Wood vs. Aluminum Bats and the NCAA Test Protocol

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I will focus my remarks entirely around the procedure used by the NCAA to control the performance of non-wood bats. I will describe that procedure, then estimate the margin by which aluminum bats outperform wood bats in the field. I will then discuss possible modifications to that procedure that reduce the gap in the field performance between wood and non-wood bats. First a disclaimer: Although I am a member of the NCAA Baseball Research Panel, the remarks given below are my own and do not necessarily reflect the NCAA position. Moreover, I am providing no information that is not already in the public domain, either through scientific publications or the web.

The NCAA started subjecting bats to performance testing during the 2000 season. The procedures are described in their September 1999 report, which can be downloaded from their web site http://www.ncaa.org/releases/miscellaneous/1999/1999092901ms.htm. Bats are tested by impacting a ball moving at 70 mph with a bat rotating about a point 6" from the knob (toward the barrel) such that the speed of the bat at a point 6" from the barrel (toward the knob) is 66 mph. The post-impact ball speed is measured at different impact locations in the vicinity of a point 6" from the barrel end of the bat. Bats are certified for use in an officially sanctioned NCAA game if the ball exit speed does not exceed 97 mph at any of the impact locations. The 97-mph upper limit was arrived at by testing a large sample of different wood bats, where it was found that the maximum exit speed was 96 mph. The maximum for aluminum was increased by 1 mph to allow for the statistical fluctuations in the measurements. This limit implies that *for bats swung with comparable speed*, the ball exit speed is essentially the same for wood and aluminum bats.

In 2006, the NCAA changed their test procedures, as described in their November 2005 document which can be downloaded at the web site http://www.ncaa.org/champadmin/baseball/bat_standards/2006_certification_protocol.pdf. The performance limits have not changed, only the procedures used to measure the performance. In particular, it is still true that for bats swung with comparable speed, the ball exit speed for aluminum bats does not exceed that of the best-performing wood bats.

The testing does not guarantee that wood and aluminum bats will perform identically in the field. The reason is that wood and aluminum bats are not swung at comparable speeds. Even for bats with the same weight, the *weight distribution* is generally very different for a wood and aluminum bat in that a typical wood bat has much more of its weight concentrated in the barrel and further from the hands. One way to characterize the weight distribution is the so-called moment of inertia (MOI), which is a measure of how far the weight is concentrated from the hands. A bat with a smaller MOI has the weight concentrated closer to the hands and will be easier to swing. Likewise, a bat with a larger MOI will have the weight further from the hands and will be harder to swing. Typically, aluminum bats of a given length and weight have a smaller MOI than a wood bat with the same length and weight. There is now a growing amount of scientific data that show an inverse relationship between the MOI of a bat and the speed with which it can be swung. See, for example, the paper of Fleisig, et al., published in the journal Sports Engineering, volume 5, pp 1-14, 2002. The unpublished batting cage study of Crisco and Greenwald show a similar result. The smaller the MOI, the faster the bat can be swung. Since aluminum bats generally have a smaller MOI than a wood bat of comparable length and weight, an aluminum bat can be swung faster.

The impact testing described above does not take into account the MOI of the bat. The consequence is that two bats of different MOI that perform identically during the test procedure will not perform identically in the field. Since the lower MOI bat can be swung faster, it will have a larger hit ball speed in the field. Recognizing the importance of bat weight and MOI for swing speed and therefore for field performance, the NCAA supplements their impact testing by placing weight and MOI restrictions on nonwood bats. The weight restriction is the so-called "-3 rule", which means that a 34" bat must weigh at least 31 oz. The MOI restriction is also based on length. For example, a 34" bat can have an MOI no smaller than 9700 oz-in^2; for reference, a typical wood bat of that length has an MOI of about 11,000 oz-in^2. Both MOI are with respect to a point on the bat 6" from the knob.

Even with this restriction, aluminum bats outperform wood bats in the field. As an example, consider two bats: A wood bat with an 11,000 MOI performing at 96 mph in the test and an aluminum bat with a 9700 MOI performing at 97 mph in the test. I estimate that with a higher swing speed, the aluminum bat will perform at about 101.5 mph, based on the Fleisig and Crisco/Greenwald swing speed data. Nevertheless the NCAA has succeeded in at least putting a cap on how much better aluminum can perform relative to wood. Indeed, the NCAA seems quite satisfied that their recent rule changes have had the desired effect of lowering offensive statistics (see, for example, the report on their web site http://www.kettering.edu/~drussell/bats-new/NCAA-stats.html.).

If it were deemed desirable to restrict aluminum bats to perform even more similar to wood, there are at least three possible that goal could be achieved:

1. Make the MOI restriction on aluminum bats comparable to wood bats (i.e., 11,000 rather than 9700 for 34" bats). This would be quite easy to do in that bat manufacturers would shift weight from the knob to the barrel cap to increase the MOI.

2. Require that aluminum bats pass the laboratory test of hit ball speed less than 97 mph with a bat speed higher than 66 mph, with the exact speed depending on the MOI of the bat. Of course, one would need a prescription for the relationship between bat speed and MOI, which one could obtain from the data of Fleisig or of Crisco and Greenwald or from additional testing.

3. Use the same 66 mph bat speed as in the NCAA test but a "sliding scale" for the hit ball speed. That is, the upper limit on hit ball speed, currently set at 97 mph for all bats, would be less than 97 mph for bats with a lower MOI. Once again, one would

need to obtain data (or a reasonable simulation of the ball-bat collision) to determine how to set the scale.

Of the three possibilities list above, #1 is by far the easiest to implement. It does not require any additional testing or any model for how a batter swings a bat. Such a procedure could be implemented immediately. It is worthwhile emphasizing this point strongly:

If two bats have the same length and MOI and perform identically during the NCAA laboratory test, then the current state of the science suggests that they will perform identically in the field.

Of course, one could utilize either of the other two methods also, but careful thought would have to be given as to how to set the bat speed for #2 or the sliding scale for #3.