Hybrid III Small Female Neck Interaction with a Driver Airbag: Preliminary Observations

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Introduction: The Hybrid III 5th-percentile female (HIII-05F) anthropomorphic test device (ATD) has been widely used to represent the small female occupant in frontal collision testing since the 1990s. Upper neck loads in the HIII-05F are currently used to predict neck injury in frontal collisions. In a recent series of sled tests, large compressive loads occurred in the upper neck of the HIII-05F during 30-kph tests, but did not occur during 56-kph tests, or in any tests using the THOR 5th-percentile female ATD (THOR-05F). One 30-kph HIII-05F test, which was characterized by early airbag deployment, also did not have large compressive loads occur in the upper neck. Therefore, it was decided to look more closely at the interaction between the HIII-05F and the airbag and analyze how neck response can be affected by differences in deployment timing.

Methods: Frontal sled tests were conducted using a custom test buck designed to represent a 2012 Toyota Camry driver seat. Eight tests were conducted using the HIII-05F: 4 tests at 30kph, and 4 tests at 56kph. Six tests were conducted using the THOR-05F: 3 tests at 30kph, and 3 tests at 56kph. The test buck used production parts, including a driver airbag. A Camry seatback was modified to allow lines of sight to the ATD spine.

For the 30-kph tests, the 1st stage of the airbag was fired at 10ms after the start of sled motion and the 2nd stage was fired at 40ms. Both stages were fired at 10ms for the 56-kph tests. For one of the four 30-kph HIII-05F tests, the 2nd stage of the airbag was fired at the same time as the 56-kph tests (i.e., 10ms), which was 30ms earlier than the other 30-kph tests.

Results: Peak compression in the 30-kph HIII-05F test with early airbag deployment was -599N while the average peak compression in the other HIII-05F upper neck 30-kph tests was -4630N, greatly exceeding the FMVSS 208 limit of -2520N. Average peak compression in the 56-kph HIII-05F tests was -976N. For the 30-kph HIII-05F tests, the airbag contacted the HIII-05F chin at the onset of compressive loading in the upper neck before full inflation. Further inflation of the airbag forced the chin toward the chest, which is likely associated with the upper neck compressive loading and an associated flexion moment at the OC joint.

Conclusion: Different upper neck loads were likely caused by different head-airbag interaction. Compression in the upper neck was greater in the 30-kph HIII-05F tests when the 2nd stage of the airbag was fired at 40ms compared to when it was fired at 10ms. This indicates a need to further study how airbag interaction affects neck response. Neck injury risk predicted by the HIII-05F was much greater in the 30-kph tests than the 56-kph tests, which reinforces the need for more crashworthiness research at lower speeds. Preliminary data from matched PMHS tests might also be included in this current study if tests are conducted and data are processed in time.