REPORT ON DYNAMIC TESTING OF THE MASTERLINK MARKETING SEAT BELT ADJUSTER

Prepared by

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Via Fax 905 - 459 - 2234

Mr. Bill Reilly
Masterlink Marketing
Brampton, Ontario

RE: Sled Testing of Master Design Seatbelt Adjuster

Dear Bill:

As you know, the sled testing of the Master Design Seatbelt Adjuster was completed on 16 January 1995. I will soon begin to analyze the data and prepare a report on the testing. This may take a few weeks to complete. In the interrim, I thought you might like to know my initial thoughts on the Master Design's performance.

I am pleased to report that in all tests with the Master Design Seatbelt Adjuster, the adjuster did not interfere with the seatbelt restraint system. The Adjuster fractured early in the test as was intended which permitted the seatbelt to release from the adjuster and operate as it normally would for the particular configuration. Based on the preliminary results, the chest accelerations and head injury criteria (HIC) values were within acceptable levels for this type of test.

I shall forward the report describing the details of the test and results as soon as it is completed. Please call me if you have any questions.

Sincerely yours,

Miller Engineering, Inc.

Bruce W. Main

Purpose

This testing was conducted to evaluate the dynamic performance of the Masterlink Marketing Master Design Seat Belt Adjuster during simulated 30 mph vehicle impacts. Testing was performed using an anthropomorphic dummy belted to an impact sled using standard seat belt materials.

Background

With this product, Masterlink indicated that two key design attributes were desired: movement of the shoulder harness off the occupant's neck and on the occupant's shoulder, and quick release (failure) in the event of a crash. Prior investigations performed by Miller Engineering consisted of several types of analyses focusing on issues other than dynamic impact conditions. The prior investigations are documented separately (see report of April 1993). Several findings resulted from the prior investigation which supported the product design, but could not offer any definitive resolution to how the product would or would not perform under simulated accident conditions. As a result, this testing was undertaken to evaluate the product performance under dynamic conditions.

Test Location

The testing was conducted under the direction of Miller Engineering at the University of Michigan Transportation Research Institute (UMTRI) in Ann Arbor, Michigan on 16 January 1995.

Equipment

In addition to the Master Design Seat Belt Adjusters, two anthorpomorphic dummies were used in this testing: a 5th %ile adult female and a 50th %ile 6-year-old child. The weights and dimensions for these dummies as listed at FMVSS 571.208 Subsection S7.1.3 are:

	50th-percentile 6-year old child	5th-percentile adult female
Weight	47.3 pounds	102 pounds
Erect sitting height	25.4 inches	30.9 inches
Hip breadth (sitting)	8.4 inches	12.8 inches
Hip circumference (sitting)	23.9 inches	36.4 inches
Waist circumference (sitting)	20.8 inches	23.6 inches
Chest depth		7.5 inches
Chest circumference:		
(nipples)		30.5 inches
(upper)		29.8 inches
(lower)		26.6 inches

The test laboratory provided the anthorpomorphic dummies and the sled testing equipment. Details of the equipment can be found in UMTRI's test report (see report ML 9501-11, 16 January 1995).

Method

The general test procedures are summarized below as taken from the UMTRI report.

The simulated impact testing operates on a rebound principle. The "sled" (actually a seat fastened to a moveable test platform mounted on a track) is moved in a forward direction and then quickly reversed in order to simulate impact. The desired velocity change is achieved by reversing the sled's direction during the impact event. One of two different anthorpomorphic dummies (5th %ile adult female or 6-year-old child) was belted with an NHTSA 3-point belt anchor onto an FMVSS 213 standard seat with a fixed seat back facing forward in the left (driver's) seat position in the sled.

The crash pulse was trapezoidal in shape and was similar to that of a small automobile. Sled velocity was calculated by integrating the sled deceleration time-history. The peak deceleration as well as average Gs within the central 60% of the crash pulse were recorded. Frontal impact is simulated at a velocity of 30 mph and a peak acceleration of 23 G. Upon impact, measurements were taken for head and knee excursions, head peak resultant, head injury criterion, and chest resultant. The test data were digitized on-line and analyzed on an 80486 microcomputer. All test signals were filtered according to the requirements of SAE J-211, and signal output conformed to its recommended sign convention.

The actual sled deceleration pulse lasted approximately 80 msec while the dummy dynamics lasted approximately 100 msec. To evaluate the dynamic performance of the dummy and product during this brief interval, high speed (1000 frames/second) 16-mm motion picture cameras were used as well as an 8-frame rapid-sequence Polaroid camera. The cameras were mounted overhead and to the side of the point of impact.

The Master Design product was repeated once for each dummy size for a total of two tests per dummy. This was done in order to obtain greater confidence in the repeatability of the results with the Master Design.

Prior to each test the seat belt adjuster being tested was placed in a configuration typical of expected use. These configurations are shown in the pre-test photos included in the UMTRI report. The adjusters were located so that the shoulder belt traversed over the dummy's shoulder (off the neck).

Results

Four tests were conducted with the Masterlink Seat Belt Adjuster. The results for all tests conducted with the Master Design product are presented in Table 1. Figure 1 presents an example of the typical output obtained from a test.

Table 1 Master Design Seat Belt Adjuster Test Results

Test Number	9501	9502	9507	9508
Dummy	5th %ile female	5th %ile female	6-year-old	6-year-old
Velocity	48.3 km/h (30.0 mph)	48.1 km/h (29.9 mph)	48.9 km/h (30.4 mph)	48.8 km/h (30.3 mph)
Peak Acceleration	23.2 G	23.2 G	22.6 G	23.0 G
Head Excursion	640 mm (25.2 in)	645 mm (25.4 in)	551 mm (21.7 in)	589 mm (23.2 in)
Knee Excursion	787 mm (31.0 in)	782 mm (30.8 in)	569 mm (22.4 in)	561 mm (22.1 in)
Head Peak Resultant	76 G	72 G	65 G	61 G
HIC	1253	1351	729	734
Chest Peak Resultant	53 G	50 G	52 G	53 G
Duration Over 60 G	0 ms	0 ms	0 ms	0 ms
Chest Resultant (3ms)	50 G	48 G	51 G	50 G

CHILD RESTRAINT SYSTEM
TEST DATA SUMMARY

Test Number: ML 9501

Test Date: 16 Jan 1995

Model: Master Design shoulder belt deflector attached to lap/shoulder belt

Manufacturing Status: production

SET-UP

VIP-5F 5th %ile female	Frontal impact
Forward facing	MVSS 213 standard seat
Left*seat position	Fixed seatback
NHTSA 3-point belt anchors	48 km/h (30 mph), 23 G

RESULTS

Velocity	48.3 km/h	(30.0 mph)
Peak Acceleration	23.2 G	
Head Excursion	640 mm	(25.2 in)
Knee Excursion	787 mm	(31.0 in)
Head Peak Resultant	76 G	
Head Injury Criterion	1253	
Chest Peak Resultant	53 G	
Duration over 60 G	0 ms	
Chest Resultant (3ms)	50 G	

Figure 1 Typical Test Output

Miller Engineering Test Results

The following is an excerpt of the test results taken from the findings of Miller Engineering Inc., a leading safety test laboratory located in the United States which is recognized by the big 3 Automakers.

They include results of comparison tests conducted on the following:

1. Auto Comfort - Comfort Clip (Pincher type of device)
2. 3R Adjuster - 2-piece sliding adjuster
3. Master Design - 1-piece sliding adjuster

Structurally, the Master Design product fractured during the tests. With the child dummy, the Master Design fractured at the rear hinge point as intended and remained in place relative to the dummy. With the adult dummy, the product fractured at the rear hinge point as intended but also fractured at the front tongue. In one test the tongue portion flew off the sled buck. In the other test the parts were found on the dummy's lap. The Master Design products are shown after the tests in Figure 2.

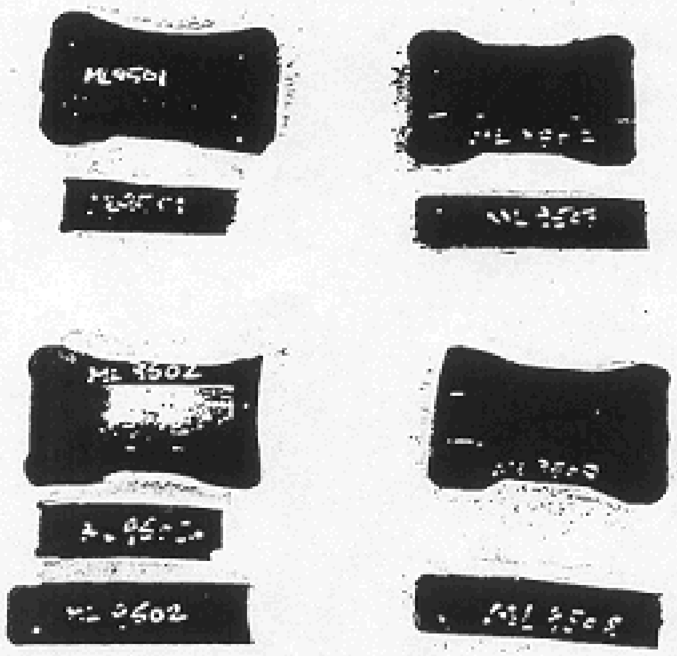

Figure 2. Master Design™ Seatbelt Adjusters After Testing
(Adult Dummy Tests on Left, Child Dummy Tests on Right)

Discussion

Based on the above results, the Master Design Seatbelt Adjuster did not interfere with the normal operation of the seatbelt. As intended, the Seatbelt Adjuster released early in the test. The occupant was restrained during the test by the seatbelt restraint system.

There is no specific or published baseline or standard for this type of testing. This creates difficulties in comparing the results to external measures in a meaningful way. We have attempted to draw on objective measures from the published literature and our experience to make some comparisons between the products on relative and absolute bases. These bases include HIC values, chest accelerations, structural performance, and head excursions.

HIC Values

Occupant protection in the automotive environment has been thoroughly studied. One result of this research has been the development of a U.S. Federal Motor Vehicle Safety Standards (FMVSS). These standards fall under the Part 49 of the Code of Federal Regulations. At FMVSS 208 (49 CFR 571.208), Subsection S6. *Injury criteria* reads:

> The resultant acceleration at the center of gravity of the head shall be such that the expression:
>
> $$\left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a\,dt \right]^{2.5} (t_2 - t_1)$$
>
> shall not exceed 1,000 where a is the resultant acceleration expressed as multiple of g (the acceleration of gravity), and t_1 and t_2 are any two points in time during the crash of the vehicle which are separated by not more than a 36 millisecond time interval. (note that similar text is written for the Hybrid III dummies at Subsection S6.2.2).

The above expression is referred to as the head injury criteria (HIC). The HIC value is a measure based on the head accelerations of the anthropomorphic dummy during the test. This criteria was developed to permit categorizations and comparisons of accidents of varying vehicles and circumstances, and has been used to improve vehicle crashworthiness.

However, the HIC criteria has been the subject of considerable debate and disagreement. Part of the debate centers on whether the HIC corresponds in a meaningful way to actual head injuries. Additional debate discusses the appropriate limit for HIC values (1000 or 1500). Further, there is disagreement whether the HIC should be used to define acceptable belt restraint performance in the absence of head impact (see Prasad & Mertz, 1985). As with many regulations, the HIC criteria is based in part on empirical testing but also includes opinions and politics. There is also debate as to the length of the time interval to be used in the HIC calculation. Bowman (1994) notes that:

> Since the original introduction of HIC, research has shown that, for proper interpretation of results *vis a vis* injury potential, the maximum permissible separation between t1 and t2 should be 36 ms, and for direct head impacts the separation should not be more than 15 ms. The associated calculations define what are called the 36-millisecond HIC and the 15-millisecond HIC.

The significance of this disagreement to the present testing is twofold. First, one should not view HIC values as absolute measures of safety or likelihood of head injury. Second, the HIC values obtained in this testing are conservative. The HIC values for this testing used the full HIC calculation method. If the 36-millisecond HIC or the 15-millisecond HIC methods were used, the calculated HIC values for these tests would be lower.

Chest Accelerations

The standard for chest accelerations is 60Gs. If the peak value exceeds 60Gs, then there is cause for concern regarding the effects on the occupant. If the peak value is below 60 Gs, there is basically no cause for such concern. None of the samples in these tests had any peaks over 60Gs which suggests that the Seatbelt Adjuster does not detrimentally affect chest accelerations.

Structural Performance

The primary concern of this dynamic testing was to determine if the Seatbelt Adjuster would release early in a simulated impact and allow the seatbelt restraint system to operate normally. The test results have shown that the Master Design Seatbelt Adjuster did release early in the test and permitted the seatbelt to operate normally.

A secondary concern results from the loose pieces flying about the occupant compartment due to the fractured front tongue on the Seatbelt Adjuster. This concern was also voiced by the UMTRI personnel as noted in their report. I have discussed the concern of the front tongue fracturing during our tests with Mr. Chris Staeheli of Contico Manufacturing Limited. It is my understanding that Contico Manufacturing molded the products. Mr. Staeheli was very pleased to learn of our tests and results. I understand that they are currently in the process of changing the mold for the adjuster and that he will work to incorporate the results of our tests into product improvements.

Head Excursion

Head excursion is a measure of how far forward the dummy's head moved during the impact. Unlike the HIC, there is no recognized value which is used as a guideline. The head excursion number is a single dimension value which may or may not be useful in predicting head impact. Since the three dimensional shape and seat adjustments of a particular vehicle determine the permissible excursion to avoid head impact, predicting head impact from the excursion is difficult.

In testing conducted in the UK, Freeman and Bacon (1988) compared the trajectories of two different test dummies under simulated crashes. Data were obtained for tests of changes in the vertical location of the upper anchor point (over the shoulder). While these tests do not address the circumstances of the Master Design seat belt adjuster, they do provide values for comparing the head excursions. The head excursions reported for Freeman and Bacon's tests were 651, 655, and 670 mm. The excursions for the present seatbelt adjuster testing yielded similar but somewhat lower values. While there are differences between the Freeman and Bacon tests from the present testing, these values do provide a general baseline to suggest that there is nothing particularly unusual concerning these head excursion values.

Findings

The results from these tests indicate that the Master Design Seatbelt Adjuster did not interfere with the seatbelt restraint system. The Adjuster released early in the test as was intended which permitted the seatbelt to operate normally.

The dummies used in these tests are older and do not reflect the most modern technology. Because newer dummies such as the Hybrid III typically yield lower values than the older dummies, these tests are therefore conservative.

These test results suggest that the Master Design Seatbelt Adjuster meets a minimum level of safety in the configuration tested. Specifically, these data cannot be used to reject the Master Design Seatbelt Adjuster as unsafe.

References

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Respectfully submitted,

Miller Engineering, Inc.

Bruce W. Main, P.E., CPSM