



FEDERATION OF INDIAN PILOTS

FIP/MOCA/26-03

01 May 2026

**Minister of Civil Aviation,
Ministry of Civil Aviation,
MOCA, Rajiv Gandhi Bhawan,
Sri Aurobindo Marg,
New Delhi-110003**

**TECHNICAL NOTE IN COMPLIANCE OF ANNEX 13 I.R.O AIR INDIA
171 ACCIDENT OF 12TH JUNE 2025, PROPOSING OEM/ INCIDENT
INVESTIGATION REPORT EVIDENCE LED ELECTRICAL REVERSE
VOLTAGE PATHWAY DUE TO BATTERY SHORT CIRCUIT AS A
CREDIBLE CAUSE FOR DUAL ENGINE FUEL SWITCHES TRANSITION
TO CUTOFF.**

Respected Sir,

1. Reference is drawn to the subject and annexures. Also, refer to our previous emails dated 12 and 22 Mar 26.
2. **Introduction:** The Federation of Indian Pilots, vide letter dated 12 March 2026, informed the AAIB that Ahmedabad Airport security camera images show that the RAT is deployed during the take-off roll (Refer Annexure 1), suggesting a pre-lift-off technical issue. Manual deployment is unlikely, as the system is automatic with guarded control. Media reports (Annexure 2) continue to suggest pilot action; however, the International Civil Aviation Organisation Annex 13 requires all credible technical causes be ruled out first. This Technical Note suggests a credible cause.
3. **Proposed Mechanism:** Aircraft DC electrical systems require a steady positive supply and ground (return). If disturbed, systems may behave abnormally. As per OEM Hamilton Sundstrand B 787 documentation (Refer Annexure 4, Image 3), the RAT deployment occurs after loss of power to:
 - a) Captain and First Officer's instrument buses
 - b) C1 or C2 TRUs
4. Once the RAT deploys, the Captain and First Officer instrument buses are connected through the Captain Instrument Transfer



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(CIT) and First Officer Instrument Transfer (FIT) contactors, creating a common return path for current, allowing any electrical disturbance to affect both engines (Refer Annexure 4, Image 3).

5. Although system safeguards exist (generator separation, protection devices, and independent channels), a high-current disturbance in the common return path can still affect multiple systems simultaneously as follows:
 - a) Boeing 787 battery failures, investigated by the Japan Transport Safety Board (Takamatsu, 2013; Annexure 3) and the National Transportation Safety Board (Boston, 2013; Annexure 6), documented “electrical arcing between a cell case and the battery case”, “current flow... between 44 and 45 amperes into the battery”, and damage “consistent with resistive heating”, with “the appearance of the cell case and the adherence of the electrodes were consistent with localized heating, melting, separation, and solidification ..from electrical arcing” (Refer highlighted text pp. 11, 13–14, 24, 79 Annexure 6).
 - b) When high current flows through a resistive return path, the voltage of the ground point rises as per Ohm’s Law ($V = I \times R$). If the battery supply to the relay drops due to a short circuit, the voltage across the relay coils may reverse.
 - c) The Boeing 787 fuel system uses dual-coil latching relays. Leach International (a typical aerospace relay manufacturer) states, “Relay will not be damaged by applying reverse voltage to the coil, although the relay may transfer” (Refer Annexure 5, Image 4, para 8). These relays control the fuel shutoff and spar valves (Refer Annexure 4, Image 1).
 - d) With a common return path after RAT deployment, **reversal of voltage across the dual-coil relay energises the cut-off path driving the spar valve closed**, as shown in the Fuel Relay (P300) to Spar Valve section of the diagram, **which can affect both engines, causing near-simultaneous switching from RUN to CUTOFF without pilot input** (Refer Annexure 4, Image 2).
6. **Timeline Consistency:** Fuel cut-off at ~08:08:43 UTC and RAT hydraulic power at ~08:08:47 UTC (Refer Aircraft Accident Investigation Bureau Preliminary Report) show a 4-second gap; as “the RAT deploys and supplies hydraulic power in 6 seconds”, it must have deployed earlier, matching take-off-roll photos (Refer Annexure 1 & 7).
7. **Conclusion:** Based on lithium-ion battery failures, relay behaviour



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under abnormal voltage, and Boeing 787 electrical design, a pre-lift-off electrical disturbance could have caused unintended relay operation and dual engine fuel cut-off without pilot input.

8. **Submission:** It is submitted that this may be treated as a testable hypothesis and examined through detailed electrical analysis by IIT Bombay, Aeronautical Development Agency, or Hindustan Aeronautics Limited. Technical causes cannot be ruled out till this analysis is made. Also, in our last letters and emails we had requested the verification of the timings as given in the preliminary report of AAIB by carrying out a simulator session on B-787.

With warm regards,

(Capt. CS Randhawa)
President FIP

Encls:

Annexure 1– RAT Deployment Evidence: Ground photographic sequence showing RAT deployed during take-off roll.

Annexure 2: India Today report quoting Corriere Della speculative report of 12.2.26 on pilot action.

Annexure 3– Battery Failure Mechanism (Takamatsu): JTSB Takamatsu Report (2013), documenting internal short circuit and grounding path formation.

Annexure 4– Electrical & Fuel Control Architecture: B 787Powerplant, Engine, Fuel & Control, and Engine Controls – Powerplant Book 2 of 3, GEnx Engine, GE Engines – Control (2) General Description 787 Training Lab Notebook (image 1), Boeing 787 Electrical Power Distribution – 235V AC and 28V DC Control of Spar Valve (Fuel Shutoff System schematic (image 2), B 787 Document Section 24-41-00, Page 32 | Revision: 2011 MAR 14 (image 3)

Annexure 5 – Relay Behaviour: Leach KL Series relay datasheet.



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Annexure 6 – Battery Electrical Effects (Boston); NTSB Report No. NTSB/AIR-14/01, Auxiliary Power Unit Battery Fire, Japan Airlines Boeing 787-8, JA829J, Boston, Massachusetts, January 2013
Referenced sections: pp. 11, 13–14, and 79.

Annexure 7 -Part 147 “TECHNIC DREAMLINER – ATA 29 HYDRAULIC POWER” Engineering Training Manual internal page ~174/235

Copy To:

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AI-171 probe not concluded, says AAIB; warns against speculative reporting (Photo: ITG)



Amit Bhardwaj



New Delhi, UPDATED: Feb 12, 2026 21:06 IST

Edited By: [Priyanka Kumari](#)

ANNEX - 2



Summarise This



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The Aircraft Accident Investigation Bureau (AAIB) on Thursday dismissed an Italian media report that claimed the probe into the Air India Flight AI-171 crash had concluded the disaster was the result of an “intentional act”, calling such suggestions “incorrect and speculative”.

Responding to [a report by Italian daily *Corriere della Sera*](#), which cited unnamed sources as saying investigators had ruled out technical failure and were preparing a final report, the aviation accident probe body said the investigation remains underway and no final conclusions have been reached.

SYNOPSIS

Summary of the Serious Incident

On January 16 (Wednesday), 2013, a Boeing 787-8, operated by All Nippon Airways Co., LTD., registered JA804A, took off from Yamaguchi Ube Airport for Tokyo international Airport at 08:11 local time as its scheduled flight 692. When it was climbing through 32,000 ft over Shikoku Island, an EICAS message of battery failure came on at 08:27 accompanied by unusual smell in the cockpit. The airplane diverted to Takamatsu Airport and landed there at 08:47. An emergency evacuation was executed using slides on T4 taxiway at 08:49.

Four passengers out of 137 occupants (the Captain, seven crewmembers and 129 passengers) suffered minor injuries during the evacuation.

Although the main battery was damaged, it did not lead to a fire.

Incidentally, a similar incident had occurred prior to Takamatsu event by nine days in the United States, on January 7, 2013 (Eastern Standard Time) at Logan International Airport, Boston, Massachusetts.

About one year after the serious incident, another similar main battery incident occurred at Narita International Airport on January 14, 2014.

Probable Causes

The emergency evacuation was executed on Takamatsu Airport taxiway in the serious incident, which was a consequence of emergency landing deriving from the main battery thermal runaway during the airplane's takeoff climb.

Internal heat generation in cell 6 very likely developed into venting, making it the initiating cell, resulting in cell-to-cell propagation and subsequent failure of the main battery. It is very likely that cell 6 internal heat generation and increased internal pressure caused it to swell, melt the surrounding insulation material and contact the brace bar creating a grounding path that allowed high currents to flow through the battery box. The currents generated arcing internal to the battery that contributed to cell-to-cell propagation consequently destroying the battery.

Cell 6 heat generation was probably caused by internal short circuit; however, the conclusive mechanism thereof was not identified.

In the serious incident, the internal short circuit of a cell developed into cell heat generation, thermal propagation to other cells, and consequently damaged the whole battery. The possible contributing factors to the thermal propagation are that the test conducted during the developmental phase did not appropriately simulate the on-board configuration, and the effects of internal short circuit were underestimated.

Safety Recommendations

1. Actions to be taken by the Federal Aviation Administration

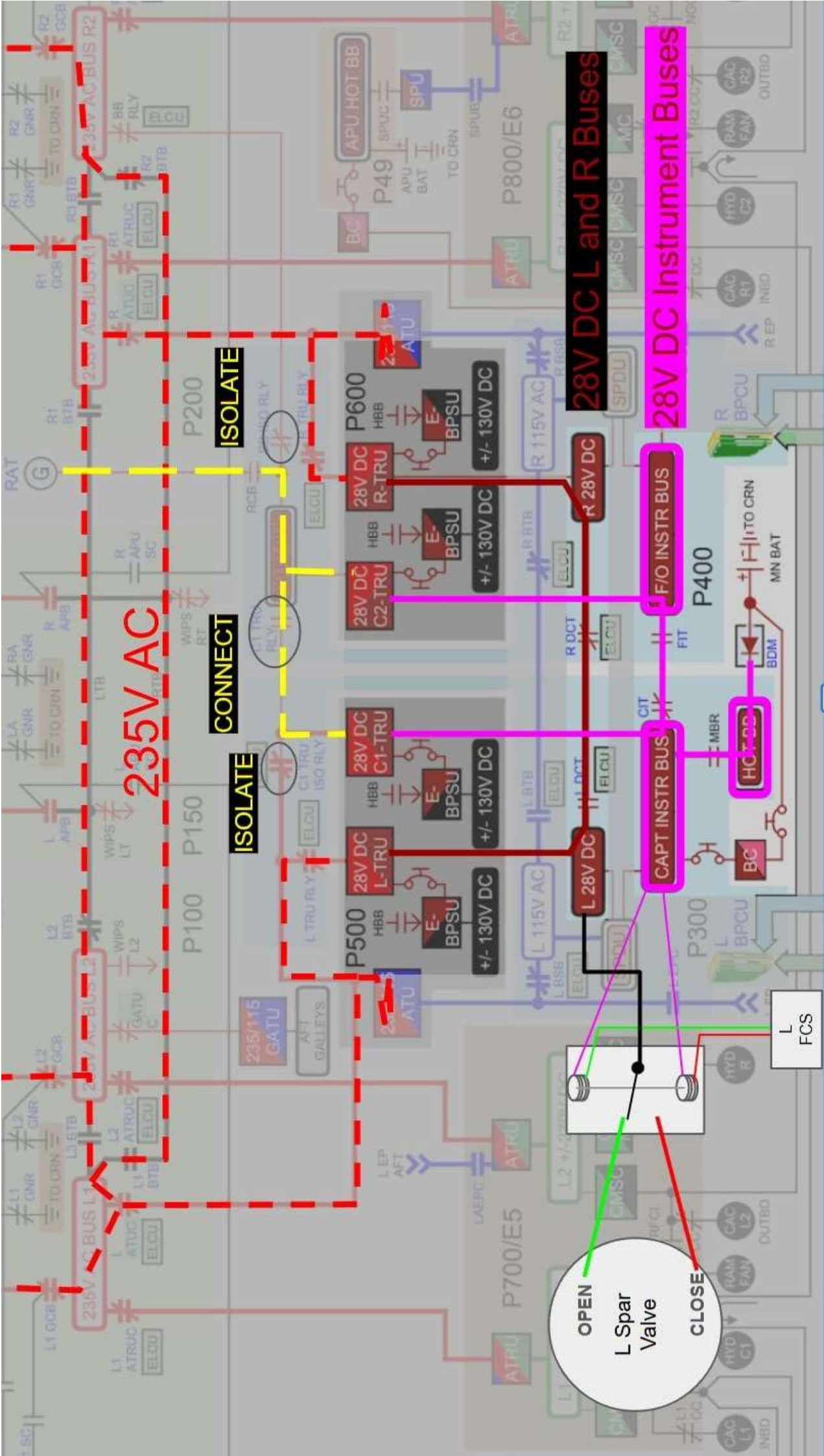
The internal short circuit test by nail penetration method under the simulated on-board configuration with the battery ground wire demonstrated a thermal runaway, while the test without the ground wire did not.

Given the facts and analyses of other tests combined, in the serious incident the

ANNEX - 4



IMAGE 2



235V AC

28V DC L and R Buses

28V DC Instrument Buses

ISOLATE

CONNECT

ISOLATE

OPEN
L Spar Valve
CLOSE

L
FCS

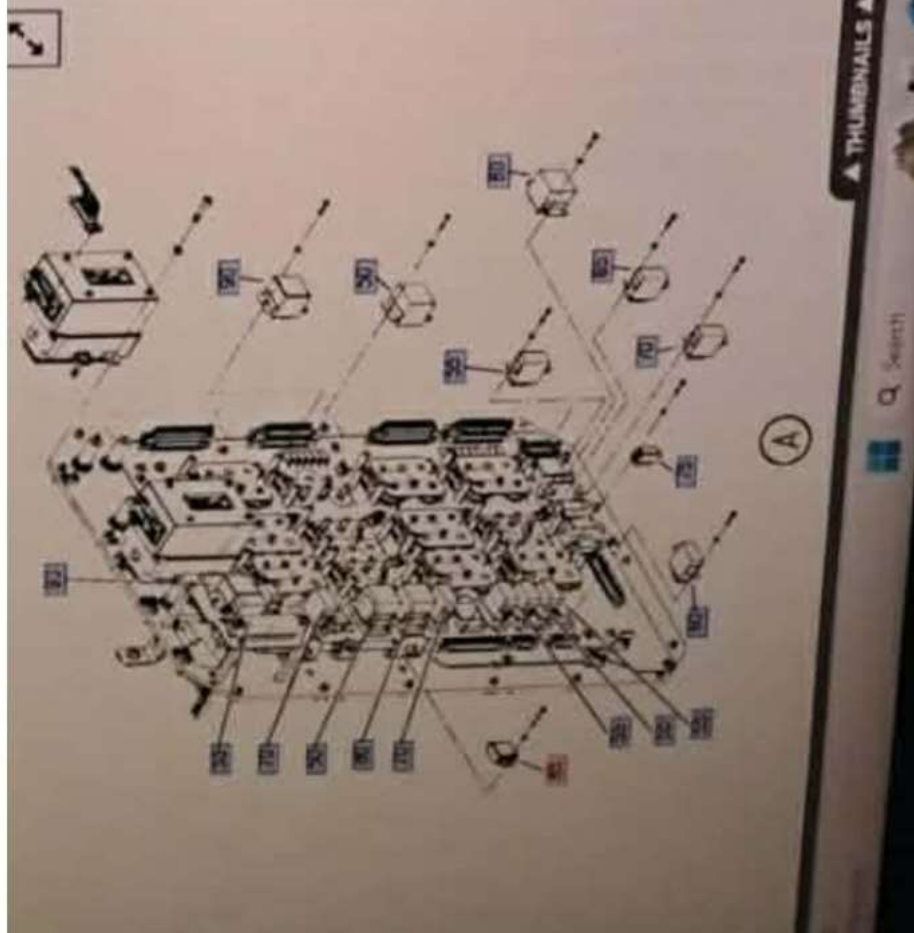


- The BPCU manages the Standby Operating Mode to ensure the Backup Bus (BB) and critical loads are powered.
- Each BPCU independently requests RAT deployment and go into Standby Operating Mode 15 seconds after detecting a continuous loss of source power to the BB and Captain's and First Officer's Instrument buses in any of the following conditions:
 - Continuous loss of 235 VAC Bus L1 and loss of BB
 - L ATUC open and loss of BB
 - C1 TRU Isolation Relay and BB Isolation Relay fail to close
- The RAT deploys automatically in the air when C1 or C2 TRUs lose power, loss of hydraulic power, or loss of all engines.
- The RAT deployment request is communicated through the CDN to the Hydraulics, Controllers which command a RAT deploy within 200 msec of receiving the request from either BPCU.
- The RAT deployment request is inhibited when not in Air mode.
- Standby Operating Mode is also entered when the RAT Circuit Breaker (RCB) is closed and no AC buses are powered.
- Standby Operating Mode is reset if any AC bus is powered from another source or the airplane is on the ground and Main Battery Switch is Off.
- In Standby Operating Mode, with primary electrical power unavailable and regardless of RAT availability, the MBR is closed and the instrument buses paralleled through closure of the CIT and FIT contactors, even if a main battery fault or main battery discharge inhibits exist.
- Other protections (e.g., overcurrent) or control functions (e.g., Electrical System Indication Control (ESIC) lockouts) are not affected or prevented by Standby Operating Mode.
- Transitions between standby and battery only mode do not cause a power interrupt to the battery only mode loads.
- If the RAT is deployed for checkout purposes, the system prevents the RAT generator from supplying the BB while 235 VAC Bus R2 is available.
- The RCB control is electrically interlocked with the BB Iso Rly, preventing the RCB from closing if the BPCU has not opened the BB Iso Rly.
- If the RAT is powering the C1 TRU/C2 TRU and a VFSG or ASG are commanded on during Standby Operating Mode, the Captains Instrument Bus and the F/O Instrument Bus continue to be powered from the RAT.
 - This configuration is terminated when the RAT Generator drops offline.

24-41-00

RELAY	REFERENCE DESIGNATOR	RATING	VOLTAGE	TYPE	
RLY ENG TR DCV L	K7834811	5A	28VDC	2PDT	HELD
RLY EEC ALT PWR L	K7321101	2.5A	28VDC	2PDT	HELD
RLY ENG IGN L1	K7411811	15A	28VDC	2PDT	HELD
RLY ENG IGN L2	K7411812	15A	28VDC	2PDT	HELD
RELAY FRIT SPAR VLV START SWITCH/AIR GND LEFT	K7621801	15A	28VDC	2PDT	HELD
ALTN EXT RELAY B	K3235020	50A	28VDC	1PDT + 1PST NO	HELD
ALTN EXT RELAY A	K3235010	50A	28VDC	1PDT + 1PST NO	HELD
PITOT PROBE HTR L	K3031310	15A	115VAC	2PDT	HELD
WDO HT 1R BU	K3041402	25A	115VAC	3PDT	HELD
WDO HT 2R	K3041404	25A	115VAC	3PDT	HELD
APU REMOTE WARNING	K2615401	15A	28VDC	2PDT	HELD
APU EXT SHUTDOWN RELAY MASTER	K2615404	15A	28VDC	4PDT	HELD
APU EXT SHUTDOWN RELAY SLAVE	K2615405	15A	28VDC	2PDT	HELD
APU FIRE EXT BTL AUTO DISCHARGE	K2622403	10A	28VDC	2PDT	HELD T/D 10s
GROUND CREW CALL HORN TRANSFER RELAY	K4443001	2A	28VDC	2PDT	HELD T/D 10s
GROUND CREW CALL HORN PWR SUPPLY	K4443002	2A	28VDC	2PDT	HELD
RELAY ENG FUEL CONT #2 LEFT	K7621102	2A	28VDC	4PDT	LATCH
RELAY ENG FUEL CONT #1 LEFT	K7621101	2A	28VDC	4PDT	LATCH
RELAY ENG FUEL CONT T/D #2 LEFT	K7621104	2A	28VDC	2PDT	HELD T/D 250ms
RELAY ENG FUEL CONT T/D #1 LEFT	K7621103	2A	28VDC	2PDT	HELD T/D 250ms
NLG CTRL SYS 1	K3234001	10A	28VDC	2PDT	LATCH
NLG BYPASS/OFF SYS 1	K3235031	10A	28VDC	2PDT	LATCH
NLG DR CLOSE SYS 1	K3235035	10A	28VDC	2PDT	LATCH
RESET SYS 1	K3235039	15A	28VDC	2PDT	HELD
FLT OK GND PWR TOW RLY	K2431804	15A	28VDC	4PDT	HELD

24-51-00



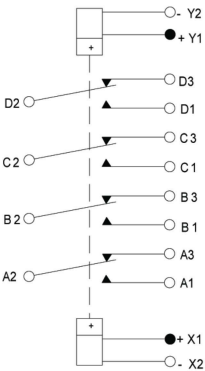
Change Type	Fig Item	Part Number	Nomenclature	Effect From To	UPA
	85	7000292-139	RELAY ASSY SUPPLIER CODE 09167	25, 26, 28, 30, 32, 35, 46, 54, 60, 65, 72, 90, 91, 158, 180, 208, 232, 250, 273, 311, 489	1
			Supplier Code : 99167 HAMILTON SUNSTRAND CORPORATION 4747 HARRISON AVE ROCKFORD, IL 61108- 7929 FORMERLY 09284	IDENTICAL TO 7000292- PROCEDURE 7000292-139 REFERENCE DESIGNATOR 7 7000292-690, 99167 7 7000292-714, 99167 LUAL REF	
	85	7000292-140	RELAY ASSY SUPPLIER CODE 09167	25, 26, 28, 30, 32, 35, 46, 54, 60, 65, 72, 90, 91, 158, 180, 208, 232, 250, 273, 311, 489, 511, 579, 592, 595, 618, 975, 993, 1027, 1049, 1107, 1145, 1251	1
			MISCELLANEOUS DATA 376B4020P28VCC IS IDENTICAL TO 7000292- 140. FOR SPARES PROCEDURE 7000292-140 DESIGN ROLE REFERENCE DESIGNATOR K7621102 USED ON 7000292-749, 99167 MAINTENANCE MANUAL REF 24, 106, 84		

Cross Reference | NSN 5945-00-528-9724

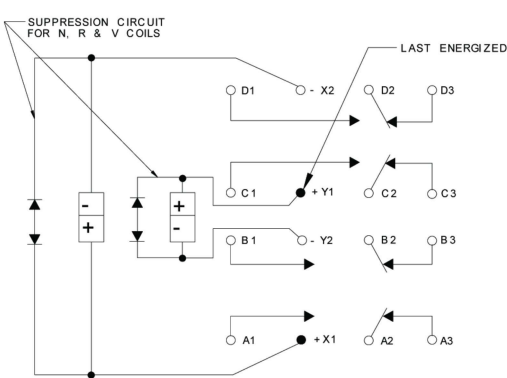
Part Number	Cage Code	Manufacturer
939D685-5	83843	SUNDSTRAND CORP ELECTRIC POWER SYSTEMS DIV
939D685-5	99167	HAMILTON SUNDSTRAND CORPORATION
DA1L010	58657	LEACH INTERNATIONAL CORPORATION DBA LEACH INTERNATIONAL NORTH

SCHEMATIC DIAGRAM

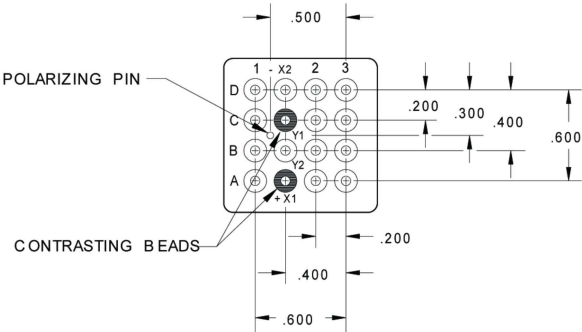
SCHEMATIC DIAGRAM



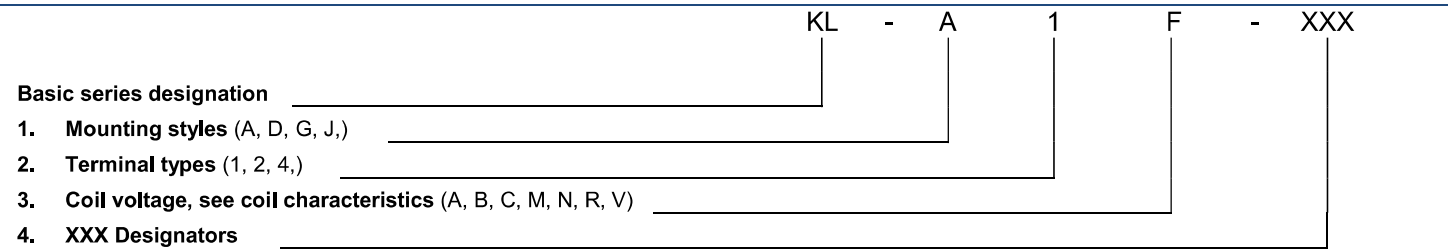
WIRING DIAGRAM



STANDARD TERMINAL LAYOUT



NUMBERING SYSTEM



NOTES

1. Standard Intermediate current test applicable.
2. 500 Vrms with silicone gasket compressed, 350 Vrms all other conditions.
3. Applicable military specification: MIL-PRF-83536
4. Special models available: Dry circuit, established reliability testing, etc.
5. Inductive load life, 20,000 cycles.
6. 60 Hz load life, 10,000 cycles.
7. "N, R, V & W" coils have back EMF suppression to -5 volts maximum.
8. Relay will not be damaged by applying reverse voltage to the coil, although the relay may transfer.
9. Time current relay characteristics per MIL-PRF-83536/18 & /19.

For any inquiries, please contact your local sales representative: leachcorp.com

The APU controller operates the valves, motors, and sensors that control the operation of the APU and contains nonvolatile memory to record various APU parameters, including battery voltage. The APU controller in the 787 airplane is located near the bulk cargo door on the right side of the aft fuselage (where it is separated from the APU battery and the BCU). The incident APU controller was manufactured by Hamilton Sundstrand.¹⁸ Examination and testing (as part of obtaining the nonvolatile memory) showed that the APU controller operated normally and that the APU's function did not affect the battery's operation at the time of the failure.

The start power unit (SPU) converts DC battery power to AC power for starting the APU and provides excitation power for the APU during startup. The SPU of the incident airplane was manufactured by Securaplane Technologies. ATP testing of the SPU found no anomalies, and the SPU's function did not affect the battery's operation at the time of the failure.

1.2.3 Postincident Airplane Examination

The aft E/E bay (the APU battery installation location) showed damage consistent with heat generated from the APU battery and smoke, hot gases, and electrolyte discharged from the battery. Evidence of material expelled from the battery (in the form of residue and thermal damage) was observed in an area that extended about 20 in from the battery installation. No primary structures (that is, those associated with airplane flight loads) exhibited damage; secondary structures—specifically, the avionics rack and the floor panel—exhibited thermal damage near the APU battery's installation location.¹⁹

The wires that connected to the battery case had been thermally damaged, and the front of the battery case showed thermal damage near the J1 and J3 connectors, where the mechanic's drawing indicated two small flames. The shielded bundle of signal wires, which were the circuits between the BMU and BCU, had burned away from the J1 connector. The copper conductors and shield braiding were melted, which was consistent with resistive heating due to high levels of electrical current (beyond the level that the wires were capable of carrying). The single wire designed to be the battery case ground wire (an intended electrical ground path) remained connected at each end, with the wire insulation partially melted and slightly blackened on the interior surface, which was also consistent with resistive heating due to high levels of electrical current.

The aft E/E bay contains electrical cabinets (referred to as panels) that house components used to distribute electrical power from each engine and the APU. The panel labeled P49 is the source of electrical power distribution for the APU battery bus. No physical damage was noted to the P49 panel. When the circuit breakers on the P49 panel were disengaged, continuity checks of the circuit breakers, contactors, and battery cables to the BCU and battery bus revealed no faults.

The environmental control system (ECS) on the incident airplane was designed to provide pressurized and heated or cooled air to the 787 passenger cabin and E/E bays. The ECS

¹⁸ Hamilton Sundstrand later merged with Goodrich Corporation to form UTC Aerospace Systems.

¹⁹ The avionics rack separated the APU battery from the BCU.

On January 14, 2014, an LVP65-8-403 main battery failed on a JAL 787 airplane that was parked at a gate at NRT. (The airplane was being prepared for scheduled flight.) The Japan Civil Aviation Bureau is investigating this incident with assistance from the JTSB and the NTSB. Maintenance personnel reported seeing smoke outside the cockpit window. Preliminary information indicated that one cell had overheated and vented electrolyte and that the enclosure for the battery case contained the vented electrolyte.

1.3 Flight Recorders

The BOS incident airplane was equipped with forward and aft General Electric model EAFR 2100 enhanced airborne flight recorders (EAFR), which recorded cockpit voice recorder (CVR) audio data and FDR parametric data.²⁵ The forward and aft recorders, which were powered by the left and right 28-volt DC buses, respectively, recorded the same set of flight data independently of each other. The forward recorder had an independent power supply to provide backup power to the recorder for about 10 min if the left 28-volt DC bus lost power.²⁶ (The aft recorder had no backup power supply.)

The CVR portion of the EAFR recorded 2 hours of audio data from the cockpit area microphone, the captain's audio selector panel/hot microphone, the first officer's audio selector panel/hot microphone, and the jumpseat/observer's position. The audio information from the forward recorder was used to produce a transcription summary for this incident. The summary began at 0828:21, when the airplane was level in cruise flight at 39,000 ft, and ended at 1031:35, when the forward EAFR stopped recording.

According to the transcription summary, at 1021:41, the CVR recorded sounds associated with the APU shutting down. Conversations among maintenance personnel and the turnaround coordinator about the APU shutdown began about 9 seconds later. At 1024:10, the turnaround coordinator reported smoke in the cabin. No voices were heard on the CVR from 1024:22 to the end of the recording (1031:35).

FDR data before 1021:01 showed no abnormal voltage or current indications. At 1021:01, the voltage of the APU battery decreased from 32 to 31 volts. Three seconds later, the data showed a change in current flow from 3 amperes out of the battery to between 44 and 45 amperes into the battery.²⁷ The current flow into the battery occurred for about 4 seconds; the remainder of the recording showed either no current flow or current flow out of the battery. Between 1021:07 and 1021:09, the battery voltage continued to decrease. At 1021:10, the battery voltage returned to 31 volts. At 1021:27, the battery voltage began decreasing again, reaching

²⁵ Specifically, the EAFR is a multifunction recorder that records flight (FDR) data; audio (CVR) data; and communication, navigation, and surveillance air traffic management messages. The EAFR is a new recording system with a new flight data recording format that allows multiple predefined frames of data that can vary in length and structure. This format provides more flexibility for storing data than older formats that use a single fixed-frame length and structure. The EAFR is currently installed only on 787 airplanes.

²⁶ A lithium-ion battery was used for the recorder independent power supply.

²⁷ This behavior was consistent with the BCU attempting to charge the battery.

28 volts at 1021:30, and the APU shut down 7 seconds later.²⁸ Table 2 shows selected events recorded before and after the APU shutdown. The FDR did not record any data indicating that the APU battery voltage had exceeded 32 volts.

Table 2. Events surrounding APU shutdown.

Time	Event
1000:24	Airplane touched down.
1004:10	APU started.
1006:15	Airplane completed turn into parking location.
1006:48	Parking brake set.
1006:52	Engine 1 shut down.
1006:54	Engine 2 shut down.
1021:01	APU battery bus voltage decreased from 32 to 31 volts.
1021:04	APU battery current increased from 3 amperes out of the battery to between 44 and 45 amperes into the battery.
1021:07	APU battery bus voltage decreased to 30 volts.
1021:08	APU battery current flow returned to 3 amperes out of the battery.
1021:09	APU battery bus voltage decreased to 29 volts.
1021:10	APU battery bus voltage increased to 31 volts.
1021:15	Engine indicating and crew alerting system (EICAS) message discrete indicated that the APU battery failed.
1021:27	APU battery bus voltage began decreasing 1 volt per second during the next 3 seconds.
1021:30	APU battery bus voltage reached 28 volts.
1021:37	APU battery bus voltage decreased to zero volts and returned to 28 volts three times, and APU battery current began to move between zero and 4 to 5 amperes out of the battery.
1021:37	APU controller went offline, and APU had shut down.
1021:37	Aft EAFR stopped recording. Forward EAFR continued recording for about 9 min 58 seconds.
1021:40	EICAS message discretes indicated that the left and right 1 and 2 AC buses became unpowered.
1021:41	EICAS message discrete showed that the APU battery failure was no longer indicated.
1022:00	EICAS message discrete indicated that the main battery was discharging.
1022:10	APU controller went back online.
1022:53	EICAS message discrete indicated that the main battery power switch was off.
1023:16	Airplane systems providing data to the EAFR had shut down.
1031:35	Forward EAFR stopped recording.

Note: The APU controller is the source of 32 recorded parameters, including APU shaft speed and APU battery bus voltage.

The EAFR has an integral flight data acquisition function, which receives data from various sources and then transmits those data to the FDR function according to a predetermined schedule for storage into crash-protected memory. If no new value has been received since the last time that a parameter's value was sent to the FDR function, the flight data acquisition function continues to transmit the last value received from the source. These data are referred to as "stale data."

For some parameters, the flight data acquisition function has multiple prioritized data sources from which it receives parameter values. For these parameters, a separate source index

²⁸ Key parameters that showed the APU battery failure and APU shutdown are presented in figure 2 of the FDR Group Chairman's Factual Report, which is available at www.nts.gov in the public docket for this incident (DCA13IA037). The EAFR records two parameters that indicate the APU battery voltage. Details about the sources of these parameters (APU_Batt_VDC_A and DCBus_APU_Battery_Volts) are included in addendum 1 of the FDR Group Chairman's Factual Report.

also impact aircraft safety if an operator's maintenance activities were based on these data.

11. The poor audio recording quality of the enhanced airborne flight recorder could impede future aircraft investigations because the recorded conversations and other cockpit sounds might be obscured.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this incident was an internal short circuit within a cell of the auxiliary power unit (APU) lithium-ion battery, which led to thermal runaway that cascaded to adjacent cells, resulting in the release of smoke and fire. The incident resulted from Boeing's failure to incorporate design requirements to mitigate the most severe effects of an internal short circuit within an APU battery cell and the Federal Aviation Administration's failure to identify this design deficiency during the type design certification process.

temperature of the separator material. Sections 1.4.5.1 through 1.4.5.4 provide additional details about the teardown of cells 5 through 8, respectively.⁴⁰

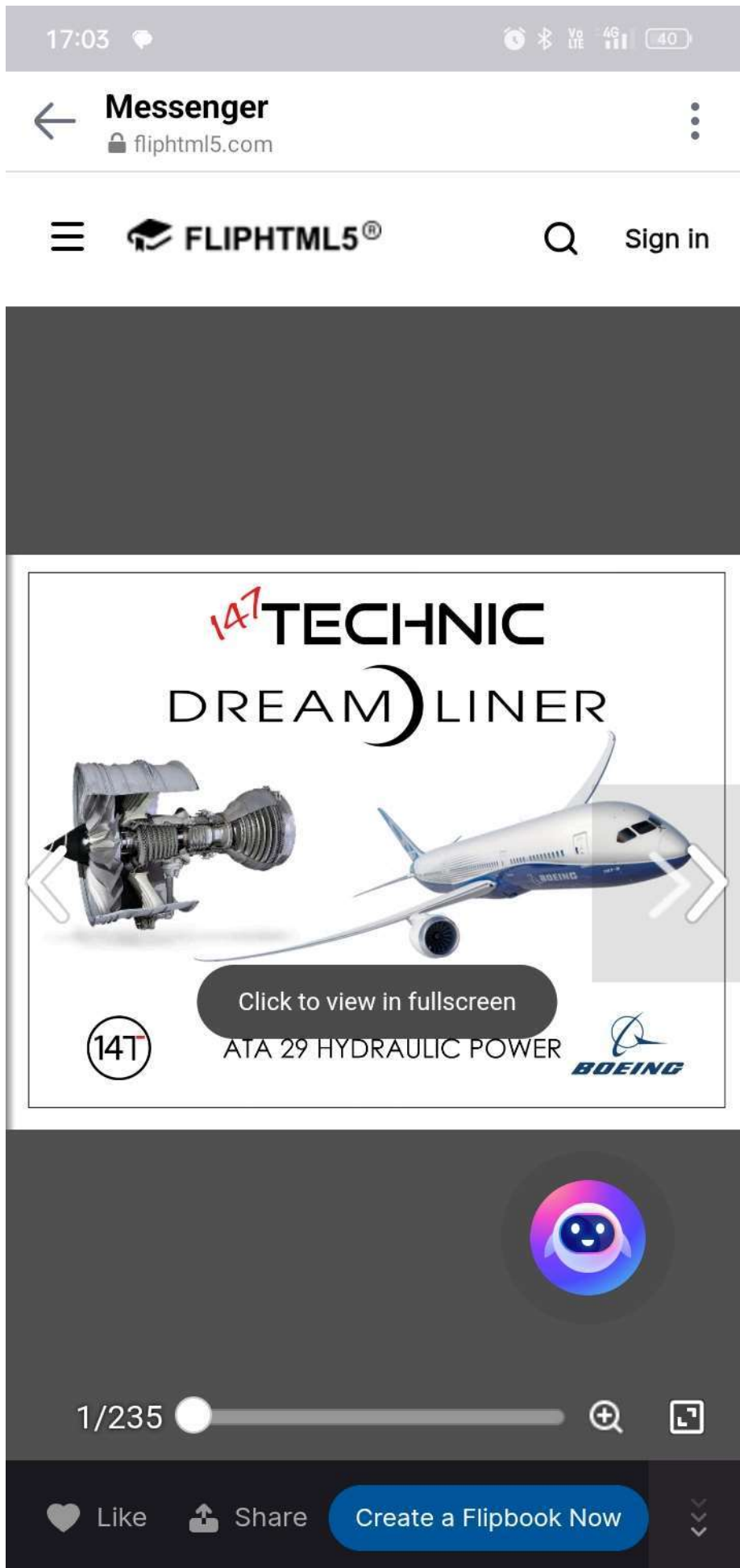
1.4.5.1 Cell 5

The cell 5 examination found evidence of arcing damage on the cell case interior and relatively minor damage to the winding adjacent to the protrusion in the battery case. The cell case was mostly intact. The lower half of the winding closest to battery case side 3 and adjacent to the protrusion in the battery case had adhered to the cell case. The appearance of the cell case and the adherence of the electrodes were consistent with localized heating, melting, separation, and solidification from electrical arcing. No visible portion of the thermoplastic insulation in the cell case remained. Black residue was present on the interior surfaces of the cell case and the exterior of the windings. SEM/EDS analysis found that the chemical composition of the residue was consistent with that of the thermoplastic insulation.

The condition of the aluminum cathode and the copper anode in each winding was consistent with high heat exposure. Most of the cathode material was present but was brittle. Most of the uncoated aluminum foil (at the edges of the windings) remained intact, but portions were missing. The coated aluminum foil was discolored and fractured with areas of the foil missing generally near the header (top) or footer (bottom) fold. Most of the missing aluminum foil had melted and solidified into oblong-shaped globules. The copper foil was intact but had discolorations and small pinholes that propagated through several wraps. The coating on the copper foil had mostly flaked off. The separator was not found during the examination.

For the winding that was closest to battery case side 3, the copper foil was discolored at the header fold with small ripples. The copper foil also exhibited a band of darker color adjacent to the nodular protrusion, which was consistent with high heat exposure. This band of color propagated from the exterior to interior wraps of the winding. The center winding copper foil had ripples along the header fold. This winding appeared to have more overall damage than the other two windings. The winding closest to cell 6 showed the most fragmentation of the aluminum foil and the coated material. The first and second wraps of the winding had thermally adhered to the interior of the cell case, and portions of the first wrap had also thermally adhered to subsequent wraps of the winding. One of the innermost wraps showed folds in the copper foil on the side facing cell 6, which were present through several layers of the winding, as shown in figure 13. Other notable features found during the winding examination were the lack of any sizeable repeating rifts in the windings and the greater amount of damage to the exterior wraps of the windings compared with the interior wraps.

⁴⁰ For additional information about the teardown of cells 1 through 4, see Materials Laboratory Factual Report 13-060, which is available at www.nts.gov in the public docket for this incident. Also, during the teardown of the eight cells, numerous specimens were excised to examine, using SEM and EDS, the physical and chemical characteristics of various internal components. Materials Laboratory Factual Report 13-060 also includes information from these examinations.



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(8) RAM AIR TURBINE – EXTENSION – FUNCTIONAL DESCRIPTION

Teaching Points

- The RAT deploys automatically when signals are received
 - HYDIF
 - BPCU
- A list of conditions which cause automatic deployment of the RAT

student notes
- Manually
 - Pressing the guarded RAM AIR TURBINE switch on the flight deck
- The RAT blades will not turn until after it is deployed
 - Prevents blade contact with RAT compartment or door
- Hydraulic power available in 6 seconds
- Electrical power available in 10 seconds

Student Notes

Description

The RAT is deployed into the airstream by a spring-loaded actuator. It can be deployed manually by a flight deck switch or automatically when the HYDIF or the BPCU. The signal for RAT deployment is sent to the RAT. Only one of the two solenoids is necessary to deploy the RAT. When commanded, the solenoids release a set of locking pawls in the airstream, allowing the spring to extend and force the turbine into the airstream, preventing accidental automatic deployment on the ground. The turbine is mechanically linked to the RAT door, which is driven open by RAT deployment.

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The RAT deploys and supplies hydraulic power in 6 seconds.

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