Introduction

Brain injuries can occur in all sports and work activities. Sports and recreational activities contribute to about 21 percent of all traumatic brain injuries among American children and adolescents. For example, in hockey traumatic brain injuries constitute 10-15% of all head injuries. With the high percentage of injuries being traumatic, extensive design improvements have implemented to helmets[1]. These improvements reduce risk of cerebral contusions by providing more padding around the skull and a chin strap that keeps the helmet snug.

The following 20 sports/recreational activities represent the categories contributing to the highest number of estimated head injuries treated in U.S. hospital emergency rooms in 2009:

Cycling – 85,389 Football – 46,948 Baseball & Softball – 38.394 Water Sports – 28,716 Powered Recreational Vehicles – 26,606 Scooters – 23,114 Winter Sports – 16,948 Horseback Riding – 14,466 Hockey – 8,145 Other Unspecified Ball Sports – 6,883 Rugby/Lacrosse – 5,794 Roller & Inline Skating – 3,320 Ice Skating – 4,608[2]

Accordingly, with the study made by an American University, the actual helmets don't provide the necessary safety and energy dissipation[3]. The solution presented in this document was to reduce both linear and rotational energy that arrives to the head.

Experimental Protocol

To determine the amount of impact energy that arrives to the brain of the end user, it is necessary to follow the standards that exist in the market. Due to the large amount of standards and access to laboratories we found and used a laboratory in Portugal that has universal acceptance. It was decided to follow the standard that exists with the CTCP- Centro Tecnológical do Calçado de Portugal. This lab is responsible for the certification of personal protection equipment. In these tests were used the standards EN-1621-2 level 1 and level 2. For small impact energies the standard is EN-1321-1.

In these tests the material used by HITT-PG LLC was evaluated. The material supplied was 6mm, 12mm and 20mm. the dimensions of the specimens were according to the standards used. The tests were done at 23^{o} C.

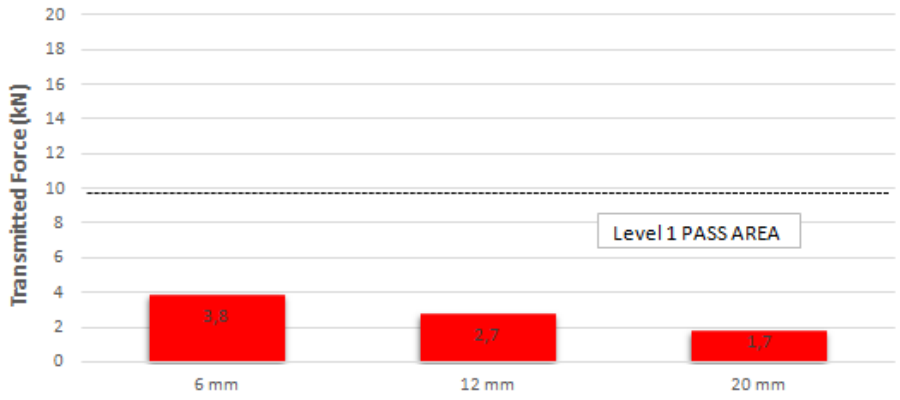
[1] https://en.wikipedia.org/wiki/Sports-related_brain_injury

[2] http://www.aans.org/patient%20%information/conditions%20%treatments/sports-related%20%head%20%injury.aspx

[3] http://www.abcactionnews.com/news/local-news/i-team-investigates/i-team-how-safe-are-your-childs-football-helmets

Results

The first test was made at low impact energy-in this case 10 joules. The standard used was EN-161-1. The following figure shows the results:



According with the standard used in this test, the HITT-PG material is approved to be used in the market, if it only absorbs 20% of a load of 50,000 N. In this case the material is only allowed to transmit 10,000 N. The material used by HITT-PG absorbed higher than the required. The material with a thickness of 6 mm transmitted 3,800 N. The material with the thickness of 12 mm transmitted 2,700 N. The material with the thickness of 20 mm transmitted 1,700N.

After these initial tests, the material was evaluated at higher level of impact energies. In this test we used the standard EN-1621-2 level 1 and level 2. Firstly will be presented the results obtained to the level 1. In the figure 2 is presented the results for this level.

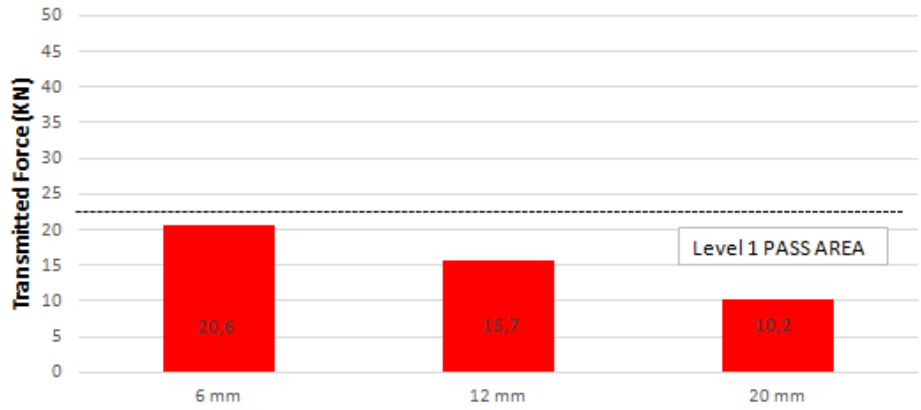


Figure 1 load transmitted for the standard EN1621-2

In these tests were used a load impact of 200,000 N. According with the standard used at this level of energy the minimum allowed to pass is a transmission load of 24,000 N in a single strike and 18,000 of the mean value. In these tests we used the single strike. The material with a thickness of 6 mm absorbed

a load of 179,400 N and transmitted 20,400 N. The material with a thickness of 12 mm absorbed 184,300 N and transmitted 15,700 N. The material with a thickness of 20 mm absorbed 189,800 N and transmitted 10,200 N.

In the following figure will be presented the results obtained for the level 2 of the norm used.

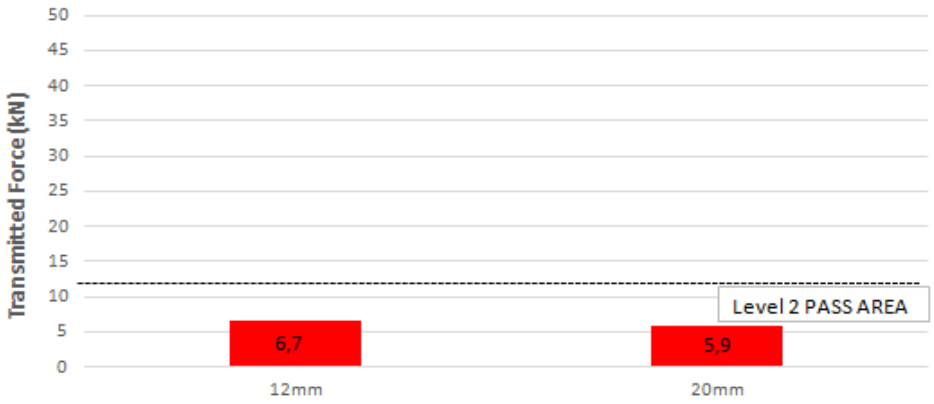


Figure 2 load transmitted for the standard EN1621-2 level 2

At this level the maximum allowed transmitted energy in a single strike is 12,000 N and 9,000 N to mean value. The material with a thickness of 6 mm hadn't pass. The material with a thickness of 12 mm transmitted a load of 6,700 N and absorbed energy of 193,300 N. The material with a thickness of 20 mm transmitted energy of 5,900 N and absorbed a load of 194,100 N.

Conclusion

Based on the results obtained it is possible to conclude that:

- Except the material with a thickness of 6 mm, the other specimens have passed the entire norms requirement in terms of energy transmitted.
- In average all the sample have absorbed more than 80% of the load applied
- Higher the thickness, smaller the energy transmitted.
- Higher the energy applied the better results of the material.
- The HITT-PG product is 12 mm and weighs 270 grams.