Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

Aircraft Circuit Breaker Maintenance & Operation

AWB 24-011 **Issue :** 1
Date : 27 April 2016

1. Effectivity

Any aircraft fitted with circuit breakers (CB).

2. Purpose

This AWB highlights known issues associated with CBs. There are recommendations for maintenance, installation and operation of CBs.

3. Background

CBs are classified as circuit protective devices and are requirements of airworthiness standards under FAR parts 23, 25, 27 and 29.

A CB that fails to trip does not meet the airworthiness standard which requires, *if an overload or circuit fault exists the device will open the circuit regardless of the position of the operating control*. Faulty CBs are considered one of the key sources of electrical arcing. As aircraft continue to age, the likelihood of an arcing event will increase.

There are two principle methods of operation for a CB:

1. Electromagnetic
2. Thermal (commonly found in aircraft)

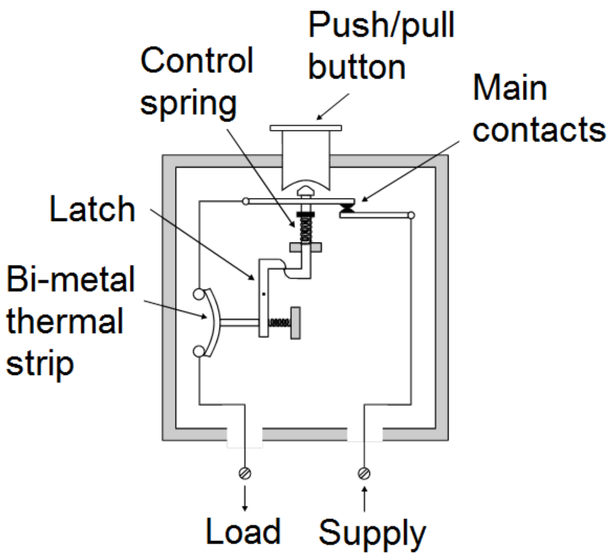

Figure 1 - Thermal CB mechanism

Thermal CBs are composed of a thermal actuator and mechanical latch. The actuator is made of a bimetal strip that carries the current and responds to heat. Because the two metals have different rates of expansion, heat causes the bimetal to flex until it triggers a spring-loaded latching mechanism. The design can distinguish between safe in-rush and temporary current surges and harmful sustained overloads. A typical thermal circuit breaker will trip within one hour at 140 percent of its rating. The mechanism is prone to different failures such as corrosion of metallic elements, spring failure and other discontinuities.

There are essentially 3 ways a CB can fail:

- Does not open – resulting in a closed circuit without protection
- Fails to close – no power to corresponding system
- Fail indeterminate - (various factors including manufacture faults, opens without command, intermittent operation, vibration, arcing/sparking, contact deterioration, voltage drops etc).

i. High resistance/Corrosion of contacts

High hour CBs have been found with pitted contacts which can cause high resistance or open circuits. Pitting can occur due to electrical arcing and worn or deformed contacts.

Corroded contacts have been known to cause high resistance connections (see Figure 2). This CB was used to power AC invertor in a Piper 31-350 aircraft. The high resistance resulted in strong burning electrical smell and smoke in the flight compartment. This causes low voltage delivery to the equipment and heating at high resistance connections which can result in a fire in high ampere loads. The output voltage had reduced from approximately 27VDC to 6VDC as a result of the corrosion. In extreme cases the contacts have been known to weld together preventing the CB from tripping.

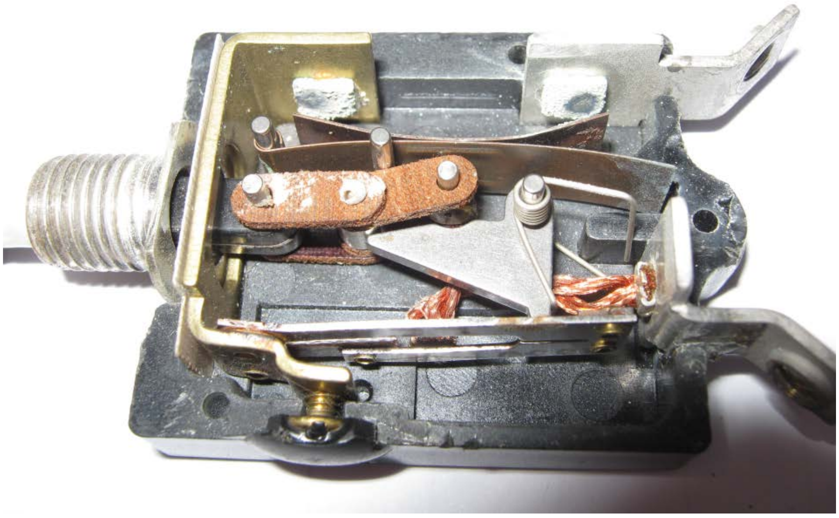

Figure 2 - Corroded contacts

A Socata TB10 Tobago used for flight training, had a failure with CB part number ZOO.N7173141105, that was used in the Taxi light circuit had an internal short circuit see (Figure 3). Pilot reported smoke in cabin and electrical burning smell. High hours were suspected as the contributing factor. These CBs are push-reset and they cannot perform a deliberate circuit isolation function.

Figure 3 - Internal short

ii. Design issues

In the case below in Figure 4, three-phase CB part number 6TC25, fitted in a BAe 146-100 that supplied power to windshield heat circuits, had failed causing damage to wiring and terminals. Investigation into the cause of overheating has identified a possible age related deterioration of the units. This problem was the subject of CASA AD/BAe 146/124.

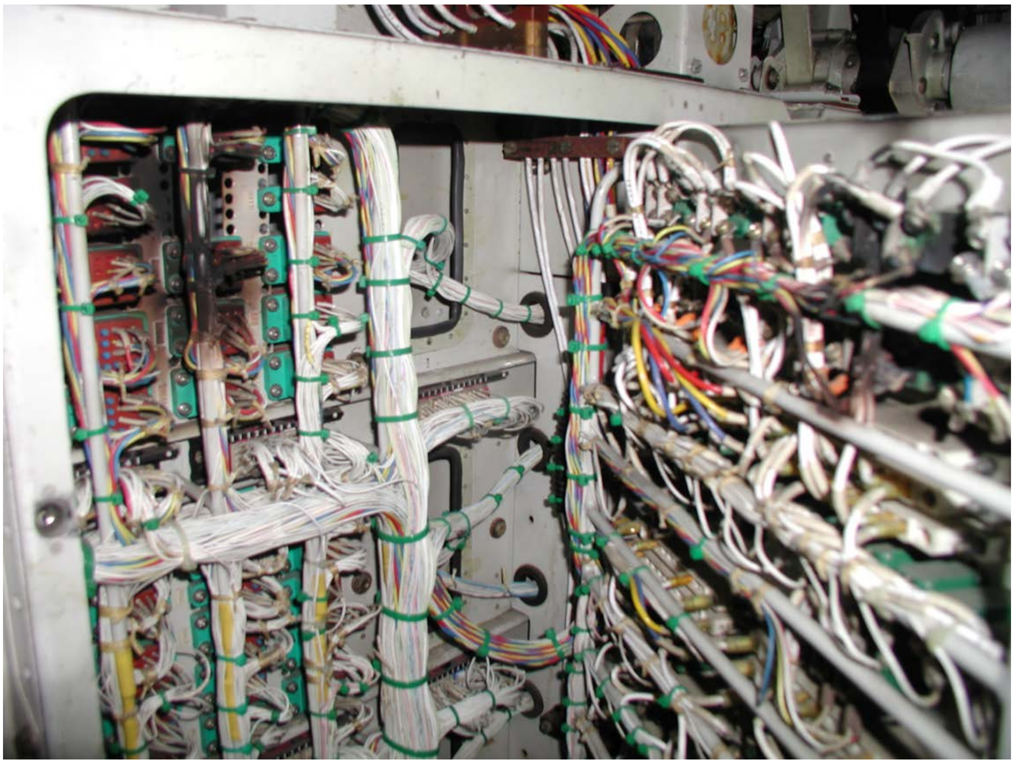

Figure 4 – Burnt wiring and 3 phase CB for windshield heat

In the CB shown in Figure 5, the problem was caused by the position of the CB on the panel fitted to a Bombardier DHC-8402. This CB for the propeller auxiliary feather power is located on the most forward position on the panel. The damage occurred when the associated panel was opened for maintenance, the CB caught on the structure. This could have been a major problem as there was no way to tell there was a problem if the need to use the Aux Feather controls in flight was required. CBs that are improperly placed are prone to damage.

Figure 5 – Propeller Auxiliary feather CB damaged by placement on panel

In a different issue the CB part number W31X100050 fitted in a Cessna 441, had failed internally possibly to corrosion. The CB was located on a CB panel just below the flight compartment sliding window.

iii. Manufacture issues

An SDR reported CB part number W31X2MIG10 had internally failed. The operator has advised the manufacturer who apparently agreed that there were some quality control issues with a batch of Circuit Breakers used during manufacture of GA8 aircraft. The issue has been resolved however some CBs may still exist in stores or in service.

iv. Maintenance issues

In the difficulty reported in Figure 6, the CB part number 452K14LN2, the power wire had not been correctly crimped. This CB was fitted to emergency medical equipment in a Pilatus PC12. This could cause intermittent arcing or sparking of wiring with associated fires and possible loss of patient life in service. For further information on crimping see the current applicable maintenance data on standard wiring repairs or in the absence of this information see Chapter 6 of AC 21.99.

Figure 6 - Improperly crimped CB fitted to emergency medical equipment

In an extreme case that was reported, a broken CB part number BACC18A05 had been repaired at a line station using superglue. The glue had filled the base of the CB and prevented any tripping. This repair is not allowed according to the applicable maintenance data.

Other maintenance related issues have been:

- Misalignment of the CB – causing binding or failure to engage
- Incorrect values installed contrary to approved design
- Over/under torqueing of terminals on CBs

Circuit breaker resetting procedures – EX AWB 00-007 Issue 1

There are risks associated with inappropriate resetting of tripped CB's see Figure 7. CASA recommends exercising caution in resetting tripped CB's and adhering to general safety practices.

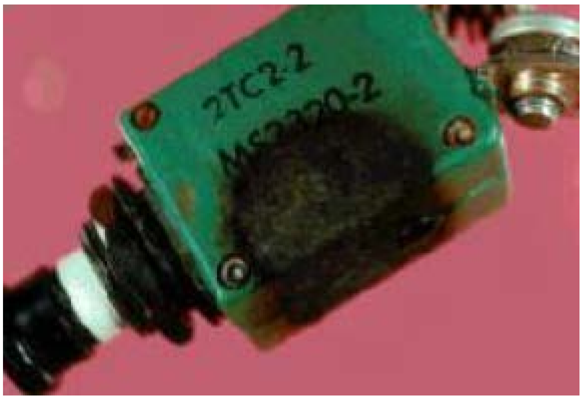

Figure 7 - Heat damaged CB

Resetting a tripped CB is often thought to have no adverse results. However, a review of Service Difficulty Reports involving tripped and reset CB's reveals that the opposite is sometimes true. Smoke, burned wires, electrical odours, arcing, and loss of related aircraft systems have been reported as a result of resetting tripped CB's. These findings are supported by other National Airworthiness Authorities.

Aircraft manufacturers normally provide guidance in their flight crew operating manuals (FCOM), maintenance manuals, and aircraft servicing manuals. Data from the OEM will enable flight crews and maintenance personnel to perform their tasks with a high degree of safety.

Operators should develop training programs and procedures for use by all involved personnel with regarding policy on resetting tripped CB's. There is a latent danger in resetting a CB tripped by an unknown cause because the fault usually still exists. Generally equipment is remotely located from the flight compartment making confident determination of fault difficult. Flight crews or aircraft ground servicing personnel usually have no way of knowing the consequences of resetting a tripped CB and this requires a maintenance action.

Do not reset a tripped CB in flight unless allowed in the approved operating manual used by the flight crew. A pilot in command can reset a CB if they believe that a catastrophic event could occur if it is not reset.

An entry in the aircraft Maintenance Release/Maintenance Tech Log with details of the defect and troubleshooting is a proven safety practice for tracking purposes. A detailed entry provides maintenance personnel with trouble-shooting information and effective corrective action on the ground.

The defect write-up and corrective action should include the following:

- the conditions existing when the CB trip occurred
- the conditions existing when the CB was reset
- the results of resetting the CB

It is ok to reset a tripped CB on the ground after maintenance has determined the cause of the trip and has a LAME has determined any possible safety issues. Cycling CBs under power (tripped or reset) a trouble-shooting procedure is not recommended, unless stated in the maintenance data.

If an operator’s minimum equipment list (MEL) contains procedures that allow a tripped CB to be reset, then the same cautions with reference to resetting tripped CB's identified elsewhere in this AWB also apply.

Special cautions are appropriate where fuel pump circuits and/or FQIS are involved, because of the possibility that arcing might lead to ignition of fuel or fuel vapours. Applicable maintenance data may have Critical Design Configuration Control Limitations in conjunction with CBs used in fuel systems.

CASA has issued airworthiness directives (AD) and manufacturers have issued Service Bulletins affecting certain aircraft makes and models that:

- prohibit the resetting of fuel boost pump CB's in-flight;
- prohibit resetting a fuel boost pump CB while the aircraft is on the ground, without first identifying the source of the electrical fault; and
- because of similar arcing potential, resetting FQIS CB's should be likewise restricted.

Mechanical products 3 phase circuit breaker – incorrect marking – EX AWB 24-3 Issue 1

Hydraulic pump motor CBs were found with incorrect phase labelling. If not picked up in time, motors on hydraulic pumps would cause the pump to run in the opposite direction, fans in Transformer Rectifier Units would direct air in the wrong direction against incoming ram therefore air reducing air flow and causing overheating and premature failure.

4330 series CBs manufactured by Mechanical Products Inc. were previously found with manufacturing defects caused during labelling of the terminals (see Figure 8). Investigation by the supplier of this item revealed a number of similar anomalies over a range of these products. These issues have not been an issue recently; however stocks may exist that have not been removed from potentially entering service.

The faulty CB's were found included as part of service bulletin kit supplied by Bombardier. Bombardier produced notification to inspect the circuit breakers prior to use and to inspect those in service.

The faulty C/B had the phasing identifications interposed on the line and load sides of the C/B see Figure 88.

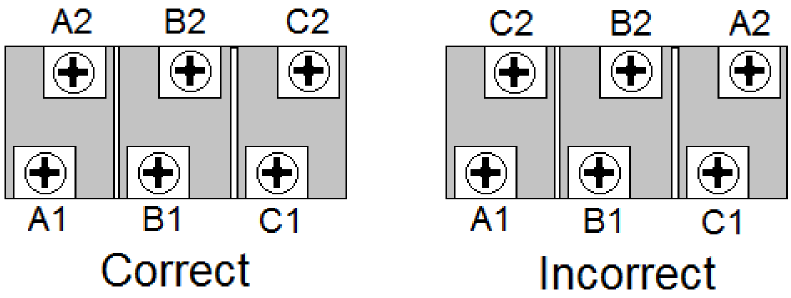

Figure 8 - Faulty circuit breaker phase identification

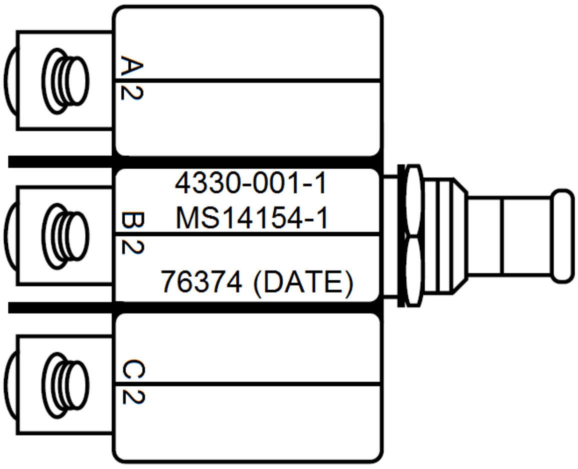

Figure 9 - Product and date code identification

On the side of the breaker stamped with the part number you will find the date code see Figure 9, it is printed immediately after the "U.S. Government Cage Code" 76374.

The first two digits are the year of manufacture; the second two digits are the week of manufacturer. So "0046" indicates the breaker was manufactured in the year 2000, in week forty-six. The faulty products of which Mechanical Products is aware of are limited to week 46.

4. Recommendations

It is mandatory to follow instructions that are detailed in the applicable maintenance data for conducting any repairs.

Exercising (cycling) of circuit breakers under no load will assist to remove any possible internal surface corrosion and is therefore strongly recommended as part of the aircraft's scheduled maintenance either:

- As required by the applicable OEM maintenance data or
- when carrying out inspection of circuit breakers under Schedule 5 of CAR (if applicable).

Push-reset CBs cannot cycle due to their design see Figure 10; therefore it is difficult to test these CBs in-situ and replacement is considered appropriate after a period of time in service.

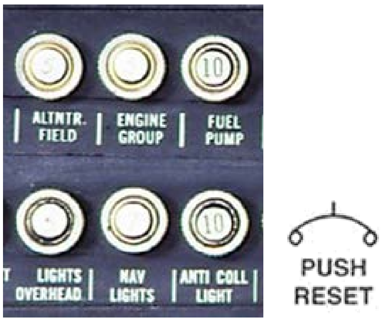

Figure 10 - Push-reset CB

It is not recommended to use CBs as a switch with systems under load. CBs are not snap-acting devices they can remain in a partially actuated position causing arcs. The use of a CB as a switch will cause premature wear on the latching mechanism.

In the absence of hard replacement times from the OEM it is recommended to replace the CBs. FAA has put out Special Airworthiness Information Bulletin CE-13-22 which recommends discarding CBs every 2000 hours.

CASA recommends that all aircraft Registered Operators and Maintenance Organisations, quarantine all affected stock as per Figure 8 and Figure 9 of this AWB.

Do not reset a circuit breaker unless the nature of the fault is positively confirmed and no further risks will occur. CASA recommends following OEM procedures for resetting CBs. In the absence of this information, the guidance in this AWB can assist in the development of procedures and/or approved manuals.

5. Reporting

CASA encourages reporting any service difficulties with CBs via the CASA SDR system.

6. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link e-mail address:

AirworthinessBulletin@casa.gov.au

or in writing, to:

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