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ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Report – 200605505
Final

Engine in-flight shutdown
74 km west-north-west Brisbane Airport, Qld.
18 September 2006
9M-MRM
Boeing Co 777-2H6

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Abstract

On 18 September 2006, at 1417 Eastern Standard Time, a Boeing Co 777-2H6 aircraft, registered 9M-MRM, departed Brisbane Airport, Qld for Kuala Lumpur, Malaysia. The flight crew reported that, at approximately 1422, when the aircraft was 74 kms west-north-west of Brisbane Airport and climbing through 10,300 ft, they felt a 'sudden jerk' followed by an Engine Indication and Crew Alerting System message 'ENG FAIL R'. The crew informed Brisbane Air Traffic Control of the right engine failure and performed the relevant checklist items to successfully restart the right engine.

After dumping fuel to reduce the landing weight, the crew returned the aircraft to Brisbane Airport. The company's ground handling agent's engineering personnel replaced the right engine Fuel Metering Unit (FMU) and the aircraft was returned to service.

The investigation found that there had been a loss of damping fluid in the turbine overspeed servo valve, adversely affecting the operation of the servo valve. As a result, the turbine overspeed servo valve became de-latched, and the engine shut down in flight.

A number of safety actions were carried out as a result of this incident, including by the:

- manufacturer of the turbine overspeed servo valve, who will check the servo valve when the units are returned for overhaul; and
- manufacturer of the FMU, who mandated a check of the torque setting of the turbine overspeed servo valve retaining bolts when the units are returned to their repair bases.

In addition, the engine manufacturer:

- is investigating the feasibility of the development of a test to confirm the serviceability of the turbine overspeed servo valve damping fluid in installed engines; and
- has published non-Mod Service Bulletin NMSB73-F408. That bulletin recommended the on-wing torque inspection of the turbine overspeed servo valve bolts in all installed engines or engines in overhaul shops where the life of the FMU is greater than 5,000 hours.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and, where applicable, relevant international agreements. The object of a safety investigation is to determine the circumstances in order to prevent other similar events. The results of these determinations form the basis for safety action, including recommendations where necessary. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. While the Bureau issues recommendations to regulatory authorities, industry, or other agencies in order to address safety issues, its preference is for organisations to make safety enhancements during the course of an investigation. The Bureau prefers to report positive safety action in its final reports rather than making formal recommendations. Recommendations may be issued in conjunction with ATSB reports or independently. A safety issue may lead to a number of similar recommendations, each issued to a different agency.

The ATSB does not have the resources to carry out a full cost-benefit analysis of each safety recommendation. The cost of a recommendation must be balanced against its benefits to safety, and transport safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed (for example, the relevant regulatory authority in aviation, marine or rail in consultation with the industry).

FACTUAL INFORMATION

Reported information

The report presented below was prepared principally from information supplied to the Bureau.

History of flight

On 18 September 2006, at 1417 Eastern Standard Time[1], a Boeing Co 777-2H6 aircraft, registered 9M-MRM, departed Brisbane Airport, Qld for Kuala Lumpur, Malaysia. The flight crew reported that, at approximately 1422, when the aircraft was 74 kms west-north-west of Brisbane Airport and climbing through 10,300 ft, they felt a 'sudden jerk' followed by an Engine Indication and Crew Alerting System message 'ENG FAIL R'. The crew informed Brisbane Air Traffic Control of the right engine failure, and performed the relevant checklist items to successfully restart the right engine.

After dumping fuel to reduce the aircraft's landing weight, the crew returned the aircraft to Brisbane Airport. The company's ground handling agent's engineering personnel replaced the right engine Fuel Metering Unit (FMU) and the aircraft was returned to service.

System description

Fuel flow to the engine for combustion is controlled by the engine's fuel control components, including the FMU. Within the FMU, the fuel metering valve supplies metered fuel for combustion while the high pressure fuel shutoff valve starts and stops the flow of fuel. Both of these units are controlled by the Electronic Engine Control (EEC).

The high pressure fuel shutoff valve is closed via the fuel shutoff valve torque motor in response to input from a number of components including the:

- engine fire switch, when selected to the FIRE position
- engine fuel control switch, when selected to the CUTOFF position.

The high pressure fuel shutoff valve is also closed via the turbine overspeed servo valve in response to input from a number of components including:

- the overspeed protection unit, if a severe engine over speed is detected
- the EEC, in response to the detection of a low pressure turbine shaft failure.

1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

Examination of components

Digital flight data recorder

The Digital Flight Data Recorder was examined by the aircraft's manufacturer. That examination revealed that the engine had shut down as the fuel flow reached zero and that the exhaust gas temperature and the engine high pressure compressor speed dropped significantly, consistent with that reduction in fuel flow. The thrust lever resolver angle remained constant during the shutdown, indicating that there was no recorded movement of the thrust lever that might have contributed to the shutdown.

Fuel Metering Unit

The FMU was returned to the unit's manufacturer for technical examination. That examination found that the four retaining bolts that secured the turbine overspeed servo valve to the FMU were at less than the required torque, which reduced the clamping load being applied to the torque motor assembly. There was also evidence of fretting between the servo valve mounting pads and the body of the FMU.

In addition, the turbine overspeed servo valve armature cap o-ring seal was damaged and there was no damping fluid in the armature cavity. There was also evidence of fluid leakage from the base of the servo valve and from around the retaining bolts. The damping fluid lubricates and preserves the armature components. Fine black debris was found inside the servo valve and was heaviest in the armature air gaps, interfering with the flapper control[2].

An examination by the FMU manufacturer of the relevant maintenance documentation found that the FMU had a total of 33,384 hours time since new (TSN) and was last overhauled at 27,265 hours TSN.

The turbine overspeed servo valve had a total of 33,384 hours TSN and was last overhauled at 8,774 hours TSN (24,610 hours time since overhaul (TSO)). The servo valve was not overhauled at the last overhaul of the FMU as it was not being maintained to the Component Management Programme.

The manufacturer of the FMU reported that this was the first incidence of the loss of the damping fluid from the turbine overspeed servo valve in the valve's cumulative service life, across a number of FMU models, of about 16,000,000 hours.

2 Controls the fuel pressure across the high pressure fuel shutoff valve, allowing the valve to open and close.

ANALYSIS

The less than required torque on the turbine overspeed servo valve retaining bolts, and resulting insufficient clamping load of the torque motor assembly, allowed the loss of damping fluid in the turbine overspeed servo valve. The investigation was unable to determine whether the low torque on the servo valve retaining bolts was due to the valve's extended period of time in service since it was last overhauled, or as a result of their not being properly tightened during that overhaul.

The loss of damping fluid in the armature cavity resulted in fretting of the components within the turbine overspeed servo valve. The fretted fine black material around the armature air gaps prevented the flapper control from moving its full range and reduced its latching force. It was likely that the reduction in the flapper control's latching force allowed the turbine overspeed servo valve to become de-latched, and the engine to shut down in flight.

SAFETY ACTION

As a result of this incident, the following Safety Action has been undertaken by the manufacturers of the turbine overspeed servo valve, Fuel Metering Unit (FMU) and engine:

Manufacturer of the turbine overspeed servo valve

The manufacturer of the turbine overspeed servo valve will check the condition of the armature cap o-ring seal when the units are returned for overhaul.

Manufacturer of the Fuel Metering Unit

The manufacturer of the FMU mandated a check of the torque setting of the turbine overspeed servo valve retaining bolts when the units are returned to their repair bases.

Engine manufacturer

The engine manufacturer:

- is investigating the feasibility of the development of a test that will be able to confirm the serviceability of the turbine overspeed servo valve damping fluid in installed engines
- published non-Mod Service Bulletin NMSB73-F408. That bulletin recommended the on-wing torque inspection of the turbine overspeed servo valve bolts in all installed engines or engines in overhaul shops where the life of the FMU is greater than 5,000 hours.