C13 Forensic Testing and the Characteristics of Seat Belt Webbing Force Limiting Expansion Loops

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After attending this presentation, attendees will have an understanding of seat belt force limiting expansion loops, the associated testing methodologies, and the force-displacement characteristics of several designs incorporated in late model vehicles.

This presentation will impact the forensic community and/or humanity by demonstrating expansion loop characteristics and providing several data points useful in analyzing vehicle occupant interaction with the seat belt system.

THEORY OF THE ANALYSIS: Seat belts remain the primary occupant restraint system in passenger vehicles. In the event of a collision, 3-point lap and shoulder belts help to reduce the risk of injury due to impacts with interior components or ejection. Seat belts offer ride-down by providing restraining forces early in the collision event, thereby decreasing the relative velocity between the vehicle and occupant. Seat belts also help distribute restraining forces over the skeletal areas of the body.

In an effort to modify occupant kinematics and to reduce the injury producing restraining forces, seat belt designs often incorporate expansion loops. An expansion loop is a commonly used force-limiting device whereby the seat belt webbing is folded along the short axis, and stitched in place by parallel rows of threading. The thread material and stitch pattern used to make the rows of stitching will tear at predetermined webbing tension levels. When the stitches tear, the webbing fold will open thereby lowering the tension in the webbing. A warning label is often visible after the stitches tear. Replacement of the seat belt assembly in this condition is strongly advised.

Testing was conducted on new and used front outboard seat belt assemblies of three different vehicle models to evaluate the percent elongation of the webbing, and to determine the force-displacement characteristics of the expansions loops. The instrumentation and scientific methodology used were typical and standard for this type of forensic testing and data acquisition.

SEAT BELT WEBBING TEST SET-UP: 14 type 2 seat belt assemblies were obtained for testing. Six new assemblies were purchased from local dealers, and eight used assemblies were obtained from salvage vehicles. Preparation of the samples included separating the webbing from the retractor mechanism. The rubber-like escutcheons that often encase the expansion loops were preserved and left intact for use in the second of two test series.

TEST SERIES: Two series of tension tests were conducted. The first series (Series A) contained 14 tests, one test per webbing sample. The test protocol was designed to determine the percent elongation of the webbing, and did not include the effect of the expansion loop. Webbing samples tested were sectioned from the portion of webbing nearest the seat belt retractor.

Webbing ends were held by split drum grips of the type specified under Federal Motor Vehicle Safety Standard (FMVSS) 209. One split drum grip was rigidly anchored to the test bench, while the other grip was secured to the crosshead of the test machine. Tension in the webbing was applied by raising the crosshead. A webbing pre-load of approximately 222.4N was used. The grip separation rate was 51mm per minute. The force was measured by a load cell. Elongation of the webbing was determined with a laser extensometer, as well as with an engineering scale, when the tension in the webbing rose to 11,120N.

The second test series (Series B) contained 14 tests, one test per webbing sample. These tests were performed to evaluate the forceextension characteristics of the expansion loop of the lap belt. The webbing section tested in this series was the portion nearest the outboard lap belt anchor. One end of the sample was secured to the test bench using the existing anchor bracket to which the webbing was sewn. The expansion loop remained concealed in its rubber-like escutcheon to maintain the original in-vehicle condition.

The other end of the webbing sample was held by a split drum grip attached to the test machine crosshead. The grip separation rate was 100mm per minute, a rate commonly used by the seat belt manufacturing industry. Force was measured with a load cell. The peak force to tear each row of stitching was determined. As tension in the webbing sample increased, the rows of stitching in the expansion loop subsequently failed. As the rows of stitching were torn, tension in the webbing decreased as a small amount of webbing was added to the sample overall length. This phenomenon produced a saw tooth-like force-displacement curve. Sample testing was stopped after all rows of stitches were completely torn.

TEST RESULTS: The results of Series A varied by vehicle model. For new samples, the webbing elongation was between 5.2% and 14.8% using the laser extensometer, and between 5.9% and 13.6%

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using the engineering scale. For used samples, the webbing elongation was between 5.5% and 11.4% using the laser extensometer, and between 5.8% and 10.7% using the engineering scale.

The results of Series B were dependent on the expansion loop design, i.e. by the fold pattern, the number of rows of stitching, the thread material, and the stitching pattern. One expansion loop design added an average 218mm of webbing at an average peak force of 2733N for new samples tested. The used samples added an average 267mm at an average peak force of 1900N.

Another expansion loop design added an average 238mm of webbing for the used samples. The first three rows of stitching yielded at an average peak force of 5067N and the remaining rows yielded at an average peak force of 3244N. The testing of the new sample in this vehicle model resulted in a failure of the webbing during the test. The results of this sample were suspect and therefore not included.

The last expansion loop design added an average 248mm of webbing for the new samples. The first three rows of stitching yielded at an average peak force of 5910N and the remaining rows yielded at an average peak force of 4225N. For the used samples, an average of 231mm of webbing was added. The first three rows of stitching yielded at an average force of 4943N, and the remaining rows yielded at an average peak force of 3600N. **CONCLUSION:** Expansion loops are often incorporated in seat belt designs to modify occupant kinematics and reduce occupant-restraining forces during the collision event. Expansion loops vary among vehicle models and each design exhibits unique force-displacement characteristics. Forensic testing of seat belt expansion loops can be used to quantify the force necessary to break the stitching and measure the amount of additional webbing added to the seat belt assembly. Subsequent testing results will be offered in future publications.

Seat Belt Webbing, Force Limiters, Expansion Loops

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