

# Installation and Operational Use of Circuit Breakers

## Background

Ever since Boeing certified the first two-crew Flight Deck configuration, the use of electrical circuit breakers (C/Bs) in published procedures has been strongly discouraged by Boeing flight operations policy and certified systems design. With two notable exceptions on the 737, the procedural pulling or cycling of C/Bs (1) by the flight crew, either on the ground or in flight, is not allowed has been an interesting and debated subject for over two decades.

## Discussion

Flight crews are allowed one reset of C/Bs located on the Flight Deck (2). Only one reset is allowed because it is assumed that a tripped C/B indicates an authentic problem with the wiring. A standard note in the non-normal checklist section of the Operations Manual reads as follows:

***"Resetting circuit breakers is not generally a requirement in flight. However, a tripped circuit breaker may be reset at the Captain's discretion, after a short cooling period (approximately 2 minutes). If it trips again, no further attempt is to be made to reset that circuit breaker."***

Airplane-level criteria for locating C/Bs in the Flight Deck are as follows:

- (1) Minimum equipment required for controlled flight (3), navigation, detection & warning, PAX safety, and landing.
- (2) Essential equipment for which no other Flight Deck indication exists to show preflight dispatch indication of an open protective device.
- (3) Equipment, which is powered in flight, is a potential OVHT/SMOKE source, and is located in an occupied area with no other means of removal of power than by the flight or cabin crew. Equipment having thermal protection is not considered an OVHT/SMOKE source.
- (4) Equipment that requires power to be removed as part of routine maintenance requirements.

From an electrical systems design standpoint, C/Bs are sized to prevent the occurrence of airplane wiring insulation breakdown (which in turn prevents fires). Whether a C/B is located on the Flight Deck is integral to any thorough systems design consideration. These primary systems design considerations include the following:

- (1) Nuisance C/B trips (nuisance trips are rare on modern airplanes, however),
- (2) Ability to de-energize systems if an electrical smoke or fire exists,
- (3) The need to easily check proper preflight configuration to verify that essential equipment is not inoperative because of a pulled or tripped C/B,
- (4) Cost and weight savings due to reduced wire routing,
- (5) Wire separation requirements (Left/Right systems installation, etc),

(6) Maintainability and functional test requirements, and

The long-standing Flight Operations policy states that "C/Bs are not to be used in published Flight Crew procedures." Although this policy has been especially adhered to since the advent of the 757 and 767 models, there are exceptions to this policy in 737 procedures. Namely, the GEAR LEVER WILL NOT MOVE UP AFTER TAKEOFF procedure requires pulling the Landing Gear Air/Gnd Relay and Lights C/B on the P6-3 circuit breaker panel. Another 737 procedure involving a C/B is the DITCHING procedure which requires pulling the Aural Warning C/B, also on the P6-3 panel (the 737 P6 panel is directly aft of the First Officer's seat, while the P-18 C/B panel is aft of the Captain's seat).

**Why such a strict policy against the Flight Crew's use of C/Bs?**

The documented reasons behind this operational policy follow:

(1) The use of C/Bs in procedures is contrary to the two-crew certification basis. C/Bs are not installed in locations easily accessible or viewable from the pilots' seated positions nor are the locations of specific C/Bs readily apparent.

(2) Indiscriminate pulling of C/Bs can render unintended systems inoperative in addition to resetting or de-energizing the system in question. It can also result in additional and unanticipated EICAS messages, which could present a more confusing situation to the flight crew.

(3). Habitual resetting or cycling of C/Bs can mask system anomalies or failures and hinder engineering system design fixes. Flight Crews can become accustomed to the use of C/Bs and be less likely to record anomalies in the airplane's maintenance log.

(4) C/Bs are not designed to be used as switches to operate a system and extensive use can degrade reliability.

Some airlines have required unique, color-coded C/B collars in selected locations to assist with routine maintenance procedures. Boeing, however, does not normally provide C/B location information in Operations Manuals. The following are some of the reasons an airline may be more prone to have the flight crew use C/Bs.

(1) When no operationally acceptable alternative exists, the cycling of C/Bs has prevented or remedied anomalous system conditions in flight, especially for airplane models new to revenue service

(2) Cycling of C/Bs on the ground has cleared EICAS status messages, enabling on-time dispatch.

(3) Airlines want the ability to reset C/Bs to avoid expensive and unnecessary air turnbacks or diversions.

(4) Some airlines require optional color-coding for selected C/B collars to assist in routine maintenance procedures.

Boeing responds to a myriad of airline in-service problems and queries, which in some way involve the use of C/Bs. In very few cases Boeing has referred indirectly to C/Bs in airline responses. For example, the technical system response to cycling a particular C/B is described in the answer to the airline query, but a No Technical Objection is not given or implied for its use in procedures. The "C/B cycling is not part of crew procedures" statement

is given along with a technical description of what happens when the C/B is cycled in order that the airline is aware of all the ramifications of their actions.

## PHYSICAL INSTALLATION ASPECTS

Flight Deck circuit breaker panel installations vary across Boeing airplane models. Most C/B panels consist of a main power distribution panel called the P6, which is located aft of the First Officer's seat (directly aft on the 737 and further aft, outboard, and lower on the 747/757/767; the 777 does not have a P6 panel in the Flight Deck). The 747, 757, 767, and 777 have an overhead C/B panel directly aft of the P5 overhead control panel. The 737 is unique in that the P18 C/B panel is directly aft and overhead of the Captain's seat.

Circuit breaker panel arrangements vary due to differing systems design. However, the standby and battery system C/Bs on the 757, 767, and 777 P11 overhead C/B panels are located in the most forward three or four rows. This was done in order to preclude the pilots from leaving their seats in the event the standby system C/Bs had to be reached (747-400 P7 panel arrangement comments to be added later).

Model	P6	P6 (Aux.)	P7	P11	P12	P18	P1 26	Total
	737NG	315	-----	-----	-----	-----	170	
747-100	409	20	204	-----	182	-----	30	845
747-400	304	-----	156	-----	-----	-----	-----	460
757	103	-----	-----	390	-----	-----	-----	493
767	125	-----	-----	450	-----	-----	-----	575
777	-----	-----	-----	130	-----	-----	-----	130

All are approximate #s of C/Bs as each airplane and airline's configuration are different

As shown, the number of circuit breakers located in the Flight Deck has decreased dramatically since the 747-100. Evolved systems design philosophy has de-cluttered the Flight Deck by eliminating many unnecessary C/Bs. This decrease is also the result of the elimination of the Flight Engineer coupled with the 2-crew design philosophy and a general redefinition of space allocations within the Flight Deck. (e.g.: the Maintenance Access Terminal on the 777 in place of the traditional P6 C/B panel).

- (1)The following definitions are provided:

**"Pulling C/Bs":** Refers to removing power from a function by pulling a CIB out. **"Resetting C/Bs":** Refers to the re-application of system power after a C/B trip by pushing a UB in.

**"Cycling C/Bs":** Refers to repeated resets of a function by first pulling,, then pushing its W back in.

- (2) A temporary exception applies to 747 center wince, or horizontal tail tank fuel pump C/Bs (reference AD' 98-2552, 4Q98), which does not allow resets of C/Bs until required fuel pump inspections are performed.
- (3) An exception is on the 777, which does not have any flight control C/Bs installed in the Flight Deck.