

How Do We Know That You Wore Your Seat Belt?

In modern days investigators find it more convenient to simply look at the download from an event data recorder ("Black Box") in order to determine whether a front-seat occupant was wearing a seat belt during a crash. But this information is sometimes incorrect because of issues such as power failure, buckling the seatbelt behind the body or simply because the occupant of interest is not a driver. It is important therefore to be familiar with the physical evidence to independently confirm that a seat belt was worn. But not only that. Such analysis can also determine how the system was worn; as in whether it was worn properly.

The following data is taken from some old cases (1980's era) but the issues still apply. I apologize for the quality of the images but like I said, they are old.

Sometimes you just have to know when something is not right. The image below is of a collision-loading mark on the lower bar of a D-ring taken from a severe head-on collision involving a Jeep. Notice anything unusual?

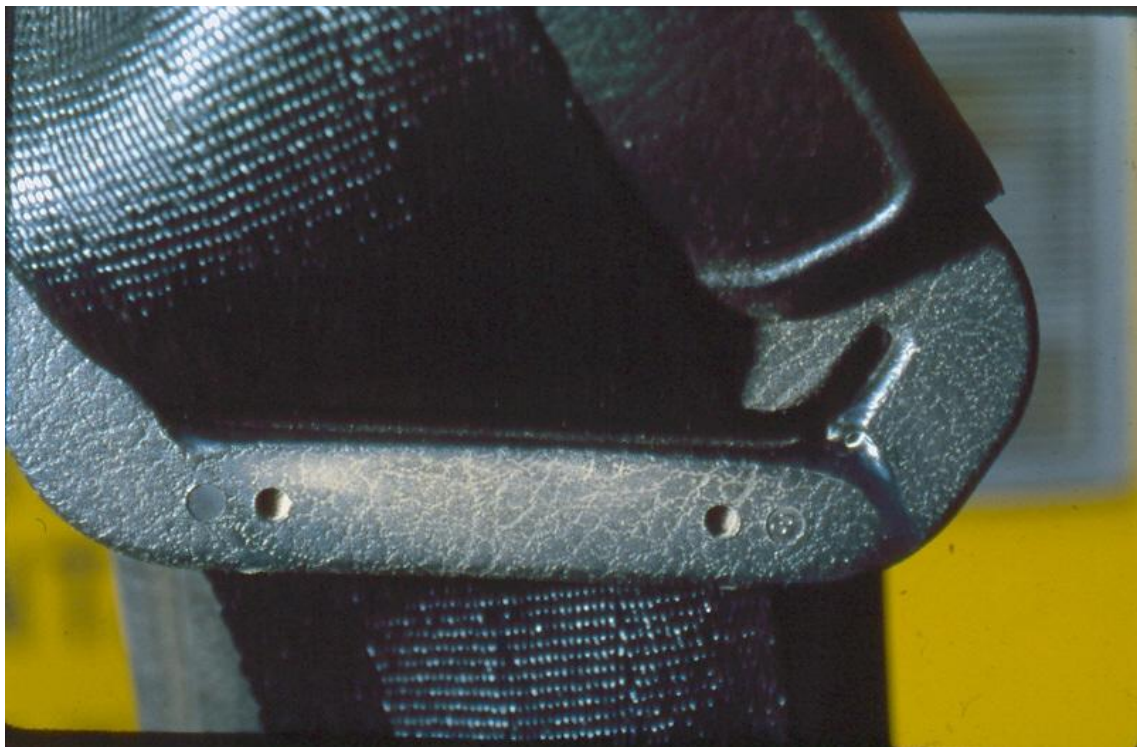


If you know anything about loading marks you will know that a normal mark on a D-ring will contain uniform striations in the zone where the seatbelt webbing has melted the plastic on the lower bar. This is because the occupant's body has been pulling on the webbing during the crash. The angle of those striations should immediately tell you whether you are dealing with a driver or a right front occupant because the angle of those striations will be directly opposite. The angle of those striations for a driver should be toward the bottom right. Think about how the driver's body moves forward with

respect to the vehicle interior and how this rotates the D-ring forward and you will appreciate why this angle occurs.

But more importantly you should be able to recognize in the above photo that the seat-belt webbing has moved on the bar during the loading. Look again. See how the loading mark on the left appears to look normal and then note how it was shifted to the right and bunched up toward the right? That it not normal. A loading mark should contain uniform striations, all along the same angle, all across the lower bar of the D-ring. You should automatically realize that the occupant's body is not moving normally with respect to the seat-belt and that this is occurring during the loading, or in other words during the 120 milli-seconds (or so) of the crash when injuries could occur. This is not just minor loading, it is significant and a lot of energy is being dissipated at this time.

But loading marks on a D-ring should not be confused with usage grooves created from use of seat belts over an extended time. The photo below shows an example of a prominent usage groove but the evidence can vary, often resulting a polished buffing on the lower bar.



I have said for many years that the two primary areas where one should look for loading marks on a restraint system are at the D-ring and at the point on the webbing where the tongue (latch plate) contacts it when the system is buckled. This still remains true however new system designs may require different procedures.

It is easier to locate loading marks if you know where to look. This is helped if you know the size of the occupant, male or female, if you know how many doors the vehicle has (2 or 4 door) and if you have data from previous cases for that vehicle model.

The figure below shows the results of a SAS, statistical analysis I did back in the late 1980's regarding the location of loading marks from the tongue (latch plate) of seat belts in approximately 177 cases where such data was obtainable. The numbers below represent the length of lap belt used by the occupant. This length is measured from the output foot anchor (OFA) to the crease on the webbing where the latch plate produced the loading mark. I have compared these lap belt lengths to factors such as OCCSEAT (whether a driver or right front occupant), and SEX (whether the occupant was a male or female).

| Summaries of By levels of | | TONGUE OCCSEAT SEX | Tongue Crease Seating Position Occupant Sex | Mean | Std Dev | Cases |
|------------------------------|-------|--------------------------|---------------------------------------------------|------|---------|-------|
| Variable | Value | Label | | | | |
| For Entire Population | | | | 87.4 | 11.5 | 177 |
| OCCSEAT | 1.00 | Driver | | 87.5 | 10.8 | 131 |
| SEX | 1.00 | Male | | 85.4 | 9.8 | 75 |
| SEX | 2.00 | Female | | 90.4 | 9.7 | 41 |
| SEX | 9.00 | | | 90.5 | 15.9 | 15 |
| OCCSEAT | 2.00 | Right-Front | | 87.2 | 13.5 | 46 |
| SEX | 1.00 | Male | | 87.4 | 15.2 | 17 |
| SEX | 2.00 | Female | | 86.7 | 12.6 | 27 |
| SEX | 9.00 | | | 91.5 | 19.1 | 2 |
| Total Cases = | | 186 | | | | |
| Missing Cases = | | 9 OR | 4.8 PCT. | | | |

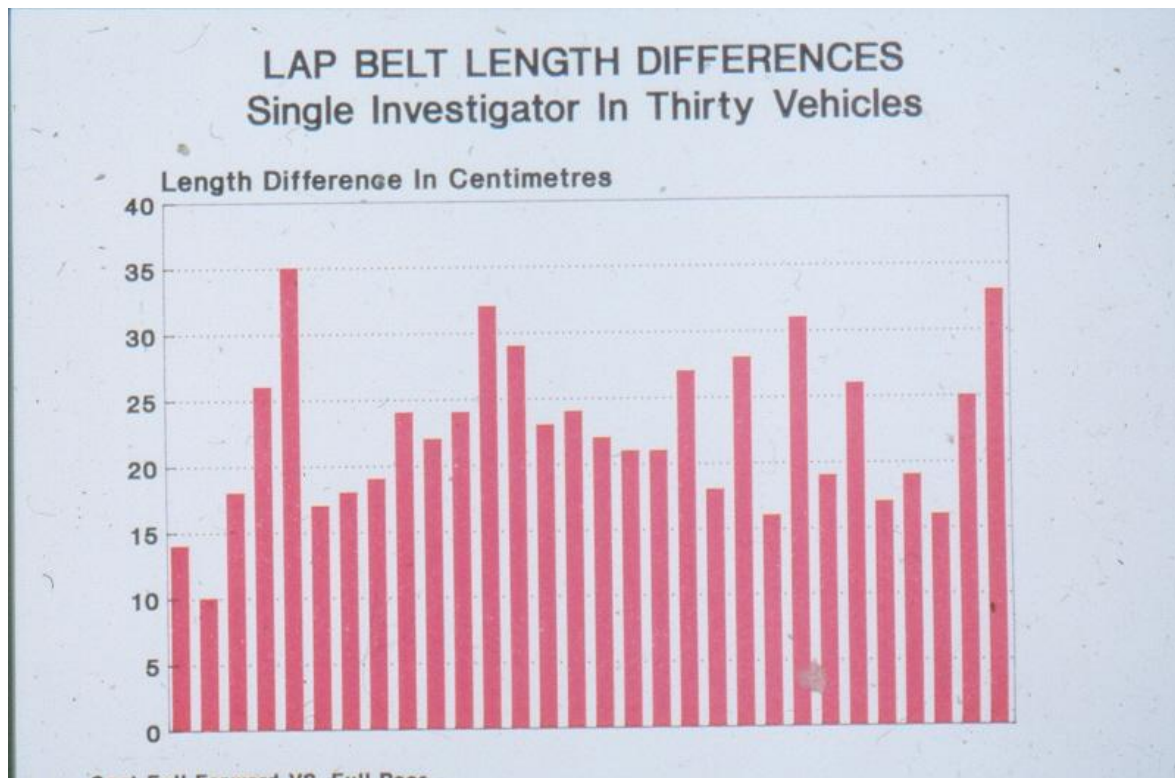
Reading from the above figure you can note that for drivers, the lap belt length for males is 85.4 centimetres while for females it is 90.4. Initially that might sound strange since females should be smaller in height and weight. But remember, a smaller driver pulls his/her seat further forward on the seat track and therefore the seat belt webbing has a longer distance to go around the body of a person seated further forward. So this is simply indicating that, despite the smaller size of females, their tendency to move their seats further forward causes them to use a longer length of webbing during a serious crash.

This is verified when we look at the data for right front occupants. Here there is no need to bring the seat forward because the occupant does not need to reach the foot pedals. And here we see that the seat belt length for right front occupants who are males is 87.4 centimetres versus 86.7 for females. So this might mean that, despite the possibility that

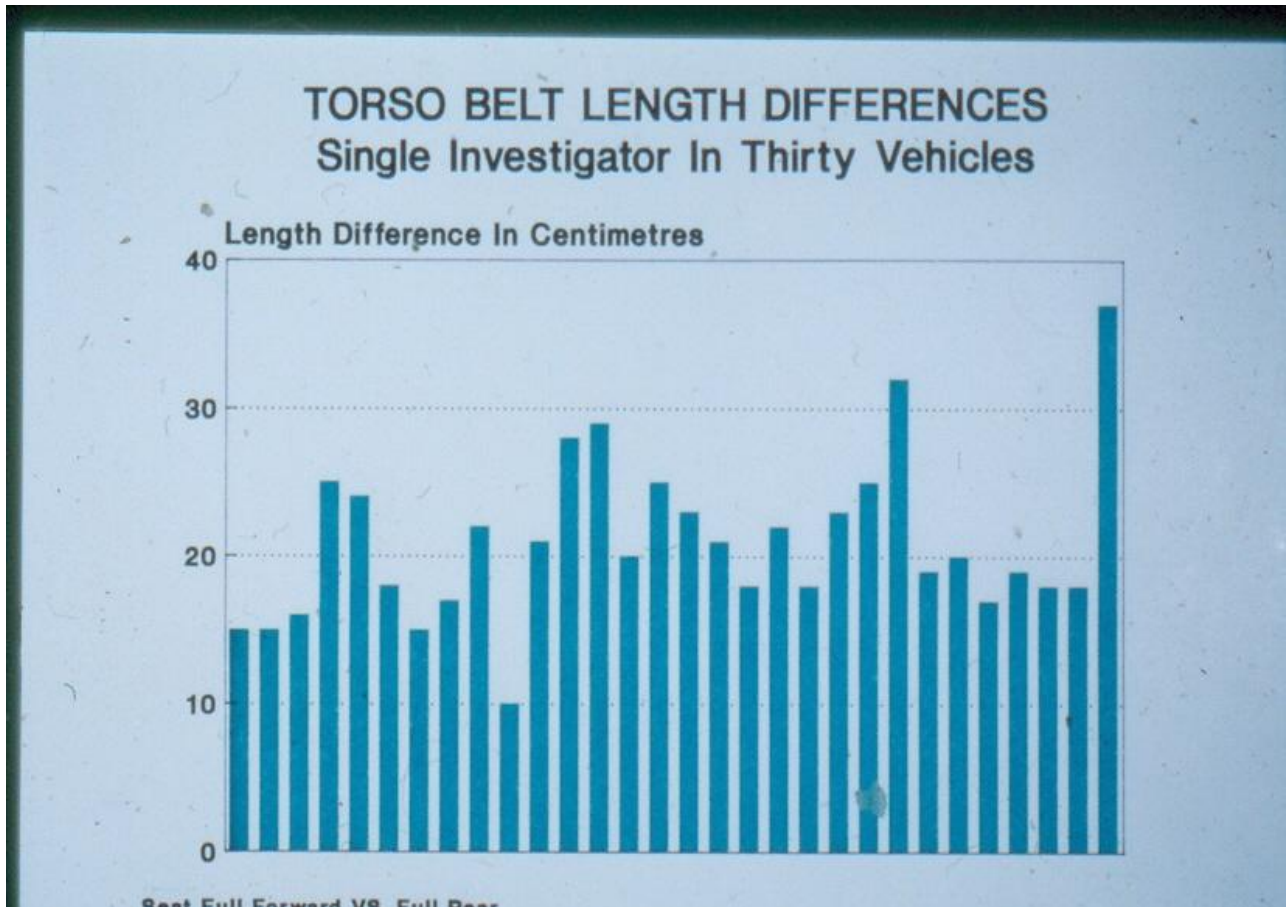
males might move their right front seats further back than females, the lap belt lengths used by males are slightly longer than females.

But when I said earlier that it is important to know where to look on a seat belt to find the loading mark from a tongue (latch plate) all this data suggests you should look in the vicinity of 87 centimetres from the outboard floor anchor. So, as an investigator, if you find a loading mark at 100 centimetres from the OFA you'd better be prepared to explain why the mark is where it is.

But also note that seat belt lengths change from one vehicle to another. The figure below shows me wearing a seat belt in 30 different vehicles. First I moved the seat to a full rear position and then I measured the length of lap belt that I required to surround me. Next, I moved the seat to a full forward position and took the same measurement. I then compared the length of lap belt used when the seat was full rearward versus when it was full forward. The difference (in centimetres) is what is shown in the figure below.



So, for example, in the first test at the far left of the figure the difference in lap-belt lengths used was about 14 centimetres. So this is simply a measure of how the forward/rearward movement of a seat changes from one vehicle to another. The figure below shows similar experiments for measurements of the torso (shoulder) belt lengths.



Another experiment is where I documented the length of torso (shoulder) belt length used in severe collisions where I knew the location of the tongue crease and the D-ring transfer on the webbing. What I mean is that the following lengths are taken directly from loading marks found on seat belts that were worn and where those marks clearly identified the length of torso belt used. I examined the difference between two-door and four-door vehicles in a grouping of over 100 severe, real-life collisions.

| Summaries of By levels of | DRING2 DOOR | Torso length only Number of Doors | Mean | Std Dev | Cases |
|------------------------------|----------------|--------------------------------------|-----------|---------|-------|
| Variable | Value | Label | | | |
| For Entire Population | | | 97.1 | 14.8 | 104 |
| DOOR | 2.00 | | 103.4 | 15.2 | 46 |
| DOOR | 4.00 | | 91.6 | 12.5 | 54 |
| OTHER | | | 97.5 | 10.2 | 4 |
| Missing Cases = | | 82 OR | 44.1 PCT. | | |

As can be seen above, the torso belt length used in two-door vehicles was 103.4 centimetres while for four-door vehicles it was 91.6 centimetres. This is important if you are going to suggest that someone was wearing a seat-belt improperly. A torso belt length of 103 centimetres might sound long and therefore the investigator might think the belt was worn with too much slack. But obviously the data could simply have come from a two-door vehicle.

There are many other experiments and data that can be obtained from studying the physical evidence of loading on a seat belt system. Surprisingly, investigators have been slow at looking at and analysing this type of material. It is only in the last 4 to 6 years that I have seen several research papers being presented the Society of Automotive Engineers Congress dealing with physical evidence on seat belts. Yet I had been examining that evidence a good 20 years before that. I have stated that investigators should maintain a database of seat belt loading evidence from each vehicle they examine and that all this data should be pooled into a single database. Such information would be extremely valuable in understanding how occupants are protected (or not) in real-life accidents and how improvements to automotive safety could be made.

0 Comments

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