Ag Work

The Robinson R22 type has been operating in New Zealand since 1984 and is by far the most prolific helicopter type, with some 133 on the current register. Initially there were some instances of the helicopter being operated into a zero G condition, with consequential very alarming fatal accidents. The manufacturer, in conjunction with Airworthiness Authorities and the pilot trainers, quickly revamped the training programmes, and included placards, safety notices and cautions in the helicopter and Flight Manuals. The instances of zero G in-flight break-ups appear to have ceased. The R22 has gone on to gain an excellent reputation for its simplicity, reliability, and capabilities – especially given its small size and low power.

Kiwis soon had cargo hooks installed to enable the carriage of farming equipment, venison, and moss. Later, agricultural spray equipment was fitted. The helicopter entered work roles that the manufacturer was (and is still) not that comfortable with!

A Recent Accident

The recent and well publicised event, whereby a main rotor blade failed at the root on a Robinson R22 Beta II when the helicopter was only just airborne, is the first reported failure of this type in New Zealand. There have, however, been several instances of failures overseas. These failures are still subject to current investigations by Robinson, the FAA, and in the New Zealand case, CAA of New Zealand.

Circle shows the location of the blade after the accident.

Mandatory Service Bulletin

In December 2004, Robinson issued a Mandatory Service Bulletin (SB94) requiring staged removal of the A016-2 blades. These blades are to be replaced with the "new" A016-4 blade. The Dash 4 blade has design changes in the grip, but Robinson's stated major change was the stainless steel blade skin with improved resistance to corrosion and the increase of calendar finite life from 10 to 12 years. CAA New Zealand recommends that you follow this Service Bulletin; it is possible that an Airworthiness Directive will be issued.

and the R22

The Australian Experience

The first cases of rotor blade failure in the blade grip area occurred in Australia and were attributed to the mustering role of the helicopters. The CASA belief is that the large cyclic control inputs, the frequency of these inputs, and the strong likelihood of under-recording of time in service, were the principal reasons for the blade fatigue failures. CASA Airworthiness Directive AD/R22/31 Amendment II (available off the CASA web site, www.casa.gov.au) details the Australian compliance requirement. Robinson and CASA are investigating the specific Australian mustering role, and they will be considering changes to the inspections and fatigue life limits of blades working in this role.

So, is our New Zealand R22 role likely to have similar instances to the failures in Australia?

The Australian situation is likely to have the helicopter operating at lighter weights, and considerably more cyclic inputs. Our situation, however, is that, in our agricultural roles, especially spraying, the helicopter will be involved in a much greater number of rated power lift-offs at (and sometimes substantially over) maximum certificated takeoff weight (MCTOW). The New Zealand coastal environment would also be likely to be more corrosive in comparison to the mustering regions in Australia, and most certainly corrosion has the potential to significantly degrade fatigue life of any component.

Some Technical Stuff

The centrifugal/centripetal loads are the greatest loads on the blade grips and spindles, but it may not be so well understood that these loads increase, not steadily, but **more and more rapidly with rpm increase**.

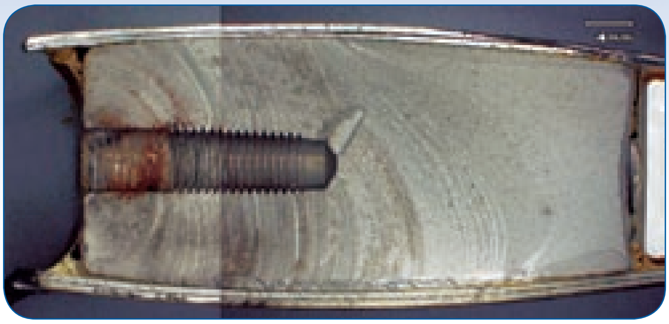
A feature of the Robinson R22 rotor head (which is not shared with other manufacturer's semi-rigid rotor head systems) is that it has individual blade coning hinges, as well as a teetering hub. The blades are, therefore, individually free to flap up and/or down, and during cyclic inputs the Coriolis effect of each individual blade mass effectively moving inboard, or outboard, of the hub has the resultant effect of the blades either wanting to lead or lag.

The R22 teetering hub, coupled with individual blade coning hinges and its relatively low inertia disc, means that the cyclic is very light and responsive. During rapid and large cyclic inputs, an upward moving blade will have the tendency to be trying to lead, while the opposite down-going blade will be trying to lag. The problem is, that the rotor head, in common with all two-blade rotor heads, does not allow for blades to lead and lag, so excessive cyclic inputs will result in the blade grip area taking excessive bending loads as well as the centrifugal loads. At 530 rotor rpm, for example, these Coriolis loads are occurring around nine times per second, and practices such as using excessive manifold pressure, or exceeding rotor rpm limits by overriding the governor with the "big twist and heave" will have the effect of seriously eating into the certificated safety margin. **And it could well precipitate the onset of fatigue cracking in regions not as yet able to be readily inspected.**

Even at the correct rpm, the use of full throttle at sea level would involve the drive train and rotor system in an excess of 22% above the manufacturer's published limits on a R22 Beta, and 37% on a R22 Beta II. There is **no** agricultural overload allowable for helicopters. The main reason for change of powerplant to the Lycoming 0-360-J2A in the Beta II was **not** to give the helicopter any **additional** sea level performance**.** It was to provide the rated 131 hp limitation to a greater altitude than that of the R22 Beta with the smaller Lycoming 0-320-B2C.

In point of fact, looking at the manufacturer's out of ground effect (OGE) hover ceiling versus gross weight, the regular Beta chart indicates that it would OGE hover to a pressure altitude of 4000 ft at 20 degrees C, and the Beta II chart indicates approximately the same. The Beta II advantage only becomes apparent at pressure altitudes above 4500 ft. **The Beta II will lift more than the Beta at sea level only when the manufacturer's limits are ignored.**

All these factors have an influence on fatigue lives and expected component overhaul TBOs.



Fracture surface of an R22 blade root, showing fatigue cracking in the root fitting. Note: Growth of fatigue is obscured by external skin and doubler.

R22 Safety Alert

Robinson added an R22 Safety Alert on 1 Dec 2004 with warnings 29310, 29311 and 29312 which say:

1. If the helicopter has occasionally operated above manifold pressure limits, replace the main rotor blades!
2. If the helicopter is normally parked outside in humid climates, particularly in tropical or coastal areas, replace the A016-2 blades within 5 years time in service, due to possible internal corrosion. **Note:** This has now been superseded by SB94

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3. If main rotor vibration increases during flight, make an immediate safe landing and determine the cause of vibration before further flight. If cause cannot be determined, replace the main rotor blades before further flight!

Finally, Robinson asks that operators re-read Safety Notices SN-37 and SN-39!

Robinson has a good web site, and all their important information is available at **www.robinsonheli.com**. More importantly, all this information is in the **Flight Manual.** It's worth a read, and **adhering to** if you want to keep your helicopter in one piece and stay alive**!**

Full throttle at sea level is automatic cause to reject R22 rotor blades. The regular Beta for instance has a maximum manifold pressure of 23.7 in Hg, and the Beta II only 23.5 in Hg at sea level on a 20 degree C day. Exceeding this limit is **cause for blade replacement**. These limits also **reduce** with either reductions in temperature, or increases in altitude.

Some New Zealand Scenarios

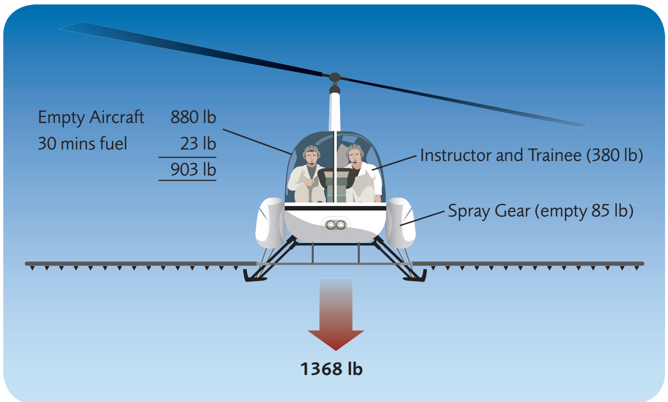
Does overloading, or use of excess manifold pressure occur in New Zealand?

R22 empty weight	880 lb
Pilot	170 lb
Spray gear	85 lb
Fuel (30 minutes)	23 lb
AUW =	**1158 lb**

R22 Beta (and Beta II) gross is 1370 lb. This leaves a useful product load of approximately 212 lb or 96 litres of water, (when operated with only 30 minutes of fuel, remember). Many machines have spray gear weighing more than the figure used, and there are a good many pilots of slightly greater stature than the 170 lb used as well.

If one looks at Agricultural training, where the R22 is occupied by both a pilot and an instructor, we have the following:

R22 empty weight	880 lb
Instructor and Trainee (solid)	380 lb
Spray gear (say)	85 lb
30 minutes fuel	23 lb
AUW =	**1368 lb** **(leaving 2 lb for product!)**



Robinson Safety Notice SN-37

Issued: Dec 01

Exceeding Approved Limitations Can Be Fatal

Many pilots do not understand metal fatigue. Each time a metal component is loaded to a stress level above its fatigue limit, hidden damage occurs within the metal. There is no inspection method which can detect this invisible fatigue damage. The first indication will be a tiny microscopic crack in the metal, often hidden from view. The crack will grow with each repetition of the critical stress until the part suddenly breaks. Crack growth will occur quite rapidly in drive system parts from the high frequency torsional loads. It will also occur rapidly in rotor system components due to the high centrifugal force on the blades and hub. Damaging fatigue cycles occur with every revolution of an overloaded drive shaft or rotor blade.

If a pilot exceeds the power or airspeed limits on a few occasions without failure, he or she may be misled into believing it is safe to operate at those high loads. Not true. Every second the limitations are exceeded, more stress cycles occur, and additional fatigue damage can accumulate within the metal. Eventually, a fatigue crack will begin and grow until a sudden failure occurs. If the pilot is lucky, the part will have reached its approved service life and be replaced before failure. If not, there will likely be a serious or fatal accident.

View of fractured blade root.

Warning

1. Always operate the aircraft well below its approved V_{NE} (never exceed speed), especially in turbulent wind conditions.
2. Do not operate the engine above its placarded manifold pressure limits.
3. Do not load the aircraft above its approved gross weight limit.
4. The most damaging conditions occur when flying or manoeuvring at high airspeeds combined with high power settings.

By the CAA's reckoning, any R22s being used for agricultural training conducted with two POB and spray product, would most likely already be in an overweight configuration! This is **unsafe, undesirable, and illegal.**

Conclusion

The Robinson R22 is a light helicopter which has been designed according to the task the manufacturer intended. To achieve simplicity and low cost, the rotor head design does not have the sophistication of larger helicopters. This makes it even more important to respect its limitations. In private operations, the R22 (if operated within its limitations) has proven to be a reliable and safe machine. Given a fair go, it will perform with safety and reliability!

The blade failures reported to date should be proof enough that operating outside the limits can be lethal.

The new A016-4 blades have been designed to increase corrosion resistance and inspectability. They are not designed for increased load carrying ability. These blades should not be considered as a cure-all for operations outside the detailed Flight Manual parameters, and the best advice must be to operate within these limits.

Operating outside the limitations of the Flight Manual will put the pilot in the role of a **test pilot.** Not only will this cause unnecessary personal risk to the pilot, but it may also leave the helicopter in an unsafe condition for the operator – or indeed any future operator! ■