1. Effectivity

All helicopter operators, pilots, crew members and maintenance personnel involved in human external cargo (HEC) winching operations.

2. Purpose

To alert helicopter operators and crew members to the potential for a serious accident by providing safety information in relation to HEC winching operations including:

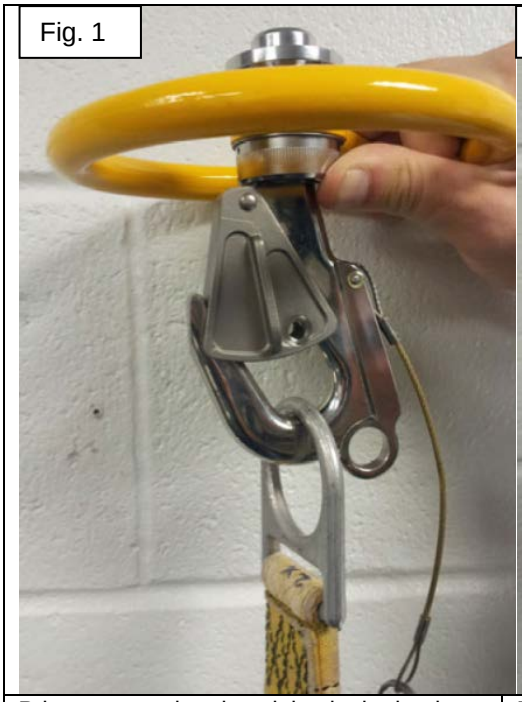
(a) unintended disconnection of the personnel harness primary engaging ring from the winch hook (‘Ring Reversal’ or ‘Dynamic Rollout’), and

(b) winch cable cutting squib malfunctions, which have resulted in serious injury and fatalities.

3. Background

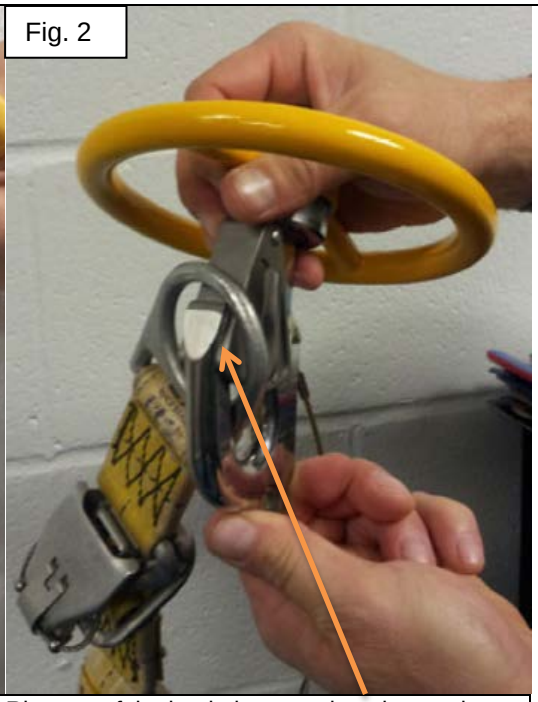
(a) Winch hook – Primary Engaging Ring Reversal or Dynamic roll-out.
Unintended disconnection between the helicopter winch hook and the primary engaging ring on the occupants rescue harness typically occurs during a pause in the winching sequence, when the ring in the rescue strop and the hook are temporarily relieved of the load. With no weight on the hook and ring, under the dynamic conditions of this type of operation, it becomes easy for the ring to travel up and flip over the tip of the hook and to rest on the spring–loaded keeper. The ring is now only supported by the spring-loaded keeper (Fig.1 & 2 below).

Fig. 1



Primary engaging ring sitting in the hook throat under the keeper.

Fig. 2



Ring out of the hook throat and resting on the keeper

Source: Royal Candian Air Force Report CH149913 Cormorant – From the Investigator

When the winching sequence commences, the load is re-applied, and the ring opens the spring-loaded safety catch slips off the hook and the occupant or load falls to the ground.

During training at Five Islands, Nova Scotia, the Royal Canadian Air Force suffered a ring reversal/disconnect (Figures 1 & 2 above). During Search and Rescue (SAR) training, it appears that the harness engaging ring and winch hook became 'misaligned' after initial hook-up just before winching commenced. Shortly after winching commenced, the harness ring disengaged from the hook, and the occupant fell to the ground. *Report: CH149913 Cormorant - From the Investigator - Royal Canadian Air Force (Occurrence date: November 14, 2013).*

In December 1995 a fatal accident occurred when the engaging ring in the rescue strop separated from the winch hook of a Royal Australian Navy (RAN) S-70B-2 helicopter. The accident was caused by ring reversal which occurred when the winch hook was relieved of the weight of the load when it touched the ground seconds before being winched up. It appears that under a certain combination circumstances, such as variation in loading angles, keeper design, load oscillations and other factors, the harness ring can rotate out of the hook and engage just the tip of the hook in the very brief period between being unloaded and the load being re-applied. This unstable connection may carry the crew member for a period of time before the ring slips off the tip of the hook and on to the spring-loaded keeper which cannot support the load.

The Australian Naval Board of Enquiry into the 1995 accident found that the United States Military Standard MS 18027-2A hook, which was widely used by on both civil and military helicopters, permitted ring reversal or dynamic roll-out and subsequent separation of the occupant or the load from the helicopter.

Fig 3. MS 18027-2A Hook with simple spring-loaded safety catches. Note the exposed hook tips.

Fig 4. One type of hook which incorporates a mechanical lock latch gate design. The keeper also guards the tip of the hook.

Fig 5. Hook used in a popular winch system which uses a simple spring-loaded safety latch or keeper.

Whenever the personnel harness ring moves up and over the tip of the hook and rests on the simple spring-loaded keeper or guard, the ring will open the guard and slip off the hook when the load is re-applied. Dynamic–rollout or ring reversal is prone to occur with hooks which only have a simple spring-loaded keeper or guard and no mechanical keeper locking mechanism.

As a result of this accident, the RAN tested a then new design hook, which had been developed by the US Company, Life Saving Corp. (LSC). The new design, known as the D-LOK hook, features a keeper or guard which can be mechanically locked or unlocked by one hand. As a result of these tests, slight modifications were made by LSC and the production model was then introduced to all RAN helicopters involved in external human cargo winching operations at that time.

This video demonstrates ring reversal or dynamic roll-out and shows how quickly the primary engaging ring can escape from a hook which has only a simple spring-loaded keeper or guard.

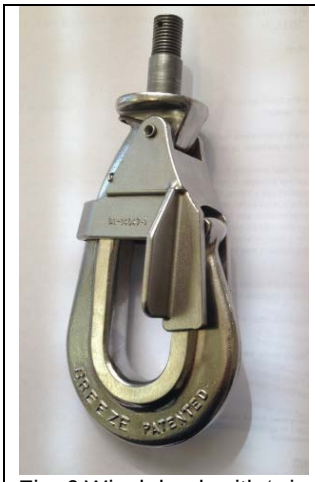


Fig. 6 Winch hook with 'winged' keeper

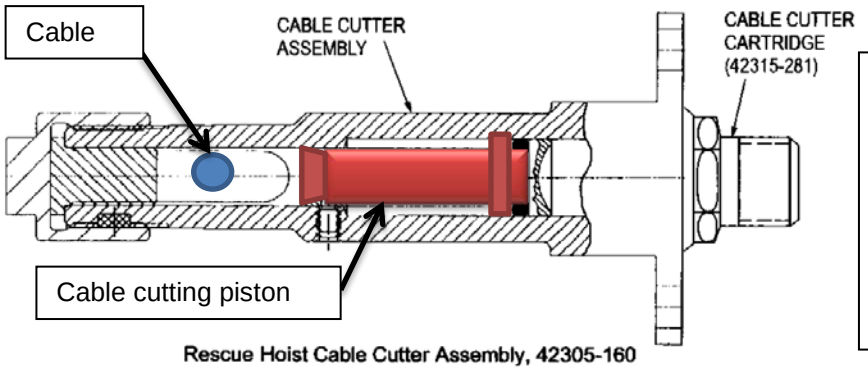
Further investigation has been carried out by CASA into winch hook designs which use a 'winged' hook keeper or latch design. (Fig. 6)

The evidence suggests that there are situations where the "winged" section of the spring-loaded latch can engage with the primary engaging ring and compromise the intention of the latch design, allowing ring reversal or dynamic roll-out and subsequent load disengagement.

HEC rescue winch hooks with manually locking keepers or guards have a hand-operated mechanical latch or keeper lock, in addition to spring pressure used to initially close the keeper. Such designs are intended to prevent partial hook engagement and deflect the primary engaging ring safely back into the throat of the hook thus preventing ring reversal.

(b) Winch Emergency Cable Cutters.

Electrical hoist assemblies fitted with pyrotechnic cable cutting devices have been shown to be susceptible to uncommanded firing of the explosive squib or cartridge resulting in the hoist cable being severed. Inadvertent firing may be caused by wiring malfunctions, stray electromagnetic signals, static electricity and lightning strikes.



The squib or cartridge is a pyrotechnic device where a small amount of electrical energy is used to liberate a large amount of chemical energy (an explosion) which powers the cable cutter or guillotine.

Fig. 7. Typical external winch cable cutter arrangement. (Adapted from: Bell SIL 214-03-10 & 214ST-03-19)

Earth Bonding

Ineffective bonding between component parts of the hoist assembly or between the hoist assembly and the aircraft have caused uncommanded squib firing. Various hoist and aircraft manufacturers have adequately addressed this problem for specific hoists and aircraft combinations. However, it is possible that not all hoist and aircraft bonding requirements are adequately covered by manufacturer's data or other Airworthiness Directives. Refer: **AD/SUPP/16 - Electrical Hoist Assemblies – Earth Bonding Testing**; **AD/SUPP/13 Amdt 1 - Air Equipment Hoists - Earth Bonding.**

Internal winch component failure.

Winch motor circuit malfunctions can also cause uncommanded squib firing. In one instance, the helicopter was hovering at a height of 35 ft as part of a training exercise to provide a doctor and a paramedic with experience in winching procedures. The doctor, who was in the sling suspended on the winch cable, was raised to within 5 ft of the helicopter when there was an uncommanded firing of the explosive cable cutter. The doctor fell 30 ft and sustained serious injuries. An investigation revealed the uncommanded firing had resulted from a short circuit in the winch electrical system caused by a blown power resistor in the winch motor circuit, which resulted in substantial current flow to the cable cutter, sufficient to fire the squib. Refer: **ATSB Occurrence No. 199002013.**

Squib firing control circuit malfunction defect reports also include control wires shorting due to water immersion, switch malfunctions, and inadequate shielding from electromagnetic interference.

Electromagnetic Interference (EMI)

If any unshielded firing control wires between the back of the squib control switch and the wire cutter squib (or to the release solenoid in the belly mounted cargo hook) are exposed to electromagnetic radiation from on-board or external radio transmitters, high voltage transmission lines or microwave towers, the control wires can easily generate enough electrical potential to fire the cable cutter squib or trigger cargo hook release.

Protection against potential internal and external sources of EMI which includes lightning strikes, stray electromagnetic signals and static electricity generated by the helicopter during flight is therefore necessary. To prevent inadvertent squib firing and load release, winch and hook systems should be certificated to the accepted standard for electrical shielding requirements for HEC operations which are found in FAR 27.865 (adopted by CASR (*1998*) Part 27). Guidance material is provided in FAA AC 27-1B.

Additional References

CASA Airworthiness Directives – Supplementary Equipment (including Rescue Hoists)

AWB 25-005 Aircraft Seat Belts (FAA SAIB NM-04-37)

AWB 25-006 Rotorcraft Underslung Loads

AWB 25-017 Goodrich Hoist Cable Cutter Wiring Inspections

AWB 25-025 Rescue Strops (Clarifies Australian Technical Service Order (ATSO) C1003)

CASA CAO 29.11 Winching and Repelling operations

CASA CAO 29.6 External sling loads

ATSO – C1003 Helicopter External Personnel Lifting Devices

ATSO – C1001 Dispatchers Restraint Strap

4. Recommendations

CASA strongly recommends that operators engaged in HEC winching operations take the following actions:

(a) Winch Hooks.

(i) Use only rescue winch hooks which have mechanical locking keepers or guards to prevent ring reversal / dynamic roll-out.
(ii) Ensure winch operational training is tailored for each helicopter type and winch combination and is carried out on a regular basis.
(iii) Operate and maintain winches, hooks and harnesses in accordance with approved data.

(b) Winch Emergency Cable cutters.

(i) To prevent inadvertent squib firing and load release, winch and cargo hook systems should be certificated to FAR 27.865 Amdt 27-36, FAR 29.865 Amdt 29-43 or later revision, or EASA equivalent.

(ii) Operate and maintain winch systems, including control circuits and switches in accordance with approved data.

5. Reporting

All incidents of inadvertent load loss, hook and winch malfunctions during winching operations and maintenance should be reported to CASA via the SDR system.

6. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link e-mail address:

AirworthinessBulletin@casa.gov.au

or in writing, to:

Airworthiness and Engineering Standards Branch
Standards Division
Civil Aviation Safety Authority
GPO Box 2005, Canberra, ACT, 2601