AAIB Bulletin No: 4/95 **Ref: EW/G95/02/03** **Category: 1.3**

Aircraft Type and Registration:	ARV 1 Super 2, G-BSRK
No & Type of Engines:	1 Hewland AE75 water cooled three cylinder 2-stroke inverted inline piston engine
Year of Manufacture:	1986
Date & Time (UTC):	4 February 1995 at 1230 hrs
Location:	Near Peterborough (Sibson) Airport, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller, landing gear and forward fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	323 hours (of which 108 were on type) Last 90 days - 7 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and examination of the aircraft by the AAIB

Whilst nearing the end of a flight from Sleap to Sibson, the pilot and passenger became aware of a smell of burning rubber. As all engine indications were apparently normal, and the smell then disappeared, the flight was continued until, when downwind in the circuit at Sibson, a smell of burning oil was detected. It was also noticed that the engine coolant temperature gauge indication had risen into the cautionary amber zone. When the aircraft was at approximately 700 feet on base leg there was a sudden loss of power and despite the application of full throttle, a forced landing became inevitable. Throughout this period the pilot reported that the propeller had continued to rotate. The aircraft landed on a soft waterlogged field and, on touchdown, the nose and right landing gear 'dug in' and it nosed over to an almost vertical attitude before falling back level. The lap and diagonal occupant restraints held and the crew were able to escape from the aircraft in the normal manner. As they did so, steam was seen to be coming from the cowling area. A brief examination of the aircraft a short period later revealed that compression was present on only two of the three cylinders and that the drive belt to the water pump had failed.

The aircraft was recovered to the AAIB facility at Farnborough where a detailed examination of the engine was carried out. Two main defects within the engine were identified. Firstly, it was apparent that the front cylinder head had partially 'lifted' and that the threads of two of the four aluminium cylinder head nuts had stripped. Coolant was escaping from the consequent gap and was also present within the cylinder. After the head had been removed it was also apparent that the inner rubber O ring seal (cylinder to water jacket) was missing over an approximate 60° arc, this whole arc exhibiting evidence of sooting and overheating. Secondly, it was apparent that the bearing assembly within the water pump, located on the rear of the engine, had partially collapsed and that the shaft was stiff to turn.

The water pump on this engine is positioned directly below the alternator at the rear of the engine and is driven by a belt with six grooves from a pulley on the alternator drive shaft. A similar, but slightly larger diameter, pulley is mounted on the water pump shaft, belt tension being achieved by appropriate selection of a shim plate beneath the pump, as shown in Figure 1. The pump shaft/bearing assembly is made such that the shaft itself provides the inner raceways for two ball bearings, the outer raceways being integral with the outer sleeve. This sleeve is fitted with a seal at each end to retain the internal grease and exclude contamination; the six balls in each bearing are separated by a cage.

Detailed examination of the shaft and outer sleeve showed that they were only lightly greased and that the grease was in reasonable condition. The outer and inner raceways at both ends of the bearing assembly had been damaged by impressed solid particles and wear. The outer raceway at the pulley end had been damaged to the extent that metallic 'burrs' were present around its rim. The balls from the impeller end bearing had all been temper-coloured to a mid straw colour and showed evidence of softening and damage where they had tracked in the raceways. The balls from the pulley end bearing, however, were much more heavily damaged. One of the six was generally temper-coloured to a dark straw shade with very small patches of blue and had been barrelled by softening and wear against the mating raceway. The remainder were excessively worn and distorted. This type of damage appeared an extension of that present on the balls from the impeller end bearing which, together with the condition of the grease and raceways, indicated that the damage had resulted from a local breakdown in lubrication caused by excessive bearing loads, but over a relatively short period of time. A general view of the dismantled bearing assembly is shown in Figure 2.

When the water pump was examined generally and compared with assembly instructions and drawings, it became apparent that the drive pulley had not been correctly positioned onto the shaft. It was a requirement that the pulley should be flush with the end of the shaft, a position that would place it close to, but not binding against, the pump body and ensure its correct alignment with the drive pulley on the alternator shaft. The pulley is a press fit onto the shaft and, as found, it was apparent

that it had been pressed insufficiently far onto the shaft by approximately 0.2 inch. This had the effect of misaligning the drive belt onto the drive pulley such that it had been running one groove displaced, as indicated in Figure 1. The pulley was tight on the shaft and witness marks indicated that it had never been correctly located. Collapse of the bearing had several effects; to allow the pulley rim to contact and probably jam against the rear of the engine, to permit the impeller to rub against both the housing and water inlet fitting and loss of belt tension due to reduction in pulley centre distance. The belt itself had failed by being burnt through/eroded at one location whilst stationary by the rotating alternator shaft pulley. Evidence of the rubber dust at this location and rubber deposits in five of the six pulley grooves is shown in Figure 3.

The aircraft had recently undergone maintenance for a renewal of its Permit to Fly, at which time the water pump drive belt was reported to have been changed. To accomplish this the alternator/water pump assembly has to be removed from the engine. It was not possible to establish from the examination if the belt tension had been correctly set or had influenced the bearing failure, but the greater offset of the pulley from the bearings would have increased the bearing loading for any given belt tension. However, no evidence was discovered to indicate that the water pump or its pulley had been recently replaced.

Loss of the cooling flow on this engine leads to rapid overheating which, in this case, would appear to have precipitated the seal failure on the No 1 cylinder head. Water from the cooling system was then able to enter this cylinder and become trapped between the head and piston at Top Dead Centre, resulting in the failure of two of the cylinder head nuts and the consequent loss of power.

ARV SUPER 2 WATER PUMP INSTALLATION SCHEMATIC

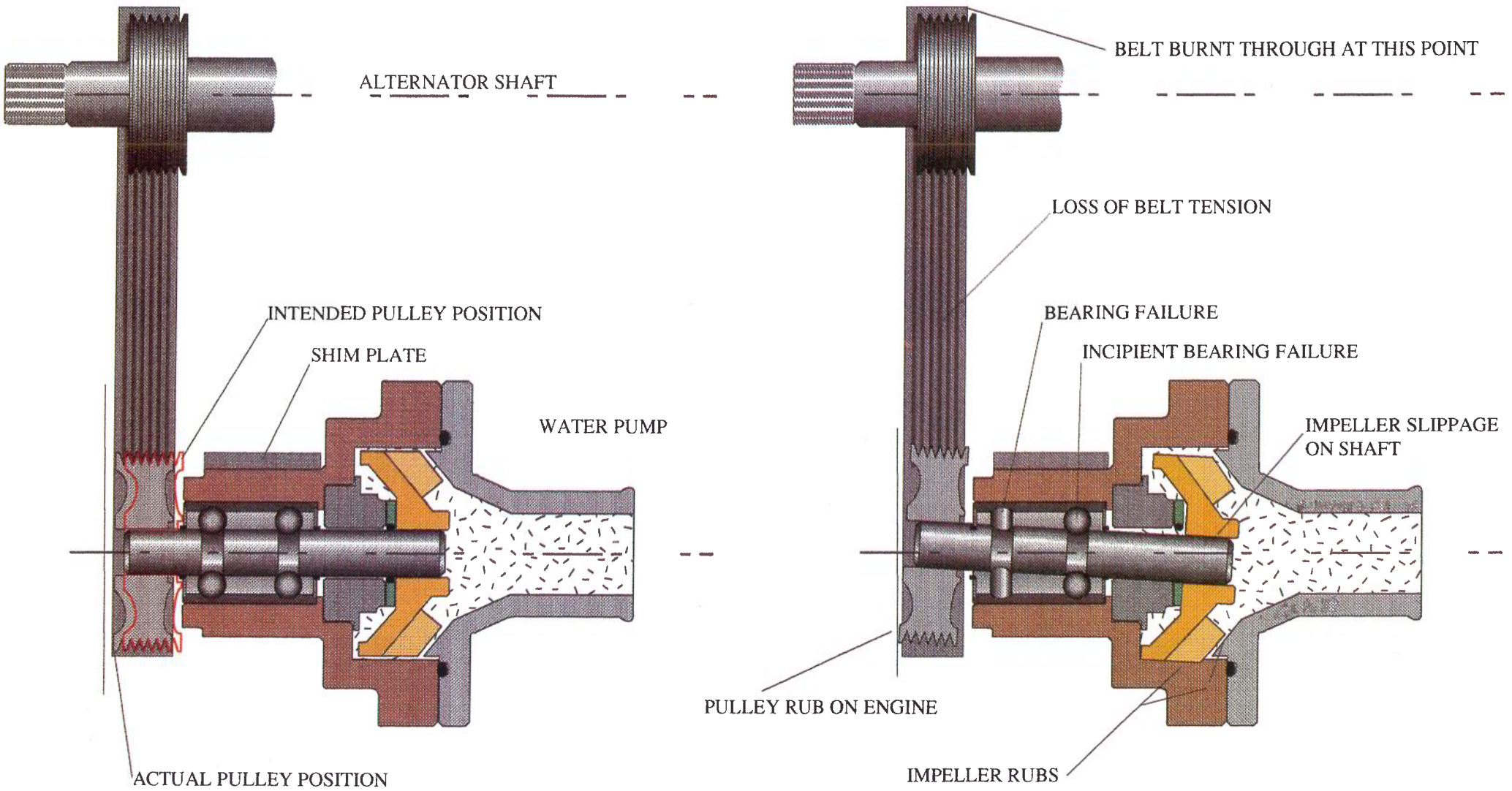

FIGURE 1

FIGURE 2

Bearing andShaft Assembly. Sleeve broken open during examination.

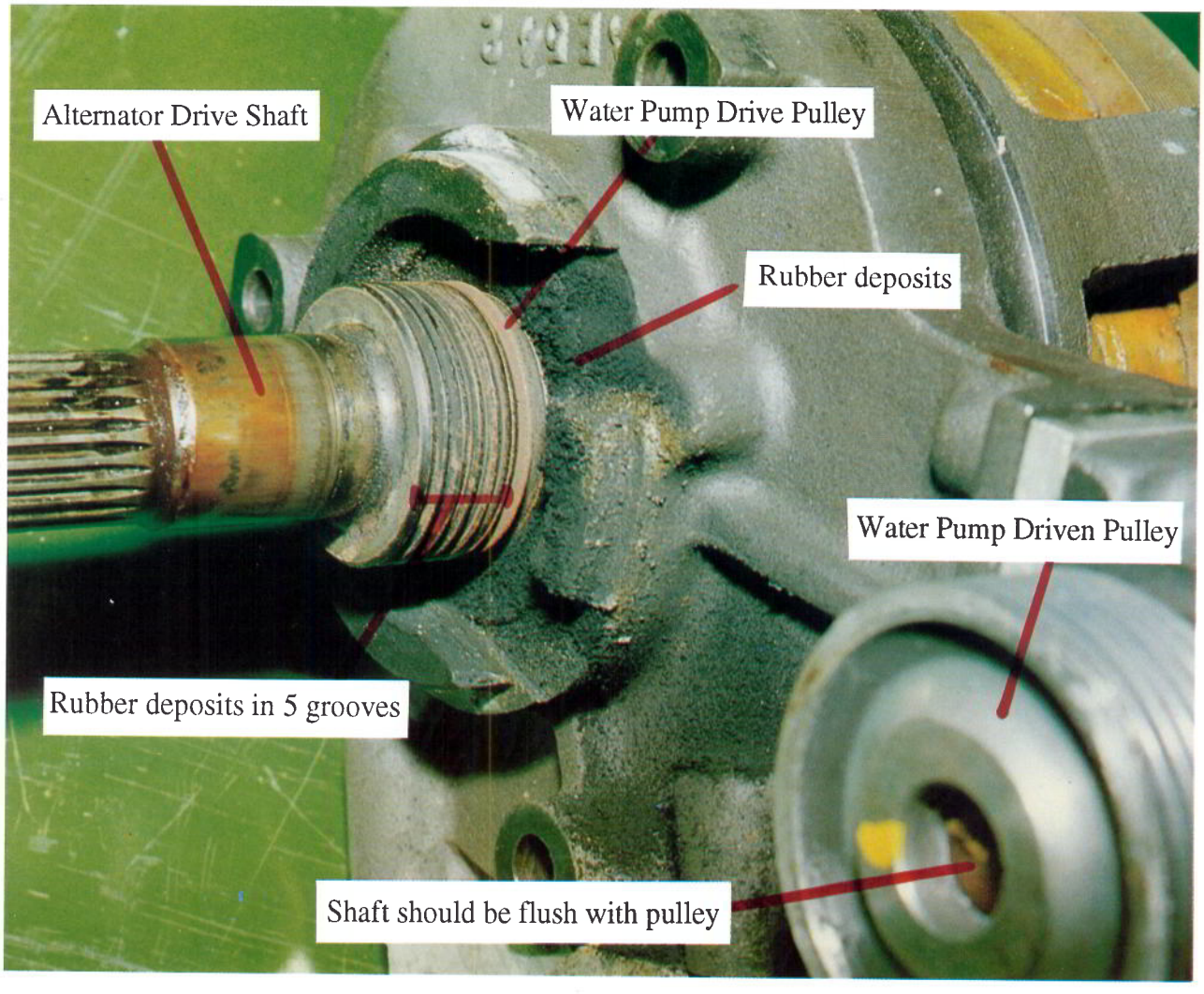

FIGURE 3