Comparisons EBB 11/12/02

Snell M2000, DOT, BSI 6658-85 Type A and EN 22/05

The tables compare four standards: M2000, DOT, BSI 6658-85 Type A and Regulation 22 Rev. 5, also known as EN 22/05. M2000 and the current DOT Standard (Federal Motor Vehicle Safety Standard 218) apply largely to helmets intended for the US and Canada. EN 22/05 applies to helmets for sale in Europe and BSI 6658 Type A is the premium level of the helmet requirement once mandatory in England. Although all four standards differ in details, in order of severity they rank firstly Snell M2000, then BSI 6658-85 Type A, then DOT and, lastly, EN 22/05. The following tables and discussion are the basis for this ranking.

The first page of the tables compares impact requirements set by the four standards. There are two general areas of concern. The first of these is the impact regimen which describes the sorts of stresses to which the helmets will be subjected, the second is the criteria by which the helmet’s response will be evaluated. All four standards call for helmet samples to be placed on anthropomorphic headforms and dropped to impact rigid surfaces (anvils) with prescribed severities. The differences are in the anvil shapes, the prescribed severities, the number of impacts at a particular point on the helmet surface and the coverage, that is, the range of points on the helmet surface that are subject to testing. All four then measure the shock transmitted through the helmet into the headform by means of an accelerometer mounted at the headform’s center of gravity. Old wisdom has it that it’s not the fall that kills, it’s the sudden stop. The accelerometer measures just how suddenly the headform is required to stop. Each of the standards describes how to evaluate the accelerometer measurement to determine the effectiveness of the helmet.

The first four items considered in the tables are the various impact surfaces and the impact severities the helmet must withstand striking these surfaces. The first of these surfaces is the flat anvil. All four standards call out impacts against this anvil which distributes the impact over a broad area of the helmet shell and which effectively sets limits on the density of the helmet’s impact managing liner. The second is the hemispherical anvil used by Snell, DOT and BSI. This hemispherical anvil applies a concentrated loading which tests the rigidity of the helmet shell and the depth of the impact managing liner. That is, the shell and liner must work together to keep the anvil from punching through the helmet, collapsing a small segment of liner and, finally, delivering a massive shock directly to the test headform and, potentially, to a wearer’s head. EN 22/05 does not use the hemi anvil but instead applies an anvil shaped like a length of curb. This ‘kerbstone’ anvil replaced the hemi anvil when Regulation 22/03 was revised to produce EN 22/04 but it does not appear to concentrate the loading as much as the hemispherical anvil.

The EN 22/05 impact regimen is less severe than it may appear for another reason as well. Snell, BSI and DOT all call out guided fall impact test mechanisms which effectively align the headforms with the centers of the anvils and which limit the headforms' rotational response. EN 22/05 equipment allows the headform to move freely in all six degrees of freedom in response to the impact loadings but the device frustrates any alignment so that much of the severity of an impact is lost to rotations. This loss has been documented for flat anvil impacts and is suspected to be even greater for impacts with the kerbstone anvils.

The last of the anvils is the edge anvil. This edge impact surface effectively tests shell toughness and is called out only in the Snell standards.

The impact severities are given in terms of the kinetic energy of the headform and associated hardware. This formulation takes into account the differences in impact velocity and in headform mass between these standards. Snell M2000 and BSI both require that the effective masses of the impact headforms be 5.00 kg regardless of headform size but DOT and EN 22/05 specify headforms with a cubic mass to size relationship. That is, the headform mass is proportional to the headform circumference cubed. Although this cubic may appeal to engineers, anatomical studies show little if any relationship between the weight of a human head and any of its external dimensions. The only strong correlation noted is with total body weight; that is: heavy people have heavy heads regardless of hat size and vice versa. Even so, DOT and EN 22/05 specify these size dependant headform masses which effectively means that larger sized helmets must manage more energy than smaller ones but are permitted to transmit larger levels of shock.

The next line in the table shows relative coverage. Snell M2000 calls out a test line on the helmets and all impacts must be centered on or above this test line. The values in the table show, for the front, back and sides of the helmet, how much higher (+) or lower (-) the three other standards may place their impacts. As can be seen, all three allow more severe (lower) placements than M2000. However, these placements are all largely offset by the relative weakness of the impacts themselves. For example, even though the DOT standard allows impacts outside the Snell M2000 test line, there are many shorty helmets that qualify to DOT and none to M2000. The reason is that the helmet structure below the testline is critical to its capabilities to manage Snell levels of impact. A shorty helmet does not need this structure to manage DOT impact levels but the Snell test assures that the structure is present.

The final element in this table is the impact test criteria. Snell and BSI call out the same 300 g limit on the peak acceleration transmitted to the test headform. DOT allows 400 g but also places limits on time duration, that is: how long the shocks may persist above the 150 g and 200 g levels. EN 22/05 limits acceleration to 275 g and also imposes a limit on HIC, the head injury criterion which is an involved calculation based on the entire time history of the acceleration pulse transmitted to the headform. The DOT time durations and the HIC are questionable criteria for crash helmet evaluation as they are both based largely on skull fractures observed in bareheaded cadaveric subjects struck with a shaped impactor. The HIC itself was developed largely for evaluation of the injury potential of head strikes in passenger car interiors where the victims would almost certainly be unhelmeted. The actual level of HIC considered potentially injurious is 1000 rather that the 2400 level in EN 22/05. However, there is some doubt whether HIC applies to helmeted impacts at all.

The rest of the tables compare other aspects of helmet performance. The two European standards pursue a number of items not addressed by either Snell or DOT. This is not necessarily a shortcoming in Snell M2000. The Foundation evaluates those aspects of helmets that:

1. Have a demonstrable bearing on protective performance.
2. Can be tested repeatably and reliably.
3. Are invisible, that is: cannot be easily evaluated at purchase time by the riders themselves.

If the wearer can make the determination for himself, he is likely neither to need or want the Foundation’s advice. Unless it’s important, hard to measure and we know it for a fact, we won’t waste anyone’s time.

The oblique impact tests required by BSI and EN 22/05, for example, have not been taken up by Snell largely because there is no body of evidence demonstrating that such testing is useful. Pertinent crash studies indicate that helmets are neck injury neutral. Furthermore, the tests themselves are difficult, if not impossible, to reproduce so that the procedures are, at best, a research tool and have no place in the administration of a standards enforcement program. In another regard, conspicuity is a well regarded safety feature but do riders really need help identifying conspicuous helmets?

Helmet selection cannot be a matter of simply looking at certifications. We hope that Snell certification will help narrow the range of choices but riders still have many important decisions to make. Proper fit is essential and reasonable comfort is critical as well. So is the look of the helmet; even the most rational and conservative rider will not wear a helmet he thinks is ugly, at least, not very long. Vision is important as well. Some new riders may notice the edges of the headgear at the limits of their peripheral vision but at speed, a rider’s visual field contracts. However, if the face shield distorts or obscures, it’s got to be replaced and, maybe, the helmet as well. Hearing is also essential. Although most helmets actually improve hearing at speed over riding bareheaded, prolonged exposure to wind noise may destroy hearing over time. A helmet’s effectiveness in reducing wind noise depends on its structure and on the fit quality. Finally, it’s not sufficient to make these decisions when the helmet is purchased, these decisions must be reconsidered every time the helmet is worn.

Comparisons

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	M2000	DOT (current)	BSI 6658-85 Type A	EN 22/05
Impact Regimen				
Flat Anvil	Two Drops 1st 150 j 2nd 110 j	Two Drops S - 63 j M - 90 j L - 109.8 j	Two Drops 1st 141 j 2nd 70 j	One Drop S - 115.3 j M - 132.2 j L - 157.5 j
Hemi Anvil	Two Drops 1st 150 j 2nd 110 j	Two Drops S - 47.3 j M - 67.6 j L - 82.5 j	Two Drops 1st 123 j 2nd 63 j	-
Kerbstone Anvil	-	-	-	One Drop S - 115.3 j M - 132.2 j L - 157.5 j
Edge Anvil	One Drop 150 j	-	-	-
Coverage (Medium Sizes)	(baseline)	Front -25 mm Side -20 mm Back -15 mm	Front -26 mm Side -33 mm Back -3 mm	Four Prescribed Locations Top Front -18 mm Side -46 mm Back +42 mm
Impact Criteria				
Peak G	300 g	400 g	300 g	275 g
Dur @150	-	4 msec	-	-
Dur @200	-	2 msec	-	-
HIC	-	-	-	2400

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	M2000	DOT (current)	BSI 6658-85 Type A	EN 22/05
Retention System				
Retention Strength	Dynamic 23 kg static 38kgx12cm shock 30 mm criterion	static 50 lb baseline 290 lb load 1 inch criterion	Dynamic 15 kg static 10kgx75cm shock 35 mm criterion	Dynamic 15 kg static 10kgx75cm shock 35 mm criterion
Roll-off	4kgx60cm shock retention criterion	-	4kgx100cm total shock retention criterion	10kgx50cm shock 30° criterion
Strap Micro-slip	-	-	yes	yes
Strap Abrasion	-	-	yes	yes
Inadvertent release	-	-	yes	yes
Release Durability	-	-	yes	yes
Removability	yes	-	-	-
Free End Retention	velcro forbidden	-	-	required for D-rings

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	M2000	DOT	BSI 6658-85 Type A	EN 22/05
Shell Requirements				
Shell Penetration	60° cone 3 kg 3 m fall	same as M2000	same as M2000	-
Shell Rigidity	-	-	-	loading to 630 n (141 lb) from 30 n (6.74 lb) baseline 40 mm max deflection 15 mm max residual
nape clearance	-	-	-	yes
conspicuity	-	-	-	yes
Oblique Impact	-	-	Yes	Yes