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The LifeBelt Potential; a Synopsis

The initial test report reviewed and discussed the full test program of 20 tests.

The full test program included testing of the standard LifeBelt concept and various experimental concepts. To clearly assess basic effectiveness of the LifeBelt concept it is necessary to consider only the standard concept tests and so these are documented in the following review.

LifeBelt Standard Concept

HIII 5%ile test performance

There are five relevant tests with the standard design and the 5%ile female dummy.

The first two tests compare a standard (basic) rear seat from a Honda Jazz tested with a standard seat belt and LifeBelt.

The control test S090258 was conducted at a different test facility and so the data collected is not completely compatible to the further test program.

Significantly, the LifeBelt test D1-4189 prevented submarining, reduced the HIC15 and chest G's. Chest compression remains outside tolerance.

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The next test D1-4260 uses a thick foam seat base (considered worst case for creating submarining) and a standard seat belt system. Compared to the control test, this system provides reduced chest G's but still suffers from submarining. It also exhibits very high head displacement.

The next test D1-4258 uses a thick foam seat base and LifeBelt. Submarining is prevented and reduced head displacement achieved.

The final test D1-4309 uses a thick foam seat base and LifeBelt fitted with a 5.5Kn Load Limiter retractor. Submarining is prevented and now the chest compression is reduced to within tolerance. The head displacement increases, but is still less than that with the standard seat belt.

Conclusion

LifeBelt prevents submarining and provides reduced head displacement with no negative effect in other performance measures.
The reduced head displacement can provide capacity to include a load limiter to reduce the chest compression without creating excessive displacement.

This is particularly of interest in rear seat applications where an airbag isn't used.

The following table summarises the peak test results from the various tests with the 5%ile female dummy.

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Peak Responses of HIII 5th%ile for a LifeBelt dynamic test, the Injury Assessment Reference Values (IARV) are included for comparison. Submarining was observed as noted in the matrix

Parameter	Unit	Control Test S090258 Honda Rr Seat Std. Seat Belt	LifeBelt D1-4189 Honda Rr Seat Lifebelt	Control Test D1-4260 Foam Base Std. Seat Belt	Lifebelt D1-4258 Foam Base Lifebelt	Lifebelt D1-4309 Foam Base Lifebelt with 5.5kN LL	IARV
		max / min	max / min	max / min	max/ min	max/ min	
Submarining – measured by observation after test	Y/N	Y	N	Y	N	N	
Dummy		HIII 5F	HIII 5F	HIII 5F	HIII 5F	HIII 5F	HIII 5F
Resultant head acceleration	G	78.8	65.8	71.7	60.9	67.7	193
HIC15		1098 (HIC36)	423	598	367	511	779
Upper neck force FX	kN	0.1/-1.7	0.16/-1.15	0.0/-1.22	0/-1.04	0.01/-1.18	1.9
Upper neck force FY	kN	0.4/-0.3	#	0.51/-0.10	0.28/-0.07	0.08/-0.11	1.9
Upper neck force FZ	kN	**2.7**/-0.3	**2.31**/-0.02	**2.54**/-0.03	**2.08**/-0.02	**2.32**/-0.03	2.07
Upper neck moment MX	Nm	21.9/-25.8	#	14.2/-11.5	9.2/-5.9	12.8/-14.2	
Upper neck moment MY	Nm	34.8/**-60.0**	61.2/-31.4	58.7/**-39.4**	49.3/-32.3	44.4/-22.8	95 (flexion) 39 (extension)
Upper neck moment MZ	Nm	14.0/-12.2	#	11.5/-3.8	4.5/-2.6	1.8/-3.5	
Resultant chest acceleration (3ms)	G	**80.6**	53.5	52.4	53.8	39.7	73
Chest compression	mm	**-51.0**	**-55**	**-56**	**-57**	-39	41
Viscous criteria	V.C		0.75/-0.48	0.82/-0.39	0.8/-0.3	0.64/-0.18	1.0

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Upper sternum deflection rate	m/s		1.61/-3.40	0.78/-3.59	1.37/-3.73	0.37/-4.23	8.2
Lower sternum deflection rate	m/s		1.96/-3.83	0.57/-3.59	1.36/-3.49	0.61/-3.32	8.2
Femur moment left MX	Nm	43.8/-49.2					
Femur moment left MY	Nm	272.7/-96.9					
Femur moment left MZ	Nm	38.5/-24.9					
Femur force left FX	kN	0.20/-0.90					
Femur force left FY	kN	0.20/-0.10					
Femur force left FZ	kN	2.80/-0.60	2.09/-0.30	2.0/-0.25	1.79/-0.68	1.79/-0.32	6.19
Femur moment right MX	Nm	83.1/-32.8					
Femur moment right MY	Nm	226.6/-48.4					
Femur moment right MZ	Nm	33.0/-24.4					
Femur force right FX	kN	0.30/-0.80					
Femur force right FY	kN	0.20/-0.20					
Femur force right FZ	kN	3.00/-1.10	2.51/-1.41	1.49*/-2.27	0.77/-3.45*	2.73/-1.17*	6.19
Pelvis acceleration GX	G	11.4/-43.3	23.7/-56.6	10.1/-54.4	38.8/-52.8	21.4/-48.4	
Pelvis acceleration GY	G	13.7/-12.5	7.7/-20.9	7.8/-6.4	9.1/-9.8	10.1/-14.1	
Pelvis acceleration GZ	G	9.4/-31.7	7.5/-35.0	10.3/-32.0	6.4/-35.0	4.7/-39.1	
Resultant pelvis acceleration (3ms)	G		65.0	55.4	56.2	55.3	
Shoulder belt force	kN	6.6	8.5	8.41	9.22	5.21	
Lap belt force	kN	6.9					
Head excursion x	mm		278	503	389	491	
Head excursion z	mm		65	219	103	145	
Knee excursion x	mm		182	156	167	136	
Knee excursion z	mm		0	52	41	36	

* Noisy Sensor # Data not available

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HIII 50%ile test performance

As the LifeBelt concept was initially perceived to address submarining issues with smaller occupants, only a limited number of tests were conducted with the 50%ile male dummy. Therefore there are only three relevant tests related to the standard LifeBelt concept.

The first test D1-4306 uses a front seat from a current production vehicle which meets 5 Star ANCAP. This seat (Ford Territory) has full anti-submarining structure and both inner and outer lap anchorages are on the seat frame. This seat was chosen as a good example of seat performance. The test was conducted with a standard seat belt and no airbag. The result was a marginal HIC15 and chest deflection outside of tolerance. No submarining.

The next test D1-4259 uses the thick foam seat base and LifeBelt. There was a substantial reduction in HIC15, with chest compression still outside tolerance. Head displacement in x increased slightly, but reduced in z.

The third test D1-4307 uses the thick foam seat base and LifeBelt fitted with a 5.5Kn Load Limiter retractor. HIC15 improved even further as did most measures. The chest deflection was just outside tolerance. Head and knee displacement remained acceptable compared to the standard system.

Conclusion

LifeBelt provides a very favourable performance on a foam seat when compared to a well developed structural seat.

The revised dummy kinematics achieved with LifeBelt contribute to a lower HIC15 without creating excessive head displacement.

The addition of the Load Limiter improved performance without any detriment to dummy displacement.

The following table summarises the peak test results from the various tests with the 50%ile male dummy.

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Peak Responses of HIII 50th%ile for a LifeBelt dynamic test, the Injury Assessment Reference Values (IARV) are included for comparison. Submarining was not observed in any of these tests

Parameter	Unit	Control Test D1-4306 5 Star Front Seat Std Seat Belt max / min	LifeBelt D1-4259 Foam Base Lifebelt max / min	Lifebelt D1-4307 Foam Base Lifebelt with 5.5kN LL max/min	IARV
Dummy		**HIII 50M**	**HIII 50M**	**HIII 50M**	**HIII 50M**
Resultant head acceleration	G	81.1	69.3	58.1	180
HIC15		**699**	446	294	700
Upper neck force FX	kN	0.01/-1.57	0.06/-1.78	0.0/-1.16	3.1
Upper neck force FY	kN	0.41/-0.14	0.25/-0.11	0.13/-0.23	3.1
Upper neck force FZ	kN	**3.66**/-0.03	2.55/-0.02	2.3/-0.23	3.29
Upper neck moment MY	Nm	114/-35.3	120.6/-34.4	78.1/-37.9	190 (flexion) 77 (extension)
Resultant chest acceleration (3ms)	G	50.7	45.1	46.6	60
Chest compression	mm	**-55**	**-61**	**-52**	-50
Viscous criteria	V.C	0.49/-0.26	0.47/-0.28	0.56/-0.26	1.0
Femur force left FZ	kN	2.5/-0.31	2.31/-0.79	2.67/-0.39	9.07
Femur force right FZ	kN	2.24/-0.16	2.65/-0.72	3.25/-0.41	9.07
Pelvis acceleration GX	G	9.1/-50.1	25.2/-42.1	22.2/-50.7	
Pelvis acceleration GY	G	4.8/-5.8	5.1/-10.8	6.1/-12.7	
Pelvis acceleration GZ	G	6.6/-38.5	14.3/-31.3	6.7/-37.7	
Resultant pelvis acceleration (3ms)	G	58.7	49.2	61.6	

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Shoulder belt force	kN	10.53	11.28	5.39	
Head excursion x	mm	438	489	479	
Head excursion z	mm	319	241	126	
Knee excursion x	mm	264	243	220	
Knee excursion z	mm	15.6	21.5	41	

Application Discussion

From discussion with potential suppliers and customers of LifeBelt it has been indicated that in general there would be a preference for separating the LifeBelt portion in the seat from the basic seat belt assembly outside the seat. This would enable the under lap section of LifeBelt to be built into the seat with greater ease and would enable normal assembly processes at the vehicle manufacturer. Also, it would help to isolate the responsibilities of seat and restraint manufacturers. This separating of the in-seat section from the standard seat belt assembly can be achieved by utilising the existing designs of 'delatchable anchors' which are in common use today with several front applications and many rear applications.

Where would LifeBelt be useful?

Rear Seat Applications: - as an alternative to the application of pretensioners in rear seats. The revised dummy kinematics of LifeBelt provide an option in finding ways of preventing hard head contact in rear seats, in addition to the prevention of submarining. This can be used in regions where NCAP demands rear seat performance measures or where improved rear seat performance is desired by the end customer. The LifeBelt concept has the potential for use in marketing as a passive solution.

Front Seat Applications: - as an alternative to the existing heavy structural seat systems used today. LifeBelt may offer an opportunity to revise dummy kinematics and reduce the mass of the total system.

- in the ultra low cost environment of some emerging markets, LifeBelt may be able to offer a safety level that limits the compromise of removing the airbags and pretensioners, without adding much cost or weight. As well as providing improved safety for the end users, this may satisfy the general business ethics of working in such a market situation.

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Future Potential

During the development testing of Lifebelt, the concept of Lapbelt Positioning System (LPS) was created. Although this concept has not been developed further, initial tests showed promise on further improving control/positioning of the lap portion of the belt during crash. This concept therefore has potential to adjust the dummy kinematics and may allow the selection of the best kinematics for passive restraint conditions. LPS is therefore a further enhancement of LifeBelt.

Final Words

This synopsis gives a clear indication that LifeBelt has the potential to make a progressive contribution to automotive safety.

What is needed now is a global partner that will develop the concept to the optimised product stage and explore the potential for improved safety at lower cost and weight, in various vehicle applications and markets.

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