ISS 0803-3633

THE AIRCRAFT ACCIDENT INVESTIGATION BOARD/NORWAY
(AAIB/N)

REP.: 06/96

REPORT ON THE AIR ACCIDENT AT TROMSØ AIRPORT, NORWAY, 20 APRIL 1995 WITH BEECH SUPER KING AIR B200 LN-MOE

SUBMITTED JUNE 1996

TABLE OF CONTENTS

REPORT ON THE AIR ACCIDENT AT TROMSØ AIRPORT, NORWAY, 20 APRIL 1995 WITH BEECH SUPER KING AIR B200 LN-MOE

Aircraft type:	Beech Super King Air B200
Registration:	LN-MOE
Owner:	A/S Mørefly, Ålesund Airport Vigra N-6040 Vigra Norway
User:	Owner
Crew:	3
Passengers:	2
Accident site:	Tromsø Airport, Norway 69°41'N 018°55'E
Time of accident:	20 April 1995, 0943

All times given in this report are local times, if not otherwise stated.

NOTIFICATION

Aircraft Accident Investigation Board, Norway (AAIB/N) was on 20 April 1995 at 0950 informed about the accident by the duty Air Traffic Controller at Tromsø Airport. AAIB/N representatives arrived Tromsø Airport the same day 1630 and started the investigation without delay.

SUMMARY

A MEDEVAC aircraft (aircraft used for transportation of patients) operated by Mørefly took off from Alta Airport 20 April 1995 at 0834. A patient accompanied by a midwife was to be transported to Hammerfest. Immediately following landing gear selection to "UP" position, the crew heard a thud from somewhere in the aircraft. A red warning light in the landing gear handle indicated a landing gear problem, and this was confirmed by the Alta control tower observing the left gear in down position. Landing gear was then selected to "DOWN" position, and this resulted in an indication that left gear was unlocked (unsafe). The Pilot in Command (PIC) then decided to fly to Tromsø where the circumstances for a potential emergency landing would be better. En route to Tromsø the crew attempted a landing gear extension utilizing emergency procedures without obtaining normal indications. A flyby past the Tromsø control tower verified that all three gears were extended, but the left gear collapsed during the landing roll at Tromsø Airport. The aircraft slid the last 500 meters of the landing roll on the right main wheel, the nose wheel, the folded left main wheel and the left wing. No persons were injured and the material damages were limited to left wing, propeller, landing gear and landing gear doors. The problems with the landing gear were caused by a fracture of Clevis Assy part number 101-810180-5 in the mechanism for left landing gear.

1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1 A patient was to be transported from Alta to the maternity ward at Hammerfest Hospital. MEDEVAC air transportation was arranged. The crew included Pilot in Command (PIC), First Officer (FO), and a nurse. Due to the condition of the patient, a midwife took part in the transportation. The patient was traveling in a litter. The aircraft, with radio call signal MOR 55, took off from Alta Airport at 0834 on 20 April 1995, with fuel for a 3 hour endurance. Following a normal take off, landing gear was selected UP. A thud was heard and the red warning light in the landing gear selector remained on. This was an indication that landing gear position was not in correspondence with the position of the landing gear lever. The problem was confirmed by Alta Control Tower (TWR) from where it was reported that left gear remained down. MOR 55 was holding south of the airport at 2 500 ft

for some time while a technician in Alta was contacted via cellular telephone. The crew then selected gear down. Right and nose gear indicators both illuminated their green lights, indicating that they were down and locked. The warning light in the gear selector remained on, and the green light for the left gear was not illuminated. The "Landing Gear Relay circuit breaker" disconnected the power supply (popped).

1.1.2 Taking into consideration the requirements of the patient, the weather, runway conditions and the status of emergency services, potential landing fields were evaluated. It was decided to go to Tromsø Airport, and Air Traffic Control was informed about this. Tromsø Airport received a message at 0900 hours that a MEDEVAC flight was bound for Tromsø with potential landing gear problems. En route to Tromsø the nurse expressed concern that turbulence might trigger a premature birth. The crew went through emergency check lists "Emergency/Abnormal Procedures", including "Landing Gear Manual Extension", without succeeding in getting normal indications for the left gear. A visual check from the cockpit found both main gears in what appeared to be identical positions. At 0915 MOR 55 contacted Tromsø Approach Control (APP) and requested that emergency services were alerted that a gear-up-landing was pending. Ambulance service, fire services and the local police were alerted by the airport staff about the problem. The PIC first requested a straight in visual approach, but changed that to a request for permission to hold north of field. At 0933 the PIC reported a request to fly past the tower for a visual check of the landing gear status. Following the fly-by the crew received information that both main gears appeared to be parallel. Due to the patient's condition it was decided to land without further delay. A visual approach to runway 19 was planned and executed.

1.1.3 According to the report from the PIC, he tried to cushion the landing by using a landing speed of 80 kt and full flap. The aircraft touched down at 0943 about 600 meters from the threshold and continued about 500 meters before left gear folded forward and the left wing touched the runway. The aircraft followed the runway centerline another 500 meters before coming to rest. The wheel brakes were not used during the rollout. The engines were shut down, the propellers feathered and Fuel Firewall Shutoff Valves closed when the left wing came in contact with the runway.

1.1.4 Three firetrucks from the airport services followed the aircraft down the runway and started foaming immediately after the aircraft had come to rest. Evacuation of passengers and crew was performed without problems. The aircraft was lifted off the ground with jacks and removed from the runway, and normal services were resumed with next landing at 1212.

1.2 Injuries to persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL			
SERIOUS			
MINOR/NONE	3	2	

1.3 Damage to aircraft

The damages to the aircraft were extensive.

1.4 Other damage

None

1.5 Personnel information

1.5.1 Pilot in Command (PIC)

The PIC, male 31 years, has a Commercial Pilot License (CPL) issued 8 November 1994, which was valid until 26 September 1995. Latest medical for CPL was performed 9 September 1994, valid until 26 September 1995. His total flying experience at the time of the accident was 4903 hours, 494 hours on type. Last Periodic Flight Training (PFT) was performed 7 November 1994.

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	4:10	4:10
LAST 3 DAYS	10:45	10:45
LAST 30 DAYS	74	74
LAST 90 DAYS	146	146

1.5.2 First Officer (FO)

The FO, male 30 years, has a CPL issued 11 January 1991, which was valid until 17 August 1995. Latest medical for CPL was 17 August 1994, valid until 17 August 1995. His CPL has following limitations: Correcting lenses must be used when flying. His total flying experience at the time of the occurrence was 1335:20

hours. He had been checked out on the aircraft type in question 3 February 1995, and had 132:05 hours on type.

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	2:45	2:45
LAST 3 DAYS	10	10
LAST 30 DAYS	85:05	85:05
LAST 90 DAYS	118	118

1.6 Aircraft information

1.6.1 General

1.6.1.1 A/S Mørefly acquired the aircraft from Beech Aircraft Corporation in 1993. The aircraft had been operated for a short period by the manufacturer before it was sold. When Mørefly received it, it had accumulated 30 hours. The aircraft was registered in the Norwegian Aircraft Registry 22 November 1993 and given the registration letters LN-MOE, Certificate of Registration No. 2631. The Certficate of Airworthiness was valid until 30 November 1995.

1.6.2 Aircraft data

Manufacturer:	Beech Aircraft Corporation, Wichita, Kansas, USA (Raythcon Aircraft Company)
Type:	Beech Super King Air B 200, twin engine turboprop with interior modifications for MEDEVAC purposes
Serial Number:	BB 1460
Year of manuf.:	1993
Total time (TAT):	958:19
Total No of landings:	1861 (cycles)
Engines:	2 Pratt & Whitney Canada PT6A-42
Propellers:	2 Raisebeck/Hartzell HC-D4N-3A/D9383K

1.6.3 Maintenance

1.6.3.1 The aircraft was maintained in accordance with a maintenance program based on the manufacturer's (Beech) recommendations, approved by Beech and the Civil Aviation Administration/Norway (CAA/N). Daily Inspection (DI) shall be performed by an authorized technician and is normally valid for 24 hours. An expanded DI shall be carried out every 75 flying hours. An Interim Inspection shall be performed every 150 flying hours. A Detailed Inspection shall be carried out every 600 hours. This inspection has been sectioned in four parts, and each part has been added to the following 150-hour inspection. This work is performed at one of the company's two maintenance bases at Vigra and Alta. More comprehensive structural inspections apply as a higher number of flying hours are accumulated.

1.6.3.2 Latest DI carried out on LN-MOE was signed by a technician 19 April 1995 at 1000 hours with no remarks. At the time there were no "Hold Items" in the aircraft records which had any relevance to the accident. Latest 150 hour inspection performed on LN-MOE was signed 20 March 1995 at a total time of 899:32 hours, and a total number of landings of 1727. The part of this inspection related to the landing gear was carried out in accordance with Work Card C6.B11: Inspection and lubrication of main gear and brakes - LH. This inspection program does not include any particularinspection or inspection procedure for the Clevis assy in question. Other parts of the maintenance program do not at any point include any inspection suitable for detection of cracks in the threaded portion of the Clevis at this stage of the aircraft life.

1.6.4 Weight and balance

1.6.4.1 Based upon information from the PIC about load, the weight of the aircraft at the time of take off was 11 600 lbs (5 262 kg). This weight includes 2 000 lbs of fuel (907 kg). Maximum Take Off Weight (MTOW) for this type is 12 500 lbs. At the landing approximately 1 000 lbs (454 kg) of fuel was left in the tanks. Weight at landing was then 10 600 lbs (4 808 kg). Based on available information, the center of gravity was within its limitations.

1.6.5 Landing gear mechanism

1.6.5.1 The aircraft has two main landing gears and one nose wheel. The landing gear is of the "High Flotation" type, a modification carried out by the manufacturer, which means among other things that the wheels have a larger diameter than the standard type. Each main gear is equipped with a double set of wheels and brakes (see Appendix 1). The landing gear is installed in the rear part of the landing gear wells and folds forward into the wells on retraction. The landing gear is covered by doors that closes the wells as the gear retracts. The doors are opened by springs, mechanical lock in down position, and closed by mechanical means by the retracting landing gear. The main landing gears are supported longitudinally by a foldable drag brace. The drag brace is locked in an "over center" position when the gear is extended. When gear up is selected, the lock is released and the drag brace

folds and pulls the gear to the up position. The drag brace and its locking mechanism is operated by a hydraulic actuator. The actuator pushes the rod out when gear is lowered and retracts it when the gear is raised. The gear is locked in the up position by hydraulic lock in the actuator caused by the gear control valve. The control valve is activated by an electric switch operated by the landing gear when it reaches the up position. Manual extension of the gear may be performed using a dedicated hand pump in the cockpit. The pump draws oil from a separate tank through separate lines to the down-side of the hydraulic actuator.

1.6.5.2 Electrical switches individually register when the three landing gears are in down and locked/unlocked position, or up position. Down and locked position is indicated by green lights "GEAR DWN" for each gear. Disagreement between selected position of the gear lever and actual position by one or more of the gears is indicated by a red light in the gear handle.

1.7 Meteorological information

Actual weather (METAR) at Alta, Hammerfest and Tromsø at the time of the accident:

Alta at 0945: Wind: 160° 10 kt, Visibility: more than 10 km, Clouds: Scattered at 2 500 ft, broken at 3 500 ft, Temperature: 3 °C, Dewpoint: -2 °C, Atmospheric Pressure (QNH): 997 hPa.

Hammerfest at 0930: Wind: 220° 8 kt, variable between 180° and 250°, Visibility: more than 10 km, Clouds: scattered at 3 000 ft, Temperature: 5 °C, Dewpoint: -2 °C, Atmospheric pressure (QNH): 996 hPa.

Tromsø at 0950: Wind: 180° 6 kt, variable between 110° and 250°, Visibility: more than 10 km, Clouds: scattered at 3 000 ft, scattered at 4 500 ft, Temperature: 5 °C, Dewpoint: -2 °C , Atmospheric pressure (QNH): 995 hPa.

1.8 Aids to navigation

Not relevant

1.9 Communications

Throughout the flight normal VHF communication was established between MOR 55 and the applicable ATS units. Emergency or priority communication was not used.

1.10 Aerodrome information

ATS at Tromsø Airport was warned by the ATS at Alta at 0851 that a MEDEVAC aircraft was having a landing gear problem and might elect to go to Tromsø. At 0900 it was confirmed that the aircraft was bound for Tromsø. This gave the airport services ample time to plan for the pending emergency situation. Ambulance personnel, fire services and local police were informed. Alert level B1 was declared in accordance with the emergency plan for the airport, and three fire fighting trucks were positioned adjacent to the runway. Foaming was used to prevent a fire. Evacuation of the patient, the midwife and the crew was performed without problems of any kind.

1.11 Flight recorders

Not required, not installed.

1.12 Wreckage and impact information

1.12.1 Accident site

Runway 19 at Tromsø Airport is paved with asphalt, 2158 meters long and 45 meters wide. The aircraft followed the runway centerline and came to rest about 500 meters from the end of the runway.

1.12.2 Damage to the aircraft

1.12.2.1 During the landing the aircraft was damaged in outer portion of left wing, left flap and propeller. Since the propeller had struck the runway, the engine was removed and shipped to Pratt & Whitney Canada for inspection. The inspection found the engine serviceable with no damage related to the occurrence. Shortly after the aircraft came to rest, its left side was jacked up to allow extension of left landing gear. The gear came down and locked normally, and the aircraft was towed off the runway. Examination of the landing gear found the gear actuator (hydraulic) to be torn loose from the rest of the landing gear mechanism. The actuator had a fracture in the Clevis rod end. Both landing gear doors had been damaged in their contact with the runway. The inner door was in extended position allowing the lower half to be ground away by the runway surface. The outer door had partially folded under the outer wheel. This had resulted in extensive wear, caused by the wheel on one side and the runway surface on the other. The gear door operation mechanism showed signs of being stressed to overload in a manner compatible with a situation where the doors were held in open position when the gear was forced back into the wheel well. The landing gear Drag Brace Assembly had minor damage from being forced against the actuator rod in extended (Gear Down) position during the landing roll.

1.12.2.2 The landing gear mechanism was examined for any malfunction with a potential for overloading the hydraulic actuator. No such malfunction was found.

1.13 Medical and pathological information

As a matter of routine, the PIC and FO were subject to drug testing following the accident. No indication of alcohol or other drugs was found in the tests.

1.14 Fire

There was no fire in the accident. The friction between left main wheel and the wheel doors resulted in some smoke during the last part of the landing roll. According to rescue service personnel, sparks were flying from the left wing in its contact with the runway.

1.15 Survival aspects

It is the opinion of the AAIB/N that the potential for escaping this accident without injuries to persons was good. The risk in accidents of this type are to a large degree determined by runway dimensions, and possibly surface conditions along the runway and at the end of the runway.

1.16 Test and research

1.16.1 Examination of the left Clevis assy, LN-MOE

1.16.1.1 The part that had caused the failure of left landing gear, Clevis assy P/N (part number) 101-810180-5, was removed for closer examination. The part had been separated in two halves, one still attached to the Drag brace assembly with a bolt (see Appendix 1). The other half was threaded into the landing gear actuator. This part had extensive deformation from hitting the Drag brace assembly when the gear retracted during the landing roll. The fracture surface of this was distorted to a degree where not much information about the failure mechanism could be obtained. The other half attached to the landing gear drag brace had a relatively undistorted fracture surface, and this surface was examined carefully. Det Norske Veritas Industry AS (DNVI) has assisted AAIB/N with this work. The part was examined visually, by Scanning Electron Microscope (SEM), by metallographic examination, and hardness testing was performed.

1.16.1.2 The findings from the testing and examination were compiled in DNVI report No. 95-3340. The investigation found the threaded portion had fractured in a complex manner in the area of threads No. 5 - 14 as seen from the "fork-end" (see Appendix 2).In the photograph in Appendix 3, it can be seen that the fracture has followed the

machined groove on one of the "sides" of the part. The fracture may be divided into three main zones:

- a crescent-shaped radial zone in the same level as thread No. 14
- an axial wall "down" to thread Nos. 5 - 7
- a crescent-shaped irregular fracture covering the area around thread Nos. 5 - 7

From the photograph it also can be seen that the upper part of the fracture surface has been bent to the left. (as seen in the photograph)

1.16.1.3 SEM examination found the fracture zone at thread No. 14 level to have a narrow edge zone covering approximately half the circumference. The edge zone was about 0,3 mm wide near the machined groove, and about 0,5 mm wide 90° away from the groove (see Appendix 4, Fig. 5). Large portions of the microstructure in the fracture surface had been distorted when the surfaces had been pressed against each other again in the process of widening the crack (see Appendix 4, fig. 6). Still it was possible to find parallel lines (striations) in the edge zone (see Appendix 5, figs. 5 and 6). These are lines characteristic of a fatigue crack. The edge zone also has radial lines (brak-over marks) which indicate that the fatigue cracking has started at different levels, and at a later stage run together. In the microstructure within the edge zone, "dimples" can also be found (see Appendix 6, fig. 9). The dimples are characteristic of a fracture caused by overload in a ductile material.

1.16.1.4 SEM examination of the thread bottom surfaces "below" the fracture found cracks in this area (see Appendix 6, fig. 10). The cracks are found in two different areas of the circumference. One is near the machined groove, and the other is 180° opposite the groove. One of the cracks was forced open and examined, and the microstructure had a pattern similar to what was found in the edge zone of the fractured surface.

1.16.1.5 Metallographic examination has not revealed any deficiency in the material in the part. Hardness testing gave a result of 420 HV 10 at three individual tests. Converting this hardness to the Rockwell scale and tensile strength using the ASTM A370 standard table, the respective numbers are 43 Rockwell C and 1390 MPa. These values are within the specification for the component.

1.16.1.6 The report from DNVI concludes:

> "From the total clevis rod examination carried out by DNVI, it is to be concluded that the thread base surface cracks have been initiated by the mechanism of fatigue as a consequence of dynamic service loads. One of the cracks is found to be responsible for the clevis rod fracture suffered by the aircraft LN-MOE".

1.16.1.7 The Clevis assy had been coated with white paint in areas outside the threaded portion. It had not in any way been marked to facilitate status and identity.

1.16.2 Examination of the right hand Clevis assy from LN-MOE

1.16.2.1 The rod end from the right hand landing gear was removed and brought to DNVI for examination. The cadmium coating was removed. A SEM examination found cracks in bottom of all threads from No. 1 to 12 as seen from the "fork end".

1.16.3 Examination of other Clevis assy coming from B200 aircraft operated by Mørefly A/S

1.16.3.1 The fracture in the landing gear mechanism of LN-MOE led to an examination of Clevis assy P/N 101-810180-5 on the remaining six B200 aircraft operated by the company. The examination was carried out by DNVI for the purpose of checking the threads for cracks. This examination was done on request from Mørefly. Out of a total of twelve units examined, cracks were found in the thread bottoms of nine units. According to the report there is no clear pattern as to location of the crack on the circumference. Cracks were found in what would be unengaged threads when the rod end is installed. The examination was visual examination under an optical microscope, Nondestructive Testing (NDT) utilizing Magnetic Particle Inspection (MPI), SEM, and by optical projector. The examined rod ends had been in operation from 923:27 hours to a maximum of 1025:35, and between 1636 and 1861 landings. The examination also found major differences among the units regarding thread profile and surface quality (see Appendix 8, fig. 39, and Appendix 9, fig. 43). According to DNVI this is related to variations in manufacturing process of the threads. None of the rod ends had any identity marking.

1.16.4 Examination of two new Clevis assy received as replacement parts

1.16.4.1 Mørefly contracted DNVI to examine two new rod ends. The components showed great variations in thread profile and surface quality, thus representative of two main types. These two main types were named A and B respectively (see Appendix 7, fig. 4 and 5). Both units was provided with inspections marks, date and the text "Harlow Acft. MFG." (Ref. 1.16.1.7).

1.17 Organizational and management information

1.17.1 A/S Mørefly dates back to 10 June 1955 when the company was founded. At the time of the accident, A/S Mørefly was a wholly owned subsidiary of Helikopter Service A/S, and was managed by an Accountable Manager. The company owned nine Beech 200/B200 and three helicopters (2 ea AS 350 B1 and 1 SA 365 N). At the time of the accident a total of 139 persons were employed by the company, 45 working in the Maintenance Department. MEDEVAC flights were the main occupation of the company, only two helicopters were utilized for other purposes. Activities were divided among the main base, Vigra, and six satellite bases.

Together with Vigra, Alta was a main base for maintenance. The base at Alta was headed by a manager with double duty as administrative and maintenance supervisor, and an operations manager. The organization at Alta was reporting to the main base at Vigra in all administrative and maintenance matters. The Maintenance Department was headed by a maintenance manager. The quality assurance manager was reporting to the maintenance manager in all administrative matters, but in all matters where the company standard of safety was not met, he was to report directly to the Accountable Manager of the company.

1.18 Additional information

1.18.1 Checklists

The company is utilizing the Flight Safety Training Checklist as checlists. Following are relevant extracts from the checklists:

1.18.1.1 EMERGENCY. LANDING GEAR WILL NOT RETRACT (HYDRAULIC SYSTEM)

1. Landing Gear Relay CB .....CHECK IN
2. Emergency Extension Lever.....STOWED
3. Landing Gear Handle.....UP

If gear will not retract:

4. Landing Gear Handle.....DOWN
5. Landing Gear Relay CB.....PULL
6. Maximum Airspeed.....185

1.18.1.2 LANDING GEAR MANUAL EXTENSION (HYDRAULIC SYSTEM)

1. Airspeed.....130
2. Landing Gear Relay CB.....PULL
3. Landing Gear Handle.....DOWN
4. Extension Lever.....PUMP UNTIL THREE GREEN LIGHTS
5. Extension Lever.....STOW

WARNING

If for any reason the green GEAR DOWN lights do not illuminate (i.e. in case of an electrical system failure), continue pumping until sufficient resistance is felt to ensure that the gear is down and locked.

WARNING

After manual (emergency) landing gear extension has been made, do not move any landing gear controls or reset any switches or circuit breakers until the airplane is on jacks, since the failure may be in the gear-up circuit and the gear might retract on the ground.

1.18.1.3 LANDING UNSAFE GEAR

NOTE

The following procedures referencing landing with an unsafe gear have been derived from the best information available. They are recommendations only and are not considered mandatory. The pilot can, and should, deviate from any procedure if he feels that the procedure will compromise safety.

TYPE II (One Main Gear Up or Unsafe)

If the left or right landing gear fails to extend and the other gear extends normally, a break in the drive mechanism to the unextended gear has probably occurred, and the emergency gear extension procedure did not work.

The remaining gear should be retracted, and a type I (All Gear Up) landing should be accomplished.

If these attempts fail and the airplane must be landed with the nosewheel extended and one main gear indicating unsafe, the landing should be made on a hard surface runway. It is not recommended that a one-main-gear-up landing be attempted on a grass/sod runway or grassy area next to the runway.

The fuel load should be reduced as low as possible (not less than 265 pounds per side).

1. Fuel Load.....REDUCED
2. Passenger Briefing.....COMPLETED
3. Seatbelts/Harness for Passengers.....SECURED
4. All Loose Equipment.....SECURED
5. Baggage Compartment Light.....ON*
6. Bleed-Air Valves.....ENVIRO OFF
7. Cabin Press Switch.....DUMP (WHEN PSID IS ZERO)
8. Emergency Exit.....REMOVED (OPTIONAL)
9. Emergency Gear Extension Pump/Handle.....SECURED
10. Landing Gear Handle.....UP
11. Landing Gear Relay CB.....PULL
12. Seatbelt/Harness for Crew.....SECURED
13. Nonessential Electrical Equipment.....OFF*
14. Before Landing Checklist.....COMPLETED

On final approach:

15. Boost Pumps/Crossfeed.....OFF
16. Landing Gear Warning Horn CB.....PULL
17. Flaps.....100%
18. Yaw Damper.....OFF
19. Airspeed.....NORMAL APPROACH SPEED
20. Power Levers (Runway Assured).....IDLE
21. Propellers.....FEATHERED
22. Condition Levers.....CUT-OFF
23. Fuel Firewall Valves.....CLOSED
24. Master Switch (Gang Bar).....OFF*

CAUTION

Execute normal approach; touch down as smoothly as possible and well to the same side of the runway as the extended gear to allow room for possible ground loop. Roll on the down-and-locked gear, holding the opposite wing up and the nose straight as long as possible. As the wingtip strikes the runway, apply opposite brake to maintain directional control.

*If the landing is to be performed at night, the pilot may elect to turn on the cabin lighting prior to touchdown and leave master switch on for a lighted evacuation. The baggage light is hot-wired and should be on regardless of the master switch position.

1.18.2 Blueprint criteria for Clevis assy

According to the manufacturer's, Beech Aircraft Corporation, blueprint criteria, the threads on the Clevis assy should be manufactured by rolling ("Rolled threads required").

1.18.3 Relations with State of Manufacture (USA) and the manufacturer, Raytheon Aircraft Company

1.18.3.1 The accident was reported in accordance with international regulations. A representative from the manufacturer came to Norway and was given all information and kept current about the accident. Raytheon Aircraft has continued to work with the problem, but has not, when asked by AAIB/N, provided any information. Approaching the manufacturer through National Transportation Safety Board (NTSB), has resulted in confirmation that Raytheon Aircraft is working on the case, that they have found surface cracks in other rod ends of this type, and that AAIB/N will be informed about their findings. No such information has been received before this report is published.

1.18.3.2 When queried by Mørefly A/S, Raytheon Aircraft suggest that all rod ends are replaced when they reach 1500 landings. Raytheon Aircraft has volunteered to cover the exchange program under warranty.

1.18.4 Relations with the Civil Aviation Aaministration/ Norway (CAA/N)

AAIB/N has informed CAA/N of all findings during the investigation. This includes presentation of the report prepared by DNVI on behalf of AAIB/N.

1.19 Useful or effective investigation techniques

During the investigation, no special or unusual investigation techniques have been utilized.

2 ANALYSIS

2.1 Cracking mechanism in Clevis assy

2.1.1 AAIB/N has not succeeded in establishing without doubt the initiating cause of the crack development in the thread bases of the Clevis assy . It could not be determined whether the cracks were initiated by the thread manufacturing process or not. If the normal service loads initiated the fatigue mechanism, it could be expected that the cracks started where they did since the thread grooves represent a stress concentration point.

2.1.2 Cracks, including the fracture, were found in 11 out of a total of 14 Clevis assy examined during the investigation. The aircraft manufacturer has reported finding cracks in identical parts installed in aircraft in USA. Based on this information AAIB/N finds the failed part in LN-MOE not to be an isolated case caused by abnormal operations, or a failure caused faulty or negligent maintenance.

2.1.3 The landing gear is held in its up position by the actuator being locked by the landing gear control valve. This design applies dynamic loads in tension to the Clevis in all situations where the landing gear is not down and locked. The load will vary with the weight of the landing gear and the g-load on the aircraft. It is the opinion of AAIB/N that a High Flotation Landing Gear results in a load different from what is applied by the standard gear. The manufacturer has not made available the information required to make a precise assessment of this situation. However, it seems to be evident that the Clevis assy is not of a design, material, manufacture or of dimensions required to sustain normal service loads over an extended period of operation. This view is supported by the fact that Raytheon Aircraft Company, upon request from Mørefly, suggested the part to be replaced when it reached 1500 landings, and that this replacement was accepted as a part of the warranty program.

2.1.4 One of the DNVI-reports concludes that "improper machining" is evident in the thread bottoms on some of the rods. Furthermore it is reported large variations in thread profiles and surface quality. The photograph in Appendix 9, fig. 43, is indicating a surface which, in the opinion of AAIB/N, does not correspond with the requirement in the blueprints to manufacture the threads by rolling. However, due to the lack ofinformation, it can not be determined whether the cracks in the rod ends are initiated by the manufacturing process or not.

2.1.5 AAIB/N has informed the manufacturer and the authorities of the State of Manufacture about the findings. The report prepared by DNVI has been presented to the proper authorities. In the opinion of AAIB/N, these precautions should be sufficient for the purpose of flight safety. Based on this AAIB/N does not find it useful to continue the investigation of cracking mechanism in the Clevis assy.

2.2 Maintenance routines at A/S Mørefly

2.2.1 AAIB/N did not find any indication that the operator did not comply with the current regulations covering the maintenance of the landing gear on the B200 aircraft it owned. The cracks in the threaded portion of Clevis assy P/N 101-810180-5 were, in the opinion of AAIB/N, of a nature which could not be expected to be found by visual inspection before the accident.

2.3 The emergency landing

2.3.1 In the opinion of AAIB/N, the crew acted in a rational manner when the emergency situation arose, and the emergency landing was handled in a safe way. The airport emergency service, alertness and procedures at the emergency landing and the ensuing evacuation, contributed in a high degree to prevent injuries to persons and damage to materiel. It is also considered a correct decision to carry out the emergency landing at Tromsø Airport where the best resources in emergency service and runway facilities could be found.

2.3.2 The check list "Landing Unsafe Gear" (See 1.18.1.3):

"The fuel load should be reduced as low as possible (not less than 265 pounds per side)."

The emergency landing was performed with approximately 1 000 lb fuel in the tanks. This is appreciably more than recommended in the check list. The timing of the landing was, however, determined based on the condition of the patient, and it is the opinion of AAIB/N that this decision should not be questioned.

2.3.3 The emergency landing was carried out without use of brakes. Moderately used, the brakes could possibly have prevented the gear from folding forward in this case. The emergency check list recommends use of brakes only for directional control. The crew were not aware of the actual nature of the landing gear problem and

elected not to use brakes for the purpose of minimizing the load on the gear during the landing roll. AAIB/N support this decision.

3 CONCLUSIONS

a) The Pilot in Command and the First Officer possessed the required licenses for the actual flying duty and had passed the periodic training required.

b) The aircraft was properly registered .

c) The aircraft had been maintained in accordance with the approved maintenance program.

d) The aircraft was equipped with High Flotation Landing Gear.

e) At the time of the accident, the aircraft had accumulated 958:19 operating hour and a total of 1861 landings.

f) The emergency landing was precipitated by a fracture in Clevis P/N 101-810180-5 in the left main landing gear. (Cause factor)

g) The emergency landing was carried out at Tromsø Airport with no injuries to persons.

h) An examination performed by DNVI concludes that the surface cracks in thread bottoms in the Clevis assy have been initiated by a fatigue mechanism as a consequence of dynamic service loads. One of the cracks has been found to be the main cause of the fracture in Clevis assy. (Cause factor)

i) It has not been possible to determine why the loads applied to the Clevis assy initiated a fatigue mechanism leading to failure after 1861 landings.

j) An examination carried out by DNVI concludes that cracks also were found in the thread bottoms of the Clevis assy installed in the right landing gear.

k) The Clevis assy had not been marked in any way to provide information about identity and status.

l) Out of a total of 12 rod ends examined by DNVI for A/S Mørefly, cracks were found in 9. The parts had accumulated between 1636 and 1865 landings.

4 SAFETY RECOMMENDATIONS

AAIB/N is recommending that CAA/N conducts a study of the safety of flight aspect in connection with the findings of cracks in Clevis assy P/N 101-810180-5 in Beech aircraft with a hydraulic landing gear.

5 NOTE

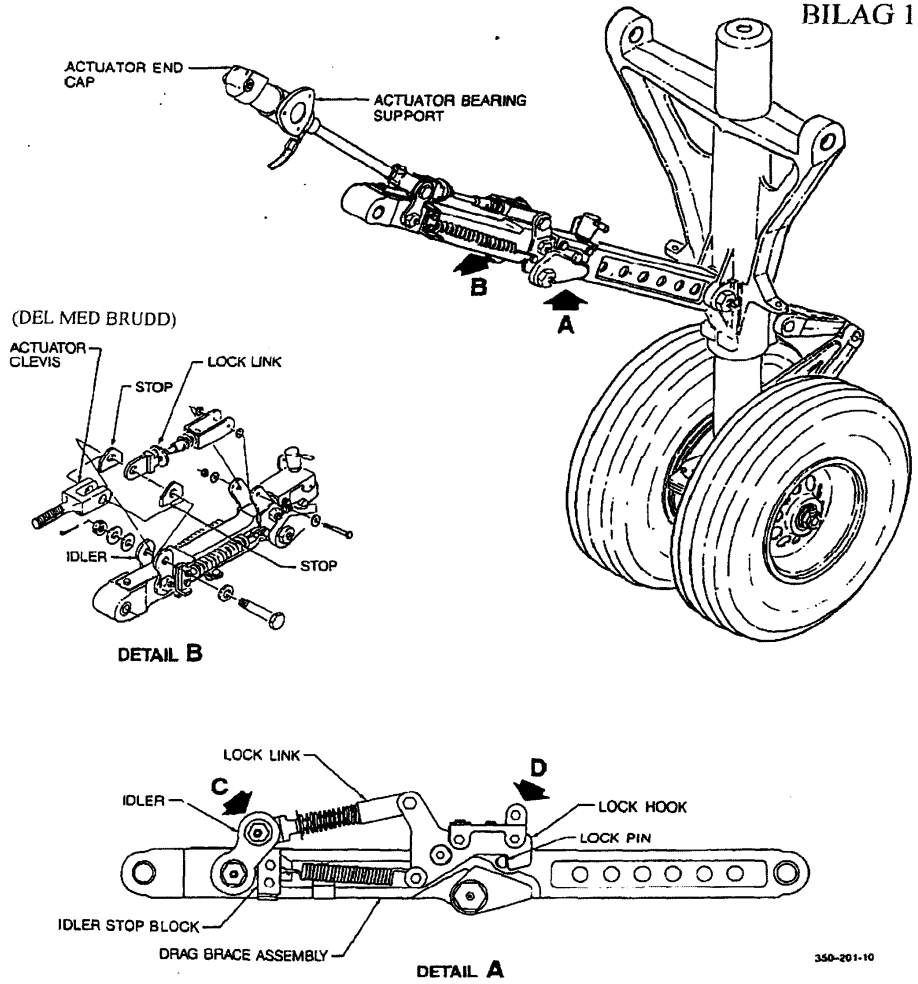
After completion of the investigation, and after the 60 days limit for comments on the draft Final Report, the AAIB/N received the following information from Raytheon Aircraft Company:

Raytheon Aircraft Company has analyzed clevises from 11 airplanes in addition to the 7 operated by A/S Mørefly. From the analyses of the 11 airplanes, 12 clewises were found to have shallow cracks. Flight tests conducted in May 1996 indicated that the clevis is exposed to loads high enough, in their opinion, to significantly shorten the fatigue life of the clevis. Based on this, they are evaluating various options to increase the fatigue life of the clevis. The likely solution will be to design a new clevis and possibly some associated parts. Raytheon Aircraft Company has also revised the part planning to call for thread rolling after heat treat. Previously the part planning called for the treads to be rolled prior to heat treat.

6 APPENDICES

1. Landing gear layout
2. General view of one half of broken Clevis assy
3. Close-up of fracture
4. SEM photographs of fracture surface
5. SEM photographs of fracture, microstructure
6. SEM photographs of fracture surface, microstructure and cracks in threads 3-7
7. SEM photographs of threads
8. SEM photographs of irregularities from manufacturing process
9. SEM photographs of irregularities from manufacturing of thread bases
10. Abbreviations.

BILAG 1



Main Landing Gear Drag Brace Assembly (Sheet 1 of 2)
Figure 215

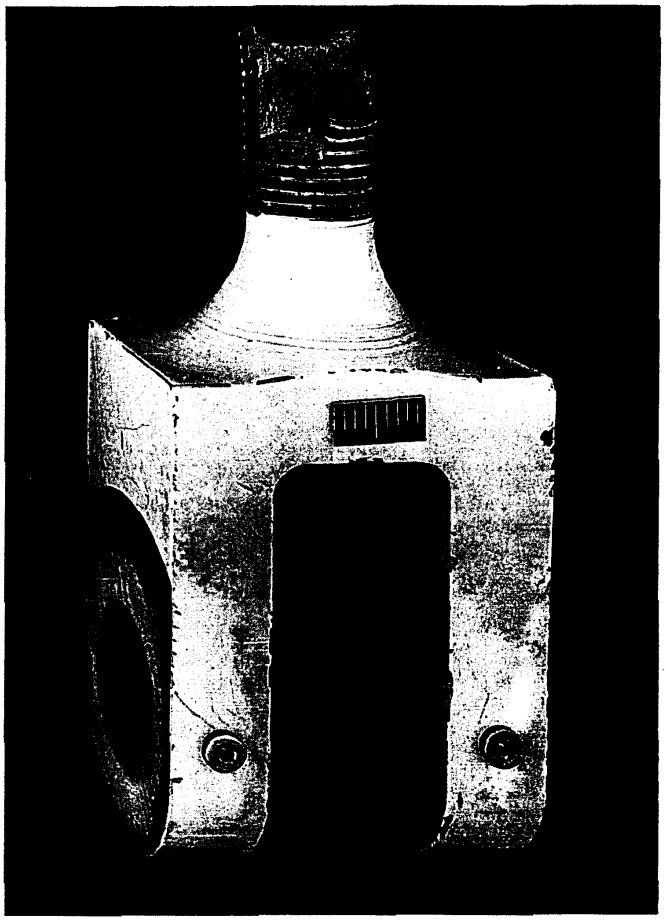


Fig. 3 General view of the broken L/H clevis rod from the aircraft reg. LN-MOE. The machined groove in the one side of the threaded portion is seen at the top of the photo.

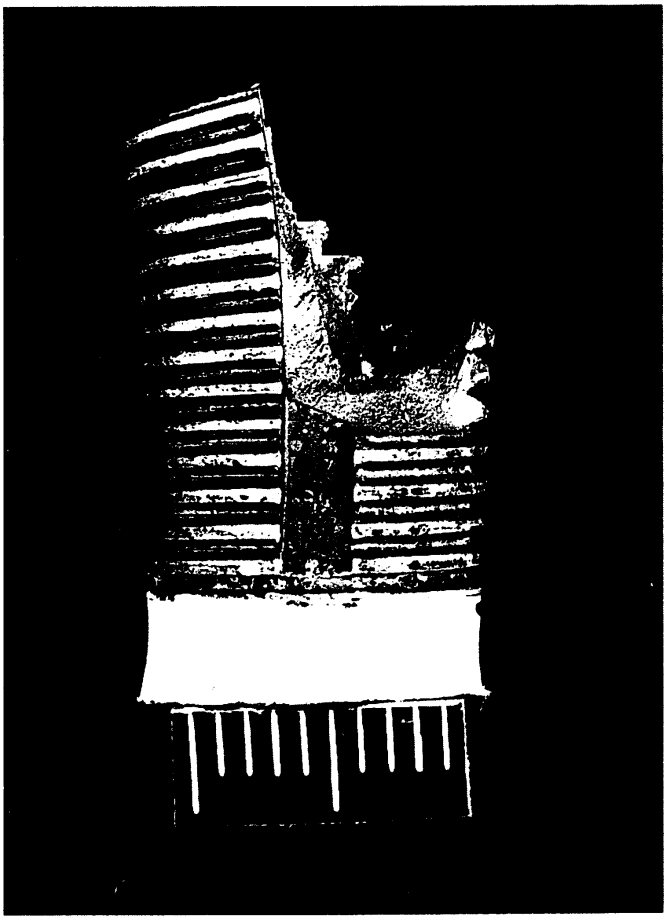


Fig. 4 Close-up photo of the broken clevis rod revealing the side profile of the fracture surface. The machined groove has obviously influenced the axial section of the fracture. It is also seen that the threaded section is slightly bent towards the left side (ref. photo only).

Fig. 5 General SEM view of the upper semi-circular section of the fracture. A narrow edge zone of a somewhat different (darker) appearance is noted. Magnification 10 X

Fig. 6 SEM close-up photo showing a "smeared" micropattern within the narrow edge zone seen in Fig. 5. Magnification 1500 X

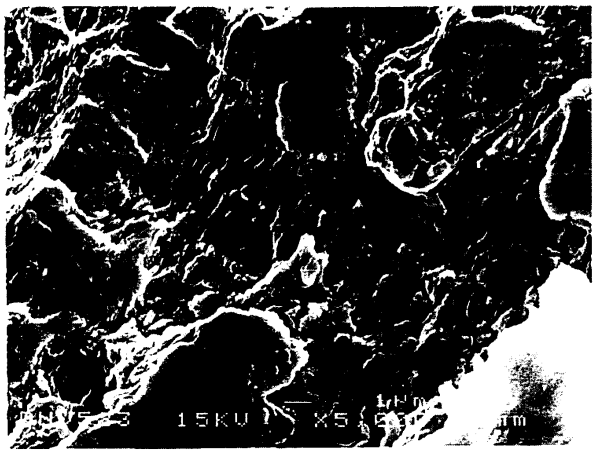


Fig. 7 SEM photo representing the intact micropattern of the narrow edge zone at a location close to the machined groove (ref. Fig 5). Fatigue striations and parallel microcracking is noted. Magnification 5000 X

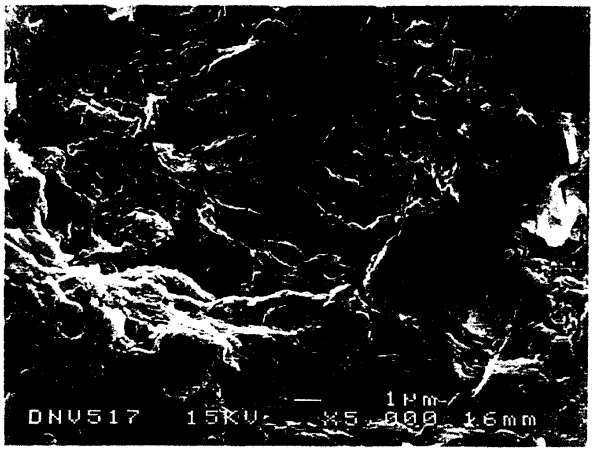


Fig. 8 SEM photo representing intact micropattern of the narrow edge zone at a location nearly 180 degrees opposite to the machined groove (ref. Fig. 5). Fatigue striations and parallel microcracking is indicated. Magnification 5000 X

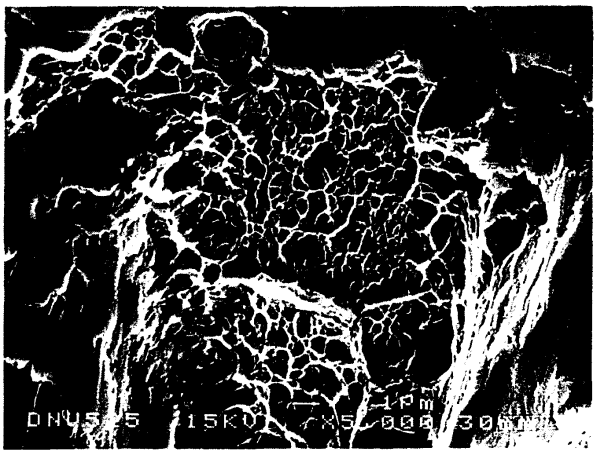


Fig. 9 SEM photo showing the micropattern of the fracture outside the narrow edge zone, representing so-called "dimples" which are characteristic for a ductile material overload. Magnification 5000 X

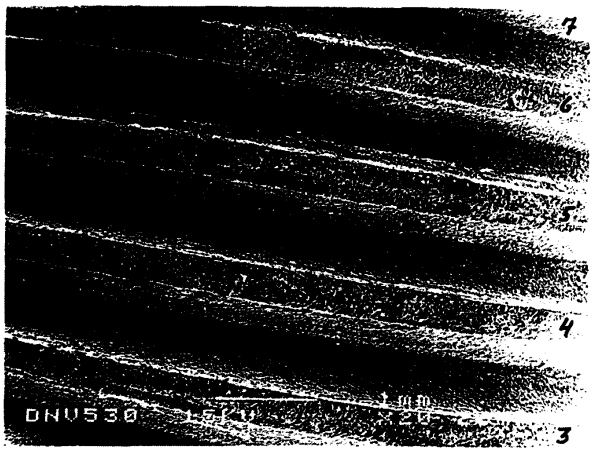


Fig. 10 SEM photo representing the threads No. 3 to 7 from the fillet area. Base area cracking is seen between all the threads in question. Magnification 20 X

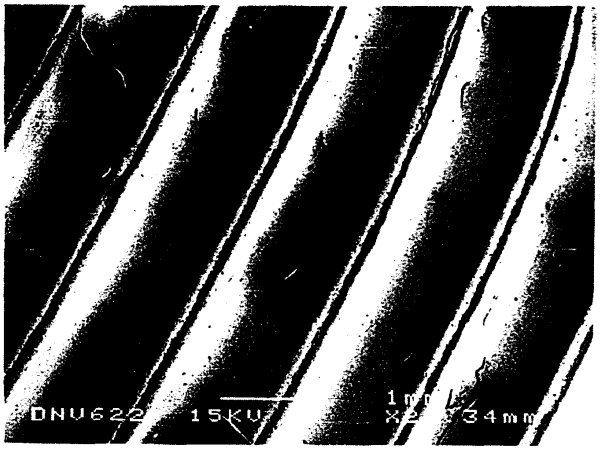


Figure 4 SEM photo showing the threads of the clevis rod marked "A". Due to improper cleaning of the specimen, some particles are present on the surface. Magnification: 20X

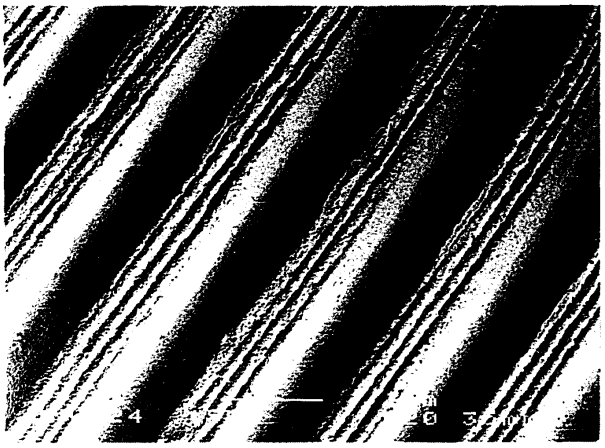


Figure 5 SEM photo showing the threads of the clevis rod marked "B". Magnification: 20X

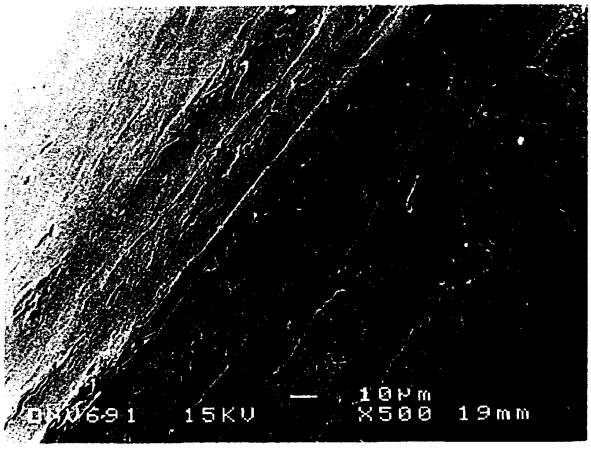


Figure 39 SEM detail photo of the base area No. 1 from the fillet area of the L/H clevis from the aircraft LN-MOG. Score marks, most likely caused by some improper machining, can be observed. Magnification: 500X

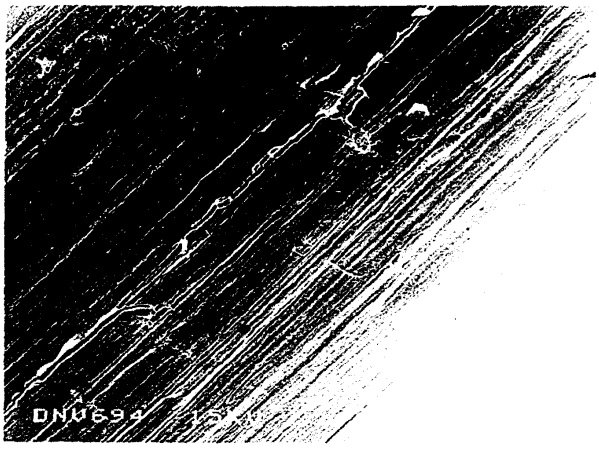


Figure 42 SEM detail photo of the crack shown in Fig. 41. Magnification: 500X

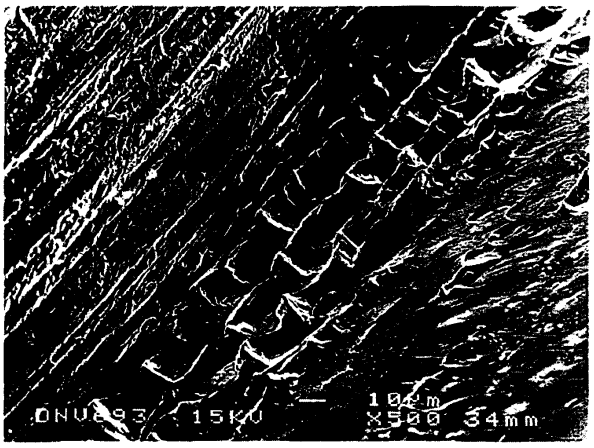


Figure 43 SEM detail photo showing score marks from improper machining in the base area No. 1 from the fillet area of the R/H clevis rod for the aircraft LN-MOG, seen after a HCl cleaning. Magnification: 500X

APPENDIX 10

AAIB/N	Aircraft Accident Investigation Board, Norway
CB	Circuit Breaker
DNVI	Det Norske Veritas Industry
E	East
ft	feet
hPa	hectopascal
kg	kilogram
km	kilometer
kt	knot (nautical miles/hour)
lb	pound (0454 kg)
LH	left (hand)
MPI	Magnetic Particle Inspection
N	North
NDT	Non Destructive Testing
NTSB	National Transportation Safety Board (USA)
PFT	Periodic Flight Training
P/N	Part Number
RH	right (hand)
SEM	Scanning Electronic Microscope
TWR	Tower (control tower)