

Unplugged

A maintenance error caused oil to be lost from all four engines on a British Aerospace BAe 146 used to transport the Royal Family.

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ON 6 NOVEMBER 1997, THE CREW of a UK Royal Air Force (RAF) British Aerospace BAe 146 shut down one engine and later another during an emergency landing at London Stansted Airport after indication of significant oil depletion.

The UK Ministry of Defence said in its report that the incident was caused by maintenance error. The report found that magnetic chip-detector plugs (MCDPs) had been installed without oil seals ("O" rings) in all four engines of the BAe 146.

The aircraft was one of three BAe 146s used to transport members of the Royal Family. Although operated by the military, the aircraft is maintained according to civilian maintenance programs.

In its contract proposal to the RAF, the maintenance organisation said that the nightshift maintenance staff would comprise 12 workers: one chargehand (general foreman), two senior leading hands (senior supervisors), three leading hands (supervisors) and six fitters (technicians). The company, however, had a personnel shortage. When the maintenance was performed on the incident aircraft, the night shift comprised nine workers; the staff did not include the two senior supervisors and one of the three supervisors.

The general foreman told one of the supervisors on duty to draw spectrometric oil analysis program (SOAP) samples and to change the MCDPs in all four engines. This is a routine BAe 146 maintenance procedure that is conducted every 50 engine cycles or 50 flight hours, whichever occurs sooner.

The supervisor was a former military airframe technician who had received no engine maintenance training. Nevertheless, he was authorised by the company to perform some engine work.

The supervisor searched for MCDP change kits in the maintenance hangar, but

found none. MCDP change kits – which include oil plugs, plug seals and SOAP sample bottles – normally were assembled by technicians who worked the company's engine bay. Because of the personnel shortage the engine-bay night shift had been eliminated. The engine-bay day shift assembled change kits upon request.

"The engine bay [day shift staff] had not been advised of the requirement for an MCDP change, and there were no prepared kits available," the report said.

The supervisor consulted with the general foreman and then went to the engine bay to assemble kits from items available there. The supervisor found MCDPs in an area of the engine bay that he believed contained BAe 146 engine parts that were ready for use. The area, however, contained MCDPs that had been cleaned, but had not been inspected or fitted with seals. The supervisor assembled four change kits with MCDPs from this area.

When the supervisor returned to the hangar, he found that none of the techni-

cians was available to obtain the SOAP samples and install the MCDPs. The supervisor decided to do the work himself.

The supervisor did not consult the aircraft maintenance manual (AMM), which said that SOAP samples must be obtained from the engine oil tanks within 15 minutes of engine shutdown, that MCDPs must be installed with new seals and that the engines then must be operated to check for oil leaks and satisfactory engine operation. The supervisor did not comply with these requirements.

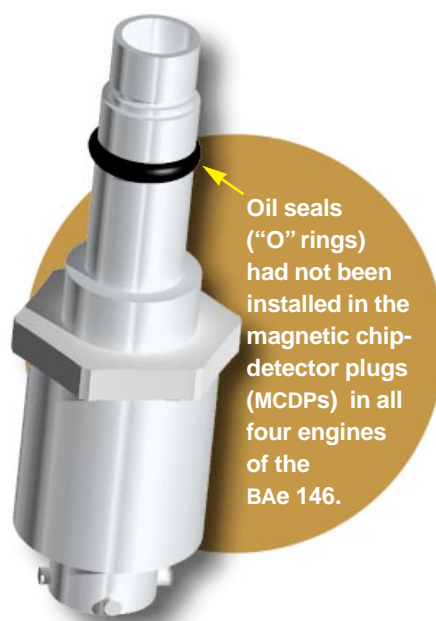
"Sign-off": The job card required the work be signed off by the person who performed the work and by the person who supervised the work. The supervisor asked a technician to sign the job card as the person who performed the work, and the supervisor signed the job card as the person who supervised the work.

Before the flight the aircraft crew chief assumed each engine contained at least three-quarters of its total oil capacity of 11.5 litres. Ground crew members saw no oil leaks and noticed no engine abnormalities when the engines were started and when the aircraft taxied to the runway.

The aircraft departed RAF Northolt at 1510 local time. Fifteen minutes later, while climbing at about 5,000ft in instrument meteorological conditions, the crew saw that the oil quantity gauges for the number 2 engine, number 3 engine and number 4 engine indicated empty, and that the oil quantity gauge for the number 1 engine indicated less than one-quarter full.

The crew began flying the aircraft back to RAF Northolt. The low oil pressure warning light for the number 3 engine then illuminated. At 1527, the crew shut down the engine, declared an emergency and requested – and received – immediate clearance to land at Stansted.

The low oil pressure lights for the number 2 engine and the number 4 engine then began to illuminate intermittently. The crew conducted



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an instrument landing system approach to Stansted with the thrust levers for the number 2 engine and the number 4 engine at flight idle, and the thrust lever for the number 1 engine at maximum thrust. When the crew was sure that the aircraft was in position for a safe landing, they shut down the number 2 engine. They shut down the number 4 engine during the landing roll and taxied clear of the runway using the number 1 engine.

The engine cowls were covered with oil, and oil spilled to the ground when the cowls were opened. The MCDPs were removed and found to have no seals.

Contributing factors: The inquiry suggested that the main factors contributing to the incident were:

- Half of the normal complement of supervisory personnel was available on the night shift. Despite the reduction in supervisory resources, the general foreman did not reduce the amount of maintenance work planned or expected that night.
- The elimination of the engine-bay night shift was not planned adequately by management, resulting in the unavailability of serviceable MCDP kits.
- Despite the risks involved in performing identical maintenance on all aircraft powerplants, MCDP changes were scheduled to be conducted simultaneously on all four of the BAe 146 engines.
- The supervisor exceeded his capability, and exercised poor judgment in attempting to assemble serviceable MCDP kits from items obtained in the engine bay.
- The supervisor had not been trained to perform the routine engine maintenance task and performed the task without consulting the AMM.
- The supervisor did not comply with AMM procedures.
- The supervisor asked a technician to sign for work that the technician had not performed. The supervisor performed the work, but he signed as having supervised the work.
- No ground operation of the engines was performed after the maintenance.
- The general foreman did not adequately monitor the work performed by the night-shift personnel and did not ensure that their work was done according to safety standards.

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Sources of maintenance error

An analysis of the Ministry of Defence report on the inquiry into the incident involving the Royal jet suggests events and factors that could have led to the depletion of the engine oil and the resultant emergency landing of the aircraft were:

- Half of the normal complement of supervisory personnel was available on the night shift. Despite the reduction in supervisory resources, the general foreman did not reduce the amount of maintenance work planned or expected that night. (O,S).
- The elimination of the engine-bay night shift was not planned adequately by management. This resulted in the unavailability of serviceable MCDP kits for the maintenance hangar night shift (O,S).
- Despite the risks involved in performing identical maintenance on all aircraft powerplants, MCDP changes were scheduled to be conducted simultaneously on all four of the BAe 146 engines (O, Q, S).
- The supervisor exceeded his capability and experi-

ence, and exercised poor judgement in attempting to assemble serviceable MCDP kits from items in the engine bay (S, W, M, T).

- The supervisor had not been trained to perform the routine engine-maintenance task and performed the task without consulting the AMM (S, W, T, M, R).
- The supervisor did not comply with AMM procedures (O, S, M, R).
- The supervisor asked a technician to sign for work that the technician had not performed. The supervisor performed the work, but he signed as having supervised the work (R, P).
- Ground operation of the engines was not conducted after the maintenance was performed (M, T, R).
- The general foreman did not adequately monitor the work performed by the night shift personnel and did not ensure that their work was performed according to safety standards (C, O, S, R).

Factor	Related elements
C Communications	Verbal, written, visual, direct, indirect, flight crew, work assignment, shift turnover, etc.
D Design	Original, modification, supplemental type certificates, service bulletins.
E Environment	Weather, lighting, indoor/outdoor temperature, noise.
G General maintenance manual	Organisation or company policies, procedures, rules, maintenance organisation requirements, issued authorisations and approvals.
H Hardware	Equipment, tools, parts, materials, ground support equipment, etc.
I Inspection	Preliminary, progressive, final, non-destructive inspection, duplicate inspection.
L Limitations	Weight, reach, sight, access.
M Manufacturing manuals, data	Maintenance and service, non-destructive inspection, service bulletins, aircraft flight manual, minimum equipment list, structural repair manual, illustrated parts catalogue, life-limited parts.
O Organisational structure	Division of or shared responsibility, support resources, top management quality/safety commitment, planning.
P Paperwork, record systems	Technical logbooks, forms/job cards, records, documents, etc.
Q Quality management, audit	Maintenance organisation/air operator certificate formal programs, requirements, effectiveness.
R Regulations	Airworthiness design, maintenance organisation, personnel, programs, airworthiness directives, maintenance organisation/air operator certificate, health/environment, workplace safety.
S Supervision, middle management	Work assignment, oversight, major decision making.
T Training	Basic skills, product technical, special program requirements, initial, recurrent, records.
W Worker	Aircraft maintenance, ground support, fuelling, technical administration staff, licensed, unlicensed, line, hangar, shop.
X Physiological, psychological	Stress, fatigue, drugs, alcohol, mental illness.