WHY YOU SHOULD FLY WITH AN ENERGY-ABSORBING SAFETY CUSHION

The pilot of this glider comments:

'Flying doesn't always go as planned and whether it's your own mistake or a circumstantial one, having a properly specified energy absorbing seat cushion installed is as vital as wearing a parachute. I didn't have one and my consultant estimated that my recovery time would have been reduced by 30% with an energy absorbing cushion. In my case that was two months! Don't learn this lesson the hard way - go and get an energy absorbing cushion today. It might be the best £100 you ever spent...'

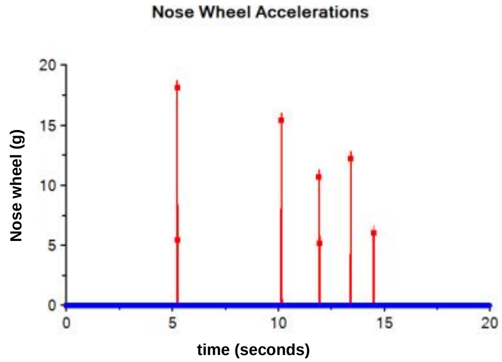
Edition 2, March 2017

BRITISH GLIDING ASSOCIATION

THE REAL FORCES INVOLVED IN A HARD LANDING AND IN A CRASH

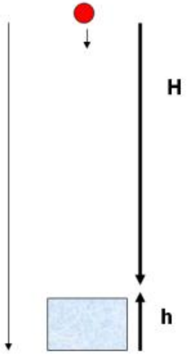
Self-evidently, every hard landing and crash inflicts very different forces and decelerations on a pilot. When you make a hard landing, you will typically be exposed to a series of short-duration pulses in the range 5 to 15g. By comparison, a crash that results in severe structural damage to the glider is likely to produce a small number of relatively sustained decelerations that could well be in the range 20 to 100g.

There is no absolute certainty about what decelerations will inflict injury or be fatal. Depending on your posture, 40g lasting for about 5 milliseconds is likely to result in injury. 100g for the same amount of time is likely to be fatal.



This chart shows the series of short duration decelerations (measured in gs) calculated to be inflicted on a K13 airframe and then its occupants by the nose-wheel impacting a hard runway when the glider fails to round out and the instructor does not succeed in intervening. The decelerations shown are measured vertically.
Results courtesy of J2 Aircraft Dynamics (info@j2aircraft.com)

WHAT DOES A SAFETY CUSHION REALLY DO?
MYTHS REMOVED, LIMITS EXPLAINED



This shows an object free-falling for a distance H and then being decelerated uniformly to rest in distance h.

Simple physics shows that the deceleration measured in number of g that would be experienced by the object in this ideal result would be H/h

Number of g = H/h

Simple physics dictates that if you free fall for a distance H and are then uniformly decelerated to rest in a distance h, you must experience a constant deceleration of H/h measured in g (e.g. if you fall 1 metre and are decelerated in 2 cm (0.02 m) you will experience a constant 50g).

In practice, decelerations produced in real-life are not perfectly uniform. Over the decelerating period, any deceleration less than this perfect result MUST be compensated by higher decelerations to bring you to rest in the available distance. These higher decelerations produce peaks that might even be three or four times that of a uniform deceleration.

There is a further complication: bouncing. Unless you remain firmly locked in step with whatever is decelerating you, you may bounce away from it. Some materials like rubber or furniture foam are renowned for such behaviour. As you then descend in free fall from your bounce, you may well then meet, travelling in the opposite direction, the rebounding glider structure as it jumps back up as the result of its first impact with the ground. When you and the rebounding structure meet, you may well experience an even more rapid deceleration than would have been the case if you had stayed in step with the decelerating glider.

Energy-absorbing cushions are made out of what is termed viscoelastic foam. This has the property that if it is compressed slowly, it will yield. However, if compressed rapidly it acts almost as if it is rigid and will strongly resist giving way. Two commercially available materials are known to be effective in glider cockpits: Confor (CF45/CF47) and Dynafoam.

In the light of all this, what does an energy-absorbing safety cushion do and what can't it do?

- Firstly, it tries to conform as much as possible to the shape of your buttocks. This means that the decelerating forces are spread over a large area meaning that the pressures experienced are minimised.
- Secondly, energy absorbing cushions become virtually rigid on impact and couple you to the decelerating glider.
- Thirdly, given the limited energy that they do absorb, they give very little back – some foams absorb 97% or more. This means that almost no energy is returned to you in the form of a bounce.

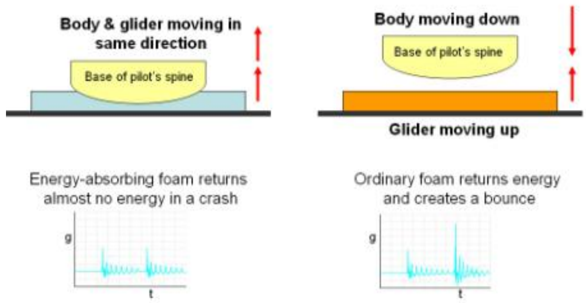
- Fourthly, as they transition into this rigid state and absorb limited energy, they remove some of the transient high g spikes and reduce the jolts (rates of rise of g) that the breaking glider structure may inflict on you as it too absorbs energy in a crash.
- Lastly, what it cannot do. From the first section it is obvious that around 1 inch (about 2.5 cm) cannot possibly provide a sufficient decelerating distance to provide a guaranteed low deceleration in a crash – think H/h! In other words it is physically impossible for it to absorb all the energy in a major crash.

Luckily, the undercarriage, cockpit, nose section, and wings can absorb energy, if they have been designed to do so safely.

It is clear from the above that inflatable cushions are particularly dangerous and should not be used. Firstly, in a crash you will initially continue to descend as the cushion compresses (or even bursts) and then encounter a compensating higher deceleration as you meet the glider structure. Secondly, if the cushion does not burst, it will elastically bounce you away from the glider structure and you might then experience an even more severe second deceleration.

Some gliders were fitted with inflatable cushions as original equipment. You may wish to remove any inflatable cushion from your glider and replace it with an energy absorbing cushion.

BOUNCING



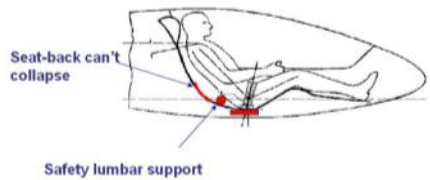
Recognised energy-absorbing foams return almost no energy in a crash. Ordinary foams and many other materials do the opposite. The returned energy separates the pilot's bottom from the seat. This means the pilot can end up descending and meeting the glider structure coming the other way as it, in turn, bounces off the ground. The gs experienced in such circumstances might be greater than the initial impact. This is illustrated in the graphs in the figure.

OTHER PRECAUTIONS:
THE SAFETY CUSHION IN CONTEXT WITH OTHER GLIDER STRUCTURES

During a crash deceleration, the forces can be so large that your body, in particular your lower spine, will be overwhelmingly unable to resist. This means that your lower spine may be forced into bending angles that may damage vertebrae and even the nerves carried within them. It is thus very important that the seat-back cannot collapse under the shock loads experienced. This is down to glider designers.

However, you may well have a space between your lower back and the seat back. In a severe crash load, your spine may be forced into this area. To prevent this, any large void can be filled with a safety lumbar support made out of the same energy-absorbing foam. Being viscoelastic, it will become rigid on impact and minimise the distance that your lower spine displaces and so reduce the potentially catastrophic bending that might otherwise occur.

For identical reasons, if there is a void behind the seat back, there is a safety benefit from filling the void with energy absorbing foam. This is permitted if the foam is personal, carry-on equipment.



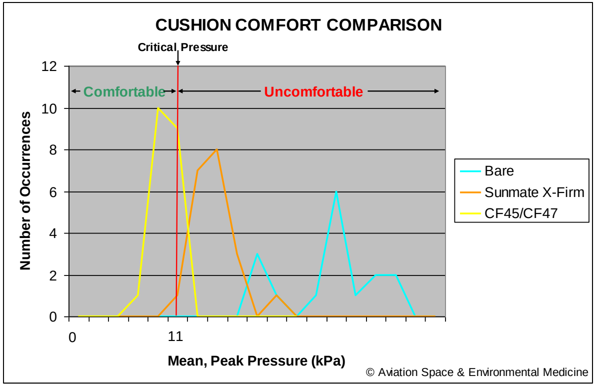
Other precautions, which count as personal removable equipment, are a lumbar support made out of a recognised energy-absorbing foam and a removable insert made out of the same material to place in any large void behind the seat back. Under the overwhelming forces that can be involved in a crash, these measures should help stop the lower spine being bent and forced into the space that would otherwise exist.

This shows a lumbar support on the right-hand side made out of energy-absorbing foam sitting on top of the back of a fitted energy-absorbing safety cushion.

THE COMFORT - SAFETY PROBLEM

Some safety cushions can be hard to sit on. You only realise this about forty minutes into a flight. This is because a hard seat cuts off the blood flow in the capillaries in the buttock tissue and it takes about this long for the resulting pain to become noticeable. As a result, some pilots do not fit safety cushions, preferring to remain comfortable during a long flight and assuming that they will never crash.

Surprisingly, some modern energy-absorbing foams provide a very high degree of comfort and allow buttock region capillary blood flow to continue during a glider flight. A combination of Confor foams (CF45 on CF47) has been shown to be comfort-able for 85% of pilots. They also provide superior energy-absorbing properties. Thus a safety cushion with such materials can make you very comfortable in normal flight and also minimise distractions due to discomfort at the end of a long flight. This can lead to greater safety in this phase of flight.



When you are seated, high pressure points are created in the buttock tissue that can cut off capillary blood flow, depending on how high this pressure is. A lack of blood supply eventually causes discomfort.

The vertical red line shows the pressure at which this blocking of the capillary blood supply occurs. The different coloured zig-zag lines show the maximum pressures that were achieved by differ-ent safety cushion materials across a spectrum of pilots who were statistically representative of UK pilots. Those to the left of the vertical red line were comfortable because buttock tissue blood flow could be maintained.

A combination of Confor CF45 and CF47 gave the best result amongst those tested. Sunmate foam is an American product sold under the trade name Dynafoam in the UK. "Bare" shows the results of sitting on a bare seat.

These tests were reported by the US National Institute of Aviation Research in 1994[1], in the OSTIV Technical Soaring journal [2,3] in 1995 and 2009, and in Aviation, Space, and Environmental Medicine[4] in 2009. The BGA cannot vouch for the accuracy or otherwise of these results .

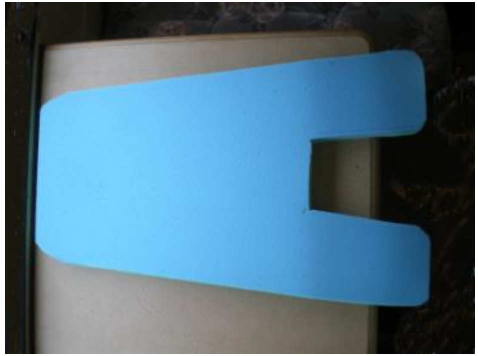
HOW TO FIT A SAFETY CUSION

In some gliders it can be straightforward to install a safety cushion. Sometimes, however, placing a slab of energy-absorbing foam into a cockpit may not be compatible with the required whole body posture. There can be many reasons for this: the extra thickness can push up a pilot's head too near to the canopy, the legs can be canted up to an uncomfortable angle with respect to the cockpit floor, the repositioned feet can become set at an uncomfortable angle on the rudder pedals, the raised seating can generate an uncomfortable back position, etc.

This shows a standard square safety cushion installed alongside a parachute. The thickness of the safety cushion matches the base of the parachute. This has minimised any void and consequent lack of support in the lumbar region.

As a result, fitting a safety cushion may, for example, involve removing part of or all existing standard seat cushions, readjusting the seat back at the base and perhaps its angle of inclination, or readjusting the rudder pedals.

In some cases it may be better to remove the filling of standard cushions and replace it with energy-absorbing foam.



This energy-absorbing foam insert was designed to also support the area under the pilot's thighs. This also prevented discomfort from being generated in those areas. Note that the foam inserts are always placed within a protective cloth cover to prevent them being damaged when in use.

The picture below is a side-view of the same cushion. This shows how the thicknesses of the energy-absorbing foam layers have to be tapered where they go under the pilot's thighs. If they are too thick, they will generate discomfort by setting the legs and feet at inappropriate angles.

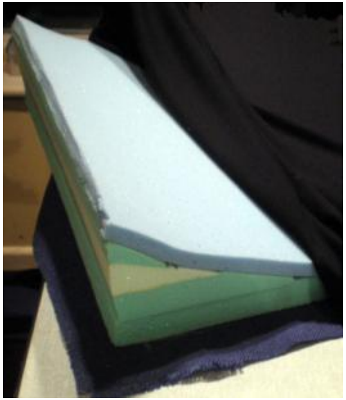
Try to avoid installing an energy-absorbing cushion on top of existing material that is not viscoelastic or that does not remain fully compressed in flight. In a crash loading, the original material will not go rigid immediately and may produce an effect similar to a bounce. This is because you and your energy-absorbing cushion may initially move on without decelerating as you compress the material whilst the underlying glider structure starts to decelerate immediately in the crash – maybe bouncing back up.

Many of these potential problems can be overcome by viewing existing installations or seeking advice from pilots with experience of installing safety cushions.

This particular safety-cushion insert shows how the energy-absorbing foam layers have had to be built up to match the cockpit space available and also to maintain a comfortable body posture for the pilot when seated. In use, the foams are contained within a protective cloth cover.

Safety cushions need to be secured so that they remain located in a safe position and cannot accidently slide into obstructing positions before or during flight. Where manufacturers' standard shaped cockpit cushions are replaced by safety cushions of an identical shape and secured by the manufacturers' location methods there will be no problems. Where a separate cushion is inserted into the cockpit, it should be secured by either Velcro or other loops of material to preclude such slipping movements.

Where safety cushions are in close proximity to the base of the stick and the fixing mechanisms are sufficiently slack to permit the cushions to move and interfere with it, a "u-shaped" portion of the forward part of the cushion should be cut out to remove such a possibility.



This shows the energy-absorbing foam layers used in the make-up of a particular safety lumbar support. It is important that such a support is not oversized so that it generates discomfort. The lower back should rest comfortably on this during flight so that, in the event of a crash, the lower back immediately starts to decelerate with the aircraft as opposed to first passing through a void and bending significantly in the process.

HOW THIS PARTICULARLY BENEFITS INSTRUCTORS

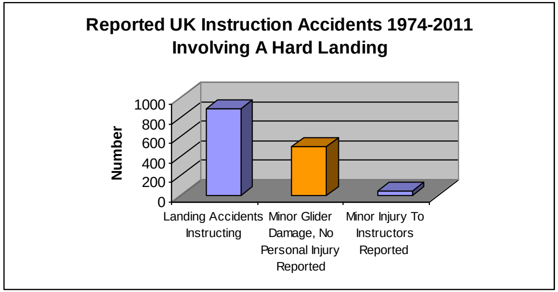
If you are an instructor, you are at a higher risk than most of having a hard landing inflicted on you – perhaps several times during your career.

These may not result in any structural damage to the glider but, if you are sitting on a normal glider seat, your lower spine will receive a short series of unpleasant jolts. This was described at the beginning of this document.

Such lumbar vertebral axial shock loads are also experienced regularly by ski jumpers. It is known that such shocks are associated with an increased risk of microtrauma to the vertebral column. Over time these microtrauma can accumulate to give you a "bad back" and an x-ray may show “degeneration”.

However, thinking H/h again, such landings are one of the few cases where energy-absorbing safety cushions can absorb most of the energy involved – and thus remove the risk to your back.

If you are an instructor, you should be sitting on an energy-absorbing cushion.



Only a small percentage of landing accidents involving instructors result in reported minor injury to the instructors. However, the shock loads inflicted on the spinal column in the large percentage where no minor injury is reported may, nevertheless, contribute to cumulative microtrauma (orange column). In addition, there are other unreported hard landings that result in no injury or glider damage but where severe jolts are inflicted on both instructors and pupils.

RECOMMENDATION

Always fly with an energy absorbent cushion!
It is not expensive, and helps protect your spine.

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