

## Re: K4 Karabiner Safe Return To Use

To Whom It May Concern

03/11/10

Following a well publicised report of a K4 Triple Locking Karabiner breakage, SpanSet Australia Ltd gave an undertaking to publish the findings of the resulting investigation.

Due to the time lag between the incident and confirmation of both internal and independent testing, a full public recall was initiated with the Australian Competition & Consumer Commission (PRA 2010/11857) as a precaution, and in the interests of public safety.

The findings indicate that the breakage of the karabiner was not as a result of any manufacturing fault, nor flaw in raw material of the product, but most likely due to a combination of factors as detailed in this report.

**It is hereby our assessment that there is no risk in the continued use of this batch, or future batches of SpanSet K4 Karabiners when used within manufacturer's instructions.**

The national recall has now been closed off by the ACCC.

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*The following is a summary, interpretation, and explanatory notes of this investigation.*

### **Review of test certificates and QA procedures**

The test certificates exceeded the stated break strength of the product and all receipt procedures and documentation were performed as per the stated QA procedures.

### **Review of instruction manuals and advice**

The instruction manual for SpanSet horizontal lifelines clearly states the use of a karabiner exceeding 50kN in strength, whereas the karabiner used in the incident had a displayed rating of 30kN.

The following warnings for the use of connectors are evident

- \* *Always ensure that all gates are closed and locked tight prior to use*
- \* *Check for smooth spring & gate function prior to use*
- \* *Check for corrosion, distortion or damage prior to use*
- \* *Ensure all springs and gates are free of dirt and dust*
- \* *Never connect 2 snap hooks together*
- \* *Ensure any locking latch is furthest from the body when making a connection*
- \* *Do not use snap hooks or karabiners for lifting or towing*
- \* *Do not apply a load sideways to the gate*
- \* *Avoid overcrowding*

### **Internal tensile testing**

Tensile testing from the same batch revealed a tensile strength substantially exceeding that of the stated strength of 30kN, almost double in many cases.

Tensile testing with the gates taped open revealed a retained tensile strength of at least 25kN and reconstructed a near identical break to that reported in the incident ie: breakage through the spine at the retaining pin hole.



Reproduced breakage at 25kN with the gate taped in the open position

### **Internal pre conditioning & testing**

Pre conditioning consisted of pre loading the karabiners to 1000kg for a continuous period of 72 hours to encourage hydrogen residue migration (normally occurs within 12-24 hours) prior to tensile testing, with a worst case test result being 46kn which is still over 50% above the rated strength of the karabiner.

A total of 2,500 karabiners were proof tested to 16kN without failure.

## **Independent metallurgical testing**

There was no evidence of hydrogen embrittlement as a result of the heat treatment process.

There was some evidence of delayed hydrogen migration (see preconditioning tests) due to the zinc plating process, quantified at 20% strength reduction.

The chemical analysis of the alloy steel was within the stated specification

There was no evidence of any "hairline" crack

There was some evidence of side force shear

Hardness was at 42 Rockwell which is at the high end of the specification - also borne out by the excessive tensile strength.

The arbitrary claim of failure at 150kg was inaccurate.

## **Site visit**

The visit to the site revealed –

The webbing retaining pin was not in place in the karabiner.

The static line was approximately 6 metres in length.

Assurances that the line was not used as a lifting point and there were no cranes in the area which could have snagged the line.

All K4 karabiners had been quarantined on site.

## **Manufacturer factory visit & review**

Representatives from SpanSet Australia visited the manufacturing plant involved and confirmed the conformance to international quality assurance systems being ISO9001, UKAS, and CE certification.

The manufacturer had engineered, in good faith, a significant safety margin above the rated strength through the use of alloy steel and increased hardness.

## **Conclusions**

The findings indicate that the breakage of the karabiner was not as a result of any manufacturing fault, nor flaw in raw material of the product, but most likely due to a combination of -

\*high multiplied loadings (high tension + short span + low stretch) Fig1.1,

\*the width of the eye of the safety line or attachment sling Fig 2.1,

\*possibly with the gate not fully closed Fig 3.1, 3.2, 3.3.

The karabiner hardness, being at the high end of specification, did not cause the breakage but induced the failure point to move from the gate to the spine, at the retaining pin hole, due to reduced malleability - further indicated by the metallurgical report of side force shear Fig 4.1. This uncommon type of break caused some alarm within the industry, as opposed to the more common gate failure normally seen through overloading, cross gate loading, or other factors.

While some evidence of delayed hydrogen migration was found in the microscopic analysis, there was still retention of over 80% of original tensile strength in all samples tested after conditioning. The claim of breakage at 150kg is therefore refuted\*. The pretension of the SpanSet high performance ratchet of the safety line is known to be between 600 and 1000 KGF not 150kg as reported, and therefore no "hairline" crack was possible, as it was tensioned initially without incident.

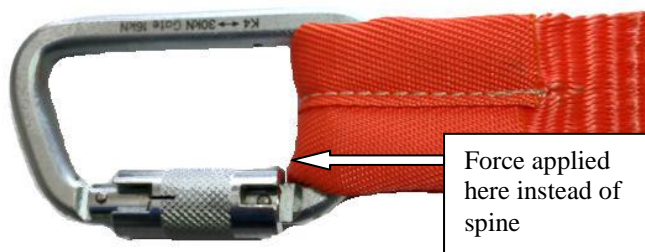
The lack of the supplied retaining pin in the karabiner may have also been a contributing factor as it could have, though unlikely in this case, led to incorrect orientation prior to tensioning.

\*If the claimed 150kg force was applied vertically to the centre of the line which is common practice to "check" the line (as opposed to tension in the horizontal plain) and a worse case force multiplication factor applied,  $150\text{kg} \times 5.76 = 864\text{kg}$  + ratchet pretension up to  $1000\text{kg} = 1,864\text{kg}$ , and combined with the reduction in strength from the width of the eye or crowding, the forces quickly approach the terminal strength of a karabiner with the gate open ( $2500\text{kgf}$ , which is less than half the break strength of the equivalent karabiner with the gate closed).

**Fig 1.1 Force multiplication chart re: static lines**

Angle to Horizon	Angle Between legs	Force Multiplication factor
10°	160°	5.76
15°	150°	3.86
20°	140°	2.92
25°	130°	2.37
30°	120°	2.00

**Fig 2.1 Potential eye crowding**



**Fig 3.1 Potential gate jamming**



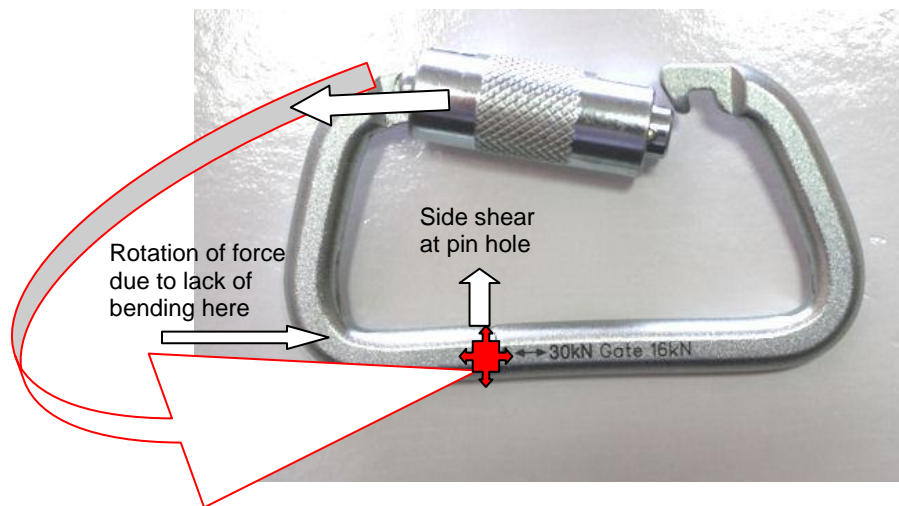
**Fig 3.2 Potential gate jamming**



Fig 3.3 Potential gate jamming & crowding



Fig 4.1 Karabiner with high hardness failure point (with gate open)



## Recommendations

The continued use of karabiners (of any brand or rating) when installing SpanSet temporary static lines must be discouraged due to the following potential risks, particularly when the force multiplication of static lines is considered –

- \*Karabiners may be incorrectly oriented leading to cross gate loading (even gates rated to 16kN are not sufficient to guarantee integrity)
- \*Karabiners may be of insufficient rated strength to cope with the forces involved
- \*Karabiners with manual screw gates may be left unlocked
- \*Karabiners may have the auto-locking gates jammed open due to snagging or crowding of the attachment sling (the locking of the gate has a significant effect on the performance of the karabiner)
- \*Karabiners may be an unsuitable shape to transfer loads and cope with wider slings ( shapes are oval, D, equal D, pear etc,)
- \*Karabiners may be loaded in more than one direction due to multiple attachments
- \*Karabiners may be overcrowded by the attachment slings, particularly in basket formations
- \*Karabiners may be overcrowded by the attachment eye of the safety line
- \*When tensioning the line, the karabiner at the opposite end of the line may be out of site or harder to verify the orientation
- \* Karabiners, as they are often supplied as separable items, may have been previously used for purposes they are not designed for such as lifting, towing etc.
- \* A practice known as “flicking” where the karabiner gate is opened and flicked by the operator after loading to check for tension in the line. This can lead to the gate not returning to its closed position due to the karabiner body flexing under load and preventing the pin and nose interfacing correctly.

Fig 5.1 Karabiner “flicking” after tensioning (note: gate spring in good order)

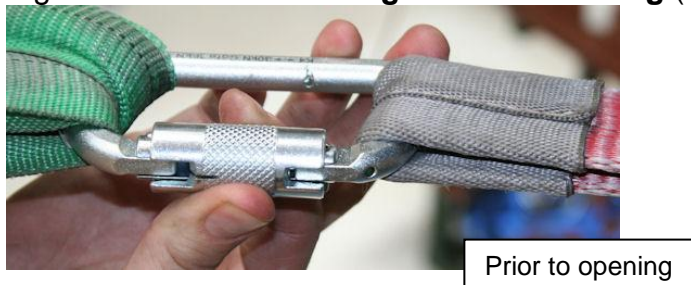
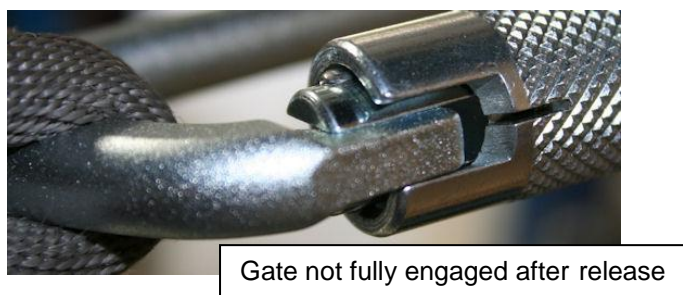


Fig 5.2



As a consequence of these inherent risks, SpanSet has withdrawn the use of karabiners from the Horizontal Safety Line instructions for use.

SpanSet Recommends that the connection interface between static lines and anchorage attachment slings be made via a grade 80, or higher grade lifting component such as a safety shackle, safety bow shackle or self locking latch hook, which will give a higher safety margin and be less susceptible to the above conditions.

3.2T WLL (4.1 safety factor = 13T break) safety bow shackles are now included in all SpanSet 3400 and 3400 UK Horizontal Safety Lines.

**Note: Karabiners used in direct fall arrest systems such as energy absorbing lanyards, inertia reels, vertical fall arrest lines, and horizontal single point fall arrest lines are still safe for use in these applications and unaffected by this notification.**

All methods of attachment have their limitations, and assessments should be made as to the suitability of the fittings to be used in any application.

Installation of static lines should only be performed by a qualified rigger.

Operators should be trained to the minimum requirements as set out in AS/NZS1891.4.

Manufacturers generally concentrate on minimum hardness levels for high tensile applications. SpanSet Australia has now reversed this to specify maximum hardness and a minimum tensile strength to ensure malleability and consistency.

The conclusions of this investigation are based on the scientific evidence and NATA certified laboratory testing results. This report is ©Copyright protected by SpanSet Australia Ltd 2010 and may only be reproduced in full. Permission is hereby granted to circulate this report in its entirety as desired.

Yours Sincerely



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