

GLORIA: Design and Development of a Calibration Jig for H-Point Machines Used for the Measurement of Head Restraint Geometry

Matthew Avery

Thatcham, the Motor Insurance Repair Research Centre

David Zuby

Insurance Institute for Highway Safety

John Gane

Insurance Corporation of British Columbia

Mark Cox

Automotive Accessories Ltd

Copyright © 2008 SAE International

ABSTRACT

The SAE J826 H-point machine was designed to measure occupant accommodation dimensions relative to a loaded seat. It has become an intrinsic part of various crash dummy set up processes, but it has never had a formal calibration procedure. Whilst H-point location appears to be consistent from one device to another, the weight hanger locations show greater variability, and this can consequently affect the height and backset measurements of head restraints taken with a head restraint measuring device mounted upon the weight hangers. This paper describes the development of a calibration procedure and jig to measure the location of the weight hangers so that adjustments can be made if necessary. This procedure and calibration tool will enable more consistent seat evaluations, dummy set up, and consistently effective anti-whiplash seat designs.

INTRODUCTION

Head restraints are the principal safety device aimed at reducing whiplash injuries in rear crashes. They have been required in passenger vehicles since 1969 in the United States and since 1978 in Europe. Fitting vehicles with head restraints reduces the incidence of neck injuries in rear crashes by up to 18% [1-3], but whiplash injuries continue to be a major problem. Insurers in the United States spend \$8 billion annually on injury claims in which the most severe injury is a whiplash type injury of the neck. Costs in other jurisdictions are similarly

high; for example, whiplash claims in the United Kingdom are approximately £1.2 billion per year [4].

Head restraints reduce the risk of neck injury by supporting the head and moving it forward with the rest of the body during a rear crash in which the vehicle occupant's body is violently pushed forward. Consequently, head restraints must be tall enough to fit behind the heads of most vehicle occupants. Unfortunately, US safety standards requiring head restraints have been weak, and many legal designs are not tall enough to support the heads of even average-sized adult males. European regulations require taller head restraints, but most vehicles on both continents are equipped with adjustable head restraints that are often left in the lowest position [5,6]. Despite research showing that head restraints fitting closer to the backs of heads are more effective than those farther away [7], safety standards will not regulate this design characteristic, called backset, until September 2009, when a revised Federal Motor Vehicle Safety Standard (FMVSS) 202 [8] goes into force in the United States.

Insurers have tried to encourage vehicle manufacturers to fit better head restraints in vehicles by publishing consumer information ratings. Beginning in 1992 the Insurance Corporation of British Columbia (ICBC) published ratings of head restraint fit based on measurements made relative to an average-sized male subject. ICBC developed the head restraint measuring device (HRMD), which is supported by the H-point machine (HPM), to establish a more repeatable measure of head restraint geometry in 1995 [9]. The Insurance Institute for Highway Safety (IIHS) also published head restraint fit ratings in 1995 [9].

way Safety (IIHS) first published its ratings of head restraint geometry based on HRMD measures in 1996, and the measurement and rating procedure established by ICBC and IIHS was further harmonized by Thatcham and adopted as an international standard by the Research Council for Automobile Repairs (RCAR) in 2000 [10]. More recently the International Insurance Whiplash Prevention Group (IIWPG) developed a dynamic evaluation procedure for vehicle seats and head restraints that was adopted by RCAR in 2006 [11]. The new RCAR dynamic evaluation procedure begins with a geometric evaluation using the earlier standard and also uses the HPM and HRMD in combination to establish the test dummy (BioRID) setup targets for the dynamic test. Not only are these tools used in insurer-sponsored consumer information evaluation procedures, but the revised FMVSS 202 also prescribes their use to establish compliance with new minimum backset requirements.

However, it appears that HPMs used in conjunction with the HRMD appear to have more variation than desirable in dimensions critical to HRMD measurements. This paper describes our effort to document the extent of this variation and develop procedures that could be used to measure and correct variations that exceed prescribed limits.

H-POINT MACHINE (OSCAR)

The HPM is a three-dimensional manikin consisting of moulded reinforced plastic representations of the back and seat contours of an adult male that are connected through a hinge joint located at a reference position known as the hip point (H-point), plus two-dimensional representations of the legs and feet and internal structure that supports various weights. The complete machine weighs 76.9 ± 1.5 kg (169.6 ± 3.4 lb). According to Reed et al [12], who have compiled a brief history of the machine, the HPM's shape is based on a single subject approximately 1800 mm tall and weighing 77 kg, and the basic design is based on a General Motors prototype from the late 1950s. Weights appropriate to a 50th percentile male are added to the legs, thighs, bottom, and torso points to allow a rough representation of human mass distribution.

The HPM was designed to measure three vehicle interior dimensions better than was previously possible without the seat cushion and seat back being loaded by the occupant's weight. These dimensions were H-point (a general predictor of the occupant's position on the seat), torso angle, and leg room. The current version of the HPM also includes a probe for measuring headroom relative to the loaded seat cushion.

The Society of Automotive Engineers (SAE) Recommended Practice J826 describes the HPM and details its installation procedure. First adopted in 1962, the current version of the standard was revised in 1995 [13]. The International Organization for Standardization (ISO)

standard 6549:1999(E) – “Road Vehicle – Procedure for H- and R-point determination” [14] parallels SAE J826. While several copies of the original drawings [15,16] exist, neither standard provides details about the dimensions, contours, or construction of the HPM. HPMs certified to conform to the requirements of SAE J826 are available through SAE, but numerous machines fabricated by suppliers other than the current SAE one are in use throughout the industry. The HPM has been in international widespread use since the mid-1960s without significant modification. An example of an older model is shown in Figure 1.



Figure 1. Example of older HPM unit dating from 1960s in everyday use.

A major use of the HPM nowadays is to locate the position of the H-point in vehicle seats to serve as a guide for positioning crash dummies in safety tests.

Both US (FMVSS) and European (ECE R and EC) regulations — for example, FMVSS 208 [17] and ECE R 94 [18] — stipulate the use of the HPM, but the different standards refer to it differently. US federal test requirements [17] refer to the SAE J826 Automotive Seating Manikin. The official manufacturer since the 1990s has been Technosports in Detroit, Michigan, United States, producing the white units shown in Figure 2.



Figure 2. HPM unit manufactured by Technosports, United States.

European test requirements [18] refer to the HPM as a 3-D H. The principal European manufacturer is Automotive Accessories Ltd in Southampton, United Kingdom. Early 3-D H manikins were light blue in colour (Figure 3) and dimensionally similar to the US version, but could not be used with an HRMD without modification. Later versions of the manikins were changed to allow fitment of the HRMD, and were coloured a darker mid-blue to distinguish them from earlier versions. Regulatory crash test seating procedures are similar in both US and European standards and intended to identify the same H-point on the same seat design.



Figure 3. HPM units manufactured by Automotive Accessories, United Kingdom: light blue version (left), and mid-blue version (right).

HEAD RESTRAINT MEASURING DEVICE (HRMD)

The HRMD was developed by ICBC to measure head restraint geometry (height and backset) relative to an average-sized adult male seat occupant [9,19]. It consists of a head form on top of a two-linkage support structure of which the lower portion is designed to connect to and be supported by the weight hanger arms of a modified HPM, as shown in Figure 4. To facilitate the fitting of the head form and to compensate for its mass, a varied set of torso weights are used. The head room probe is removed from the HPM when fitted with the HRMD, so the measurement of torso angle is consequently taken using a digital inclinometer held against the vertical torso weight hanger support of the HPM.



Figure 4. HRMD installed on manikin.

The two links of the HRMD are connected through an adjustable pivot located at the approximate position of the first thoracic vertebra. This pivot enables the head form to be levelled to represent a forward-looking posture. The position of the head form relative to the H-point of the HPM is based on anthropometry data from a National Highway Traffic Safety Administration (NHTSA) study from 1983 [20]. Probes fitted to the head form allow the measurement of both head restraint height and backset [9,10].

All HRMDs are supplied by ICBC in Vancouver, Canada, and there are two versions currently in use. The earlier version is a modified size J helmet-test head form [21] made from cast magnesium, and the current version is made from milled aluminium. Both have the same nominal dimensions, but the current version is fabricated with tighter tolerances.

SET UP FOR DYNAMIC SEAT ASSESSMENTS

Because the RCAR procedure is only a static assessment of whiplash protection, various insurance-sponsored research organisations collaborated to author a dynamic seat assessment test using a specific rear impact dummy — BioRID [11]. Complete with a flexible spine, BioRID more accurately replicates the posture of an adult male and allows a more biofidelic interaction with the seat and head restraint during the dynamic test than a conventional Hybrid III dummy. It was necessary for the IIWPG to define a seating procedure for BioRID because there was not one already available at the time. Following research and consultation with manufacturers, the use of the HPM was recommended with the addition of the HRMD head form to allow not only H-point location but also backset. The dynamic test procedure involves two steps, firstly to use the HPM and HRMD to define the static geometry of a seat/head restraint, and secondly to use the HPM and HRMD to measure the H-point and backset for the seat/head restraint that are in turn used to position BioRID. The criteria chosen to evaluate a seat/head restraint for rear impact performance are sensitive to variation in backset. Therefore, minimal variation in the test equipment used to evaluate seats is critical.