## D20 Forensic Analysis and Testing to Evaluate Football Helmet Environmental Degradation and the Effects of Repeat Impacts

*Mark C. Pozzi, MS*, Sandia Safety Sciences, 2 Marietta Court, Ste A, Edgewood, NM 87015; Kenneth J. Saczalski, PhD*, 1440 W Bay Avenue, Newport Beach, CA 92661; Mark N. West, BS, Environmental Research & Safety Technologists, 1440 W Bay Avenue, Newport Beach, CA 92661; Luis Frausto, MS, Exova OCM, C/O ERST Inc, 1440 W Bay Avenue, Newport Beach, CA 92661; and Todd Saczalski, BSMET, 140 Calle Irena, Sedona, AZ 86336*

The goal of this presentation is to present a method for improved scientific evaluation and certification of football helmet head impact potential when used in common, but not currently tested, conditions of both high temperature and humidity, as well as repeat impacts.

Certification and evaluation of new and reconditioned football helmets should include impact performance evaluations under high temperature and high humidity soak conditions that more realistically replicate early season environmental use conditions. This presentation will impact the forensic science community by discussing why this type of evaluation can be beneficial in the early phases of helmet design, and in the reconditioning of used helmets, to assist in the proper selection of energy-absorbing padding that is more resistant to degradation of impact safety performance in high temperature and high humidity environments.

Forensic evaluation of football helmets requires evaluation of factors and variables that can adversely affect the impact-attenuating performance of Energy Absorbing (EA) pad materials as well as helmet shells, face masks, and retention straps. All these safety devices are needed to minimize transmission of linear and rotational forces applied to the head, so that risk of head injury is reduced.

One factor largely ignored by current safety standards is player head heat and contact sweating, which can induce high temperatures (>120°F) and humidity (100%) within a helmet system (Hot-Wet condition) even in moderate environmental weather conditions. This can result in degradation of helmet EA capacity and result in significantly increased risk of head injury.

In this study, adult and youth football helmets of various designs were subjected to a range of varying temperature, humidity, and mechanical impacts (of both varying amplitude and number of load cycles). Quasi-Static (QS) compression testing of commonly used EA materials and dynamic impact testing of full helmet systems were conducted. A long-recognized "multivariable" experimental method was utilized to demonstrate an efficient means for assessment and comparison of currently representative helmets.

The QS tests revealed that a short Hot-Wet soak time of only a few hours noticeably diminished EA levels. The EA pad types that were QS tested included: Thermo-Plastic Polyurethane (TPU) "waffle shaped" EA pad configurations; load-rate sensitive "gel" foam padding; and dual- and single-density elastomeric foam padding.

Dynamic helmet repeat-impact tests were conducted by using a pendulum-impact test device where various helmet designs were mounted to a Hybrid-III head and neck system and impacted against a non-yielding surface after being subjected to ambient and Hot-Wet conditions, at energy levels of 108J and 130J. These energy values are typical of the energy levels resulting from speeds (5.95- to 6.12-second 40-meter dash speeds) of 11-year-old youth players to high school athletes who often run a 40-yard dash in 5.2 seconds, which generates an energy level of approximately 125J. Dynamic full-helmet system testing demonstrated that the "Hot-Wet" condition tended to degrade helmet impact attenuation performance such that, depending on the size and type of EA material provided in the crush zone, head injury risk measures tended to significantly increase.

The Hot-Wet effect was confirmed by testing during a 1992 forensic study of helmet energy-absorbing padding performance and injury risk from only minor to moderate head impacts while wearing a "reconditioned" helmet. It was confirmed that increased helmet temperature and moisture significantly increased head injury severity levels. These earlier forensic studies were recently compared to newer helmet designs, which also showed the likelihood of increased injury risk. Clearly, increasing temperature and moisture in EA padding is an important variable that must be considered in the safe design of any helmet.

Finally, the use and benefits of a "multivariable" experimental method for helmet injury risk assessment, not reported on previously, is provided. QS testing is useful as an economical, effective "first step" to evaluate various EA materials under a range of environmental and loading conditions. Then, "second step" dynamic helmet testing provides reliable evaluation of helmet safety and head injury risk over a wide range of variables, or factors, through the use of only a relatively small amount of test combinations. The multi-variable analysis concept is used to demonstrate how the Head Injury Criteria (HIC) response for a specific helmet design varies over a range of temperature-moisture conditions and impact energy levels generated from "high-low" tests. This two-step test methodology using QS screening of EA loss followed by realistic dynamic test multivariable assessment of the full helmet system as it relates to meeting the defined levels of head injury risk protection provides a valid, cost-effective, and efficient scientific approach for studying the interrelated effects of many variables without resorting to a limited trial-and-error approach examining individual variables in isolation. The implications of this design for helmet testing and analysis may affect most types of helmets since head heat and contact sweat are factors present anytime a helmet is worn.

**Football Helmet Testing, Head Injury Severity, Helmet Repeat Impacts**



*Presenting Author