

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ENG23LA033

AIRCRAFT SYSTEMS

Group Chair's Factual Report

July 23, 2025

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A INCIDENT

Location: Jacksonville, Florida
Date: August 3, 2023
Time: 0835 Local Time
Airplane: JetBlue flight 18, an Airbus A320, registration N649JB

B AIRCRAFT SYSTEMS GROUP

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C SUMMARY

On August 3, 2023, at 0835 eastern daylight time, a JetBlue Airbus A320, registration N649JB, flight 18, experienced a loss of both electrical generators during approach to Jacksonville International Airport, Florida. The airplane's ram air turbine deployed automatically. The airplane landed without further incident or injuries

reported by any of the occupants. The flight was an IFR flight conducted under 14 CFR Part 121 from Fort Lauderdale, Florida to Jacksonville, Florida.

During the investigation, the group met at the Collins Aerospace facilities in Phoenix, Arizona and Miramar, Florida to examine the following four components removed from the airplane:

1. Generator Control Unit, Position Number 1
Part Number: 767584K
Serial Number: AAAY011839
Date of Manufacture: 6/2013
Amendment Status: 1-7, 9-12, 16 marked
2. Generator Control Unit, Position Number 2
Part Number: 767584K
Serial Number: AAAY002870
Date of Manufacture: 12/2005
Amendment Status: 1-7, 10, 11 marked
3. Integrated Drive Generator (IDG), Position Number 1
Part Number: 772292
Serial Number: 0701
4. Integrated Drive Generator (IDG), Position Number 2
Part Number: 772292
Serial Number: 1824

Following the Integrated Drive Generator (IDG) examinations, Collins provided metrology and further examination of the removed oil samples. In addition, examination of the overhaul information of the IDGs and hydraulic cylinder blocks were accomplished.

Examination of the IDGs found that both generators had worn fixed hydraulic blocks (to the point of shedding sleeve material in all bores) resulting in the degraded ability of each IDG to maintain the proper output frequency. The loss of proper IDG output frequency resulted in faults that caused the IDGs' associated Generator Control Unit (GCU) to take its respective IDG offline (trip). The resultant loss of both IDGs without the auxiliary power unit (APU) operating caused the airplane to enter an emergency electrical configuration. This configuration automatically deployed the ram air turbine (RAT).

D DETAILS OF THE INVESTIGATION

1.0 Electrical Power System Description

The airplane's electrical power system (EPS) consists of a three-phase 115/200 Volt, 400 Hertz (Hz) constant-frequency Alternating Current (AC) system and a 28 V Direct Current (DC) system.

The EPS comprises two electrical busses denoted AC BUS 1 (left) and AC BUS 2 (right). There is also a third bus, called the "AC Essential" (ESS) Bus, which is supplied by either AC BUS 1 or AC BUS 2; the AC ESS BUS supplies power to most of the critical aircraft systems.

In normal flight configuration, each IDG supplies its own distribution network via its Line Contactor (GLC). The two IDGs are never electrically coupled. Also, the airplane's flight data recorder (FDR) is supplied by AC BUS 2 and the cockpit voice recorder (CVR) is supplied by AC BUS 1 via AC ESS BUS.

The distribution Network One consists of:

- the Alternating Current Bus 1 (AC BUS 1),
- the Alternating Current Essential Bus (AC ESS BUS),
- the Alternating Current Sheddable Essential Bus (AC SHED ESS BUS).

The AC BUS 1 and AC BUS 2 networks are designed to be normally independent of one another, so that the failure of one network should not affect the other. The power supplies for flight critical systems are mostly segregated, so that the loss of a single power source should not cause concurrent failures of systems necessary for continued safe flight.

The EPS also comprises a third generator (APU GEN) that is driven directly by the Auxiliary Power Unit (APU); it produces the same electrical output as each of the main engine generators. Additionally, a ground power connector near the nosewheel allows ground power to be supplied to all busbars. A ground and auxiliary power control unit (GAPCU) regulates the frequency and voltage of the APU generator; it also protects the network by controlling the external power contactor and the APU generator line contactor.

The electrical system is controlled via the electrical panel located on the overhead console in the cockpit. This panel provides for annunciation of the status of the electrical system and fault conditions. The generator control switches¹ are identified as GEN 1, GEN 2 and APU GEN for the left, right and APU generators. If a fault occurs with a generator, an amber fault message will illuminate on the respective

¹ The selectors on the panel consist of alternate-action push-button selector switches, whereby consecutive pushes cycle the switch between the ON and OFF settings.

generator control push button (PB) switch indicating the channel is offline. For a generator fault, pressing the PB once turns the generator to OFF. Pressing the PB a second time is required to reset the generator back to ON.

With the loss of a single IDG, the EPS is designed for automatic reconfiguration. The EPS will automatically reconfigure so that the remaining IDG provides power for both systems; the complete network (normal and emergency) remains available and is supplied by the remaining generator. In this configuration, both the FDR and CVR continue to be powered. Note: this reconfiguration assumes the APU is not powered.

1.1 Emergency Electrical Configuration

If both IDGs fail or are otherwise taken offline by their respective GCUs, the airplane is designed to revert to emergency electrical power (EMER ELEC) configuration. In the event of loss of both the AC BUS 1 and AC BUS 2 busbars in flight, vital services can be fed by an AC 5 kVA emergency generator which is driven by the RAT. The RAT deploys either automatically (usually because of loss of both main AC busbars) or by manual, flightcrew selection. RAT deployment is indicated by a green icon on the hydraulic system page on the lower Electronic Centralized Aircraft Monitor (ECAM) flight deck display².

In the EMER ELEC configuration, the DFDR is no longer powered; the CVR remains powered.

1.2 Description of Integrated Drive Generators

Two engine-driven AC generators (GEN 1 & GEN 2), one mounted on each engine accessory gear panel, normally power the EPS system. Each generator is driven from the engine high-pressure spool via the engine accessory gearbox and an integrated hydro-mechanical speed regulator. The regulator transforms variable engine rotational speed into a constant-speed drive for the generator. The constant-speed drive and the generator together form the Integrated Drive Generator (IDG).

1.3 Cylinder Block Subassembly of Integrated Drive Generators

As part of the IDG, the pump and motor assembly provide trim speed to the gear differential that converts a variable input speed into a constant output speed. Within the pump and motor assembly there are two rotating cylinder blocks, one with a fixed displacement and one with a variable displacement. The variable cylinder

² The A320 family is equipped with six flight deck display units (DU). Two DUs are in front of each pilot and two central DUs (upper and lower) between the pilots.

block is hydraulically governed by an attached servo valve; the other (fixed) cylinder block's displacement is fixed. Each cylinder block includes nine cylindrical bores with pistons fitted inside each bore. The nine bores and pistons of a newly manufactured cylinder block are matched to meet the manufacturer's specification for tolerance between the bore diameter and piston size; the bore diameter and piston size, for a newly manufactured cylinder block, are defined as "Size 1".

The fixed and variable cylinder blocks work together, using the flow of hydraulic fluid and a governor to produce a constant output speed. As the hydraulic fluid moves through the rotating cylinder blocks, the pistons move -back and forth- within each of the nine cylinder bores.

Over time, the friction caused by the piston movement wears the inside of the bores. When the wear passes a set limit, the bore diameter becomes too large³, the IDG cylinder block is removed, and replaced with a new or repaired cylinder block. The FAA has approved repair processes that allows for a "re-sleeving" of each bore; for the repair, a brass bushing is secured inside each worn bore. The bushing thickness, when placed in the bore, decreases the bore diameter back to Size "1"⁴.

1.4 Description of Generator Control Units

Each IDG is controlled by a Generator Control Unit (GCU). The GCU's main functions are to control and monitor its associated IDG output (voltage and frequency) and to protect the network by controlling the associated GLC. In case of an IDG failure or shutdown, the controlling GCU will protect the network by transferring the electrical load to the other IDG. The GCUs are located in the airplane's avionics compartment.

The GCUs also determine, annunciate, and record faults related to its associated IDG. Software resident in the GCUs monitors the IDG's function and output. The GCU has the authority to take an IDG offline if the software monitors detect a serious fault. The GCU records the fault into its internal memory in addition to sending the fault information to the airplane's maintenance system.

The airplane is also fitted with a Ground and Auxiliary Power Control Unit (GAPCU), which controls the airplane's auxiliary power unit (APU) and ground power when the airplane is attached to an external power source.

³ Collins indicated that a new cylinder block will have bores with a diameter that is defined as Size "1". As the bore sleeving wears and its diameter increases, the diameter will reach a Collins-defined Size "2" or larger.

⁴ One company that performs the re-sleeving process, Aircraft Component Repair, etches "CB-31773" on the exterior of the effected cylinder block to denote a repaired part number.

2.0 Examination of Generator Control Units

The group met at the Collins Aerospace facility in Phoenix, Arizona to examine the airplane's two GCUs. JetBlue shipped the GCUs to the Collins facility in Phoenix after removing them from the airplane.

Prior to the group's arrival, the GCUs were removed from their shipping boxes and inducted into the Collins component tracking system. Once inducted, the GCUs were placed into secure storage until the group examination.

The two GCUs were then examined by Collins's technicians under the group's instruction, as follows:

2.1 Examination of GCU Serial Number AAAY011839, Position Number 1

2.1.1 Visual Inspection of the GCU

The GCU was examined and photographed for a general assessment of its condition. The unit passed the visual inspection with no anomalies noted. An unbroken Lufthansa Technik square anti-tamper seal was found on the side of the unit.

The GCU's part and serial numbers were confirmed from the information provided by the operator at the time of removal from the airplane. See Figure 1.



Figure 1. The number 1 GCU, front data plate. (Photograph courtesy of Collins Aerospace)

2.1.2 Download of GCU Non-Volatile Memory

The GCU was attached to a Collins automated test equipment bench. The information recorded in the unit's non-volatile memory (NVM) was successfully accessed and downloaded. The information was then converted into a human-readable format.

For more information regarding the contents of the NVM, please see Section 2.3, Summary of the Non-Volatile Memory Information.

2.1.3 Acceptance Test Protocol of the GCU

The Collins Receiving Acceptance Test Protocol (ATP), as denoted in the

Component Maintenance Manual (CMM 24-23-23), was accomplished on the GCU. The ATP was completed on the GCU and the unit passed with no faults found.

2.2 Examination of GCU Serial Number AAAY002870, Position Number 2

2.2.1 Visual Inspection

The GCU was examined, the general condition of the unit was visually assessed, and photo documented, as necessary. The unit passed the visual inspection with no anomalies noted. A Collins anti-tamper seal on the side of the unit was found unbroken.

The GCU's part and serial numbers were confirmed from the information provided by the operator at the time of removal from the airplane. See Figure 2.



Figure 2. Front data plate of the number 2 GCU. (Photograph courtesy of Collins Aerospace)

2.2.2 Download of GCU Non-Volatile Memory

The GCU was attached to a Collins automated test equipment bench. The information recorded in the unit's NVM was successfully accessed and downloaded. The information was then converted into a human-readable format.

For more information regarding the contents of the NVM, please see Section 2.3, Summary of the Non-Volatile Memory Information.

2.2.3 Acceptance Test Protocol of the GCU

The Collins Receiving Acceptance Test Protocol (ATP), as denoted in the Component Maintenance Manual (CMM 24-23-23), was successfully accomplished on the GCU with no faults found.

At the conclusion of the tests, the GCUs were returned to their respective shipping containers and held in secured storage until they were returned to the operator.

2.3 Summary of the Non-Volatile Memory Information

Collins reviewed the NVM data and confirmed that the GCUs recorded information for the August 3, 2023 incident flight leg.

By combining the two data sets by date/time for the event flight leg, previous flights, the post flight report⁵ (PFR), and post-incident flight leg troubleshooting, Collins provided a summary of the GCU's recorded fault information. See Figure 3. Note that faults recorded by the number 1 GCU are in blue type and the faults recorded by the number 2 GCU are in red type. The "Block" column refers to the chronological record number of the recorded memory. The loss of date/time information related to the number GCU records is due to the loss of airplane time at the time the faults were recorded.

⁵ Please see section F1.0, Post Flight Report for more information related to the PFR generated by the airplane following the incident flight.

Block	Leg	#	Date--Time	Ph	Fault Description	Fault Ambiguity Group
306	2	3	06/27/23--20:37:48	1	170 FIRE SW ACTION	170 ENGx FIRE PB SW(1WD)/
305	2	1	06/27/23--21:14:42	1	080 OIL PRESS CKT	080 IDGx(Ex-4000XU)LOP
304	3	1	06/28/23--17:46:18	2	160 IDG DISCONNECT	160 IDGx(Ex-4000XU)
61	26	1	07/29/23--02:07:42	6	081 LOW OIL PRESS	081 IDGx(Ex-4000XU)
60	26	1	07/29/23--02:09:00	6	113 OF3 TRIP	113 IDGx(Ex-4000XU)SERVO
47	20	1	07/30/23--12:48:30	9	112 OF/SERVO (-)	112 IDGx(Ex-4000XU)/SERVO
46	20	1	07/30/23--12:48:30	9	081 LOW OIL PRESS	081 IDGx(Ex-4000XU)
7	0	1	08/03/23--12:33:42	6	112 OF/SERVO (-)	112 IDGx(Ex-4000XU)/SERVO
6	0	8	08/03/23--12:33:54	6	081 LOW OIL PRESS	081 IDGx(Ex-4000XU)
2	0	1	00/00/00--00:00:00	0	113 OF3 TRIP	113 IDGx(Ex-4000XU)SERVO
1	0	4	00/00/00--00:00:00	0	198 UNCONTROLLED SD	198 IDGx(Ex-4000XU)/
4	0	1	08/03/23--22:38:00	1	067 OIL TEMP SENSE	067 IDGx(Ex-4000XU)TEMP
3	0	1	08/03/23--22:38:12	1	080 OIL PRESS CKT	080 IDGx(Ex-4000XU)LOP
2	0	1	08/04/23--03:51:00	2	160 IDG DISCONNECT	160 IDGx(Ex-4000XU)
1	0	1	08/04/23--04:43:18	1	028 BTC SENSE LOW	028 PB SW BUS TIE(10XU)/

Figure 3. Table of combined fault information. The recorded time shown is coordinated universal time (UTC).

Collins provided the following information related to the pertinent Fault Descriptions:

- 12:33:43 (8/3/2023) 112 OF/SERVO, Number 1 GCU - An IDG output frequency too high. This fault would cause the GCU to take the associated IDG offline.
- 12:33:54 (8/3/2023) 081 LOW OIL PRESS, Number 1 GCU - IDG oil pressure below a threshold required for designed performance.
- (8/3/2023) 113 OF3 TRIP, Number 2 GCU - An IDG output frequency too high. This fault would cause the GCU to take the associated IDG offline.
- (8/3/2023) 198 UNCONTROLLED SD, Number 2 GCU - An abnormal loss of output without a normal shutdown.

For more information regarding the relationship of the GCU fault codes to the incident flight, please see Section G, CONSOLIDATION OF FDR DATA AND GCU FAULT DATA of this report.

3.0 Examination of the IDGs

3.1 Examination of the Number 1 IDG, Serial Number 0701

According to the records provided by Lufthansa Technik (via JetBlue), the IDG serial number 0701 was previously overhauled in July 2021 by Lufthansa Technik, Germany. As part of the overhaul, both the fixed and variable cylinder blocks were

replaced with blocks with re-sleeved cylinder bores. The IDG had accumulated 4,283 hours of operation since installation on N649JB.

JetBlue also indicated that, during troubleshooting of the IDG per Aircraft Maintenance Manual (AMM) Chapter 24-21-51, prior to its removal from the airplane, the IDG Differential Pressure Indicator (DPI) was found in the extended position.

The examination of the IDG was conducted by Collins personnel, under witness by the group, in the following manner.

3.1.1 Removal from Shipping Container and Visual Inspection

The IDG was removed from its shipping container prior to the start of the investigation and the group's arrival. The IDG's scavenge and charge filters had already been removed. In addition, Collins had also performed the IDG electrical and leakage tests on the unit.

The group performed a visual inspection. The IDG's serial number was confirmed. See Figure 4.



Figure 4. The number 1 IDG, Serial Number 0701 nameplate. (Photograph courtesy of Collins Aerospace)

The following was noted during initial visual inspection of the exterior:

- The DPI indicator had been reset (pushed in)
- The electrical connectors had plastic caps installed
- Electrical connector A was deformed such that the electrical connector could not be installed. The connector rim was adjusted and the connection made.
- No other visible leaks, cracks or other physical damage noted
- The grommet was missing in the base of connector C

The group also examined the previously removed filters. Debris was noted in both filters. A piece of bronze-colored metal, approximately 1/8th inch square in size, was found in the scavenge filter. In addition, portions of silver stringers, and large black flakes of an unknown material, possibly electrical impregnating compound, were found in the filters.

Based on the debris findings, the group opted not to conduct the Collins ATP bench test on the unit. Rather, the group decided to re-conduct static electrical checks,

filter check, and leak check before internal inspection of the IDG.

3.1.2 Automated Electrical Test

The IDG was moved to an automated electrical test bench and connected to the test bench via electrical cables. The Collins automated electrical connection test procedure was accomplished on the IDG, including dielectric checks. Following completion of the automated procedure, the test results were compiled and indicated the IDG passed the test with no faults found.

3.1.3 Submersion Leak Test

The IDG was charged with air to 20 psi and then submerged into a tank of Stoddard solution for 20 minutes to check for leaks. After a nominal time to allow the liquid and unit to stabilize, bubbles were noted leaking from the input shaft seal. The IDG was considered to have failed the test and the test aborted after approximately 8 minutes. The IDG was then dried.

3.1.4 Hydraulic Test of Filter

The scavenge and charge filters were tested for blockage. The scavenge filter was highly occluded. With an input oil flow rate of 1.5 gallons per minute, the resultant measured pressure difference across the filter was 91 psi.

The charge filter was unobstructed. With an input oil flow rate of 3 gallons per minute, the resultant measured pressure difference across the filter was 6.7 psi. The values for both filters were considered acceptable by Collins and indicated that the filters were not plugged.

3.1.5 Acceptance Test Protocol

Due to the internal condition of the IDG, the group elected not to conduct the ATP on the unit.

3.1.6 Disassembly of the IDG, Internal Examination, and Servo Valve Test

The IDG was then disassembled on a Collins bench. The disassembly steps deviated from the CMM procedure to focus on the removal of the hydraulic cylinder blocks. The following was noted during the disassembly:

- Some carbon deposits were noted on the inner diameter of the dynamic seal and on the input shaft.
- The disconnect solenoid pin was noted as out and not retracted.
- After the IDG was opened, small flecks of bronze-colored metal and an

unknown black material were noted on some of the internal components.

- Some of the internal wire bundles were secured with zip-ties instead of lacing – the Collins standard practice.

The IDG's servo valve was visually examined and tested. Trace amounts of brown-colored debris were noted on the servo valve screens. Once the servo valve was moved to the servo valve test stand, the servo valve test was accomplished with no faults found.

3.1.7 Disassembly of the Hydraulic Module and Cylinder Blocks

The hydraulic module was removed from the IDG for additional disassembly. During the removal of the hydraulic module, the module control rod was observed with no play on the ball joint. A thick, clear residue was noted on the outer surface of the wobbler housing and several small bronze-colored particles were noted on the ceramic wobbler disk.

Once the hydraulic module was disassembled, the fixed cylinder block was examined. The fixed block exhibited the marking "CB-31773", indicating the block had been repaired by an FAA-approved re-sleeving process. See Figure 5. The block's serial number was noted as Y13-46-15. Each of the nine fixed cylinder block pistons were examined; all were marked as manufactured by Collins, and all were marked as Size "1".



Figure 5. The etched number, indicating the cylinder block had been re-sleeved.
(Photograph courtesy of Collins Aerospace)

Each of the fixed cylinder block's nine bores had areas that were worn through the bronze sleeve bushings, with sections of the sleeve missing. Significant wear was noted at the bottom of several bores, with areas showing wear through the sleeve to the steel. The exposed areas of the block substrate appeared intact. See Figures 6 and 7.



Figure 6. Fixed block bore number 3, showing wear at the bottom of the bore through the sleeve, to the cylinder block steel. (Photograph courtesy of Collins Aerospace)



Figure 7. The fixed cylinder block bore number 5, showing typical wear through the bushing sleeve material to the cylinder block steel. (Photograph courtesy of Collins Aerospace)

The variable block was also marked "CB-31773" to indicate that this block was repaired by an FAA-approved re-sleeving process. The etched serial number was Y13-78-32. The bores and sleeves showed minimal wear; none of the bores showed wear through the bushing to the cylinder block. See Figure 8. Each of the nine variable cylinder block pistons were examined; all were marked as manufactured by Collins, and all were marked as Size "1".



Figure 8. One of the variable cylinder block bores, showing minimal wear. (Photograph courtesy of Collins Aerospace)

The Collins air spindle tool was used to measure the diameter (the worn size) of each of the nine cylinder bores for the fixed and variable blocks. For the fixed block, the air spindle test showed each of the bores were worn beyond the measurable limits of the air spindle tool; by this method, each of the nine bore diameters were greater than Size "5". For the variable block, the air spindle measured each of the bores at Size "2".

The IDG's differential, rotor, variable unit, and pumps were examined, and all noted in good condition.

3.2 Examination of the Number 2 IDG, Serial Number 1824

According to the records provided by Lufthansa Technik (via JetBlue), the IDG was last overhauled in January 2021 by Lufthansa Technik, Germany. As part of the overhaul, both the fixed and variable cylinder blocks were replaced with blocks with re-sleeved cylinder bores. The IDG had accumulated 8,012 hours of operation since installation on N649JB.

According to records provided by JetBlue, the number 2 IDG had been removed from the airplane due to a "generator 2 fault" that would not reset.

3.2.1 Removal from Shipping Container and Visual Inspection

The IDG had been misplaced during the shipping movement to the Collins Miramar, Florida facility. Several weeks later it was located and then shipped to Miramar. The IDG was originally shipped in a standard shipping container but had been removed during shipment. As received at Miramar, the IDG was in a cardboard box on a wood pallet. The IDG was wrapped in a plastic garbage bag.

The IDG was removed from its cardboard shipping box prior to the group's arrival. The group performed a visual inspection. See Figure 9.



Figure 9. IDG #2 (Serial Number 1824) nameplate. (Photograph courtesy of Collins Aerospace)

Once the IDG's part and serial number were confirmed, the following was noted during the visual inspection of the exterior:

- The electrical connectors had plastic caps installed.
- A corner of the terminal block cover was broken off and the terminal block bracket beneath was heavily abraded and bent over. See Figure 10.



Figure 10. Damage to the terminal block. (Photograph courtesy of Collins Aerospace)

- The electrical connector A shell was deformed (pushed in) such that the mating electrical connector could not be installed. Three pins near the deformed portion of the connector were found bent from their normal position.
- Several corners of the IDG were dented and the paint chipped off.
- One of the jumper cable connector shells was deformed (pushed in).

Based on the damage to electrical connector A, the group decided to delay the electrical checks until after the leak check and conduct the electrical checks using pin to pin connectors.

The scavenge and charge filters were removed. Some small flecks of bronze-colored metal were noted in the scavenge filter. In addition, numerous small flecks of bronze-colored metal were noted in the bottom and internal wall of the scavenge filter bowl. For the charge filter, one small fleck was noted in the filter bowl.

Both filters were tested for blockage on the Collins Filter Pressure Test stand. For the scavenge filter, the measured pressure difference across the filter for a 6.3 gallons per minute flow rate was 19.4 psi. For the charge filter, the measured difference across the filter pressure was 17.3 psi at a rate of 6.3 gallons per minute. Both values were considered acceptable by Collins and indicated that the filters were not plugged.

A sample of IDG oil was taken for analysis by Collins. See section E.1.0 for the results of the analysis.

The IDG was prepared for the leak check by injecting pressurized air into the unit. When the air started, the group and test conductor heard an audible leak. A crack in the IDG was discovered on the lower input housing near the sump. See Figures 11 and 12.



Figure 11. View of the IDG housing with a crack, in the red circle. (Photograph courtesy of Collins Aerospace)



Figure 12. A close-up photograph of the crack found in the IDG housing.
(Photograph courtesy of Collins Aerospace)

Based on the crack in the housing and the large amount of debris found in the IDG's filters and filter areas, the group decided not to conduct the Collins ATP Test.

3.2.2 Automated Electrical Test

The group decided not to complete the automated electrical test, due to damage to the IDG exterior. Rather, the group decided to conduct manual electrical checks of the IDG servo valve and the exciter stator. No faults were found.

3.2.3 Acceptance Test Protocol

The ATP was not conducted on the unit due to the damage exhibited on the exterior of the IDG.

3.2.4 Disassembly of IDG and Internal Examination

The IDG was disassembled on a Collins bench. The disassembly steps deviated from the CMM procedure to focus on examination of the hydraulic cylinder blocks.

During the disassembly process, the following was noted:

- When the input shaft was removed, the dynamic seal appeared undamaged with minor wear.
- When the IDG was opened, flecks of bronze-colored metal were noted on the internal components.
- Some of the internal wire bundles were secured with zip-ties instead of lacing - the Collins standard practice.
- The crack in the IDG housing was visible from inside of the unit.

3.2.5 Disassembly of the Hydraulic Module and Cylinder Blocks

The hydraulic module was removed from the IDG for additional disassembly. The control rod-control arm linkage pin was observed with some axial play. The control arm was tight on the wobbler trunnion. The linkage that connects the control piston with the wobbler was intact with no excessive play noted. On the wobbler housing, a thin clear residue was noted on the outer surface. The fixed wobbler showed a small pit through its coating.

Once the hydraulic module was disassembled, the fixed cylinder block was examined. The fixed block exhibited the marking "CB-31773", indicating the block had been repaired by an FAA-approved re-sleeving process. See Figure 13. The block's serial number was noted as Y11-313-27. The nine pistons removed from the fixed block were manufactured by Collins and all were marked as Size "1".



Figure 13. Exterior of the number 2 IDG fixed cylinder block, showing the etched number corresponding to an FAA-approved block re-sleeving process. (Photograph courtesy of Collins Aerospace)

The fixed cylinder block's bores were examined. Each of the nine bores showed some wear spots through the bronze sleeves, with sections of the sleeve missing. Severe wear was noted at the bottom of all nine bores, with areas showing wear through to the cylinder block's substrate. The exposed areas of the block substrate appeared intact.

As an example, see Figure 14. The figure shows wear at the bottom of bore number 1.



Figure 14. Fixed cylinder block bore number 1, showing wear through the sleeve bushing to the cylinder block steel. (Photograph courtesy of Collins Aerospace)

See Figure 15, noting the wear at the bottom of bore number 7.



Figure 15. Fixed cylinder block bore number 7, showing wear through the re-sleeved bushing to the cylinder block steel. (Photograph courtesy of Collins Aerospace)

On the fixed block valve plate, scrape marks were noted between the kidneys on the plate.

The variable block was also marked "CB-31773" indicating this block was modified by an FAA-approved re-sleeving process. See Figure 16. The etched serial number on the block's exterior was Y07-43-35. The bores and sleeves showed minimal wear; none of the bores exhibited wear through the bushing. As a comparison, see the minimal wear noted on variable block bore number 5, in Figure 17. The nine variable block pistons were removed from the block. All nine pistons were marked as manufactured by Collins and all were noted as Size "1".



Figure 16. Etching on variable block exterior indicating the block was modified by an FAA-approved re-sleeving process. (Photograph courtesy of Collins Aerospace)



Figure 17. The bottom of variable block bore number 5, showing minimal wear. (Photograph courtesy of Collins Aerospace)

The IDG was prepared for the servo valve sub test. One piece of debris was noted on one of the servo valve screens. The servo valve test stand was moved to the area of the IDG disassembly, and the servo was connected to the stand. The servo valve passed the test with no faults found.

The Collins air spindle tool was used to measure the diameter (the worn size) of each of the nine cylinder bores for the fixed and variable blocks. For the fixed block, the air spindle test showed each of the bores were worn beyond the measurable limits of the air spindle tool; by this method, each of the nine bore diameters were greater than Size "5". For the variable block, the air spindle measured each of the bores at Size "2".

The differential, PMG rotor, and variable unit were all noted in good condition. Insulation resistance and dielectric tests were conducted on the PMG stator. The stator passed each of the tests with no faults found.

After the examinations were completed, both IDGs were placed into secure storage until the units were released from the investigation and returned to the

operator.

The following items removed from the IDGs during the examination were sent to the Collins facility in Rockford, Illinois for further metrology:

From the Number 1 IDG

1. Oil sample
2. Scavenge Filter
3. Charge Filter
4. Two sets of nine pistons removed from the Variable and Fixed blocks
5. Fixed cylinder block
6. Variable cylinder block

From the Number 2 IDG

1. Oil sample
2. Scavenge Filter
3. Charge Filter
4. Set of nine pistons removed from the Fixed cylinder block
5. Fixed cylinder block

E INFORMATION PROVIDED BY COLLINS FOLLOWING THE EXAMINATION

Collins examined the removed IDG components at their Rockford facility in March 2024. Collins provided an Investigation Summary Report, dated June 11, 2024, of the findings.

In the report, Collins provided the following information regarding the examination of the removed items:

1.0 IDG Oil Sample Testing Results

The oil samples removed from the IDGs were tested in a chemical profile that included a measurement of its water content, acid level, and chlorine concentration.

The results indicated that the oil from the number 1 IDG was in poor condition, due to an excessive water content. The other test measurements were within limits for used oil.

The results indicated that the oil from the number 2 IDG was within acceptable limits for a used oil.

2.0 IDG Filter Examination Results

Collins examined the charge and scavenge filters from both IDGs. For each filter, copper material and other metallic debris were found on the filter surface. The copper debris appeared to be similar to the bushing sleeve material found in the fixed (and variable) cylinder blocks and used for an FAA-approved re-sleeving repair.

Black flakes of an epoxy coating were also found the filters. The flakes appeared to be similar to the coating used on the inside of the IDG housing.

3.0 Further Examination of the IDG Cylinder Blocks

Collins conducted a detailed examination of the cylinder blocks sent to the Rockford facility – the two fixed cylinder blocks and one variable cylinder block. The examination confirmed that, for each of the fixed cylinder blocks, all nine bores showed bore wear and damage to the re-sleeved bushings. In addition, Collins determined that the lower portion of the bushing in each bore had separated from the steel cylinder block underneath. This was from the shedding (loss) of bushing material in the bores. Some of the shed fragments of the re-sleeve bushings were found in the IDG filters.

According to Collins, the block bore conditions, as found, would limit the ability of the IDG to maintain stable frequency during operation.

Collins confirmed that none of the nine bores in the variable cylinder block exhibited wear all the way through the bushing sleeve to the block substrate.

No further examinations were conducted on the sets of pistons removed from the IDGs.

F INFORMATION RECEIVED FROM JETBLUE

As part of the investigation, JetBlue provided the following information:

1.0 Post Flight Report

JetBlue provided the PFR generated by the airplane following the flight. See Figure 18.

```

A/C ID   DATE   GMT   FLTN   CITY PAIR
.N649JB  04AUG  0354  JBU18  KFLK KJAX

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: MAINTENANCE :
: POST FLIGHT REPORT :
:              :
: DB/N        :
: A320FAMILY-010
:
-----

A/C ID   DATE   GMT   FLTN   CITY PAIR
.N649JB  03AUG  1139/1240  JBU18  KFLK KJAX

WARNING/MAINT. STATUS MESSAGES
-----
GMT   PH   ATA
1233 06 24-00 ELEC GEN 1 FAULT
1233 06 24-00 ELEC IDG 1 OIL LO PR (2)
1235 06 77-11 ENG 1 REVERSE UNLOCKED
1235 06 24-00 ELEC GEN 1 FAULT
1235 06 24-00 ELEC GEN 2 FAULT
1235 06 34-00 NAV ILS 2 FAULT
1235 06 34-00 NAV ATC/XPDR 1+2 FAULT
1235 06 34-48 NAV GPWS TERR DET FAULT
1235 06 34-41 NAV PRD W/S DET FAULT
1235 06 34-00 NAV GPWS FAULT
1235 06 27-00 F/CTL DIRECT LAW
1235 06 22-00 AUTO FLT FAC 1+2 FAULT
1235 06 23-28 COM SATCOM FAULT
1235 06 27-00 F/CTL
1235 06 34-00 ADR
1235 06 36-00 AIR BLEED
1235 06 36-12 AIR APU BLEED FAULT
1235 06 26-00 SDCU
1235 06 23-28 COM SATCOM FAULT
1236 06 24-00 ELEC IDG 1 OIL LO PR (3)
1237 08 22-00 AUTO FLT RUD TRV LIM SYS
1238 09 24-00 ELEC IDG 1 OIL LO PR

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Figure 18. A portion of the Post Flight Report. Note the three items boxed in red.

The PFR indicated the loss of the number 1 IDG, followed by the loss of the number 2 IDG, and then a reversion from Normal flight control law to Direct law⁶.

2.0 ECAM Messages from Previous Flights

JetBlue provided information for N649JB developed on the airplane in the days prior to the incident flight (on August 3, 2023):

- July 29, 2023: The ECAM cautions ELEC GEN 1 FAULT and ELEC IDG 1 OIL LO PR were triggered. Both caution messages were related to the operation of the number 1 IDG.

⁶ According to Airbus, if the landing gear was not extended when the airplane entered the EMER ELEC configuration, the Normal flight control law would have reverted to Alternate law.

- July 30th, 2023: The ECAM cautions ELEC GEN 1 FAULT and ELEC IDG 1 OIL LO PR were triggered. Both caution messages were related to the operation of the number 1 IDG.

3.0 Information About the Overhaul of IDGs

JetBlue indicated that the IDGs had been received from Lufthansa Technik, (Hamburg, Germany) following an overhaul. The IDGs were installed on N649JB after receipt from Lufthansa Technik.

Lufthansa Technik provided the following information related to their overhaul of the IDGs:

1. Number 1 IDG, Part Number 772292, Serial Number 0701:

The overhaul work was described in Lufthansa Technik Workshop Report 61796262, dated August 24, 2021, which indicated that the as-found condition of the IDG included "Fits between cylinder block bores and piston out of limit". As part of the overhaul actions, the paperwork stated, "Pump & motor unit overhauled" as well as "Unserviceable parts replaced or repaired". This included the fixed cylinder block.

2. Number 2 IDG, Part Number 772292, Serial Number 1824

The overhaul work was described in Lufthansa Technik Workshop Report 61759518, dated January 20, 2021. The report indicated that the as-found condition of the IDG included "Fits between cylinder block bores and piston out of limit". As part of the overhaul actions, the paperwork stated, "Pump & motor unit overhauled" as well as "Unserviceable parts replaced or repaired". This included the fixed cylinder block.

G CONSOLIDATION OF FDR DATA AND GCU FAULT DATA

An examination of the PFR results, download of the GCU fault codes, and FDR data provided the following flight history:

July 29th, 2023:

The ECAM caution messages ELEC GEN 1 FAULT and ELEC IDG 1 OIL LO PR were annunciated during flight. Both caution messages were related to the operation of the number 1 IDG.

The ECAM messages were corroborated by related faults recorded in the number 1 GCU memory. The number 1 GCU fault messages recorded on July 29 were

OF3 TRIP, indicating that an overfrequency condition was detected, leading to the number 1 IDG trip offline, and a LOW OIL PRESS message.

July 30th, 2023:

The ECAM caution messages ELEC GEN 1 FAULT and ELEC IDG 1 OIL LO PR were annunciated during flight. Both caution messages were related to the operation of the number 1 IDG.

The ECAM messages were corroborated by related faults recorded in the number 1 GCU memory. The number 1 GCU fault messages recorded on July 30 were OF/Servo, indicating that an overfrequency condition was detected, leading to the number 1 IDG trip offline, and a LOW OIL PRESS message.

August 3rd, 2023:

Incident Flight Details

Note: Times are approximated using the FDR elapsed time and the GCU recorded fault times (assumed to be airplane ship time in UTC), subtracting 4 hours to Local Time.

7:45 - Takeoff from Ft. Lauderdale.

8:24 - Start of descent (into JAX) in normal electrical configuration.

8:33:42 - Number 1 IDG Overfrequency Fault (at 2,330 ft FDR Pressure Altitude), followed 12 seconds later (8:33:54) by a number 1 IDG low oil pressure fault. The airplane's FDR data shows a normal transfer of electrical power to AC BUS 2.

8:34:00 - The FDR data indicates the Battery 2 Contactor Line changes state from "Open" to "Closed". Airbus indicated that this is consistent with flightcrew actions to start the Auxiliary Power Unit (APU).

8:34:25 - IDG#2 Overfrequency Fault with the number 2 IDG trip offline. Note: this time is estimated since the ship time is lost due to the loss of the second AC BUS. The FDR showed a loss of data for approximately 55 seconds. The loss of FDR data is an indication of EMER ELEC condition.

8:35:21 - FDR data is recovered through the remainder of the flight. In addition, the FDR data showed that the airplane was in Pitch and Roll Direct Law following the recovery of the electrical power.

8:37 - The airplane landed without further incident.

H POST INCIDENT ACTIONS TAKEN BY AIRBUS

Following the incident (and a similar, previous incident in February 2020⁷), Airbus took the following actions in response:

1.0 Maintenance Planning Document

Airbus updated the A320 Family Maintenance Planning Document (MPD) to add repetitive IDG maintenance tasks to verify the correct behavior of the airplane's three generators (both main IDGs and the APU Generator) on a regular basis, and their capability to takeover and control the airplane's entire electrical load if required.

The updated A320 Family MPD was issued on November 1, 2023. The updated MPD requests an operational check of the electrical network reconfiguration in a single IDG configuration every 3,000 flight hours, under a high electrical load.

2.0 Aircraft Maintenance Manual

An updated version of the Aircraft Maintenance Manual (AMM) Task 24-20-00-710-801-A (and referenced by the MPD) is currently under Airbus study, to:

- Switch ON additional electrical loads (e.g., hydraulic electrical pump, window anti-ice, etc.)
- Perform an APU start in a single IDG configuration, to verify the capability of the remaining IDG to cope with the electrical peak during the APU start.

3.0 Trouble Shooting Manual

Airbus conducted a review of the Trouble Shooting Manual (TSM) tasks related to ECAM alerts ELEC 1/2 GEN FAULT, to improve the TSM tasks when they are potentially related to an IDG mechanical issue or failure. The purpose was to direct maintenance personnel more quickly towards a change of the IDG.

4.0 Communications to Operators

Airbus provided the following communications to operators:

- Airbus Technical Follow-Up (TFU) [reference 24.20.00009] titled "Emer Elec events global analysis."

⁷ NTSB investigation ENG20LA016.

- Airbus Operator Information Transmission (OIT) [reference 999.0053/24 Rev 00] "MPD task preventing EMER ELEC situation".
- Forwarded Collins Service Information Letter (SIL) #899, "Dual Integrated Drive Generator (IDG) Loss in Flight".

Submitted by:

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