CIVIL AVIATION AUTHORITY
OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT

OCCURRENCE NUMBER 02/1167

NZ AEROSPACE FU24-950

ZK-EGO

12 KM SOUTH-SOUTH-EAST OF MASTERTON

19 APRIL 2002

Glossary of abbreviations used in this report:

AD	Airworthiness Directive
CAA	Civil Aviation Authority
E	east
km	kilometre(s)
m	metre(s)
mm	millimetre(s)
nm	nautical mile(s)
NZST	New Zealand Standard Time
UTC	Coordinated Universal Time

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Aircraft type, serial number and registration:	NZ Aerospace FU24-950 (Fletcher), 237, ZK-EGO
Number and type of engines:	1 Lycoming IO-720-A1B
Year of manufacture:	1977
Date and time:	19 April 2002, 1013 hours[1]
Location:	12 km south-south-east of Masterton Latitude[2]: S 41° 04.36' Longitude: E 175° 42.05'
Type of flight:	Agricultural - topdressing
Persons on board:	Crew: 1
Injuries:	Crew: 1 fatal
Nature of damage:	Aircraft destroyed
Pilot-in-command's licence	Airline Transport Pilot Licence (Aeroplane)
Pilot-in-command's age	37 years
Pilot-in-command's total flying experience:	10,165 hours, 152 on type
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr A J Buckingham

[1] Times are NZST (UTC + 12 hours)

[2] NZ Geodetic Datum 1949 co-ordinates

Synopsis

The Civil Aviation Authority was notified of the accident at about 1030 hours on Friday 19 April 2002. The Transport Accident Investigation Commission was in turn notified shortly thereafter, but declined to investigate. A CAA site investigation was commenced later the same day.

The aircraft was on a topdressing run when the tail fin separated and fell to the ground. Some 870 m further on, the aircraft collided with a ridge and caught fire on impact. The pilot was killed and the aircraft destroyed.

1. Factual information

1.1 History of the flight

1.1.1 On the morning of Friday 19 April 2002, the pilot was engaged in spreading superphosphate on a hill-country property to the south-east of Masterton. Operations had commenced at 0735 hours, after the pilot and loader driver had flown to the airstrip from Masterton.

1.1.2 The topdressing proceeded normally for two hours, the pilot taking a refuel and "smoko" break from 0935 to 1000 hours. The left tank only was topped off, as the fuel system design permitted the fuel levels to equalise between the left and right tanks. As was his usual practice, the pilot carried out a full pre-flight inspection during the break.

1.1.3 The loader driver noted the time of the first takeoff after the break as 1001 hours. This sortie was completed normally; but the aircraft became overdue on the second. Looking over towards the area being worked, the loader driver saw a column of black smoke; he immediately telephoned the company chief pilot, who was operating another aircraft on a property a short distance to the south-west.

1.1.4 The chief pilot had already seen the smoke, and flew across to investigate. He saw the aircraft burning fiercely on the shoulder of a ridge and telephoned emergency services to report the accident. He briefly contemplated landing by the accident site, but decided against it and continued to the airstrip to pick up the loader driver.

1.1.5 They flew back to the site, but could see no sign of the pilot, so returned to Masterton. They had seen that there was a person and a motorcycle on the ground by the wreckage: this was the farmer whose property was being topdressed, and who had been working on the eastern side of the valley being sown.

1.1.6 While the aeroplane was on its last run, the farmer saw an object fall from it and "flutter" to the ground. He was unable to tell what the object was, but thought at first that it may have been a superphosphate bag by the way it fell.

1.1.7 Two fencing contractors were working near the farmer's position; they also saw an object fall from the aeroplane, and shortly afterwards one remarked to the other

that the aeroplane "had no tail". They watched the aeroplane climb and "veer to the left" before striking the ground near the top of the ridge at the southern end of the valley. It caught fire on impact.

1.1.8 The farmer, although he did not see the impact because of intervening terrain, realised something was amiss and quickly moved to a position where he could see the accident site. He then drove his four-wheel motorcycle to the site; he estimated that this took about three minutes.

1.1.9 On arrival, he found the centre section of the aircraft well ablaze; he could see no sign of the pilot at this stage, despite being able to get as close as the left wingtip. He reported that there were a number of explosions while the fire was burning, and that once the fire had subsided, he saw the pilot's body in the wreckage.

1.1.10 The impact (but not the falling object) was also witnessed by another farmer on the ridge to the western side of the valley. He estimated that some 10 seconds elapsed between impact and the first sign of fire, and had expected to see the pilot jump clear.

1.1.11 The falling object was later found to be the tail fin (vertical stabiliser); it had landed in a clearing in a small patch of bush near where the fencers had been working, 870 m from the point where the aircraft struck the ground.

1.1.12 The accident occurred in daylight, at 1013 hours NZST, 12 km south-south-east of Masterton, at an elevation of 1240 feet. Grid reference 260-T26-370116, latitude S 41° 04.36', longitude E 175° 42.05'.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	0	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 Three wooden fence posts were destroyed in the post-impact fire.

1.5 Personnel information

1.5.1 The pilot, aged 37, held an Airline Transport Pilot Licence (Aeroplane), and a Class 1 medical certificate valid to 11 February 2003.

1.5.2 He had flown a total of 10,165 hours, most of which was on multi-engined aircraft on air transport operations. In 2001 he had decided, for personal reasons, on a career change, and commenced agricultural flying training on 28 September 2001. At the time of the accident he had flown 152.7 hours in the agricultural role, having obtained his Grade 2 Agricultural Rating on 6 April 2002.

1.6 Aircraft information

1.6.1 New Zealand Aerospace FU24-950 (Fletcher), serial number 237, was manufactured in 1977 and registered as ZK-EGO. At the time of the accident, the aircraft had accrued 7665.8 hours in service.

1.6.2 The engine, Lycoming IO-720-A1B serial number L-874-54 was installed in the airframe on 1 October 2001, and at the time of the accident had run 127.9 hours since overhaul.

1.6.3 Hartzell HC-C3YR-1RF propeller, hub serial number DY3431A had run 1988.1 hours since overhaul.

1.6.4 The most recent scheduled maintenance was a 300-hourly check performed on 6 December 2001, at 7585.6 airframe hours. An annual review of airworthiness was carried out on 17 July 2001.

1.6.5 On 13 December 2001, the aeroplane sustained substantial damage in a landing accident. The left main undercarriage was torn from the wing when the main wheel struck an unseen lip at the threshold of a farm airstrip. Some tailplane damage occurred, but the fin was not affected.

1.6.6 Repairs were carried out at a Masterton maintenance facility, and the pilot assisted during the repair process, taking the opportunity to carry out a substantial amount of refurbishing and general tidying-up in the cockpit area. After test flying on 18 March 2002, the aeroplane was returned to service.

1.6.7 As the 19 April accident involved an apparent failure in the empennage (tail section), a brief description is warranted at this point. The FU24 empennage is conventional, comprising a vertical stabiliser or fin, rudder, and a "slab" or all-moving tailplane.

1.6.8 The fin attaches to the fuselage at stations[3] 314.00 and 355.0 (rear bulkhead), and consists of: a rear post or beam extended to form the rear attachment; three full ribs externally stiffened by doublers; a root rib; ribbed nose skin incorporating the forward attachment; and skin panels formed to provide vertical stiffening. A hinge bracket mounted at the top of the rear post provides support for the rudder upper pivot. A detachable fibreglass tip houses the anti-collision beacon. See Figure 1.

1.6.9 The rudder attaches at its top rib to the hinge bracket at the top of the fin, and at the bottom by a torque tube to the elevator trim jack mounting bracket, which

[3] Expressed in inches aft of the datum point (at the nose of the aircraft).

attaches in turn to the rear fuselage bulkhead. It pivots in phenolic bushes at both points. See Figure 2.

1.6.10 The all-moving tailplane is of conventional construction, is both aerodynamically and mass-balanced, and pivots about two hinge brackets mounted on the rear fuselage bulkhead. It incorporates an anti-servo tab that also serves as a pilot-adjustable trim tab.

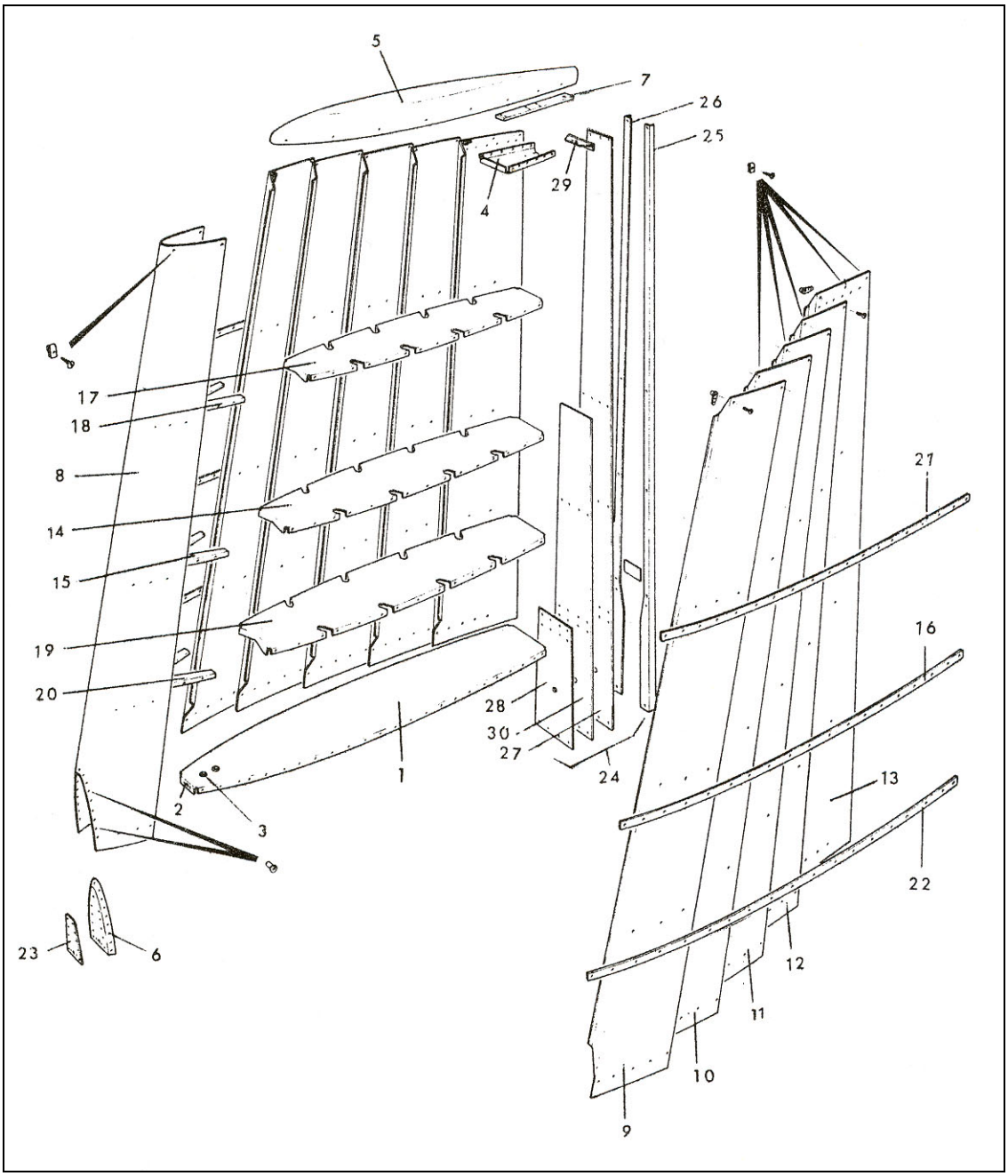

Figure 1: fin construction

(8 is the leading edge skin; 6 and 23 are the forward bulkhead and doubler plate respectively; 24, 25 and 26 comprise the rear post assembly.)

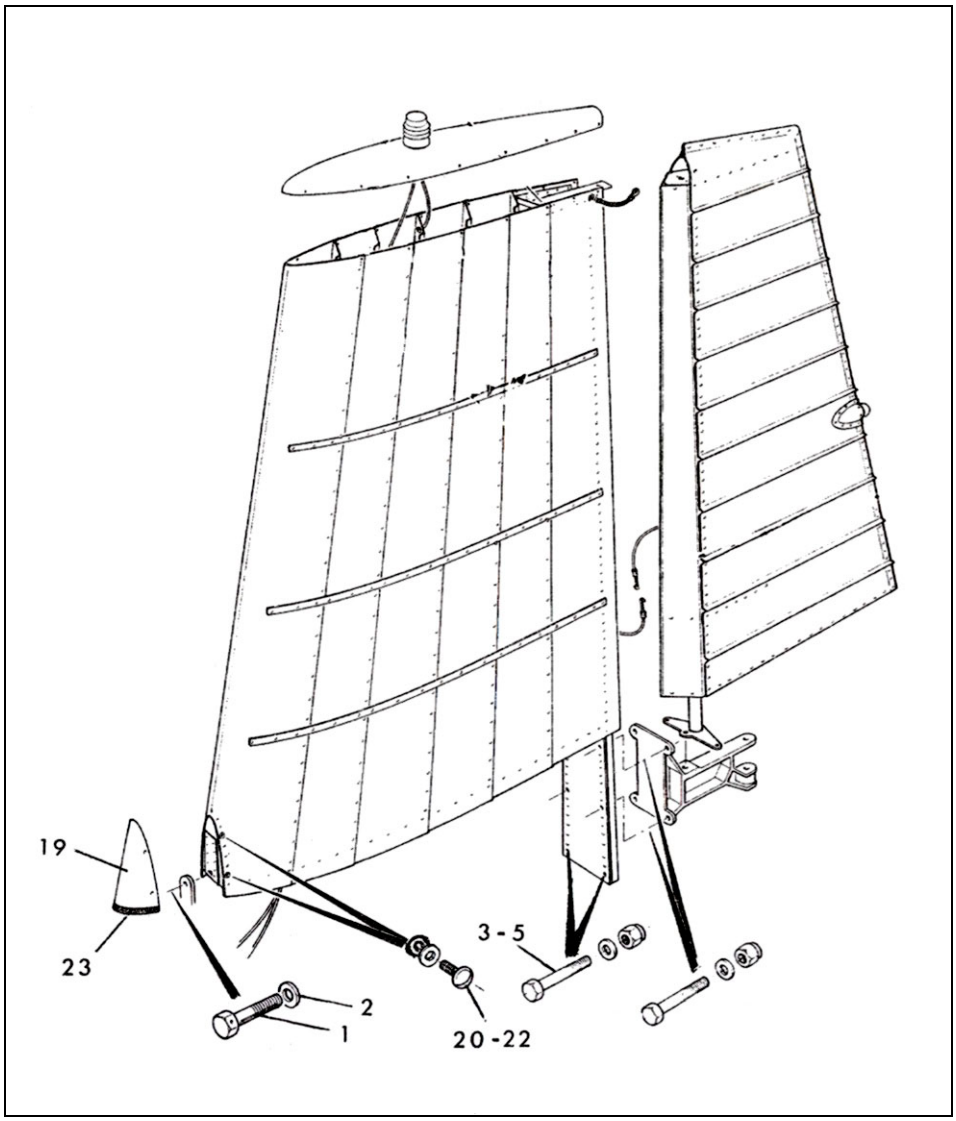

Figure 2: fin and rudder assembly

(19 is the forward fairing, to the right of which can be seen the fuselage attachment point. The fairing is attached by two screws each side, which mate with captive nuts inside the bulkhead flange.)

1.7 Meteorological information

1.7.1 Conditions at the time of the accident were overcast, with a light south-easterly wind. Although there was light rain in the general area during the morning, this did not affect the operation.

1.7.2 Weather was not a factor in this accident.

1.8 Aids to navigation

1.8.1 Not applicable.

1.9 Communications

1.9.1 The aircraft was not fitted with a radio transceiver.

1.10 Aerodrome information

1.10.1 Not applicable.

1.11 Flight recorders

1.11.1 Not applicable.

1.12 Wreckage and impact information

1.12.1 The aeroplane struck rising ground (20° slope) on a track of approximately 160° magnetic, in a right bank of 12° and with pronounced sideslip to the right. Horizontal distance travelled during the impact sequence was 13.5 m.

1.12.2 The initial impact was taken by the nosewheel and leg, which folded rearwards and to the left. The engine was forced upwards and far enough to the left to penetrate the fuel tank in the leading edge of the left wing. Propeller scars and the anticlockwise rotation of the entire engine through 90° indicated that it was still developing power at impact. This was confirmed when the propeller was later dismantled for inspection, all three pitch change knobs showing clear evidence of overload (impact) failure.

1.12.3 The right wing had sustained crush damage along the leading edge as a result of striking a small ground irregularity; the crush damage appeared to have extended into the fuel tank area. Both main undercarriage legs collapsed as a result of impact forces.

1.12.4 Little useful information could be gleaned from the cockpit area because of the extent of the destruction by fire, but it was established that the flaps were selected up, the hopper lever was in the closed position and the pilot had been wearing his safety harness, a fastened buckle being found among the ash. Although severe cockpit area disruption had occurred, this was forward of the pilot's seat, the steel frame of which was located in its normal position relative to the rest of the aircraft.

1.12.5 The hopper had been destroyed by fire, and only a minute amount of fertiliser was found in the hopper area. Fire damage to the fuselage extended to about one metre aft of the hopper.

1.12.6 It was found that the fin leading edge skin had failed in the area of the forward bulkhead, which remained attached to the corresponding fuselage fitting. The fin post had failed in overload, the fracture surface indicating that the fin had rotated downward and to the left as it departed. Mutually compatible impact marks indicated that the top of the fin had struck the leading edge of the tailplane during the departure sequence.

1.12.7 The rudder, although badly bent, remained attached to its torque tube, the top hinge on the fin having failed as the latter departed. A gash on the upper surface

of the tailplane was found to have been made by the rudder tip, and further experimentation found that the rudder tip had been at some point actually lodged in the tailplane (see Figure 3). This would have restricted elevator travel, but it could not be determined whether this was a momentary phenomenon or it had persisted from the time of the fin failure until ground impact.

1.12.8 Apart from the missing fin, all extremities of the aircraft were present, and pre-impact integrity of all flight control runs was established during the site examination.

Figure 3: rudder tip embedded in tailplane

1.13 Medical and pathological information

1.13.1 Post-mortem examination determined that the pilot had died as a result of the post-impact fire rather than from impact, but also that death had probably occurred in a matter of seconds.

1.13.2 No pre-existing medical conditions were discovered, and toxicological tests disclosed only a blood carbon monoxide level of 5%.

1.14 Fire

1.14.1 An intense fire broke out at or shortly after impact and consumed the centre section, including the cockpit area, the inboard portion of each wing in the area of the fuel tanks, and the fuselage to about one metre aft of the hopper.

1.14.2 The left wing leading edge in the area of the fuel tank had been penetrated by the displaced engine, and crush damage visible on the steel retention straps for the right tank suggested that it also had been ruptured on impact. The loader driver

estimated that there was a total of 140 to 150 litres of fuel in the tanks at the time of the accident.

1.14.3 Ignition sources included the hot engine exhausts and possible arcing from disrupted electrical wiring.

1.15 Survival aspects

1.15.1 The pilot was restrained by lap and shoulder harness, and was wearing a protective helmet. The helmet was found, virtually unscathed and with the chinstrap still fastened, about 3 m in front of the wreckage, along with numerous fragments of the cockpit canopy.

1.15.2 The post-mortem indications were that the impact injuries sustained by the pilot were unlikely to be fatal, but it was possible that he was rendered unconscious at impact.

1.15.3 The aircraft was equipped with a Pointer 3000-10 ELT, which was destroyed by fire. The detachable ELT antenna was found undamaged close to where the pilot's helmet had landed. No ELT signal was reported by other pilots or detected by satellite.

1.16 Tests and research

1.16.1 The detached fin, together with the fin bulkhead that had remained attached to the airframe, was subjected to metallurgical examination.

1.16.2 It was found that the leading edge skin had cracked along most of the left side of the fin forward bulkhead, in line with the edge of the fin fairing, and about a quarter of the way along the right side. The remainder of the right side had failed in overload. This left the fin unrestrained at the front and free to pivot either way about the rear post.

1.16.3 Microscopic examination found that the cracking was due to fatigue, and had originated from an apparent cut or score mark in the outer surface of the skin. The score mark corresponded to the edge of a rubberised protective strip that had been applied to the fin leading edge, and trimmed to accommodate the fairing. The score mark was present along at least 80% of the failure surface, and there was evidence of fretting on the crack surfaces on the left side. This indicated that the crack had been developing over a considerable period of time.

1.16.4 It was evident that when the protective leading-edge strip was being applied, it had been trimmed in situ, and the cutting tool used had cut into the metal skin beneath the rubberised strip. The cut had then acted as a stress riser from which the fatigue crack had initiated. The skin was originally 0.020 inches (0.5 mm) in thickness; the cut had penetrated to a depth that ranged from 25 to 30% of the skin thickness.

1.16.5 By whom and when this strip was applied could not be determined. The weathered and cracked appearance of the strip suggested that it had been in place

for several years, and no logbook or worksheet entries were found that referred to it specifically.

1.16.6 As a result of the site investigation, an emergency Airworthiness Directive (AD) was issued on 23 April 2002, effective 26 April 2002, requiring all FU24 aircraft to be inspected within seven days for cracking in the forward area of the base of the fin.

1.16.7 In complying with the AD, the operator (of ZK-EGO) discovered similar score marks, without cracks, on the fin leading-edge skins on three other FU24 aircraft (see Figure 4). The aircraft were immediately removed from service and the leading edge sections replaced.

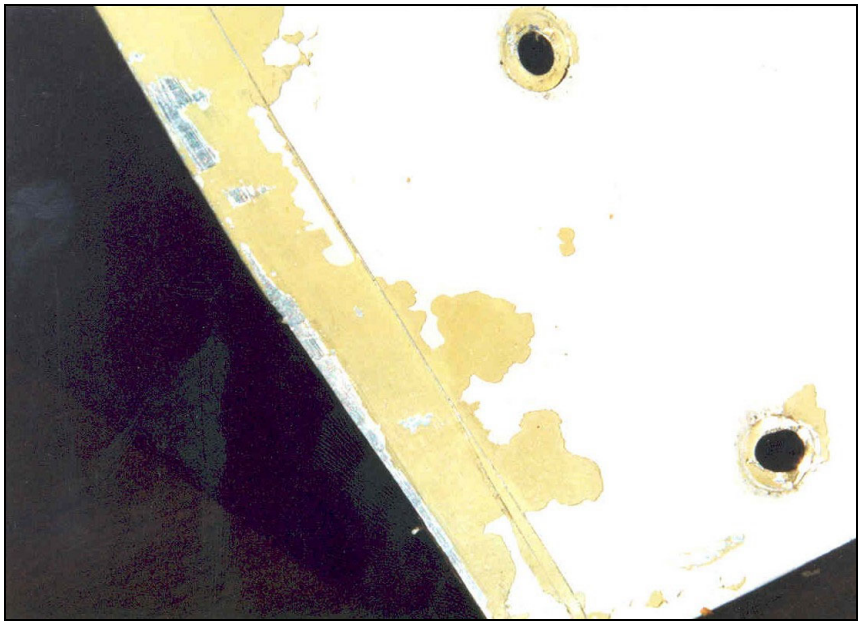

Figure 4: cut mark on discarded leading edge section

1.16.8 One of the discarded sections was passed to a CAA Field Safety Advisor, who in the course of his duties routinely visits all aircraft maintenance organisations in the North Island. Aircraft engineers have been able to view this potential failure at first hand, and the information has also been extended to other trades, such as aircraft painters. The crux of the matter is the need to avoid cut or score marks in stressed skin assemblies. The same exercise is to be repeated in the South Island when the North Island coverage is complete.

1.17 Organisational and management information

1.17.1 Other than the issue of the method of affixing the abrasion strips, and this is discussed elsewhere in this report, no organisational or management issues were identified as relevant to the investigation.

1.18 Additional information

1.18.1 The fitting of abrasion strips to FU24 tailplane and fin leading edges is a widespread industry practice, to avoid abrasion damage. These are not supplied with a new aircraft, and there is no formal modification to fit them subsequently. It is a practice that has become entrenched over the years and widely accepted as routine.

1.18.2 In this case, the rubberised strip appears to have been applied to the fin leading edge, and surplus material trimmed with a sharp tool. The person who carried out this operation was unlikely to have been aware of the safety implications of this method; an alternative method would have been to locate the strip in place using tape or a small amount of adhesive, marking it and then removing it before cutting it to size. At least one other operator is known to have a ready-made template for producing abrasion strips.

1.18.3 Fins have separated from FU24 aircraft in the past, with a variety of outcomes ranging from landing without further damage to semi-controlled landings resulting in serious injury to the pilot. However, all past failures have originated in the fuselage fitting to which the fin forward bulkhead attaches. These were originally manufactured from aluminium alloy, but their replacement by steel versions was subsequently mandated by Airworthiness Directive. ZK-EGO was found to have a steel fitting, the integrity of which had not been compromised.

1.18.4 The edge of the skin at the base of the fin had been fitted with a rubber or plastic bead, presumably to avoid metal-to-metal contact when the fin was placed in position. A further bead of silicone or similar sealant had then been applied at the fin-fuselage interface to prevent the ingress of fertiliser or other material.

1.18.5 The day before the accident, the pilot had noticed that the rubber beading had come partly adrift on the left side, over a distance of about a foot from the leading edge. He tucked it back in as best he could and continued with the operation. Later, he found that the bead had come out further, so he removed it altogether and placed it in the locker aft of the hopper.

1.18.6 At the accident site, evidence of fretting was found on the top of the fuselage, along virtually the full length of the left edge of the fin. This was sufficient to have polished the paint off the metal skin, the width varying up to about 10 mm in places, but the skin had not been penetrated at all.

1.18.7 Three days before the accident, on arrival back at base, the pilot reported a vibration from the rear of the aircraft, and suggested that the tailplane pivot bushes were worn. The local maintenance provider found that there was in fact wear in the bushes and replaced them; at the end of the next day's work the pilot reported that the vibration had been cured.

1.18.8 Early in the investigation of this accident, a widespread and persistent rumour was found to be circulating, to the effect that the tail fin had been struck by the loading vehicle prior to the accident. However, the investigation determined conclusively

that this was not the case. Such was the intensity of the rumour, that the point needed to be stated in this report.

1.19 Useful or effective investigation techniques

1.19.1 Nil.

2. Analysis

2.1 The loss of the fin was clearly beyond the pilot's control, and placed him in a difficult position. The departure of the fin would undoubtedly have been accompanied by loud noises from the rear of the aircraft, feedback through the elevator and rudder controls, and probably uncommanded random yawing and pitching.

2.2 The pilot probably found that he had restricted elevator control, with the tip of the rudder jammed into the upper surface of the tailplane, but it is not possible to say whether this persisted until ground impact or the pilot managed to free the restriction. He may have been able to achieve this by a vigorous application of rudder or by a brief, sharp application of down elevator.

2.3 In any event, the aeroplane climbed some 400 feet after the fin separation; this should have put the aeroplane in a position where the pilot had some time and space in which to manoeuvre. Had he maintained his heading, he would have emerged from the valley, after which a turn to the right through about 90° would have presented an unobstructed track back to Masterton Aerodrome, 6.5 nm distant.

2.4 The "veering to the left" and subsequent impact near the top of the ridge on the left side of the valley could indicate a deliberate attempt by the pilot to get the aeroplane on to the ground as soon as possible. With restricted rearward visibility from the cockpit, he would have been unable to determine the extent or the damage in the tail area, and the effects described in 2.1 would have raised major doubts as to whether the remainder of the empennage or even the entire rear section of the fuselage was about to fail.

2.5 In any event, if this did represent a deliberate landing attempt, it was a reasonable choice in the circumstances. The profile of the ridge was such that a successful forced landing could have been executed near the top, and had the pilot had only a small amount of extra height (say another 100-150 feet) at his disposal, the chances of his doing so would have been greatly enhanced. The 20° slope where the aeroplane struck the ground presented a formidable obstacle to an aircraft that had achieved a nett climb angle of 8° from where the fin was lost.

2.6 It is possible that the climb angle had diminished as the aeroplane neared the top of the ridge, as in the early stages the pilot would have had some airspeed that could be converted to height, giving a higher initial rate of climb. Also, if the elevator control was still restricted by the jammed rudder, the pilot could have had difficulty in flaring the aeroplane to reduce the rate of closure with the terrain.

The resulting impact was severe, with high vertical and horizontal deceleration forces.

2.7 Although this was not the first time a fin had separated from this type of aircraft, it was the first failure involving the structure of the fin itself, all others having been due to the failure of the fuselage attachment point.

2.8 It was clear that the failure resulted from the propagation of one or more fatigue cracks, which had in turn been initiated by knife cuts in a critical area of the leading edge skin. As the skin in this area is load-bearing and subject to cyclic stresses, the development of fatigue cracks from what could be described as classic examples of stress risers was only a matter of time.

2.9 Subsequent propagation of the cracks went undetected, the cracks being masked by the rubber abrasion strip, the fin fairing and the sealant used around the edge of the fairing. A subsequent indicator may have been the loose beading on the left lower edge of the fin; by this time the skin on the entire left edge of the fin bulkhead had probably failed, allowing lateral movement of the lower edge.

2.10 Because this type of failure had not occurred previously, it was unlikely that the pilot or others who may have observed the loose beading had attached any significance to it.

2.11 As to the method of applying the leading-edge abrasion strips, this issue has been addressed by continuing industry-wide safety education on the importance of avoiding even minor damage to stressed-skin assemblies.

2.12 No specific safety recommendations were made as a result of this investigation, in light of the safety actions already carried out (see section 4).

3. Conclusions

3.1 The pilot was appropriately licensed, experienced and fit to carry out the series of flights.

3.2 The aeroplane had been operating normally up to the time of the accident.

3.3 An undetected fatigue crack, or series of cracks, had been propagating in the forward area of the tail fin for some time.

3.4 The cracks developed to a point where the remaining structure was unable to accommodate normal flight loads, and the fin separated from the aircraft.

3.5 The departure of the fin probably resulted in some uncommanded yawing and pitching effects, with accompanying control feedback and unusual sounds.

3.6 The rudder became lodged in the tailplane upper surface as the fin departed, with the potential to restrict elevator control.

3.7 The extent and duration of any elevator control restriction could not be determined.

3.8 The resultant impact with terrain may have been an attempt by the pilot to carry out an immediate forced landing, or may have been a result of limited control available to the pilot.

3.9 The impact and subsequent fire were not survivable.

3.10 The fatigue cracking in the fin originated from cuts in the skin, made when the leading-edge abrasion strip was being trimmed in situ.

3.11 It was not determined when and by whom the cuts were made, however, measures have been taken to prevent a recurrence.

4. Safety actions

4.1 An emergency AD (DCA/FU24/173) was issued by CAA on 23 April 2002, effective 26 April 2002, requiring all FU24 aircraft to be inspected within seven days for cracking in the forward area of the base of the fin. The Civil Aviation Safety Authority (Australia) followed suit with a similar AD effective 1 May 2002.

4.2 "Hands-on" education of aircraft engineers and related trades by the CAA Field Safety Advisers was still in progress at the time of publication of this report.

4.3 An educational article is to be published in the November/ December 2002 of *Vector* (the CAA's bi-monthly safety magazine).

Report written by:

(Signed)

Alister Buckingham
Investigator-in-Charge
5 November 2002

Authorised by:

(Signed)

Richard White
Manager Safety Investigation