Department of Transport

Bureau of Air Safety Investigation

INVESTIGATION REPORT
B/902/1080

Cessna 210N VH-PLD
Near Oakdale, New South Wales
22 December 1990

Released by the Director of the Bureau of Air Safety Investigation
under the provisions of Air Navigation Regulation 283

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GLOSSARY OF TERMS AND ABBREVIATIONS

agl	above ground level
amsl	above mean sea level
ATS	Air Traffic Services
CAA	Civil Aviation Authority
FIS	Flight Information Services
MHz	megahertz
NM	nautical miles
NSW	New South Wales
RAAF	Royal Australian Air Force
TCM	Teledyne Continental Motors
VOR	Very high frequency omnidirectional radio range

All times are Eastern Summer Time (Co-ordinated Universal Time plus 11 hours) unless specifically stated.

SYNOPSIS

At 1144 hours Eastern Summer Time, on 22 December 1990, during a search for a missing aircraft, Cessna 210 aircraft VH-PLD crashed in inhospitable terrain following a complete loss of engine power. The aircraft was destroyed by impact forces; the pilot, co-pilot, and two observers received fatal injuries and two other observers suffered serious injury.

The Bureau determined that a failure of a connecting rod bolt resulted in the loss of engine power. The connecting rod penetrated the crankcase, allowing engine oil to escape. The oil was blown back onto the windscreen, probably obscuring the pilots' vision during the forced landing approach.

1. FACTUAL INFORMATION

1.1 History of the flight

On Friday 21 December 1990, a Cessna 152, VH-BUO operated by the NSW Air Training Corps, failed to return from a training flight. Its last known position was over the north-west arm of Lake Burragorang. A limited search was commenced that afternoon but was unsuccessful.

On Saturday 22 December, a full-scale search organised by the CAA commenced at first light. The search was directed from the CAA's Rescue Co-ordination Centre at Mascot Airport and involved eight helicopters and five fixed-wing aircraft. The single engine fixed-wing aircraft were allocated search areas which generally were located within designated flying training areas and over terrain which offered pilots a reasonable opportunity to conduct a safe forced landing in the event of an engine failure.

A Cessna 210, VH-PLD, was allocated a search area 'Charlie' west of Camden Aerodrome and bounded on the west by roads running north and south from Oakdale. The crew was tasked to carry out a creeping line-ahead search oriented east-west at 1,000 ft AGL. At 0651 hours VH-PLD departed Camden for its search area, but returned at 0725 hours without completing the search due to low cloud in area 'Charlie'.

The crew, consisting of two pilots and four observers, then boarded the aircraft and departed at 1040 hours to continue the search in area 'Charlie'. Sydney Flight Service received scheduled operations-normal calls from the aircraft at 1109 and 1138 hours.

At 1141:22 hours, a Mayday call was received stating the aircraft was approximately 5 NM west-south-west of Oakdale, with a partial loss of engine power and tracking to The Oaks airstrip. At 1142:01 hours, a further call was received reporting a complete loss of engine oil pressure, that the engine power was decreasing and that the aircraft was descending through 2,000 ft. Its location was reported as being in the Kangaroo Point area, in the valley west of Tumbledown Mountain. Later, at 1143:44 hours, the crew reported that the engine had stopped, and that the aircraft was descending through 1,000 ft south of Tumbledown Mountain.

The crew of search helicopter VH-NSA monitored the emergency calls, established two-way communications with the pilots of VH-PLD and attempted to make visual contact. VH-NSA

and media helicopter VH-HPB proceeded to the reported location of VH-PLD but neither crew was able to establish visual contact.

The last recorded transmission received from VH-PLD was at 1144:02. Ground impact probably occurred within 30 seconds and the aircraft's emergency locator transmitter commenced operating soon after.

VH-NSA and VH-HPB, together with other search aircraft who monitored the Mayday call, proceeded to the Tumbledown Mountain area. The wreckage was visually located at 1158 hours by the crew of VH-HPB. A crewman from VH-NSA was winched into the accident site at 1205 hours to determine the condition of the survivors and to render assistance.

The accident site was at 34˚11'S 150˚23'E, and about 520 ft AMSL, in heavily timbered sloping terrain, approximately 12.5 km outside the boundary of search area 'Charlie'.

The crew of VH-PLD did not seek authorisation to search outside their assigned search area, nor did they advise Sydney Flight Service of operations outside area 'Charlie'. A Sydney Visual Terminal Chart found on board the aircraft after the accident, had an area similar to search area 'Charlie' drawn on it, but with the western boundary running west of Tumbledown Mountain.

1.2 Injuries to persons

	Crew	Passengers	Others
Fatal	4	–	–
Serious	2	–	–
Minor/None	–	–	–
TOTAL	6	–	–

1.3 Damage to aircraft

The aircraft was destroyed in the accident.

1.4 Other damage

Nil.

1.5 Personnel information

The pilot in command, aged 26, held a current Commercial Pilot Licence, endorsed with a Grade One Flight Instructor Rating and a Command Instrument Rating. He was employed as the Chief Flying Instructor of the company which operated the aircraft. At the time of the accident he had a total flying experience of 2,296 hours. His hours on Cessna 210 aircraft could not be determined, but he had flown at least 18 hours on the type in the last 2 years. His last aircrew medical was on 26 October 1990.

The co-pilot, aged 27, also held a current Commercial Pilot Licence. He was employed as a general duties pilot in the RAAF. His total flying experience was 4,186 hours, of which 2,012 involved civil flying, including 19 hours on Cessna 210 type aircraft. His last civil aircrew medical was on 15 November 1990.

Of the two observers who suffered fatal injuries, one held a Commercial Pilot Licence and the other a Private Pilot Licence. The two observers who survived the accident both held Student Pilot Licences.

All three commercial pilots on board the aircraft had been involved in organising the various fixed-wing aircraft at Camden searching for VH-BUO.

1.6 Aircraft information

The aircraft, Serial Number 21064704, was manufactured in the USA in 1982 and had flown approximately 2,620 hours at the time of the accident. The aircraft had a current Certificate of Airworthiness. A Maintenance Release had been issued on 12 December 1990 at 2,587.0 airframe hours.

The engine, Continental IO-520L Serial Number 577017, was fitted as new to the aircraft during manufacture. It had been overhauled in 1988, and had operated for 707.3 hours prior to the accident. All mandatory replacement parts had been changed and a new set of connecting rod bolts were installed during the overhaul.

Post-accident calculations indicate that the aircraft's weight and centre of gravity were within allowable limits.

1.7 Meteorological information

The weather at the time of the accident was fine. There was scattered cloud above 2,500 ft AMSL, the wind was a light northerly and visibility was in excess of 10 km.

1.8 Aids to navigation

Not relevant.

1.9 Communications

All aircraft involved in the search maintained radio communications with Sydney FIS on 121.1 MHz. The automatic voice recording tape of communications between Sydney FIS and VH-PLD showed that satisfactory two-way communications existed until shortly before the accident.

1.10 Aerodrome information

Not relevant.

1.11 Flight recorder

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was any required by regulation.

1.12 Wreckage and impact information

The aircraft collided with several large trees whilst on a southerly heading. It then impacted the ground in a steep nose-down attitude and came to rest upright, heading north-west, some 48 m from its first contact with the trees.

An examination of the wreckage revealed the outboard sections of both wings were severed by impact with limbs and branches of large trees. The fuselage was severely damaged by the subsequent heavy ground impact, during which the engine was driven back into the forward cabin area. The landing gear was retracted and the flaps extended 10° at the time of impact. Damage to the propeller indicated little evidence of rotation.

The engine suffered an internal material failure. The number 6 connecting rod cap bolts had failed and liberated the connecting rod. The rod punctured, and became jammed in, the top of the crankcase. Further internal damage after the bolt failure resulted in the loss of oil pressure and the subsequent total loss of engine power. Oil from the ruptured crankcase flowed back over the windscreen.

1.13 Medical and pathological information

There was no evidence that the pilots had any medical or psychological conditions which might have contributed to the accident.

1.14 Fire

There was no evidence of pre- or post-impact fire.

1.15 Survival aspects

Two helicopters operating above the search area monitored VH-PLD's Mayday call and unsuccessfully attempted to gain visual contact before the accident. These aircraft arrived in the general vicinity of the accident site soon after ground impact but did not sight the wreckage until some 14 minutes later. Six minutes later a crewman was winched into the accident site to determine the condition of and render assistance to the occupants. A paramedic team reached the site at about 1230 hours and administered first aid to the survivors.

The accident was non-survivable for the occupants of the front and middle seat rows due to the severe longitudinal decelerative forces and the entry of the engine into the forward cabin area. The rear-seat survivors were subjected to a combination of forces. The initial severe forward deceleration was followed by a secondary vertical deceleration as the aircraft's tail slapped down onto the ground at the termination of the accident sequence.

The aircraft's occupant restraint harnesses were of an approved type and remained intact during the accident. All occupants were wearing restraint equipment at the time.

1.16 Tests and research

A detailed investigation of the connecting rod bolt failure mode determined that the failure was due to fatigue cracking at the central guide portion of the bolt, an area where no manufactured geometric stress concentrator exists. The crack had initiated from fretting damage as a direct result of movement between the connecting rod and the cap because bolt tension was insufficient to arrest the movement. Poor surface finish and lubrication between the surfaces were noted. The threaded end of the bolt with the nut and safety pin were not recovered so no determination could be made of the reason for the low bolt tension. Examination of the bolts from numbers 1, 2, 3 and 4 connecting rods revealed that fretting was present on the central guide portion of the bolts. The extent of the fretting was variable. The bolt extensions were not measured prior to disassembly of the engine.

The engine manufacturer's assembly data indicates that the surfaces should be lubricated prior to assembly. A check of various engine overhaul facilities indicated uncertainty in this area, with some assembling wet and others dry. However, it could not be determined how the rods from VH-PLD were assembled.

Some reasons for a reduction in pre-load, assuming the correct torque has been applied to the nut are: the condition of the bolt and nut threads; the geometric thread forms and match of the bolt and nut; and interference of the bolt in its assembly hole. Additional variation associated with the torque tolerance to accommodate fitting the safety pin to the nut is seen in service engines.

Fretting of the connecting rod to cap mating surfaces has not been observed in GTSIO-520 model engines. This model rotates at a higher RPM (3,300) than the IO-520 (2,850) but the connecting rod bolt torque is increased to 45.8–47.9 ft lb. (IO-520 bolt torque was 35.4–39.6 ft lb until it was increased in September 1992.)

There have been four similar recorded failures of connecting rod bolts in O-470 and IO-520 engines in Australia and New Guinea since 1975 but investigation of the failures was not of sufficient depth to determine if the fatigue cracking was initiated by fretting due to cap slip in service.

1.17 Additional information

The engine manufacturer, Teledyne Continental Motors, originally specified a torque value of 35.4–39.6 ft lb for connecting rod bolts when the IO-520 series engine was introduced in 1963. The torque value was increased to 45.8–47.9 ft lb in late 1963, and then lowered to the original value in 1966, where it remained until September 1992 when it was increased to 39.6–43.8 ft lb.

An engineering report from TCM, number A-30-2 dated 8 December 1987, recommended increasing the torque values for connecting rod bolts in 470-in^3 and 520-in^3 straight drive engines to 39.6–43.8 ft lb to provide a greater margin against connecting rod cap split line separation.

TCM advised in a telecopier message dated 5 July 1991 that the torque for connecting rod bolts was increased to 39.6–43.8 ft lb from June 1988; however, this increased figure was not promulgated to the industry until the publication of Service Bulletin M92-15 in September 1992. Analysis of the fracture surface of the failed bolt and calculations based on the results of the fracture analysis, indicated that the preload established in the bolt during engine assembly is consistent with preloads developed by the application of a torque of the order of 35 ft lb.

Although all TCM-published engine assembly instructions indicate that the connecting rod/cap mating surfaces should be assembled lubricated, a further telecopier message from TCM dated 19 September 1991 advised that the surfaces should be assembled dry.

1.18 Air Traffic Services aspects

The search for the missing aircraft VH-BUO had been carried out in accordance with laid-down procedures. There were no ATS deficiencies which might have contributed to the accident.

2. ANALYSIS

2.1 Engine failure

The engine failure occurred in two stages. The initial material failure of the number 6 connecting rod bolt resulted in a loss of power from number 6 cylinder and was evident as a partial loss of power. Continued rotation of the engine inflicted secondary (internal) damage resulting in a complete loss of power and the cessation of propeller rotation. Penetration of the crankcase by the failed connecting rod allowed the escape of engine oil which was blown back onto the windscreen, restricting the pilots' visibility.

The fatigue crack of the bolt was initiated by fretting damage at the mid-point of the bolt. The fretting resulted from movement of the mating surfaces of the connecting rod and cap. This movement is normally restrained by big-end bolt tension or pre-load obtained by applied torque on the nut. The investigation determined that the presence of a lubricant between the cap and rod assembly may have been a contributing factor in allowing slip to occur between the connecting rod and cap. In this case, the threaded end of the failed bolt together with its nut and safety pin was not recovered after the accident, so no determination of the reason for the low bolt torque could be made.

The engine was overhauled in 1988 and had since operated for 707.3 hours. At the time of the overhaul the TCM manual specified torque figures of 35.4–39.6 ft lb for the connecting rod bolts for IO-520 engines. However, since June 1988, TCM's factory assembly and overhaul have been using torque values of 39.6–43.8 ft lb, although the company did not issue amended figures for their published assembly data until September 1992.

2.2 Aircraft outside search area

It could not be determined why the aircraft was operating outside the western boundary of search area 'Charlie'. The pilot in command of VH-PLD was based at Camden and should have been familiar with the road south from Oakdale which formed the western boundary of the search area. The map found on board the aircraft with area 'Charlie' drawn, suggests that the search area had been incorrectly plotted. However, it is possible that the pilot in command extended the search area to the shores of Lake Burragorang to obtain more accurate visual fixes during the creeping line-ahead search which required a track spacing of 1 NM.

2.3 Forced landing aspects

The initial malfunction was reported as a partial power loss associated with a rough running engine and the pilot's action to divert to the nearest suitable airstrip was considered appropriate. However, as the condition of the engine deteriorated to the point where there was a complete loss of power, the pilot was then committed to a forced landing in unsuitable terrain. An additional problem confronting the pilots was that their forward vision was probably at least partially obscured by engine oil on the windscreen.Although the aircraft's attitude at initial tree impact could not be accurately determined due to the degree of subsequent damage, it appears the aircraft was in a controlled descent. Following the severing of part of its left wing, it then dived almost vertically into the ground. The aircraft appeared to have been yawed about 30° to the left as a result of the initial tree impact. The speed at impact could not be determined but the damage to the trees and aircraft indicated that it was probably in excess of the stall speed. The trees initially struck by the aircraft were slightly higher than most in the general area but probably could not be distinguished from the background vegetation.

The aircraft's configuration at ground impact was flap extended 10° and the landing gear retracted. A lower approach speed immediately prior to impact with the trees could have been achieved if full flap had been extended. The reason why the pilot did not extend full flap remains unknown. The conduct of a forced landing in tall, heavily timbered terrain seldom has a successful conclusion.

3. CONCLUSIONS

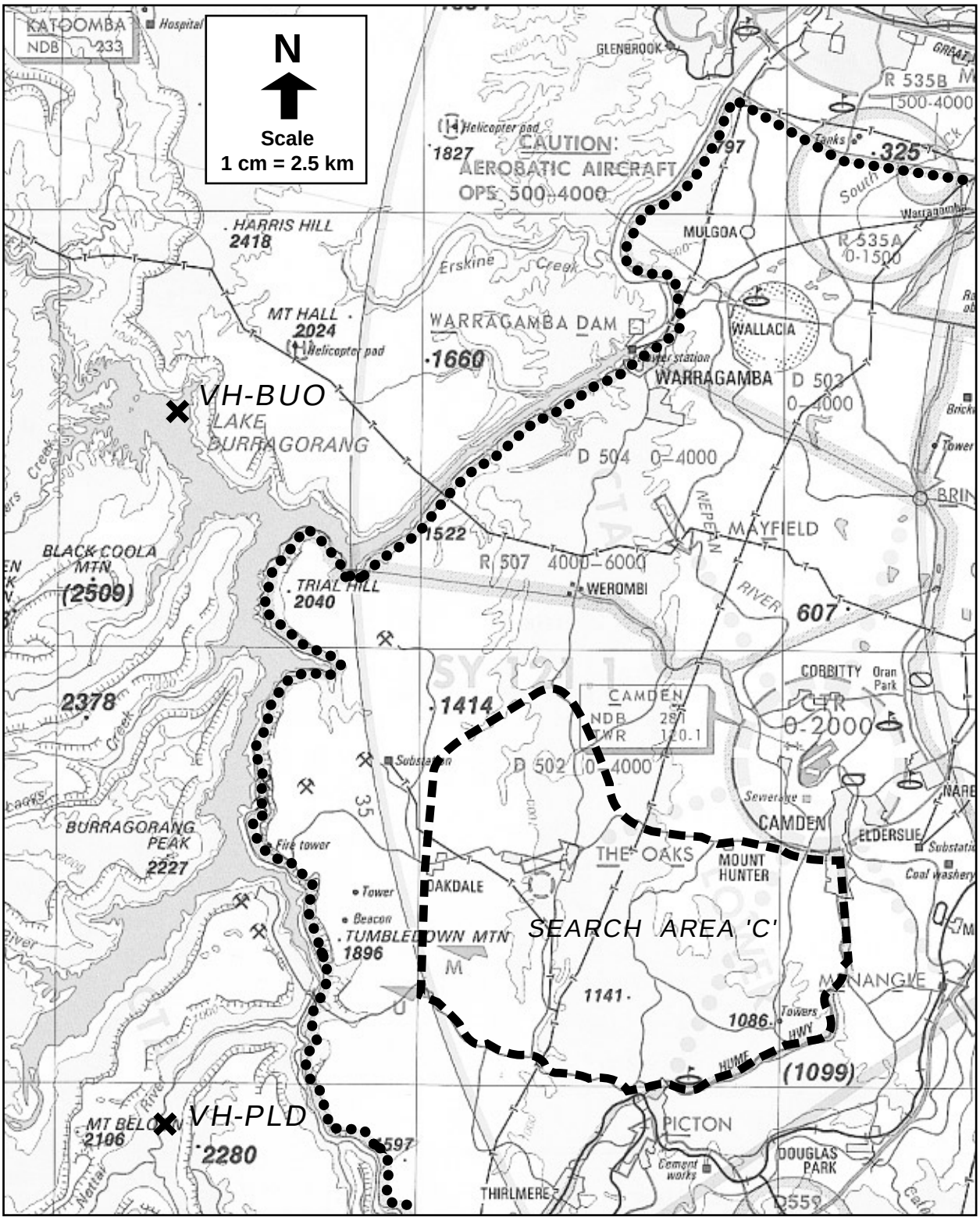
3.1 Findings

1. The operating crew were medically fit, correctly licensed and qualified for the flight.
2. The aircraft was airworthy and complied with all regulatory requirements prior to the engine failure.
3. Meteorological conditions at the time of the accident were not significant.
4. Power loss from the engine was due to fatigue failure of a connecting rod bolt and the subsequent loss of oil pressure.
5. The aircraft was outside its assigned search area at the time of the engine power loss.
6. When the engine finally ceased to deliver power, the aircraft was over terrain unsuitable for a forced landing.
7. The pilots' vision through the windscreen was probably affected by engine oil.
8. The aircraft remained under control until initial collision with tall trees.
9. The ground impact was not survivable for the operating crew or the second seat row occupants.

3.2 Significant factors

1. Material failure of a critical engine component resulted in a complete loss of power.
2. The aircraft was operating over terrain unsuitable for a forced landing.

APPENDIX A



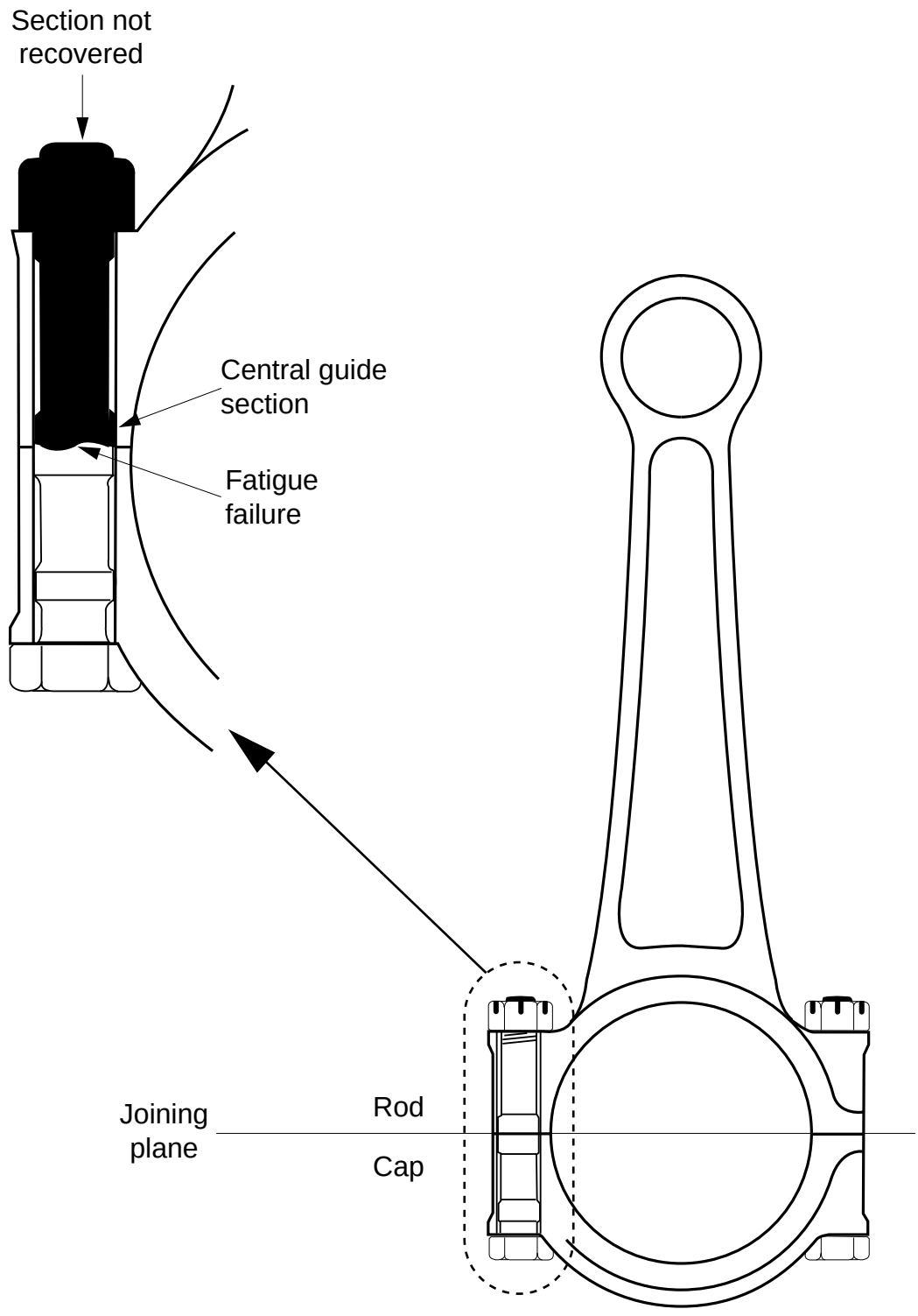
LOCATION OF SEARCH AREA 'C'

Approximate boundary search area 'Charlie'

Training area boundary

Accident sites for VH-BUO and VH-PLD

Connecting rod bolt failure



Connecting rod assembly

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