NEO X KOROYD: AN ENGINEERING PARTNERSHIP

9 YEARS OF PRODUCT DEVELOPMENT COLLABORATION

NEO and Koroyd have been working together to develop safer paragliding equipment since 2013. The first tests lasted two and a half years to find the right combination of Koroyd and foam to meet the standards. In these tests we realised that the Koroyd technology alone did not work and had to be constrained by a special envelope. Therefore, we joined forces with Koroyd to develop a specially shaped foam to meet this need. The tested and registered NEO-KOROYD technology was born from this collaboration.

Our common interest has always been to develop the protections and this protection system, which has allowed over the years to reduce the thickness while maintaining the shock absorption capacity.

ABOUT KOROYD

Koroyd is dedicated to engineering a safer tomorrow. Its tireless pursuit of smarter, safer and more sustainable protective solutions underpins its patented and award-winning innovations. From its original, transformative impact absorption technology, to the leading-edge safety solutions under development in its state-of-the-art laboratory, Koroyd offers scientifically researched, rigorously tested and user validated integrations to brand partners, with optional full-scope design and development consultancy. Koroyd is engineered for advanced protection and designed for peace of mind.

Koroyd is a dedicated and dynamic team with a truly global operation. Our HQ is based in the Principality of Monaco on the Mediterranean Sea nestled between the south of France and Italy. From here we manage research and development, sales, finance and operations. Additionally we have teams across the UK, North America and China. We operate across 5 major business units; Sports, Motorsport, Industrial Safety, Family and Defence and serve customers from the US to South Korea.

With insight across multiple categories, we bring cutting-edge R&D facilities and deep expertise in user requirements and test protocols to every partner engagement in order to engineer extraordinary protective solutions and protect what matters most. We believe when standards advance, life improves. From sending it down the tallest mountain, to driving home from the hospital with your newborn, and all the moments in between.

WHAT IS KOROYD?

LIMITATIONS OF TRADITIONAL FOAM TECHNOLOGIES

Traditional impact attenuating materials include expanded polystyrene, expanded polypropylene and vinyl nitrile closed-cell foams which absorb energy through the collapse of internal pores, the compression of air and the bending, buckling or fracturing of cells when compressed[1]. The stochastic arrangement of the internal geometry of foams means that the bead walls get closer to each other during compression, increasing the load necessary to continue the compression. In other terms, the material hardens and thus transmits more force to the body.

The optimization of traditional foam pads is essentially limited to two design variables: material composition and density.[2]

THE 'IDEAL' ENERGY ABSORBER

Foam technologies typically harden during compression.

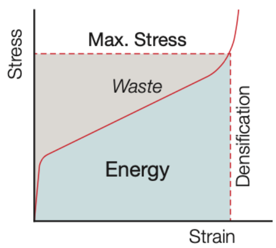

Figure 1: Idealised stress-strain schematics of a foam energy absorber[4]

[1] M. Avalle et al. "Characterization of polymeric structural foams under compressive impact loading by means of energy-absorption diagram." Journal of Aerospace Engineering · October 2008

[2] Eric C. Clough, Thomas A. Plaisted, Zak C. Eckel, Kenneth Cante, Jacob M. Hundley, Tobias A Schaedler, "Elastomeric Microlattice Impact Attenuators," Matter 1, 1519-1531, 2019.

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This type of energy absorber doesn't obtain maximum possible energy absorption. An 'ideal' energy absorber is a theoretical structure which transmits constant force throughout the crushing. The energy absorbed is maximised and the force transmitted minimised.

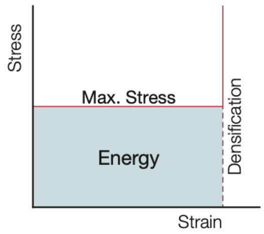

Figure 2: Idealised stress-strain schematic of an ideal energy absorber.[4]

OVERVIEW OF KOROYD TECHNOLOGY

Koroyd's flagship technology was developed out of an aerospace project[3] following a high-profile UK air disaster. The resulting material is an array of extruded and thermally welded tubes which crumple instantly and consistently on impact, absorbing more force with greater reliability compared to any other helmet technology.

Koroyd's ordered architecture and thin tube walls (59µm to 290µm) utilise a combination of controlled buckling and efficient packing up to densification in order to achieve high volumetric energy absorption.

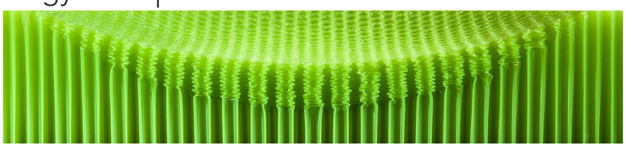

Figure 3: Koroyd's post-impact 'crumple zone' effect

Koroyd's material properties very closely represent that of an idealised energy absorber under compression. Koroyd's mechanical properties are linked to its crumpling behaviour. Unlike traditional foams Koroyd does not harden during compression, the stress plateau is completely flat until material densification at around 70 to 80% compression.

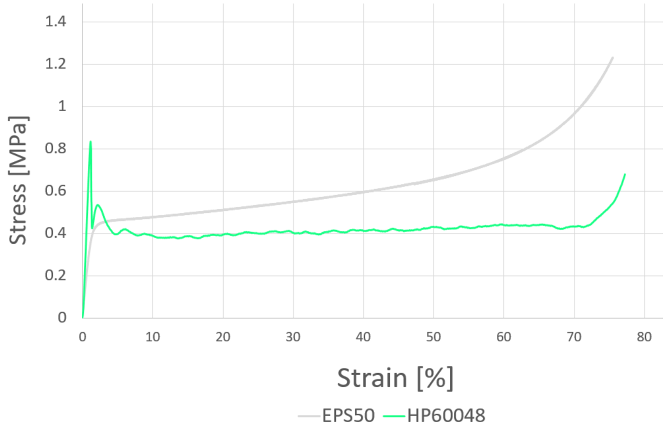

Figure 4: Stress-strain graph of 48kg/m^3 Koroyd, 50kg/m^3 EPS against an ideal energy absorber

HIGHLY TUNABLE CHARACTERISTICS

A highly flexible production process allows optimisation of a number of variables independently including: wall thickness, cell diameter, base polymer, engineered pre-crushing, cell-to-cell bond and tube inclination to adjust the mechanical properties to a variety of different impact scenarios (velocity, mass, shape of the impactor).

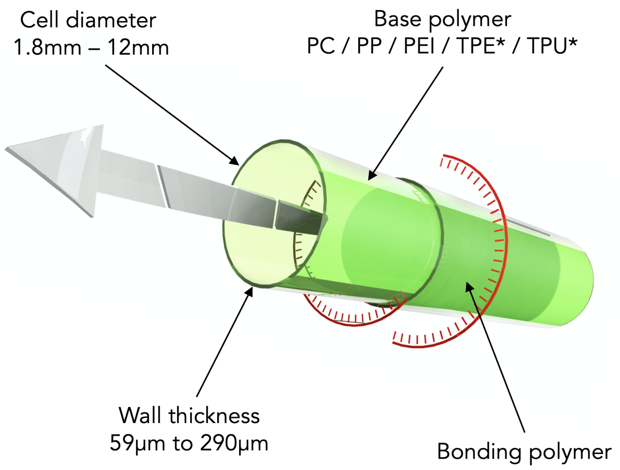

Figure 5: Tunable characteristics of Koroyd's tube anatomy.
*Indicates under development

[3] Crushing Modes of Aluminium Tubes under Axial Compression, Pled et al, Crashworthiness of Composite Seats for Civil Aircraft, V M Stephens, Buckling of Thin-Walled Cylindrical Shells Under Axial Compression, Himayat Ullah

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ENGINEERING A BETTER PARAGLIDING HARNESS IMPACT PAD

EN 1651:2018+A1:2020 - PARAGLIDING EQUIPMENT - HARNESSES - SAFETY REQUIREMENTS AND STRENGTH TESTS

EN 1651:2018+A1:2020 is the European Standard deemed applicable to harnesses for paragliders. Where the manufacturer claims the harness is equipped with an impact pad, the damping of the impact pad is verified using apparatus consisting of a vertical impact dummy and various measurement tools.

The impact pad test is conducted at an ambient temperature 20°C (±5°C).

Although the test is limited to a vertical impact, manufacturers are encouraged by EN1651 to extend the impact pad more widely over the back area.

The dummy is installed in a rearwards leaning position at an angle alpha α between 20° and 25° as illustrated.

The falling mass shall be a minimum of 50kg

The drop height is measured from the impact surface to the lowest point of the test dummy and shall be not less than 165cm

Maximum recorded peak acceleration during the test shall be below 50g.

There is also a stipulation within EN1651 to minimise levels of acceleration over certain time periods;

At a value of 38g, maximum duration of 7ms
At a value of 20g maximum duration of 25ms

It is well documented that the body can endure high acceleration for very short periods of time. Efficient body protection devices minimise acceleration over time.

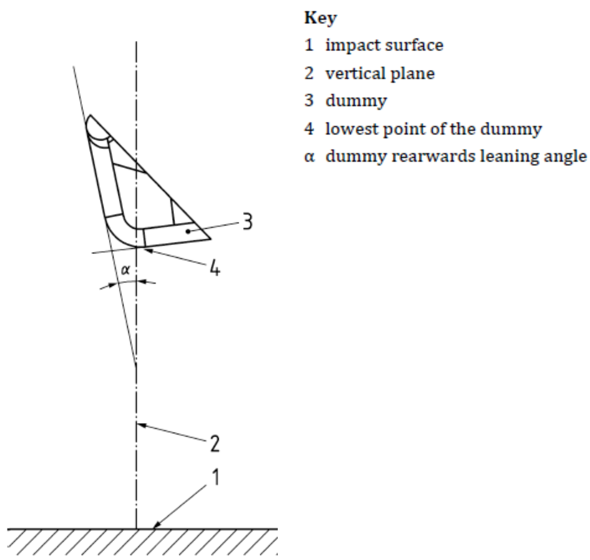

Figure 6: Taken from EN1621:2018+A1:2020
Angle of attack of the impact pad test dummy

NEO-KOROYD'S PERFORMANCE IN PARAGLIDING HARNESS IMPACT PADS

The impact energy associated with EN1651 is 809J with a theoretical impact velocity of 5.7m/s (20.5 km/h). The role of the energy absorbing material is to absorb the maximum amount of energy without densifying (bottoming out) and transferring residual force to the pilot.

The Koroyd specification chosen for the NEO paragliding application is Koroyd HP60048. This specification has a 6.0mm cell diameter, a 48g/l density. Depending on the protection reference the size of the Koroyd inserts change.

The Koroyd is combined to a 24kg/m^3 density foam. The foam gives the overall shape of the protection and holds the Koroyd inserts in position. It also gives a certain flexibility to the protection.

LOW IMPACT EFFICIENCY

Tests have been made on a drop test machine to evaluate the material on low intensity impact. The impactor used is a 5kg flat impactor.

Tests show that the Koroyd's insert starts to crumple from a 30cm high drop. The falling speed is 2,4m/s.

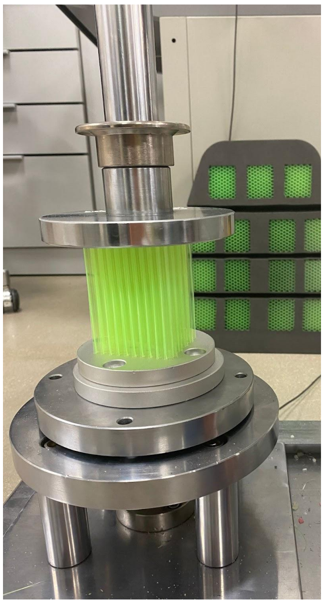

Figure 7: Drop test machine showing the 5kg flat impactor

DYNAMIC TEST PERFORMANCE

Figure 8 shows the results at low and high impact heights following the EN1651 test procedure with a 50kg dummy.

We have tested the NEO-Koroyd 3.0 with NEO Suspender harness at 0.5m, 1m and the EN Standard height of 1.65m in Air Turquoise Laboratory, Villeneuve, CH.

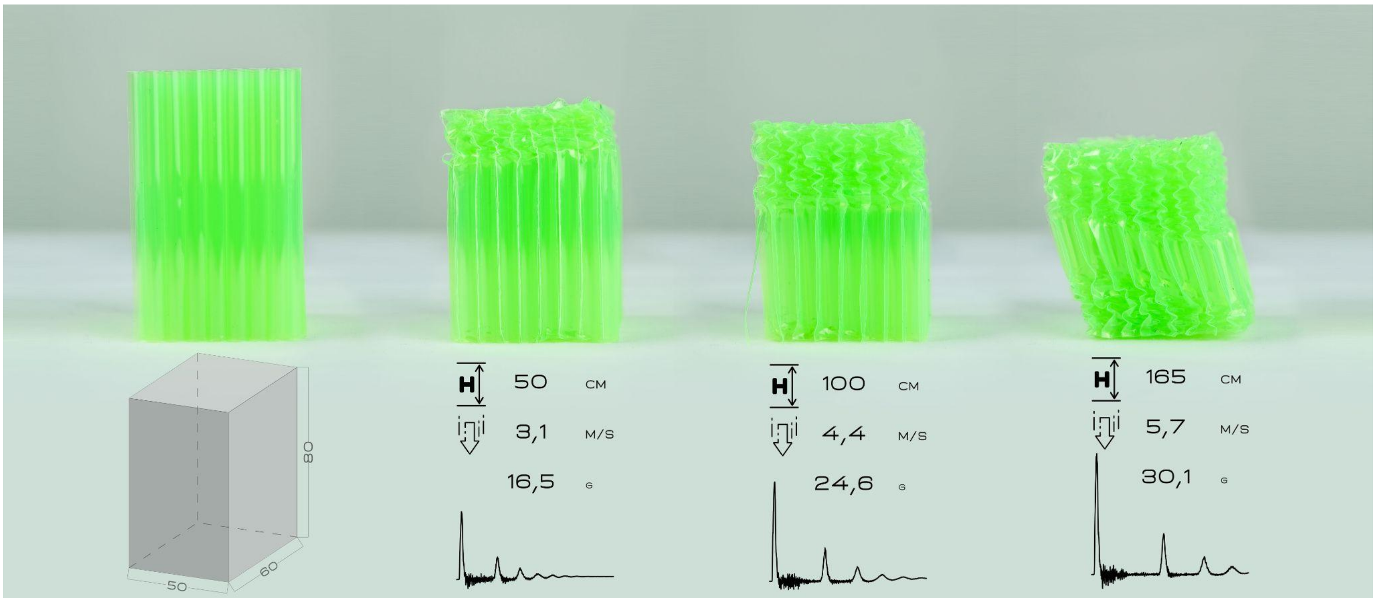

Figure 8: Inserts after dynamic test with the EN 1651 dummy

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NEO-KOROYD'S ADVANTAGES

Advantages in impact absorption of the NEO-Koroyd protection:

- The energy of the impact is absorbed by the deformation of the material, noise and heat.
- There is no energy restitution following the impact, the rebound is very low.
- The duration of exposure to high energy is very short.
- Complete back protection
- 100% efficient in all flight phases (take off and landing)

Advantages in the harness of the NEO-Koroyd protection:

- Lighter protection
- Thinner protection for aerodynamic performance
- Thinner protection for packing volume
- Rigidity for more comfort and handling in flight