HEADS UP

Cycle helmets are a contentious subject. Brian Walker, of helmet-testing lab Head Protection Evaluations, looks at the science instead of the rhetoric

Helmets cause heated arguments among cyclists. Let me start by saying that this article is *not* about whether or not you should wear a helmet. Nor is it about the impact of compulsory helmet use on cycling levels or on overall cycle safety. It will focus on what helmets are designed to do in the event of a fall. Whether or not you want to wear a helmet, it should help inform your decision.

HELMET BASICS

Cycle helmets protect the head by reducing the rate at which the skull and brain would be accelerated or decelerated by an impact. The helmet acts like a shock absorber. As it is impacted, the expanded polystyrene shell of the helmet dissipates the energy over a rapidly increasing area like a cone. Movement of a helmet about the head and breakage of the helmet shell also assist with the reduction of some energy.

Cycle helmets in their present form are a 'spin off' product from the development of expanded polystyrene foams for shock absorbing liners in motorcycle helmets. It was noted that the protection provided was superior to the old 'hair net' style of head gear, and the helmets were also easier to make.

> "Cycle helmets are designed for falls without any other vehicle involved"

These new helmets were produced simply to improve on those that preceded them, rather than to meet any specific type of hazard. A little later most of the helmets were improved to meet the Snell B-84 (Bicycle 1984) standard – the only relevant performance specification in print at that time.

Photos this page: jason@cycling-images.co.uk; Opposite: Specialized Ltd

WHAT THEY'RE DESIGNED FOR

The earliest cycle helmets standards were principally concerned with protecting from falls from a cycle without any third party involvement, and generally at lower speeds. The foreword to BSI Standard 6863:1987 read as follows:

'It (the standard) specifies requirements for helmets intended for use by pedal cyclists on ordinary roads, particularly by young riders in the 5 years to 14 years age group, but which may also be suitable for off the road. It is not intended for high-speed or long distance cycling, or for riders taking part in competitive events. The level of protection offered is less than that given by helmets for motorcycle riders and is intended to give protection in the kind of accident in which the rider falls onto the road without other vehicles being involved.'

Cycle helmets could be designed like motorcycle helmets to offer much greater levels of protection. But such helmets would be uncomfortably heavy and hot, and few cyclists would want to wear one. Cycling is an athletic activity and its helmets must therefore be light and well-vented – even though this restricts the protection they can offer.

Cycle helmets are primarily designed for falls without any other vehicle involved. In many legal cases I have studied where a cyclist was in collision with a motorised vehicle, the impact energy potentials were of a level that outstripped those that we use to certify Grand Prix motor racing helmets.

The tests that cycle helmets currently go through mean that they should offer similar protection to a pedestrian who trips and falls to the ground. Whether they might be used to reduce head injuries inside motor vehicles is a moot point. Cycle helmets are *not* suitable for use by children in play areas where they can climb: the helmet straps can get caught and strangle the child.

HELMETED VS UNHELMETED

It's easy to find accounts of the 'helmet saved my life' variety, just as it is to find critiques of those accounts. While helmets should offer improved impact protection, the issue isn't cut and dried.

> "Helmets may be more useful for certain user groups than for others"

Cycle helmets come in a wide variety of styles and designs. And every accident has features that differentiate it from other events. If the accidents were more alike, designing helmets and writing performance criteria would be much easier. The problem is compounded by the fact that cycle helmets are the most fragile type of safety helmet. In today's road traffic accidents, it's not unlikely for a cycle helmet to be subjected to severity loads greater than it is designed to cope with.

One recent court case that I was involved with was even more telling. I was one of the specialists in the case. A respected materials specialist argued – against me – that a cyclist who was brain injured from what was essentially a fall from their cycle without any real forward momentum would not have had their injuries reduced or prevented by a cycle helmet. This event involved contact against a flat tarmac surface with an impact energy potential of no more than 75 joules, in his estimate. I agreed with his energy potential estimate but not his conclusion. The court found in favour of his argument.

Cycle helmets have to be vented and lightweight to be tolerable to wear

So in at least one case now, a High Court has decided that the balance of probability was, in the matter before the Court, that a cycle helmet would not have prevented the injuries sustained when the accident involved simply falling from a cycle onto a flat surface, with barely any forward momentum.

In this same case, the QC under whose instruction I was privileged to work tried repeatedly to persuade the neurosurgeons acting for either side, and the technical expert opposing me, to state that one *must* be more safe wearing a helmet than would be the case if one were not. All three refused to do so, claiming that they had seen severe brain damage and fatal injury both with and without cycle helmets being worn. Cycle helmets, in their view, were too complex a subject for such a sweeping claim.

BEST CASE, WORST CASE

As a result of the design parameters of cycle helmets, they are likely to be more useful in some circumstances – and for certain user groups – than others. For instance, younger children (alluded to in BS6863) might well derive the greatest benefits from wearing cycle helmets, because of their lower riding speeds, lower falling heights, and lack of riding skills generally.

Among adult cyclists, helmets likewise have a greater potential benefit in incidents that take place at lower speeds and without any third party involvement. So in circumstances in which the cyclist is more likely simply to fall off, there is a stronger argument for helmet wearing. Such circumstances might include icy roads or off-road cycling.

Most cycle helmets can manage more energy when impacted against a flat surface than any other, mainly because of the necessity to have good ventilation. If a tight radius or angular cornered surface is impacted, it could reduce dramatically a cycle helmet's ability to protect the wearer. Anything that has the potential to penetrate, even if not actually pointed, can be disastrous.

All cycle helmet standards demand higher impact energy tests against a flat surface than for other profiles. This is because of the product's limitations, not because you need less protection from irregular surfaces. In an ideal standard the same impact energy levels would be employed against all test profiles. As noted earlier, a motorcycle helmet would provide far superior protection – at the cost of excessive bulk and inadequate ventilation for cycling.

HELMET TESTING

The worst accident scenario, in terms of head and brain injury, is when the head strikes a solid object that cannot move. Because of this all safety helmet standards use test rigs in which the helmet is mounted on a headform, which usually weighs 5kg (the average weight of the human head), and dropped down guide wires onto various shaped anvils. The anvils are mounted on top of a concrete block with a thick steel surface with a total weight of around 500 kilos to 1 imperial ton, depending on the standard. This huge difference in mass replicates the worst case accident.

The test headforms contain instrumentation: an accelerometer that plots the onset of G forces transmitted through the helmet to the headform.

Normal dry laboratory conditions aren't representative of the outdoor environment. All cycle helmet standards therefore include tests in hot, cold and wet conditions.

Chinstraps are tested against breakage and buckle slippage, normally with a dynamic snatch loading device. The chinstrap effectiveness is also assessed by various methods that attempt to pull or roll the helmet off a test headform. A penetration test is not normally included for bicycle helmets, because the ventilation holes makes such a test rather meaningless.

Different impact shapes demand different protective qualities in a helmet

SAFETY STANDARDS

When looking at safety standards, the most important sections to consider are those dealing with the impact tests. That's because the main reason for wearing a cycle helmet is to give some protection to your skull and brain from impact hazards.

There are two variants in impact testing: the impact energy, which can be varied by dropping the helmeted headform from different heights to vary the velocity; and the shape of the surface impacted.

Dropping from different heights is easy to understand. The effect of differing impact surfaces is more complicated.

A safety helmet's outer surface loosely mimics the shape of the human head. It consists of compound curvatures. Therefore in an impact the initial point of contact will be located in a small area, even against a flat surface. If the helmet outer shell were made of steel and did not flex, only a small amount of shock absorbing material inside the helmet would be brought into play to reduce the forces threatening the head.

For optimum protection against flat surface, the helmet needs to flex easily to rapidly increase the area of contact and utilise much more shock absorbing material. If we make a helmet less rigid, so that it flexes more, we will increase the amount of energy absorbed and reduce the G forces transferred to the head.

We cannot know that the helmet *will* strike a flat surface, however. If we take our softer, optimised-against-flat-surfaces helmet and drop it onto a spherical surface with the same impact energy, the results are very different. Unlike the flat surface, the spherical shape can dig into the helmet shell.

Initially the spherical anvil will come into contact with the same area on the helmet's shell as the flat surface, but it will do so in a shorter period of time. Critically, when it has approximately the same contact surface area as the flat anvil, the spherical surface will have intruded far deeper into the helmet shell. The danger here is that the helmet will be compressed into a solid mass, at which point any residual energy will transmitted straight through to the brain.

Therefore a helmet that is too rigid can fail badly against a flat surface, while a helmet that is too soft can fail badly against a spherical surface. Optimum protection against the two different surfaces sit at opposite ends of the safety helmet performance 'spectrum'.

Other anvil shapes are designed mainly to represent specific hazards, such as a kerbstone. Apart from penetration hazards, these alternative shapes have impact profiles that sit somewhere between the flat and spherical surface extremes. Because of this, I would not write a safety helmet standard for any application that

G forces transmitted through the helmet are carefully measured

did not include flat *and* spherical surfaced anvils.

DECLINING STANDARDS?

All safety helmet manufacturers have to sell their goods in a brutally competitive global market. The problem here is not so much that they will be made down to a price, but that they will be made down to the lowest standard permitted in a given 'local' market.

Cheap helmets can be as good as expensive helmets, because cycle helmets are manufactured from relatively inexpensive materials. During the early 1990s there were helmets available in the UK for less than £10, which nevertheless offered extremely good performance. The helmets were manufactured to the Snell B-90S standard, were fashionably stylish, were not heavier than the norm, were well ventilated, and had a comfort factor on a par with other makes. None of these helmets is available today.

Cycle helmets sold in the UK today generally offer a lower level of protection than those sold in the early 1990s. This is due in the main to the introduction of the European EN1078 standard, which is weaker than the Snell standards then used (see below).

In the early 1990s, market research suggested that in excess of 90% of the cycle helmets sold in the UK were certified to the Snell B-90/95 standards, at that time the most stringent cycle helmet standard in the world. In 1998, Head Protection Evaluations conducted a test programme for the Consumer's Association's assessment of UK cycle helmets.

By that year, all of the helmets were manufactured to the EN1078 standard. The results showed that many of the helmets tested were totally incapable of meeting the higher Snell standards, to which some of the models had been previously certified. Some tests suggested that certain helmets were even incapable of meeting the weaker EN1078 standard.

WEARING A HELMET PROPERLY

Apart from racing cyclists either off or on road, I hardly ever see a cycle helmet worn properly. The effectiveness of any type of protective headgear in an accident is influenced to a large degree by the fit on the head and the correct wearing position. The best advice here comes from the Snell Memorial Foundation:

> "Apart from racing cyclists, I rarely see a helmet that is worn properly"

'Position the helmet on your head so that it sits low on your forehead; if you can't see the edge of the brim at the extreme upper range of your vision, the helmet is probably out of place. Adjust the chinstraps so that, when buckled, they hold the helmet firmly in place. This positioning and adjusting should be repeated to obtain the very best result possible. The procedure initially may be time consuming. Take the time.'

REPLACING A HELMET

Expanded polystyrene, the principal material from which cycle helmets are manufactured and the bit that protects you, is not known to deteriorate with age. However, you should avoid putting anything heavy on top of the helmet, or exposing it to unnecessary knocks.

You will get greater useful life from a helmet if you: (a) reserve a safe storage place for it when not in use, preferably in a strong small box; and (b) if your helmet gets a good soaking, you allow it to dry out for as long as is practical, at a dry room temperature.

Most manufacturers recommend that a helmet be changed after five years – a fair guideline, if you're unsure about checking your helmet yourself.

In testing, the hemispherical and flat anvils are the two most crucial

Left and opposite: by Brian Walker

WHICH HELMET?

Buying a helmet certified to the EN1078 standard is easy: all UK bike shops carry them. Of these helmets, the one with the best fit (and perhaps best venting and style) should serve best.

Buying a Snell-approved helmet in the UK is less easy. While the Snell Memorial Foundation's website (www.smf.org) does list B-90 and B-95 certified helmets, not all of these are available in the UK. Some have Euro-versions with the same name that are certified to the EN1078 standard instead, while others meet Snell and EN1078 standards but in the UK carry only the EN1078 sticker!

In the rush before going to press, your editor found just five non-full face helmets available in the UK that meet Snell standards. All from Specialized, and in the UK all carrying the EN1078 sticker (but nevertheless manufactured to Snell standards), they are: the Aurora, Telluride, AirForce, KidCobra, and Deuce.

We'd be happy to hear of others!

DIFFERENT STANDARDS

	IMPACT ENERGIES, FOR EACH ANVIL SHAPE USED				
	Flat anvil	Hemispherical anvil	Kerbstone anvil	No. of impacts per helmet	Total Impact Energy/helmet
Snell B-84	97.8 joules	58.7 joules	N/A	4 (2 each anvil)	313 joules
BS: 6863	52.2 joules	N/A	52.2 joules	2 (1 each anvil)	104 joules
Snell B-90	100 joules	65 joules	N/A	4 (2 each anvil)	330 joules
Snell B-95	110 joules	72 joules	72 joules	4 (1 each anvil +1)	Min 326 joules Max 364 joules
EN 1078	S - M - L 46 - 69 - 90	N/A	S - M - L 35 - 49 - 64	2 (1 each anvil)	Min 81 joules Max 154 joules

Note: European EN helmet standards uses test headforms varying from 3.1kg for the smallest to 6.1kg for the largest size. The different weights, and tests, are listed for Small, Medium and Large headforms.