The heart of the system is a magnetic, inductive particle sensor. It captures and retains ferromagnetic debris particles and provides an output signal for each capture.

The General Electric GE90 ultrahigh bypass turbofan engine, which has logged close to 3 million flight hours on the Boeing 777 aircraft, is the first commercial aircraft engine with a quantitative electronic debris monitoring system (DMS). This system consists of an inductive debris sensor/collector, a highly efficient vortex debris separator, and an electronic module that sends debris particle count signals to the full-authority digital engine control (FADEC). The FADEC, in conjunction with the aircraft's central maintenance computer, determines whether pre-set particle count alert algorithms have been exceeded and generates alert messages on the aircraft's maintenance access terminal in the cockpit. In addition, alert messages can be transmitted to key airline maintenance personnel via VHF radio downlink through the ARINC communication addressing and reporting system (ACARS). Following a debris alert message, line maintenance personnel can easily remove the sensor to inspect the debris for failure verification. Using current techniques, the debris can also be collected and analyzed to determine if a critical engine component failure is imminent.

The heart of the system is a magnetic, inductive particle sensor. It captures and retains ferromagnetic debris particles and provides an output signal for each capture. Eaton's Tedeco brand markets this sensor under the trademark QDM® (quantitative debris monitor). It has an internal magnet, an inductive coil, and a secondary test coil for injecting a BIT (built-in-test) signal into the sensor, simulating the arrival of a debris particle. The sensor is housed in a self-closing valve to allow its removal for inspection with minimal oil loss.

The effectiveness of any DMS is a direct function of the quantity of debris presented to it by the oil system. The GE90 DMS sensor is installed in a vortex debris separator that is mounted on the oil tank on the engine fan case. It has a capture efficiency of 90% at maximum engine rpm for debris particles characteristic of a rolling-contact-fatigue type bearing failure. The scavenge system of a gas turbine engine contains large amounts of air from the pressurization of bearing sumps. As an added feature, the vortex separator also removes the air from the oil, with an efficiency of 95%. The air, vented back into the top of the reservoir, contains only 0.05% of the oil.

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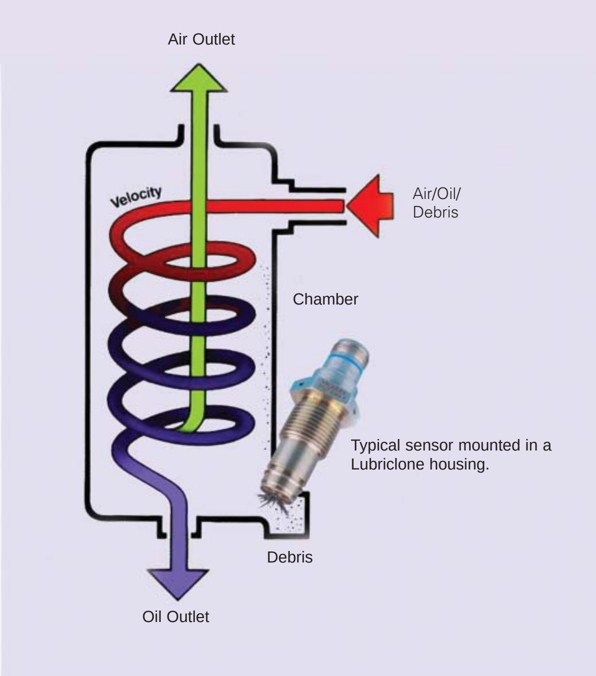
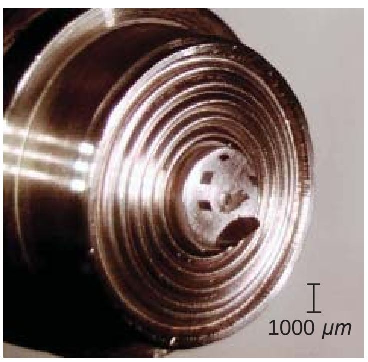


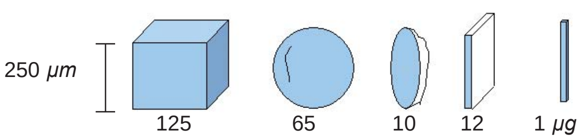
Lubriclone® 3 Phase Vortex Separator (Fig. 1)

Sensor Face With Particles



Debris Particle Size, Mass and Material:

The sensor has a magnetic pole piece that captures and retains debris particles for easy failure verification. The picture shows the sensor face with three test particles (squares), together with three irregular, actual spall flakes from a bearing undergoing rolling-contact fatigue failure. Although particle size is widely used as a parameter to characterize different failure modes, it should be noted that all inductive debris sensors (including flow-through sensors), generate a signal proportional to particle volume or mass rather than linear dimension or size. Particle magnetic properties and shape also affect the signal. The sketches below indicate schematically the wide variation of particle mass, even though all "particles" (cube, sphere, circular and rectangular flake, and sliver) have the same linear dimension



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