

الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY



Air Accident Investigation Sector

Safety Occurrence

- Final Report -

AAIS Case N°: AIFN/0021/2014

Remote Control Circuit Breaker Short Circuit

Operator: Emirates

Aircraft Type: A380-861 / GP7270

Registration: A6-EDD

Place of Occurrence: Engineering Hangar, Dubai International Airport

State of Occurrence: The United Arab Emirates

Date of Occurrence: 12 December 2014



Occurrence Brief

Name of the Operator	:	Emirates
Manufacturer	:	Airbus SAS
Aircraft model	:	A380-861
Nationality	:	The United Arab Emirates
Registration	:	A6-EDD
State of Occurrence	:	The United Arab Emirates
Place	:	Engineering Hangar, Dubai International Airport
Date and time	:	12 December 2014, 0616 LT
Injuries	:	Nil

Investigation Objective

This Investigation is performed pursuant to the United Arab Emirates (UAE) Federal Act No. 20 of 1991, promulgating the *Civil Aviation Law, Chapter VII- Aircraft Accidents, Article 48*. It is in compliance with *CAR Part VI Chapter 3*, in conformity with *Annex 13* to the Convention on International Civil Aviation, and in adherence to the *Air Accidents and Incidents Investigation Manual*.

The sole objective of this Investigation is to prevent aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

The information contained in this Report is derived from the factual information gathered during the investigation of the Occurrence.

Investigation Process

The Air Accident Investigation Sector (AAIS) of the UAE was informed about an electrical smoke from the main avionics compartment whilst the Emirates Airbus A380 Aircraft was undergoing scheduled maintenance. The Occurrence was notified to the AAIS Duty Investigator (DI) hotline, +971506414667.

This occurrence was classified as a 'Safety Occurrence' which does not fall under the definition of 'accident, serious incident, and incident' since the Aircraft was not in a condition of preparation for flight.

The significance of the occurrence caused the AAIS to open an 'Aircraft Accident Investigation File (AIFN)' and follow the rules of investigations established in the Civil Aviation Regulations and the Standard and Recommended Practices set forth in Annex 13.

The AAIS assigned an Investigation Team (Team), and the Aircraft State of Manufacturer and Design, France, was notified and assigned an Accredited Representative



to the investigation. The AAIS led the investigation and issued the Final Report. Selected photos and investigation findings from the investigation report issued by Airbus and Zodiac are included in this Final Report.

The AAIS Reports are made publicly available at:

<http://www.gcaa.gov.ae/en/epublication/pages/investigationReport.aspx>

Notes:

1. Whenever the following words are mentioned in this Report with first Capital letter, they shall mean the following:
 - (Aircraft)- the aircraft involved in this Occurrence;
 - (Investigation)- the investigation into the circumstances of this Occurrence;
 - (Occurrence)- this investigated safety occurrence;
 - Report- this Safety Occurrence Report;
2. Unless otherwise mentioned, all times in this Report are local time (Local time in UAE was UTC+ 4h);
3. Photos and figures used in this Report are taken from different sources including the reports provided by Airbus and Zodiac and are adjusted from the original for the sole purpose to improve the clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast, or addition of text boxes, arrows or lines.
4. This Investigation also reviewed information from the following:
 - The UAE Mandatory Reporting of Safety Incidents (ROSI)- A380 smoke 2010 to October 2015;
 - The United Kingdom (UK CAA) *CAP 1036* issued in June 2013- *Global Fatal Accident Review 2002 to 2011*;
 - The UK CAA CAP 1076 issued in June 2013- *In Focus*;
 - The UK CAA CAP 1100, *Safety Plan 2014 – 2016 (Significant 7)*;
 - The Royal Aeronautical Society- *Smoke, Fire and Fumes in Transport Aircraft – Part 1*; References; 3rd Edition 2014;
 - The Royal Aeronautical Society; *Smoke, Fire and Fumes in Transport Aircraft – Part 2*; Training; 2nd Edition 2014;
 - In-service Contamination of Thermal Acoustic Insulation; International Fire & Cabin Safety Research Conference Philadelphia 2013 by RGW Cherry and Associates Ltd.;
 - Airbus; Flight Operations Briefing Notes;
 - Australian ATSB Safety Report; An analysis of fumes and smoke events in Australian aviation Research 2008 to 2012; AR-2013-213; May 2014.



Abbreviations

AAIS	Air Accident Investigation Sector, UAE GCAA	MEL	Minimum equipment list
AC	Alternating current	SB	Service bulletin
APU	Auxiliary power unit	MPD	Maintenance planning document
CAP	UK CAA Civil Aviation Publication	MSN	Manufacture serial number
CB	Circuit breaker	OMDB	Dubai International Airport
CBMS	Circuit breaker monitoring system	PEPDC	Primary electrical power distribution center
CMS	Central maintenance system	PFR	Post flight report
CT	Current transformer	QRH	Quick reference handbook
DC	Direct current	RCCB	Remote control circuit breaker
ECAM	Electronic Centralized Aircraft Monitor	ROSI	Reporting of a Safety Incident (the UAE mandatory reporting program)
EP	External power	S/N	Serial number
FC	Flight Cycles	SIL	Airbus Service information letter
FH	Flight Hours	SOP	Standard Operating Procedures
FIN	Functional item number	UAE	The United Arab Emirates
FOD	Foreign object debris	UK CAA	The United Kingdom Civil Aviation Authority
GCAA	General Civil Aviation Authority of the UAE	UTC	Co-ordinated Universal Time
GEN	Generator	V	Volt
GGPCU	Generator and ground power control	VAC	Voltage alternating current
HSMU	Hydraulic system monitor unit	VDC	Voltage direct current
Hz	Hertz	VFG	Variable frequency generator
IIC	Investigator in Charge		
LT	Local time		



Synopsis

On 12 December 2014, an A380 Aircraft, whilst undergoing scheduled maintenance, had an electrical short circuit of a remote control circuit breaker, RCCB, causing smoke and melting of the RCCB.

The Aircraft was inducted for a scheduled minor maintenance check on 10 December 2014, with a release to service planned on 12 December 2014. As part of the post maintenance checks, uneventful engine ground runs were performed. Thereafter, the Aircraft was towed to the vicinity of the engineering hangars where the outstanding maintenance work was planned for completion.

Before the ground external electrical power was switched over from the APU to EP1, there was a flashing light and smoke seen coming from the lower avionics compartment, located below the cockpit.

Upon inspection of the source of the smoke, it was found that an Aircraft electrical remote control circuit breaker (RCCB) located in the primary electrical power distribution center, (PEPDC) was burnt and melted.

The Air Accident Investigation Sector determines that the smoke and melting of the remote control circuit breaker was due to a short circuit of RCCB 991JV6 caused by an unheeded significant buildup of dust and fluid conductor mixture between phases B1 and C1 of RCCB 991JV6.

The AAIS has addressed a total of nine Safety Recommendations, five to Airbus, three to Emirates and one to the GCAA, based on the safety issues identified during this Investigation. Safety recommendations addresses training, maintenance program, redesign of the RCCB hardware and protection, as well as predictive technology for smoke identification.



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1. Factual Information

1.1 The Occurrence

On 10 December 2014, the Aircraft, an Airbus A380, was inducted for a scheduled minor maintenance check with a release to service planned on 12 December 2014.

As part of the post maintenance checks, uneventful engine ground runs were performed. Thereafter, the Aircraft was towed to the vicinity of the engineering hangars at approximately 0530 LT on 12 December 2014 where the outstanding maintenance work was planned for completion.

At 0616 LT, with electrical power being supplied by the Aircraft Auxiliary Power Unit, (APU), the engineer on the flight deck at that time requested that the Aircraft power supply be provided by ground power.

Accordingly, external power 1 (EP1), was connected, and the cockpit indication "AVAIL" lit, but with no supply to the Aircraft main electrical bus AC1. As per the statement from the maintenance engineer, before the ground external electrical power was switched over from the APU to EP1, there was a flashing light and smoke seen coming from the lower avionics compartment, located below the cockpit.

The engineer immediately disconnected the electrical power from the Aircraft using the switch in the cockpit. Upon inspection of the source of the smoke, it was found that an Aircraft electrical remote control circuit breaker (RCCB) located in the primary electrical power distribution center, (PEPDC) was burnt and melted. The engineer did not use a fire extinguisher.

There were no injuries to the maintenance personnel.

Sequence of events:

1. During the 2-day maintenance check, external electrical ground power was used continuously as normal.
2. At approximately 0400 LT, the external ground power was disconnected and the Aircraft electrical power continued from the APU as a preparation for the post maintenance check engine runs.
3. Prior to the Aircraft being towed for the engine runs, the engineer noticed a "CB MONITOR SYSTEM FAULT" message on the ECAM¹.
4. In order to reset the ECAM message, the APU electrical power was shut down which is referred to as a "cold start".
5. The APU was restarted, and after the APU electrical power was switched on to power the Aircraft electrical systems, the following were observed:
 - The CB MONITOR SYSTEM FAULT message had disappeared;
 - RCCB 997MC1 TRIP message was observed on the circuit breakers (CB) ECAM page (RCCB 997MC1 controls electrical power to the first class galley);
 - First class galley electrical power was confirmed to be off.

¹ An electronic centralized aircraft monitor (ECAM) is a system, developed by Airbus that monitors aircraft functions and displays them to the pilots and maintenance personnel. It also produces messages detailing failures and in certain cases, lists procedures to undertake to correct the problem.



6. During the engine ground runs, the message RCCB 997MC1 TRIP remained on.
7. With electrical power off, the RCCB 997MC1 was replaced.
8. Electrical power was reapplied from the APU, and no message was observed on the CB page for the next 10 minutes.
9. After 10 minutes, with the Aircraft still powered electrically by the APU, the RCCB 997MC1 TRIP message reappeared.
10. Shortly thereafter, the engineer heard a popping noise followed by light and smoke emitting from the avionics compartment.
11. The engineer immediately switched off the APU.
12. External electrical ground power was connected to the Aircraft external connector, but was not in use at the time of the Occurrence.
13. A thick cloud of smoke formed in the avionics compartment and remained for a while.
14. The inspection of the PEPDC front side revealed that the RCCB 991JV6 was burnt, together with the back plate.
15. On the aft face of the PEPDC, the busbar 100PP and the current transformers, located on the aft side of the back plate of RCCB 991JV6, were also found burnt.

Initial Actions after the Occurrence:

The following actions were taken by the Operator together with Airbus, and the manufacturer of the PEPDC, Zodiac:

1. The Operator's engineering personnel reviewed the affected area and it was noted that there was soot and melted parts around the RCCB 991JV6 location.
2. The Aircraft manufacturer and the manufacturer of the electrical parts deployed an engineering team to support Aircraft Recovery.
3. Gathering of data captured from the Aircraft on-board computers to assist with fault analysis.
4. Thorough inspection of the burnt areas and associated parts.
5. Damaged parts were removed from the Aircraft and sent to Zodiac for investigation.
6. Inspection of the PEPDC fluid protection, also called umbrellas, located above the PEPDC to determine condition and evidence of fluid leaks. This included the eight similar A380 aircraft on fleet.
7. A review of the Aircraft's previous post flight reports (PFR) did not show any failure messages associated with the Aircraft electrical systems.

1.2 Injuries to Persons

There were no injuries to any of the Operator's aircraft maintenance staff.

1.3 Damage to Aircraft

Several components on the PEPDC adjacent to the burnt RCCB 991JV6 were affected by the electrical short circuit and resulting smoke. Arcing was noted on busbar 100PP. The support structure surrounding the burnt RCCB 991JV6 was damaged by heat created from the short circuit.

The Figures 1, 2 and 3 show the location of the PEPDC, the RCCBs, and damaged parts.



Figure 1. Front and Back view of PEPDC



Figure 2. Burnt RCCB 991JV6



Figure 3. Burnt Busbar 100PP

1.4 Other Damage

There was no report of damage to the ground electrical power unit that was connected to the Aircraft, nor did any damage occur to the environment.

1.5 Personnel Information

There was no flight crew onboard at the time of the Occurrence as the Aircraft was undergoing a scheduled maintenance check.

The Engineer who was in the cockpit at the time of the Occurrence was appropriately qualified on the A380 Aircraft.

1.6 Aircraft Information

The Airbus A380 fleet has been in service with the Operator since 2008 when four aircraft were introduced. At the time of the Occurrence the Operator' A380 fleet consisted of 56 aircraft.

The Aircraft, MSN 20, started flying with the Operator from 30 December 2008. The first flight was carried out at Airbus in July 2008.

1.6.1 Aircraft General Data²

Table 1. Aircraft data

Aircraft Type:	A380-861
Aircraft Manufacturer:	Airbus Industrie
Aircraft MSN:	20
Date of Delivery :	30 December 2008
First flight at Airbus	July 2008
TSN Hrs / CSN cycles	25290 / 3005

² Information provided by the Operator.

1.6.2 The A380 Primary Electrical Power Distribution Center (PEPDC)

1.6.2.1 Location of the PEPDC- Main Avionics Compartment

The PEPDC is within the main avionics compartment. This is known as zone 120 and is located below the floor of the forward main deck cabin in the lower fuselage of the aircraft, and forward of the forward cargo compartment. There is one floor access point that can be used to access the main avionics compartment from the aircraft cockpit. This access was used by the engineer.

On the Occurrence Aircraft, above the PEPDC, toilets are installed on the main deck floor and associated water and waste plumbing are circulating between the ceiling of the avionics compartment and the main deck cabin floor.

The majority of computers and the main electrical distribution hardware are located within the main avionics compartment.

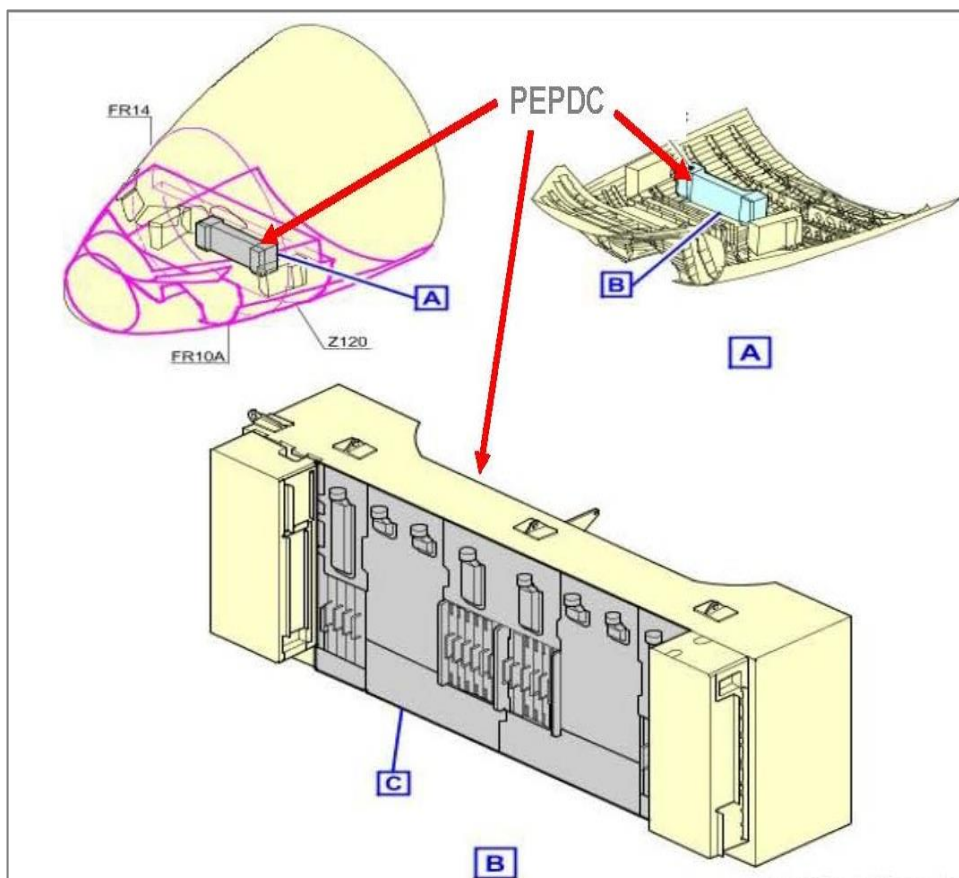


Figure 4. PEPDC Location- Main Avionics Compartment

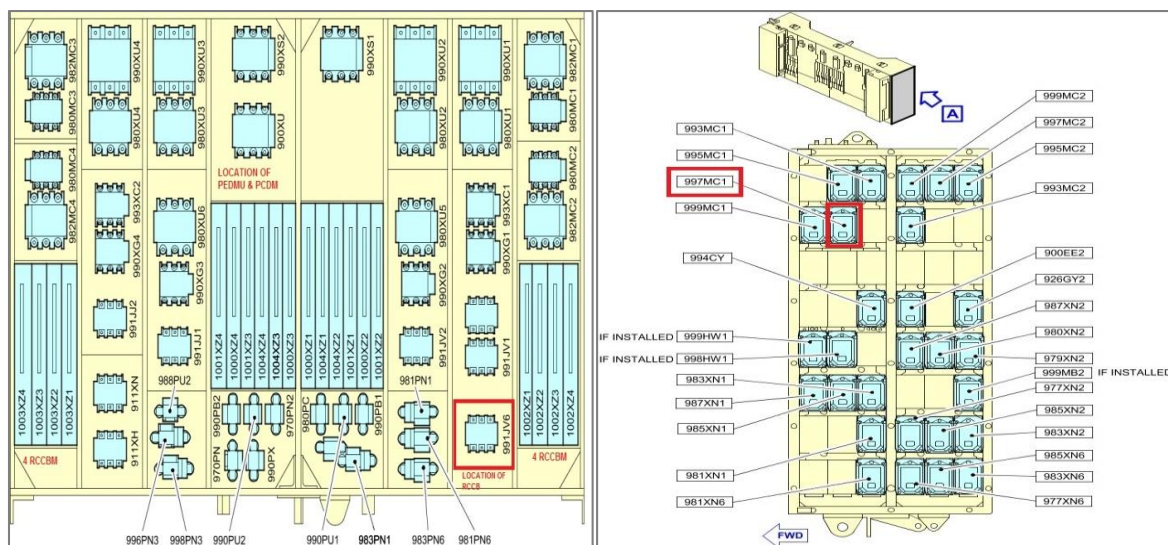


Figure 5. PEPDC Partial layout- Front face and LH side

1.6.2.2 PEPDC Description

The Aircraft primary electrical power distribution is managed by the Primary Electrical Power Distribution Center (PEPDC). The PEPDC distributes 115VAC variable-frequency electrical power and 28VDC voltage to all the electrical consumers on the Aircraft and protects the electrical network from short circuits and overloads. The PEPDC is divided into two identical parts (side 1 and side 2). The PEPDC includes the main AC and DC contactors, the Remote Control Circuit Breakers (RCCB) and the circuit breakers that supply the high AC power-loads (above 15 amperes).

The PEPDC contains other units: the electronic units include the Primary Electrical Distribution Management Units (PEDMU), the Primary Driver Control Modules (PCDM), the Remote Control Circuit Breaker Modules (RCCBM), the Safe Redundant Power Supplies (SRPS), and the Secure Open, and the Trip Resident Memory (STRM).

1.6.2.3 PEPDC Functions

The PEPDC has two functions:

1. Commutation function .
 - To distribute electrical power to the aircraft electrical loads.
 - To configure the network.
 - To connect and disconnect the loads.
2. Protection function
 - To protect the electrical network from short circuits and overloads.
 - The items of equipment that provide protection and commutation functions are:
 - Line contactors, Transfer contactors, Galley line contactors;
 - Protection and/or commutation devices of the main and secondary busbars (AC and DC);



- Protection and commutation devices of high power loads;
- Circuit breakers.

1.6.3 PEPDC- Aircraft Main Electrical Power Supplies

The PEPDC electrical power is supplied to the normal network from:

1. Four Variable Frequency 115VAC Generators (VFG) which are mounted on and driven by the Aircraft engines.
2. Two auxiliary 115VAC generators (APU generators) with constant frequency.
3. On ground 115VAC external ground power unit(s) which can be connected to four external-power receptacles.
4. The PEPDC receives 28VDC power from three transformer rectifiers and two batteries.
5. Confirmation of the Aircraft electrical power at the time of the incident (figure 7);

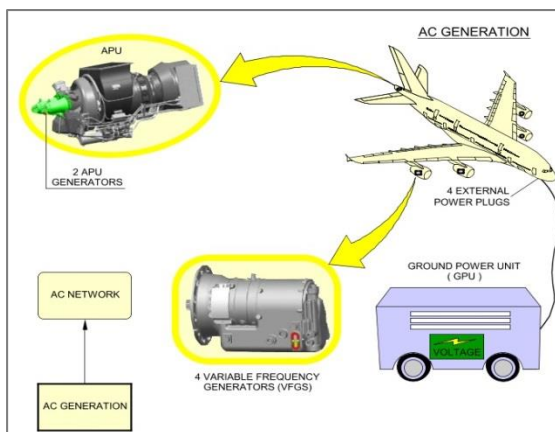


Figure 6. A380 AC Electrical Power Source

- Aircraft was electrically powered by APU GEN1 and APU GEN2 respectively supplying AC1 + AC2 and AC3 + AC4.
- External power 1 was connected but was not supplying AC1 (i.e. "AVAIL" / EPC1 open).

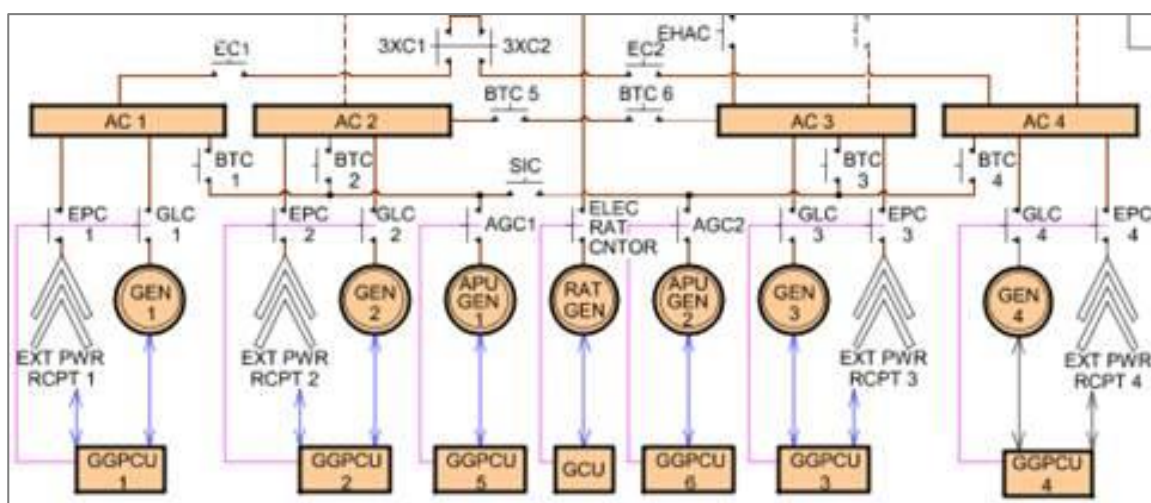


Figure 7. A380 Electrical Power Schematic



1.6.4 The A380 AC external power supply

In normal configuration, the external power supply is one of the AC power sources. It is used on the ground when the engine driven Variable Frequency Generators (VFG) and the APU generators are not available. The Integrated Control Panel (ICP) 1225VM, located in the cockpit, controls the entire aircraft electrical network from the ground power unit through the external power receptacles. The Generator and Ground Power Control Unit (GGPCU) controls and monitors the electrical power supplied.

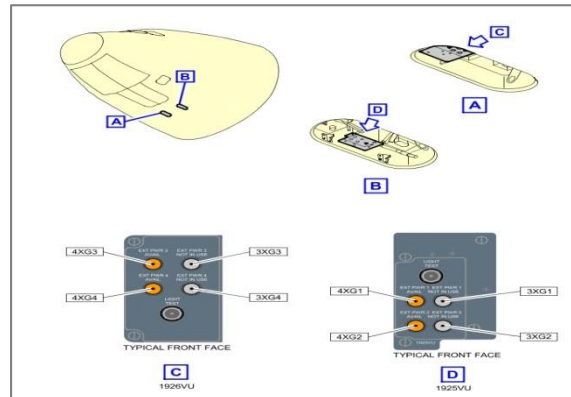


Figure 8. External Electrical Power

The ground power units supply the aircraft electrical network through four external power receptacles installed aft of the nose landing gear. Each external power receptacle has a capacity of 90 kVA, with a fixed frequency of 400 Hz. One ground power unit connected to two to four external power receptacles can supply all the aircraft electrical network with three-phase power of 115/200VAC, 400 Hz.

1.6.5 The Generator and Ground Power Control Unit- GGPCU

The four GGPCUs, all located in the main avionics compartment, Zone 120, have a voltage regulation function and a current measurement function. The current is measured through the Current Transformers (CT) installed in the Primary Electrical Power Distribution Center (PEPDC).

When the ground power unit is connected to the external power receptacle, the related GGPCU immediately monitors the voltage and the frequency. If the monitored parameters (voltage, frequency and phase) are correct, the GGPCU sends a signal to:

1. On the electrical section of the integrated control panel, ICP, in the cockpit, the “AVAIL” legend of the pushbutton switch comes on in green.
2. On the external power, EXT PWR, panel, the EXT PWR AVAIL caution light comes on in red, and the “EXT PWR NOT IN USE” indicator light comes on in green.
3. The green “EXT PWR NOT IN USE” indicator light comes on to show that the ground power unit is connected to the external power receptacle.
4. The “EXT PWR AVAIL” caution light and the “EXT PWR NOT IN USE” indicator light show the status of the ground power unit to the ground personnel.

GGPCU1 monitors the current delivered by the EP1 (frequency and voltage) to ensure that it delivers at the minimum 400Hz/115V. If this is the case, the GGPCU1 displays AVAIL in the cockpit, if not it disconnects the EP1.

RCCB 991JV6 inputs are powered as soon as the EP1 is connected and even if the EP1 is not powering the aircraft but is “AVAIL”. As stated by Airbus, “In this Incident, the short circuit at the RCCB 991JV6 level created a high current demand and the voltage delivered by the External Power 1 dropped. As part of the protection function, the GGPCU 1 detected the short circuit and thus disconnected External Power 1, thereby isolating RCCB 991JV6.”

Post incident analysis of the GGPCU1 recorded information showed that GGPCU1 isolated the RCCB 991JV6 by disconnecting the EP1 before the ground engineers cut off the aircraft power manually.



1.6.6 The Circuit breaker Monitoring System (CBMS) application

The circuit-breaker monitoring system (CBMS) is an Aircraft application which monitors the circuit breakers for primary power distribution, secondary power distribution and emergency power distribution. The circuit-breaker monitoring (CBM) monitors the status of the circuit breakers and the remote control circuit breakers (RCCB) of the aircraft.

The primary power distribution monitoring includes mechanical circuit breakers and programmable RCCB installed in the PEPDC.

The secondary power distribution monitoring includes solid state power controllers (SSPC), installed in the secondary electrical power distribution center (SEPDC).

The CBMS system concentrates data related to the status of the circuit breakers installed in the PEPDC and the SEPDC. It sends data related to the abnormal status of circuit breakers to the Aircraft Control and Display System (CDS), the Central Maintenance System (CMS), and sends data related to abnormal events, and to partial and total loss of monitoring, to the Flight Warning System (FWS).

1.6.7 PEPDC Fluid Protection Umbrellas

The A380 aircraft is fitted with fluid protection for the PEPDC which is referred to as an umbrella, or drip panel. Its main purpose is to avoid any contamination of the PEPDC coming from condensation. Preventing spilled fluid coming from the cabin galleys or toilets from entering the PEPDC is ensured by the sealing of the cabin floor.

The PEPDC fluid protection is of two designs, design 1 and design 2, on the A380 aircraft and consists of the following:

- Four horizontal umbrellas at door one entrance area which are fixed on the floor structure and sealed between each member by tape.
- In design 1, waterproofness between horizontal and vertical umbrellas is ensured by a gutter equipped bonded foam.
- In design 2, waterproofness between horizontal and eight vertical umbrellas is ensured by a gutter equipped elastomer seal.
- The Occurrence Aircraft was fitted with design 1.

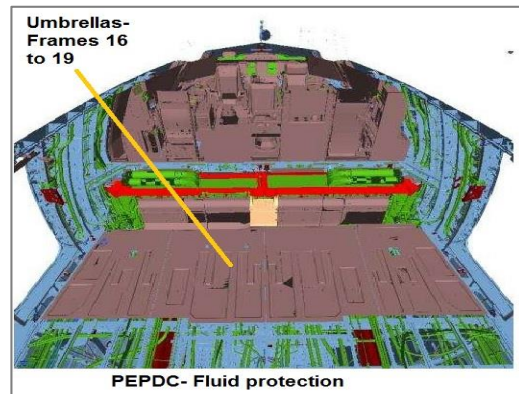


Figure 9. PEPDC Umbrella

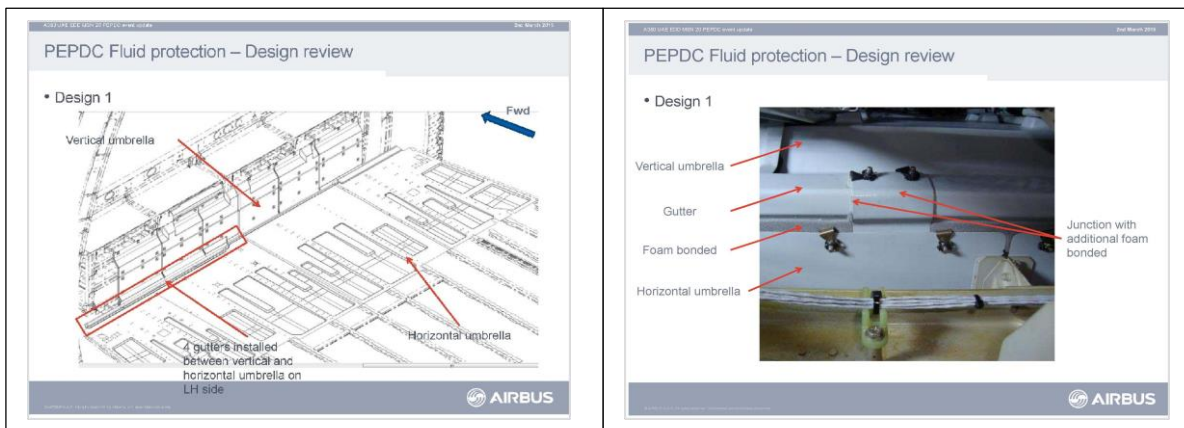


Figure 10. Design 1 Fluid Protection

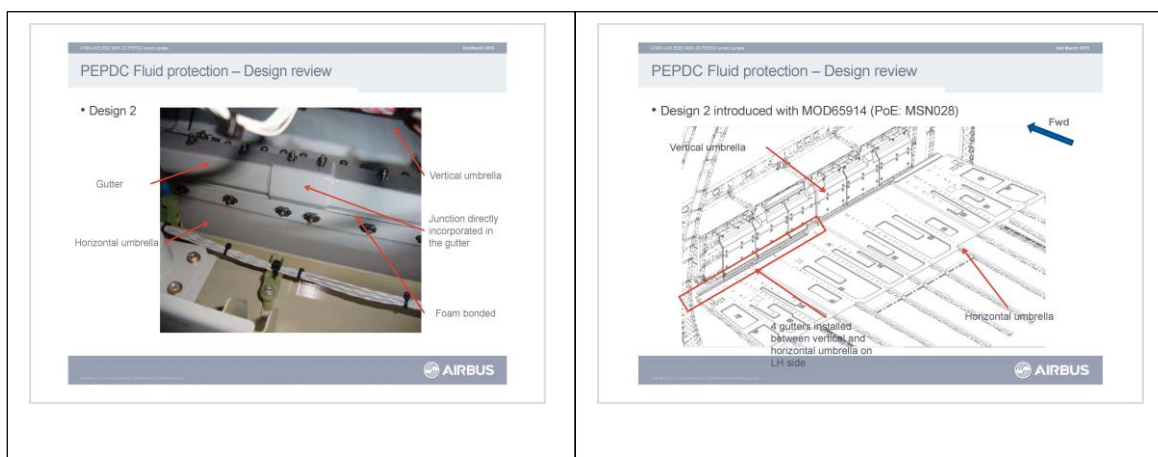


Figure 11. (A) Design 2 Fluid Protection



Figure 12. (B) Design 2 Fluid Protection



1.6.8 PEPDC fluid protection inspection

The Operator was requested to inspect the Aircraft and the other eight A380 aircraft, fitted with design 1, to determine the condition of the fluid protection and for fluid leakage. The inspection results confirmed that there were signs of fluid leakage that had bypassed the PEPDC fluid protection on five of the nine aircraft, including the Occurrence Aircraft. The leakage on the five aircraft was due to the sealing of the PEPDC fluid protection which was found to be compromised as there were existing gaps.

On the Occurrence Aircraft the following were noted:

1. The PEPDC fluid protection was found to be deteriorated.
2. Foam was found to be debonded and missing at some locations, and in particular at the junction.
3. Fluid stains were found in areas below the umbrella, including stains on the PEPDC.



Figure 13. PEPDC protection- Foam condition and stains

1.6.9 RCCB Description

Each RCCB directly controls the power supply to the connected units. It automatically opens the contactors and stops the power supply if there is an overload, or a short circuit. The RCCBs are remotely controlled by the computers. These computers control the load condition of all available power supply sources (Engine generators, APU, External Power) and the load condition of the consumer systems. If a power source is not available, the computer(s) calculate the input load from the power sources and the output load to the consumers. If there is an overload or a short circuit, the RCCBs open through the Remote Control Circuit Breaker Module (RCCBM) and stop the power supply to the connected feeder. The RCCB can be manually reset in case of an overload, or can be reset by computer in case of a short circuit.

1.6.10 RCCB 991JV6

1.6.10.1 Operation

The RCCB involved in this Occurrence is known on the A380 by a functional item number (FIN) RCCB 991JV6, and was the original part installed during production. The part number of this RCCB is 879CA01Y01.

This RCCB 991JV6 enables electrical power to the aircraft hydraulic system green electrical pump 1 (ELEC PMP1) when the aircraft is on the ground and the electrical power supply is in the ground servicing configuration.

The RCCB is not electrically supplied when the aircraft is in flight mode.

To be actuated on the ground, this RCCB needs the embodiment of Service *Bulletin* (SB) No. A380-29-8011, issued August 2012. This SB introduced dedicated command logics within the hydraulic system monitor unit (HSMU). At the time of the Occurrence, the Operator had not implemented this SB on the Aircraft.

Whenever external power is connected and the “AVAIL” light comes on, the RCCB is electrically supplied. At the time of the Occurrence, the external electrical power source was connected providing 3-phase 115VAC to the RCCB 991JV6. However, the RCCB was electrically open at the time of the occurrence, due to the non-embodiment of the service bulletin.

1.6.10.2 RCCB 991JV6 normal installation

Figure 14 shows the normal architecture of the RCCB panel fitted in a sister in-service A380 aircraft.

In this installation, the six screws of the RCCB, A1/B1/C1/A2/B2/C2, are all exposed. A1/B1/C1 screws are located on the underside of the RCCB. The PEPDC ventilation blows air directly on the RCCB as the cut-out for the airflow is located next to the RCCB. The RCCB was dusty with fluid stains.



Figure 14. RCCB 991JV6 normal installation

1.6.10.3 Initial assumptions- RCCB 991JV6 short circuit

Together with the manufacturer of the PEPDC and Airbus, the following scenarios were examined in an attempt to determine what caused the RCCB short circuit:

1. The torque of the RCCB screws

Airbus stated that this was ruled out due to:

- “The involved RCCB was open at the time of the occurrence and therefore no current was passing to the connector’s outputs.
- As seen in figure 15, it is noted that the middle screw (B1 phase) and the right screw (C1 phase) have lost some material (due to overheat) in the lower part of the screw (thread part).
- If there would have had a torque issue, overheat would have been located at the screw head where the connection takes place and therefore would have some loss of material at this level.”



Figure 15. Burnt RCCB

2. Foreign object debris

- This was investigated during the shop detailed analysis
- Laboratory inspection of the burnt parts eliminated this theory. No foreign material was noted during the analysis of the material removed from the Aircraft burnt parts.

3. Dust and fluid mixture

- For the six years the Aircraft was in-service, Airbus commented that RCCB 991JV6 was more prone to accumulate dust than upper contactors as it is located just above the PEPDC ventilation hole.
- Airbus mentioned that the short circuit across the RCCB was most likely generated by the mixture of dust and liquid that created an electrical arc between two phases, B1 and C1, of the RCCB as noted on figure 16.
- The Investigation could not determine the amount of dust that would have accumulated.



Figure 16. RCCB 991JV6 ventilation airflow

1.6.11 Zodiac Investigation final report

1.6.11.1 Burnt RCCB 991JV

The affected parts removed as a result of the RCCB short circuit were sent to Zodiac facilities for further examination. However, in this section of the Report, factual information on RCCB 991JV6 and Busbar 100PP has been taken from the investigation report³ published by Zodiac.

The examination included the following: Identification plate; status of each of the six terminal screws on the RCCB; fluid traces; possible corrosion traces on the terminals; separators between the terminals, especially upstream of B1 and C1; and torque traces (stud/cables/screws/washers and torque marks).

No identification plate was found on the RCCB.

Figure 17 shows the condition of the RCCB screws A1, B1, C1. The screws are electrically powered with 3-phase 115VAC once the ground electrical power is connected to the aircraft electrical system. B1 and C1 screws were melted as noted: B1 screw 10mm and C1 was 12mm. The C1 screw melted material was still attached to the screw. The external chamber separation was missing between B1/C1. Screw A1 was not affected.

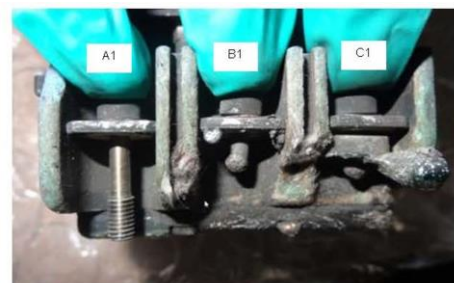


Figure 17. RCCB 991JV6 melted screws B1 and C1

³ ZS.PSE.MTE.15-0140- The final report reference issued by Zodiac Aerospace. Parts removed from the Aircraft were sent to Zodiac Electrical & Power Systems (ZEPS) at Niort and to Zodiac Sensor & System Management (ZSSM) to Plaisir for investigation.

Figure 18 shows the condition of the screws A2, B2 and C2. As SB No. A380-29-8011 had not been embodied on this Aircraft, the contactor is normally open, and thus, there was no electrical power available at screws A2, B2 and C2. The screws were not affected.

Figure 19 shows where traces of dried fluid was found on the exterior surface of the RCCB.

Figure 20 shows where traces of dried fluid was found after the soot was cleaned from the cavities of phases B1 and C1.

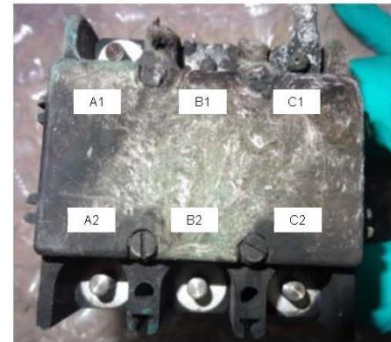


Figure 18. RCCB 991JV6 pins A2, B2, C2.



Figure 19. RCCB 991JV6 exterior dried fluid

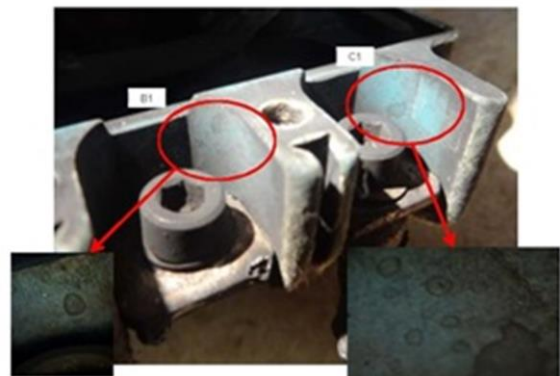


Figure 20. RCCB 991JV6 dried fluid in cavities B1 and C1

1.6.11.2 Busbar 100PP

The Zodiac examination report, stated that “The arcing found on the busbar 100PP [see figure 3] confirmed that the busbar 100PP was in contact with terminal screw phase B of the RCCB. A second short circuit occurred between the RCCB phase B 115VAC and the 28VDC of the busbar 100PP.”

1.6.11.3 Zodiac report conclusion

In conclusion, the report stated that:

1. “There was no solid FOD found during the laboratory investigation according to analyzed materials.
2. Analysis of the fluid found on the RCCB and the backplate was a mixture of various origins constituents:
 - Several compounds used in the formulation of detergent products
 - Various substances including protein (food waste, etc.)
 - Cellulose fibers (paper, fabric, etc.)
 - Fragments of polypropylene, gypsum, talc, etc.
 - Condensation/humidity was ruled out as the origin of the fluid
 - Based on the findings, it is actually more likely that this fluid was coming from the toilets or the aircraft sink circuit.”



3. It was determined that the first short circuit was due to a mix of fluid and dust that heated and an electrical arc was created between phases B1 & C1 of the RCCB 991JV6.
4. A second short circuit was caused when the 115VAC phase B of RCCB 991JV6 dropped, after it had burnt, and then contacted the 28VDC busbar 100PP causing this to burn also.

1.6.12 RCCB 997MC1

Prior to the Aircraft being towed for the planned engine runs, the engineer noticed an ECAM message which stated “CB MONITOR SYSTEM FAULT”, and “RCCB 997MC1 TRIP” message was observed on the Aircraft ECAM CB page.

RCCB 997MC1 controls electrical power to the first class galley, galley feeder 11, and the electrical power was confirmed to have tripped.

The trip events of RCCB 997MC1 was recorded and retrieved from the Aircraft central maintenance system memory. It was noted that there were no failure messages recorded for 997MC1.

As per the Aircraft *Trouble Shooting Manual (TSM)*, RCCB 997MC1 was replaced by the engineer after an initial, but unsuccessful, attempt to reset the message. In spite of this replacement, the same message (RCCB 997MC1 TRIP) reappeared after 10 minutes with the Aircraft powered electrically by the APU. This replacement was the first time for the RCCB during the Aircraft’s 6-year operational life, and it was the original part fitted on delivery of the Aircraft.

The Aircraft manufacturer stated that:

1. The trip events were due to a current overload on the galley power supply.
2. The removed RCCB 997MC1 was not investigated.
3. Both events (RCCB 997MC1 trip and PEPDC short circuit) are not correlated.
4. There is no link between RCCB 991JV6 and RCCB 997MC1 as each RCCB has a different A/C power supply.
5. RCCB 997MC1 is located away from the contaminated zone as it is located on top of the left hand side of the PEPDC while RCCB 991JV6 which burnt, is located at the lower left on the front side of the PEPDC.

1.6.13 A380 maintenance program for PEPDC

An MPD task requesting inspection of the PEPDC for dust removal existed at the time of the event, but for the involved aircraft, the recommended threshold had not been exceeded.

The MPD task 247200-00101-01 “VISUAL CHECK OF PEPDC TO PREVENT DUST ACCUMULATION” had been introduced in the MPD on 01 OCT 2014. The threshold interval mentioned in the MPD is 72 months. As the delivery date of the Aircraft was 30 December 2008, this inspection was due before the end of December 2014.

In May 2014, six months before this Occurrence, Airbus published a (SIL) 24-088, advising A380 operators about the findings related to dust accumulation.



The *SIL* states that:

“On the A330/A340 operators have reported multiple ‘ELEC TR FAULT’ warnings on several aircraft. After investigation it has been demonstrated that the issue is partly related to temperature rise. Temperature rise which is directly linked to dust contamination of the grid and ventilation ducts of the TRU (refer to *SIL 24-088*). Similar design is used on A380. Additionally, presence of dust accumulation on some areas (e.g. EEPDC, PEPDC upper grid) has been noticed during A380 health checks performed by Airbus on several aircraft.”

Airbus mentioned in the *SIL* that a new maintenance task would be added to visually inspect the PEPDC for dust presence. The *SIL* does not mention fluid contamination inspection. This new requirement provides for a visual inspection of the PEPDC for dust accumulation every 72 months, and to perform cleaning as required. However, Airbus advised operators to adjust the interval of inspections based on operational experience.

1.6.14 Maintenance records review

The PEPDC fluid protection is located below the flooring of the A380 main cabin deck. The plumbing supply and drain pipes for the water and waste systems pass below the cabin flooring and above the PEPDC fluid protection.

A maintenance records review did not indicate any occurrence of fluid leakage during the Aircraft operational life. Thus, the Investigation could not determine when, or how, the PEPDC was contaminated.

Prior to the Occurrence, the Operator did not perform any visual inspection of the PEPDC. The MPD task introduced on 1 October 2014 was not due until 30 December 2014.

1.7 Meteorological Information

Not a factor in this Occurrence.

1.8 Aids to Navigation

Not a factor in this Occurrence.

1.9 Communications

Not a factor in this Occurrence.

1.10 Aerodrome Information

At the time of the Occurrence, the Aircraft was parked outside the Operator's maintenance hangars. Rescue and firefighting services were available but not required because the electrical short circuit was contained by the Aircraft electrical protective systems.

1.11 Flight Recorders

The Investigation did not request the flight recorders to be offloaded, since the Occurrence took place during Aircraft maintenance.

Airbus, together with the manufacturer of the PEPDC, utilized the computers non-volatile memory (NVM) and the Aircraft built-in test equipment (BITE) to determine any Aircraft related system failures leading to the short circuit. The following data was provided by Airbus:

1. “Post incident analysis of GGPCU1 recorded information showed that GGPCU1 isolated the RCCB 991JV6 by disconnecting the external power, EP1, before the engineer removed the Aircraft power.



2. The Aircraft central maintenance system (CMS) was reviewed for the three week period prior to the Incident with the following data:
- No abnormal event reported until 0616 LT except CB tripped alert or known/spurious/minor BITE messages.
 - C/B tripped 2TP (printer 2) before engine run
 - No trace of C/B tripped 997MC1 - RCCB galley feeder 11
 - At 0616 LT several ECAM warning reported without BITE messages:
 - External power 1 fault (triggered by GGPCU1)
 - AC1 bus fault
 - DC1 bus fault
 - At 0616 LT PEPDC reports 3 BITE messages:
 - SRPS 2.1 and 2.2 overload
 - GALT1 command discrepancy detected by PCDM1.1 compared with the other PCDM.
 - No BITE messages or warning for AC2. This confirmed that AC2 was supplied until APU shutdown”.

1.12 Wreckage and Impact Information

The Aircraft was intact.

1.13 Medical and Pathological Information

Not a factor with this Incident.

1.14 Fire

The electrically short circuit across RCCB 991JV6 was contained within the lower left hand area of the PEPDC. No external fire extinguisher was used.

1.15 Survival Aspects

Not a factor in this Occurrence.

1.16 Tests and Researches

Additional testing was not performed except for what is summarized and mentioned in section 1.6 of this Report.

1.17 Organizational and Management Information

Not investigated.



1.18 Additional Information

1.18.1 A380 Electrical short circuit occurrences

1.18.1.1 PEPDC FOD - A380 (MSN 11)

A previous case⁴ of an internal PEPDC short circuit on the Operator's A380, MSN 11, occurred on 2 September 2008. The first flight for this aircraft was at Airbus in September 2007 and this was the first A380 aircraft to start service with the Operator in July 2008.

The aircraft experienced a short circuit within the PEPDC during landing. An uneventful landing was performed, and the cockpit crew was able to taxi to the parking stand.

A strong burning smell was reported in the cockpit shortly after the event. The short circuit resulted in the loss of one main busbar, but the aircraft electrical protections designed for such cases were able to isolate the damaged network.

At the time of that incident, it was suspected that a foreign electrical conductive material caused a short circuit between two sub-busbar connections, producing significant heat, and damaging the surrounding cables and sockets.

The 3-phases of power busbar located upstream of RCCB 999MB2 had mostly vanished. The PEPDC examination revealed the presence of a foreign object partially melted. Although the RCCB 999MB2 was heavily damaged on the exterior, the RCCB did not show any internal failure, which confirmed a short circuit on the busbar itself. The generator and ground power control unit 2 (GGPCU2) detected an overcurrent on AC2 and sent a command to isolate the AC2 busbar.

The RCCB FIN 999MB2 function is to control electrical power to the left-side cabin shower water heater.

The investigation into that incident concluded that the short circuit was created by a foreign object debris (FOD) inside the PEPDC that had probably existed prior to aircraft delivery to the Operator.

Following the incident, several remedial actions were initiated by Airbus to prevent another PEPDC short circuit due to foreign object:

- Inspection to identify any FOD on all aircraft as detailed in service bulletin SB A380-24-8009
- Inspection as per SB A380-24-8016
- Reinforcement of PEPDC protections introduced in the *aircraft maintenance manual (AMM)* and specific ground support equipment
- Introduce a plastic sleeve for PEPDC delivered to Airbus after the end of 2009. This retrofit is not available for aircraft in-service prior to the end of 2009
- PEPDC upper grid mesh installation introduced by the *Vendor VSB 380GZ02Y-24-002*, and SB A380-24-8022
- From 2009, insulation material protecting the main busbars will be applied in order to cover, as much as possible, all the exposed areas. This retrofit is not available for in-service aircraft prior to 2009

⁴ Reference Airbus technical follow-up TFU 24.72.00.001.



- Additional PEPDC rear side protection (main busbars). Shielding panel/cover introduced on new aircraft and also available for in-service aircraft as an option.

1.18.1.2 Annex 13 Investigation - A380 (MSN 08)

An investigation was carried out by the Air Accident Investigation Bureau of Singapore (AAIB) into an in-flight electrical fire on-board an A380 operated by Singapore Airlines. The final report contained the following facts and conclusions⁵:

The aircraft was MSN 8 and the first flight with Airbus was in March 2007. The following is stated in the final report:

“At 10.45 p.m. on 31 January 2011, a cabin crew member on an Airbus A380 flight from Hong Kong to Singapore heard a loud bang when he was in a lavatory. He later noticed an electrical burning smell and smoke. He discharged a fire extinguisher into the area from where the smoke was coming out. The smoke subsequently cleared and the aircraft landed without further incident. No passenger or crew was injured.

The aircraft was inspected after landing in Singapore. Signs of burning was found on the feeder terminal block for the No.1 VFG located in the forward cargo compartment below lavatory LM35, on the feeder cables connected to the feeder terminal block and on the insulation blankets

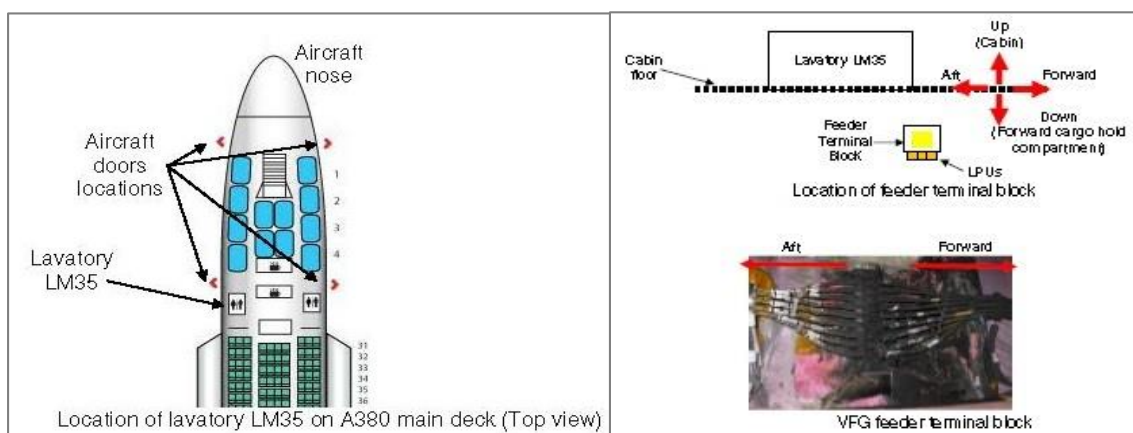


Figure 21. Photos from Singapore Annex 13 report AIB/AAI/CAS.072

around the feeder block. The lightning protection units (LPUs) connected to the feeder terminal block showed signs of melting. The inner surface of the cover of the feeder terminal block was partially covered with soot but did not show any sign of heat damage.

A degraded main excitation cable had probably caused an over-voltage across the lightning protection units (LPUs) attached to the feeder terminal block, resulting in a short circuit between the three phase feeder cables and structural grounding. The short circuit caused excessive current to flow through the feeder cables attached to the

⁵ Reference: AAIB final report No. AIB/AAI/CAS.07



feeder terminal block. The operation of the Over-Current protection limited the damage due to overheating.”

The analysis in this report, mentions that there was no fire detection or suppression system in the vicinity of the feeder terminal block nor was there a means for the cabin crew to access the damaged feeder terminal block to fight the fire. In addition, the report mentions that the flow of the fire extinguishing agent discharged by the cabin crew at lavatory LM35 could not reach the fire at the feeder terminal block. It was stated that the fire that damaged the feeder terminal block had probably extinguished by itself, but it remains a concern that there is no ascertained way to detect and extinguish a fire in that area.

Four safety recommendations were issued by the AAIB with one recommendation requesting “The aircraft manufacturer, as holder of the type certificate, review the need for fire detection and suppression in the vicinity of the feeder terminal block. [AAIB Recommendation R-2012-003]”.

As a result, Airbus issued a *technical follow-up (TFU) document No. 24.20.00.009* dated 07 April 2011- *Wiring damage due to VFG overvoltage*. This document highlighted the following:

- Suspected cutting tool damage to the cable sheath.
- Remove the GEN reset in the ECAM procedures in case of “ELEC GEN 1(2)(3)(4) FAULT or ELEC APU GEN A(B) FAULT”.
- Create a new standard GGPCU to trigger the “Fast Over-Voltage” protection in case of a similar event. Target date Q3 2016.
- Proactive monitoring through AIRMAN of the different fault codes (FMC) with the recommended maintenance action required.

1.18.2 UAE ROSIs- data on A380 electrical smoke

The data reviewed for the UAE A380 operators reported occurrences until August 2015, showed that the approximate total number of flight hours was 796,000, and flight cycles was 112,000. From the UAE mandatory reporting system (Reporting of a Safety Incident 'ROSI'), the reviewed results of the data collected from 2010 to October 2015 is shown in Table 2.

Table 2. A380 Electrical fires/smoke - UAE ROSI data			
Year	Aircraft System	Galley Equipment	Total Reports
2010	2		2
2011	1	1	2
2012		5	5
2013	2	13	15
2014	1	7	8
2015	5		5
Total Reports	11	26	37



The ROSIs referred to are related to crew reports of smoke related to aircraft system and galley equipment defects. From the 11 aircraft system related defects, two resulted in an aircraft diversion. Five reports were significant which includes the Occurrence discussed in this Report. Of the five significant reports, four occurred within the past 11 months, December 2014 to October 2015.

Four significant aircraft system defects were as follows:

1. MSN 28 – Diversion- on 22 October 2011:

“ECAM warnings displayed: ELEC AC BUS 4 FAULT, ELEC AC BUS 3 FAULT ELEC GEN 4 FAULT, ELEC GEN 3 FAULT, and ELEC GEN 1 FAULT VFG 2 was supplying AC bus 1 & 2 (AC bus 3 & 4 unpowered).”

After initial investigation⁶, Airbus concluded that the most likely cause of the generator tripping was an intermittent connection on one phase at the input of the shower power supply.

In a report issued later⁷, Airbus tests showed that the ECU internal wire chafing led to a short circuit and the engine generators tripped due to activation of the differential current protection (DP). In that report, the shower heater scenario was discarded stating that “Shower control unit and heater were no fault found, NFF.”

2. MSN 119 on 28 March 2015:

Similar incident to the AAIB Annex 13 Investigated incident (section 1.18.1.2) was reported by the Operator.

The Operator's filed report stated:

“Multi ECAM Failures during Climb- During climb and passing FL140, sudden smell of burning triggered in cockpit and in cabin throughout. Immediately ECAM ELEC AC Bus 2 fault and AIR L Outer wing leak. Air bleed system automatically isolated leak by switching engine bleed 1 & air x-bleed valve closed. Burning smell dissipated quickly thereafter. No sign of smoke was visibly sighted anywhere on board. Purser switched off IFE very early on detection of smell. IFE remained off throughout flight since commenced partially shed msg was displayed on EICAS electrical SD page. Since burning smell disappeared very quickly on isolation of bleed leak & also no smoke was sighted anywhere, flight proceeded to destination.”

The initial maintenance action was taken by replacing the VFG 2 however, the fault returned. During extensive troubleshooting recommended by Airbus, terminal block was found burnt (VFG 2 feeder cable), damage to wiring in left hand wing as well as insulation damage and lightning protection module damages.

It is noted that in spite of the reported smoke and ECAM failure messages, the crew's decision was to continue the flight to the destination.

⁶ Airbus report issued on 17 November 2011

⁷ Airbus report issued on 17 July 2012



3. MSN 42 – Diversion- on 25 June 2015:

The Operator's filed report stated:

“Aircraft dispatched under MEL 28-25-19a requiring manual fuel outer transfer when feed tanks less than 13 tons fuel. During flight fuel left outer tank pump fail requiring outer tank transfer by emergency outer tank transfer valve. Procedures combined to retrieve fuel from both outer tanks. Fuel manual balance procedure applied to maintain left & right total wing asymmetry within reasonable limits of approximately 3 tons difference. Approaching completion of fuel transfer circuit breaker transfer, valve outer left and right, popped with smoke emanating from left hand overhead panel. There was No ECAM. A red ‘smoke’ light appeared in the caution and warning push button. Abnormal smoke/fumes procedures applied followed by QRH procedures...”

The Airbus shop report stated that “the short circuit and burnt pins were found in the cockpit integrated control panel, ICP, (FIN 1211VM), circuit board but reason for the short circuit was unknown.”

4. MSN 57 on 01 October 2015:

The Operator's filed report stated:

“Aircraft parked- burning smell in aircraft with forward cargo smoke warning in flight deck. Burning smell in aircraft cabin and flight deck. Smoke warning in flight deck. Forward cargo door opened found smoke in forward cargo. Aircraft immediately depowered and evacuated. Ground power leads disconnected and found aircraft ground power receptacle no 2 pin b burnt. Ground power unit no 5181 lead no 2 found burnt. Forward cargo floor board panel opened and found external power receptacles 1xg1 and 1xg2 completely burnt.”

As stated by the Operator, a contributing factor to the failure of the external power receptacle, was the non-use of the weight restraint strap which helps to off-load the weight felt at the connection. The final report from the manufacturer was not available at the time of publishing of this Occurrence Final Report.

1.19 Useful or Effective Investigation Techniques

No new investigation techniques were used during this Investigation.



2. Analysis

2.1 General

This Occurrence, involving an electrical short circuit of the RCCB within the Aircraft PEPDC hardware, highlights the potential risks involved with aircraft electrical systems. Despite the fact that the Occurrence took place during maintenance, and that the built-in system protection isolated the affected failures, the circumstances allowing the short circuit to occur are important, but sometimes overlooked

As mentioned in section 1.18 of this Report, smoke and fire as a result of aircraft electrical systems short circuits and arcing continues to pose risks to aircraft operations. . The significance of a combination of environmental factors, together with the contamination of electrical parts by dust, fluids, and oils, continue to effect aircraft safety. This is compounded by foreign object debris, defective workmanship during production as well as during the service life of an aircraft. Other factors that may affect air safety include the lack of, or insufficient, maintenance inspections, aircraft system design limitations, which includes identification and extinguishing of on-board fires to which crew members may have limited access.

Aviation safety literature on all types of aircraft contains electrical incidents that were not limited to in-flight events, but also include severe incidents that have occurred on the ground, with some of them leading to aircraft hull loss due to electrical short circuits or current overload.

Improvements made to pilot's training using data from previous aircraft accidents has shown that flight crews do react correctly and in a timely manner when making a decision to divert and land as soon as possible in case of in-flight smoke or fire. Even though international statistics have shown that the majority of smoke indications are false. However, each incident has to be managed based on the information available to the flight crew at the time.

As for electrical system arcing and short circuits, these conditions will produce good indicative information to the crew, such as advisory and caution messages, associated with physical sensory indications such as smell, smoke, or heat. In spite of this, investigations conducted into different operators' incidents concluded that there is still an area of doubt in regard to the decisions made by the crew especially as to whether to divert and land as soon as possible or to continue the flight. Following the Swiss Air 111 accident the SOP for pilots is to land ASAP in the event of smoke or fire.

2.2 Aircraft Maintenance Practices

For aircraft maintenance personnel, training and the relevance of what can go wrong is as important as troubleshooting of a defect. An engineer may not appreciate the consequence of non-technical related defects if reference to previous aircraft incidents is not available or referenced during training. In addition, having an inspection task without clear visual aids, so as to allow an engineer to know what to look for, can defeat the defenses of a highly sophisticated aircraft.

In order for a fire to be sustained, a source of fuel for combustion must exist. Insulation blankets, which may be located in some inaccessible areas, can provide that source. As the aircraft ages, flammable contaminants such as remains due to spillage from the aircraft toilet system, lubricants, corrosion inhibitors, hydraulic fluid and dust, may saturate the insulation blankets and then reach to the electrical components. Aviation literature and evidence from previous investigations has shown that this type of contamination was a good fuel for fire.

Regular inspection of wiring and electrical components is an essential check of the overall health of an aircraft. Wiring bundles should be inspected particularly for conductive



material that can chafe the insulation and allow arcing. Inspection of remote or hidden areas of the aircraft should be scheduled regularly for wiring that can be covered with dust, grease and other contaminates. All nearby thermal acoustic insulation blankets should also be carefully inspected. Cleaning or removal of contaminates should be a priority so that a source of fuel for a fire can be eliminated.

Prior to the A380 entering service, there have been many aircraft in-flight fires and ground fire incidents as a result of electrical arcing and short circuits. The Swiss Air flight SW111 on 2 September 1998 was an example of how electrical arcing may be very significant. Because of that accident, aircraft manufacturers included detailed visual inspections of electrical wiring and components in the aircraft maintenance program. However, the methods of inspection were most of the time visual checks, which means that there is room for error.

From the laboratory investigation report issued by Zodiac, it was only through magnification that the fluid contamination was noticed on RCCB 991JV6. If the maintenance task to visually inspect the components on the PEPDC was planned and performed, obvious signs of fluid and dust might have been found, but it is unlikely that visual inspection would have found the dried fluid contaminants identified by the magnification used in the Zodiac shop examination. The manufacturer should review the means of inspection in order to increase the possibility of detecting contaminants.

As in-flight smoke and fires continue to pose a threat, aircraft manufacturers are encouraged to produce concise training visual aids and video material aimed at reducing fire risks associated with maintenance. Although maintenance practices to reduce fire risk are well understood, the reality is that the practices are not always effectively applied.

2.3 PEPDC- Umbrella Fluid Protection

The PEPDC is located in the main avionics compartment. Above the PEPDC is the forward section of the passenger cabin which contains galleys and lavatories with their under floor water and plumbing lines.

Between the main cabin and the PEPDC, there is the main cabin panel flooring and an added umbrella fluid protection for the PEPDC. On the Occurrence Aircraft, design1 fluid protection was fitted. During the post Incident inspection, the umbrella was found to be in a deteriorated condition with foam debonded and missing at some locations, in particular at the joints.

Signs of dried fluid contamination were found on the aircraft structure below the umbrella, as well as on the PEPDC assembly.

It is unknown when this leak occurred. Nor is it known whether the PEPDC umbrella assembly was ever removed from the Aircraft after delivery to the Operator. The Operator could not verify whether there had ever been a reported leak from the water and toilet waste system.

Both design 1 and design 2 were fitted on the Operator's fleet. Other aircraft with design 1 also showed signs of fluid leak penetrating the umbrella, which, as per the findings in the Zodiac shop report, may indicate that there is a possibility of imminent electrical failures and short circuits. Design 2 umbrellas appear to be of a better fitment as inspections for signs of fluid leaks returned satisfactory results.

Unlike other systems on the A380 aircraft, the umbrella, design 1 and design 2, has no means of verification that it is leak proof, thus allowing for the possibility of installation errors. The aircraft manufacturer should implement a means whereby maintenance staff are reminded of the importance of correct installation, as well as verifying positive sealing of the PEPDC fluid protection umbrella.



2.4 RCCB 991JV6

The Aircraft service life was six years, with about 25,000 flight hours and 3,000 cycles.

The RCCB 991JV6 was fitted during Aircraft production and remained inactive during the Aircraft service life. The Operator opted not to implement the manufacturer *SB No.: A380-29-8011*. Provided that this SB is embodied, the contactor 991JV6 would then enable 115VAC electrical power to the green electrical pump 1 (ELEC PMP1), but only when the aircraft is on the ground, and the electrical power is in the ground servicing configuration.

After the planned engine ground runs were completed, and before disconnecting the APU electrical generator, the ground staff connected the external power, EP1, and 115VAC was available with the "AVAIL" cockpit light on. This allowed 3-phase 115VAC to be supplied to RCCB 991JV6 input connections A1, B1 and C1. As *SB No.: A380-29-8011* was not implemented, the contactor was in an open state, and thus the output connections A2, B2 and C2 were not powered. This is the continuous state of the RCCB whenever the Aircraft is on the ground and External Power 1 (EP1) is connected and "AVAIL". The short circuit of the RCCB occurred soon after the external power 115VAC became available.

The electrical arcing on RCCB 991JV6 was contained within the PEPDC as GGPCU1 built-in protection detected the short circuit and isolated the AC Bus 1 from the rest of the Aircraft electrical system. EP1 was automatically stopped by GGPCU1.

Based on the Zodiac shop report, it was noted that the RCCB was not compromised, but was a support of electrical arc creation, which was initiated due to fluid and dust accumulation between the two phases B1 and C1. This arcing caused the two screws to melt; the arc fusion damaged the backplate, and the nuts maintaining the two studs on the backplate broke causing the release of the two current transformers (CT) of the B1 and C1 phases; the CT of the B1 phase dropped down and impacted the DC1 busbar (100PP) initiating the second short circuit.

Analysis of the material found on the burnt RCCB determined that there was an amount of accumulated dust-fluid mix that was significant enough to bridge the physical barrier between the B1 and C1 screws. The laboratory examination of the solid remnants of the fluid found in the cavities of the RCCB B1 and C1 phases revealed various chemical compounds of protein and cellulose fibers indicating that the fluid had, most likely, come from the Aircraft toilet system. Airbus commented that liquid alone would most likely not have been enough to bridge the empty space between B1 and C1 phases and create arcing.

The Investigation could not determine the exact amount of the dust-fluid mixture and the detrimental amount required to cause the bridging of the two screws. However, the post-Occurrence inspection of RCCBs installed on other Operator's A380 fleet revealed contaminants on the surface of the RCCB but with no reports of short circuits.

The location of RCCB 991JV6 in the lowest position on the PEPDC, and adjacent to the PEPDC ventilation cutout, makes it most susceptible to dust build up, as air is blown directly onto the RCCB. Since there is no physical cover over the six screws [A1, B1, C1, A2, B2, C2] there is a possibility that there was more dust accumulation on the lower screws [A1, B1, C1] than on the upper screws [A2, B2, C2]. The Investigation could not determine the quantity of dust accumulation on the RCCB prior to the Occurrence.

It is possible that uncontained fluid spillage can contaminate the PEPDC as it can pass from the ventilation duct and structural opening located at the upper surface of the PEPDC. As the location of the RCCB 991JV6 is at the lowest vertical position on the backplate, any fluid would first have to contaminate the other RCCBs before reaching the RCCB 991JV6. Phases A1, B1 and C1 are all located on the underside of RCCB 991JV6, thus, the least probability for any fluid to get in contact with the screws. Any spilled fluid would probably bypass these screws.



Assuming that the quantity of dried fluid and dust mixture was significant enough to cause the short circuit across phase B1 and C1, and assuming that this was the only reason for the short circuit, there is a possibility of reoccurrence if the recommended Airbus inspections and cleaning are not performed.

The location of the PEPDC, below the wet cabin, makes it susceptible to maintenance deficiencies that may void the sealing created by the PEPDC fluid protection. Also, as the phase screws on the RCCBs are open to air, dust will accumulate on the screws and other parts of the PEPDC. Thus, regular but effective inspection techniques are required to reduce the risk associated with dust build-up.

The Investigation could not confirm when and how RCCB 991JV6 was contaminated with the dried fluid that was found in the cavities of B1 and C1 phases.

2.5 RCCB 997MC1

Prior to the engine runs, troubleshooting of the CB MONITOR SYSTEM FAULT message was performed by removing all electrical power from the Aircraft. This message was cleared upon application of electrical power but an RCCB 991MC1 TRIP message appeared on the ECAM CB page. Replacement of the RCCB did not resolve the defect as the same message reappeared after 10 minutes. Shortly after this message, the engineer heard a popping sound coming from the main avionics compartment followed by a flash of light and smoke.

As RCCB 997MC1 is located on the left side of the PEPDC and away from the short circuit of RCCB 991JV6, it was believed by the Aircraft manufacturer that the most likely reason for the RCCB tripping was overload in the galley, thus indicating that the replaced RCCB was serviceable.

The Investigation noted that the two trip events of RCCB 997MC1 occurred whilst the Aircraft was under maintenance and galley loads were not in high demand, as no testing or use of galley equipment was taking place. In addition, both RCCB 991JV6 and RCCB 997MC1 are electrically powered from the main Aircraft bus AC1.

RCCB 991MC1 was not investigated because no failure messages were recorded by the Aircraft CMS.

2.6 PEPDC Maintenance Inspections

Prior to this Occurrence, the Aircraft manufacturer identified the issue of the dust build-up and the consequences on the electrical systems and made the recommended communication with operators.

An MPD task requesting inspection of the PEPDC for dust removal was introduced on 1 October 2014, but for the Occurrence Aircraft, this task was not due before 30 December 2014 as the Aircraft had been delivered to the Operator on 30 December 2008. The task introduced with an inspection interval of 72 months included:

- MPD task 247200-00101-01: PEPDC: Visual check of PEPDC to prevent dust accumulation,
- AMM task 247200-200-801-A: Visual Check of PEPDC to prevent dust accumulation.

In May 2014, six months before this Incident, Airbus published a service information letter (*SIL*) 24-088 advising A380 operators about the findings related to dust accumulation.

The *SIL* mentions that:



“On the A330/A340 operators have reported multiple “ELEC TR FAULT” warnings on several aircraft. After investigation it has been demonstrated that the issue is partly related to temperature rise. Temperature rise which is directly linked to dust contamination of the grid and ventilation ducts of the TRU (refer to *SIL 24-088*). A similar design is used on the A380. Additionally, the presence of dust accumulation on some areas (e.g. EEPDC, PEPDC upper grid) has been noticed during A380 health checks performed by Airbus on several aircraft.”

The *SIL* does not mention other types of contaminants that may affect the integrity of the PEPDC and components.

It was not confirmed whether or not the Operator generated an inspection task based on the *SIL* and if any inspection was performed.

The Investigation believes that avoiding reoccurrence of similar incidents and in-service defects requires good involvement and feedback from operators to the Aircraft manufacturer so as to ensure that potential risks are identified, addressed, and timely solutions are implemented.



3. Conclusions

3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this Safety Occurrence. These shall not be read as apportioning blame or liability to any particular organization 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 Safety Occurrence. The findings are significant steps in this Safety Occurrence sequence but they are not always causal or indicate deficiencies.
- **Causes-** are actions, omissions, events, conditions, or a combination thereof, which led to this Safety Occurrence.
- **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 accident or 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 Findings relevant to the Aircraft

- (a) The Aircraft was certified, equipped, and maintained in accordance with the existing requirements of the *Civil Aviation Regulations* of United Arab Emirates.
- (b) The Engineer who was in the cockpit at the time of the Occurrence was appropriately qualified on the A380 Aircraft.
- (c) At the time of the Occurrence, the Aircraft had accumulated 25,290 flight hours during the six years of operation.
- (d) The Aircraft was undergoing a scheduled minor maintenance check planned for 2 days.
- (e) Prior to engine runs the maintenance engineer noticed an ECAM message, which stated "CB MONITOR SYSTEM FAULT".
- (f) RCCB 997MC1 TRIP message observed on ECAM CB page (RCCB 997MC1 controls electrical power to the first class galley).
- (g) During the engine ground runs, the message RCCB 997MC1 TRIP remained on.
- (h) RCCB 997MC1 was replaced after the engine run.
- (i) After 10 minutes, with the Aircraft still powered electrically by the APU, the RCCB 997MC1, TRIP message reappeared on CB page.
- (j) Ground electrical power was connected and available at EP1 but was not used.
- (k) A noise followed by light and smoke emitted from the avionics compartment.
- (l) Inspection of the PEPDC front side found RCCB 991JV6 burnt, together with the back plate.



- (m) On the aft face of the PEPDC, the busbar 100PP and the current transformers located on the aft side of the back plate of RCCB 991JV6 were also found burnt.
- (n) The support structure surrounding the burnt RCCB 991JV6 was damaged by the heat generated by the short circuit.
- (o) Post Occurrence analysis of GGPCU1 recorded information showed that the GGPCU1 had isolated the RCCB 991JV6 by disconnecting the External Power 1, before the ground engineer manually cut off the Aircraft power.
- (p) The first short circuit was due to a mix of fluid and dust that heated, and an electrical arc was created between phases B1 & C1 of RCCB 991JV6.
- (q) A second short circuit was caused when the 115VAC phase B of RCCB 991JV6 dropped, after it had burnt, and then contacted the 28VDC busbar 100PP also causing this to burn.
- (r) The PEPDC fluid protection of the Aircraft was found in a deteriorated condition There was foam debonded and missing at some locations and, in particular, at the junction
- (s) Fluid traces were found in areas below the umbrella including stains on the PEPDC.
- (t) RCCB 991JV6 enables electrical power to the Aircraft hydraulic system green electrical pump 1 (ELEC PMP1) when the aircraft is on the ground and the electrical power supply is in the ground servicing configuration.
- (u) For RCCB 991JV6 to be actuated on ground, embodiment of *Service Bulletin No.: A380-29-8011* is required.
- (v) As *SB No.: A380-29-8011* was not embodied on the Aircraft, RCCB 991JV6 was electrically open at the time of the Occurrence.
- (w) Maintenance records indicated that there were no reported occurrences of fluid leakage at any time during the six years the Aircraft service life.
- (x) Inspection of the PEPDC as per the MPD task MPD 247200-00101-01, introduced on 1 October 2014, was not due until 30 December 2014.

3.2.2 Findings relevant to the Operator

- (a) MSN 11; September 2008, had a short circuit within the PEPDC during landing that was caused by a foreign object probably introduced prior to aircraft delivery to the Operator.
- (b) From 2010 to October 2015, the Operator has had 11 electrical aircraft system related defects relating to smoke generation with two resulting in an aircraft diversion.
- (c) Five reports were significant, which includes this Occurrence. Of the five significant reports, four occurred within the past 11 months, December 2014 to October 2015.



3.2.3 Findings relevant to the Aircraft Manufacturer

- (a) The A380 aircraft has two types of PEPDC fluid protection, design 1 and design 2. The Aircraft was fitted with design 1.
- (b) No foreign object debris was noted during the analysis of the material removed from the Aircraft burnt parts.
- (c) Analysis of the dried fluid found in the cavities of RCCB 991JV6 indicates that it most probably came from the toilets or the aircraft sink circuit.
- (d) The reason for RCCB 997MC1 to trip was not investigated as it was considered unrelated to the short circuit of RCCB 991JV6.
- (e) A post Incident review of the A380 MPD indicated that MPD task 247200-00101-01 "VISUAL CHECK OF PEPDC TO PREVENT DUST ACCUMULATION" had been introduced on 1 October 2014.
- (f) In May 2014, six months before this Incident, Airbus published a *service information letter (SIL) 24-088*, advising A380 operators about the findings related to dust accumulation.
- (g) RCCB 991JV6 and RCCB 997MC1 were original parts fitted prior to Aircraft delivery.
- (h) The six screws of RCCB 991JV6, A1/B1/C1/A2/B2/C2, are exposed. A1/B1/C1 screws are located on the underside of the RCCB.
- (i) The PEPDC ventilation blows air directly onto RCCB 991JV6 as the cut-out for the airflow is located next to the RCCB.
- (j) *Service Bulletin (SB) No.: A380-29-8011* was first issued in August 2012.

3.3 Causes

The Air Accident Investigation Sector determines that the smoke and melting of the remote control circuit breaker was due to a short circuit of RCCB 991JV6 caused by an unheeded significant buildup of dust and fluid conductor mixture between phases B1 and C1 of RCCB 991JV6.

3.4 Contributing Factors to the Incident

- (a) Toilet and waste system spillage from the forward cabin above the PEPDC.
- (b) Deterioration of the PEPDC umbrella fluid protection allowing fluid to contaminate the PEPDC.
- (c) Exposed phase screws of RCCB 991JV6 that allowed dust and fluid to collect.
- (d) *Service information letter (SIL) 24-088* had not been implemented by the Operator.



4. Safety Recommendations

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*⁸, and are based on the conclusions listed in heading 3 of this Report; the GCAA expects that all safety issues identified by the Investigation are addressed by the receiving States and organizations.

4.2 Safety Actions taken

4.2.1 Actions taken by Airbus

Implementation of the following maintenance task:

1. MPD task 247200-00101-01 issued 1 October 2014: PEPDC: Visual check of PEPDC to prevent dust accumulation,
2. AMM task 247200-200-801-A: Visual Check of PEPDC to prevent dust accumulation.
3. Airbus plans to issue in January 2016, an Inspection Service Bulletin (ISB ref. 92-8092) that will request an inspection of all PEPDC fitted with Fluid Protection Design 1 in order to detect any internal traces of fluid and any compromised sealing of the Fluid Protection. The ISB will also provide recommendations for repair in case of findings.

4.2.2 Actions taken by Emirates

Implementation of the following:

1. Following the discovery of liquid contaminants beneath the area protected by the PEPDC umbrella, Emirates conducted a one-off inspection (SEWC380-24-0027 refers) of the 57 aircraft in its fleet at the time of the event. The first aircraft was inspected on 24-12-2014 and the last was inspected on 18-05-2015. This was then translated into ARN-04723 (see point '2' below).
2. Airbus introduced MPD task (247200-00101-01) with a repeat interval of 72 months (6 years). Emirates introduced an internal amendment (ARN-04723 refers) to this time interval, reducing it to 24 months (2 years).

⁸ Paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation* states: 'At any stage of the investigation of an accident or incident, the accident or incident investigation authority of the State conducting the investigation shall recommend in a dated transmittal correspondence to the appropriate authorities, including those in other States, any preventive action that it considers necessary to be taken promptly to enhance aviation safety'.



4.3 Safety Recommendations addressed to Airbus

SR02/2016

Enhance maintenance programmes with new effective inspection technology, including graphics, instead of relying on visual inspection alone when inspecting for dust and other contamination.

SR03/2016

Review and improve the method of PEPDC ventilation to reduce the risk of dust particles contaminating the electrical components.

SR04/2016

Review the method of RCCB installation and protection so that the 115VAC phase screws and studs are not affected by the effects of dust accumulation and any other contaminants.

SR05/2016

Improve on the PEPDC fluid protection design, sealing confirmation after installation and the inclusion of warning placards to minimize the associated risk due to in-service maintenance interference.

SR06/2016

The use of predictive technology should be expanded to include monitoring, prediction and intervention for components that can cause smoke events.

4.4 Safety Recommendations addressed to Emirates

SR07/2016

Re-emphasize to aircraft maintenance personnel the importance of returning the aircraft to its original condition after maintenance work is performed.

SR08/2016

Training, and publication of effective reminders to aircraft maintenance personnel, about the negative effects of dust and other contaminants buildup as a fuel source.

SR09/2016

Review and implementation of the Aircraft manufactures maintenance planning document interval of inspection of electrical circuits that may be affected by dust accumulation, taking into consideration the effects of environmental conditions of operation.

4.5 Safety Recommendations addressed to the General Civil Aviation Authority of the United Arab Emirates

SR10/2016

To disseminate this report to other UAE operators so that they are aware of this Occurrence and the potential associated hazard.

This Report is issued by:

**The Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates.**