BHSI

Bicycle Helmet Safety Institute

A program of the Washington Area Bicyclist Association

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February 14, 1996

Office of the Secretary
Consumer Product Safety Commission
Washington, DC 20207

Re: Comments on the revised proposed Safety Standard for Bicycle Helmets.

Dear Ms. Dunn:

We appreciate this opportunity to comment on the proposed Safety Standard for Bicycle Helmets published in the Federal Register of December 6, 1995.

We are still impressed with the draft standard. It is significantly strengthened in several areas, although it has given up some ground regarding the required area of coverage. We support the new provisions for testing child helmets but urge you to consider new data before finalizing your rule. We encourage you to flesh out the section on retro-reflectivity requirements. With that revision we believe that this draft will provide a good standard for today and a basis for future improvement as technology and industry capabilities permit. In light of the certain need for revision we urge you to make provision now for the process by which that would be done.

Conspicuity

It is important for cyclists to be seen by other road users. The Worcester Poly team's investigation made it clear that the outcome of up to 55 per cent of nighttime bicycle crashes could have been affected by the use of better reflectors on bicycles and helmets. That would constitute 12 per cent of total bicycle-car crashes. The team recommended helmet reflectivity requirements, and we agree with their conclusions. We would also note that a study by Owens and Sivak at the University of Michigan concluded that reduced visibility is a problem unique to pedestrians and cyclists, since other elements on nighttime roads are normally well marked, and that reduced nighttime visibility is a greater problem in nighttime bicycle-car crashes than even alcohol consumption.

Reflective trim or graphics will add 20 to 40 cents to the manufacturer's cost per helmet, with some minimal effect on prices to the consumer. As helmet prices drop, this appears more and more reasonable. The need for regulation here is evident. Consumers find it difficult to judge which trim is reflective and which is not in a normally lit store. We even received one helmet in a box which proclaimed "reflective trim" but which did not in fact have reflective trim. Further, among the 1996 lines are helmets using a silver tape which mimics silver reflective trim but is not reflective. Consumers can be misled into thinking that they are more visible than they actually are after dark. This is an issue with reflectors generally, but much more so when false reflectors appear in the marketplace.

We commend to your attention the attached draft language prepared for balloting to the ASTM F-08.53 headgear committee. It attempts to simplify for the manufacturer the process of procuring reflective tape by basing the specification on the photometric performance of tape before application to the helmet. Thus manufacturers would not be required to test the tape on a helmet, which would add many variables. The tape or other material can be oriented in any way to fit the physical contours and graphic treatment of the helmet, as long as some part of the reflective surface is visible for 360 degrees around the helmet. This gives the helmet designer wide latitude to fit the reflective material into the graphic treatment of the helmet, which is important for fashion considerations.

A black bicycle helmet makes no more sense than a black safety vest. We continue to believe that all helmets should have bright outside colors for daytime conspicuity. There is no excuse for black, purple or camouflage helmets, but all have been used by manufacturers, and 1996 helmet lines are still dominated by dark colors. New Zealand's bicycle helmet standard actually requires a brightly colored outer cover. We should consider such a requirement in future revisions if not in this rule.

Impact attenuation

We applaud the introduction of a 250 g impact threshold for child helmets. We have long advocated that threshold for all helmets, both child and adult. Testing by *Consumer Reports* has shown that the better current helmets can meet the standard comfortably at that level, and there is no excuse for permitting less effective helmets to be marketed.

The same logic leads us to support the requirement in this draft for 250 g for children. As the attached test results from Bell Sports Inc labs show, the Bell child helmet tested already meets the draft standard. This test data indicates that the change should be regarded as fine tuning rather than a radical change, even when coupled with lower headform weights.

Bell technicians have noted that when they have examined their large collection of crashed child helmets, there has been no liner crush from inside evident in any of the helmets. We believe that helmets should show damage, primarily liner crush, after severe impacts. If they do not, the child's head stopped a half inch or more too short, without benefit of the crushing which is the basic protective mechanism of all EPS helmet liners. That half inch is critical. Lack of crush in a severe impact means there was an increase in the peak g's to the wearer's brain over what an optimal helmet would have produced. There is no magic about the 300 g standard, which is not a real-world test, but the reading taken in a magnesium lab headform. I do not believe we know exactly what that translates to in a flexible child head during a crash, and therefore must advocate the "softer landing is better" approach.

We are impressed by expressions of misgivings about this change by some highly respected researchers in this field. Before your final decision on this point I would urge you to consider the new research on this subject to be published after the final date for comments on this draft but before your final rule is adopted. But the Bell lab test results show that the 250 g requirement would not force major changes in today's helmets, and if the level is left at 300 g the current helmets would meet with standard with no change at all, despite the lighter child-size headforms. Changes necessitated by the 250 g level would be needed primarily to provide a margin to allow for variance in quality control. In the absence of other data we conclude that the requirement will not force radical change and should stand as drafted. We would urge you to extend it to adult helmets as well.

Coded Dates

The draft permits the coding of the date of manufacture. Since manufacturers commonly recommend replacing a helmet after five years, the consumer needs this information as a key to when they bought the helmet. Coding it prevents the identification of recalled helmets by the date. Information on recalls is often passed verbally, and a rider or bicycle shop owner who sees someone wearing a potentially recalled helmet will not be able to remember a coded lot number to identify which lots were recalled. They are more likely to remember that all helmets of that model manufactured in 1995 have been recalled, for example. We urge that the Commission require clear dates, either month of manufacture or at least the year, to supplement the lot numbers if used.

Still Missing

It is unfortunate that there has been little advance in basic helmet standards-making in the past decade. Although we are not suggesting that this standard be held up for any reason, we note that this and most other standards are lacking in the following areas:

- There is no test for retention system design which would require that the helmet must be easily adjusted by the user for a good fit, even though this is the main problem with today's helmets. The standards community has not even begun to develop such a test, and no current standard has one.
- There is no test for protection of a user against rotational injury, which is a known injury mechanism and which can be affected by such variables as the sliding resistance of the outer surface of the helmet. Again there is no other standard yet with a test for this parameter.
- There is no test which requires that the helmet should prevent localized loads or point loads from exceeding a given level. The Australian standard has such a test.

- There is no test for damage by oil or other preparations which consumers normally use on their hair. The Japanese standard has this test.
- There is no testing of retention systems after impact to simulate field conditions where helmets can break up after a first impact. There is no other bicycle helmet standard which specifically requires this testing sequence.
- There is no test of visors and mirrors for shatter-resistance and easy peel-off in the event of a crash. Several other standards do have such tests, notably the Australian standard and several motorcycle helmet standards.

We do not believe that any of these points would warrant holding up the publication of this final standard. But they do argue strongly for an ongoing strategy by CPSC which will facilitate upgrading of this standard as progress is made in developing new tests, and as new needs become apparent from research now under way. The ability to revise this standard will be essential and should be foreseen in your adoption of it now.

Conclusion

Apart from the comments above we believe that this draft provides the basis for a fine standard which will meet consumers' widespread belief that the U.S. Government does not permit sale of a defective or inadequate safety appliance.

Thank you for your continued efforts to provide protection for consumers.

Sincerely yours,

Randy Swart
Director

Attachment 1: Conspicuity standard draft prepared for ASTM ballot

Attachment 2: Bell Sports Inc. Lab test results (used with permission)

Attachment 2: Bell Sports Inc. Lab test results (used with permission)

6/7/95 Jim Sundahl

To ASTM Task Force

Subject:

1. Infant helmet test and draft standard.
2. Roll Off draft.
3. Test Lines.

1. Infant helmet test and draft standard.

We completed our study of varying liner density and drop mass for infant helmets; the report is attached. Based upon this I drafted a proposed infant standard. I would like to get some feedback, make revisions and get the result turned in for ballot by 6/20/95.

Key points of this draft are that F 1447 drop heights are used with the flat and curbstone anvils, I added a CG tolerance to accommodate monorail test machines and I rearranged the test sequence. I put in a 300 G max..

2. Roll-Off draft.

I wrote two versions of this, one as a stand alone and one as section 19.2 of F 1446. I put in a 7 kg static mass and a 200 gm max. for the cable and hook. I didn't specify the stiffness of the cable assembly because in my opinion it is okay for a test lab to make one of arbitrary stiffness. I specified a cushion not to exceed 2 mm thick without specifying a hardness since, in my opinion, it is okay for a test lab to make any cushion they want within what the laws of physics allow with 2 mm to work with. In both cases the lab can go to the worst case with respect to failing a helmet.

I liked the pass/fail criteria of:

After the drop the test assembly must be supported by the helmet and the apex of the headform at x = 0 and Y = 0 must be covered by a portion of the helmet that is subject to impact testing.

Dean and Don made me rewrite that.

3. Test Lines.

Cleaned up drawings are included based upon our final Denver calculations.

Please comment soon so that I can edit this stuff and get it in for ballot.

Thanks,

Jim JGS

6/6/95 Jim G. Sundahl

EFFECTS OF LINER DENSITY & HEADFORM MASS ON INFANT BICYCLE HELMETS

In recent ASTM meetings regarding F 1446 & F 1447, much consideration has been given to a proposed infant bicycle helmet standard for ASTM and also for CSA. Questions raised include:

1. Is it feasible and desirable to mandate a lower maximum acceleration level of 200 or 250 G's instead of the usual 300 G's used for adult helmets?

2. Should the drop masses be reduced for small headforms to 3.2 kg for the A ISO and 4.0 for the E ISO?

3. What anvils should be specified.

4. Should the drop height be 1.5 m for all anvils or should it be the same as in F 1447?

5. Where should the test line be?

6. Can infant helmets be made softer than they are now? Should they be?

7. How big a can of worms might result from making several of these changes all at once?

Some facts are agreed upon. We all agree that a lot of coverage is desirable like we have on existing helmets. The test lines should be as low as practical considering the edge of the headform and other limitations. Secondly, today's infant helmets are known to do an excellent job in that none of us in the business know of any serious head injury when using typical infant helmets. Thus it would be foolish to change a lot of helmet parameters without carefully studying the consequences.

We at Bell undertook a project to answer some of these questions. We selected our Lil'Bell 3 model as typical of the genre. This helmet is made in a small/medium (52 cm) and medium/large (54 cm). The production density of this model was originally 4.0 $\#/ft^3$, one version of the helmet was all the way up to 5.75 $\#/ft^3$, the current nominal density is 4.5#. We tested both sizes in 3.5 $\#/ft^3$, 4.0 $\#/ft^3$ and 4.5 $\#/ft^3$.
In each density we tested four helmets (ambient, wet, hot, cold) in four locations against the hemi anvil and another four against the flat anvil. Drop heights were per F 1447 - giving an impact velocity of 6.3 m/s for the flat and 4.9 m/s for the hemi. Thus there are 16 data points for each size, density and anvil.

We selected "easy" impact locations away from edges and vents so that the test was more of a material test than a design test. We would expect to fail some impacts at lower densities with the DOT A headform at 5 kg if we were trying for "sweet spots."

If there is a surprise in the attached results it is in how little anything made a difference. Consider first that each data point used in the table and graphs consists of four test conditions, four locations and production variability in liner density. The standard deviations on G's and crush are only about 10% except for the one combination that was approaching failure; the m/l size in the lowest density on the DOT A headform.

Could this helmet model be manufactured to a 200 G limit in some density on some headform? Clearly not from these drop heights. We would like to pass flats with a good two sigma to spare. It would be possible to manufacture this model to a 250 G limit but there wouldn't be much room for production tolerances. The helmet would need to be thicker and softer to consistently stay below new, lower failure criteria. I don't think that any practical hard shell helmet could be kept under 250 G's.

Would lower drop masses cause peak G's to increase? Yes, in the worst case of comparing the production 4.5# s/m on the DOT A at 5 kg and the ISO A at 3.6 kg we saw about a 25% increase in peak G's on flats. This could and would be adjusted out by decreasing the density. Meanwhile, these results show that if indeed little heads weigh less than medium heads, infants are being exposed to 25% higher peak G's than they would be if the helmets were optimized for the correct weight. The results show that a 4.0 to 4.5# helmet can work with any of the headform sizes and drop masses. Thus the hard part is to determine whether or not the variable mass approach used by most standards is appropriate for an ASTM infant standard.

Note that the displacements range from about 20 mm to 28 mm over the entire range of variables tested. This never happens in the field. I suspect three causes for this: a. Infants don't usually fall as hard as 6.3 m/s. b. Infant heads are not as rigid as magnesium heads. c. Infants seldom fall on hemi anvils.

What anvils should be specified for an infant standard? The flat anvil of course. The next question involves the choice of hemi, curbstone and bar. Most current helmets are designed to pass hemi impacts from 1.2 to 1.3 m drop heights. This constraint limits ventilation design and forces density upward. Even small vents have to be carefully located to prevent failures with the hemi anvil. The curbstone anvil would offer slightly lower unit loads on the helmets by bridging a larger area and the bar anvil less still. The curbstone would be a good compromise with what information we have.

As for drop heights, current helmets work with the current adult drop heights and there is no evidence that drop heights should be increased - accident helmets aren't bottoming out. One concept was to increase the hemi drop height and decrease the flat impact height to make them the same at, say, 1.5 m. The problem with this is that higher hemi or curbstone drop heights would wreak havoc with existing helmet designs. Accident experience doesn't indicate a need for increased hemi or curbstone drop heights and current helmet designs don't need a lower flat impact to allow an improvement in design.

It is agreed that infant test lines can offer more coverage than adult test lines. The lines that I propose are limited in the front and back by the need to stay away from the edge of the test headform. The limit on the side is caused by the need for an ear cavity and that the headform hits the guide arm and cannot be rotated further. The A size lines are based upon the Biokinetics lines but are rotated onto the headform. The E size is an extension of the A.

Can and should infant helmets be made softer? The lighter head forms would allow us to reduce the nominal density from 4.5 to 4.0. This would soften the helmets slightly. There is no data proving that this would make a safer helmet, but our collection of accident helmets show that they wouldn't be less safe either. Infant helmets aren't being crushed on the inside.

This test series convinces us that changing to lighter headforms and using the curbstone anvil instead of the hemi while staying with today's drop heights and the 300 G limit will not cause new design problems and won't allow less safe helmets to be made. On the other hand, if we don't implement an infant standard we cannot guarantee that all manufacturers will comply with the extended protection area that we all agree is important.

With this in mind, I offer the attached draft for review and hopefully for ballot approval.

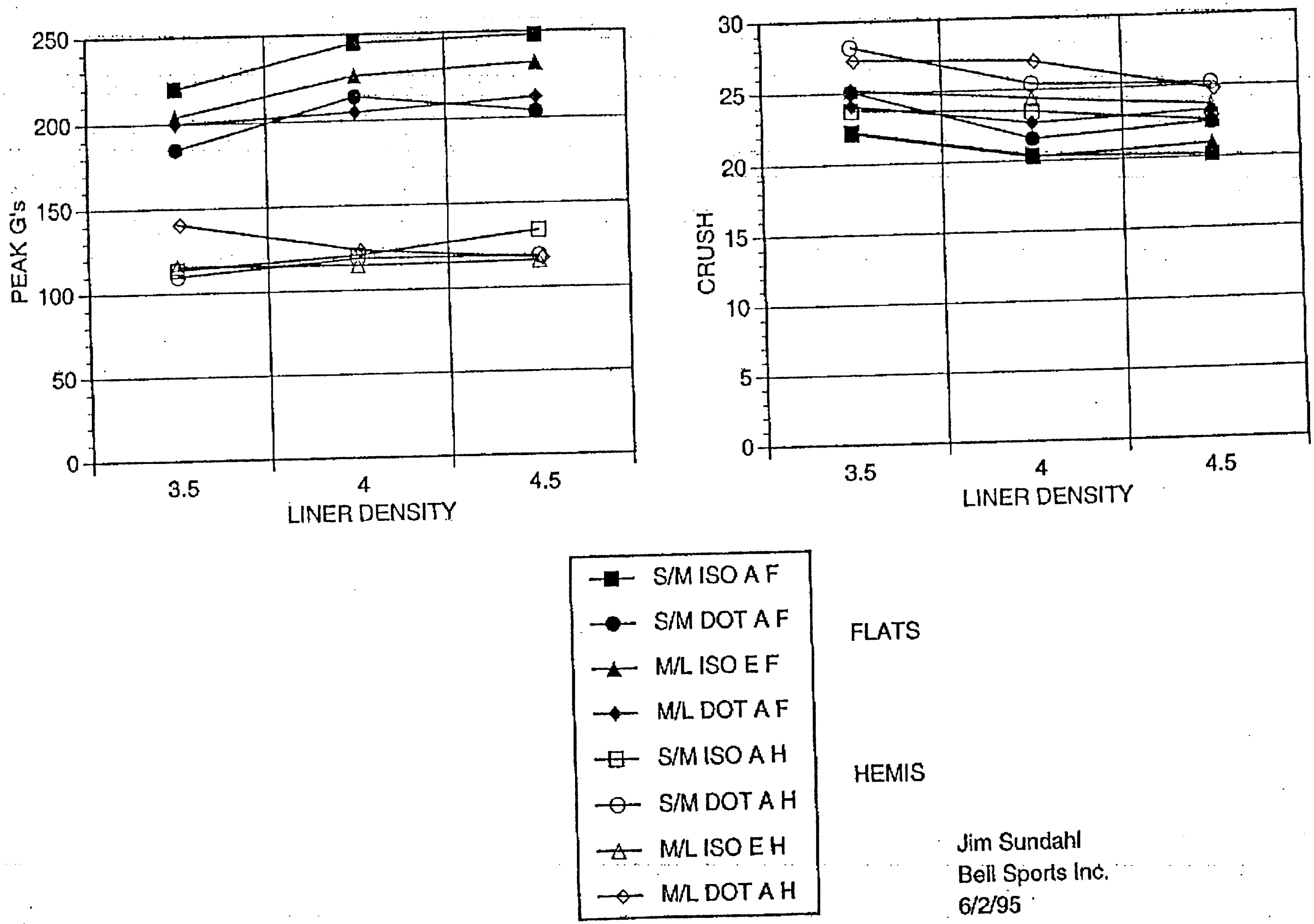
Jim G. Sundahl

LIL' BELL 3 IMPACT TEST

Jim Sundahl
6/2/95

HELMET SIZE/ HEADFORM SIZE & WEIGHT	Impact Anvil		LINER DENSITY: 3.5 #/cubic ft. Peak G's	3.5 #/cubic ft. mm Crush	4.0 #/cubic ft. Peak G's	4.0 #/cubic ft. mm Crush	4.5 #/cubic ft. Peak G's	4.5 #/cubic ft. mm Crush
S/M	FLAT	Average	220	22.3	245	20.4	248	20.2
ISO A, 3.61 kg	6.3 m/s	Std. Dev.	14.6	1.9	23.3	3.2	13.7	2.2
S/M	FLAT	Average	185	25.1	214	21.6	204	22.5
DOT A, 5 kg		Std. Dev.	14.9	2.7	15.7	2.9	22.1	3
M/L	FLAT	Average	204	22.2	226	20.3	232	21
ISO E, 4.66kg		Std. Dev.	13.9	1.7	15.2	3.1	22.8	2.2
M/L	FLAT	Average	200	24.1	205	22.7	212	23.3
DOT A, 5 kg		Std. Dev.	12.2	3.1	13.3	2.4	15.4	1.8
S/M	HEMI	Average	114	23.8	121	23.5	134	22.6
ISO A, 3.61 kg	4.9 m/s	Std. Dev.	10.1	3.4	9.1	2.7	20.8	3.5
S/M	HEMI	Average	110	28.2	119	25.4	119	25.2
DOT A, 5 kg		Std. Dev.	10.2	3	7.8	2.2	8.1	1.9
M/L	HEMI	Average	116	25.2	115	24.4	116	23.7
ISO E, 4.66kg		Std. Dev.	13.4	2.7	6.9	3.7	10.5	2.3
M/L	HEMI	Average	141	27.3	124	27	118	24.8
DOT A, 5 kg		Std. Dev.	49.3	1.7	13.8	2.4	5	2.8

Lil'Bell 3 Impact test



Jim Sundahl
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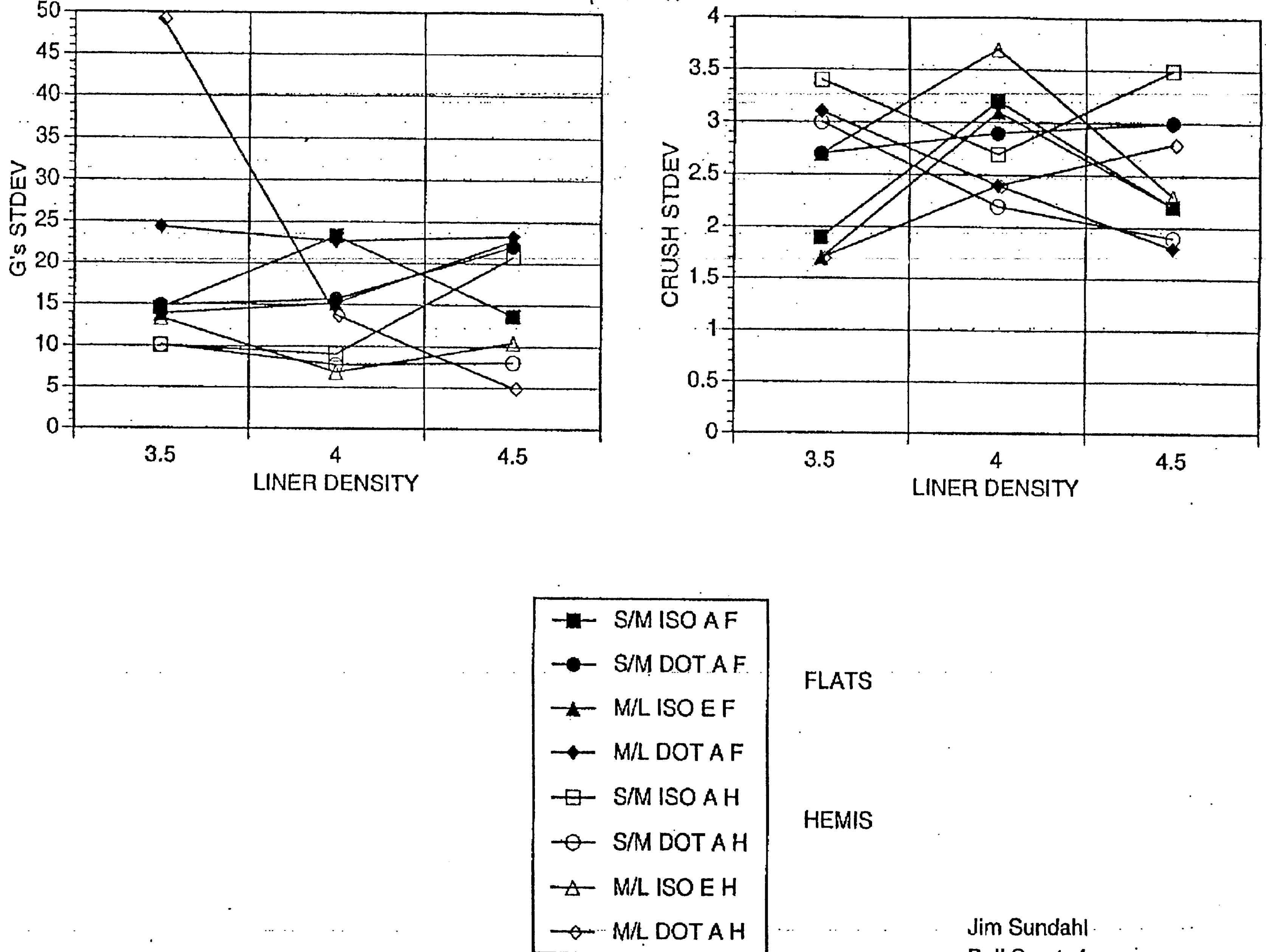
6/2/95

Lil'Bell 3 Impact Test



Jim Sundahl
Bell Sports Inc.
6/2/95

Proposed Wording for Standard on use of Retroreflective Materials on Bicycle Helmets:

3. Terminology

3.1 The terms and definitions in Terminology E284 apply to this practice/test method.
3.2 Definitions:
3.2.1 *coefficient of retroreflection*, R_A, *n--of a plane reflecting surface*, the ratio of the coefficient of luminous intensity (R_I) of a plane retroreflecting surface to its area (A), expressed in candelas per lux per square metre ($cd \cdot lx^{-1} \cdot m^{-2}$). $R_A = (R_I/A)$.
3.2.2 *entrance angle*,β, *n--in retroreflection*, angle between the illumination axis and the retroreflector axis
3.2.3 *observation angle*, *n*--angle between the axes of the incident beam and the observed (reflected) beam, (*in retroreflection*, α, angle between the illumination axis and the observation axis).
3.2.4 *orientation sensitive*, *adj*--materials having coefficients of retroreflection that differ by more than 15% when measured at the two rotation angles $\varepsilon_1 = 0°$ and $\varepsilon_2 = 90°$.
3.2.5 *retroreflection*, *n*--reflection in which the reflected rays are preferentially returned in directions close to the opposite of the direction of the incident rays, this property being maintained over wide variations of the direction of the incident rays.
3.2.6 *retroreflectivity*, *n*--property of a material or device in which, when directionally irradiated, the reflected rays are preferentially returned in directions close to the opposite of the direction of the incident rays, this property being maintained over wide variations in the direction of the incident rays.
3.2.7 *rotation angle*, ε, *n*--angle indicating the orientation of the specimen when it is rotated about a selected axis fixed in it (for plane specimens, usually the specimen normal); *in retroreflection*, angle indicating the orientation of the specimen when it is rotated about the retroreflector axis.

DISCUSSION--The rotation angle is the dihedral angle from the half-plane originating on the retroreflector axis and containing the positive part of the second axis to the half plane originating on the retroreflector axis and containing the datum mark. Range: $-180° \leq \varepsilon \leq 180°$

Section 000 Retroreflectivity

000.1 The surface of each helmet shall have a minimum retroreflective area which is equal to or greater than the surface area of an 8mm band around the largest horizontal circumference of the helmet. (See Fig. 1) This requirement can be satisfied by tape or another material which meets the area, coefficient of retroreflection, and location requirements described in this standard.

NOTE: Retroreflective material on the helmet is one component of enhanced visibility and should be used in conjunction with other visibility enhancements such as the CPSC reflectors on the bicycle, or retroreflective clothing.

000.2 The retroreflectivity shall comply with the requirements of Table 1 (below). Materials which are orientation sensitive, as defined above, shall be handled as follows: the material must comply with the minimum requirements for the coefficient of retroreflection stated in Table 1 at one of the two rotation angles (0° or 90°), and shall be at least 75% of the value stated in Table 1 at the other rotation angle.

000.3 Material used should be certified by the manufacturer to meet the required level of retroreflectivity. The manufacturer's certification should be third party certified by an approved certification organization which is not owned or controlled by manufacturers or vendors of the product being certified. The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability. Additionally, retroreflectivity may be tested to confirm the manufacturer's certification using ASTM E809 Standard Practice for Measuring Photometric Characteristics of Retroreflectors and ASTM E810 Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting.

000.4 Material shall be located on the helmet to pass the following test: Place the helmet on the reference headform. Turn the headform 360° in the horizontal plane while observing from a single point on the level of the reference plane at a distance of 1 meter from the center of the headform. Some part of the retroreflective surface on the helmet must be visible throughout the 360° turn.

000.5 Material used shall be designed to last the life of the helmet in normal use.

Figure 1:

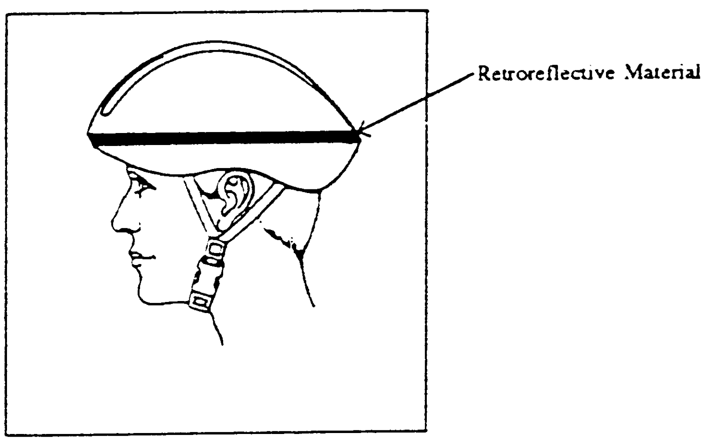


Table 1:

Minimum Coefficient of Retroreflection in cd/(lx·m²)				
	Entrance Angle			
Observation Angle	5°	20°	30°	40°
0.2°	330	290	180	65
0.33°	250	200	170	60
1°	25	15	12	10
1.5°	10	7	5	4