

# Application Note

## Auxiliary Power Unit Failure in a Commercial Aircraft

### Purpose of an APU

The primary purpose of an aircraft APU is to provide power to start the main engines of an aircraft. APUs also generate electrical and pneumatic power to run the heating, cooling, and ventilation systems prior to starting the main engines. This allows the cabin to be comfortable while the passengers are boarding without the expense, noise, and danger of running one of the aircraft's main engines.

Electrical power is also used to power up systems for preflight checks. Some APUs are also connected to a hydraulic pump, allowing maintenance and flight crews to operate the flight controls and power equipment without running the main engines. This same function is also used as a backup in flight in case of an engine failure or hydraulic pump failure.

APUs fitted to Extended-range Twin-engine Operations (ETOPS) such as the Boeing 777 aircraft are a critical safety device as they supply backup electricity and compressed air in case of a dead engine or failed main engine generator. If the APU or its electrical generator is not available, the airplane cannot be released for ETOPS flight and is forced to take a longer, non-ETOPS route.

### Equipment

Boeing 777 aircraft from a major commercial airline.

### Component

Auxiliary Power Unit (APU) in service since overhaul for 2714 hours.

### Discussion

The maintenance report stated that the APU shut down automatically two times. In addition, the main filter and the scavenger pump filters were reported to be clogging. Two days later, an inspection of the magnetic plug confirmed the presence of metal. After another two days of operation, the APU was removed and replaced.

### Findings

An oil sample was taken when the APU was delivered to the maintenance depot for inspection and repair. A evaluation of the oil sample by Carbon Filter Analysis by Atomic Emission Spectroscopy (CFA/AES), a technique optimized for the detection of large particles, suggested bearing failure due to the extremely high concentrations of iron along with elevated levels of chromium, copper, vanadium, molybdenum, aluminum and nickel. Other elements were also detected but in less significant quantities. The table below shows an analysis of the clean oil by itself and the analysis with the CFA/AES technique. The severity of the problem is readily evident in the data. Results are in parts per million (ppm)<sup>1</sup>.

Element (ppm)	Fe	Cr	Cu	V	Mo	Al	Ni
New Oil	0.86	0.33	0.16	0.39	0.46	0.00	0.25
Sample at 2714 Hours	> 2203	75	11	13	56	82	19

A subsequent tear down of the APU revealed that an engine compressor main shaft ball bearing had failed as shown in the figure below.

### Conclusion

The normal oil analysis sampling interval for the APU is set at 660 hours of operation. Complete failure of the bearing probably could have been avoided if oil samples were taken more frequently to provide more timely warning of an imminent problem. Earlier indications of the wear process through oil analysis would have resulted in significant costs savings by negating the need for a complete APU overhaul and repair of secondary damage caused by total bearing failure.



<sup>1</sup> The CFA system is calibrated with metallo-organic standards at varying concentrations because standards with actual metal particles are not available.

## What is Carbon Filter Analysis by Atomic Emission Spectroscopy (CFA/AES) ?

*Carbon Filter Analysis (CFA) is an analytical technique that enables Atomic Emission Spectroscopy (AES) to detect and analyze large wear and contaminant particles in fluids. CFA supplements standard spectroscopy by providing additional information that can be used to determine the mechanical condition of machinery.*

### Background

Routine spectrometric analysis of used oil samples becomes less responsive to particles as they increase in size. Atomic absorption (AA) and inductively coupled plasma (ICP) spectrometers suffer the most from the problem. Rotating disc electrode (RDE) spectrometers are responsive to somewhat larger particles, but even their detection capabilities decrease rapidly as particles approach 8 to 10 micrometers in size. With the addition of CFA analysis, the RDE technique can analyze particles greater than 10 micrometers in used oil samples. By trending the change in the ratio between standard RDE spectroscopy and CFA results, the two methods can be used to improve the detection and analysis of progressive wear.

### CFA System

The Carbon Filter Analysis System is a completely automated analytical accessory to the Spectroil M/C or M/N Oil Analysis Spectrometers. It consists of one stand-alone cabinet and includes a five-station disc electrode preparation fixture, vacuum/pressure pump, a reservoir for cleaning solvent, a sump for waste oil, and electrode clamp assemblies. It requires only external electrical power for operation and uses only readily available and affordable solvents. The entire system is on casters and can be easily transported.



### Features of the CFA System

- *Complements normal spectrometric analysis with analytical results for large particles.*
- *Separates and concentrates particles on a disc electrode for analysis.*
- *Automatic and simultaneous preparation of up to five samples at one time.*
- *Economical and simple to use.*
- *Only consumables are the CFA filters, rod electrodes and readily available solvent.*
- *Samples can be prepared and stored until ready for analysis.*

