

Boeing 757-225, G-OOOV, 27 January

AAIB Bulletin No: 4/98 Ref: EW/C97/8/1 Category: 1.1

Aircraft Type and Registration:	Boeing 757-225, G-OOOV
No & Type of Engines:	2 Rolls Royce RB211-535-E4
Year of Manufacture:	1985
Date & Time (UTC):	27 January at 0121 hrs
Location:	Birmingham International Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 9 - Passengers - 228
Injuries:	Crew - Nil - Passengers - Nil
Nature of Damage:	Nosewheel axle and two wheel hubs destroyed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	Not relevant
Commander's Flying Experience:	Not relevant
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was engaged on two sectors; Birmingham to Malaga and return. At the end of the first sector at 1655 hrs, after an uneventful landing at Malaga, the aircraft left the runway via the rapid exit taxiway. At a speed of about 20 kt a vibration was felt through the steering as the aircraft was turned left through approximately 120°, onto the parallel taxiway. The commander initially thought that the vibration was due to the taxiway surface, however, after 100 to 150 yards of straight taxiing the vibration returned again in a more marked fashion. The aircraft was brought to a stop immediately and ATC and the airport emergency services were informed. Passengers were disembarked via steps and taken by bus from the taxiway.

Upon inspection the right hand nosewheel was found canted over at an angle, the outer bearing having disintegrated. The operator's Duty Engineer, in Maintenance Control at Manchester, was informed at 1715 hrs and despatched an authorised certifying engineer (a Licenced Aircraft Engineer - referred to throughout this Bulletin as 'the LAE'), and a wheel change kit from Manchester by diverting another Boeing 757, G-OOOV bound for Tangier, to Malaga where it landed at 2115 hrs. The LAE visually examined the axle and found some axle damage that had been caused by the wheel bearing failure. He dressed out this damage, changed both nosewheels and OV

took off from Malaga on its return flight to Birmingham. The nose gear axle failed inboard of the right hand outer bearing land (Figure 1) as the aircraft turned off the runway at Birmingham.

Subsequent metallurgical examination showed that the fracture of the axle was the result of the degradation of the axle material properties, due to penetration of liquid cadmium from the surface plating into the steel wall of the axle (cadmium embrittlement), while it was subjected to heating and tensile stresses during break up of the bearing at Malaga. Additionally, the axle had been further weakened by mechanical damage to a depth of 33% of the wall thickness, also caused during the break up of the bearing at Malaga.

Chapter 055117 of the Aircraft Maintenance Manual (AMM) called up an examination of the nose gear axle for overheating after a wheel bearing failure (Appendix 1) and required the use of a borescope to enable the internal bore of the axle to be examined for evidence of overheating of the cadmium plating. This check was not known to the Duty Engineer or to the LAE before OW departed for Tangier via Malaga, nor was it found by the Duty Engineer during his subsequent document search. Consequently the examination was not carried out. The Duty Engineer continued to search for repair limits to the axle, but was unsuccessful (because no repairs were authorised).

Detailed Sequence of Engineering events

Actions at Manchester

At 1715 hrs the operator was informed that the aircraft was unserviceable at Malaga with a right nose wheel bearing collapse. This information was passed to the Duty Engineer, a certifying engineer with airframe authorisations which included landing gear, who worked as a maintenance co-ordinator in Maintenance Control, located adjacent to the Operations Control. He advised the commander by telephone that the aircraft could be towed slowly to clear the taxiway and that the consequential damage to the axle could be accepted. By this time the Duty Engineer had anticipated that an axle change would be required and called the contracted maintenance organisation, both at Manchester and Gatwick, to enquire about the availability of two engineers to go to Malaga, but was told that they were unable to meet the requirement.

Another aircraft GOOOW, full of passengers and due to take off for Tangier at 1800 hrs, was held with the intention of diverting it to Malaga with wheels and a wheel change kit. At about the same time another certifying engineer ('the LAE') rang Maintenance Control from home to check on shift allocations. He was told by the Duty Engineer that a nose wheel failure had occurred in Malaga, that an aircraft full of passengers was waiting, and was asked if he was available. In spite of feeling tired after a day spent flying a microlight, he confirmed that he was available. At 1730 hrs he was told that his offer to go had been accepted.

The Duty Engineer then spent some time arranging for spare wheels, jacks and tools to be delivered and loaded onto OW. He also provided a photocopy of extracts from the AMM giving torque loading figures for the wheel changes. The AMM also contained within Chapter 5- 'Time Limits/Maintenance Checks' a mandatory borescope inspection to be carried out after a bearing failure to detect cadmium embrittlement, but the availability of this information was not generally known of amongst the operator's engineers, and the sub-chapter was not consulted.

At 1815 hrs the LAE arrived at Manchester Airport and asked for the assistance of a mechanic, who had volunteered to go. However, there was only one spare seat available on the aircraft, and whilst it

would have been possible to off load one member of the cabin staff, the possibility was not considered. OW took off for Malaga at 1825 hrs.

The LAE was therefore sent off without an assistant, without the knowledge that an overheat check was required following a bearing failure, and without a borescope to enable him to carry out such a check. He did not have time to look at the AMM at Manchester and neither OV nor OW carried a copy, so he had no opportunity to see the sub-chapter containing the inspection requirement following a bearing failure. An AMM could have been obtained at Malaga or pages could have been faxed out by the Duty engineer, albeit perhaps with some difficulty, but the LAE did not see the need to seek such additional information.

The maintenance organisation exposition issued by the operator and approved by the CAA defined the procedures, accepted by the CAA, to be used in the repair of aircraft. All certifying engineers directly employed by the operator would be expected to know these procedures and would be tested periodically on their content. In particular, the exposition required that repairs to aircraft structures which fall outside the scope of the aircraft Structural Repair Manual are to be referred to the Technical Services Department, who would employ the aircraft manufacturer or an approved design organisation to provide an approved repair scheme. The only method authorised by the aircraft manuals for the nose wheel axle was repair by replacement, any other method would therefore require an approved repair scheme. The exposition further required that all repairs were to be detailed and documented for record purposes.

At about 1830 hrs the Duty Engineer received a call from OV saying that the aircraft had been jacked, the wheel was off, and the axle was 'not too bad'; but the Spanish engineer was having trouble getting the bearing off. At 1900 hrs an avionics engineer took over as Duty Engineer in the UK maintenance control and passed the information from OV on to the LAE who was by now airborne in OW. Sometime after 2115 hrs the Duty Engineer was informed of the extent of the damage to the axle, and he was still concerned that no information about possible repair limits could be found in the aircraft manuals. He therefore contacted the Boeing 24hour Engineering Support desk to see if the damage could be worked to limits. Boeing referred the Duty Engineer to the AMM and asked for further details in the form of a sketch if the AMM did not find the information he needed. No further information was passed because the aircraft was declared serviceable by the LAE in Malaga and it took off at 2259 hrs.

Actions at Malaga

At 2115 hrs the LAE arrived in Malaga and was asked about the anticipated length of the delay as he unloaded kit from GOOOW. He missed the first cue of serious trouble because the damaged wheel was already loaded on OV, and was inaccessible because it had been placed behind luggage in the forward freight bay. He noticed that the bush fitted to the inside of the threaded end on the axle was damaged (see Figure 2), as was the axle nut, but decided not to change the bush as sufficient locking holes remained available. He identified the mechanical damage between the bearing lands on the axle caused by the damaged wheel and bearing, and assessed it as being 1 1/2" long and 1/16" deep. He could not see any signs of bluing or overheating on the outside of the axle and considered that it would be satisfactory for the aircraft to return to Birmingham, after the damage had been blended. These details were passed to the Duty Engineer in Manchester.

The LAE examined the inside bore of the axle after cleaning it as best he could, but as he only had a torch and not a borescope he could not see 7" into the bore (as the AMM required). He therefore missed the signs of overheating inside the bore of the axle as the change of section behind the

internal locking bush hid the damage from a torch inspection. Having decided that it would be satisfactory to blend the external damage to allow the return flight to proceed, the LAE did so with a half round file and emery cloth. He did not raise an Acceptable Deferred Defect on what he considered to be a temporary repair as he had no drawings or blend limits to work to. In fact there were no limits published because no blending was allowed.

During the inspection of the axle he had to handle a distraction from the commander of G-OOOW, who approached him about a refuelling problem, at that point he gave advice. Later, during blending, the same commander again approached him with his refuel problem; this time the LAE left the axle job to assist with the refuelling.

The LAE replaced the right hand wheel, which was fitted without a problem, and changed the left hand wheel, using the photocopied maintenance manual extracts giving the appropriate torque figures. He contacted maintenance control at 2215 hrs, just one hour after arriving in Malaga, with brief details of the damage and stated that the aircraft was satisfactory for service, but that an axle change should be planned when the schedule allowed. It was agreed that this would happen at Manchester after the Birmingham sector. The aircraft took off for the return flight to Birmingham at 2259 hrs. (Flight crew duty time would have required the aircraft to take off from Malaga by 0200 hrs).

At 0121 hrs OV arrived at Birmingham and landed on Runway 33. A replay of the flight data recorder gave the landing parameters for the last 12 flights. These indicated that the relevant parameters of the accident flight landing, where known, were no worse than average.

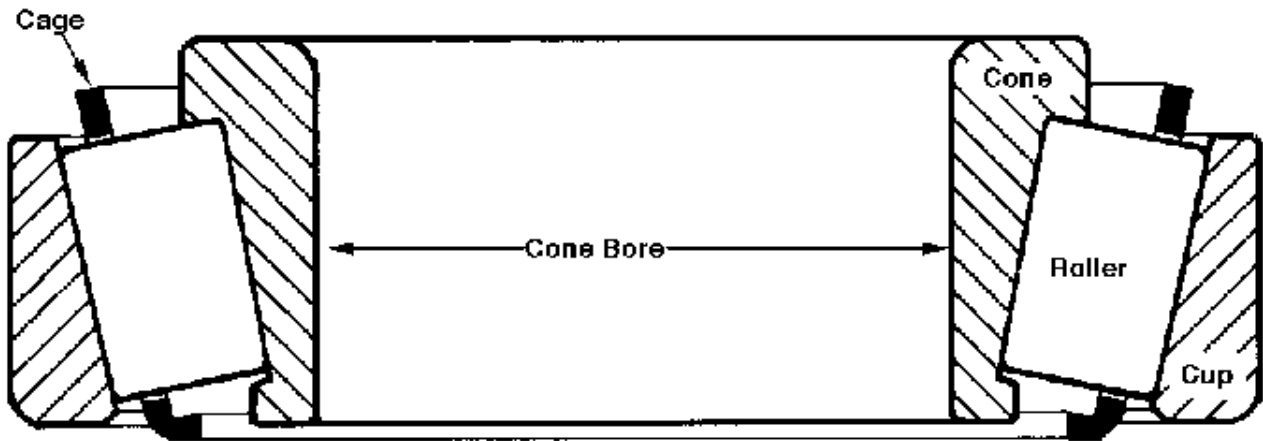
G-OOOV turned off Runway 33 via the rapid exit taxiway; at a speed of 12 kt a 'snap' was heard and vibration was felt through the steering. The aircraft was brought to a full stop over a distance of 20 yards and ATC and the airport emergency services were informed. Passengers were disembarked via steps and taken by bus from the taxiway. Inspection revealed that the nose landing gear axle had failed inboard of the right hand outer bearing land, in the region of the axle damage dressed out in Malaga.

Subsequent Examination of Components

Bearing Failure at Malaga

The failed bearing had achieved 440 landing cycles since installation. This life was slightly higher than the average time to rejection of a random selection of 7 nose wheel bearings rejected during tyre changes.

The bearing was visually examined by a representative of the manufacturer in the presence of AAIB. With the exception of water corrosion on the cone bore the inboard bearing was in reasonable condition. The outboard bearing was severely distressed with most of the debris exhibiting plastic deformation from softening at the high temperatures experienced during the bearing failure.



Fourteen rollers out of a full complement of 27 were available for examination. The spherical grinding on the ends of some of the rollers was nearly undamaged indicating that wear at this sliding contact area had not been a problem before the rapid collapse of the bearing. The bearing cone also exhibited sections of thrust rib in relatively undamaged condition, again endorsing a rapid collapse. Several rollers showed line etching caused by water corrosion, and, in some cases, fatigue damage at these sites of corrosion.

It was concluded that the outboard bearing had collapsed rapidly. This is characteristic of a cage failure and may be caused by corroded and fatigued, spalled roller bodies wearing or 'machining' the cage arms until they are sufficiently weakened to break. Corrosion of bearings on a variety of nose wheel applications is a well known phenomenon as the bearings are generally not backed up with a brake pack which helps shield main wheel bearings from water ingress.

Examination of the bearing indicated that there had not been a lubricant failure, although the grease may have carried contaminants. The grease recovered from the bearing was therefore examined in a laboratory of the Defence Evaluation and Research Agency (DERA) at Farnborough to check for the presence of water, detergents or deicers. One grease sample was taken from the wheel carrying the failed bearing, and another sample was extracted from the bearing components in the laboratory. Unused Aeroshell 5 grease, the type used in the bearing, was also examined as a reference.

The water content of the sample taken from the bearing was not significantly higher than that of the clean grease. Detergents and deicers were not found in the samples.

Axle Failure at Birmingham

Visual and macroscopic examination of the axle gave the following information (Figure 3):

- a. A generally circumferential fracture had occurred between the wheel bearing lands at one end.
- b. There was considerable mechanical damage in the vicinity of the separation on the underside of the axle; some of this damage had been mechanically smoothed out. Measurements showed that up to 33% of the wall thickness had been removed from this region.
- c. Some of the chromium plated lands upon which the bearings sat varied in width around the circumference indicating a lack of concentricity between the axle centreline and the centreline

used during the grinding of the lands (although the axle met all of the relevant drawing requirements).

Detailed examination of the fracture surface in the initiation region showed that it had been partially 'wetted' with cadmium from the axle bore. It was also seen that cadmium in the bore, and adjacent to, the initiation region had melted and re-solidified as globules. The melting point of cadmium is 321°C.

A section of the initiation region was extracted and polished. It showed that extensive cracking had occurred around the macrograins as a result of the penetration of liquid cadmium when the material had been subjected to tensile stresses. This phenomenon is known as liquid cadmium embrittlement. Hardness tests indicated that a loss in tensile strength from approximately 118.4 tons/in² to 113 tons/in² had been caused by the localised heating when the mechanical damage occurred. However, the additional degradation by the liquid cadmium had further dramatically reduced the overall strength. Further hardness tests showed that a peak temperature of between 400°C and 500°C was reached when the axle sustained further mechanical damage at Birmingham (Figure 3).

Axle Dimensions

Some of the chromium plated lands upon which the bearings sat varied in width around the circumference. Measurements taken indicated that there was a 0.020" lack of concentricity between the axle and bearing lands centre lines (see diagram). Whilst this lack of concentricity had not contributed to the axle failure, it may have indicated a quality discrepancy; the axle was sent to Boeing, who were asked for their comments.

Boeing received the axle and conducted a thorough dimensional inspection and analysis, a review of the axle drawing was also conducted. The inspection revealed that the axle inner and outer diameters were concentric to within 0.019" as measured along its length. The drawing review showed that there was no specific drawing requirement for the internal diameter (ID) to outer diameter (OD) concentricity for the design of this axle. The axle therefore met all the applicable drawing requirements as noted on drawing 162N11511, Rev C (dated 10 June 1997).

A review was conducted of other similar axles for which Boeing holds design responsibility. Typically, the drawings called for all IDs (there are several different IDs along the length of the axle as strength, manufacturing and assembly requirements dictate) to be concentric with a single ID to within 0.010". The lack of such a requirement on drawing 162N1151 appeared to be an oversight during the design process. This will be corrected with an amendment issued at the next drawing revision, due for release in the near future.

Several discussions took place between Boeing and the 757 nose landing gear axle manufacturer, Menasco. As Menasco manufactures other similar axles for Boeing in which the ID and OD concentricity is established, the manufacturing process for these different axles is also similar and records are kept for each axle. Unfortunately, the serial number on the failed axle's records was incomplete, and an inspection of the axle did not produce a legible number; therefore the records for this axle could not be traced.

A stress analysis was conducted for the 162N1151 axle, based specifically on a lack of concentricity between the ID and OD of 0.030". This tolerance, 300% larger than that of other similarly manufactured axles, was chosen as an all-encompassing tolerance. It was felt that a lack of concentricity

beyond this would make the remaining downstream manufacturing processes for the axle difficult to complete without the discrepancy being noticed and the axle rejected. The analysis showed a positive margin of safety in both static overload and fatigue characteristics at this extreme condition.

A search of Boeing's records showed no incidences of 757 nose landing gear fractures as a result of 'thin walls' generated by non-concentric inner and outer diameters since the original design in 1979. Based upon their assessment, Boeing concluded that the lack of an internal and external diameter concentricity requirement on existing 757 nose landing gear axles does not constitute a structural or functional concern. However, in order to ensure the consistency and quality of those axles in service, Boeing intend to release a revision to the overhaul manual to inspect the concentricity of the inner and outer diameters during periodic overhaul of the axle.

Other Information

The CAA Mandatory Occurrence Reports (MOR)

The CAA MOR data base contained five reports of nose wheel bearing failures on Boeing 757 aircraft between 1985 and the failure at Malaga described above. The data base contained no previous reports of nose wheel axle failures.

Duty Engineer's Job Description

The operators exposition contains the following description of the Duty Engineer's duties: 'A licenced engineer who operates as a maintenance coordinator. Effects control of repetitive defects, co-ordinates line engineering activities to ensure that operational aircraft requirements are satisfied'.

Qualifications and Experience

The LAE who carried out the work on the axle at Malaga was aged 36 years and held a current Aircraft Maintenance Engineer's Licence with company authorisations to issue Certificates of Release to Service for repair on nominated systems, including landing gear, on A320200 and Boeing 757200 aircraft. He had held the licence since 1982.

On his return to Manchester he was re-examined on company procedures and his knowledge was found to be satisfactory. He could not account for his violation of company procedures at Malaga.

Training

Discussions with several certifying engineers indicated that they were vaguely aware of the principles of cadmium embrittlement, having heard about the phenomenon during basic training for their licences. However, the subject is not generally reinforced later during the 757 type rating course. Three training organisations used by the operator were asked whether cadmium embrittlement was included in their Boeing 757 courses. As a distinct subject cadmium embrittlement was not discussed on the Boeing 757 courses presented by these companies, although it may be referred to as an aside if there are any ongoing 'in-service' problems related to this condition.

Documentation

At the time of the accident the operator was evaluating a computer based system which would allow personnel at mainbases to access aircraft maintenance documentation from PC workstations. This system was not available on aircraft. Since the accident the operator has provided Maintenance Control with two 'fly-away kits', each comprising a laptop computer with Boeing 757 and Airbus A320 technical information stored on CD ROMs. These kits allow the user to search the documentation for any word or phrase and would identify the bearing failure check requirements if a search were to be conducted using the word 'bearing'.

Analysis

Bearing Failure

The bearing failure was initiated by water corrosion of some of the rollers; this led to heavier roller damage from fatigue. and eventually to break-up of the bearing as the roller cage was broken. The lack of shielding from a brake pack made the Boeing 757 nose wheel bearings more susceptible to water ingress than main wheel bearings. Nevertheless, the CAA MOR data base showed that failures of this bearing on Boeing 757s have only occurred in the UK approximately once every two years, and that no axle failures had been reported.

Axle Dimensions

The failure occurred on an area between the axle bearing lands and the dimensions associated with this area were satisfactory. The dimensions of the bearing lands themselves showed a positive margin of safety for both the static and fatigue strength of the axle.

Axle Failure

The axle should have been rejected at Malaga on two counts: the area between the bearing lands was severely damaged and had suffered a 33% reduction in wall thickness; and the application of the inspection contained in the AMM would have shown symptoms of cadmium embrittlement. The failure of the axle was therefore a result of deficiencies in:

The application of basic airframe trade knowledge during the inspection of the damaged axle,

The knowledge of the check for cadmium embrittlement required by the AMM,

The provision of information for the use of the LAE,

The Quality oversight of the operations in Malaga.

Training

The LAE held a basic licence and was trained to hold an authorisation for the relevant systems on the Boeing 757, he was experienced on type and was familiar with the operator's procedures to be used during rectification. He was not aware of the requirements of the AMM chapter dealing with landing gear wheel bearing failures and did not recognise that the axle was susceptible to cadmium embrittlement.

The subject of cadmium embrittlement, and its relevance to Boeing 757 landing gear axles, was not covered on three 757 type rating courses examined by the operator. It is recommended that

organisations offering type rating courses amend their syllabus to include the subject of cadmium embrittlement, where relevant.

The Despatch of G-OOOW

The decision to divert G-OOOW to Malaga reduced the preparation time available to the Duty Engineer, and this had far reaching consequences. Although he realised that the incident (as it then was) was probably going to result in an axle change because of both the mechanical damage caused by the failed bearing and the subsequent damage incurred during the towing of OV off the taxiway, he spent 40 minutes arranging a wheel change kit. No provision was made for an axle change, nor for documentation or borescope equipment to help assess the damage to the axle.

The use of OW and the implicit timescale imposed precluded an effective assessment of the probable technical problems, and the provision of appropriate information and equipment. A satisfactory solution could only have come about if the engineering problems were considered separately from the logistic problem. It is recommended that the operator carefully defines his logistic and engineering priorities in a situation where rectification is required down route.

Documentation

The LAE was despatched without knowledge of the contents of the inspection required by the AMM following the wheel bearing failure, and without knowing that such an inspection existed. He had no chance to correct this situation during his free time on the flight to Malaga because neither he nor OW carried maintenance manuals. Thus he remained ignorant of one of the two rejection criteria for the damaged axle.

The use of the fly-away kits containing a laptop computer and aircraft documentation now provisioned by the operator would have enabled the LAE to find the appropriate references. However, unless such a search was carried out at a main base before despatch, the provision of the borescope equipment would still present a logistic problem. It would therefore be prudent to provide Maintenance Control with a similar facility.

Actions in Maintenance Control after the despatch of OW

Before OW took off no-one in Maintenance Control had considered the possibility of an attempted temporary repair (rather than by replacement) to the axle, and no-one therefore considered the need to involve Quality Assurance or Technical Services Department personnel for guidance. The situation was exacerbated by the optimistic assessment of the axle condition received in Maintenance Control at 1830 hrs from OV. It was not until after 2115 hrs that the replacement Duty Engineer received a detailed assessment of the axle damage from the LAE. This was only some 90 minutes before OV took off for Birmingham.

Once the extent of the damage became known to the Duty Engineer he attempted to find repair limits in the AMM, but was unsuccessful. He then contacted Boeing in the hope that they could refer him to some existing limits. During this period Quality Assurance or Technical Services Department cover from the operator's resources could have been provided by personnel available on-call at home. However, the overall time scales tacitly accepted by the decision to use OW, and the speed of events in Malaga, mitigated against the recall and use of these personnel.

Although the Duty Engineer was responsible for co-ordinating the maintenance engineering activities concerning OV, he was the same grade as the LAE sent to Malaga, an LAE employed in the role of Duty Engineer himself. After 1900 hrs that night the Duty Engineer was an *avionics* tradesman, and he may have been reluctant to express any concern that he may have felt about the lack of repair limits to a *airframe* tradesman, 'on site', of the same grade and dealing with a component that fell within his specialisation.

Work at Malaga - Procedures and Quality

The LAE was unaware of the cadmium embrittlement rejection criteria and did not have access to the borescope equipment to allow him to apply them, he was therefore left with the physical damage plainly visible on the outside of the axle.

In spite of knowing that he was operating outside the scope of the company procedures, the LAE felt it necessary to carry out unauthorised work on the axle. This decision was illogical and against all his training; and subsequently the LAE offered no evidence to mitigate the seriousness of his violation of procedures and professional standards. Nevertheless it is possible that other certifying engineers, faced with the same circumstances, would have taken similar decisions.

The dressing-out of the abrasion damage would have had a negligible effect on the remaining static strength of the axle, and would only have affected the long term fatigue strength; it was therefore not relevant to the problem in hand. It is obvious that this action, and the fitting of two new wheels to the badly damaged axle, constituted a major breach of quality, which the quality system was too fragile to prevent.

The type of certifying engineer employed by airlines to carry out defect rectification at route stations is usually intelligent, experienced and resourceful. He has appropriate company authorisations which give him the power to declare an aircraft serviceable or *unserviceable*. He is stimulated by the challenge and stress associated with his job. He knows that if he fails to return the aircraft to service the passengers will be highly inconvenienced, and the company will be faced with a considerable cost to provide additional accommodation and/or transport. Such a person is resolute and confident and is sometimes imbued with a high amount of 'CanDo' spirit, which for the most part, works in the operator's favour. In this case the LAE returned to Birmingham with the passengers, and would no doubt, have accepted the approval expressed by them during the flight. Equally, had he not declared the aircraft serviceable 'he' would have 'failed' and felt the passengers' displeasure. There may also have been the unexpressed, but perceived, impression that he had let down his colleagues and his company. However, the engineer is trained, examined and granted an authorisation based on the premise that he is not at liberty to deviate from the company procedures or airworthiness data, without specific authority.

The LAE, who was probably tired as a result of his daytime activities, had asked for a mechanic, but one was not provided because of non-engineering reasons. He therefore had no-one to act as a backstop or to question his actions. The procedures governing his actions should have been more robust and should have removed the perception that if the aircraft was not recovered it was 'his' fault. Achieving quality in the repair to be undertaken was totally dependant on the judgement and actions of the one individual, operating in isolation, without the requisite information or significant local resources and acutely aware of the implications of not succeeding in returning the aircraft to service. The success or failure of the Operator's quality system was dependant on the performance of this one individual and was, in these circumstances, shown to be fragile.

The quality system should not allow individuals to be put into such a position. The operator's Maintenance Control, acting independently and outside the highly charged environment of the aircraft, could vet and ratify any repair decisions taken away from a main base, whether they are explicitly covered by the aircraft manuals or not. If the aircraft remains unserviceable it is then because 'engineering' have grounded it, and a significant proportion of the pressure on the certifying engineer would be removed.

It is recommended that the CAA requires the operator to review their procedures for maintenance away from a main base with the object of making them more robust, ensuring compliance with the AMM and removing some of the pressure from the certifying engineers sent to rectify aircraft down route.

Recommendations

Recommendation 98-31

It is recommended that the CAA require organisations offering type rating courses to amend their syllabus to include the subject of cadmium embrittlement, where relevant.

Recommendation 98-32

It is recommended that the CAA requires the operator to review their procedures for maintenance away from a main base with the object of making them more robust, ensuring compliance with the AMM and removing some of the pressure from the certifying engineers sent to rectify aircraft down route.

Recommendation 98-33

It is recommended that the operator carefully defines his logistic and engineering priorities in a situation where rectification is required down route.

Subsequent Action

The operator has reviewed procedures and implemented the necessary changes. The Quality Assurance Department now examine the content of all type training courses and from May 1998 they will operate their own line stations in the UK, with sufficient staff to facilitate down-route rescues.

Appendix 1 Wheel Bearing Failure/Damage Condition -Maintenance Practices Conditional Inspection

(8) Do an inspection of the Nose Gear Axle.

(a) Visually examine the wheel bearing washer, axle nut, and inner wheel bearing spacer for scoring or other damage.

1) Replace or repair the components when it is necessary.

(b) Examine the axle for damage.

- 1) Examine for scoring or discoloration of the chrome plated bearing lands on the axle.
- 2) Examine the light grey hydraulic fluid resistant paint on the axle for a brown shade caused when it becomes too hot.
- 3) Examine the green primer on the inner surfaces (bore) of the axle with a borescope.
 - a) Use the borescope to a minimum depth of 7 inches and look for discoloration or blistering.
 - b) The green primer will turn to a light brown or black colour when it becomes too hot.

NOTE If the paint shows only a small discoloration, you can do the heat damage inspection when the airplane goes back to the primary base. Do not make a landing more than three times before you do this inspection.

(9) If signs of heat damage are found in the above steps, do the Heat Damage Inspection.

(10) Replace or repair the damaged components as follows:

(a) If the cadmium plate on the axle bore shows signs of heat damage.

NOTE Heat damage to the cadmium plate can cause cadmium embrittlement of the steel substrate.

(b) If the chrome plate on the outer part of the axle shows signs of heat damage.