FAOR	O.R. Tambo International Aerodrome
FL	Flight Level
ft	Feet
FO	First Officer
GCU	Generator Control Unit
GPS	Global Positioning System
ILS/DME	Instrument Landing System / Distance Measuring Equipment
ILS GP CAT II	Instrument Landing System Glide Path
ILS LOC	Instrument Landing System Localiser
Km	Kilometre
kt	Knots
METAR	Meteorological Aeronautical Report
MPI	Mandatory Periodic Inspection
PIC	Pilot-in-command
(Pty) Ltd	Proprietary Limited
QNH	Quantity Navigational Height
QRH	Quick Reference Handbook
SAWS	South African Weather Service
TBO	Time Before Overhaul
TCAS	Traffic Collision Avoidance System
UHF DME	Ultra-High Frequency Distance Measuring Equipment
UTC	Co-ordinated Universal Time
Z	Zulu (Universal Co-ordinated Time - Zero hours Greenwich)

Reference Number	**:** CA18/3/2/1282
Name of Owner/Operator	**:** Safair Operations (Pty) Ltd
Manufacturer	**:** Boeing Aircraft Company
Model	**:** 737-400
Nationality	**:** South African
Registration Marks	**:** ZS-JRM
Place	**:** O.R. Tambo International Aerodrome (FAOR)
Date	**:** 16 September 2019
Time	**:** 0743Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to apportion blame or liability****.*

Investigations process:

The incident was notified to the Accident and Incident Investigations Division (AIID) on 16 September 2019 at about 1400Z. The investigator/s went to O.R. Tambo International Aerodrome on 4 October 2019 to make a follow up. The investigator/s co-ordinated with all authorities on-site by initiating the accident investigation process according to CAR Part 12 and investigation procedures. The AIID of the South African Civil Aviation Authority (SACAA) is leading the investigation as the Republic of South Africa is the State of Occurrence.

Notes:
1. Whenever the following words are mentioned in this report, they shall mean the following:

1.1 Incident – this investigated incident
1.2 Aircraft – the Boeing 737-400 involved in this incident
1.3 Investigation – the investigation into the circumstances of this incident
1.4 Pilot – the pilot involved in this incident
1.5 Report – this incident report

2. Photos and figures used in this report were taken from different sources and may be adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows or lines.

Disclaimer:

This report is produced without prejudice to the rights of the SACAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On 16 September 2019 at approximately 0743Z, a Boeing 737-400 aircraft with registration marks ZS-JRM (flight number FA202) departed O.R. Tambo International Aerodrome (FAOR) on a scheduled domestic flight with two pilots, four crew members and 130 passengers on-board to Cape Town International Aerodrome (FACT). The First Officer (FO) was the pilot flying.

1.1.2 During pre-flight, start-up, taxi and take-off roll, all systems operated normally. However, during rotation on Runway 03L, the master caution lights illuminated, revealing multiple system failures. Also, auto pilot (AP) 1 and 2 did not engage. Both pilots attempted to resolve the problem, as well as by reading the after-take-off checklist. Thereafter, they advised air traffic control (ATC) that they were experiencing a problem and requested to maintain 8000 feet (ft), which the ATC approved. Shortly thereafter, the ATC offered a climb to flight level (FL) 110, which the pilots accepted to clear low-level turbulence.

1.1.3 The crew followed the Quick Reference Handbook (QRH) procedures and recommendations to assess the problem. They checked all circuit breakers, particularly those associated with electrical generation, but these seemed to be in order. The crew found that the No.1 engine generator was inoperative even though the “Bus Off” light did not illuminate. However, the No.1 transfer “Bus Off” light was illuminated. Furthermore, the FO noticed that the Traffic Collision Avoidance System (TCAS) was also inoperative. The crew determined that all other failures were because of the No.1 “transfer bus” being inoperative. The crew then advised ATC of their situation, as well as reassessed the aircraft to determine what was working. The FO stated that the aircraft was flying normally, both engines were operating normally, and both hydraulic systems had normal pressure with the B system electric pump inoperative. Pressurisation system had switched to standby system mode and the cabin pressure was down to sea level.

1.1.4 With the systems available, the crew decided to fly back to FAOR for landing. The ATC was advised of the crew’s intention and accepted them before vectoring them back to FAOR. The cabin crew and the passengers were informed that they would return to FAOR for a landing. The pilot-in-command (PIC) checked the aircraft’s weight for the maximum landing weight and obtained the latest Aerodrome Traffic Information Service (ATIS) before reaching waypoint position RAGUL.

Figure 1: Generator Control Unit. (Picture courtesy of Safair)

1.1.5 The aircraft was initially assigned to land on Runway 03R, which was later changed to Runway 03L. Emergency services were not dispatched as the crew felt that the aircraft was flying normally. The landing was uneventful until the landing roll phase when the captain's flight instruments and communications 1 (COMM 1) failed, an indication that the captain's instruments were powered by standby electrical system. After shutdown, it was discovered that the lever latch of the Generator Control Unit (GCU) of the No. 1 engine had broken and the unit had moved out of its position.

1.1.6 The incident occurred during daylight after take-off from FAOR at Global Positioning System (GPS) co-ordinates 26°08'01.30"S 028°14'32.34"E and at a field elevation of 5564.5ft.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	4	130	-

1.3 Damage to Aircraft

1.3.1 The damage was limited to the lever latch of the GCU of the No.1 engine.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

Pilot-in-command (PIC)

Nationality	South African	Gender	Male	Age	50
Licence Number	0270179674	Licence Type		Airline Transport Pilot Licence	
Licence Valid	Yes	Type Endorsed		Yes	
Ratings	Instrument and Night rating				
Medical Expiry Date	28 February 2020				
Restrictions	Corrective lenses				
Previous Accidents	None				

Flying Experience (PIC)

Total Hours	17673.0
Total Past 90 Days	185.10
Total on Type Past 90 Days	115.50
Total on Type	709.05

First Officer (FO)

Nationality	South African	Gender	Male	Age	38
Licence Type	0270511322	Licence Type		Airline Transport Pilot Licence	
Licence valid	Yes	Type Endorsed		Yes	
Ratings	Instrument, Night rating				
Medical Expiry Date	31 July 2020				
Restrictions	None				
Previous Accidents	None				

Flying Experience (FO)

Total Hours	7266.02
Total Past 90 Days	194.03
Total on Type Past 90 Days	53.05
Total on Type	137.05

1.6 Aircraft Information

Airframe:

Type	Boeing 737-400	
Serial Number	28890	
Manufacturer	Boeing Aircraft Company	
Date of Manufacture	1998	
Total Airframe Hours (At time of Incident)	62848.95	
Last C Check (Date & Hours)	8 August 2019	62 581.00
Hours Since Last C Check	267.95	
Certificate of Airworthiness (Issue Date)	2 September 2016	
Certificate of Registry (Issue Date) (Present Owner)	24 August 2016	
Operating Categories	Standard Part 121	

1.6.1 The GCU of the No. 1 engine was fitted to the aircraft on 21 February 2019 by an AMO, thus, the unit was in operation for seven months at the time of the incident. The last maintenance check in the GCU area would have been on 8 August 2019. There were no reported snags on the GCU of the No. 1 engine since its installation. Also, it had accumulated 167 hours since it was installed on the aircraft. The GCU is an on-condition item, thus, does not have maintenance intervals.

Engine No.1

Type	CFM56-3C-1
Serial N umber	858856
Hours Since New	41332
Hours Since Overhaul	Modular assembly

Engine No.2

Type	CFM56-3C-1
Serial Number	857322
Hours Since New	48931
Hours Since Overhaul	Modular assembly

1.7 Meteorological Information

The weather information was obtained from the Meteorological Aeronautical Report (METAR) that was issued by the South African Weather Service (SAWS) for FAOR on 16 September 2019 at 0700Z.

Wind direction	Variable	Wind speed	4kt	Visibility	10km+
Temperature	24˚C	Cloud cover	None	Cloud base	None
Dew point	4˚C	QNH	Unknown		

1.8. Aids to Navigation

1.8.1 The aircraft was equipped with a navigational system approved by the Regulator (SACAA) for this aircraft type. There were no recorded defects on the navigation equipment prior to the incident.

1.9 Communication

1.9.1 The aircraft was equipped with standard communication equipment approved by the Regulator for this aircraft type. There were no recorded defects prior to or during the incident.

1.10 Aerodrome Information

Aerodrome Location	O.R. Tambo International Aerodrome (FAOR)	
Aerodrome Co-ordinates	26°08'01.30"S 028°14'32.34"E	
Aerodrome Altitude	5559 ft AMSL	
Runway Dimensions	03L/21R	4421m x 60m
	03R/21L	3405m x 60m
Runway Used	03L	
Runway Surface	Tar	
Approach Facilities	DVOR; DME; ILS LOC; ILS GP CAT II; ILS/DME, Runway lights	
Radio Frequency	118.1– O.R. Tambo Tower	

1.11 Flight Recorders

1.11.1 The aircraft was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR). Neither of these units were removed from the aircraft to be downloaded as the download was not deemed necessary for this investigation.

1.12 Wreckage and Impact Information

1.12.1 Not applicable.

1.13 Medical and Pathological Information

1.13.1 None.

1.14 Fire

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspect

1.15.1 The incident was considered survivable as the aircraft did not sustain any damage which would have compromised the integrity of the cockpit and cabin security that would have led to the occupants sustaining injuries.

1.16 Tests and Research (Refer to Appendices)

1.16.1 The GCUs are mounted on the electrical equipment rack and are fitted by sliding the unit rearwards into the tray with the handle lever in the open position and ensuring that the guide pins at the back of the component engage in the frame (Figure 2). Once the unit has been pushed in far enough, the hook at the bottom of the handle lever will engage with the fork assembly that is attached to the shelf (Figure 3). The handle lever is then moved into the locking detent securing the box in the tray (Figure 3). The Aircraft Maintenance Manual (AMM) provides further instructions to ensure that the handle and fork assembly have been correctly adjusted (Refer to Appendices 1 and 2).

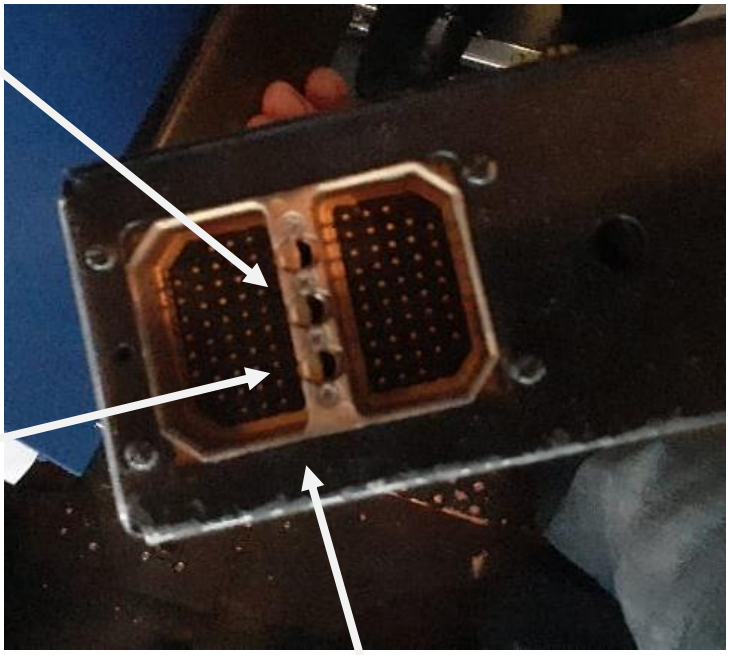


Figure 2: Arrows showing guide pins on component.

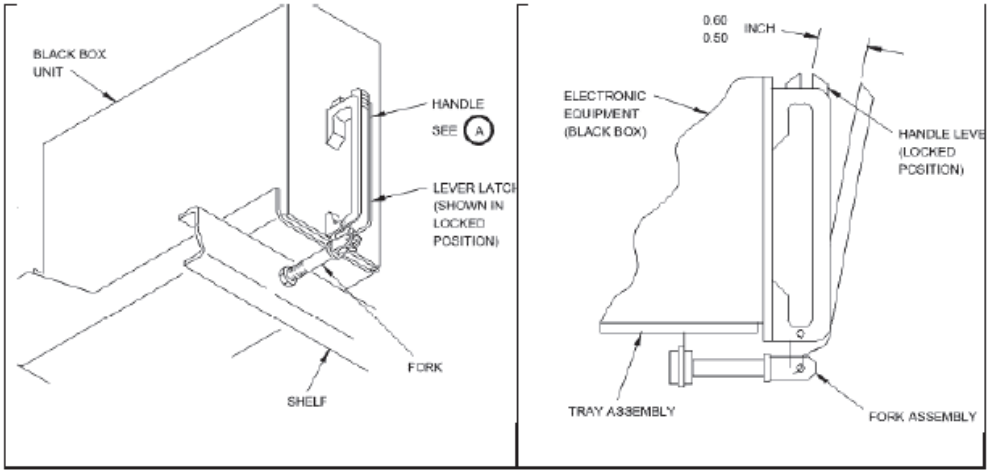


Figure 3: Racking of Generator Control Unit. (Source: AMM Boeing 737-300/400/500)

1.16.2 When the GCU of the No 1 engine was inspected, it was discovered that the lever latch tip was broken. The tip enables it to lock securely into the tray (Figure 4).

Figure 4: The main picture shows the broken hook; the inset shows a complete hook.

1.16.3 A fatigue crack normally grows in so-called mode I, with a flat fracture surface perpendicular to the loading direction. Sometimes the crack front becomes slanted, at about 45° with the loading direction (Figure 4).

Source:

https://www.researchgate.net/publication/230099568_Shear_lips_on_fatigue_fracture_surfaces_of_aluminum_alloys

1.16.4 ***AC power supply***

The AC power supply consists of two systems identified as 1 and 2 with system 1 powering the flight instruments on the left side of the flight deck, and system 2 the right side. Each generator is connected to a Gen Bus (1 or 2) and a Transfer Bus (1 or 2). The Transfer Busses normally receive their power from their respective Gen Bus and have an associated Transfer Relay which automatically selects the opposite Gen Bus as a power source if its Gen Bus loses power. At the same time, the protective automatic load-shedding circuit turns off all power to the aircraft galleys to ensure that the remaining generator is not overloaded.

The GCU monitors itself for correct voltage, frequency, ground faults in the generator or excessive current draw from any generator. If any malfunction develops, the GCU will detect the fault and disconnect the generator from its generator bus.

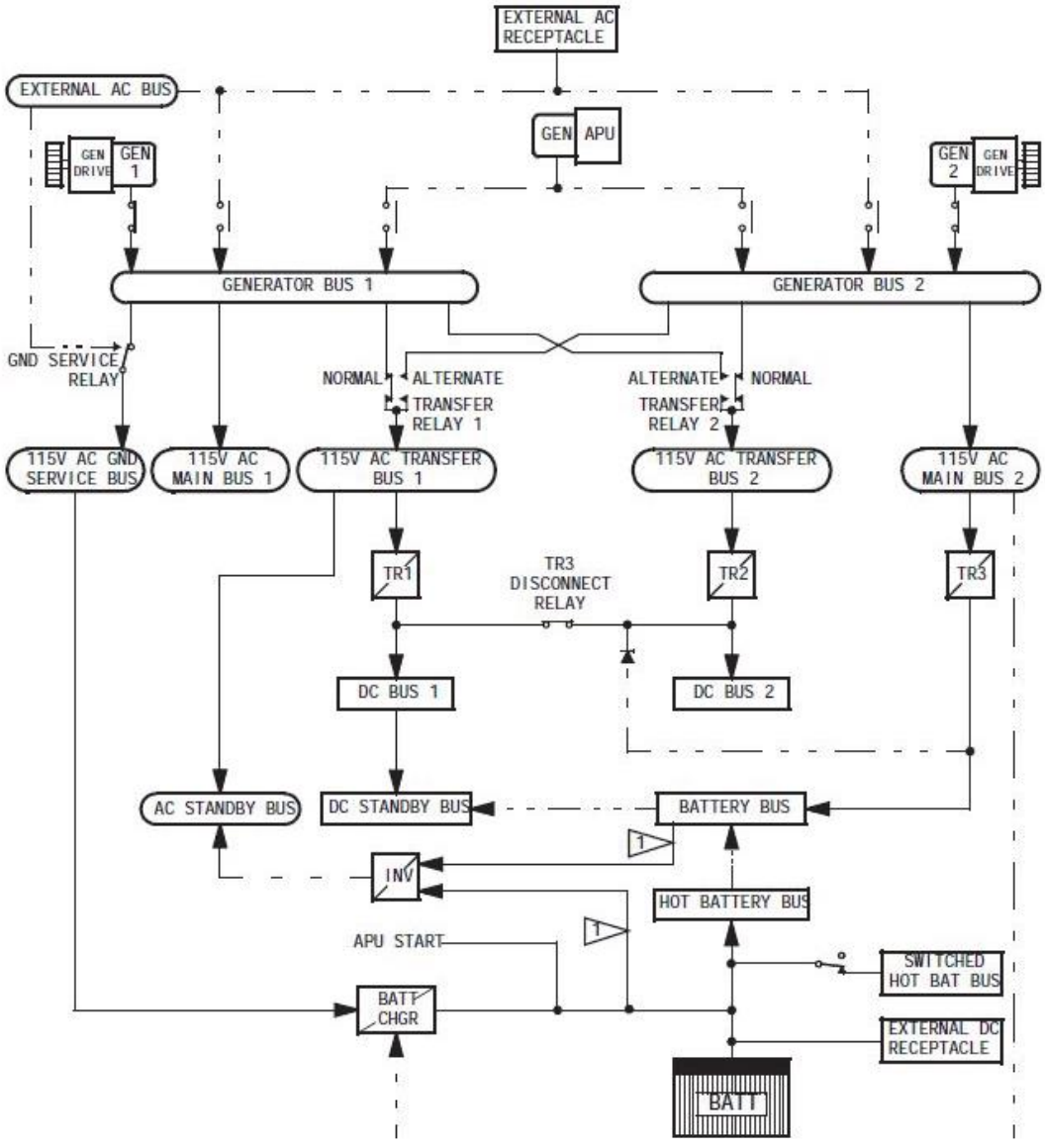


Figure 5: The schematics of the electrical power system. (Source: AMM Boeing 737-300/400/500)

1.16.5 **Generator malfunction lights**

Each generator is controlled by its own GCU located in panel P6, which is situated behind the right pilot's seat (Figure 6). If the GCU of the No. 1 engine becomes disconnected in-flight, the result would be the loss of the following busses:

115V AC Main Bus 1

115V AC Transfer Bus 1

115V AC Electronic Bus 1

28V DC Bus 1

28V DC Electronic Bus 1

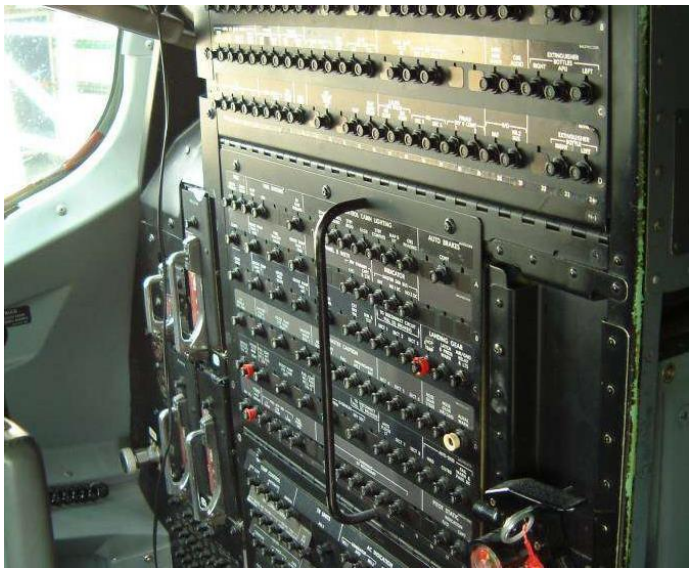


Figure 6: The P6, which is located behind the right pilot's seat.

1.16.6 Electrical panel, which is located on the overhead panel, contains four white generator malfunction lights for each generator: High Voltage (HV), Low Voltage (LV), Feeder Fault (FF) and Manual Trip (MT). These warning lights are controlled by double-coil relays inside each of the GCUs and, once energised, will be latched in the trip position by a permanent magnetic latch. The HV, LV and FF malfunctioning lights can be reset by pressing the erase button located on the electrical panel (Figure 7).

Figure 7: Overhead Electrical Panel

1.17 Organisational and Management Information

1.17.1 The operator was issued an air operating certificate (AOC) No: CAA/N942D on 26 April 2019 with an expiry date of 30 April 2020. The aircraft was authorised to operate under the AOC under Part 121 for Scheduled Commercial Operation with airline transportation.

1.17.2 The aircraft maintenance organisation (AMO) which carried out the last maintenance inspection on this aircraft prior to the incident flight was issued an AMO certificate number 1165 approval on 15 April 2019 with an expiry date of 31 March 2020.

1.18 Additional Information

1.18.1 None.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 **General**

From the available evidence, the following analysis was made with respect to this incident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

2.2 **ANALYSIS**

2.2.1 The PIC was issued an Airline Transport Pilot Licence (ATPL) on 20 October 2018 with an expiry date of 30 November 2019. He was also issued a Class 1 medical certificate on 25 February 2019 with an expiry date of 28 February 2020.

2.2.2 The FO was issued an ATPL on 5 April 2019 with an expiry date of 20 April 2020. He was also issued a Class 1 medical certificate on 8 July 2019 with an expiry date of 31 July 2020.

2.2.3 The operator was issued an AOC No: CAA/N942D on 26 April 2019 with an expiry date of 30 April 2020. The aircraft was authorised to operate under the AOC under Part 121 for Scheduled Commercial Operation with airline transportation.

2.2.4 On 16 September 2019 during rotation, the aircraft experienced multiple electrical system failures because of the broken lever latch of the GCU of the No.1 engine. The electrical failures that occurred during rotation at FAOR were caused by the GCU of the No.1 engine moving out of its rack, disconnecting the electrical connectors. The disconnection of the GCU of the No. 1 engine resulted in the Gen 1; Gen Bus 1; Transfer Bus 1; 115V AC Electronic Bus 1; 28V DC Bus 1; and 28V DC Electronic Bus 1 becoming inoperative. Electrical System 2 would have still been powered by the right engine through Gen Bus 2.

2.2.5 The lever latch of the GCU of the No. 1 engine had developed a fatigue crack on its hook which was perpendicular to the loading direction, resulting in a shear lip before its final failure (see Figure 4). The shear lip caused the unit to move out of its rack, resulting in electrical system 1 disconnection and multiple system failures controlled by the unit.

2.2.6 During multiple electrical system failures caused by the GCU of the No.1 engine moving out of its rack, the crew was still able to fly the aircraft back to FAOR without further incidents because the electrical system 2 was able to supply electrical power to the aircraft.

2.2.7 The GCU of the No.1 engine was fitted to the aircraft on 21 February 2019, seven months prior to the incident, and had accumulated 167 hours since its installation on the aircraft. There were no records of previous snags reported since the fitment of the GCU of the No. 1 engine to the aircraft.

2.2.8 It was not possible to determine when exactly did the latch lever hook failure occur as it had operated for 167 hours over a period of seven months. Also, there was no record of any maintenance work conducted around the area of the GCU of the No 1 engine post the maintenance carried out on 8 August 2019.

2.2.9 The investigation revealed that the multiple system failures and warnings which occurred during rotation were because of the broken lever latch of the GCU of the No.1 engine, which caused the GCU of the No.1 engine to move out of its rack, disconnecting the electrical connectors and resulting in multiple electrical system failures.

3. CONCLUSION

3.1 General

From the available evidence, the following findings, causes and contributing factors were made with respect to this incident. These shall not be read as apportioning blame or liability to any organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusions heading:

- **Findings —** are statements of all significant conditions, events or circumstances in this incident. The findings are significant steps in this Incident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, which led to this incident.
- **Contributing factors —** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the Incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 The PIC renewed his ATPL on 20 October 2018, which had an expiry date of 30 November 2019. The aircraft type was endorsed on his licence. He was also in possession of a valid Class 1 aviation medical certificate issued on 25 February 2019 with an expiry date of 28 February 2020.

3.2.2 The FO renewed his ATPL on 5 April 2019, which had an expiry date of 20 April 2020. The aircraft type was endorsed on his licence. He was also in possession of a valid Class 1 aviation medical certificate issued on 8 July 2019 with an expiry date of 31 July 2020.

3.2.3 The aircraft was issued a valid certificate of airworthiness (C of A) on 2 September 2016 with an expiry date of 30 September 2019.

3.2.4 The aircraft was issued a valid certificate of registration (C of R) on 24 August 2016.

3.2.5 The aircraft was issued a certificate or release to Service on 8 August 2019 at 62 581.00 airframe hours. The certificate was valid until 62 881.00 airframe hours.

3.2.6 The last maintenance inspection (C-check) that was carried out on the aircraft prior to the incident flight was certified on 8 August 2019 at 62 581.00 airframe hours. Following the inspection, a further 97.5 hours were flown with the aircraft.

3.2.7 The operator was issued a valid AOC No. CAA/N942D on 26 April 2019 by the SACAA and had an expiry date of 30 April 2020. The aircraft was duly authorised under the AOC.

3.2.8 The AMO that carried out the last maintenance inspection on this aircraft prior to the incident flight was issued an AMO certificate number 1165 approval on 15 April 2019 with an expiry date of 31 March 2020.

3.2.9 After the failure of the GCU of the No 1 engine that resulted in Gen 1; Gen Bus 1; Transfer Bus 1; 115V AC Electronic Bus 1; 28V DC Bus 1; and 28V DC Electronic Bus 1 becoming inoperative, the crew was still able to fly the aircraft back to FAOR without incident as the electrical system 2 was operating. Also, there were no injuries reported during the incident.

3.2.10 The hook that would have prevented the GCU of the No.1 engine from moving out of its rack had failed due to fatigue crack (see Figure 4).

3.2.11 The GCU of the No. 1 engine was fitted to the aircraft on 21 February 2019, seven months prior to this incident; moreover, it accumulated 167 hours since its fitment to the aircraft. There was no record of defect to the number 1 electrical system.

3.2.12 It was not possible to determine when exactly did the latch lever hook failure occur as it had operated for 167 hours over a period of seven months. Also, there was no record of any maintenance work done around the area of the GCU of the No 1 engine.

3.2.13 The investigation revealed that during rotation, the GCU of the No.1 engine moved out of its rack (forward of the aircraft), causing its electrical connectors to disconnect, resulting in

multiple system failures because of the broken lever latch of the GCU of the No.1 engine due to fatigue.

3.3 **Probable Cause/s**

3.3.1 The investigation revealed that during rotation, the GCU of the No.1 engine had moved out of its rack, causing its electrical connectors to disconnect, resulting in multiple electrical system failures because of the broken lever latch of the GCU of the No.1 engine.

3.3.2 **Contributory Factors**

3.3.2.1 None.

4 SAFETY RECOMMENDATIONS

4.1 The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report; the AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2 The Director of Civil Aviation (DCA) to review the possibility of introducing a maintenance requirement for a non-destructive testing on the lever latch mechanism of the GCU whenever the GCU is removed for bench test.

4.3 Safety Action: The operator inspected all GCU latch mechanisms in its fleet and all were found to be serviceable with no signs of cracks.

3 APPENDICES

3.1 Appendix 1: Electronic Equipment Rack Maintenance Practices.

3.2 Appendix 2: GCU Installation and Removal Procedure.

This Report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

Appendix 1

BOEING

737-300/400/500
AIRCRAFT MAINTENANCE MANUAL

E/E RACK- MOUNTED COMPONENTS - MAINTENANCE PRACTICES.

1. General

A. This procedure contains four tasks:

(1) The first task is the removal of the rack-mounted electrical/electronic (E/E) boxes.

(2) The second task is the installation of the rack-mounted (E/E) boxes.

(3) The third task is the removal of the circuit card assemblies.

(4) The fourth task is the installation of the circuit card assemblies.

TASK 20-10-07-002-005

2. Rack Mounted E/E Box - Removal

(Figure 201)

CAUTION	DUE TO THE CRITICAL ALIGNMENT OF THE INERTIAL-REFERENCE UNIT(S), DISTURBANCE OR REMOVAL OF THE E3-5 SHELF REQUIRES RE-ALIGNMENT. YOU MUST HAVE BOEING AOG PERSONNEL TO DO THIS TASK WITH THE USE OF SPECIALIZED ALIGNMENT TOOLING. MAKE SURE THAT YOU SPEAK TO BOEING BEFORE YOU MOVE THE MOUNTING SHELVES OR IT CAN CAUSE DAMAGE.

A. Location Zones

Zone	Area
100	Upper Half of Fuselage

B. Procedure

SUBTASK 20-10-07-862-057

(1) Open the applicable circuit breakers to remove electrical power.

SUBTASK 20-10-07-042-058

(2) Disconnect the electrical connectors from the E/E box.

SUBTASK 20-10-07-022-059

(3) Turn the front hold-down extractor knob counterclockwise to disengage the extractor clutch. Turn the keeper to align the deep slot with the T-hook. Lower the extractor off the T-hook.

NOTE: Apply a sufficient amount of pressure down on the front-face of the E/E box during removal.

SUBTASK 20-10-07-022-074

(4) Carefully remove the E/E box out from the tray.

NOTE: The E/E box front face can be moved right to left (about 1/8 inch). This will help disconnect the E/E box from the electrical connection.

SUBTASK 20-10-07-862-075

(5) Make sure that the connector is fully disengaged before the removal of the E/E box.

SUBTASK 20-10-07-422-060

(6) Install dust caps on the E/E box electrical connector and on the tray electrical connector.

SUBTASK 20-10-07-022-072

(7) Remove and discard the O-rings from the rack-mounted electrical connectors, if installed.

SUBTASK 20-10-07-862-076

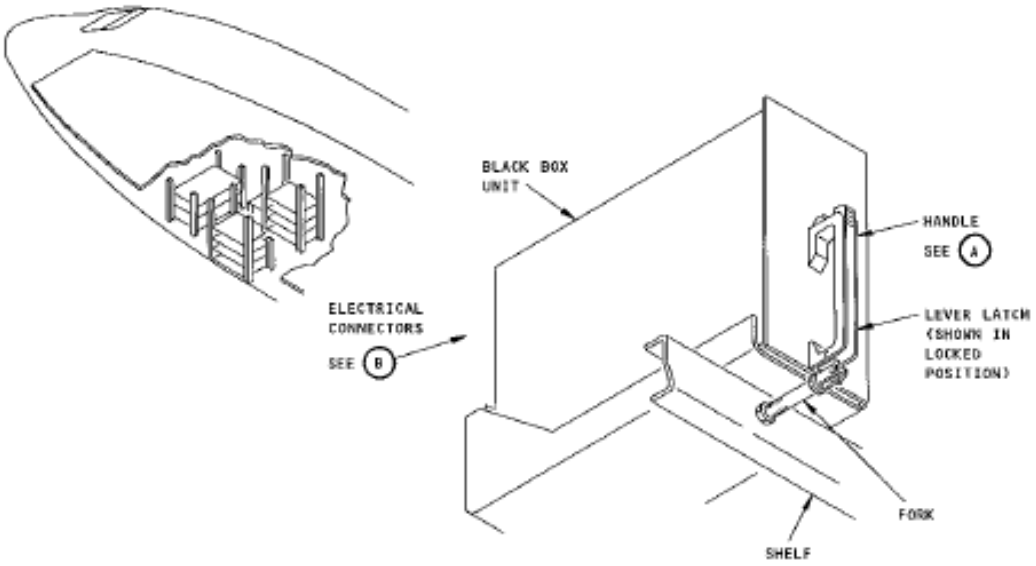
ASA ALL; AIRPLANES WITH LEVER LATCH HANDLES

(8) Depress the lever latch allowing the lever to move away from the handle.

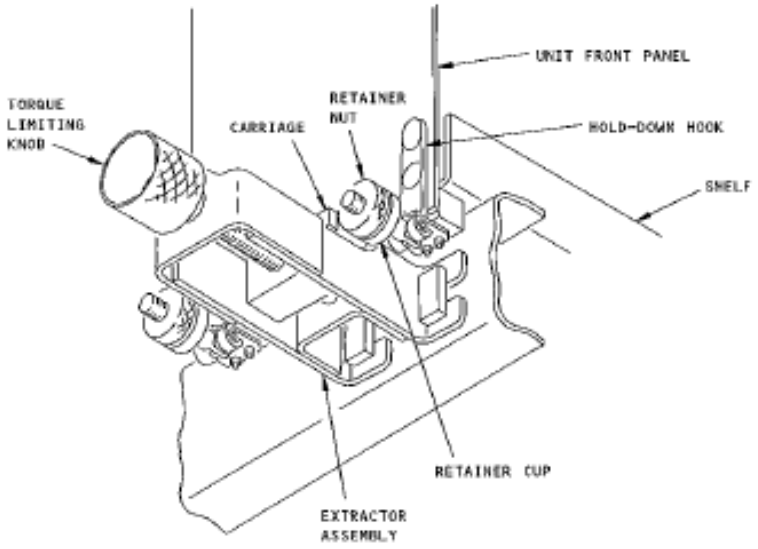
(a) Move the lever in an opening direction forcing the unit away from the shelf-mounted connector.

ASA ALL

——— END OF TASK ———



LEVER LATCH TYPE RETENTION
(EXAMPLE)



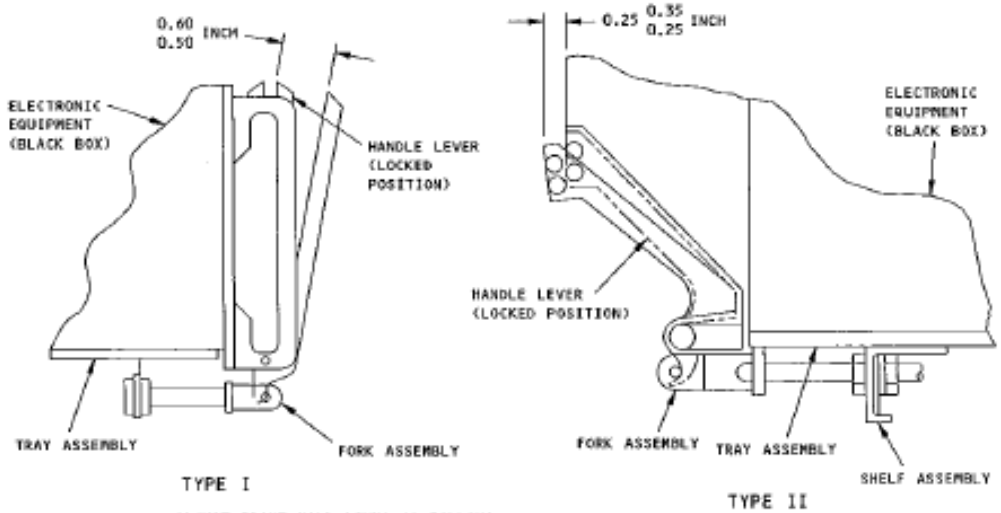
SCREW TYPE RETENTION
(EXAMPLE)

131046 S0004206167_V1

Electrical/Electronic Black Box Installation
Figure 201/20-10-07-990-801 (Sheet 1 of 3)

EFFECTIVITY
ASA ALL

D6-37584



ADJUST FRONT HOLD DOWNS AS FOLLOWS:

WITH PLUG ON THE REAR OF UNIT FULLY ENGAGED AND THE HANDLE LEVER ON THE THE FRONT OF THE UNIT AT THE DIMENSION SHOWN, ADJUST FORKS BY ROTATING TO A POSITION WHERE THEY START TO EXERT PRESSURE ON THE LOCKING LEVER.

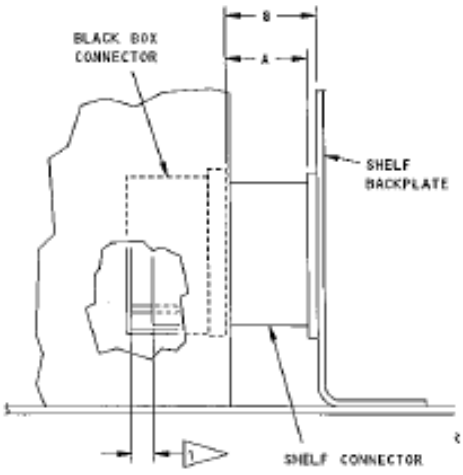
HANDLE

(A)

	A	B
CONNECTOR TYPE	INCH MAX	INCH MAX
AD2		0.297 MAX
AMP		0.297 MAX
DPA	0.157 MAX	
DPD	0.138 MAX	
DPE	UNKNOWN	UNKNOWN
DPDMA	0.138 MAX	
DPD2	0.138 MAX	
DPXA		0.297 MAX
DPXB		0.297 MAX
DPX2		0.297 MAX
SR-RAI		0.581 MAX

1 0.09 INCH MAXIMUM FOR ANY CONNECTOR FULLY MATED (ALTERNATE METHOD)

NOTE: DIMENSIONS CAN BE MEASURED WITH PUTTY OR A PAPER SLEEVE OR RING OF A SUITABLE LENGTH THAT WILL BE CRUSHED WHEN THE CONNECTOR IS IS MATED PROPERLY.

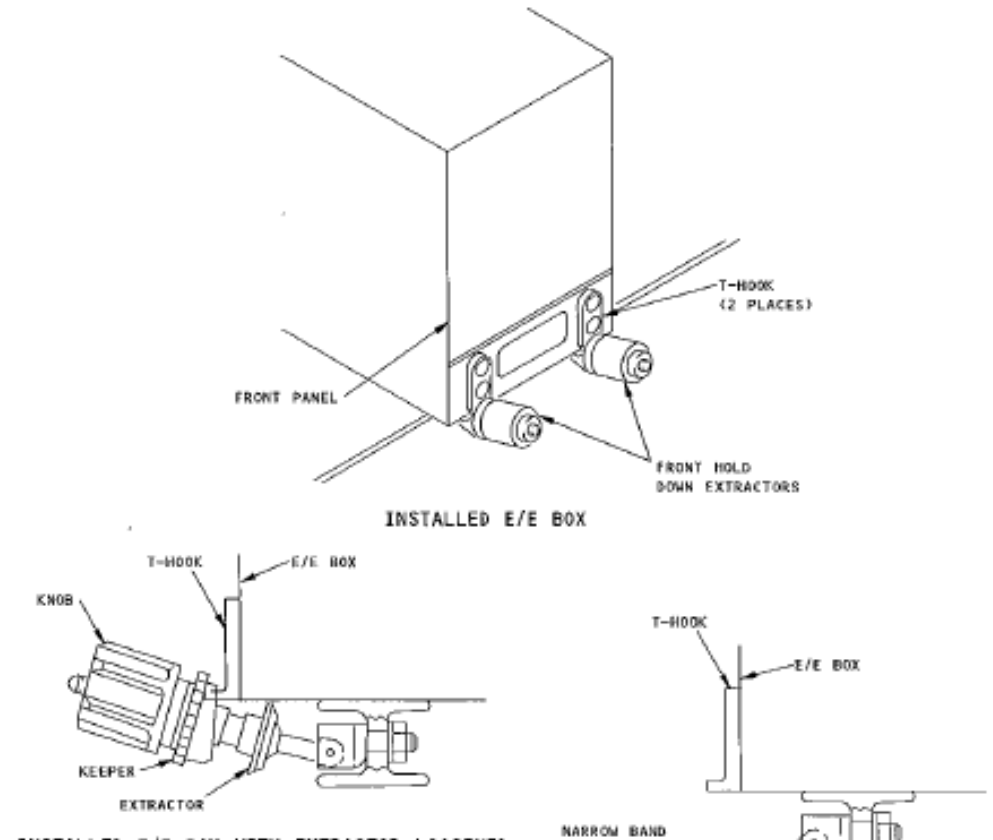


MATED ELECTRICAL CONNECTORS (EXAMPLE)

(B)

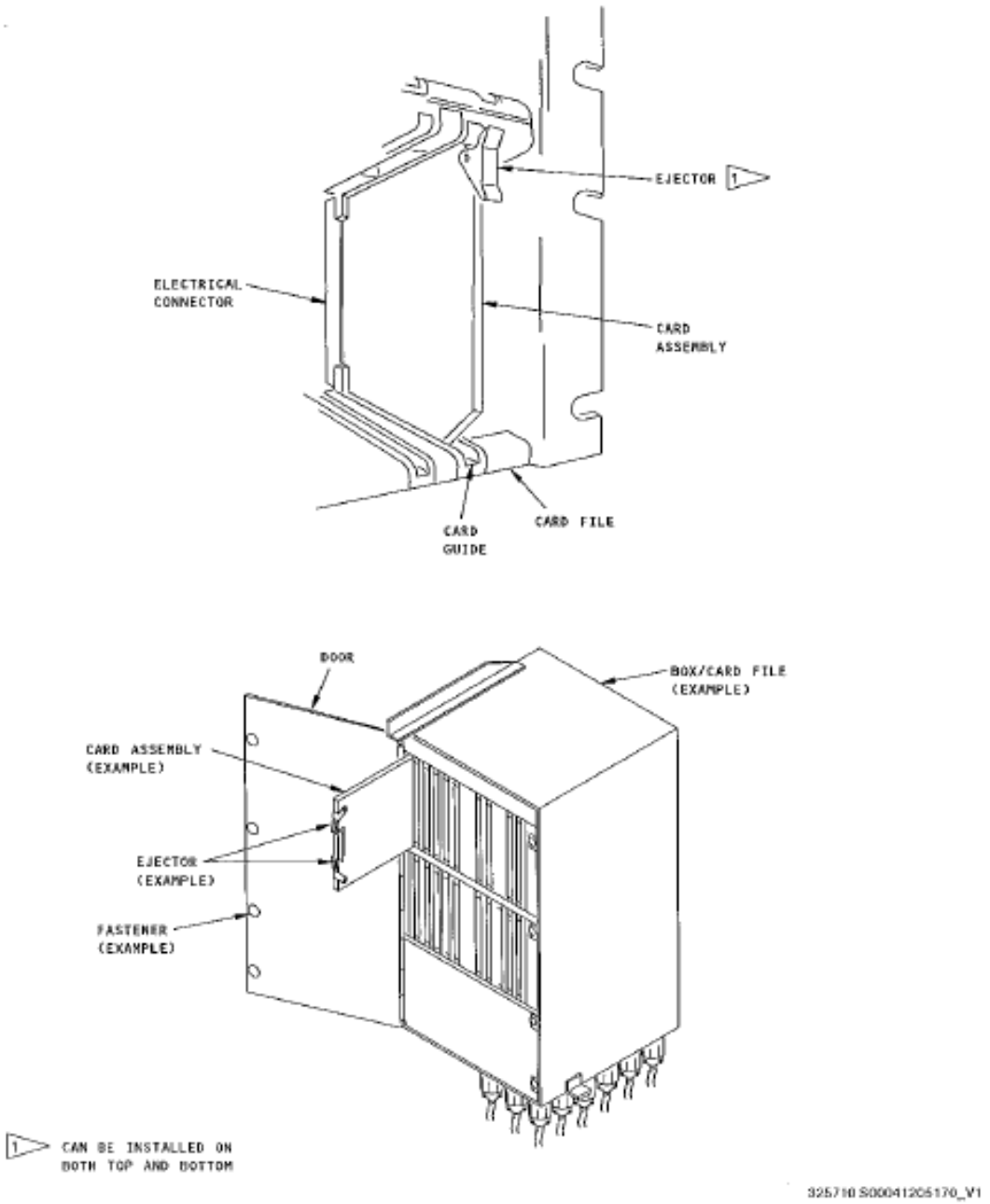
131054 S00041205168_V1

Electrical/Electronic Black Box Installation
Figure 201/20-10-07-990-801 (Sheet 2 of 3)



Electrical/Electronic Black Box Installation
Figure 201/20-10-07-990-801 (Sheet 3 of 3)

EFFECTIVITY
ASA ALL



Electrical/Electronic Card Assembly Installation
Figure 202/20-10-07-990-802

TASK 20-10-07-422-011

3. Rack Mounted E/E Box - Installation

(Figure 201)

A. Location Zones

Zone	Area
100	Upper Half of Fuselage

B. Procedure

SUBTASK 20-10-07-212-073

(1) Make sure the rubber plugs are installed in the metering tray at the correct locations.

NOTE: Compare the tray orifice configuration with that shown on the decal.

SUBTASK 20-10-07-022-051

(2) Remove the dust caps.

SUBTASK 20-10-07-212-052

(3) Make sure the tray gasket and restrictor plugs (adjustment number) did not move.

NOTE: Install new ones if it is necessary.

SUBTASK 20-10-07-212-053

(4) Make sure the guide pins on the tray will engage with the E/E box.

SUBTASK 20-10-07-212-054

CAUTION: DO NOT BEND THE ELECTRICAL PINS ON THE E/E BOX CONNECTOR AND THE TRAY CONNECTOR. INSTALLATION OF THE E/E BOX WITH DAMAGED PINS COULD CAUSE DAMAGE TO THE E/E BOX, THE TRAY ELECTRICAL CONNECTOR, OR THE SYSTEM COMPONENTS.

(5) Make sure the electrical pins of the E/E box and the tray connector are not bent or damaged. Replace all damaged components.

SUBTASK 20-10-07-862-079

(6) Carefully move the E/E box in the tray and engage the electrical connector.

NOTE: The E/E box front-face can be lifted about 1/8 inch above the tray surface. This will make the installation easier.

The E/E box front-face can be moved right to left (about 1/8 inch). This will help engage the electrical connector. During installation apply a light pressure to the front-face of the E/E box. Do not use force during installation.

SUBTASK 20-10-07-422-055

(7) Turn the keeper to align the deep slot with the T-hook.

SUBTASK 20-10-07-422-056

(8) Put the extractor on the T-hook and turn the keeper 180 degrees.

SUBTASK 20-10-07-422-057

(9) Tighten the front hold-down extractor. Turn the front hold-down extractor clockwise until the extractor clutch is fully engaged.

SUBTASK 20-10-07-712-058

(10) Move the E/E box left to right. Make sure the E/E box is tight.

SUBTASK 20-10-07-422-077

(11) Tighten the extractor.

SUBTASK 20-10-07-212-069

(12) Make sure the electrical connector is engaged.

SUBTASK 20-10-07-422-070

(13) Install the connections to the E/E box front if it is applicable.

SUBTASK 20-10-07-862-071

(14) Close all the applicable circuit breakers.

ASA ALL; AIRPLANES WITH LEVER LATCH HANDLES

C. Slide the unit into the shelf with the lever in the open position until the lever engages the shelf-mounted fork.

NOTE: Remove any protective caps or bags from the unit or shelf prior to installation.

SUBTASK 20-10-07-862-078

(1) Move the lever latch to its locked position and verify proper adjustment.

ASA ALL

——— END OF TASK ———

TASK 20-10-07-822-083

4. Lever Latch Fork Adjustment

A. Prepare For Adjustment

SUBTASK 20-10-07-012-040

(1) Open circuit breaker of unit to be adjusted.

SUBTASK 20-10-07-032-041

(2) Press trigger and pull lever latch to open position.

SUBTASK 20-10-07-022-042

(3) Remove unit by handle.

SUBTASK 20-10-07-432-043

(4) If installed, loosen jamnut on fork assembly.

SUBTASK 20-10-07-012-044

(5) Examine all parts of latching mechanism for serviceability.

B. Adjust Lever Latch Fork

SUBTASK 20-10-07-432-045

(1) Slide unit back on shelf until connectors are partially engaged.

SUBTASK 20-10-07-432-046

(2) Engage lever latch hook with fork assembly pin.

SUBTASK 20-10-07-862-047

(3) Start closing lever latch handle.

NOTE: It is possible to determine full connector engagement by feel. A sudden increase in handle pressure, resistance to handle movement, indicates that the connectors are fully engaged.

SUBTASK 20-10-07-822-048

(4) Adjust fork assembly until resistance to handle movement occurs within required gap tolerance, as shown in Figure 201).

NOTE: Loosen the nut at the shelf area for fork adjustment.

CAUTION: MAKE SURE THERE IS SUFFICIENT THREAD ENGAGEMENT IN THE LATCH FORK. WITHOUT SUFFICIENT THREAD ENGAGEMENT THE LATCH LEVER COULD FAIL, ALLOWING THE BLACK BOX TO SLIDE OUT OF POSITION.

(a) Make sure there is sufficient thread engagement in the latch fork.

SUBTASK 20-10-07-822-049

(5) Close handle until latched.

SUBTASK 20-10-07-432-050

(6) Tighten jamnut to snug fit.

——— END OF TASK ———

TASK 20-10-07-202-037

5. Circuit Card Assembly - Removal

A. References

Reference	Title
20-40-12-002-001	ESDS Printed Circuit Boards Removal (P/B 201)

B. Location Zones

Zone	Area
100	Upper Half of Fuselage

C. Procedure

(Figure 202)

SUBTASK 20-10-07-862-051

(1) Open the applicable circuit breakers to remove electrical power.

SUBTASK 20-10-07-012-055

(2) Open the card file door.

SUBTASK 20-10-07-020-001

CAUTION: DO NOT TOUCH THE CIRCUIT CARDS BEFORE YOU DO THE PROCEDURE FOR DEVICES THAT ARE SENSITIVE TO STATIC ELECTRICITY. STATIC ELECTRICITY CAN CAUSE DAMAGE TO THE CIRCUIT CARDS.

(3) Do the procedure for devices that are sensitive to electrostatic discharge (ESDS Printed Circuit Boards Removal, TASK 20-40-12-002-001).

SUBTASK 20-10-07-862-050

(4) Turn the ejector levers 90 degrees.

NOTE: This will release the circuit card.

SUBTASK 20-10-07-020-052

(5) Push both latch levers and turn both lock release levers to release the latch lock.

SUBTASK 20-10-07-020-053

(6) Turn the ejectors on the printed card assembly until the printed circuit card is released from the electrical connector.

SUBTASK 20-10-07-022-052

(7) Carefully move the printed circuit card assembly out along the guide.

Appendix 2

BOEING

737-300/400/500
AIRCRAFT MAINTENANCE MANUAL

GENERATOR CONTROL UNIT - REMOVAL/INSTALLATION

1. General

A. This procedure contains two tasks:

(1) The removal of the generator control unit (refer to as the GCU).

(2) The installation of the generator control unit.

B. The generator control unit is found on the P6 panel.

TASK 24-21-81-004-001

2. Generator Control Unit Removal

NOTE: This procedure is a scheduled maintenance task.

A. References

Reference	Title
20-10-07 P/B 201	E/E RACK- MOUNTED COMPONENTS - MAINTENANCE PRACTICES.
24-22-00 P/B 201	MANUAL CONTROL - MAINTENANCE PRACTICES (APPLY POWER)

B. Location Zones

Zone	Area
102	Control Cabin - Right

C. Procedure

SUBTASK 24-21-81-864-005

CAUTION: REMOVE THE ELECTRICAL POWER FROM THE AIRPLANE BEFORE YOU REMOVE THE GCU. YOU CAN CAUSE DAMAGE TO THE CURRENT TRANSFORMER OR THE GCU IF YOU DO NOT REMOVE THE ELECTRICAL POWER.

(1) Remove all the electrical power from the airplane (PAGEBLOCK 24-22-00/201).

SUBTASK 24-21-81-024-003

(2) Remove the GCU (PAGEBLOCK 20-10-07/201).

END OF TASK

TASK 24-21-81-404-007

3. Generator Control Unit Installation

NOTE: This procedure is a scheduled maintenance task.

A. References

Reference	Title
20-10-07 P/B 201	E/E RACK- MOUNTED COMPONENTS - MAINTENANCE PRACTICES.
24-21-81 P/B 501	GENERATOR CONTROL UNIT - ADJUSTMENT/TEST

B. Location Zones

Zone	Area
102	Control Cabin - Right

C. Procedure

SUBTASK 24-21-81-424-008

CAUTION: REMOVE THE ELECTRICAL POWER FROM THE AIRPLANE BEFORE YOU REMOVE THE GCU. YOU CAN CAUSE DAMAGE TO THE CURRENT TRANSFORMER OR THE GCU IF YOU DO NOT REMOVE THE ELECTRICAL POWER.

(1) Install the GCU (PAGEBLOCK 20-10-07/201)

SUBTASK 24-21-81-724-005

(2) Do a test of the GCU (PAGEBLOCK 24-21-81/501).

END OF TASK

GENERATOR CONTROL UNIT - ADJUSTMENT/TEST

1. General

A. This procedure contains this task:

(1) Test of the Generator Control Unit (GCU).

B. The GCU is found on the P6 panel.

TASK 24-21-81-705-001

2. Generator Control Unit Test

A. References

Reference	Title
49-11-00 P/B 201	APU POWER PLANT - MAINTENANCE PRACTICES
71-00-00 P/B 201	POWER PLANT - MAINTENANCE PRACTICES

B. Location Zones

Zone	Area
101	Control Cabin - Left
102	Control Cabin - Right

C. Test of the control circuits for engine No. 1

SUBTASK 24-21-81-865-009

(1) Start the No. 1 engine (PAGEBLOCK 71-00-00/201).

(a) Move the selector switch on the ac meter to the GEN 1 position.

ASA 001-019, 021, 022, 102-201

(b) Make sure the LOW OIL PRESSURE light on the P5-5 panel goes off.

ASA 023-037, 101

(c) Make sure the DRIVE light on the P5-5 panel goes off.

ASA ALL

SUBTASK 24-21-81-865-005

(2) Momentarily push the ERASE button on the M238 annunciator module (behind the P6).

SUBTASK 24-21-81-865-007

(3) Set the GEN 1 switch to the OFF position.

SUBTASK 24-21-81-225-008

(4) Do a check of the voltage:

(a) Make sure the ac voltmeter reads 10 to 21 volts.

SUBTASK 24-21-81-865-025

(5) Set the GEN 1 switch to the ON position.

SUBTASK 24-21-81-225-009

(6) Make sure the ac voltmeter reads 115 ±5 volts ac.

NOTE: The control (field) relay is closed when the voltmeter reads 115 ±5 volts.

SUBTASK 24-21-81-215-010

(7) Make sure these lights are OFF:

(a) No. 1 TRANSFER BUS OFF

(b) No. 2 TRANSFER BUS OFF

(c) No. 1 BUS OFF

(d) No. 1 GEN OFF BUS.

SUBTASK 24-21-81-865-027

(8) Set the ELEC 2 switch - HYD PUMP A on the P5 panel to the ON position.

SUBTASK 24-21-81-865-028

(9) Set the ELEC 1 switch - HYD PUMP B on the P5 panel to the ON position.

ASA 001-019, 021, 022, 102-201; Airplanes with LOW OIL PRESSURE light installed on P5-5

SUBTASK 24-21-81-215-029

(10) Make sure the LOW OIL PRESSURE LIGHT on the P5-5 panel does not come on.

ASA 023-037, 101; Airplanes with DRIVE light installed on P5-5

SUBTASK 24-21-81-215-047

(11) Make sure the DRIVE light on the P5-5 panel does not come on.

ASA ALL

SUBTASK 24-21-81-225-013

(12) Make sure the frequency is 400 ±5 Hz.

SUBTASK 24-21-81-215-043

(13) Make sure the FF, LV, HV, and MT lights on the M238 annunciator panel are off.

SUBTASK 24-21-81-865-044

(14) Stop engine No. 1 (PAGEBLOCK 71-00-00/201).

D. Test of the control circuits for engine No. 2

SUBTASK 24-21-81-865-014

(1) Start the No. 2 engine (PAGEBLOCK 71-00-00/201).

(a) Move the selector switch on the ac meter to the GEN 2 position.

ASA 001-019, 021, 022, 102-201

(b) Make sure the LOW OIL PRESSURE light on the P5-5 panel goes off.

ASA 023-037, 101

(c) Make sure the DRIVE light on the P5-5 panel goes off.

ASA ALL

(d) Momentarily push the ERASE button on the M238 annunciator module.

SUBTASK 24-21-81-865-031

(2) Set the GEN 2 switch to the OFF position.

SUBTASK 24-21-81-225-018

(3) Do a check of the voltage:

(a) Make sure the ac voltmeter reads 10 to 21 volts.

SUBTASK 24-21-81-865-019

(4) Set the GEN 2 switch to the ON position.

SUBTASK 24-21-81-225-020

(5) Make sure the ac voltmeter reads 115 ±5 volts ac.

NOTE: The control (field) relay has closed when the voltmeter reads 115 ±5 volts ac.

SUBTASK 24-21-81-215-021

(6) Make sure these lights are off:

(a) No. 1 TRANSFER BUS OFF

(b) No. 2 TRANSFER BUS OFF

(c) No. 2 BUS OFF

(d) No. 2 GEN OFF BUS.

SUBTASK 24-21-81-225-022

(7) Make sure the frequency is 400 ±5 Hz.

SUBTASK 24-21-81-215-044

(8) Make sure the FF, LV, HV, and MT lights on the M238 annunciator panel are off.

SUBTASK 24-21-81-865-045

(9) Stop engine No. 2 (PAGEBLOCK 71-00-00/201).

E. Test of the control circuits for the APU generator

SUBTASK 24-21-81-865-034

(1) Start the APU (PAGEBLOCK 49-11-00/201).

(a) Make sure that the APU GEN OFF BUS light comes on.

(b) Turn the AC meters switch to APU GEN.

SUBTASK 24-21-81-865-035

(2) Push the APU GEN switches to OFF.

SUBTASK 24-21-81-765-037

(3) Look at the residual voltage from the APU generator.

(a) Make sure that the AC voltmeter shows 10 to 21 volts.

SUBTASK 24-21-81-865-038

(4) Push the APU GEN switches to ON.

SUBTASK 24-21-81-765-039

(5) Look at the quality of the power from the APU generator with loads.

(a) Make sure the voltmeter shows 110 to 125 volts.

(b) Make sure the frequency meter shows 400 ± 5 Hz.

NOTE: Airplanes with APU GTCP85-129 LOADED frequency is 397-417 Hz.

SUBTASK 24-21-81-865-040

(6) Make sure these lights go off:

(a) APU GEN OFF BUS

(b) BUS OFF No. 1 and No. 2

(c) TRANSFER BUS OFF No. 1 and No. 2.

SUBTASK 24-21-81-865-041

(7) Make sure the FF, LV, HV, and MT lights on the M238 annunciator panel are off.

SUBTASK 24-21-81-865-042

(8) Stop the APU (PAGEBLOCK 49-11-00/201).

F. Put the Airplane Back To Its Usual Condition

SUBTASK 24-21-81-865-032

(1) Set the ELEC 2 switch - HYD PUMP A on the P5 panel to the OFF position.

SUBTASK 24-21-81-865-033

(2) Set the ELEC 1 switch - HYD PUMP B on the P5 panel to the OFF position.

——— END OF TASK ———