# SUPREME COURT OF QUEENSLAND

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| CITATION: | *McDermott & Ors v Robinson Helicopter Company* [2014] QSC 34 |
| PARTIES: | **GRAHAM JAMES McDERMOTT**<br>(first plaintiff)<br>**JUANITA CAROL McDERMOTT**<br>(second plaintiff)<br>**NTB PASTORAL HOLDINGS PTY LTD**<br>(third plaintiff)<br>v<br>**ROBINSON HELICOPTER COMPANY**<br>(first defendant) |
| FILE NO/S: | BS 4573 of 2007 |
| DIVISION: | Trial Division |
| PROCEEDING: | Trial |
| DELIVERED ON: | 17 March 2014 |
| DELIVERED AT: | Brisbane |
| HEARING DATE: | 13 September 2012 – 21 September 2012; 20 May 2013 – 12 June 2013; Judgment delivered 28 March 2014. |
| JUDGE: | Justice Peter Lyons |
| ORDER: | **1. The claims of the plaintiffs are dismissed.** |
| CATCHWORDS: | TORTS – NEGLIGENCE – DANGEROUS AND INJURIOUS THINGS, ETC – BREACH OF DUTY OF CARE – where the plaintiff was seriously injured in a helicopter accident – where the first defendant was the manufacturer of the helicopter and the helicopter Maintenance Manual – where the plaintiff alleged that the accident and its consequences were caused by the first defendant's negligence in failing to exercise reasonable care to ensure that the Maintenance Manual provided an adequate inspection procedure to detect the cause of the accident – where the first defendant alleged that the Maintenance Manual provided for all appropriate and adequate inspection procedures – whether the Maintenance Manual was adequate to prevent the cause of the accident.<br><br>TRADE AND COMMERCE – COMPETITION, FAIR |

TRADING AND CONSUMER PROTECTION LEGISLATION – CONSUMER PROTECTION – LIABILITY OF MANUFACTURER OR IMPORTERS FOR DEFECTIVE GOODS – where the plaintiff was seriously injured in a helicopter accident – where the first defendant was the manufacturer of the helicopter and the helicopter Maintenance Manual – where the plaintiff alleged that the instructions relating to inspections in the Maintenance Manual were inadequate – where the plaintiff alleged that those inadequacies rendered the Maintenance Manual and the helicopter defective – where the plaintiff alleged that those defects caused the plaintiff to suffer damage and loss – whether the helicopter and/or the Maintenance Manual had a "defect", for the purposes of s 75AD and s 75AE of the Trade Practices Act.

*Trade Practices Act* 1974 (Cth), s 75AB, s 75AC, s 75AD, s 75AE, s 75AI, s 75 AN

*Carey-Hazell v Getz Bros & Co (Aust) Pty Ltd* [2004] ATPR 42-014, considered

*Merk Sharp & Dohme (Australia) Pty Ltd v Peterson* (2011) 196 FCR 145, considered

COUNSEL: W Sofronoff QC, with M Eliadis and C George, for the plaintiffs

G Newton QC (September 2012), R Bain QC (May-June 2013), with M Hickey, for the first defendant

SOLICITORS: Shine Lawyers for the plaintiffs

CLS Lawyers for the first defendant

[1] **PETER LYONS J**: Mr McDermott, the first plaintiff, was seriously injured in a helicopter accident on 30 May 2004. The first defendant (*Robinson*) was the manufacturer of the helicopter. The plaintiffs have sued Robinson and a number of other defendants. The claims against the other defendants have been settled.

[2] The claims against Robinson raise issues both of liability and quantum. The trial was conducted in two stages. The first was intended to deal with issues relating generally to liability; and the second, with issues relating to quantum. Evidence of matters intended to be dealt with in the first stage was not completed in the time allotted for that stage. Nevertheless, it will be convenient in these reasons to deal separately with the matters intended to be dealt with at the first stage of the hearing, and to refer to them as the liability issues; leaving the remaining issues for separate consideration[1].

**Background for liability issues**

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1 References to the transcript of the first hearing are identified by the letter *T*; and to the second hearing, by *2T*.

[3] The helicopter was a Robinson R-22 Mariner II helicopter. Its registration number was VH-MIB. At the time of the accident, the helicopter was owned by the third plaintiff (*NTB*).

[4] On 30 May 2004, the helicopter was being used to inspect fence lines on Tobermorey Station, a very large cattle property then owned by NTB, and located immediately to the west of the Queensland-Northern Territory border. The helicopter was also used for mustering on Tobermorey. The pilot of the helicopter at the time of the accident was Mr Kevin Norton. Mr McDermott, who conducted the affairs of NTB, was a passenger in the helicopter.[2]

[5] The only evidence of the accident came from Mr McDermott. I accept this evidence. Mr McDermott said that they were flying above the eastern fence line at approximately 70 feet above the ground. He saw a gap in the fence line, and some cattle tracks. He instructed Mr Norton to swing to the left and land. While they were still over the top of trees there was a loud bang, and a massive vibration. Mr Norton attempted to keep the helicopter under control, by keeping the rotor spinning, for the purpose of achieving a landing without engine power. The helicopter descended at what Mr McDermott described as a "fairly heavy rate of sink", until Mr Norton "flared the helicopter". It then hit the ground and bounced forward, "probably 20 feet". By this time, the helicopter was on fire. Mr Norton escaped from the helicopter. Mr McDermott could not get out immediately, as he was trapped by his harness, but eventually he managed to do so. He went for help, leaving Mr Norton beside a creek. However Mr Norton did not survive.

[6] After the accident, the wreckage was inspected on behalf of the Australian Transport Safety Bureau (*ATSB*). Photographs of the wreckage were taken, and some parts were removed for further examination.

[7] Otherwise, the wreckage remained at Tobermorey until 2005. It was then transported to another property purchased by NTB, called Lindley Downs. Initially, the wreckage was stored in a shed on Lindley Downs. However, Mr McDermott instructed Mr Diener, an employee (who later married Mr McDermott's daughter Anna) to bury the wreckage. Mr Diener excavated a hole on the property, near a rubbish tip, and buried the wreckage there. After the first stage of the hearing, Mr McDermott arranged for the wreckage to be exhumed. What was exhumed included two loose nuts referred to as "palnuts".

[8] The helicopter had been manufactured in the United States of America in 2002. It was fully assembled there, and flown for a short time. It was subsequently disassembled, exported to Australia, and reassembled in this country. It was the subject of regular inspections and maintenance thereafter. The time at which such work occurred is recorded both by date, and by reference to hours identified as "total time", apparently related to the time of operation of the helicopter's engine. Of particular interest are the maintenance carried out by the fourth defendant (*Helibiz*) on 17 February 2004 at a total time of 384 hours, relating to compliance with an Airworthiness Directive (*AD*); the maintenance inspection carried out by Helibiz on 27 March 2004 at a total time of 396 hours being a 100 hourly inspection; and the maintenance inspection carried out by the seventh defendant

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[2] See generally T 2-76 to 2-77.

(*Heli Centre*) on 12 May 2004 at a total time of 476.1 hours, again being a 100 hourly inspection.

[9] The helicopter had been purchased by the third plaintiff by a contract dated 13 March 2004, with delivery on 19 April 2004, when the total time was 450 hours. The total time at the time of the accident on 30 May 2004 was 506 hours.[3]

**Forward flexplate assembly**

[10] It is common ground that the accident occurred because the forward flexplate failed. It is necessary to say something of its function; to describe it and the assembly of which it forms part; and to describe what else is to be found in its immediate vicinity in a Robinson R22 helicopter.

[11] The forward flexplate forms part of the drive system by which torque is transferred from the helicopter's engine to the rotor shaft, causing it, and the rotor, to rotate. Pulleys driven by belts from the engine are fixed to a shaft called the clutch shaft, causing it to rotate when the helicopter is operating. Rotation is in an anti-clockwise direction, observed from the rear[4]. A clutch or belt tension actuator permits the rear end of the clutch shaft to drop, releasing the pulleys from the belts, with the result that no torque is then applied to the pulleys and the clutch shaft.

[12] The forward flexplate assembly enables the transfer of torque from the clutch shaft to the main rotor gearbox, immediately forward of the forward flexplate assembly.

[13] The flexplate itself may be loosely described as having a shape akin to that of a four-pointed star, or a cross with round ends. It is made of relatively thin metal, with some degree of flexibility. At the end of each of its arms is a hole, to accommodate a bolt. A yoke fixed to the forward end of the clutch shaft connects it to the flexplate. The yoke is, as the name suggests, a rigid item which is slightly curved, its ends also containing holes for the bolt which secures it to the flexplate. The clutch shaft is fixed to the centre of the yoke. The ends of the yoke are bolted to ends of opposite arms of the flexplate. By a similar arrangement, a yoke fixed to the main rotor gear box is bolted to the other two arms of the flexplate. This system permits the transfer of torque from the clutch shaft to the main rotor gear box, while accommodating some change in alignment of the clutch shaft when the clutch is used to lower the shaft.

[14] The failure occurred at the location of one of the bolts connecting the main rotor gear box yoke to the flexplate. This bolt has been referred to as Bolt 4; with the bolt at the end of the opposite arm of the flexplate (and the opposite end of the main rotor gear box yoke) being referred to as Bolt 3. The bolts connecting the clutch shaft yoke to the forward flexplate have been referred to as Bolts 1 and 2.

[15] The forward flexplate assembly is located in a space within the helicopter's fuselage, immediately to the rear of the cabin. As will have been apparent, the clutch shaft adjoins it to the rear, and the main rotor gear box, and the main rotor,

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3 See Ex 1, vol 7, tab 1, p 4; although this records the instructions to Robinson's witnesses, the facts appear to be uncontroversial. See, for example, Ex 1, vol 1, tab 2, p 13/83.

4 See Dr Tunour's report dated 31 January 2013, Ex 21, p 16/211.

are forward of it. Viewed from rear, to its right is the fuel tank. To its left is the auxiliary fuel tank. The assembly is separated from the engine below it by a metal fire wall. The space containing the forward flexplate assembly is otherwise bound by the air frame, which is constructed of steel tubing and riveted aluminium. There is also wiring in this vicinity.

[16] Immediately forward of the flexplate assembly, and attached to the main rotor gear box, are relatively small pieces of equipment called Hall Effect Senders. Bolted to the main rotor gear box, just forward of the main rotor gear box yoke, is a larger part, the rotor brake assembly.

[17] On both sides of the flexplate, at each bolt hole, washers are attached by adhesive to the sides of the flexplate (*bonded washers*). They assist in the transmission of rotational force from the clutch shaft yoke to the flexplate, and from the flexplate to the main rotor gear box yoke. The maintenance manual provided by Robinson for the R 22 helicopter (*Maintenance Manual*) specifies how the bolts connecting the yokes to the forward flexplate are to be installed[5]. The head of each of the bolts connecting the gear box yoke is to the rear of the flexplate, with an additional washer separating it from the bonded washer on that side of the flexplate. Immediately forward of the flexplate and its other bonded washer is an additional washer (if required) ; then the end of the yoke; and then another washer; a nut, which is the primary or locking nut; and an additional nut referred to as a "palnut". A palnut is described as a "secondary locking mechanism"[6]. Specific torques to which the bolt and locking nut, as well as the palnut, were to be tightened, were identified in the Maintenance Manual.[7] Once the bolt, washers and nuts have been installed, a paint strip, described in various ways, but which I shall refer to as a *torque stripe*, is to be applied to both nuts, and to exposed bolt threads, continuing to the part being fastened[8]. The bolted connexions securing the clutch shaft yoke to the flexplate are similarly arranged, save that the bolt head is forward of the flexplate, and the nuts are to the rear of the yoke.

**Introduction to some witnesses on liability issues**

[18] Dr Romeyn was the only metallurgist called in the case. He had earlier carried out investigations of the accident for the ATSB.

[19] A number of mechanical engineers gave evidence. Dr Gilmore and Mr Kerr were called by the plaintiffs. Mr Kerr also has expertise in aircraft design; and in the certification of modifications to aircraft for the Civil Aviation Safety Authority (*CASA*). Dr Casey and Dr Orloff were called by Robinson. Dr Orloff also owns and operates an aircraft maintenance facility, and is an experienced pilot and flight instructor, his experience extending to flying helicopters. He is a certified Airframe and Power Plant Mechanic from the United States (a person with the equivalent qualification to a Licensed Aircraft Maintenance Engineer (*LAME*) in Australia; in the case, people with this or a similar qualification were referred to as LAMEs, a practice I shall adopt). He operates an aircraft maintenance facility.

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5 See Ex 1, vol 3, p 1166-1168.
6 See Ex 1, vol 3, p 880.
7 See Ex 1, vol 3, p 882.
8 See Ex 1,vol 3, p 880; p 1165.

[20] Dr Turnour is an aerospace engineer. He is Robinson's certification manager. He is also a pilot, with some experience flying helicopters.

[21] Mr Ogier, called by the plaintiffs, is an aviation safety expert. He also plays a regulatory role in relation to the issue of certifications of airworthiness for aircraft, and was formerly a LAME. He has experience in evaluating aircraft maintenance systems and maintenance manuals. Mr Lay was called by the plaintiffs to give evidence as a LAME. He is also an experienced pilot, his experience extending to pilot testing and training. He has also carried out helicopter accident investigations.

[22] The plaintiffs also called Mr Fisher, the LAME who carried out the 100 hourly maintenance inspection on 22 March 2004, and Mr Bray, the LAME who carried out the 100 hourly maintenance inspection on 12 May 2004. Robinson called Mr Cox and Mr Boyle as expert LAMEs. Mr Cox is Robinson's Technical Support Supervisor, and a co-author of the Maintenance Manual. Mr Boyle carries on his own maintenance business.

[23] Robinson called Mr Doyle for expert evidence as a pilot. The plaintiffs called Mr McKendry and Mr Lewis, pilots who flew the helicopter on a number of occasions early in 2004.

**How the flexplate failed**

[24] Dr Romeyn was called by the plaintiffs to give evidence of the mechanisms by which the flexplate failed. His evidence on this topic was, in effect, adopted on behalf of Robinson in final submissions, and should for the most part be accepted. His evidence was that the failure originated from a lack of clamping force in Bolt 4. The flexplate assembly is designed so that much of the rotational force is transmitted to (and by) the flexplate as shear force, a consequence of sufficiently strong clamping of the clutch shaft yoke and the associated washers to the forward flexplate, and of the flexplate and associated washers to the gear box yoke (in truth the design appears to be such that all of the rotational force is so transmitted, without contact between the bolt shaft and the sides of the holes in the yokes and flexplate[9]). The absence of sufficient clamping force meant that the rotational force was transmitted only by the bolt coming into contact with the wall of the bolt hole in the flexplate and the yoke. Disbonding of the bonded washers increased the magnitude of the stresses around the bolt hole and allowed local flexure of the tip of the flexplate arm[10]. Contact between the bolt shaft and the elements of the wall of the bolt hole resulted in fretting wear around the circumference of the bolt shank. The increased force applied in the vicinity of the bolt hole, and the local flexure of the flexplate arm, resulted in fatigue cracking around the bolt hole[11]. Had the washers remained bonded to the flexplate, there would have been greater resistance to cracking[12].

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9 See Ex 1, vol 7, tab 5, p 717. Dr Turnour's diagrams show no bearing load between the bolt and the walls of the bolt hole, when the bolt is properly clamped up. He also shows a gap between the bolt shaft and the wall of the hole through the flexplate, yoke and washers. The text in para 2.8 is consistent. See also Ex 1, vol 1, tab 8, p 4, second last par.

10 See Ex 1, vol 1, tab 6, p 7 last par; p 10, second par; p 13. See also tab 8, p 4, first par.

11 See Ex 1, vol 1, tab 6, p 7 last par; see also Ex 1, vol 1, tab 8, p 4, second last par.

12 See Ex 1, vol 1, tab 6, p 4, second last par.

[25] Two cracks developed adjacent to Bolt 4. The first, Crack A, extended from the bolt hole generally in the direction of the tip of the flexplate arm. The second, Crack B, extended from the bolt hole to the edge of the flexplate, in a direction somewhat away from the tip of the flexplate arm[13]. Dr Romeyn considered that Crack B commenced to form after Crack A had extended to the outer edge of the flexplate[14]. When both cracks reached the edge of the flexplate, a small piece of the flexplate was no longer attached to the rest of the flexplate, and it came away, with the result that one end of the flexplate became detached from the gearbox yoke. This led to a loss of drive to the main rotor, a loss of control of the helicopter, and a rupture of the fuel tank[15].

[26] There was no evidence contrary to Dr Romeyn's view that the failure mechanism was the result of a lack of clamping force in Bolt 4. When it was last installed, on Dr Casey's evidence, assuming that the bonding which attached washers to the flexplate was intact, and that there was no wear of the components, the items between the bolthead and locking nut left a space or "gap" of .15 mm (or .006 inches) unaccounted for[16]. With wear, and loss of bonding material, the gap grew. After the crash, it was calculated by Dr Gilmore, based on measurements taken at that time, to be .42 mm[17]. It appears to be correct to conclude that the bolt was left loose when last installed. There was evidence to indicate that it had not, at the time of installation, been more tightly clamped up than it was at the time of the accident[18]

[27] Dr Romeyn described the sequence of processes leading up to the failure of the flexplate as being: the breakdown of the bonding between the flexplate and the washers; fretting wear on the surface of the bolthole; the initiation and growth of Crack A; and the initiation and growth of Crack B[19]. Dr Casey agreed with this in his oral evidence[20]. However, elsewhere Dr Casey stated that the failure started with fretting wear at the bolt hole[21]. Dr Turnour conducted a "tie down" test for a helicopter with a bolt set up incorrectly, to simulate the effect of the incorrect installation of Bolt 4. It resulted in fretting wear on the bolt shaft, and on the face and in the hole of a bonded washer, with minimal fretting within the hole in the flexplate; and no indication that the bonding had deteriorated[22]. Dr Romeyn also said that the processes of fretting wear and local bending associated with lack of bolt clamping might affect the integrity of the bonding. It might be observed that the condition which gave rise to fretting existed once Bolt 4 was installed without proper clamp up[23]. It seems to me likely that fretting commenced before the disbonding of the washers.

[28] How Bolt 4 came to be installed without the required clamping force is a matter of inference. Dr Orloff gave evidence that the Robinson factory records show that an

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13 Dr Casey, called for the defendant, provided illustrations of direction of cracking; see Ex 1, vol 7, tab 1, figures 2 and 3.

14 See Ex 1, vol 1, tab 8, p 5, first par.

15 See Ex 1, vol 1, tab 6, p 13.

16 Ex 1, vol 7, tab 1, p 5. See also Dr Gilmore, Ex 1, vol 1, tab 4, p 182.

17 Ex 1, vol 1, tab 1, p 9, first par,

18 Dr Gilmore, Ex 1, vol 1, tab 1, p 7.

19 Ex 1, vol 1, tab 6, pp 10, 13.

20 T 5-20 to 5-21.

21 Ex 1, vol 7, tab 1, p 10; see also p 13, par 3.20.

22 Ex 1, vol 7, tab 5, pp 747-752.

23 See Kerr Ex 1, vol 2, tab 34, pp 7-8; with whom Dr Turnour agreed: Ex 1, vol 7, tab 5, p 716, par 2.6.

additional washer was originally installed between the clutch shaft yoke and the forward flexplate; but this washer was not present at the time of the accident[24] (*missing washer*). Dr Turnour gave similar evidence[25]. This washer is sometimes referred to as a "shim washer" or "shimming washer". The Maintenance Manual permits its use between the main rotor gearbox yoke and the forward flexplate[26]. The Maintenance Manual suggests that it may be used to achieve the correct positioning of the clutch assembly in relation to the engine[27], thereby indicating that its use was not always necessary. However, its absence does not, of itself, explain the lack of clamping force at Bolt 4. Since it may be omitted if not required for shimming, it would seem possible to achieve proper clamping force even if it is absent.

[29] The February maintenance work, was, at least in part, for the purpose of complying with AD/R22/51 (*AD 51*). Mr Lay gave evidence that compliance with the Directive required the removal of the clutch shaft yoke; and proposed (as an hypothesis) that in the course of that work, a bolt connecting the main rotor gearbox yoke to the forward flexplate was removed; and that during reassembly, the incorrect bolt and washer combination was used in this location, without the application of the correct torque[28]. Dr Orloff agreed with this as an explanation for the incorrect installation of Bolt 4[29]. There is no evidence of any work which involved removing a bolt from the forward flexplate, after February 2004. Whether, in light of other evidence, this explanation might be correct is discussed later in these reasons.

[30] Post-accident photographs show that the palnuts were absent from Bolts 1 and 2, and a palnut was attached to Bolt 3[30]. There is a factual dispute about whether a palnut was attached to Bolt 4 post–accident, or even if a palnut was attached to Bolt 4 immediately prior to the accident.

**Pleaded liability issues**

[31] The plaintiffs pleaded that the cause of the accident was a mechanical defect, in effect, that the bolted joint, of which Bolt 4 formed part, had been assembled incorrectly; and that Bolt 4 was not correctly tensioned. Of these allegations, Robinson alleged that Bolt 4 was not properly tightened; and that a cause of the accident was the failure of the maintenance organisations (Helibiz and Heli Centre), and the pilot, (Mr Norton, during his pre-flight inspection) to detect the loose bolt and the resulting fretting and cracking.

[32] The plaintiffs pleaded that the Maintenance Manual did not provide adequate inspection procedures to detect cracks initiating at the bolt holes in the forward flexplate, the presence of fatigue cracking in that location, a lack of torque in the bolted joints in the flexplate, fretting wear of the bolt shaft or the joint components, and disbonding of the bonded washers. Robinson denied these allegations, on the

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24 See Dr Orloff's report dated 1 February 2013, Ex 21, p 5/255, par 3.3.
25 See Ex 1, vol 2, tab 12, p 624E, answer 2.
26 See item 26 at Ex 1, vol 3, pp 1166–1167; see also p 1168.
27 See item 26 at Ex 1, vol 3, p 1168.
28 See Ex 1, vol 2, tab 27, p 423.
29 See Dr Orloff's report dated 1 February 2013, Ex 21,, p 5/255; and Ex 1, vol 7, tab 7, p 801, par 2.10.5.
30 Ex 1, vol 5, pp 1703, 1714, 1726.

ground that the Maintenance Manual provided for all appropriate and adequate inspection procedures for cracks initiating at the flexplate bolt holes. In response to the allegation that it had a duty to exercise reasonable care to ensure the Maintenance Manual provided adequate inspection procedures, it identified a number of passages from the Manual on which it relied, as setting out all "proper information", and complying with "all necessary standards"[31].

[33] The plaintiffs alleged that the accident and its consequences were caused by negligence and breach of duty on the part of Robinson, the particulars of which included failing to exercise reasonable care to ensure that the Maintenance Manual provided an adequate inspection procedure during inspections and servicing to detect cracks initiating at the forward flexplate bolt holes, the presence of fatigue cracking at those holes, a lack of torque in the bolted joints in the flexplate, fretting wear of the bolt shaft or joint components of the flexplate, and disbonding of the bonded washers. The allegations were elaborated in respect of inspections, particularly one hundred hourly inspections. It was alleged that the duty was breached because the Maintenance Manual failed to require a thorough inspection of the forward flexplate for cracks, nicks, or corrosions on its surface as well as on its edges or in the area of "the attaching hardware"; in directing attention only to the condition of the edges of the flexplate and not also to its entire surface and the areas of attaching hardware; in failing to require that the security of the flexplate be verified by removal of the palnuts and the re-torquing of the bolted joints with a calibrated torque wrench; by failing to require that the flexplate be removed to verify that the bonded washers remained securely bonded, and to ensure that the flexplate, and the bolts, were properly installed with the required torque; and by failing to provide adequate instructions to detect a lack of torque in the bolted joints, fretting wear, disbonding of the washers, and fatigue cracks. Robinson denied these breaches, asserting the adequacy and appropriateness of the provisions of the Manual. It also pleaded that the Manual required provision of a torque stripe, which would indicate that a bolt had become loose. Robinson also alleged that, even with zero torque clamping force, the bolted joint would survive for at least 100 hours.

[34] Robinson alleged that it was unnecessary, undesirable and uneconomical to remove parts, including the flexplate, at each one hundred hour inspection. This was denied by the plaintiffs.

[35] The plaintiffs alleged that the condition of the torque stripe would not necessarily indicate that the bolt had become loose. They also alleged that it was not possible to verify that the bonded washers were securely bonded, unless the flexplate was removed for inspection.

[36] The plaintiffs alleged that, by reason of the defects in the Maintenance Manual, Helibiz, Heli Centre, or both of them were responsible for a number of things which caused the accident. The plaintiffs alleged that Helibiz and Heli Centre did not properly examine and identify the incorrect assembly of the bolted joint at Bolt 4 and the absence of correct tensioning there; did not rectify these things and ensure satisfactory torque in Bolt 4; failed to ensure the presence of a required washer; did not properly inspect for cracks initiating at the flexplate bolt holes; did not ensure that the bonded washers remained securely bonded to the flexplate; and did not undo and check the bolted joints. The allegations against Helibiz and Heli Centre

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31 Defence par 19(b)(iii).

were admitted by Robinson, who alleged that the failures of those defendants were not a consequence of any failure to exercise reasonable care on Robinson's part, because the Maintenance Manual contained "all proper and adequate directions and warnings".

[37] Claims against Robinson by Mr McDermott and the second plaintiffs, Mrs McDermott, were based on the provisions of s 75AD and s 75AE of the *Trade Practices Act* 1974 (Cth) (*TPA*). It was alleged (and admitted) that Robinson supplied the helicopter and the Maintenance Manual, both being manufactured by it. It was alleged that by reason of the inadequacies of the Maintenance Manual relating to inspection procedures, both the helicopter and the Maintenance Manual were defective, and the defects caused Mr McDermott and Mrs McDermott to suffer damage and loss.

[38] Robinson denied the alleged inadequacies in the Maintenance Manual; and accordingly denied that the helicopter and the Manual were defective. It also alleged that relief was not available under s 75AD and s 75AE of the TPA, by virtue of s 75AI of that Act, the loss being one which could have been recovered under a law of the Commonwealth, a State or a Territory relating to workers compensation. That was denied by the plaintiffs.

[39] In response to Robinson's allegations that the Maintenance Manual was not defective, the plaintiffs alleged that it should have required the removal of the flexplate for inspection. The plaintiffs also denied that the accident was caused by the failure of the pilot, during his pre-flight inspections, to detect the loose bolt or any resulting fretting or cracking of the flexplate.

[40] Robinson alleged that Airworthiness Directive R22/41 (*AD 41*) required removal of the centre rear cowling skin after every 25 hours of flying time; and that such action would have provided a clear view of the forward flexplate and surrounding area[32]. Robinson alleged that the accident resulted from Mr Norton's negligence in carrying out these inspections; and his negligent manner of flying. Since he was an employee of NTB, it was alleged that NTB was guilty of contributory negligence. It was also alleged that Mr McDermott was an experienced pilot, who should have been aware of Mr Norton's failures; and accordingly voluntarily assumed the risk of flying in the helicopter on the day of the accident; or that he caused or contributed to his loss or damage. Of the claims made under s 75AD and s 75AE of the TPA, these matters were said to have the consequence that the damage should be reduced to nil, by virtue of s 75AN of that Act. These allegations are denied in some detail by the plaintiffs, who generally alleged that neither Mr Robinson nor Mr Norton was negligent; that the accident was not caused by any failure on the part of Mr Norton, including the manner in which he flew the helicopter; and that the accident was caused solely by the defects in the R22 Maintenance Manual.

[41] Earlier versions of the statement of claim alleged that the helicopter was defectively designed. Many of these allegations were omitted from the current version of the statement of claim; and to the extent they remained, they were not pursued at trial.

**R22 Maintenance Manual**

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[32] This was not pressed in Robinson's submissions; and is contrary to the evidence of Dr Orloff at Ex 1, vol 7, tab 7, p 14/797, par 2.6.1 which I accept, as being likely to be correct, in view of the terms of AD 41.

[42] The contents of this document are critical for the determination of liability issues. It is necessary to make some detailed reference to them.

[43] At the beginning of the Maintenance Manual, an explanation is given for notations found elsewhere in it[33]. Thus a Warning is said to describe a procedure that, if not properly followed, could result in personal injury or loss of life. A Caution identifies a procedure that, if not properly followed, could result in equipment damage. A Note identifies a procedure that requires emphasis or supplementary explanatory information.

[44] General provisions of the Manual (found in paragraph 1.300) identify torque requirements for what are called "fasteners", including Bolt 4. The use of a torque wrench is envisaged. There are instructions intended to ensure the continuing accuracy of a torque wrench; and to enable the use of a torque wrench with an adapter attached[34].

[45] A Note in this part of the Manual identifies a critical fastener as one which, if removed or lost, would jeopardise safe operation of the helicopter. It was common ground that Bolt 4 was a critical fastener. A secondary locking mechanism, such as a palnut, is required on all critical fasteners. A torque stripe is required to be applied to all critical fasteners after the installation of the palnut. The stripe is to run across both nuts and exposed bolt threads, extending to the part being fastened. The Manual states that any subsequent rotation of the nut or bolt can then be detected visually. At least two, but not more than four, threads are to be exposed above any nut[35].

[46] In the introductory paragraph in the section of the Manual which deals with inspections, there are some general statements. They include the following[36]:

> "2.000 INTRODUCTION
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> The R22 helicopter must be inspected periodically to verify it is in airworthy condition. Required inspection intervals are maximum 100 hours time in service or 12 calendar months (annually), whichever occurs first. Preventive maintenance is required between scheduled inspections. Fluid leaks, discoloration, dents, nicks, cracks, galling, chafing, fretting, and corrosion all warrant further investigation. Unairworthy items must be replaced or repaired as allowed by Robinson Helicopter Company. This section contains procedures for performing the required periodic airframe inspections."

[47] The Manual (in paragraph 2.410) sets out detailed requirements for the 100 hourly inspection and includes a checklist to be used[37]. Of present relevance, cowling

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33 Ex 1, vol 3, p 853.

34 Ex 1, vol 3, p 881. Dr Gilmore's evidence suggested that the use of an adapter would permit checking the torque with a torque wrench, while the palnut remained in place.

35 See Ex 1, vol 3, pp 880-881.

36 Ex 1, vol 3, p 903.

37 Ex 1, vol 3, p 913.

doors on the right hand side of the helicopter are to be opened[38], after which a number of steps are to be carried out. They include the following:

> "MRGB Input Yoke: Inspect condition. Verify security and operating clearance. Verify security of magnets."

MRGB is a reference to the main rotor gearbox. The Manual also includes[39]:

> "Forward Flexplate: Inspect condition, particularly edges, Verify security. See Figure 2-4A for repair limits. Verify bonded washers are securely bonded to both sides of each flexplate arm. Verify operating clearance."

[48] There is then a Warning that if a bonded washer separates from the flexplate, the flexplate is unairworthy and cannot be repaired. The Warning requires the use of a flexplate which is Revision E or a subsequent revision.

[49] The Manual then includes a figure (figure 2-4A). Notations on the figure indicate the limits to which repairs might be carried out. On the drawing of the flexplate in figure 2-4A the following words appear: "GIVE SPECIAL ATTENTION TO THESE AREAS FOR CRACKS". Arrows then point to relatively small shaded areas, adjacent to the inward-curving edges of the flexplate, approximately midway between the ends of the flexplate arms, and relatively remote from the bolt holes.

[50] It might be observed the word "verify" and the expression "verify security" are used many times in the Manual, in a number of different contexts.

[51] The inspection checklist in the Manual makes reference to the main rotor gearbox input yoke, and the flexplate, requiring an entry to indicate whether each item is either airworthy or unworthy; and if it has been repaired.[40]

[52] In summary, the Maintenance Manual identified Bolt 4 as a critical fastener, specified its torque and the number of threads to be exposed, and required the application of a torque stripe; but did not specifically refer to it in relation to 100 hourly inspections. It contained a general direction to look for such things as cracks and fretting on inspections. It gave a direction to inspect the flexplate, directing attention particularly to the edges; and drawing attention to the possibility of cracks in identified locations. It gave a direction to verify the security of the flexplate. It required verification that washers remained bonded.

**Plaintiffs' liability submissions**

[53] For the plaintiffs, it was submitted that the direction in the Maintenance Manual in respect of the forward flexplate, to "(i)nspect condition, particularly edges." was inadequate. First, it directed attention to the edges, thereby directing attention away from the surface of the flexplate itself. Secondly, figure 2-4A of the Manual drew attention to the shaded areas, relatively remote from the bolt holes at the ends of the flexplate arms. This was contrasted with the direction in the Maintenance Manual

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38 Ex 1, vol 3, p 920; and Fig 2-3B, p 915.

39 Ex 1, vol 3, p 922.

40 Ex 1, vol 3, p 948.

for the R44 Helicopter[41], which specifically required attention to be given to areas around the bolt holes for cracks; and required an inspection of the entire periphery of the flexplate for cracks[42]. Reliance was also placed on the evidence of Mr Ogier, for the proposition that this direction was insufficient for the purpose of detecting cracks in the flexplate. The plaintiffs' submissions also relied on the evidence of Mr Cox, as acknowledging the need to inspect the entire flexplate.

[54] It was submitted that the direction to verify that the washers were securely bonded to the flexplate, found in the Maintenance Manual, was inadequate, because it did not make clear that the flexplate must be removed, and that, without its removal, it is not possible to ascertain the security of the bonding. Disbonding would render the helicopter unairworthy. Had the flexplate been removed to verify that the bonding remained secured, the defects at Bolt 4 would have been discovered and rectified.

[55] It was submitted that the instruction given in the Maintenance Manual, "Verify security" in relation to the flexplate was inadequate because it gave no guidance as to how the security of the flexplate was to be verified. It was submitted that it was necessary to remove the palnut, and check the tension of the primary nut with a torque wrench, in order to verify that the flexplate was securely bolted. A visual inspection would not detect a lack of torque in the bolting of the joint, cracking of the flexplate under the bonded washers, or disbonding of the washers. Moreover, the Manual did not direct attention to the need to look for fretting wear in the vicinity of the flexplate, in contrast to the direction for the intermediate flexplate in the Maintenance Manual. Visual inspection would not identify cracks in the flexplate, unless they extended beyond overhanging bonding material. It was also submitted that the Manual should have specified the use of an inspection light and mirror. Use of a torque wrench would have identified the looseness of bolt 4, which would then have been dealt with.

[56] It was submitted that the instruction, "Inspect condition …", given in the Maintenance Manual in relation to the flexplate, was inadequate. Reliance was placed on the evidence of Mr Ogier that the flexplate was in a cramped and dark location; and that the instruction did not refer to the need to look for fretting, amongst other things.

[57] It was submitted that the instruction, "Inspect condition…" given in the Maintenance Manual in relation to the main rotor gearbox yoke was inadequate, as it made no reference to looking for cracks, corrosion and fretting at this location. It was submitted, in any event, that an inspection for fretting dust was insufficient, because of the prospect of its earlier removal.

[58] It was submitted that torque stripes were unreliable as an indicator of loss of torque. They might be incorrectly applied, and not adhere both to the bolt components and the fixed (or bolted) component, so that the torque stripe might not indicate movement of the bolt in relation to the component. Moreover, there might have been a failure to apply a torque stripe; or it might have suffered damage; or it might have come off completely. It was also possible for a torque stripe, which had been applied both to the bolt components and the fixed component, to slip when the bolt

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41 Ex 18.

42 Ex 18, p 2933.

moved, and thus not reveal the movement. Reliance was placed on the fact that none of the maintenance experts would say that a torque stripe applied to a bolt with a torque slightly less than that specified in the Maintenance Manual would necessarily break in 100 hours of operation. Reference was made to the evidence about difficulties seeing torque stripes. Reference was made to evidence that torque stripes are used by some manufacturers solely to indicate that a bolt had been correctly torqued when it was installed, and accordingly were not regarded as significant.

[59] Reference was made to changes to the Maintenance Manual, made after the accident. One change provided that the torque stripe is to be of lacquer, rather than paint. Another was a direction stating that the torque stripe "must", rather than "should", extend to the part being fastened. Another was an instruction that torque stripes are to be positioned for maximum visibility during pre-flight inspections; and that they must be periodically renewed. Yet another was an instruction to inspect the condition of fasteners and torque stripes, to verify the security of all fasteners; and to renew deteriorated torque stripes.[43]

[60] It was submitted to be material that there was no reference to torque stripes at paragraph 1.300 of the Maintenance Manual; nor in paragraph 2.410, which includes instructions relating to inspection of the area where the forward flexplate is located. Reference was made to the evidence of Mr Kerr that, where a torque stripe has been applied to a bolted joint with inadequate torque, its condition would not indicate proper torquing.

[61] For the plaintiffs, it was submitted, by reference to the fact that inspections were carried out by two LAMEs and two pilots, who did not observe the palnuts were missing from bolts at the flexplate, that the palnuts were in position immediately prior to the accident. Reference was made to Mr Kerr's evidence of mechanisms by which a palnut might separate from a bolt, during the accident; and the fact that two palnuts, of the type used at the flexplate, were recovered during the exhumation. By reference to Mr Kerr's evidence, it was submitted that the rotor brake assembly detached, with loose components being propelled in the vicinity of the flexplate, and a high potential for one of those components to strike Bolt 4. Reference was also made to Dr Gilmore's evidence that an examination of the ATSB photography shows a second palnut in position (apparently on Bolt 4). The fact that it was not on the bolt when it was received by the ATSB could be explained by a failure during the collection of parts after the accident.

[62] The submissions also referred to the evidence of Mr McKendry and Mr Lewis, each of whom gave evidence that they checked to ensure that the palnuts on the flexplate were in place before flying the helicopter in 2004.

[63] The submissions for the plaintiffs then dealt with the allegations of negligence on the part of Mr Norton. It was submitted that the instructions in the Pilot's Operating Handbook published by Robinson (*POH*) were inadequate. The specific instruction relating to the flexplate and coupling was, "No cracks, nuts tights". Reliance was placed on the evidence of Dr Gilmore that, by the time cracking extended beyond the outer edges of the bonded washers, and thus became visible, "the flexplate is

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43 See Ex 1, vol 6, tab 5, p 1968.

likely to have already failed"[44]. Reliance was also placed on the evidence of Mr Lay, relating to difficulties in seeing a crack extending beyond the bonded washers, given the confines of the location of the flexplate, and low lighting. Reference was made to evidence relating to bonding material extending over the edge of the flexplate, preventing detection of a crack. The submissions referred to evidence from Mr Doyle and Mr Bray that they had not seen fretting at the forward flexplate. Dr Orloff had never seen fretting dust in that location. The submissions referred to the evidence from a number of witnesses, identifying matters which would account for the absence of fretting dust in the vicinity of Bolt 4, or explain why it was not detected. Thus it might remain in the cavity where the bolt sat; it might lodge under the flexplate; it might be dispersed as a consequence of centrifugal force associated with the rotation of the flexplate, or by air flow, primarily from the rotor, but influenced by flow from the air cooling system, or generated by the movement of the helicopter; and it might be disguised by the presence of other dust, either from the atmosphere in the Northern Territory where the helicopter was working, or from the rotor brake.

[64] It was submitted that the direction in the POH to check the tightness of nuts was unrealistic. Reference was made to the evidence that the nut on Bolt 4 could not be seen by the pilot during inspection, and that the only method for checking tightness was by feel. Little torque was required to prevent a pilot turning the nut by hand; and additional tension could result from misalignment of the clutch shaft.

[65] It was submitted that the tightness of the bolt could not be checked by the pilot by reference to torque stripes. The torque stripe for Bolt 4 would not be visible to the pilot, using the equipment ordinarily used for pre-flight inspections. Reference was made to the evidence of Dr Turnour that he does not treat an inspection of the torque stripes as sufficient, but would also himself "handle the bolts".

[66] The plaintiff's submissions dealt with the allegation that Mr Norton was negligent by flying too low, thus preventing a safe landing by use of the auto rotation of the rotor blades. The evidence showed that Mr Norton was in the process of landing, which inevitably required him to fly the helicopter at decreasing altitudes in the course of the descent. Moreover, he managed to land the helicopter, though with some impact. Reference was made to the evidence of Mr Kerr to the effect that the failure of the flexplate influenced the operation of the rotor, preventing the execution of a safe landing by reliance on auto rotation, even from a height of 500 feet.

[67] Reference was made to the evidence that, on the day before the accident, Mr McDermott had detected a vibration of the helicopter. He described it as "a quiver in the dash…in the console"[45]. He asked Mr Norton about it, and said it was "rotor slap" associated with a heavy cross-wind, and the fact that the helicopter was "pretty much in the hover" when he noticed it. Shortly afterwards, they landed, and while Mr McDermott moved some cattle on foot, Mr Norton opened the panels of the helicopter. Mr McDermott gave evidence that on the flight back, a distance of about 20 miles, the vibration was not apparent. It was submitted that there was no evidence relating the vibration to the cause of the accident. It was submitted that in light of the evidence, allegations of voluntary assumption of risk were not made out.

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44 Ex 1, vol 1, tab 1, p 7.

45 T 2-82 to 2-84.

[68] The plaintiffs' further written submissions on liability referred to the fundamental principles relating to the existence of a duty of care, its breach, and causation of loss, both under the general law and under the *Civil Liability Act* 2002 (Qld) (*CL Act*).

[69] The plaintiffs submitted that the fact that the Maintenance Manual did not provide adequate inspection procedures rendered the helicopter defective, having regard to the provisions of s 75AC of the TPA. In particular, the instructions relating to inspection did not convey what is required in sufficiently clear or comprehensive terms.

[70] The submissions referred to the fact that in a joint report, expert LAMEs could not agree that the Maintenance Manual required the application of a torque stripe across both nuts and exposed bolt threads, extending to the component being fixed[46]. Nor did they agree about whether the security of the bolted joint should be verified by applying a torque wrench to the head of the bolt[47]. They agreed that the only way that a LAME could verify with certainty that the bolted joint was properly torqued was by use of a torque wrench[48]; and had that been done at the 100 hour inspections, it was more likely than not that the lack of torque in the bolt would have been detected, and rectified[49].

[71] With reference to the instruction in the Maintenance Manual to verify that the bonded washers were securely bonded to the flexplate, the submissions referred to the fact that the expert LAMEs could not agree about whether it was necessary to disassemble the bolted joint in order to inspect for disbonding[50]; though they agreed that if the flexplate had been removed to verify that the washers were securely bonded during a 100 hourly inspection, it is more likely than not that the defect would have been detected and rectified[51].

[72] The submissions referred to the fact that the worksheets completed by Mr Bray and Mr Fisher recorded that their inspections were carried out in accordance with the Maintenance Manual.

[73] Similar submissions were made in support of the claim made under s 75AE of the TPA.

[74] In respect of the claims under s 75AD and s 75 AE, it was submitted that s 75AI was not applicable, it not having been established that Mr McDermott was a worker, and accordingly the loss is not one in respect of which an amount might be recovered under a law relating to workers compensation.

[75] In respect of the allegation made by Robinson that the negligence of Helibiz and Heli Centre severed any causal connection between the conduct of Robinson and the loss and damage suffered by the plaintiffs, the plaintiffs submitted, by reference to *Mahony v J Krusnich (Demolitions) Pty Ltd*[52], that negligence on the part of Helibiz

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46 Ex 1, vol 2, tab 11, pp 603-604, question 4.
47 Ex 1, vol 2, tab 11, p 609, question 17.
48 Ex 1, vol 2, tab 11, p 621, question 5.
49 Ex 1, vol 2, tab 11, p 623-624, question 8.
50 Ex 1, vol 2, tab 11, p 613, question 26.
51 Ex 1, vol 2, tab 11, pp 621-623, questions 6 and 7.
52 (1985) 156 CLR 522, 528-529.

and Heli Centre was foreseeable; and that the chain of causation is only broken where it is possible to draw a clear line marking the boundary of the damage for which the earlier tortfeasor is liable; and that was not so in the present case. It was also submitted that Robinson made no attempt to establish negligence on the part of the LAMEs who performed the 100 hourly inspection, including in relation to missing palnuts. It was submitted that the conduct of Helibiz and Heli Centre was a direct result of the inadequacies in the Maintenance Manual.

[76] The plaintiffs also submitted, with respect to the allegation that negligence or breach of duty on the part of NTB caused the loss, that it had not been shown that there was a failure to perform the inspection required by AD 41, or to perform it property. It was also submitted that there was evidence that Mr Norton carried out a pre-flight inspection; and there was evidence that such an inspection would not have revealed fretting, or cracking or missing palnuts. It was also submitted that the evidence did not establish negligence in respect of the altitude at which Mr Norton was flying the helicopter.

[77] It was also submitted that Robinson had not established that damages should not be awarded by reason of voluntary assumption of risk on the part of Mr McDermott; or because he, or NTB or Mrs McDermott vicariously by reason of Mr McDermott's conduct or that of Mr Norton, were guilty of contributory negligence.

**Robinson's Liability Submissions**

[78] Robinson relied on Mr Cox's evidence that the Maintenance Manual had been approved by the United States Federal Aviation Administration (*FAA*) after substantiating data had been submitted to it, reviewed and accepted.

[79] Robinson's submissions referred to paragraph 1.003 of the Maintenance Manual, which states that only mechanics who have successfully completed a maintenance course sponsored by Robinson, or who are under the direct supervision of a mechanic who has done so, may make repairs, or perform the 100 hour inspections, on the R22[53]. Topics in the course conducted by Robinson included metal fatigue and fastener torque requirements[54].

[80] It was submitted that the instruction to inspect the condition of the forward flexplate should be read with par 2.000 of the Maintenance Manual (set out earlier in these reasons).

[81] Robinson relied on the evidence of Dr Turnour to the effect that testing has confirmed that once a joint in the forward flexible coupling is torqued, it is not necessary for that joint to be re-torqued[55].

[82] With reference to the instruction in the Maintenance Manual to inspect the condition of the flexplate, and verify its security, reliance was placed on the evidence of Mr Cox that a visual inspection was required with an emphasis towards the edges of the flexplate, utilising a mirror and flashlight, including an inspection of the bolts for looseness, detectable by reference to the torque stripe; and to check that a minimum

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53 Ex 1, vol 3, p 854.

54 Ex 1, vol 7, tab 4, p 703.

55 Ex 1, vol 7, tab 5, p 719, par 2.23.

of two and a maximum of four threads of the bolt were exposed beyond the nut[56]. Reliance was also placed on similar evidence from Mr Boyle, which in addition referred to the use of a spanner to check torque, and the removal of the bolt, nuts and washers, if fretting dust were evident[57].

[83] With reference to the instruction to verify the bonding of the washers, the submissions referred to the evidence of Mr Cox that this required a visual inspection of the periphery of the bond for signs of deterioration[58]; and the generally similar evidence of Mr Boyle, which again made reference to fretting dust, in this case at the edge of the adhesive[59]. Reference was also made to the evidence of Mr Boyle that a more detailed inspection might be carried out by removing the upper access panel[60].

[84] It was submitted that the Maintenance Manual, as understood by those who had completed the Factory Training Course, provided instructions to inspect the components of the forward flexplate for cracks, fretting, the condition of the torque stripes, disbonded washers, looseness and incorrect installation of the bolted joints; and if any of these were not in order, then to investigate further.

[85] It was submitted, by reference to the evidence of Dr Romeyn[61], that fretting wear, disbonded washers and cracks in the flexplates would have been identified by a LAME during a 100 hourly inspection.

[86] With reference to the torque stripe, Robinson relied upon the evidence of Dr Orloff[62] that a loss of torque in a bolted joint will result in rotation of the nut and bolt, relative to the flexplate, causing separation or cracking of the torque stripe, which can be detected by visual inspection; and in particular, before complete failure of the flexplate, bolt movement would be manifested by its effect on the torque stripe[63]. Reference was also made to evidence from the expert LAMEs that if the bolt had been rotating in its bolt hole, the torque stripe would have broken[64]. It was submitted that the failure bolt would have had a broken, deteriorated or missing torque stripe as a result of rotation. Reliance was placed on the evidence of Dr Orloff[65], Mr Lay[66], Mr Ogier[67], as well as Mr Bray[68], and Mr Fisher[69] to the effect that if a torque stripe was deteriorated, missing or broken, it would be necessary to check the torque of the nut and bolt.

[87] It was submitted that there was a body of expert evidence to demonstrate that fretting occurred, and no evidence to the contrary; and that accordingly it should be found that fretting dust was generated in the vicinity of Bolt 4. Reliance was placed

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56 Ex 1, vol 7, tab 4, p 686.
57 Ex 1, vol 7, tab 6, p 771.
58 Ex 1, vol 7, tab 4, p 686, par 2.9.
59 Ex 1, vol 7, tab 6, p 772.
60 Ex 1, vol 7, tab 6, p 775.
61 T 2-65, lines 22-30.
62 See Ex 1, vol 7, tab 7, p 795, par 2.3.8.
63 Ex 1, vol 7, tab 7, p 795, par 2.3.9.
64 Ex 1, vol 2, tab 11, p 608, question 15.
65 T 4-75, lines 52-58; T 4-76, lines 1-6.
66 T 3-28, lines 8-13, 22.
67 T 3-39, line 28 ; T 3-40, line 3.
68 T 4-5, lines 3-12.
69 T 4-10, lines 31-41.

on the evidence of Dr Orloff that fretting dust adheres to the adjacent surface[70], and is not removed by normal cleaning, unlike environmental dust[71]. Reliance was also placed on the evidence of Dr Casey that the fretting would have produced a maroon band which would be "obvious to everyone"[72]. Mr Doyle gave evidence that fretting dust could be identified in a helicopter working in dusty conditions[73]. Dr Casey gave somewhat similar evidence about fretting dust near a screw in a side wall of an R22 helicopter[74]. By reference to Dr Orloff's evidence[75], it was submitted that fretting dust was quite different from dust from the rotor brake. On the basis of that evidence it was submitted a finding should be made that the fretting at Bolt 4 produced dust which would be visible on inspection. The presence of such dust would have required investigation by a LAME.

[88] Robinson's submissions relied on the evidence of Dr Orloff that it was likely that, at the date of the last 100 hourly inspection, Crack A had extended to the edge of the flexplate, beyond the bonded washer, and could have been detected on visual inspection. Reliance was also placed on his evidence that, looking in from the back of the helicopter, Crack B would be clearly visible. He gave that evidence by reference to a photograph of a forward flexplate installed in an R22 Helicopter[76]. The submission also referred to Dr Casey's opinion that Crack A must have been visible beyond the bonded washer as Crack B propagated; and to Dr Romeyn's evidence that Crack B took some 228.6 hours to develop and extend to the edge of the forward flexplate.

[89] Reference was made to Dr Casey's evidence that, as fretting progressed, Bolt 4 would have become looser, and any test of its torque by means of a spanner would almost certainly have detected that it was unacceptably loose[77]. In the final stages of the bolted joint's life, the bolt could have been turned easily in relation to the flexplate, probably even with the use of fingers, and it could have been rocked in the bolt hole (along the bolt's axis)[78].

[90] It was submitted, on the basis of Dr Turnour's evidence[79], that the loss of bonding would not have reduced the fatigue life of the flexplate to the extent that its failure could occur before the failure of the bond could be identified by visual inspection. Also by reference to Dr Turnour's evidence[80], it was submitted that audible clicking would have been readily apparent after engine shut-down.

[91] Robinson submitted that palnuts were missing from bolts securing the flexplate prior to the accident, and that this should have been detected by the LAME conducting the final 100 hourly inspection, and by Mr Norton. Reliance was placed on the evidence of Dr Romeyn for a submission that there was no palnut on Bolt 4, nor on another bolt at the flexplate, prior to the accident[81]. Reference was made to

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70 T 4-45, line15.
71 T 4-45, lines 20-21.
72 Ex 1, vol 7, tab 1, page 7, par 3.18.
73 Ex 6, tab 28, p 2, question 28(b).
74 Ex 6, tab 20, p 2, par 2.5.
75 T 4-46, lines 5-8.
76 See Ex 1, vol 1, tab 1, p 6, fig 3.
77 Ex 1, vol 7, tab 1, p 7, par 3.16.
78 Ex 6, tab 20, p 3, par 2.11, 2.13, 2.14.
79 Ex 1, vol 7, tab 5, p 720, par 2.25.
80 Ex 6, tab 24, par 4.
81 T 2-56, lines 30-37.

Dr Turnour's evidence that there were no palnuts on Bolts 1 and 2[82]. Dr Orloff gave evidence of a test, based on a gap in the assembly for Bolt 4 of .012 inches[83], which showed that when a palnut was installed, and came in contact with the locking nut, the bolt assembly would rotate in relation to the flexplate[84]; and accordingly there could not have been a palnut on Bolt 4 after the work done on 17 February 2004. It was submitted, on the basis of Dr Orloff's evidence, that the palnut could not have been knocked off Bolt 4 during the accident, because there was nothing which might have caused that to occur[85]. It was also submitted, on the basis of Dr Orloff's evidence, that palnuts could not have been knocked off Bolts 1 and 2 in the accident, because the flexplate was rotating in a direction such that impact would tighten the palnuts; and because there was no relevant discernible damage to the bolts or the flexplate. Had a palnut been placed on Bolt 4 when it was loose, that, too, was evidence of negligence, as the looseness of the bolt would then have become apparent. It was submitted, by reference to Dr Turnour's evidence, that the two palnuts found when the wreckage was exhumed were not from the flexplate bolts[86].

[92] The exhumed palnuts could, on Dr Turnour's evidence, be from some other location where similar palnuts were installed[87]. Damage to the threads of Bolt 4 may have been caused by the locking nut; or by the palnut at the time of manufacture; rather than by impact to the palnut during the crash[88]. Damage to the end of Bolt 4 was likely to have occurred during manufacture[89].

[93] Dr Turnour's evidence was relied upon to refute the opinion of Mr Kerr that the palnut could be removed by a single tangential impact[90].

[94] In support of the adequacy of the Manual, reference was made to the evidence of Mr Bray that, when he was performing 100 hourly inspections, he would normally put a spanner on the head of the bolt and apply a small amount of force[91]. He would also check the torque stripe, and look for the presence of the palnut. If the torque stripe was damaged, or was missing, or there were signs of fretting, he would investigate further[92]. Mr Bray also gave evidence that if a torque wrench were applied to bolts at the flexplate, the integrity of the seal was put at risk[93]. Mr Fisher gave evidence which was broadly similar to the evidence of Mr Bray.

[95] The submissions for Robinson referred to Dr Orloff's evidence that a visual inspection by a pilot, Mr Norton, prior to the accident, should have identified "cracking, separation, or lack of torque seal and evidence of fretting"[94]. Dr Orloff considered that the instruction in the POH, "Nuts tight", was an instruction to check

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82 Ex 1, vol 7, tab 5, p 721, par 4.6.

83 This might be compared with Dr Casey's evidence that initially the gap was .006 inches, or .15mm: Ex 1, vol 7, tab 1, p 5, par 3.5.

84 Dr Orloff's report dated 1 February 2013, Ex 21, pp 14-15/264-265.

85 T 4-35, line 28.

86 Dr Turnour's report dated 31 January 2013, Ex 21, p 41/236, par 4.4.

87 Dr Turnour's report dated 31 January 2013, Ex 21, p 43/238.

88 Dr Turnour's report dated 31 January 2013, Ex 21, p 43/238, par 4.7.

89 Dr Turnour's report dated 31 January 2013, Ex 21, p 44-45/239-240, par 4.8.3.

90 Dr Turnour's report dated 31 January 2013, Ex 21, p 15/210ff.

91 T 4-4, lines 38-45.

92 T 4-5.

93 T 4-7, line 39.

94 Ex 1, vol 7, tab 7, pp 795-796.

for the application and continuity of torque stripes on the bolted joints at the forward flexplate[95]. Reliance was also placed on Mr Lay's evidence that if, in a pre-flight inspection, he saw a loose bolt or missing component, that was something that would "draw (his) attention …"[96]. Mr Doyle gave evidence that if a pilot saw fretting dust in a pre-flight inspection he should have endorsed the maintenance release, with the result that the helicopter should not be flown, and that an engineer should inspect it[97]. Mr Doyle gave evidence that a pilot in such an inspection should be able, by feel, to detect a crack extending to the outside edge in the flexplate[98].

[96] Mention has previously been made of Mr McDermott's evidence that the day before the accident he detected a vibration of the helicopter. Robinson submitted, relying on evidence of Dr Orloff[99], that Mr Norton should then have undertaken a visual inspection of the drive chain, and it is highly likely that such an inspection would have revealed indications of the improperly installed bolt, thus avoiding the accident.

[97] Robinson also submitted that, because Mr McDermott did not give evidence of observing Mr Norton carrying out any internal examination of the helicopter on the morning of the accident, it should be concluded that Mr Norton did not properly carry out the pre-flight inspection. Indeed, that should be inferred by virtue of all of the indications which were present of the difficulties with the forward flexplate.

[98] Robinson submitted, by reference to Dr Orloff's evidence, that the Maintenance Manual contained adequate inspection procedures to detect cracking of the forward flexplate, lack of torque in Bolt 4, and fretting wear and disbonding of the washers at that location[100]. The instruction to "inspect condition" of the forward flexplate, and the associated yokes, required examination by sight and touch for, amongst other things, discolouration, cracks, and fretting. Removal of the flexplate during the 100 hourly inspection was not required, because bolt rotation and movement would be identifiable as a result of fretting, and the condition of the torque stripe[101]. Reliance was also placed on Dr Orloff's evidence that the Maintenance Manual is not to be compared with manuals for other helicopters[102]. He also gave evidence that, in his opinion, the matters alleged by the plaintiffs to be omitted from the Maintenance Manual were in fact dealt with by it[103]. It was unnecessary to give a specific direction to use a mirror and torch, as basic training for LAMEs, in inspecting parts which are not directly visible would make that plain[104].

[99] Moreover, it was also submitted, by reference to Dr Orloff's evidence[105] that it could not sensibly be suggested that the Maintenance Manual should include

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95 Ex 1, vol 7, tab 7, p 813.
96 T 3-33, line 15.
97 Ex 1, vol 7, tab 3, p 666.
98 Ex 1, vol 7, tab 3, p 666.
99 Ex 1, vol 7, tab 7, p 799, par 2.8.2.
100 Ex 1, vol 7, tab 7, p 793.
101 Ex 1, vol 7, tab 7, pp 808-809, par 2.15.6.1.
102 Ex 1, vol 7, tab 7, p 812, par 2.10.4.
103 Ex 1, vol 7, tab 7, p 801.
104 T 4-62, lines 9-15; reliance was also placed on the evidence of LAMEs (Ex 1, vol 2, tab 11, p 611, par 22) that a torch and mirror should be part of a LAME's Standard Kit.
105 T 4-74, lines 51-57.

instructions to deal with every occasion on which a maintainer of a helicopter failed to follow a clear instruction in the Manual.

[100] The submissions for Robinson relied on the evidence of Mr Cox that the Maintenance Manual provided adequate instructions to ensure protection from a loss of torque at Bolt 4, fretting wear at that location, disbonding of the washers, and the presence of fatigue cracking. Mr Cox gave evidence that there were hundreds of critical fasteners, and checking each one at every 100 hourly inspection was pointless and dangerous, because a properly assembled joint would not fail, and rechecking increased the chance of reassembly error[106]. Mr Cox rejected a suggestion that, at every 100 hourly inspection, a torque wrench should be applied to the bolted joints at the forward flexplate, because of "the risk of additional error being introduced"[107]. Nevertheless, Robinson's submissions relied on evidence from experts (Mr Lay and Mr Ogier) called by the plaintiffs that it is the usual practice in service maintenance to remove palnuts and re-torque bolted joints with a calibrated torque wrench[108]. Reliance was also placed on the evidence of those witnesses that on a 100 hourly inspection of an R22 helicopter, a reasonably competent maintainer should verify security of the bolted joints at the forward flexplate by use of a torque wrench[109].

[101] It was also submitted that the condition of Bolt 4 was the result of negligence by a LAME; and that subsequent failure of a LAME carrying out a maintenance inspection to detect the condition of the bolt was also negligent.

[102] Two additional sets of written submissions dated 12 June 2013 were provided on behalf of Robinson. One set dealt with the lapse of time between the correct assembly of Bolt 4 and the accident, and with whether a torque stripe had been applied at Bolt 4. Those submissions addressed the fact that Dr Romeyn's evidence that Crack B developed over some 228.6 hours of operation by the helicopter, on the one hand, and, on the other, that the evidence put forward by Mr Lay and adopted by Dr Orloff indicated that the incorrect assembly occurred on 17 February 2004, some 122 flight hours prior to the accident. It was submitted that the inconsistency could be reconciled by reason of the fact that it was likely that some 1.7 flights occurred on each day on which the helicopter was flown, giving a total of 64 flights after 17 February 2004; and there being some evidence of more than one flight per day on some occasions. Reliance was also placed on evidence from Dr Gilmore[110] that the 64 cycles resulted in a propagation of Crack B occurred over "approximately 150 hours".

[103] With respect to the question whether a torque stripe had been applied at Bolt 4 it was submitted that it was unlikely that that occurred when the joint was last assembled, because it had not been torqued. If a torque stripe had then been applied, it was submitted that Bolt 4 would have moved sufficiently in its bolt hole, to have broken the torque stripe. Reference was made to Dr Turnour's test conducted late in 2011, where a torque stripe applied on 2 December survived for the next test run, but broke in the following run[111]. Dr Turnour's evidence indicated

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106 Ex 6, tab 26, p 1.
107 T 5-46, lines 55 to 5-47, line 1.
108 Ex 1, vol 2, tab 11, p 609, par 18.
109 Ex 1, vol 2, tab 11, p 609, par 17.
110 Ex 1, vol 1, tab 2, p 80.
111 See Ex 1, vol 7, tab 5, p 760.

that a run of 50 cycles was "the standard half hour of testing"[112]. On this basis it was submitted that, had a torque stripe been applied on 17 February 2004 it would have broken before the inspection on 27 March 2004, and definitely before the inspection on 13 May 2004. Reliance was also placed on the "circumferential ridges" on Bolt 4 as demonstrating that the bolt rotated in the bolt hole.[113] Reliance was also placed on the evidence of Mr Kerr about movement in the bolted joint, resulting in fracturing of the torque seal[114]. It was submitted that a finding should be made that the bolt moved within its bolt hole, and would have broken any torque stripe applied to it.

[104] The other submissions provided on 12 June 2013 dealt with a number of matters. It was submitted that the cause of the plaintiffs' loss and damage was the negligence of LAMEs inspecting the helicopter rather than any inadequacy in the Maintenance Manual. It was submitted that there was no duty requiring Robinson to produce a Maintenance Manual that would anticipate every possible error by a LAME, and prescribe a means for detecting it.

[105] It was submitted, by reference to reg 43 of the *Civil Aviation Regulations* 1998 (Cth) (*CA Regs*) that reliance on certification by a LAME that work has properly been done was consistent with the statutory scheme of regulation; and accordingly, it would be inconsistent with that scheme to hold that the Maintenance Manual should direct LAMEs to take steps to check work previously certified as having to be done.

[106] It was also submitted that it was not incumbent on Robinson to put to Mr Bray and Mr Fisher that they had not followed the Maintenance Manual. It was also submitted that certification by Mr Bray and Mr Fisher that each had conducted a 100 hourly inspection should not lead to a finding that they had done everything identified in the inspection checklist, because that was inconsistent with the balance of the evidence. In particular, it was submitted that the evidence showed that Mr Bray could not have followed his usual practice of applying a spanner to Bolt 4 in conducting the 100 hourly inspection on 27 March 2004; had he done so, he would have found Bolt 4 to be loose. In this context, reliance was placed on a test carried out during the cross-examination of Dr Turnour and evidence then elicited from him[115]. Moreover, Mr Fisher acknowledged that he may not have followed his usual practice when carrying out the 100 hourly inspection on 12 May 2004.

[107] It was submitted that, at the time of the inspections carried out by Mr Bray and Mr Fisher, Crack A was fully formed, and Crack B must have progressed well beyond the edge of the washer. Fretting wear, and disbonding of the washer, must also have been apparent. It followed that they had not carried out the instructions given in the Maintenance Manual. Had they done otherwise, the defect would have detected. It was submitted that the instruction to "verify security" in relation to the flexplate "could not mean anything less than to apply a torque wrench" to establish the existence of proper torque, if there was any doubt that it existed.

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112 2T 3-46, line 30.

113 The condition of the bolt was described by Dr Romeyn at Ex 1, vol 1, tab 6, p 203.

114 Ex 1, vol 2, tab 34, pp 510, 511 and 516.

115 2T 3-54 to 3–55.

[108] It was also submitted that the effect of the evidence was that, unless a torque stripe was in place (and unbroken), then it was necessary to check the torque[116].

**Dr Turnour's test**

[109] In late 2011 and early 2012, Dr Turnour conducted a test intended to establish the durability of the flexplate with a bolt loosened in a similar fashion to the bolted joint at Bolt 4. His evidence was that the test was intended to represent operations which were more severe, in terms of fatigue damage to the flexplate, than the most abusive operation reasonably to have been expected when the helicopter was in service[117]. The testing was conducted with the helicopter tied down while the engine and rotor operated.

[110] For the purpose of the test, the set up of the coupling at the forward flexplate differed from what was specified in the Maintenance Manual. For the bolts for the main rotor gear box yoke, no washer was installed between the yoke and the flexplate, on both yoke arms[118]. For one of those bolts, the nut was backed off from what was described in the test log as "snug", by one third of a turn, or some 0.014 inches, and no palnut was installed. Dr Turnour says that this is 0.002 inches smaller than the 0.016 inch gap estimated to have existed in the accident helicopter[119]. Dr Romeyn in fact measured a gap of .0855 inches, or 2.17 mm, after the accident[120]. Without the wear that had by then developed, that is, at the time Bolt 4 was initially incorrectly installed, and allowing for the space taken up by the bonding material, Dr Casey estimated that gap to be 0.006 inches[121], or 0.15 mm, a view accepted by Dr Gilmore[122]. It would seem to follow that in the test, there was a greater gap in the untorqued bolt at the commencement of the test, than there was in Bolt 4 when it was initially incorrectly installed. There is no reason to think that the bolt in the test rotated less easily than did Bolt 4 after it was incorrectly assembled.

[111] The test logs record the testing in segments, with each segment comprising a number of runs. Initially, runs included a power cycle representing take off power, with three subsequent power cycles to maximum continuous power. This is clearly recorded in the logs for segments one to three. However, later runs involved taking the power to maximum continuous power for ten seconds, then to idle for ten seconds, with each run taking just over thirty minutes to complete. These runs did not include a cycle representing take-off power[123]. The test logs record that for the last four segments, cycles were described as being for one second maximum continuous power, followed by one second idle; and the time for 50 such cycles was substantially less than half an hour, ranging from 10 to 22 minutes.

[112] The bolt and bolthole were inspected after the fourth group of cycles, which would appear to represent the end of the fourth segment.

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116 See Ex 1, vol 2, tab 11, p 608 question 16; and T 3-39, line 29.

117 The test and the data recorded in the test logs appear at Ex 1, vol 7, tab 5, pp 746-765.

118 Ex 1, vol 7, tab 5, p 754.

119 Ex 1, vol 7, tab 5, p 747.

120 See Dr Casey's evidence, Ex 1, vol 7 tab 1, p 5, par 3.4.

121 Ex 1, vol 7, tab 1, p 5, par 3.5.

122 Ex 1, vol 1, tab 4, p 182.

123 Ex 1, vol 7, tab 5, p 747 ; and note the amendement to the log cards for segments four to six, where TOP was replaced by MCP : Ex 1, vol 7, tab 5, pp 757-759.

[113] Dr Turnour's report stated that a total of 2510 power cycles were applied to the helicopter during the testing. The log cards record 2510 maximum continuous power cycles; as well as 20 cycles involving take-off power. Dr Turnour also stated that the total operating time of the helicopter with a loose flex coupling bolt was 15.55 hours[124].

[114] It is difficult to reconcile Dr Turnour's statement that the helicopter operated for 15.55 hours during testing, with the log records. For those segments where the runs was slightly longer than a half hour (segments seven and eight), the operating time was in excess of eight hours. For the subsequent segments, the number of minutes for each run (sometimes expressed as an approximation) comes to a total of some seven hours and 30 minutes. Segments four to six involved runs of a half hours' duration, and together represent an additional one and a half hours. Segments one to three involved 20 runs. Total time at maximum continuous power for these segments was one hour nine minutes and 31 seconds, though operating time was plainly longer, involving idling time, and time with the engine operating at take off power. What appear to be the start and finish times on the log records would indicate a total time for these three segments of two hours and twenty minutes. The log records therefore indicate an operational time approaching 20 hours.

[115] With respect to run two of segment one, the test log records that there were "possibly added lines" on the bolt; and with respect to run eight of the same segment there was "possibly fresh fretting powder on yoke". In subsequent segments, the bolt was inspected, and on occasion removed. In segment seven, the log entry for run five records the application of a torque stripe prior to the start of the run; and for run six, it records that the bolt spun, breaking the torque stripe.

[116] Dr Turnour's evidence is that distinct bands of wear on the bolt shank were visible, corresponding to the edge of each of the components stacked together in the joint. He also gave evidence that there was significantly less bolt wear resulting from the test, than was evident on Bolt 4[125]. There was also clear evidence of fretting on the face and within the hole of the bonded washer, though there was minimal fretting within the flexplate hole itself[126]. There was no indication that the bonding had deteriorated[127]. There was no suggestion of cracks forming in the flexplate.

[117] Dr Turnour stated that the frequency of damaging load cycles during the test was significantly higher than that likely in "the most abusive operating environment", and thus represented "many times the hours of normal operation". On that basis, he provided a calculation of what he described as the "number of flight hours to failure". To do this, he divided the number of maximum continuous power cycles (2510) by 24. The number 24 incorporates his estimate of six flights per hour; and what he described as "a knock-down factor" of four, "used to take into account uncertainty associated with a single test result". This calculation produced an estimate of equivalent operating time of 104.6 hours.

[118] It is apparent that Dr Turnour's calculation relating power cycles to what might be called typical flying time reflects a ratio of 24 cycles per hour. In part that reflects

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124 Ex 1, vol 7, tab 5, p 747.
125 Ex 1, vol 7, tab 5, pp 748, 751.
126 Ex 1, vol 7, tab 5, pp 748, 752.
127 Ex 1, vol 7, tab 5, p 748.

six flights per hour[128], which does not seem to correspond with the likely usage of the helicopter under consideration. The knock-down factor of four is described by Dr Gilmore as "ambiguous"[129]. No scientific basis for it was identified. Dr Gilmore gave evidence, the effect of which was that the equivalent flying time could be substantially greater than that estimated by Dr Turnour[130].

[119] Dr Turnour's test seems to have been directed to establishing that the helicopter could operate for 100 flight hours (the time between inspections) with an un-torqued nut at one of the bolted joints in the flexplate, without a failure of the flexplate[131]. That conclusion could not be challenged, unless it were to be said that more than 24 cycles per hour were likely to have occurred in ordinary flying; or that take-off power is likely to be of greater significance than a cycle of maximum continuous power, and substantially more than 20 take-offs would have occurred in 100 hours. It will become apparent that it is highly likely that the helicopter took off more than 20 times in 100 hours of flying, and that while the number is uncertain, it is likely that there were more than 40 take-offs in this period. However, Dr Gilmore does not suggest that the actual use of the helicopter placed greater loads or stresses at the bolted joint, than those resulting from the test. Reference has already been made to the evidence of Dr Turnour as to the severity of the testing. I accept that, in terms of fatigue damage, the loads imposed in the test were more severe than those which would have been imposed in 100 hours of flying the helicopter.

[120] However, the test provides little real assistance on the time that elapsed between when Bolt 4 was incorrectly assembled, and when the flexplate failed, beyond establishing that it was well in excess of 100 hours. It can, however, be said that when the helicopter used for the test experienced the stresses of the take off power on 20 occasions, and exposure to maximum continuous power on 2510 occasions, that was not enough to cause disbonding of the washers, nor the commencement of the formation of cracks in the flexplate.

[121] Dr Turnour recognised the limitations of a single test case, by his "knock-down factor". The only criticism of his use of this factor was that in reality, operational time may have been substantially greater than he inferred. It would follow that, notwithstanding that Dr Turnour conducted a single test, and that the bolt used in the test was a little looser than the bolt in the helicopter which crashed, 100 hours of operation would not be sufficient to cause disbonding of the washers, nor the commencement of cracks in the flexplate.

[122] Although, as has been observed, the bolt in the test helicopter was not configured identically with Bolt 4, the test tends to support the view that fretting would occur before disbonding of the washers.

[123] Dr Turnour described the fretting of the bolt and bolt hole as "significant"[132], though Dr Casey described it as "fretting to a minor extent"[133]. Although the test cards raised the prospect that fretting dust may have been visible at an early stage, Robinson's case was conducted on the basis that no fretting dust was observed

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128 Ex 1, vol 7, tab 5, p 753.
129 Ex 1, vol 1, tab 3, p 163.
130 Ex 1, vol 1, tab 3, p163.
131 Ex 1, vol 7, tab 5, pp 722-724.
132 Ex 1, vol 7, tab 5, p 724.
133 T 5-16, line 25.

during the test[134]. Dr Casey explained this by saying that the fretting dust produced in these locations could not be observed while the bolted joint remained intact, being confined to the shaft of the bolt hole[135].

**When was Bolt 4 incorrectly assembled?**

[124] Dr Romeyn gave evidence that Crack B would have developed, or propagated, over a period of 228.6 hours of operation. He was unable to provide an estimate for the time taken for the formation of Crack B, before it began to propagate; nor for the development of Crack A; nor for the time taken for Crack A to form and commence to propagate, after Bolt 4 was first left with inadequate torque.

[125] Dr Romeyn's evidence of the time for the propagation of Crack B was on the basis that the loading required to cause progression of the crack would occur as a result of flight-by-flight variable amplitude loading, which created marks or striations on the surface which was formed by the development of the crack. He associated the more obvious striations with a cycle involving take-off and landing. He identified some 64 such marks, which he said represented 64 flights. From the helicopter's log book, 64 logged flights involved a total time of 228.6 hours.[136]

[126] Dr Casey agreed with that conclusion on the basis of the assumptions made by Dr Romeyn. However, Dr Casey considered that load sufficient to advance the cracking would occur much more frequently. He initially expressed the view that failure would occur within 27 flight hours from the time the bolt was left loose[137]; but subsequently revised his views, accepting that it "would take much longer for the overall evolution of the failure to occur", than he had said in his report[138]. Dr Romeyn acknowledged that in-flight power variations caused the crack to advance; but made it clear that only the more distinct striations, likely to be associated with a cycle of take-off and landing, were relevant to his time estimate[139]. There is no reason not to accept Dr Romeyn's evidence that some 64 cycles of take-off and landing produced the more distinct striations which he observed on the surface created by Crack B. I accept his evidence about the likely number of cycles of take-off and landing associated with the propagation of Crack B (in subsequent discussions of this evidence I propose to refer to a take-off, as equivalent to a cycle of a take-off and landing).

[127] Dr Romeyn's reasoning does not allow for the fact that the helicopter's fuel capacity only permitted three hours' flying time, while many of the flights were recorded in the helicopter's log books as being substantially longer. A review of log books[140] for the 27 flights from 27 September 2003 to 6 May 2004 shows flight times up to 10 hours. An explanation for this is what was referred to as "hot refuelling", where the helicopter would land and be refuelled with the engine running, and no separate landing and take off recorded. A review of the logged flight times for these 27 flights (which totalled some 145.5 hours) would suggest that refuelling requirements would mean that the helicopter took off more than 60 times. Beyond

134 See Ex 6, tab 20, p 2, par 2.3, and T 5-16 to 5-18.
135 T 5-16, line 20; see also Ex 6, tab 20, p 2.
136 See Ex 1, vol 1, tab 8, p 224.
137 See Ex 1, vol 7, tab 1, p 12 par 3.64.
138 T 5-15, lines 23-24.
139 See Ex 1, vol 1, tab 10, esp pp 235-236.
140 Ex 1, vol 4, pp 1636, 1638.

that, there is the prospect of additional occasions when the helicopter landed for reasons relating to the work on Tobermorey (the helicopter crashed in the course of landing for such a reason; and Mr McDermott gave evidence that the helicopter landed in the course of work the previous day). It seems to me that for this reason, Dr Romeyn's estimate of the time taken for the propagation of Crack B is unduly high.

[128] An examination of the helicopter's logbook[141] shows that 57 separate entries were made for flying between 16 July 2003 and 11 May 2004. These entries record flight times varying from 0.6 hours to ten hours. If one assumes that a flight time of 3.2 hours or greater would mean that the helicopter at some point landed and refuelled, then at least 100 take-offs occurred in this period. The total flying time was 230 hours. That would result in an average flight time of (at most) 2.3 hours per take-off.

[129] The helicopter was delivered to NTB on 19 April 2004. Between 20 April and 11 May, there were some 13 separate flight records, with a total flying time of 49 hours and, allowing for refuelling, at least 22 take-offs. That provides a fairly similar (maximum) number of hours per take-off to that previously mentioned.

[130] Assuming a further 30 hours of flying occurred after 11 May 2004, that average would mean that (at least) another 13 take-offs occurred after that date. That means that at least 64 take-offs occurred after 11 January 2004. It seems to me that that is the earliest date on which the propagation of Crack B began.

[131] However, this makes no allowance for landings and take-offs which occurred, without refuelling. As mentioned, the helicopter was in the process of landing for a purpose associated with the management of Tobermorey when the accident occurred; and it had, on Mr McDermott's evidence, landed the previous day for a similar purpose. It will be apparent that, while the earliest date on which that propagation of Crack B began was 11 January 2004, the date could have been substantially later because of other occasions on which the helicopter landed without refuelling. For example, if, for each occasion on which it was refuelled, it landed on one additional occasion, then Dr Romeyn's evidence would indicate that the propagation of Crack B commenced about 23 April 2004, or about 70 operational hours before the accident. That is because, on the assumptions just stated, some 64 take-offs would have occurred between that date and the accident.

[132] The evidence did not explore on how many occasions the helicopter landed, other than the occasions on which it refuelled. Nor did the evidence indicate what time was taken for Crack B to commence to form, before propagation[142]. Dr Casey ultimately abandoned his evidence about how long it would take from the incorrect assembly of Bolt 4 to failure of the flexplate[143]. There was no other evidence about how long Crack A took to develop; nor how long the bolt was loose before the commencement of Crack A. However, Dr Turnour's test makes it likely that more than 100 hours of operation of the helicopter, with Bolt 4 incorrectly assembled, occurred before Crack B began to propagate.

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141 Ex 1, vol 4.

142 See Dr Gilmore at Ex 1, vol 1, tab 2, p 84.

143 Dr Orloff also disagreed with this evidence: see Ex 1, vol 7, tab 7, p 798.

[133] The state of the evidence makes it very difficult to identify when the bolt was left loose. However, it does not establish that the bolt must have been left loose prior to the maintenance carried out on 17 February 2004.

**Preliminary comments on liability issues**

[134] The statement of claim includes a claim for damages for negligence. The claim arose after 2 December 2002, the date on which potentially relevant provisions of the CL Act came into force[144]. By and large, the submissions of the parties have been framed without reference to the provisions of the CL Act. There appears to me to be no reason to think that the determination of claims based on negligence would differ if dealt by reference to the provisions of the CL Act, from the result which would follow under the general rule. Moreover, no attention was paid to the question whether the provisions apply, given that the helicopter crash occurred, Mr McDermott suffered injury, and some of the other damages which are claimed were suffered, in the Northern Territory. Accordingly, I propose to deal with the claims based on negligence, primarily by reference to the general law.

[135] The statement of claim pleads a duty of care, in a way that is by no means unconventional. However, it does not specifically identify the person or persons to whom that duty is said to be owed. The case has been conducted on the basis that Mr McDermott, as a person who travelled in the helicopter, was a member of a class of persons to whom Robinson owed a duty relevant to the case. That duty and its breach, provide the foundation both for Mr McDermott's claim in negligence, and one of Mrs McDermott's claims, apparently based on s 13 of the *Law Reform Act* 1995 (Qld).

[136] NTB also claims damages under the general law. The statement of claim includes an allegation that, as a result of Mr McDermott's injuries, NTB was deprived of his services; as a result of which a number of other events occurred, ultimately leading to the loss claimed by NTB. The case has been conducted on the basis that this claim is a claim by NTB for loss of services, dependent on establishing injury to Mr McDermott as a result of the negligence of Robinson. It has not been suggested that Robinson directly owed a duty of care to NTB, breach of which was the cause of the loss leading to its claim for damages.

[137] Conventionally, the negligence-based claims depend upon the existence of a duty of care owed to Mr McDermott; its breach; and resultant injury. Robinson admits that it had a duty to exercise reasonable care to ensure that the Maintenance Manual provided an adequate inspection and servicing procedure. The primary question in relation to these claims is whether the duty which Robinson owed to Mr McDermott was breached. The statement of claim alleges a number of breaches. Two of those, as I read them, allege that the Maintenance Manual did not provide an adequate inspection procedure to detect a lack of torque in Bolt 4, and its consequences[145], although one of these is specifically directed to 100 hourly inspections. The others identify specific matters which it is alleged should have been, but were not, identified in the Maintenance Manual: inspection of the attaching hardware to the forward flexplate; inspection of the entire surface of the flexplate; the removal of palnuts from the bolts which secure the flexplate, and the retorquing of the bolted

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144 See s 2 of the CL Act.

145 See Statement of Claim para 40(j).

joint; removal of the flexplate to inspect the bonded washers; and removal of the flexplate to verify it had been correctly installed, and that the torque requirements had been met[146].

[138] Ultimately, it seems to me that in respect of negligence-based claims, the question is whether the provisions of the Maintenance Manual are adequate in the sense that they make adequate provision for taking steps to prevent failure of the flexplate, an event which could have catastrophic results. It seems to me that that question is to be answered, not simply by looking at the adequacy of individual provisions of the Maintenance Manual in isolation (such as instructions relating to inspecting for cracks), but by looking at the effect of the Maintenance Manual as a whole.

[139] I would however observe that it is apparent that the Maintenance Manual itself recognised that there was a risk of catastrophic failure if one of the bolted joints for the flexplate became loose. That is apparent from the identification of the bolts as critical fasteners; the instructions relating to achieving the correct torque for them; and the requirement of a torque stripe.

[140] Robinson seeks to justify the adequacy of the instruction in the Maintenance Manual by reference to things which should have been identified if its instructions had been carried out. It is convenient to consider the question of negligence by reference to these matters.

**Torque stripe**

[141] Some of the evidence related an inspection of the torque stripe to the instruction to verify the security of the forward flexplate, and some, to the instruction to inspect its condition.

[142] As mentioned, in support of the adequacy of the instruction to verify the security of the forward flexplate, Robinson relied upon the evidence of Mr Cox and Mr Boyle. Mr Cox's evidence was that this instruction would lead him to inspect visually the four bolts attaching the flexplate to the yokes for signs of looseness and for correct installation[147]. Mr Boyle gave evidence that performance of this instruction would involve, at least initially, a visual inspection for signs of looseness of the four bolts, as well as correct installation[148]. Both he and Mr Cox referred to checking the torque stripes; and to the statement that a minimum of two and a maximum of four threads should be exposed beyond the nut. Mr Ogier also related this instruction to the security of the bolted joint[149], as did Mr Lay[150].

[143] While to a lay person, it may not seem obvious that an instruction to verify the security of the flexplate is in fact directed to the condition of the bolted joints, nevertheless I am satisfied that it does so adequately for the purposes of a LAME. However, the plaintiffs submit it is inadequate because it does not specify what is to be done, and might be interpreted differently by different LAMEs.

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146 See Statement of Claim para 40(p)-(t).
147 Ex 1, vol 7, tab 4, p 686-687.
148 Ex 1, vol 7, tab 6, p 771.
149 Ex 1, vol 2, tab 15, p 280.
150 Ex 1, vol 2, tab 27, pp 417-418.

[144] Robinson's case, based on the evidence of Mr Cox and Mr Boyle, is that it is at least necessary to examine the torque stripe. Mr Bray said, when asked about this direction, that he would normally check to see that "the torque stripe was there"[151]. Mr Lay's evidence indicates that the instruction requires the LAME to look at the torque stripe[152]. Mr Ogier's evidence treated an examination of the torque stripe as part of the response to this instruction[153].

[145] In light of all of this evidence, and the fact that the Maintenance Manual identifies the torque stripe as an indicator of rotation of the nut or bolt subsequent to the joint being torqued as required by the Manual[154], I accept that the instruction to verify the security of the forward flexplate requires a LAME on an 100 hourly inspection to examine the condition of the torque stripes for the bolted joints.

[146] The LAMEs agreed that if a torque stripe had been properly applied to the bolted joint, then it would have broken as a result of rotation of the bolt, with probable misalignment between the stripe on the bolt and the stripe on the fixed component (in this case the yoke)[155]. Mr Lay qualified his answer by reference to the instructions as to the application of a torque stripe introduced in 2007; and by reference to his experience of missing, damaged or inadequate torque stripes. I shall deal with the latter qualification later in these reasons.

[147] I understand the reference to the change to the Maintenance Manual in 2007 (*Change 26*), referred to by Mr Lay, to be the change made to pages 1.28 to 1.29[156] (particularly in para 1.310); and Drawing 2-1. Those changes emphasised the need for the torque stripe to be conspicuous, and for periodic renewal of torque stripes. However, in essence, the instruction then was for the torque stripe to be applied across both nuts and exposed bolt threads, as well as to the component being bolted. That instruction seems to me not to be materially different from that in the Maintenance Manual current prior to the accident, at least from 2000[157]. Both the text and Figure 2-1 then made clear that the torque stripe should extend from the nuts and bolt to the component being fastened (as they did in 2007); and, in both versions, the text explained the reason, namely, to permit detection of bolt rotation (which would only be possible if the stripe extended onto the fixed component). Accordingly, it seems to me that this qualification does not substantially affect Mr Lay's response, namely, that if the bolt rotated, it would break the torque stripe.

[148] Mr Ogier agreed, on the basis that the torque stripe was properly applied, and went on to say that "Change 21" did not provide "instruction reference as to how the (torque) stripe was to be applied"[158]. "Change 21" was the version of the relevant part of the Maintenance Manual in force prior to the accident. The statement is inconsistent with that version of the Manual.

[149] Elsewhere, Mr Ogier gave somewhat different evidence. He said that it is difficult for a torque stripe to adhere to a surface unless the surface is clean and dry at the

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151 T 4-4, line 45.
152 Ex 1, vol 2, tab 27, p 418.
153 Ex 1, vol 2, tab 15, p 280; see also T 3-39 to 3-40.
154 See Ex 1, vol 3, p 880.
155 See Ex 1, vol 2, tab 11, p 608, answer 15.
156 See Ex 1, vol 6, pp 1953-1954.
157 Ex 1, vol 3, p 880.
158 Ex 1 vol 2, tab 11, p 608, answer 15.

time of the application of the torque stripe; and suggested that the stripe might slip as the surface moved. He also suggested that a relatively thin stripe might "not fill a void as direction changes between surfaces and therefore is made to support its own weight, with the potential for it to crack under vibration in service."[159]

[150] The prospect that a torque stripe might slip because it had been applied to a contaminated surface was not explored in the cross-examination of Mr Lay, Mr Boyle, or Mr Cox. It was not raised by anyone other than Mr Ogier. I note that Mr Ogier has not been a practising LAME for a period of the order of 30 years; nor has he had experience in relation to the maintenance of R22 helicopters[160]. I note that none of the other experts suggested that the risk of a torque stripe slipping because it has been applied to a contaminated surface was such as to make a torque stripe an unreliable indicator of bolt movement. It seems to me quite unlikely that a torque stripe, intended to be used as an indicator of bolt movement, would be applied to a contaminated surface in the course of the manufacture of the helicopter, and I note that in the present case the plaintiffs do not allege any negligence in the course of manufacture. It also seems to me quite unlikely that a LAME, familiar with the role assigned to torque stripes in the Maintenance Manual, would apply a torque stripe to a contaminated surface. I therefore do not accept that the risk that a torque stripe might be applied to a contaminated surface, and subsequently slip, is such as to render inadequate the use of a torque stripe as an indicator of bolt movement. Moreover, the gap in Bolt 4 strongly suggests that when the bolt was incorrectly assembled, the torque was not checked. In addition, there is the evidence referred to in Robinson's submissions, to the effect that there was no torque in the bolt at this time. If follows that it is quite unlikely that a torque stripe was applied at that time. In my view, in this case there is no need to consider the prospect that the torque stripe was in place, but slipped, because I consider it more likely that, when the bolt was incorrectly assembled, no torque stripe was applied.

[151] The balance of Mr Ogier's evidence referred to earlier appears to be directed to the prospect that a crack might occur as a result of vibration, and not of rotation of the bolt. If so, it simply identifies another circumstance in which a torque stripe might be damaged, requiring investigation.

[152] There is at least implicit criticism of the language used in the Maintenance Manual, in relation to the application of torque stripes. That appears from the contrast between that language, and the more obviously mandatory language used in Change 26. However, it seems to me that the language used in the Maintenance Manual at the time of the accident was sufficiently clear. It identified the purpose of the torque stripe, and said that it should extend across both nuts, and exposed bolt threads, to the fixed component. In my view, it was sufficient to indicate to a LAME that it was necessary for the torque stripe to extend beyond the nuts and threads, onto the fixed component.

[153] Mr Kerr considered that a properly applied torque stripe might not indicate a loss of torque, because the bolted joint might subsequently settle, and lose clamping force, without rotation[161]. However, the failure of the flexplate was a consequence of bolt rotation. This evidence does not show that the Manual failed to provide an adequate

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159 Ex 1, vol 2, tab 10, p 598.

160 T 3-37, lines 40-60.

161 Ex 1, vol 2, tab 34, p 516.

instruction to protect against the failure which occurred in the present case. It does not show that any loss of clamping which might result from settling of the joint, but not bolt rotation, might cause some form of failure.

[154] Accordingly, I find that the Maintenance Manual at the time of the accident made adequate provision for a method of identifying bolt rotation.

[155] The submissions for the plaintiffs did not suggest that a torque stripe was an inadequate indicator of possible failure of the flexplate resulting from bolt rotation, because that failure might occur in a relatively short time after the bolt commenced to rotate, and before the next 100 hourly inspection. The submissions for Robinson relied on the evidence of Dr Orloff that a lack of torque in a bolted joint would result in rotation of the nut and bolt, relative to the fixed component, causing separation or cracking of the torque stripe[162]. Taken at face value, that evidence would suggest that rotation occurred virtually from the time that the joint was left in an inadequately torqued state. However, Dr Orloff went on to say that the broken torque stripe would be visually identifiable "before complete failure of the flexplate"[163], suggesting that the rotation and resultant breaking of the torque stripe might have occurred at a relatively late time.

[156] Dr Romeyn gave evidence that there was extensive wear on the bolt shaft, and that it was uniform around the circumference of the shaft[164]. Since the fretting has been explained by the fact that loads were transferred by direct contact between the bolt and the sides of the bolt hole, with small movement, it follows that fretting was produced by some rotational movement of the bolt; and the uniform wear was the result of the fact that the bolt rotated significantly. The wear which occurred in Bolt 4 is substantially greater than the wear apparent on the loose bolt used in Dr Turnour's test[165]. Notwithstanding some of my earlier observations about Dr Turnour's evidence correlating the time for testing with operational time in more common conditions, it seems to me that the wear which occurred on Bolt 4 was the result of rotation over an operational period substantially greater than 100 hours. Moreover, the condition for the bolt to rotate, that is, lack of clamping, existed from the time when the bolted joint was incorrectly assembled.

[157] I am prepared, therefore, to find that rotation commenced at Bolt 4 shortly after the joint was incorrectly assembled, and more than 100 hours before the accident. If a torque stripe had been correctly applied at the time when the bolted joint was incorrectly assembled, it would have broken relatively shortly thereafter, and would have been visible on a subsequent 100 hourly inspection.

[158] Earlier in these reasons, I have attempted to summarise the submissions made on behalf of the plaintiffs about the inadequacy of torque stripes as an indicator of loss of torque. To a significant extent, the submissions were to the effect that a torque stripe might be damaged or missing for a reason unrelated to loss of torque. However the submission included the proposition that the torque stripe might not extend to the fixed component, and accordingly, not indicate movement; or, for various reasons, the torque stripe might not be easy to see.

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162 See Ex 1, vol 7, tab 7, p 795, par 2.3.8.

163 Ex 1, vol 7, tab 7, p 795, par 2.3.9.

164 Ex 1, vol 1, tab 6, p 203.

165 Ex 1, vol 7, tab 5, pp 747-748, 751.

[159] It seems to me that a reading of the Maintenance Manual, which identifies the role of a torque stripe on a critical fastener, together with the instruction to "verify security" in relation to flexplate, would indicate to a LAME carrying out a 100 hourly inspection the need to look for a torque stripe on each critical fastener; and if it were missing, damaged, or incomplete, to take steps to determine whether the torque was adequate, and to reapply the torque stripe. It seems to me that that view of the effect of the Maintenance Manual is supported by the evidence of Mr Fisher and Mr Bray, referred to in the submissions made on behalf of Robinson[166].

[160] That view is also supported by the evidence of Dr Orloff[167]; Mr Lay[168]; and Mr Ogier[169]. On one reading of his report, Dr Orloff related an examination of the torque stripe to the instruction to inspect the condition of the flexplate[170]. If correct, this would not affect my ultimate conclusion. The same action may be made necessary by more than one direction in the Manual[171].

[161] The evidence did not deal specifically with how a LAME might respond to a torque stripe which appeared to be intact on the nuts and the thread on the bolt, but did not extend onto the fixed component. It seems to me that, if that part of the torque stripe, which the Maintenance Manual expressly nominated, was missing, that should be more significant to a LAME than chipping, or the fact that some other part of the torque stripe was missing. It therefore seems to me that the evidence of the responses of LAMEs to deteriorated torque stripes should be understood to include cases where the torque stripe, critically, does not extend from the thread of the bolt and the nuts, onto the fixed component.

[162] The torque stripe on Bolt 4 was forward of the flexplate, in a confined space, which might well be dark when maintenance is being carried out, inside a shed. I accept that maintenance might be carried out in circumstances where a LAME might not have direct vision of such a torque stripe and the inspection may be made more difficult because of lighting conditions. I note that neither Mr Bray or Mr Fisher suggested that that was in reality a problem in inspecting torque stripes. In my view, it was reasonable for Robinson to expect that a qualified LAME would use a torch and mirror to inspect a torque stripe if direct vision was not adequate[172].

[163] It may be that a bolted joint does not have the torque specified in the Maintenance Manual, but the bolt is unable to rotate. That condition is not made apparent by a broken torque stripe. However, the evidence does not show that there is a risk of a failure of the joint or the flexplate as a result of such a condition.

[164] Since the inspections occur every 100 hours, there is an obvious possibility that a bolt which is not properly torqued will rotate for up to 100 hours before an inspection. The evidence did not suggest that there was a risk of failure of the bolted joint or of the flexplate, unless more than 100 hours had passed since a bolt joint began to rotate.

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166 Robinson's preliminary submissions on liability, pp 19-20, par 83-84.

167 T 4-63 to 4-65, line 26; 4-70, line 15 to 4-71, line 4.

168 T 3-27, line 41 to 3-28, line 38.

169 T 3-39, line 28; 3-39line 57 to 3-40, line 4.

170 See Ex 1, vol 7, tab 7, pp 792-795; see also pp 808-809.

171 See Ex 6, tab 27, Dr Orloff's answer to question 3(b).

172 See Mr Boyle Ex 1, vol 7, tab 6, p 775; Dr Orloff Ex 1, vol 7, tab 7, p 793, par 2.3.2; see also Mr Bray at T 4-5, lines 50-51, indicating the likely unavailability of a mirror and a torch.

[165] One conclusion on which my finding about the adequacy of the direction to verify security of the flexplate is based, is that it would have been necessary for Bolt 4 to rotate for more than 100 hours of operation of the helicopter before the flexplate would have failed. That is follows from an acceptance of much of Dr Romeyn's evidence, including his evidence about the number of take-offs associated with the propagation of Crack B; inferences from the evidence (primarily the log books) about the use of the helicopter; and some allowance for the time taken for the occurrence of the other events which led to the failure of the flexplate. Even if that conclusion were not correct, the plaintiffs would not succeed on their case that the directions for the inspection of the flexplate were inadequate. That is a matter on which they bear the onus. Even without the analysis which has been undertaken of the log books, and the conclusions which I reached relating to the number of flights of the helicopter, the evidence does not permit a positive finding that the direction was inadequate because it was reasonably foreseeable that, rotation of the bolt having commenced at the time of a 100 hourly inspection, the flexplate might fail before the next such inspection. I should add that, particularly in light of Dr Turnour's test, and the fact that it did not result in damage to the bonding of the washers, or cracks to the flexplate, I consider it quite unlikely that failure of the flexplate would occur in less than 100 hours of the incorrect assembly of a bolted joint, or the subsequent commencement of rotation of the bolt.

[166] I am therefore satisfied that the instruction in the Maintenance Manual to verify security, in relation to the forward flexplate, was sufficient to identify a risk of failure resulting from inadequate torque in a bolted joint[173].

[167] My finding that the instruction to verify security was sufficient, if complied with, to enable detection of the inadequate torquing of Bolt 4 before the flexplate failed, is generally sufficient to dispose of the plaintiffs' allegations of the inadequacy of the instructions in the Maintenance Manual. In case my finding is incorrect, I propose to express my views about what seem to me to be the more significant of the remaining allegations, and some related matters.

**Torque wrench**

[168] The submissions for the plaintiffs refer to the inadequacy of methods of establishing that a bolt was properly torqued, other than by the application of a torque wrench. I accept that it is not possible to establish that a bolted joint is correctly torqued, save by the application of such a wrench; and that the Maintenance Manual did not specify the use of a torque wrench to verify the security of the bolted joint at the flexplate. It does not follow that the Maintenance Manual was inadequate; or that, in respect of the risk of a failure of the bolted joint of the flexplate by reason of a lack of torque, the Maintenance Manual had been negligently prepared. I consider that this risk is adequately addressed by the direction to verify security, in light of the provisions of the Maintenance Manual relating to torque stripes.

[169] My finding about the adequacy of the instruction to verify security of the flexplate, by reference to the condition of the torque stripe, means that this instruction (and the Maintenance Manual) was not inadequate because it did not specify the use of a spanner or torque wrench to check the torque of the bolted joints; and did not

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[173] Although Mr Lay did not specify the basis for it, his evidence at Ex 1, vol 2, tab 27, p 423 provides broad support for it.

require the disassembly and re-assembly of these joints, including the use of a torque wrench to ensure correct torquing.

**Fretting dust**

[170] It is clear that fretting occurred as a result of contact between Bolt 4 and the sides of the bolt hole through the flexplate[174]. There was also fretting of the washers at this bolted joint[175]. This produced fine particles, referred to as fretting dust.

[171] In my view, in the early period after the bolted joint was incorrectly assembled, it is unlikely that fretting dust would have been evident on inspection. The potential sources for such dust are contact between the shaft of the bolt, and the surfaces of the bolthole; and contact between the flat surfaces of the washers, and the flexplate, and the inner surfaces of the bolthead and locking nut.

[172] There is no suggestion that the bonded washers disbonded immediately upon the incorrect assembly of the bolted joint. While the bonding material remained functional, it seems to me that the bonded washers could not move relative to the flexplate, and fretting could not occur between the washers and the flexplate. The bonded washer on the rear side of the flexplate was separated from the head of the bolt by another washer. If the bolt head was rotating at this stage, that rotation would not have resulted in fretting on the surfaces of the bonded washer (except, perhaps, on the shallow surface which formed part of the bolt hole). The fact that Dr Romeyn refers to fretting wear to the shank of the bolt, but not under the bolt head, nor under the locking nut, tends to suggest that fretting did not occur to the washers which adjoined these parts.

[173] Even at an early stage, it is likely that fretting dust was produced within the bolthole, from contact between its walls and shaft of the bolt. At this stage, it is likely that such dust was contained in the bolthole.

[174] It seems to me that the fact that no fretting dust was evident after Dr Turnour's test is confirmatory of the view I have expressed. Moreover, as noted by Dr Casey, there was space within the bolt hole to contain fretting dust, and, at least to some extent, it was likely to be trapped there by the components of the bolted joint (even when incorrectly bolted)[176] .

[175] Once the bonding material broke down, fretting could, and did, occur between the surfaces of the (formerly) bonded washers and the surface of the flexplate. It seems to me to be likely that at some point, fretting dust so generated could have escaped beyond the edge of the washers. At some stage, fretting dust may also have escaped from within the bolt hole.

[176] There was considerable debate in the evidence about what would happen to fretting dust which escaped from the bolted joint. Dr Romeyn considered that it could disperse; though it could remain attached to the surface of the flexplate if grease were present[177].

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174 Ex 1, vol 1, tab 6, pp 203, 208.
175 Ex 1, vol 1, tab 6, pp 203, 211.
176 T 5-18, lines 1-11.
177 T 2-64, line 5; 2-67, lines 19-21.

[177] Dr Gilmore considered that it would be blown away, or flung out, presumably by reason of the rotational movement of the flexplate, and the airflows produced in its vicinity[178]. Dr Casey considered that it would spread circumferentially on objects near the flexplate[179]. Dr Orloff gave evidence that fretting dust "adheres very much to the surface", and that it is not easy to remove[180]. However, he seemed to recognise a possibility that fretting dust might be washed away[181]. The example given in his report of undispersed fretting dust is from an aircraft skin[182]. It would appear that the metal was aluminium[183]. Moisture might have affected this dust, causing it to adhere to the skin[184]. He had, however, never seen fretting dust on a flexplate, nor photographs of fretting dust in that location[185].

[178] There were also disputes about whether, if the fretting dust had remained in the vicinity of Bolt 4 or the flexplate, it would have been observable. In part, this debate was concerned with whether the fretting dust would be red or some other dark colour; whether its visibility would be impeded or prevented by the presence of environmental dust, particularly in a location where there were other restrictions on vision; and whether it might be mistaken for dust from the rotator brake. None of the evidence was identified as being based on experience of fretting occurring at a flexplate like that under consideration. Dr Romeyn appeared to me otherwise to be the person best qualified to give evidence about the colour of such dust. Accordingly, I accept his evidence that it would be red-brown in colour[186]. I also accept that its appearance would be different from that produced by the rotator brake clamp[187].

[179] Dr Romeyn's oral evidence as to the dispersal of the fretting dust appears to reflect his knowledge of the physical properties of the metal which produced it, and the effect of the rotational movement of the flexplate. Had that metal some characteristic which would cause it to adhere to a nearby surface, such as the flexplate, it is difficult to see how he could have given the evidence which he gave. While Dr Orloff's evidence is based on substantial experience, it was not expressly stated to relate to the bolted joint and flexplate. He had elsewhere stated that he had not seen fretting dust in the vicinity of the flexplate. It is by no means clear that observations about fretting dust at other locations, potentially involving different metals, the absence of movement and airflows such as are found at the forward flexplate, and, perhaps, the presence of some substance which might cause fretting dust to adhere there, are of any assistance. The other expert evidence to the effect that fretting dust which escaped from the bolted joint would have remained in the vicinity (and thus been visible) was not explained by reference to any scientific principle or relevant experience. Absent some mechanism which would explain why the fretting dust produced by a rapidly rotating source in a location with not insignificant airflows would remain in the vicinity, it seems inherently more probable that it would disperse into the atmosphere.

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178 Ex 1, vol 1, tab 2, pp 74-75; T 3-11, line 33.
179 Ex 1, vol 7, tab 1, pp 6, 10.
180 T 4-45, lines 1-48.
181 Ex 1, vol 2, tab 12, pp 624J, answer 16.
182 Ex 1, vol 7, tab 7, p 794.
183 T 4-53, lines 56-57.
184 T 4-54, lines 36-41.
185 T 4-56, lines 48-52.
186 T 2-67, line 9.
187 Dr Orloff at T 4-46, lines 5-8.

[180] I also note that Dr Casey regarded it as highly improbable that a LAME would not notice fretting dust in the vicinity of the flexplate when carrying out a 100 hourly inspection; and on that basis concluded that it was improbable that the second defendant or the sixth defendant had left Bolt 4 loose[188]. That reasoning would suggest that it was unlikely that fretting dust had escaped from the bolted joint, and remained n the vicinity, so as to be visible, at least prior to 12 May 2004.

[181] I accept Dr Romeyn's evidence, and find that fretting dust resulting from movement in the bolted joint did not remain in the vicinity as a visible indicator of lack of torque in the joint. In essence, part of Robinson's case was that the instruction in the Maintenance Manual to inspect the flexplate, read with paragraph 2.000, was sufficient to discharge its duty of care, because such an inspection should have identified the presence of fretting dust in the helicopter which crashed; and in turn led to the identification of the lack of torque in Bolt 4. On my acceptance of Dr Romeyn's evidence, that part of Robinson's case fails.

**Cracks in flexplate**

[182] As has been indicated, Crack A formed before the commencement of Crack B. The propagation of Crack B to the edge of the flexplate took a substantial, though uncertain, period of time.

[183] It is self-evident that neither crack would have been detectable on inspection (without disassembly of the bolted joint), before it extended past the outer edge of the bonded washers.

[184] There is a debate about whether Crack A could have ever been detected on inspection, unless the bolted joint was disassembled. Dr Orloff expressed the view that Crack A could have been detected "beyond the face of the bonded washers" by a LAME carrying out the last 100 hourly inspection[189]. Dr Casey expressed a similar view.[190] Dr Gilmore referred to examples of cases where the bonding material extended to and over the edge of the flexplate, with the potential to obscure a crack in the location of Crack A[191]. Mr Cox, Mr Lay and Mr Ogier also recognised the possibility that the bonding material would obscure such a crack at the edge of the flexplate.[192] Dr Gilmore also gave evidence that major edge cracks which have opened, and where a fracture was about to occur, would be visible; but there may be hairline cracks which are not detectable visually.[193]

[185] Dr Orloff considered that Crack B would be clearly visible once (though not before) it extended beyond the adjoining washers[194].

[186] In my view, the evidence demonstrates that there is a real risk that Crack A might not be identified by compliance with the instructions in the Manual, because the bonding material might prevent its detection.

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188 Ex 1, vol 7, tab 1, p 13.
189 Ex 1, vol 7, tab 7, p 798, par 2.7.5.
190 Ex 1, vol 7, tab 1, p 10.
191 Ex 1, vol 1, tab 4, pp 182-184.
192 Ex 1, vol 2, tab 11, p 612.
193 Ex 6, tab 27, p 11, answer 22.
194 T 4-47, lines 25-26.

[187] For part of the time over which it formed and propagated, detection of Crack B was prevented (unless the bolted joint was disassembled) by the washers which had been bonded to the flexplate. The propagation of Crack B occurred over a period in which the helicopter took off and landed some 64 times.

[188] Part of the propagation of Crack B was associated with the final fracture.[195] The absence of progression marks, and the fact that little of the flexplate remained intact at this point to withstand the stresses imposed by rotation of the flexplate against the bolt, suggest that this occurred fairly quickly.

[189] Crack B was 15mm in length to the point of final fracture.[196] It is difficult to identify precisely to what extent the crack lay under the adjacent washers, but it would appear that about half of its length would have been obscured by them.[197] On that basis, fewer than 40 take offs occurred after the crack extended beyond the adjacent washers. The number of hours' flying time which that would represent is unclear. Based on the calculations from the log books, and including occasions when it was necessary to land to refuel, 40 takeoffs occurred over a little less than 100 hours of flying time; but with additional landings for other purposes, the flying time could well have been substantially less. It is not difficult to envisage circumstances in which a helicopter would regularly land after an hour or less of flying, which would mean that a crack like Crack B would progress from the outer edge of the adjacent washers to the failure point in something like 50 hours. In those circumstances, it seems to be me that reliance on visual inspection for cracks at 100 hourly intervals is an inadequate method to avoid failure of the flexplates.

[190] I am therefore of the view that, if the Maintenance Manual relied solely on visual inspections for cracks, it would provide an inadequate method for detection of a bolted joint which was not properly torqued; and accordingly would not provide adequate protection against failure of the flexplate.

**Disbonding of washers**

[191] As has been noted, the Maintenance Manual contained a specific instruction to verify the bonding of the washers to the flexplate arms. Dr Turnour considered that failure of the bonding might be determined by visual inspection, without removing the flexplate.[198] Mr Cox's evidence was to similar effect.[199]

[192] On the other hand, Mr Boyle accepted that it was not possible to do this properly without removing the flexplate.[200] Mr Lay's evidence was to similar effect.[201] So was the evidence of Dr Gilmore;[202] Mr Ogier;[203] and Mr Kerr.[204]

[193] As I understood it, Robinson's case was that a visual inspection was sufficient for this purpose; and accordingly no specific instruction to remove the flexplate was

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195 Ex 1, vol 1, tab 6, p 202, fig 2.
196 Ex 1, vol 1, tab 8, p 224, table 1; Ex 1, vol 1, tab 10, p 235.
197 Ex 1, vol 1, tab 4, p 182, fig 18; Ex 1, vol 1, tab 6, p 202, fig 2.
198 Ex 1, vol 7, tab 5, p 720, par 2.25.
199 Ex 1, vol 7, tab 4, p 686-687, par 2.9.
200 Ex 1, vol 2, tab 11, p 613.
201 Ex 1, vol 2, tab 27, p 419.
202 Ex 1, vol 1, tab 4, p 188.
203 Ex 1, vol 2, tab 15, pp 279-280; see also tab 25, p 382.
204 Ex 1, vol 2, tab 34, p 517.

required. I prefer the evidence to the contrary. To the extent that disbonding only occurred under the washers, it could not be seen without removing the flexplate. Even then it may be difficult to identify. Some parts of the external periphery of the bonding would be difficult to inspect while the flexplate remained installed, being obscured by the yokes. The evidence indicates that, with some flexplates, the bonding material is distinctively coloured and sometimes relatively thick; although in other cases that is not so.[205] In those circumstances, and given the difficulty which may well be experienced by LAMEs in getting good vision of the bonding material while the flexplate remained in position, it seems to me that this instruction was not adequate to identify disbonding of the bonded washers. If Robinson's case that the Maintenance Manual provided adequate instruction to prevent the failure of the flexplate relied solely on the instruction relating to the bonded washers, it would fail.

**Missing palnuts?**

[194] Robinson contends that palnuts were missing from the bolts securing the flexplate prior to the accident. Its pleading identifies this as one of the causes of the accident; and alleges that the manual was adequate because the inspection procedures in it, if carried out, would have detected lack of security at Bolt 4 caused by the missing palnuts.[206]

[195] The case for the plaintiffs was that all of the palnuts were positioned on the bolts securing the flexplate immediately prior to the accident.

[196] Dr Turnour gave evidence that, in his view, three palnuts were missing prior to the accident.[207] He gave a number of reasons for his conclusion, which I do not propose to repeat. Dr Orloff's evidence was generally consistent with that of Dr Turnour. Dr Romeyn's evidence referred to two palnuts being missing after the accident; although when he gave his evidence, the question of missing palnuts did not attract much attention.[208]

[197] The plaintiffs relied principally on the evidence of Dr Gilmore and Mr Kerr. Dr Gilmore and Mr Kerr considered that the photographic evidence of the flexplate showed that two palnuts remained in place on the flexplate bolts, immediately after the accident. They also considered that the other two palnuts were likely to have been removed as a result of the relatively random rotation of the flexplate after failure.

[198] There is some logic in the evidence presented in the support of Robinson's position. However I am satisfied, in particular by the evidence of Mr Kerr, that with the continuing movement of the flexplate immediately after failure, and the fact that some debris was likely to be moving in the vicinity of the flexplate at this time, there is a real prospect that the palnuts could have been removed by some form of impact in the sequence of events immediately after the flexplate failed.

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205 Photographs appear in ex 15; see also exhibits 3, 4, 14 and 17.

206 See Defence, particularly paragraph 32(g)(vi) and (k). Similar allegations appear in paragraph 55, relating to the claim under the TPA.

207 See Dr Tunour's report dated 31 January 2013, Ex 21 p 4/199.

208 T 2-56.

[199] Mr McKendry had a commercial helicopter licence in 2004. He flew the helicopter which subsequently crashed on five occasions between February and April of that year. It was his practice in pre-flight inspection to see if palnuts were missing, and had he found that one was, he would have informed maintenance staff, and otherwise not flown the helicopter.[209] His evidence strongly suggests that the palnuts were in place when he flew the helicopter.

[200] Mr Lewis was in 2004 a helicopter pilot, also with a commercial helicopter pilot's licence. He flew the same helicopter on some six days between February and March of that year. During his pre–flight inspections, he would feel specifically for the presence of a palnut; and he considered it was very easy to judge whether a palnut was in place or not.[210]His usual practice would have detected if a palnut was missing from the flexplate, and he would have alerted the maintenance organisation, to have the palnuts replaced. He had signed the maintenance release for the helicopter, which he would not have done if a palnut was missing; nor would he have flown the helicopter in that condition.[211]

[201] Both these witnesses attributed significance to the absence of a palnut from one of the bolted joints of the flexplate. It seems to me that the absence of a palnut would be easier to detect than a crack in or misalignment of a torque stripe. They both appeared to be responsible persons, unlikely not to carry out the checks they described. Their evidence makes it highly unlikely that one palnut (let alone, three) was missing on the occasions on which they flew the helicopter, including in April 2004. Nothing was identified which would suggest a palnut, in place when either of these witnesses flew the helicopter, might have subsequently become detached from a bolt in the flexplate assembly, prior to the accident. I should add that their evidence derives some support from Dr Turnour's evidence of his pre-flight checks when flying a helicopter.[212]

[202] Mr Bray gave evidence that, when doing a 100 hourly inspection, if a palnut was missing he would take out the relevant bolt and do a thorough inspection.[213] Mr Fisher gave evidence that in the course of such an inspection he would check for palnuts, and if one was missing he would use a torque wrench to check the torque on the bolt.[214] The weight to be given to their evidence is affected by the fact that each of them failed to detect the condition of the torque stripe for Bolt 4, which, on my findings must have at the time of their inspections indicated that Bolt 4 had rotated. Nevertheless, it seems to me that a missing palnut would be particularly obvious to a LAME carrying out an inspection, and its significance would be well appreciated by each of them. Notwithstanding the reservation I have noted, it seems to me that their evidence provides some support for the proposition that the palnuts remained in place at the time of their inspections.

[203] Accordingly, I find that the palnuts were in place on the bolted joints immediately prior to the helicopter's crash.

**Claims under the TPA**

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209 2T 2-65 to 2T 2-67
210 2T 2-81.
211 2T 2-78 to 2T 2-79
212 2T 3-48 to 3-49
213 T 4-5, lines 21-24; see also T 4-7, line 57.
214 T 4-10, lines 15-23.

[204] Section 75AD of the TPA creates a statutory right to compensation if three conditions are satisfied. The first is that a corporation, in trade or commerce, supplies goods manufactured by it. The second is that the goods "have a defect". The third is that, "because of the defect" an individual suffers injuries.

[205] Section 75AE also creates a statutory right to compensation, on the fulfilment of three conditions expressed in the same terms as those in s 75AD; and two others. The first additional condition (so far as is of present relevance) is that a person, other than the individual, suffers loss because of the injuries to the individual. The second additional condition is that the loss does not come about because of a business relationship between the person and the individual.

[206] As has been noted, Mr McDermott has claimed compensation under s 7AD; and Mrs McDermott has claimed compensation under s 7AE. They each allege that the Maintenance Manual did not provide adequate inspection procedures to detect cracking in the flexplate, a lack of torque in the bolted joint, fretting wear of the bolted joint, and disbanding of the bonded washers. They each allege that the Maintenance Manual constituted goods manufactured and supplied by Robinson; and because of the inadequate provision for inspection procedures, the Maintenance Manual had a defect. They also allege that, because the Maintenance Manual did not provide adequate inspection procedures in the respects which I have identified, the helicopter had a defect. They allege that because of those defects, Mr McDermott suffered injuries; and Mrs McDermott alleges that because of Mr McDermott's injuries, she suffered loss.

[207] The allegations that Robinson was a corporation which, in trade or commerce, supplied the Maintenance Manual and helicopter, both being "manufactured" by it, are not in issue. Nor did Robinson's defence allege that the loss claimed by Mrs McDermott came about because of a business relationship between her and Mr McDermott.

[208] While the issues to be determined in relation to these claims are primarily factual, it is convenient to make some observations about the provisions of the TPA.

[209] Section 75AC includes the following provisions, of some significance in determining whether a right to compensation arises under either s 75AD or s 75AE:-

> "**75AC Meaning of goods having defect**
>
> (1) For the purpose of this Part, goods have a defect if their safety is not such as persons generally are entitled to expect.
>
> (2) In determining the extent of the safety of goods, regard is to be given to all relevant circumstances including:
>
> (a) the manner in which, and the purposes for which, they have been marketed; and
>
> (b) their packaging; and
>
> (c) the use of any mark in relation to them; and
>
> (d) any instructions for, or warnings with respect to, doing, or refraining from doing, anything with or in relation to them; and
>
> (e) what might reasonably be expected to be done with or in relation to them; and

(f) the time when they were supplied by their manufacturer."

[210] The Explanatory Memorandum to the Bill which introduced these provisions to the TPA stated that its purpose was to introduce "a strict product liability regime … ".[215] Nevertheless, as is apparent from the language of the sections, the right is conditioned on establishing that goods "have a defect". Negligence is not a necessary element of a claim under these provisions.[216]

[211] The critical question is whether the goods have a defect, as identified in s 75AC. The test stated in that section is whether or not the safety of the goods is such as persons generally are entitled to expect. The test has been described as providing an objective standard; and (as the language of the section makes plain) one related to the public at large, rather than any particular individual. That the test is divorced from actual expectations (whether of an individual, a group or, indeed, the community) is apparent from the fact that the answer depends upon what persons generally "are entitled to expect".

[212] It is apparent from s 75AC(2) that the enquiry is broad-ranging, giving regard to "all relevant circumstances". In context, a relevant circumstance is one which has some bearing on what persons generally are entitled to expect with respect to the safety of the goods. Of the specific examples given in s 75AC(2), those found in paragraph (d) and, to a lesser extent, paragraph (e), are of most relevance.

[213] The Explanatory Memorandum stated that in some cases, the role of "intermediaries" may be relevant.[217] The Explanatory Memorandum referred to the role of qualified medical practitioners and qualified pharmacists, when considering whether pharmaceutical products might be said to have a defect, because instructions provided to a consumer by the manufacturer were not complete. It seems to me that LAMEs are also intermediaries, and the instructions given to them in a document such as the Maintenance Manual may be relevant to determining whether the safety of the helicopter was, or was not, such as persons are generally entitled to expect.

[214] The Explanatory Memorandum recognised as a class of defect which might mean that the safety of goods was not such as persons generally are entitled to expect, defects described as "instructional defects", said to be "caused by incorrect or inadequate warnings and instructions".[218] While it is the text of the statute to which regard is to be had in determining whether a party is entitled to compensation under these provisions, it seems to me that the Explanatory Memorandum is entirely consistent with that text.[219]

[215] It might be regarded as self-evident that, without adequate maintenance, at some time a point will be reached where a helicopter cannot be flown safely; that LAMEs could not be expected to identify all that is necessary for the adequate maintenance of a helicopter without the benefit of maintenance instructions from the

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215 The relevant passage is reproduced in *Carey-Hazell v Getz Bros & Co (Aust) Pty Ltd* [2004] ATPR 42-014 at [182].

216 *Merk Sharp & Dohme (Australia) Pty Ltd v Peterson* (2011) 196 FCR 145 at [184].

217 See *Carey-Hazell* at [189].

218 See *Carey-Hazell* at [187].

219 Compare *Merck* at [192].

manufacturer; and that where the manufacturer provides a maintenance manual, the adequacy of its provisions is a relevant circumstance in determining whether the safety of the helicopter is or is not such as persons are generally entitled to expect.

[216] I have earlier concluded that the effect of the instructions in the Maintenance Manual required a LAME, carrying out a 100 hourly inspection, to examine the condition of the torque stripe for Bolt 4; that if the condition of the torque stripe was not as specified in the Maintenance Manual, then the LAME was required to take further steps to ensure that the torque was in accordance with the Maintenance Manual; and that accordingly, compliance with the Maintenance Manual was sufficient to prevent the accident. It follows that my earlier conclusions mean that Mr and Mrs McDermott have failed to establish the existence of a defect in the goods supplied by Robinson.

[217] If I were otherwise prepared to accept the submissions made on behalf of Mr and Mrs McDermott, it seems to me that the better basis on which they would then succeed would be that the helicopter had a defect[220]; although it seems to me that it would also be correct to say that the Maintenance Manual had a defect, and accordingly the claims could succeed on that basis. Indeed, according to the written submissions for Robinson, the latter analysis would be correct.[221]

[218] I have mentioned the submission made on behalf of Mr and Mrs McDermott that s 75AI of the TPA was not applicable because it had not been established that Mr McDermott was a worker, nor that the claim was one in respect of which an amount might be recovered under a law relating to workers' compensation. That submission was not controverted on behalf of Robinson. No attempt was made to identify the laws which would be relevant to the application of s 75A; nor the factual basis for its operation. Accordingly, I would not have been prepared to find that the claims under s 75AB and 75AD and s 75AE are defeated by the operation of s 75AI.

**Voluntary assumption of risk and contributory negligence**

[219] The allegations of voluntary assumption of risk and contributory negligence pleaded against Mr McDermott were not pursued in Robinson's submissions. In any event, although on some limited occasions Mr McDermott had taken the controls of and flown a helicopter, he was neither a qualified nor an experienced helicopter pilot. He did not have the expertise to be expected of a person who was qualified, or even an unqualified person with substantial experience as a pilot.

[220] Insofar as the allegations against Mr McDermott might be related to his observation of vibrations in the helicopter the day before the accident, in my view Mr McDermott reacted reasonably. He drew Mr Norton's attention to it; Mr Norton landed and, to Mr McDermott's knowledge, appeared to carry out an inspection; and Mr McDermott was given an explanation by Mr Norton for the vibration consistent with it being safe to continue to fly.[222] In any event, there is no evidence which could be said to relate the vibration (which was in the console), to the defect at Bolted Joint 4 (behind the cockpit).

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220 Compare *Gliderol International Pty Ltd v Skervic* (2009) 170 ACTR 1 at [25], [62]-[64].

221 Robinson's quantum submissions, par 33.

222 T 2-82 to 2-84.

[221] Mr McDermott also gave evidence, which I accept, that on 30 May 2004, he saw Mr Norton doing things consistent with a pre-flight inspection, over the course of about an hour.[223] Moreover, to Mr McDermott's knowledge Mr Norton was a very experienced pilot.[224]

[222] In my view, Robinson has not established that Mr McDermott voluntarily assumed the risk of the helicopter crashing; nor that a finding of contributory negligence should be made against him.

[223] However, allegations were also made against Mr Norton, on the basis that he was employed by NTB, with the consequence that, by reason of his conduct, NTB was guilty of contributory negligence. Those allegations related to Mr McDermott's observation of vibration in the helicopter the day before the accident, and the pre-flight inspection.

[224] Based on the evidence of Dr Orloff, it was submitted on behalf of Robinson that Mr Norton, having landed the helicopter, ought to have carried out an extensive inspection of the helicopter's drive train; which was highly likely to have identified indicators of the improper installation of Bolt 4, leading to its rectification and the avoidance of the accident.[225]

[225] The submissions for NTB rely on the evidence of Mr Lay that the proper course to be taken by Mr Norton would depend on the nature of the vibration.[226] It was also submitted that there is no evidence linking the vibration to the condition of the flexplate.

[226] There is evidence from Mr McDermott[227] and from Mr Doyle[228] that vibrations in helicopters are not unusual, and often are of no concern. Mr Lay's evidence, in my view, reflects a rational approach to a vibration. Mr Norton's explanation to Mr McDermott of the cause of the vibration indicates that he considered the cause of the vibration to be unrelated to any defect in the helicopter. In those circumstances, I do not accept that Mr Norton failed to take proper care (whether of himself or Mr McDermott) by failing to inspect the drive train when he landed shortly after Mr McDermott observed the vibration.

[227] The submission that Mr Norton should have heard clicking and accordingly have taken steps which would have led to the discovery that Bolt 4 was not correctly assembled, is based on evidence that clicking was heard when Dr Turnour conducted his test. Clicking was only recorded for three runs on one day of the testing[229]. Dr Turnour's evidence suggested, with some lack of certainty, that the clicking might have been audible on other occasions[230]. I am not persuaded that this evidence provides a good basis for finding that there would have been audible clicking associated with the condition of Bolt 4. If there were, it might be expected that it could have been heard by persons other than Mr Norton, including pilots who

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223 T 2-76 to 2-77.
224 T 2-76, line 42.
225 Ex 1, vol 7, tab 7, p 799 par 2.8.1-2.8.2.
226 Ex 1, vol 2, tab 13, p 4, par 33.
227 T 2-83, lines 9-13.
228 Ex 1, vol 2, tab 13, p 4, par 33.
229 See Ex 1, vol 7, tab 5, p 760.
230 2 T 3-57 to 3-59.

flew the helicopter earlier, and Mr McDermott. There is no suggestion that any of them heard clicking.

[228] For Robinson, it was submitted that I should find that Mr Norton did not carry out an adequate pre-flight inspection on the day of the accident, because Mr McDermott did not give evidence that Mr Norton did anything inside the helicopter. It was also submitted that, had Mr Norton carried out a pre-flight inspection in accordance with the POH then he would have identified cracks in the flexplate, evidence of fretting at Bolt 4, "separation" (apparently a reference to the disbonding on the washers), and lack of torque seal; as well as the absence of palnuts.

[229] These submissions were based on the following provisions of the POH

> "Check general condition of aircraft and verify no leaks, discolouration due to heat, dents, chafing, galling, nicks, corrosion or cracks. Also verify no fretting at seams where parts are joined together. Fretting of aluminium parts produces a fine black powder while fretting of steel parts produces a reddish brown or black residue."[231]

[230] This passage appears in the introductory paragraph to the instructions for daily or pre-flight checks. In that part of the instruction for "Engine Right Side", with reference to the flex coupling, there appear the words, "No cracks, nuts tight".[232]

[231] Dr Orloff's evidence[233] provided the basis for the submission about what Mr Norton should have seen in the course of his pre-flight inspection.

[232] The submission that Mr Norton should have observed the condition of the torque stripe also relied on the evidence of Mr Doyle that a visual inspection of the forward section of the forward flex coupling (which includes the appropriate location for the torque stripe for Bolt 4) would require a mirror and flashlight.[234] It should be observed that although Mr Doyle gave evidence as a pilot, he was then commenting on the evidence of Mr Kay relating to the conduct of a "reasonably competent maintainer", which I understand to relate to a LAME.[235] It is difficult to take from Mr Doyle's evidence, in that context, an inference that a pilot should have used a mirror and flashlight. Elsewhere, Mr Lay gave evidence (not controverted) that the POH did not require a pilot to use a flashlight and mirror when carrying out a pre-flight inspection; and he disagreed with the proposition that such an inspection should have led the pilot to observe the condition of the torque stripe for Bolt 4.[236] In other evidence, Mr Doyle also disagreed with the proposition.[237] His evidence suggested the pilot would not be expected to use a torch and mirror. Dr Orloff, when dealing with the same proposition, relied on his report at paras 2.3 and 2.4[238]. That evidence was in fact based on his views about what a LAME should have done, when carrying out a 100 hourly inspection, in accordance with the Maintenance Manual.

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231 See Ex 1, vol 5, p 1780.
232 See Ex 1, vol 5, p 1781.
233 Ex 1, vol 7, tab 7, p 796, par 2.4.2.
234 Ex 1, vol 7, tab 3, p 666.
235 Ex 1, vol 2, tab 27, p 418.
236 Ex 1, vol 2, tab 13, pp 1-2, par 28a.
237 Ex 1, vol 2, tab 13, p 2, par 28a.
238 *Ibid*; and see Ex 1, vol 7, tab 7, pp 792-796.

[233] Accordingly, I find that compliance with the POH did not require a pilot to use a mirror and torch to inspect the torque stripe at Bolt 4; and the failure of a pilot to detect that it was broken (or, perhaps, missing) does not demonstrate inadequacy in the inspection carried out by the pilot.

[234] There is other evidence which supports this conclusion. The POH requires pre-flight inspections to occur daily. While it is not clear precisely when the torque stripe broke, that occurred some time well before 30 May. If, as was suggested by Mr Lay, Bolt 4 was incorrectly assembled on 17 February 2004, the log book records flights on some 28 days thereafter; and there were no doubt additional days on which flights occurred after 11 May 2004. Pilots who flew the helicopter (Mr McKendry and Mr Lewis) after 17 February 2004 gave evidence in these proceedings. They appeared to appreciate the significance of proper pre-flight inspections, and there is no reason to doubt that these were carried out. The log book also required a recording of daily inspections[239] and contains certification of such inspection on days when the helicopter was flown after 17 February 2004. If the submissions for Robinson on this issue are correct, then on each occasion after the torque stripe broke (which, on my earlier findings, was relatively shortly after Bolt 4 was incorrectly assembled), the pilot should have detected the condition of the torque stripe. In other words, on each of these occasions, the pre-flight inspection required by the POH was carried out inadequately. There is, in my view, a substantial degree of improbability about this.

[235] I have previously concluded that fretting dust would not have been present in the vicinity of Bolt 4 on the day of the accident.

[236] It is apparent that Crack A had extended to the edge of the flexplate, well before the accident. The instructions in the POH made it necessary for pilots carrying out pre-flight checks to look for cracks in the flexplate. However, I have referred to evidence indicating that the crack may have been obscured by torque stripe material. The crack was not identified by pilots on pre-flight inspection over the weeks, and perhaps months, after it reached the edge of the flexplate, prior to the accident. I am not satisfied that it could be detected by a pilot who properly carried out the pre-flight inspection.

[237] I have previously considered the time taken for the formation of Crack B. Again, that occurred over a period of weeks, and probably months. For some of this time, it would have been obscured by the washers which had been bonded to the flexplate. Until the flexplate failed, there is evidence indicating that the crack may have been a hairline crack. My earlier discussion of the development of this crack, beyond the edge of the washers, indicates that it is likely that a number of pre-flight inspections occurred after the crack extended beyond the washers. I do not consider the evidence sufficient to support a finding that a properly carried out pre-flight inspection should have detected this crack on the day of the accident.

[238] The evidence did not suggest that the pilot carrying out a pre-flight inspection should use a torque wrench, or indeed any kind of tool, to test the tightness of nuts. Rather, that would be done by "feel"[240]. I have concluded that Bolt 4 was able to rotate for a substantial period of time before the accident occurred, probably a

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239 Ex 1, vol 4, pp 1636, 1638.

240 See Mr Ogier's evidence Ex 1, vol 2, tab 15, p 285.

number of months. The evidence, however, did not establish that the bolted joint where failure occurred was entirely without torque; nor what torque in fact existed over the period it took for the joint to fail.

[239] I am conscious that Dr Gilmore expressed the view that there was no torque after the bolt was incorrectly assembled[241]. That was associated with his view that there was a gap of .42mm in the joint. He later accepted that the gap was .15mm[242]. It is unclear whether, with this gap, there would be no torque whatsoever in the bolted joint. In any event, the operation of the clutch, and rotation by hand of the clutch shaft and flexplate, are likely to increase the effective torque of the bolted joint[243]. I note that, in his test, Dr Turnour was unable to rotate the incorrectly assembled bolt by hand[244]. The tension specified in the Maintenance Manual was 240 inch-lbs[245]. The evidence varied, but torque as low as 10 inch-lbs or perhaps 4 inch-lbs, or even 1.7 inch-lbs, would be sufficient to prevent rotation by hand[246]. I also note that pre-flight inspections were carried out on a significant number of days from the time when the bolt was correctly installed, prior to the accident.

[240] I am not prepared to find that the looseness of the bolt could have been detected by adequate pre-flight inspection in accordance with the POH.

[241] It was submitted that the failure of Mr Norton to detect the indicia of looseness at bolted joint 4 provided a basis for concluding he did not carry out an internal inspection on the morning of the accident. That submission was supported by reference to the evidence of Mr McDermott, which did not refer to any observation of Mr Norton carrying out any internal inspection of the helicopter. In my view, the inference cannot be supported by the fact that Mr Norton did not detect indicia of the looseness of the bolted joint. Mr McDermott's evidence is not a sufficient basis for the inference for which Robinson contended. Mr McDermott was performing other activities, and it seems likely that his observation of Mr Norton at this time was both intermittent and casual.

[242] It follows that I would not be prepared to find contributory negligence by NTB.

**Conclusions on liability issues**

[243] While the Plaintiffs' Further Liability Submissions expressly referred to s 9 and s 11 of the C L Act, they did not attempt to apply them directly to the facts of this case; nor did they suggest that, in the circumstances of this case, their application would result in a different conclusion to that which would be reached under the general law. In my view, addressing the issues raised by s 9 of the Act would not result in different conclusions to those I have stated earlier in these reasons. On those conclusions, s 11 is irrelevant.

[244] I am satisfied that the instructions in the Maintenance Manual relating to the inspection of the flexplate, particularly the instruction to verify its security, were, in

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241 Ex 1, vol 1, tab 1, p 9.
242 Ex 1, vol 1, tab 4, p 182.
243 Ex 1, vol 2, tab 27, p 420; T 3-21, lines 40-50; Dr Gilmour T 3-9, line 42 to 3-11, line 10; see also Mr Doyle at T 5-78, lines 39-54.
244 2T 3-45, lines 15-19.
245 Ex 1, vol 1, tab 1, p 9.
246 Ex 1, vol 1, tab 2 p 86; Dr Casey at T 5-23, lines 48-51; Dr Gilmour T 3-9, lines 1-40.

light of the provisions of the Manual relating to torque stripes, adequate to address the risk of failure of the flexplate from an inadequately torqued bolted joint. It follows that Robinson took reasonable care to address that risk; and that neither the helicopter nor the Maintenance Manual had a "defect", for the purposes of s 75AD and s 75AE of the TPA. The plaintiffs' claims accordingly fail.