

# Understanding the difference between EN 1317 and NCHRP 350

*Non gating TL3 crash cushion vs redirective 110 Km/h crash cushion*



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# Introduction

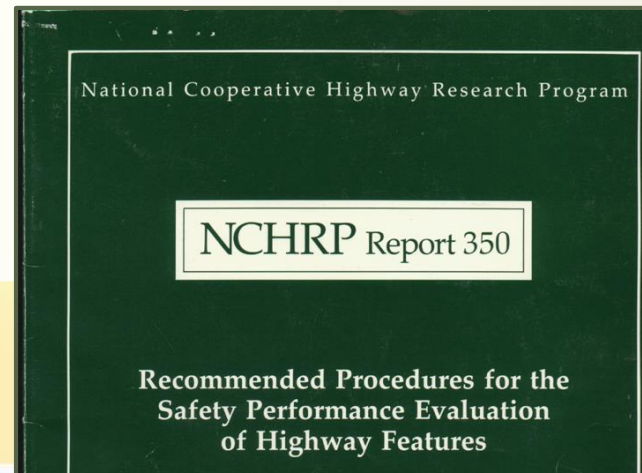
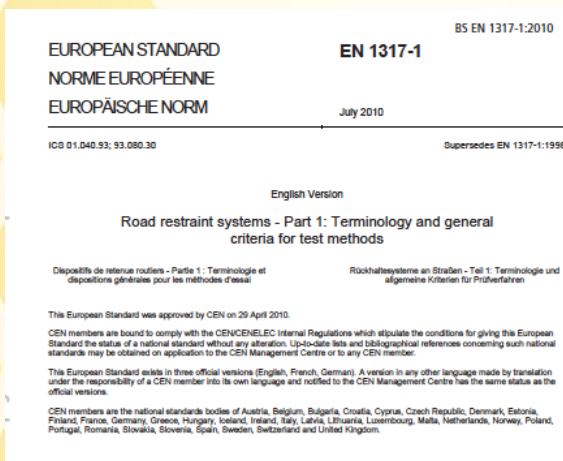


In this presentation the Norms **NCHRP 350** and **EN 1317** are compared according to the Evaluation Criteria used for the different Crash Tests.

The Norms are compared in terms of Energy Absorption and Biomechanical Parameters.

## Purpose of this presentation

- Both the Norms can be considered equivalent in terms of aim: they use strict Evaluation Criteria to certify the Crash Cushions and other Road Safety devices.
- By comparing the Norms, it is evident that the EN 1317 is even safer than the NCHRP 350 in terms of severity.
- The devices certified according to EN 1317 are safer than NCHRP 350 certified devices.



# EN 1317 vs NCHRP 350

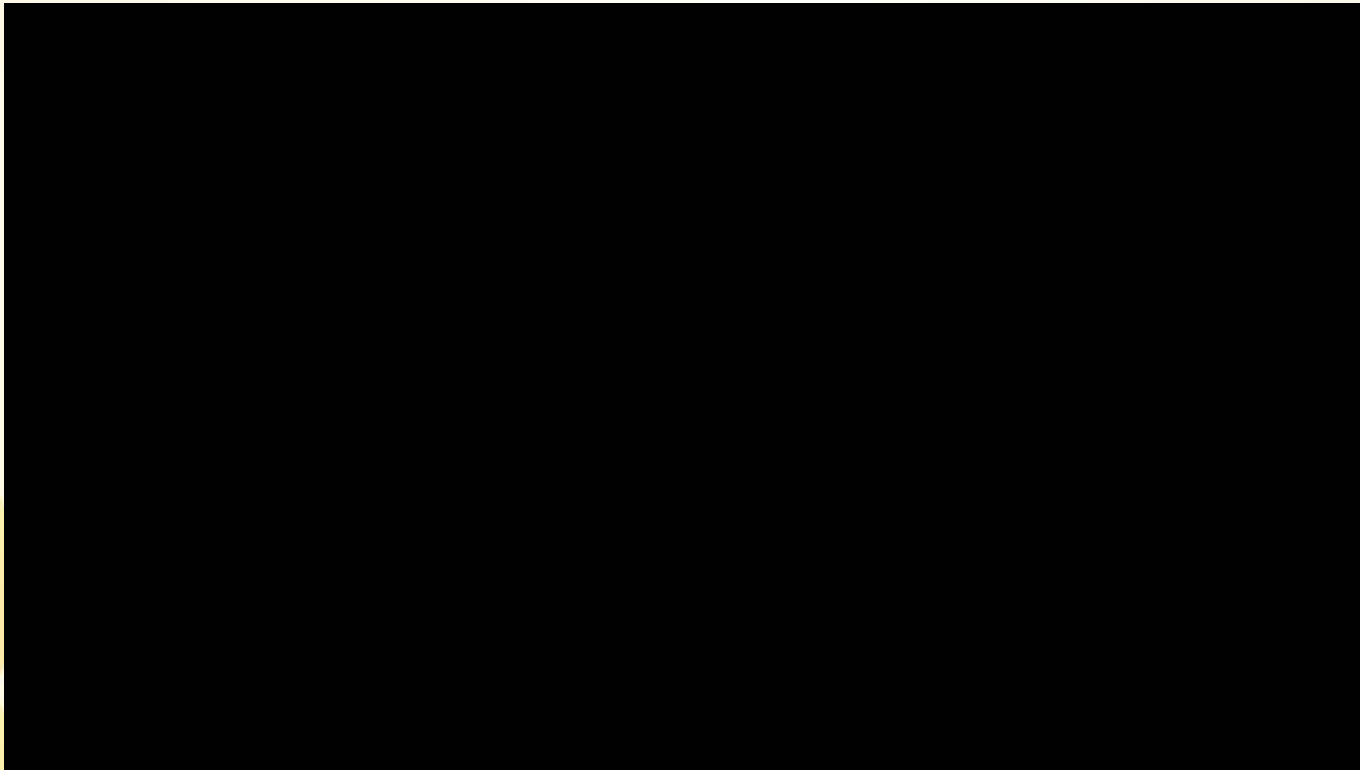
*Non gating TL3 crash cushion*

*vs*

*redirective 110 Km/h crash cushion*



**TEST 3.37**



***Testing an EN 1317 device according to NCHRP 350:  
a way to merge the two standards***

# Comparison of vehicles for the Crash Tests used in both the Norms.

In the **NCHRP 350** are used **2** vehicles for testing the Crash Cushions: a small car with a mass of 820 Kg and a pick-up with a mass of 2000 Kg.

In the **EN 1317** are used **3** vehicles for testing the Crash Cushions: a small car with a mass of 900Kg (820+80), a medium car of 1300 Kg, and a large car of 1500 Kg.

## NCHRP 350 Test Vehicle Types



820 kg car is small vehicle



2,000 kg pick up truck is large vehicle

## EN 1317-3 Test Vehicle Types



820 kg car is small vehicle plus 80 kg for dummy

1,300 kg car is large vehicle for 50 km/h, 80 km/h & 100 km/h tests



1,500 kg car is large vehicle for 110 km/h tests

# Crash test categories

## **NCHRP 350**

### **Velocities for Impact Attenuators**

<b>TL-1</b>	<b>Test level for special, minimal service requirements</b>	<b>50 km/h</b>
<b>TL-2</b>	<b><u>Basic</u> test levels for most service requirements</b>	<b>70 km/h</b>
<b>TL-3</b>		<b>100 km/h</b>

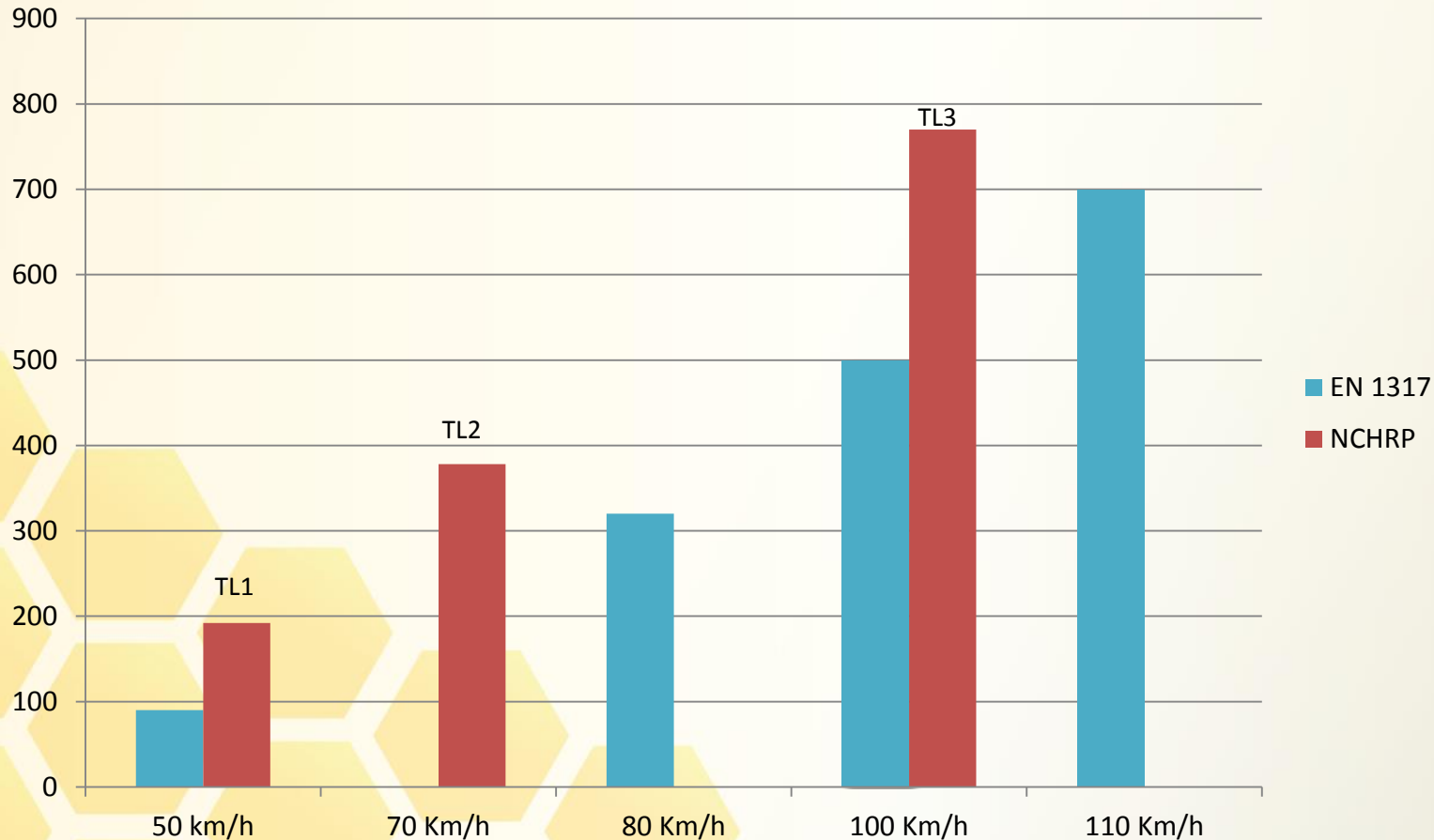
## **EN 1317-3**

### **Velocities for Impact Attenuators**

**Test speeds are 50 km/h, 80 km/h, 100 km/h & 110 km/h**

Comparison in terms of the **maximum** Impact Severity for each crash cushion class.

The data below refer to the Impact energy in Kj.



The **TL3** impact severity can be compared with the **110 Km/h**. In terms of Energy absorption, the gap is of 70 Kj.

# TL3 vs 110 Km/h



NCHRP 350

EN1317

TL3 Non gating Crash cushion

110 Km/h Redirective Crash Cushion

## Nominal Impact Severity NCHRP350 Vs EN1317

### NCHRP 350 - TL3

### EN 1317 - 110 km/h

Test	Velocity (km/h)	Mass (kg)	Energy Level (kJ)	Angle/Position	Type	Test	Velocity (km/h)	Mass (kg)	Energy Level (kJ)	Angle/Position	Type
TL 3.30	100	820	316.36	0/Offset 1/4	Mandatory	TC 2.1.100	100	900	347.22	0/Offset 1/4	Mandatory
TL 3.31	100	2000	771.60	0/Frontal	Mandatory	TC 1.3.110	110	1500	700.23	0/Frontal	Mandatory
N.A.						TC 1.1.100	100	900	347.22	0/Frontal	Mandatory
TL 3.32	100	820	316.36	15°/Frontal	Optional	N.A.					
TL 3.33	100	2000	771.60	15°/Frontal	Optional	TC 3.3.110	110	1500	700.23	15/Frontal	Mandatory
TL 3.36	100	820	21.17	15°/Side	Mandatory	N.A.					
TL 3.37	100	2000	90.26	20°/Side	Mandatory	N.A.					
TL 3.38	100	2000	90.26	20°/Side	Mandatory	TC 4.3.110	110	1500	46.90	15/Side	Mandatory
TL 3.39	100	2000	90.26	20°/Rev Side	Mandatory*	TC 5.3.110	110	1500	46.90	15/Rev Side	Mandatory

**Optional** = Possible to demonstrate the behavior of the system through engineering analysis.

# Evaluation Criteria: ORA vs ASI



## NCHRP 350

- Measure the Accelerations in longitudinal (X) and transverse (Y) directions
- Compute the moving average 10 milliseconds accelerations
- The average ridedown acceleration must be less than 20 g only after the flight time that define the Occupant Impact Velocity

ORA <20 g

## EN 1317

- Measure the Acceleration in longitudinal (X), transverse (Y) and vertical (Z) directions
- Calculate the ASI parameter as
- The ASI must be less than 1.4 during the whole impact

ASI<1.4=16.8g

## NCHRP 350: OIV

- Integrate the components of the acceleration of the center of gravity of the vehicle to get the “occupant” velocity
- The OIV (**occupant impact velocity**) **in longitudinal and lateral directions must be less than 43.2 Km/h**

## EN 1317: THIV

- Integrate the components of the acceleration of the center of gravity of the vehicle to get the “occupant” velocity
- Calculate the resultant of the impact velocity as THIV (**theoretical head impact velocity**). The **THIV must be less than 44 Km/h in frontal impacts and less than 33Km/h in lateral impacts**

# Some other comments: ORA vs ASI



**NCHRP 350** considers  $a_x$  and  $a_y$  separately.

For the ridedown acceleration to produce occupant injury, it should have at least a minimum duration ranging from 0.007 to 0.04 sec, depending on body component (70). Thus, vehicular acceleration "spikes" of duration less than 0.007 s are not critical and should be averaged from the pulse. An arbitrary duration of 0.010 s has been selected as a convenient and somewhat conservative time base for averaging accelerations for occupant risk assessment. This is accomplished by taking a moving 10-ms average of vehicular "instantaneous" accelerations in the **x and y** directions, subsequent to  $t^*$ .

Source: NCHRP 350 Manual

**EN 1317** considers  $a_x$ ,  $a_y$  and  $a_z$  at the same time.

$$ASI = \sqrt{\left(\frac{a_x}{12g}\right)^2 + \left(\frac{a_y}{9g}\right)^2 + \left(\frac{a_z}{10g}\right)^2} \leq 1.4$$

**NCHRP 350** maximum ridedown acceleration is 20 g. Both  $a_x$  and  $a_y$  could be 20 g.

**EN1317** fixes a limit on ASI equal to **1.4**, this means that the crash test is failed if only one of  $a_x$ ,  $a_y$  and  $a_z$  is larger than 12g, 9g and 10g respectively.

For example:

If  $a_x=12g$ ,  $a_y=9g$  and  $a_z=10g$ , the ASI will be **1.73**, whereas **this values are acceptable by NCHRP**

If  $a_x=a_y=15g$  the test is acceptable by NCHRP whereas not for 1317 because ASI will be 2.08

# Some other comments: OIV vs THIV

Similar considerations are also worth for the **OIV** and **THIV**.

## OIV

$$\begin{cases} x \leq 43 \text{ Km/h} \\ y \leq 43 \text{ Km/h} \end{cases}$$

## THIV

$$\sqrt{Vx^2 + Vy^2} \leq 43 \text{ Km/h}$$

**THIV** is computed putting the acceleration components together to get a resultant, the **OIV** is computed for each component of acceleration.

Moreover, in side impact, **NCHRP** considers only the longitudinal acceleration and not the lateral acceleration for the **OIV** evaluation.





**Example of a lateral acceleration:** the dummy in the car has a motion in the direction of the window.

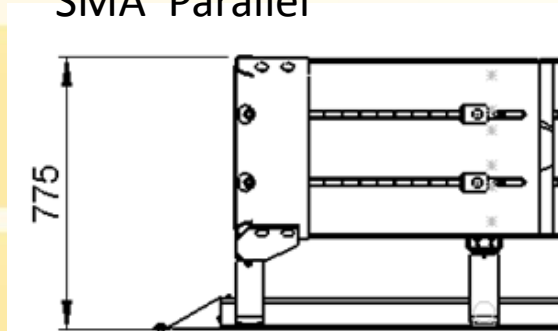
# Some other comments: Center of gravity

There is a difference in terms of **center of gravity of the vehicle**, because the NCHRP vehicle is higher from the ground than the EN 1317 vehicle.

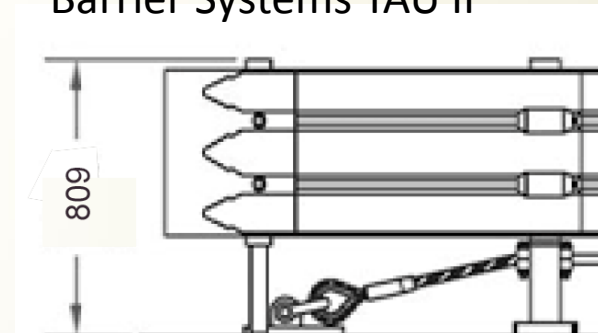
## It is a false problem:

the difference in terms of height of the crash cushions certified according to the **NCHRP 350** and according to the **EN 1317** is **irrelevant**, as shown in the pictures below.

SMA Parallel



Barrier Systems TAU II



The height difference between the two devices is 34 mm.

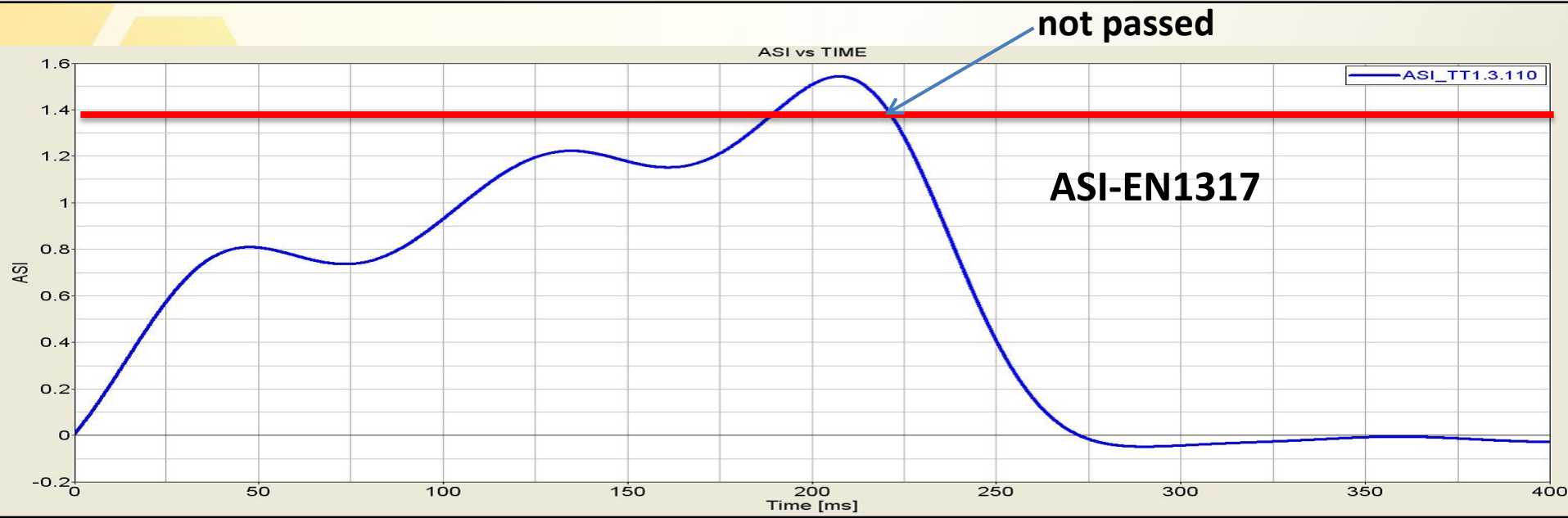
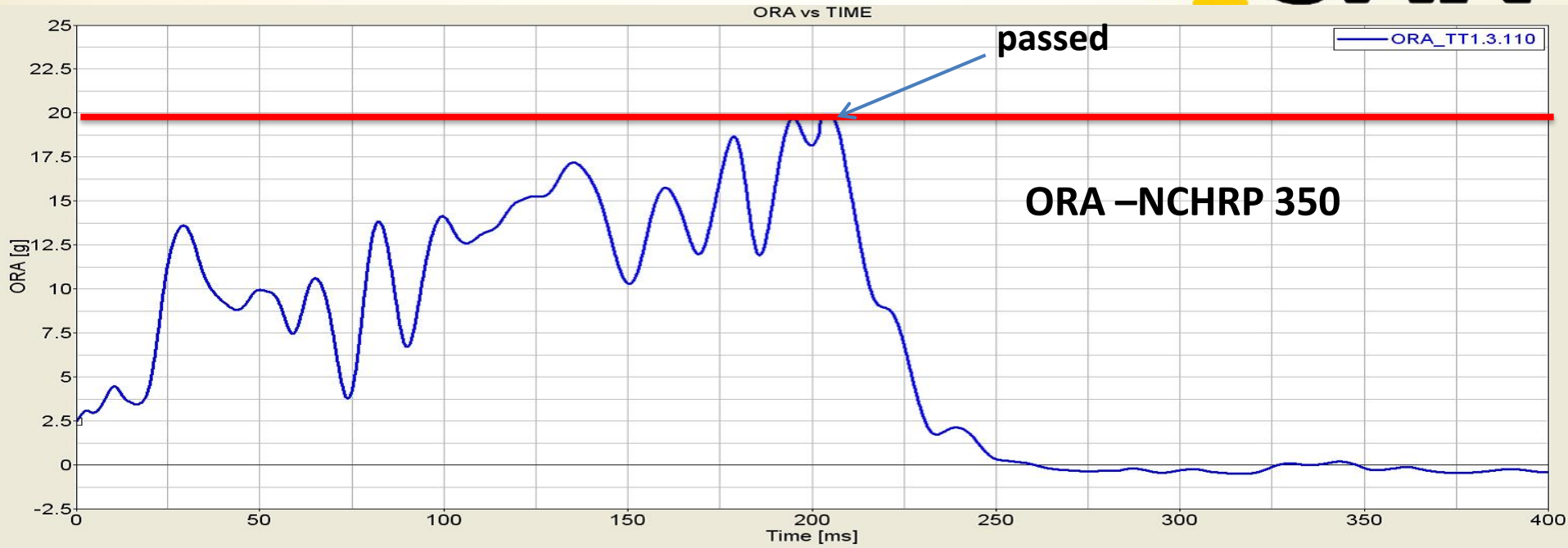
# KO biomechanical parameters evaluated with EN 1317 could become OK when evaluated according to NCHRP 350



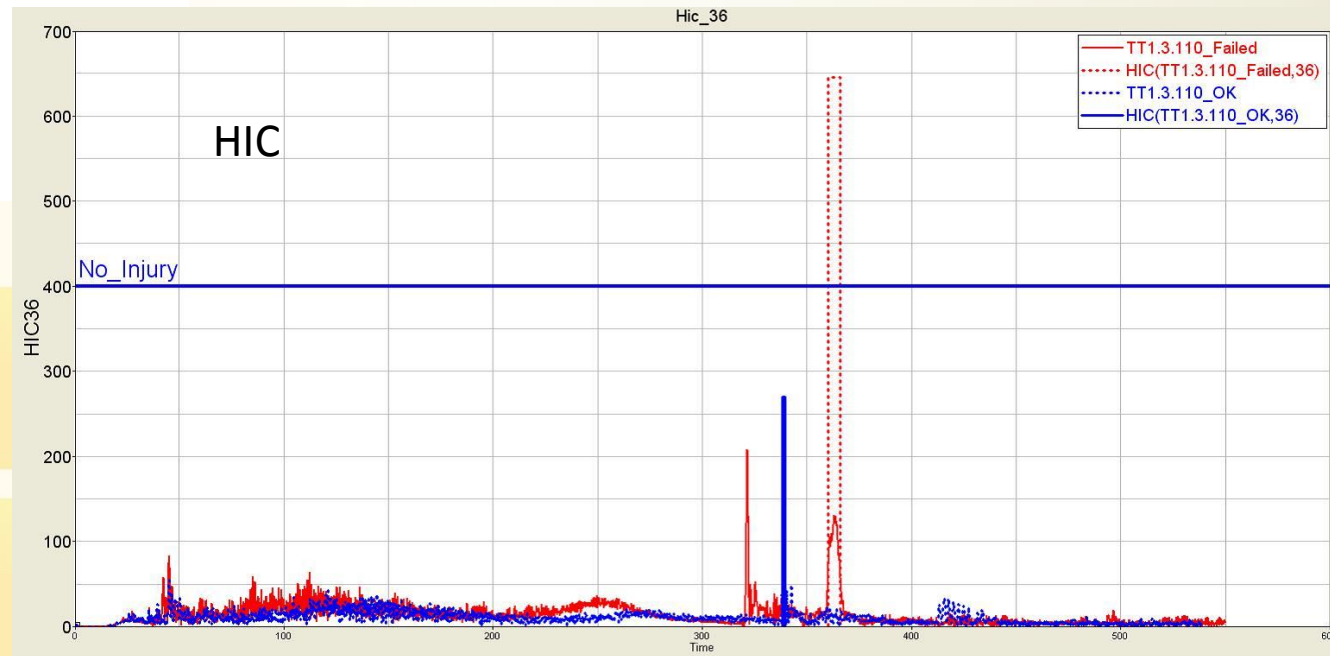
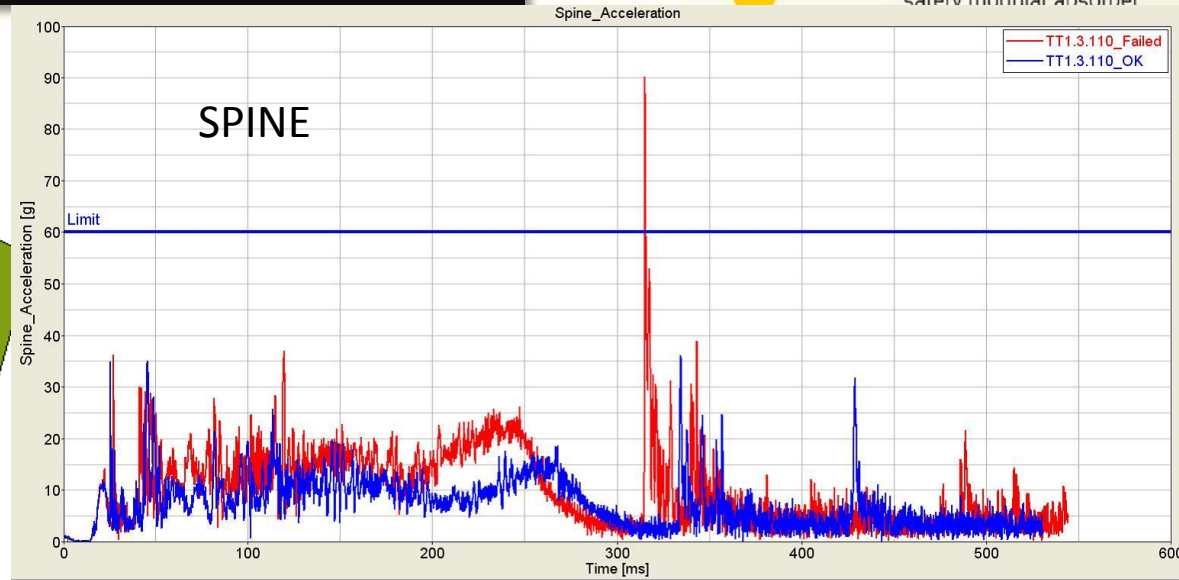
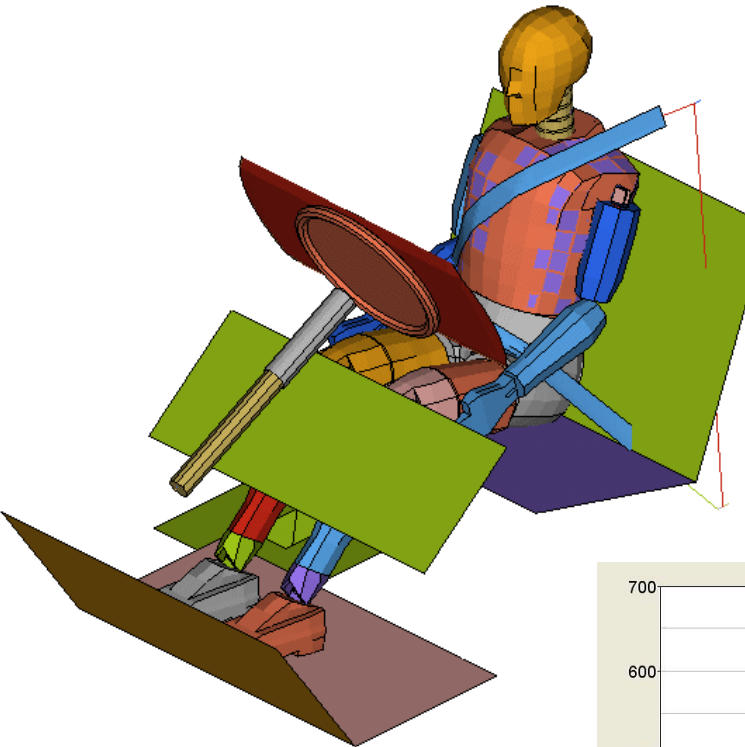
In the video you can find a crash test according to the EN 1317 which has failed because of impact severity parameters. If that test had been performed according to the NCHRP 350, it would have passed.



# KO biomechanical parameters evaluated with EN 1317 could become OK when evaluated according to NCHRP 350



Moreover...HIC and spine acceleration became less than the critical value when  $ASI < 1.4$



## Other evaluation criteria (non-biomechanical parameters) required by the two standards

Similar concerns regarding:

- Detached elements from the test article should not penetrate the occupant compartment, present hazard for the traffic, not block the driver's vision
- The vehicle should remain upright (not mandatory for 50Km/h test in NCHRP)

**For NCHRP:** After collision it is **preferable** that the vehicle's trajectory not intrude into adjacent traffic lanes. The exit angle **preferably** should be less than 60% of the test impact angle, measured at time of loss of contact with the test device

**For EN1317** In any test the wheels of the vehicle shall not encroach the line of the exit box unless the velocity of the vehicle center of mass is less than or equal to 10% of prescribed impact speed. In the EN1317 framework, the test is not passed if this criterion is not satisfied .



**Redirective  
Zone**

**Z1**

**Lateral  
Displacement**

**D1**

# How EN 1317 can become compliant to NCHRP350?



## NCHRP 350

TL3 Non gating Crash cushion

## EN1317

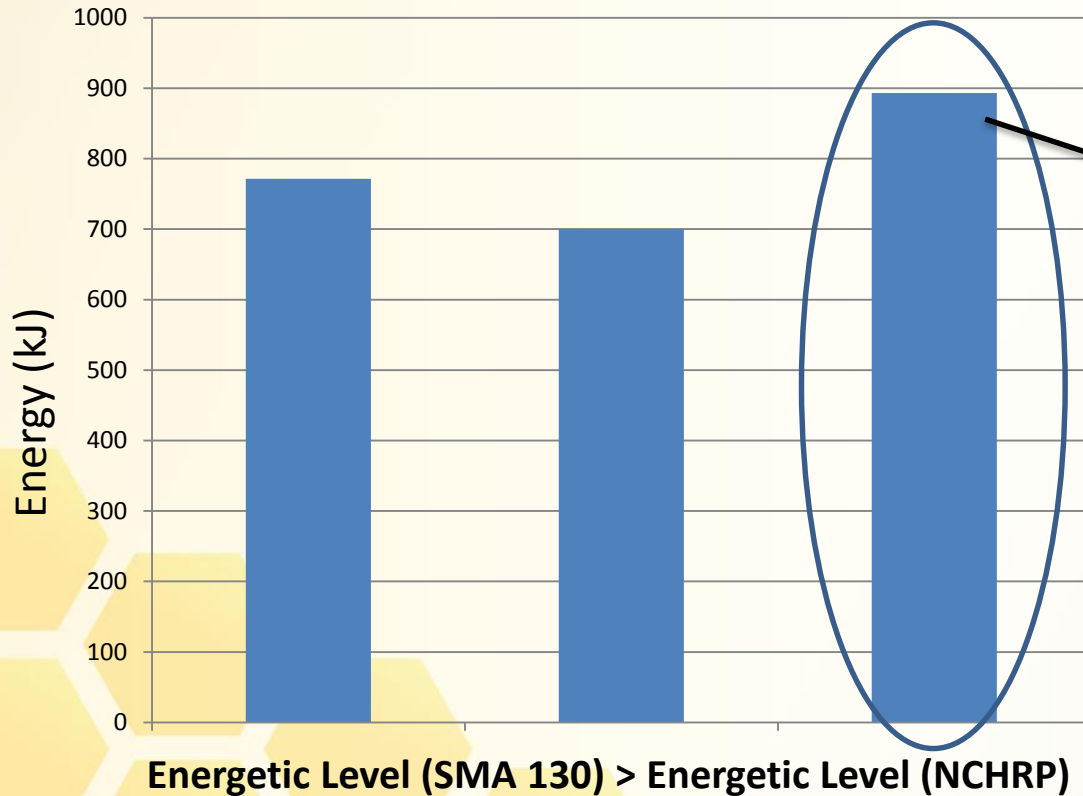
110 Km/h Redirective Crash Cushion

Test	Velocity (km/h)	Mass (kg)	Angle/Position	Type	Test	Velocity (km/h)	Mass (kg)	Angle/Position	Type	
TL 3.30	100	820C	0/Offset 1/4	Mandatory	TC 2.1.100	100	900	0/Offset 1/4	Mandatory	Frontal Impact
TL 3.31	100	2000P	0/Frontal	Mandatory	TC 1.3.110	110	1500	0/Frontal	Mandatory	
N.A.					TC 1.1.100	100	900	0/Frontal	Mandatory	
TL 3.33	100	2000P	15°/Frontal	Optional	TC 3.3.110	110	1500	15/Frontal	Mandatory	
TL 3.32	100	820C	15°/Frontal	Optional	<b>CAPACITY TEST</b>					
TL 3.38	100	2000P	20°/Side	Mandatory	TC 4.3.110	110	1500	15/Side	Mandatory	Side Impact
TL 3.39	100	2000P	20°/Rev Side	Mandatory	TC 5.3.110	110	1500	15/Rev Side	Mandatory	
TL 3.36	100	820C	15°/Side	Mandatory	N.A.					
TL 3.37	100	2000P	20°/Side	Mandatory	<b>Side test according to 350</b>					

Optional = Possible to demonstrate the behavior of the system through engineering analysis.

## EN 1317 vs NCHRP-350 TL3

### Impact Severity for Crash cushion



Test at 130km/h  
on SMA 110.  
Impact Energy: 862 Kj

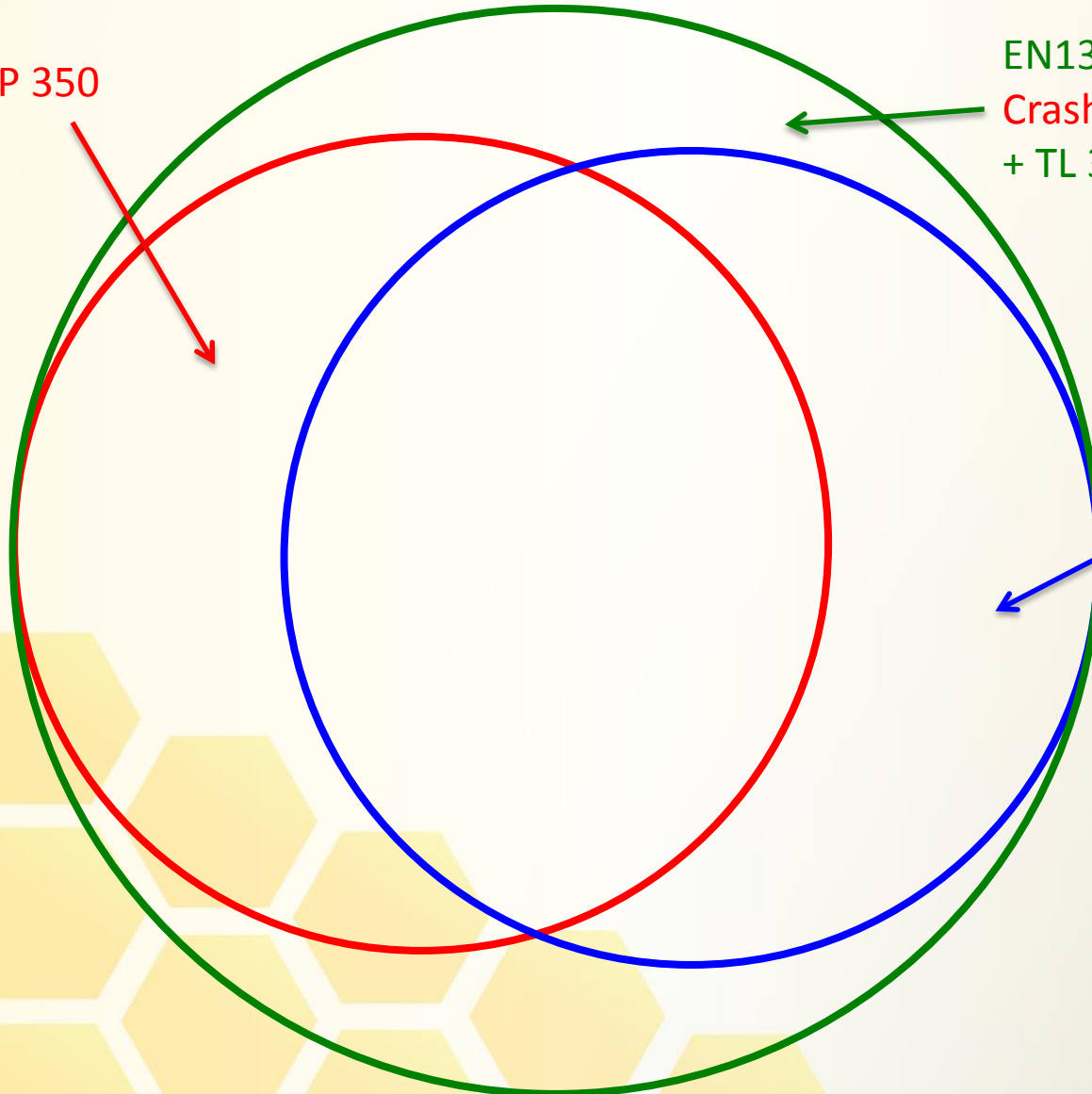
Industry A.M.S. has performed a  
Crash Test on SMA 110P at 130  
Km/h, in order to show

**NCHRP 350** and **EN 1317** are comparable but they have some differences. To fill the EN 1317 gap, it was necessary to add other 2 Crash tests.

NCHRP 350

EN1317 + TL3.31 (=   
Crash test 130 Km/h )  
+ TL 3.37

EN 1317



# Conclusions



We can conclude that **NCHRP 350** standard is heavier than **EN 1317** with respect to the capacity to absorb energy involved in the frontal impact and especially in the lateral impacts, but on the other hand **EN 1317** is heavier than **NCHRP350** with respect to the evaluation criteria because the limits of the biomechanical parameters of the **EN1317** are less than those of the **NCHRP 350**: 350 admit larger occupant impact velocities and larger average occupant decelerations. In all, **NCHRP** requires “stronger and stiffer” crash cushions, whereas **EN1317** is more focused on the passengers health.

A way to design a crash cushion that is able to be compliant to both the two standards could be to test the safety device according to the EN1317 and then to run two additional crash tests:

- The first one is a capacity crash test in order to fill the gap between the energies of the frontal impact in the two standard. Running a **TL3.31** test on a EN1317 product is enough to show that the system is able to fill the energetic gap.
- The second one is a side test able to show that the EN1317 device is also able to resist at the larger solicitations typical of the NCHRP350 side impacts. Among the side impacts of the NCHRP 350, the worst one is for sure the **TL3.37**. It is our opinion that if an EN 1317 crash cushion is able to pass also a TL3.37 test, it will be also compliant with the other requirements of the 350 related to the side tests.

**By adding these two crash tests to the standard crash tests according to EN 1317, SMA 110P completely satisfies the NCHRP Energy absorption criteria.**