SMARTER editor's note: *The below was sent to SMARTER by Hong Zhang on November 24, 2021 in partial response to our inquiries regarding the 2020 Snell motorcycle helmet standard. Hong Zhang is the Snell Foundation, Inc., Director of Education. The document was written by Mr. Ed Becker. Mr. Becker joined Snell in 1989. He holds Bachelor's and Master's degrees in Mechanical Engineering from the Massachusetts Institute of Technology. Mr. Becker served Snell as the Chief Engineer and Executive Director of Snell Foundation and oversaw the operation of all the Foundation's helmet certification programs. At the time of this writing, he had recently retired from this position but serves on the Snell Board of Directors as the Director of Standard Development.*

M2020 D&R and Rotational Testing EBB 11/21/21

Snell M2020D and M2020R

Snell M2020 includes two slightly different sets of requirements. One of these, Snell M2020D, applies to helmet models which had been developed to comply with the United States' DOT standard (FMVSS 218). The "D" in M2020D corresponds to "DOT" and M2020D itself encourages the continued production of helmet technologies developed for use with Snell M2010 and M2015. Snell's directors considered that M2010 and M2015 had specified the most protective helmets consistent with DOT demands that riders might reasonably be expected to wear. The Foundation was happy to continue to recommend them for use.

Snell M2020R is intended for compatibility with ECE Regulation 22-05 and also with FIM's FRHPhe-01. The "R" was taken from "Regulation 22" the United Nations Economic Commission for Europe's standard for motorcycle helmets. This standard had been promulgated back in 1957 and had largely languished until the formation of the common market when all the local national requirements of the common market countries were swept away in favor of a lowest common denominator update of the UN-ECE document. Snell hopes to recommend helmets certified to M2020R as the most protective helmets riders in Europe might reasonably be expected to wear.

It may seem remarkable that two different Snell motorcycle helmet standards seem necessary to serve riders in North America and Europe. After all, the heads that go into the helmets seem very much the same. But even if the motorcyclists are similar, the riding conditions are different. Motorcycle helmets sold in the US must meet DOT while those worn in traffic in Europe must meet ECE. That's the short of it.

The differences between Snell M2020D and M2020R are due to the constraints applied in North America by DOT and in Europe and elsewhere by ECE 22-06 and FIM. A helmet's protective capabilities are limited by user preferences but also by mandatory standards and traffic regulations. DOT and ECE 22-06 set bounds on the least protective performance helmets must provide. However, these standards also indirectly set upper bounds on protective performance; and the upper bound set by ECE 22-06 is distinctly below the level of protective performance Snell had demanded previously in M2015. If Snell was to fulfill its mission to recommend the most protective helmets, riders in Europe might reasonably be expected to wear, a new set of requirements, Snell M2020R, was going to be necessary.

Most of Snell's critics have questioned the flat impact requirements of M2020R and considered them a step down from the flat impact demands set in M2020D. In actual fact though, the M2020R flat impact tests demand softer liners and lower levels of shock transmission than M2020D. In a very real sense, the M2020R flat impact tests are a bit tougher than those in M2020D. Instead, these critics ought to be questioning the test demands for impacts against the hemisphere. The M2020D and M2020R impacts against the hemisphere demand impact energy management, the capability to manage really severe impacts. Impact energy management is what sets Snell certified helmets apart from all others. Unless a helmet maker has set out to develop a helmet for Snell certification, it's the Snell impacts against the hemisphere that are most likely to reject it. But, tough as they are, the M2020R impacts against the hemisphere are a little less demanding than those of M2020D. Grounds for complaint?? Maybe but there are good practical reasons for the difference.

Flat impact is essentially a test of how well the helmet limits the shock transmitted, instant to instant, through the helmet to the wearer's head. Unless the helmet can keep these shock forces within safe limits, the helmet cannot really protect. But the helmet must also manage all the energy of an impact. If the helmet's energy management is exhausted before the impact event is complete, the helmet can no longer limit the shock transmitted through to the wearer. Impacts against the hemisphere, in effect, set a lower limit on the total impact energy the helmet must be able to manage.

Snell has always looked for both energy management and shock attenuation in the helmets it recommends to riders. Helmets must limit the shock passed through to its wearer throughout the impact event. The limits on shock are expressed in different ways for current standards but, generally speaking, the Snell limits have not always been quite as low as those of the mandatory standards. Snell's directors are convinced that Snell's limits are safe and that they are consistent with current science but the difference is moot. The limits for Snell shock transmission default to DOT in North America and to ECE and/or FIM in Europe; mostly because helmet makers cannot sell helmets too stiff for DOT in the USA or too stiff for ECE and FIM overseas.

The difference, then, between Snell and the mandatory standards is in energy management; how big a hit can a helmet manage and still protect. No matter how big a hit a helmet might be able to manage, a rider is liable to encounter something even bigger. Every Snell label includes a warning to this effect. Since no helmet can provide all a rider might need, the sensible alternative is to look for the most energy management available. The energy management demands set by DOT and by ECE and FIM are pretty meager. Current helmet technology can provide a lot more. So, Snell standards look for all the energy management the helmet industry can provide in helmets riders might reasonably be expected to wear.

The essential difference between M2020D and M2020R is also energy management. ECE and FIM together demand lower levels of shock transmission than DOT. M2020D, like M2015 and M2010 before it, is well adapted to coexist with DOT but the lower levels of shock transmission written into FIM and ECE requirements necessitated some adjustments. Helmet makers might conceivably make heavier, bulkier helmets to satisfy Snell M202D demands for energy management while also satisfying ECE and FIM shock transmission limits. However, this is not really an option. Snell M2020D and M2015 were already demanding helmets close to the limits of user acceptance. Since Snell could no longer reasonably recommend M2015 and M2020D helmets to riders in Europe, we formulated M2020R in order to demand all the impact energy management that could reasonably be squeezed into an acceptable helmet of comparable weight and size to current M2015 headgear.

M2020R calls out two impacts per site against the hemisphere but the tests are a little less severe than those in M2020D, a necessary difference if the helmets are to serve riders in Europe. M2020R flat impact demands are essentially the same flat impact tests called out by FIM and ECE 22-06. Differences in test hardware may make the Snell tests a little more demanding but the point of M2020R flat impact testing is to assure compliance with the European flat impact requirements. Every M2020R certified helmet ought to be a reasonable candidate for FIM and ECE 22-06 homologation. No one should be able to game Snell by building to M2020D shock transmission limits and M2020R energy management requirements.

ROTATIONAL RESPONSE

Critics also complain that Snell standards do not include any direct measures and criteria corresponding to rotational response. Sudden rotations have been associated with concussion since the 1960’s. Concussion is a potentially serious injury but so are the sorts of head injuries that routinely kill riders who crash without helmets; injuries such as depressed skull fractures, focal brain injuries, space filling hematomas and so on. We know that helmets reduce the risk of these sorts of injury but whether helmets can further reduce the risk of concussion is uncertain at best. Even if we accept that rotational response to impact is a factor in concussion injury, there is no clear consensus on how to test for it or what criteria to apply to the results.

FIM, however, has attempted to cut through all this uncertainty. FRHPhe-01 includes a series of oblique impacts simulating a fall onto a flat surface while moving at speed along the surface. The test head form inside the dropped helmet includes instrumentation to measure rotational velocity as well as translational acceleration. Then FIM evaluates the rotational response according to two criteria, rotational acceleration as well as a Brain Injury Criterion (BrIC) which is based on the peak angular velocity’s measurements. However, data presented by FIM in September of 2019 suggests that these rotational criteria may not be a problem. Those helmets that failed FIM testing did not satisfy FIM HIC limits which depend only on translational acceleration. In effect, the helmets weren’t soft enough for FIM but the rotational response was just fine.

Given all this, it is difficult to impossible to prove that oblique impact or any of the other varieties of rotational response testing can identify safer helmets. If these tests are to be taken seriously, novel helmet features allowing slip between the head form and the helmet interior or between the helmet shell and the impact surface may be of little value. It may be that the limits on rotational acceleration and on BrIC might be tightened so that some helmets do begin to fail. However, there is little agreement anywhere what levels might be appropriate or even whether these are the correct quantities to study. However, some of the anti-rotational features being added to motorcycle helmets do not seem to add significantly to the weight and bulk of the headgear and do not degrade performance in Snell testing. Someday in the future, someone might walk into a hospital ward full of injured motorcyclists and note that the riders who had crashed wearing helmets with these anti-rotational features seem to have fewer brain injuries than those who had been wearing more standard headgear. That may be the beginning of the next advance in helmet safety. Unless biomechanical science achieves a much better understanding of the human brain and its tolerances, the best we may be able to do is identify which helmets work better in the field and then set standards to identify helmets like them.

IMPACT TESTING

The technologies that seem to be best suited to satisfying the limits on shock transmission while also maximizing energy management combine stiff helmet shells with carefully engineered liners. Ideally, when the outer shell of a helmet strikes the pavement, it stops moving almost immediately but the head inside the helmet remains in motion and crushes the liner between itself and the helmet shell as it goes. As the liner is crushed, it applies a braking force to the head slowing it, if all goes well, to a complete stop. Instead of a sudden, brain scrambling blast, the head sustains a leisurely, controlled slowing over as long as ten milliseconds. To an outside observer, either of these might be an indistinguishable eye blink but the rider with the good helmet may live to appreciate the difference. The other guy maybe not.

The stiff shell becomes a factor when the helmet strikes something other than flat pavement. Surfaces like curbing, sign posts, light poles and so on apply a concentrated loading to the helmet shell. If the shell is too flexible, it will fold around the surface working a smaller section of the liner. The braking forces will be much lower but that may not be a good thing since lower braking forces will allow the rider’s head to crush more deeply into the liner. If the liner is crushed completely, that is: if the liner bottoms out, it can no longer limit the shock transmitted into the wearer’s skull. In effect, the impact surface punches through the liner collapsing it completely passing the rest of the impact momentum directly into the rider’s head.

These two characteristics of protective performance oppose each other, softening the liner to get lower shock transmission must also reduce a helmet’s energy management. Helmet designers may get some of that back with stiffer helmet shells and thicker helmet liners but those changes will add to the weight and bulk of the helmet. Since Snell M2015 was already close to demanding all the helmet riders might reasonably be expected to wear, heavier, bulkier headgear were not an option. Instead, M2020R attempts to squeeze all the impact energy management reasonably possible in helmets of comparable size and weight to those that had been certified to M2015, somewhat less than the energy demands set for M2015 and M2020D but still substantially greater than those of DOT or of ECE 22-05 and FIM’s FRHPhe-01.