

Whilst cycling is a popular sport, it is easy to fall off and suffer serious head injuries. A helmet is therefore an essential piece of cycling equipment.

Keeping one's head

Accidents happen despite every care a cyclist may take. If this unfortunately does occur, an appropriate safety helmet can help to prevent certain injuries and reduce the severity of others.

Whilst good design is important, increased impact protection is generally achieved by increasing the strength of the outer shell and the shock absorbing properties of the inner lining. Technical limitations usually call for materials to be thicker or denser to achieve this, thus increasing the size and weight of the helmet. This, in turn, affects its ergonomic attributes, making some people reluctant to wear one or even introducing additional hazards such as neck-related injuries. Protective helmets are therefore usually a compromise between protection and ergonomics and their performance characteristics are specified under European Standard EN1078:1997.

How does the helmet work?

Safety helmets for cyclists are essentially designed to protect the wearer from head injury where sudden dynamic contact with the ground or some other hard object is likely. Most are constructed with a hard outer shell and an inner polystyrene type liner and these provide the primary impact protection. The outer shell is intended to prevent skull penetration and major distortion and also to help to reduce transmitted forces through the helmet. The liner is intended to act as a shock absorber to further reduce the force transmitted to the head.

Performance is influenced by several factors. For instance, energy from an impact is absorbed by the helmet and reduces the force of the blow to the head. While doing this, it may be weakened or damaged. This may not always be visible, especially in the case of thermoplastic materials, and the outer shell may well have been deflected inwards sufficiently to compress the lining, which does not recover its original shape. The helmet

Uvexfpl T-mobile helmet with outer shell in Makrolon polycarbonate from Bayer MaterialScience.

Bayer MaterialScience



is thus permanently weakened.

Fit is also crucial to performance and, as a general rule, it should be comfortable but close fitting. Restraints, where fitted, should be securely fastened and the chinstrap sufficiently tight to be under tension at all times. Regardless of application, most helmets incorporate a three-point fixing system and tests have been developed to measure the efficiency of this arrangement.

Testing conclusions

A number of tests have been devised to assess performance under a variety of situations and environmental conditions.

Impact protection is the primary concern and the helmet undergoes what is generally called a 'dynamic' test. In this, the helmet is fitted to an alloy head form that corresponds in both shape and weight to a human head. The helmet is then dropped on to a spike for penetration purposes or an anvil to represent hard flat surfaces such as roadside kerbs.

Head forms come in a number of sizes relating to the inside circumference of the helmet in order to enable different sized helmets to be tested and conform to European Standard EN 960. This allows the testing of helmets for children (a particularly important area) to be as accurate as possible. They also incorporate chin and neck areas for testing the retention mechanisms of helmets.

Accelerometers and load cells are used to measure the effects of impact. Triaxial or uniaxial accelerometers capable of measuring and recording accelerations in the order of thousands of 'G' (unit of gravitational acceleration which is equivalent to 9.81 metres per second squared) are mounted at the centre of gravity in the head form. The helmet and head form are then set in a cradle and the assembly is dropped in a guided free fall—using either a wire or rail guided apparatus—on to an



Impact testing a cycling helmet

SATRA Technology Centre

Expanding on head protection

For a long time the professional cyclists refused to wear helmets during road races, arguing that they were too warm and hindered performance. However, after a number of serious and fatal crashes, the professional European cycling governing body UCI ruled that helmets were obligatory for road racing. And helmets don't seem to bother anyone any more and have become an important sales generator.

In conversation, it is commonly stated that helmets are important because to a great extent they can absorb and energy thus help to prevent, or at least reduce, the seriousness of head injuries. Estimates show that bike helmets could prevent up to 88% of cycling-related brain injuries – as long as the product is well-designed and fitted properly. The 'law of conservation of energy' in physics state that the energy of a crash cannot be absorbed, but can only be converted to some other form of energy. What helmets actually do could therefore be termed as 'energy management' rather than 'energy absorption', converting some of the impact energy into heat and slowing down the speed at which the head stops and thus reducing the peak spike of energy to the head and brain.

As a safety product, bike helmets have to meet fixed standards. In the United States, the standard is defined and controlled by the 'American Society for Testing and Materials (ASTM). In Europe the standards are set by the CE-Norm EN 1078. ASTM and CE requirements and results have to be visible on a sticker stuck to the inner part of each helmet. Non-certified helmets are not allowed to be sold, nevertheless, no company is prepared to guarantee a certain level of protection or rank their helmets as offering more or less protection.

Fabrics and moulding

The most important part of a cycling helmet is the foam layer. This liner controls the energy of a crash. The liner is usually made of expanded polystyrene foam (EPS). Although more recently expanded polypropylene (EPP) or expanded polyurethane (EPU) are being used to a small extent. The shells of more inexpensive helmets are made of stamped polyethylene (PET) and higher quality heat resistant plastics such as polycarbonate are used for high quality helmets. This differentiation is necessary because of the production methods applied, that distinguish between simpler helmets and high-end products. Good shells are round with a smooth surface so that they skid on the crash surface and prevent the head from jerking and wrenching.

Most helmets are moulded. The simplest method is the standard technique used in the industry's foam shops for EPS production: EPS granules are placed in a mould and expanded with steam and pressure into a solid foam. The shell is added after moulding and glued to the foam or taped around the edges. For higher quality products the technique used is 'in moulding', where the liner is expanded directly into the shell. Because simple PET would melt, heat resistant "polys" are needed. High-end EPS helmets often have internal reinforcements made of polyester, polypropylene or even metal mesh to further stabilise the skull. They are inserted during the moulding process and the techniques used are proprietary secrets. In general, these reinforcements are not used to produce helmets that exceed the demanded standards, but are used to reduce the amount foam and open larger vents for more comfort – a procedure that would otherwise not meet standards.

Downhill and BMX helmets often have shells made of composite fibres using fibre glass and Kevlar in an epoxy. These often have added safety features such as full-face protection featuring padded chin bars and back and neck protection. But, of course, these lack ventilation and are not as lightweight. However, as they are rarely worn for long periods of time, as is the case in mountain biking or road racing helmets, this is not a crucial factor.

anvil fixed to a rigid base. The cradle ensures that the helmet meets the anvil at the designated angle, without interfering with the dynamic reaction. Tests are repeated at different points on the helmet and impact anvils are shaped to suit individual hazards.

Most cycling helmets incorporate ventilation slots and these can be tested to ensure that sharp edges such as those found on the edge of kerb stones cannot cause injury. The helmet is mounted so that when it falls, the ventilation slot corresponds lengthwise to the lengthwise edge of the anvil. An electrical connection between the anvil and the head form indicates whether any contact has been made.

Thermoplastic materials may exhibit different impact properties at extremes of temperature or after exposure to sunlight, so various conditionings, such as elevated temperatures, sub-zero temperatures, and artificial ageing using a powerful xenon lamp, are carried out before testing.

Retention of the helmet on the wearer's head in an accident situation is particularly important and a number of tests examine this aspect of performance. The helmet is fitted to a head form and the retention system fastened as in use. A downward force is suddenly applied to the retention system via a 10kg mass and any resulting peak and residual displacement is noted. This includes buckle slippage. The effectiveness of the retention system is also checked using a 'roll off' test. The helmet is attached to a head form in the normal manner and a 10kg load is applied in front of the peak via a wire attached to the rear edge of the helmet. The load is applied suddenly and any rotation is noted.

Children pose special problems

EN 1080:1997 Impact protective helmets for young children and EN 1078:1997 Cycle helmets are both European harmonised standards, so helmets that have undergone EC Type examination to these standards conform to European Personal Protective equipment (PPE) Directive 89/686/EEC.

Although helmet characteristics are generally similar, the two standards differ with regard to the harness or chin strap. EN 1080 requires the helmet to have a self-release retention system designed to release under loads greater than 15kg in order to avoid possible strangulation, etc., whilst the EN 1078 harness is designed to prevent accidental release. In this sense, they are therefore contradictory.

It has been found that young children frequently wear only one type of helmet for both cycling and playground use such as climbing on play equipment, etc. So, what are parents to do? Buy one helmet for the child to cycle to the playground and another to wear once they arrive?

The EC acknowledges this but is concerned about the safety implications (a child has already been killed after a climbing frame accident wearing an EN 1078 cycle helmet) and has indicated the possibility of removing the presumption of conformity if the standards are not amended.

The European standards body, CEN, has responded by modifying the marking information relating to the two standards to increase awareness of the implications of using the helmets inappropriately. Something will have to be resolved. But as in all these cases, it will doubtless take time.

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New on the market



Lazer's Genesis helmet.
Lazer

Since norm standards are pre-determined, features such as shell adapting systems, run systems, ventilation systems and design are the main points that distinguish simpler products from high-end helmets. In addition to this, experience has shown that, from a sales point of view, it is easier to sell an expensive helmet which offers better ventilation than by offering one that exceeds safety standards. As a consequence, no one in the industry really produces helmets with higher safety concepts, they provide only what is needed to fulfil the standard requirements.

The International Bicycle Trade Exhibition EuroBike in Friedrichshafen, Germany, awarded the EuroBike Awards for the first time last year, and two bike helmets were awarded in the 'Clothing and Equipment' category. Here too, safety was not mentioned; it was taken for granted.

The Belgian brand Lazer won an award with its 'Genesis' helmet featuring a new and revolutionary retention system "in perfect harmony between elegance, technology and safety" as the jury put it. The 'Rollsys' enables the cyclist to adjust the retention single handed while the helmet is being worn, by simply turning a button. The positive effect of this is that the Genesis delivers perfect fitting to any shape and size of head, ranging from XXS to XL.



The second award was given to the Italian safety product specialist Dainese for its downhill helmet 'D-raptor Fiber Le Helmet'. The D-Raptor is an ultra-lightweight full-face helmet with a removable visor made from a differentiated density foamed EPS liner and a fibreglass shell.

D-Raptor Fiber Le Helmet.
Dainese