

BAe 146-300, G-UKAC, 3 June 2000

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INCIDENT

Aircraft Type and Registration: BAe 146-300, G-UKAC

No & Type of Engines: 4 Lycoming ALF 502-R5 turbofan engines

Year of Manufacture: 1989

Date & Time (UTC): 3 June 2000 at 2030 hrs

Location: In the cruise Marseille to Stansted, diverted to Paris, Charles de Gaulle

Type of Flight: Public Transport (passenger)

Persons on Board: Crew - 5 - Passengers - 109

Injuries: Crew - None - Passengers - None

Nature of Damage: None

Commander's Licence: Airline Transport Pilot's Licence

Commander's Age: 43 years

Commander's Flying Experience: 7,800 hours (of which 2,916 were on type)
Last 90 days - 190 hours
Last 28 days - 64 hours

Information Source: Aircraft Accident Report Form submitted by the pilot and follow up discussions with the operator and aircraft manufacturer

History of the flight

On levelling in the cruise at FL280 a light thin layer of cloud was encountered; conscious of engine icing considerations the crew requested a further climb to FL310. When level at FL310, the crew observed on the weather radar a line of cumulo-nimbus (CB) cloud formations ahead, running approximately east-west at a range of 50 nm. When the aircraft was approaching 20 nm from the CBs a descent to FL260 was requested for a transit between two storm cells which appeared to be about 10 nm apart. Engine anti-ice was selected on at the top of the descent. Lightning was visible associated with the storm cell to the left of the aircraft and a heading change was requested to manoeuvre between the cells. When passing between the storm cells at FL260, visible moisture was

encountered but at no time was any airframe icing present on the wings, windshield or wipers or identified by the ice detector. As the aircraft was clearing the weather with no further CBs indicated ahead, the commander became aware that the fan speed (N1) of engine No 4 was decreasing slowly with an associated increase in Turbine Gas Temperature (TGT). The commander instructed the first officer to get the Rollback Emergency Check List out. After about one minute, by the time the commander had retarded the No 4 engine thrust lever, the TGT was 890°C and rising. Engine No 4 was shutdown and the Rollback drill completed. The crew transmitted a PAN call and diverted to Paris, Charles De Gaulle without further incident.

Flight recorder data analysis

The aircraft manufacturer conducted an analysis of the event based primarily on the data retrieved from the Flight Data Recorder and came to the following conclusions:-

On the balance of evidence available, the uncommanded thrust reduction was due to an ice induced engine 'Rollback' on the No 4 engine.

This conclusion was based on the following:-

Ambient conditions at the onset of the event were 31,000 feet, ISA +6°C. All previous reported Rollback events have occurred at or above 28,000 feet and at an average of ISA +11°C, with the lowest at ISA +7°C.

The aircraft was in the vicinity of a thunderstorm. In all previous events, the aircraft were reported IMC in cloud and thunderstorms in the vicinity.

The Total Air Temperature (TAT) signal suggests that the TAT probe iced up approximately 4 minutes 30 seconds after the initial decay in N1. In all previous ice induced Rollbacks for which an FDR showing TAT is available, the TAT probe appears to ice up 3 to 6 minutes before N1 decay.

The fan speed decay plot had a convex profile, which is typical of a classic ice induced Rollback.

The engine did not respond to pilot thrust lever increases and was shutdown as temperature limits were exceeded. In classic ice induced Rollback events the engine does not respond normally until the aircraft has descended below the freezing level.

From previous experience, the reason for the other engines remaining unaffected is probably due to minor variations in engine condition, which cannot be quantified.

Rollback

The term 'Rollback' is used to describe a particular uncommanded thrust reduction on the Lycoming ALF-502R engine. It manifests itself as a slow reduction in the high pressure spool speed (N1) associated with an increasing Turbine Gas Temperature (TGT) and a failure of the engine to respond to the pilot thrust lever. Following considerable research and analysis complemented by flight tests conducted by the airframe and engine manufacturers, the cause of roll-back was determined to be due to the build up of ice on the engine core super charger exit guide vanes in very specific meteorological conditions. The build up of ice on the guide vanes progressively 'chokes' the engine core. A modification (30437A) was devised to improve the anti-icing efficiency and is in the process of fleet embodiment. In the interim, following a study of the

pattern of roll-back occurrences, an operational limitation was introduced for aircraft with unmodified ALF 502R engines by the issue of a Temporary Revision to the Aircraft Flight Manual (AFM).

Aircraft operating restriction

AFM Temporary Revision 34, issue No 3 of May 1999 was current at the time of the event and included the following:-

LIMITATIONS AIRCRAFT GENERAL

REASON FOR ISSUE

Introduction of revised limitations, procedures, aircraft and engine handling associated with icing conditions for aircraft with ALF 502R engines.

When operating aircraft pre-mod 30473A the following applies:

In order to prevent uncommanded thrust reduction, flight in known or forecast icing conditions above 26 000 feet is prohibited. A forecast of cloud, including any cumulonimbus (CB) activity, must be regarded by the crew as a forecast of icing conditions.

Forecast meteorological conditions

The European Significant Weather Chart, FL100 to FL450, valid 1800 hrs UTC, 3 June 2000 provided to the flight crew did include an area en-route Marseille to Stansted which included, 'Occasional CB FL100 to FL360'. On the outbound sector, the crew had transited the area in which occasional CB activity had been forecast, during the forecast validity period, without encountering any cloud.

The aircraft manufacturer's interpretation of the Flight Manual Temporary Revision in the context of this weather forecast was that the entire flight should be conducted at or below 26,000 feet.

The Operator's interpretation was that the portion of the flight not affected by known or forecast icing conditions could be conducted above 26,000 feet. The operator also believed that the weather experienced by the crew on the outbound sector gave grounds for re-assessing the forecast.

Post incident activity

The AFM Temporary Revision 34, issue 4 document specific to the BAe 146-300 series aircraft (Doc 3.10) was issued to operators in February 2001. One of the changes was to modify the text as follows:-

When operating aircraft pre-mod 30473A the following applies:

In order to prevent uncommanded thrust reduction, flight in known or forecast icing conditions above 26,000 feet is prohibited. A forecast of **ANY** cloud, including ~~any~~ cumulonimbus (CB) activity, must be regarded by the crew as a forecast of icing conditions.

For this AAIB Bulletin only, **BOLD** indicates additional text, ~~strikethrough~~ deleted text.

During the intervening period, after the roll back on G-UKAC but before the AFM revision was issued, the aircraft manufacturer issued a Notice To Airmen (NTA) Op 42, which re-emphasised the engine limitation and introduced the forthcoming AFM amendments, which also re-titled the crew drill. In addition the aircraft manufacturer is revitalising the Rollback training programme. This includes consideration of additional customer briefing visits and providing training material to supplement the existing simulator module.

The CAA has tasked the aircraft manufacturer with reviewing the risks associated with Rollback during the period from the present until all of the engines have been modified.

Summary

The uncommanded thrust reduction was due to an ice induced, engine 'Rollback' on the No 4 engine leading to the engine being shutdown. Until all Lycoming ALF 502R engines are modified to eliminate Rollback the operation of the aircraft with unmodified engines is subject to the restrictions contained in Temporary Revision 34 to the aircraft Flight Manual. This restriction was subject to an interpretation by the operator that differed from the intent of the manufacturer and as a result the aircraft was operated in meteorological conditions conducive to Rollback. The aircraft manufacturer has amended Temporary Revision 34 and is revitalising the Rollback training programme. The CAA has tasked the aircraft manufacturer with reviewing the risks associated with Rollback during the period from the present until all of the engines have been modified.