SECTION **TWO** PART **6**

PROGRESS REPORT ON THE AIR BAG DEVELOPMENT FOR THE VOLVO EXPERIMENTAL SAFETY CAR (VESC)

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In our efforts to protect vehicle occupants from injuries during the extremely severe frontal 50 mph impact in the VESC performance specification, we have chosen the following phases in the first part of our VESC air bag development program. This work is carried out as a mutual development program between Eaton S.p.A. Safety Systems Division, Bosconero, Italy and AB Volvo.

DEVELOPMENT PROGRAM

Phase 1. Design for 30 mph

Develop a basic system design for a 30 mph head-on barrier collision acceleration level.

Phase 2.

Extend the basic system t• perform reliably at a 50 mph head-on barrier collision acceleration level.

Phase 3.

Check the extended basic system performance at a low speed collision acceleration level.

TEST DESCRIPTION AND PERFORMANCE

Phase 1. Design for 30 mph

Since barrier impact speeds up to 30 mph seem to include the usual forces developed during highway accidents, we consider the solving of problems related to collisions up to this acceleration level to be of primary importance.

Test 379 demonstrates an impact at 30.6 mph with a Volvo model 164 (Figure 1). The stopping distance is comparatively short (21.3 inches), which gives a high mean acceleration level. This level is most likely to correspond to that of the VESC at 50 mph, but obviously with a longer duration for the VESC.

In the figures RES = Resultant acceleration A–P = Anterior – Posterior acceleration measured in the head in the direction of eyeballs out, in the chest in the direction perpendicular to the spinal cord and backwards and in the pelvis in the direction of front-to-back. Dummies = 50 percentile male and 50 percentile female Sierras.

TEST 379: FULL SCALE FRONTAL BARRIER IMPACT

IMPACT VELOCITY 30.6 MPH 49.3 KM/H STOPPING DISTANCE 21.3" 54 CM

OCCUPANT	HEAD ACC g(3 MS)	CHEST ACC g(3 MS)	FEMUR LOAD LEFT LBS	FEMUR LOAD RIGHT LBS	AIR BAG SYSTEM
DRIVER	RES. 34 A-P 32	RES. 42 A-P 41	1140	860	STORED GAS
FRONT PASS.	RES. 54 A-P 50	RES. 51 A-P 50	1545	1020	

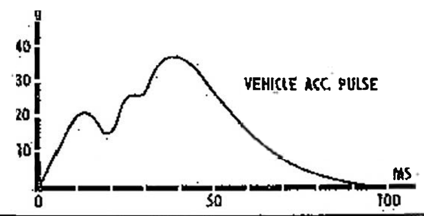

Figure 1

We are satisfied with the results obtained for the driver. However, the front seat passenger has made it with certain difficulties.

Test 73207 is a full-scale barrier impact with a Volvo model 144, which shows an entirely different vehicle pulse (Figure 2). This test was concerned only with rear seat occupants. The results are satisfactory,

TEST 73207: FULL SCALE FRONTAL BARRIER IMPACT

IMPACT VELOCITY 31 MPH 49.9 KM/H STOPPING DISTANCE 26" 66 CM

AIRBAG SYSTEM = ASPIRATOR

OCCUPANT	HEAD ACC. g (3MS)	CHEST ACC. g (3MS)	PELVIC ACC. g (3MS)	FEMUR LOAD LEFT LBS	FEMUR LOAD RIGHT LBS
REAR LEFT	RES. 32 A-P 28	RES. 37 A-P 37	RES. 42 A-P 40	655	N.R.
REAR RIGHT	RES. 30 A-P 22	RES. 37 A-P 37	RES. 45 A-P 41	N.R.	650

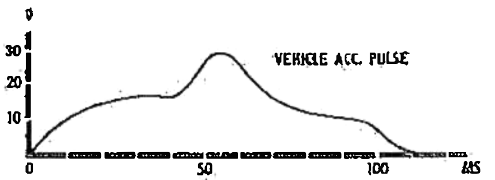

Figure 2

and please observe the correspondence between the values recorded in the different dummies.

Phase 2. Design for 50 mph

Preparations f●r tests made ●uring this phase were as follows: The volume of the front seat occupant bags were made twice the size of those designed for Phase 1. The amount of stored gas was increased by one third, but the pressure was kept the same, 3,500 psi. The rear seat occupant air bag restraint system remained the same design as in Phase 1, due to the promising low acceleration values registered with this system.

Test 980 was carried out with two front seat occupants and two occupants in the rear seat at a barrier impact speed of 51.7 mph (Figure 3). The stopping distance turned out to be rather long (48.8 inches), but the mean vehicle acceleration level was acceptable and high, due to the excessive speed. Front seat occupants came out well, except for an unnecessarily high pelvis acceleration in the driver, due to a broken knee protection. The chest acceleration of the rear seat occupants were acceptable, however, in spite of a partly broken air bag system structure. The heads hit the air bag frame structure and registered high acceleration values.

Test 864 shows another frontal barrier sled impact (Figure 4). The speed was 46.2 mph and the stopping distance 48.1 inches. The acceleration figures were excellent, even if the test conditions were less severe than what is expected in a 50 mph barrier crash. The rear left dummy head experienced a very short and high vertical acceleration. This is why the RES. 70 g:s and A–P 30 g:s have such different numerical values.

TEST 980: FRONTAL BARRIER IMPACT WITH SLED

IMPACT VELOCITY 51.7 MPH / 83.2 KM/H — STOPPING DISTANCE 48.8" / 124 CM

OCCUPANT	HEAD ACC. g (3MS)	CHEST ACC. g (3MS)	PELVIS ACC. g (3MS)	AIR BAG SYSTEM
DRIVER	RES. 56 A-P 40	RES. 55 A-P 53	RES. 58* A-P 55	STORED GAS
FRONT PASS.	RES. 55 A-P 43	RES. 60 A-P 59	RES. 44 A-P 44	STORED GAS
REAR LEFT	RES. ~96 A-P ~96	RES. 60 A-P 52	N.R	ASPIRATOR
REAR RIGHT	RES. ~98 A-P ~98	RES. 56 A-P 56	N.R	ASPIRATOR

* DRIVERS KNEE PROTECTION BROKE

NOTE: REAR AIRBAG SYSTEM STRUCTURE FAILED

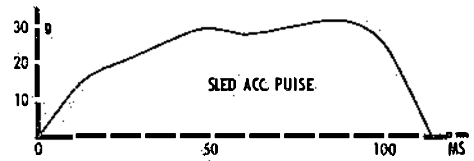

Figure 3

TEST 864: FRONTAL BARRIER IMPACT WITH SLED

IMPACT VELOCITY 46.2 MPH / 74.4 KM/H — STOPPING DISTANCE 48.1" / 122 CM

OCCUPANT	HEAD ACC. g(3MS)	CHEST ACC. g(3MS)	FEMUR LOAD LEFT LBS	FEMUR LOAD RIGHT LBS	AIR BAG SYST. SAME AS IN TEST C 975
REAR LEFT	RES. 70* A-P 30	RES. 36 A-P 34	529	441	ASPIRATOR
REAR RIGHT	RES. 36 A-P 28	RES. 31 A-P 30	353	661	ASPIRATOR

* ISOLATED PEAK

NOTE EXCELLENT RESULT DUE TO RATHER "SOFT" TEST CONDITIONS

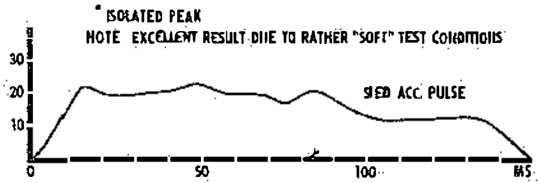

Figure 4

All other figures show good correlation between the left and the right dummy.

Phase 3. Design — same as Phase 2 — low speed

It is of importance to be able to use the same air bag system in high speed as well as in low speed impacts. We know that one can sensor one system to deploy at a low acceleration level and another system at a high acceleration level. Such a solution, however, tends to be more expensive and may introduce additional sources to produce malfunction. Accordingly, we chose to carry out Phase 3 with the same air bag system design as in Phase 2.

Low speed test C975 had an impact velocity of 19.4 mph and a 11.8 inches stopping distance (Figure 5). Registered acceleration figures were very much on the safe side and, consequently, we have succeeded in

TEST C 975: FRONTAL BARRIER IMPACT WITH SLED

IMPACT VELOCITY 19.4 MPH / 31.2 KM/H — STOPPING DISTANCE 11.8" / 30 CM

OCCUPANT	HEAD ACC. g (3MS)	CHEST ACC. g (3MS)	PELVIC ACC. g (3MS)	AIR BAG SYSTEMS SAME AS IN TESTS 864 AND 980
DRIVER	RES. 22 A-P 22	RES. 40 A-P 40	RES. 30 A-P 27	STORED GAS
FRONT PASS.	RES. 19 A-P 17	RES. 23 A-P 22	RES. 23 A-P 22	STORED GAS
REAR LEFT	RES. N.R A-P 23	RES. 27 A-P 26	RES. N.R A-P N.R	ASPIRATOR
REAR RIGHT	RES. 35 A-P 31	RES. 31 A-P 30	RES. N.R A-P N.R	ASPIRATOR

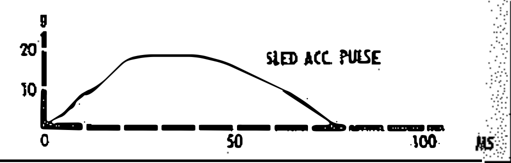

Figure 5

using the same systems for high, as well as low, speed impacts. The figures are almost equal in this test with the exception of the driver chest figures, but these are still on a reasonable level.

CONCLUSION

We have now informed you of one step in our air bag development program. The next step will repeat the described three phases but with more sophisticated designs, e.g., the front seat occupant will have an aspirator system.

We strongly believe that after the fulfillment of the next step we will have enough knowledge to equip a VESC vehicle with air bags, barrier crash it at 50 mph and get acceptable results.

The development of air bag systems is a meaningful task, but in spite of some very promising results so far, we wish in no way to underestimate the difficulties ahead of us. To mention one detail only, it may be wise to equip the VESC with complementary lap belts for additional safety in complicated traffic accidents.