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Never Stand Still

Transport and Road Safety (TARS) Research

Underride: Design, Testing and Performance Requirements in Australia (downunder)

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Transportation Research Board
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Truck underride

Truck underride

Photo F10-1 Rear view of the van. (support bracket repaired)

Photo F10-2 Side view of station wagon. A-pillar and B-pillar were torn out by the impact.

Photo F10-3 Driver's side view of crashed vehicle – note largely intact side structure

Figure A1.1 Crash Investigations: CASE F10

Photo FC12-1 FRONT VIEW OF CAR AT CRASH SCENE. NOTE EXTENT OF ROOF DAMAGE.

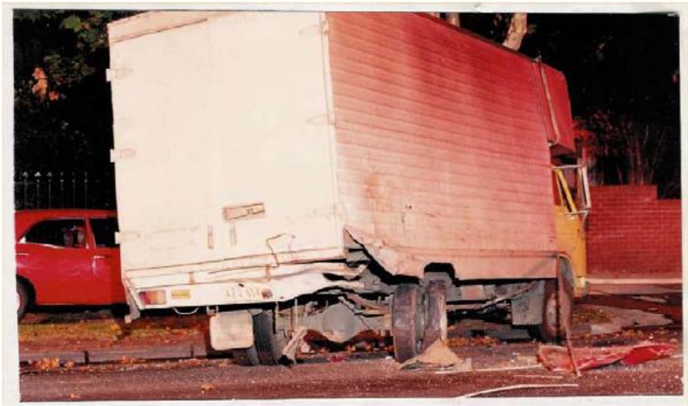

Photo F33-1 Side view of the car, showing flattening of A pillar and shearing of roof back to the C pillar

Photo F33-2 Rear view of damaged trailer. Note partial width of underrun bar and damage to the rear corner of the fiberglass body of the van.

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Truck Underride Crashes

- Ongoing safety issue in both industrialised and developing countries
- Worldwide, thousands killed and seriously injured

Truck Underride Crashes

- Car occupant protection features ineffective
- Severe/fatal injury risk to vehicle occupants
- Highly aggressive:

  extreme geometric, stiffness and mass incompatibility

Truck underride in Australia – 50 km/h

10 ton truck with handbrake on

Truck underride in Australia – 50 km/h

30 years waiting for an ADR! ECE has regulation

10-12 per year

300 dead!

Jane Mansfield – Hollywood actress

Darren Malain talented Aussie rules football star

Truck underride

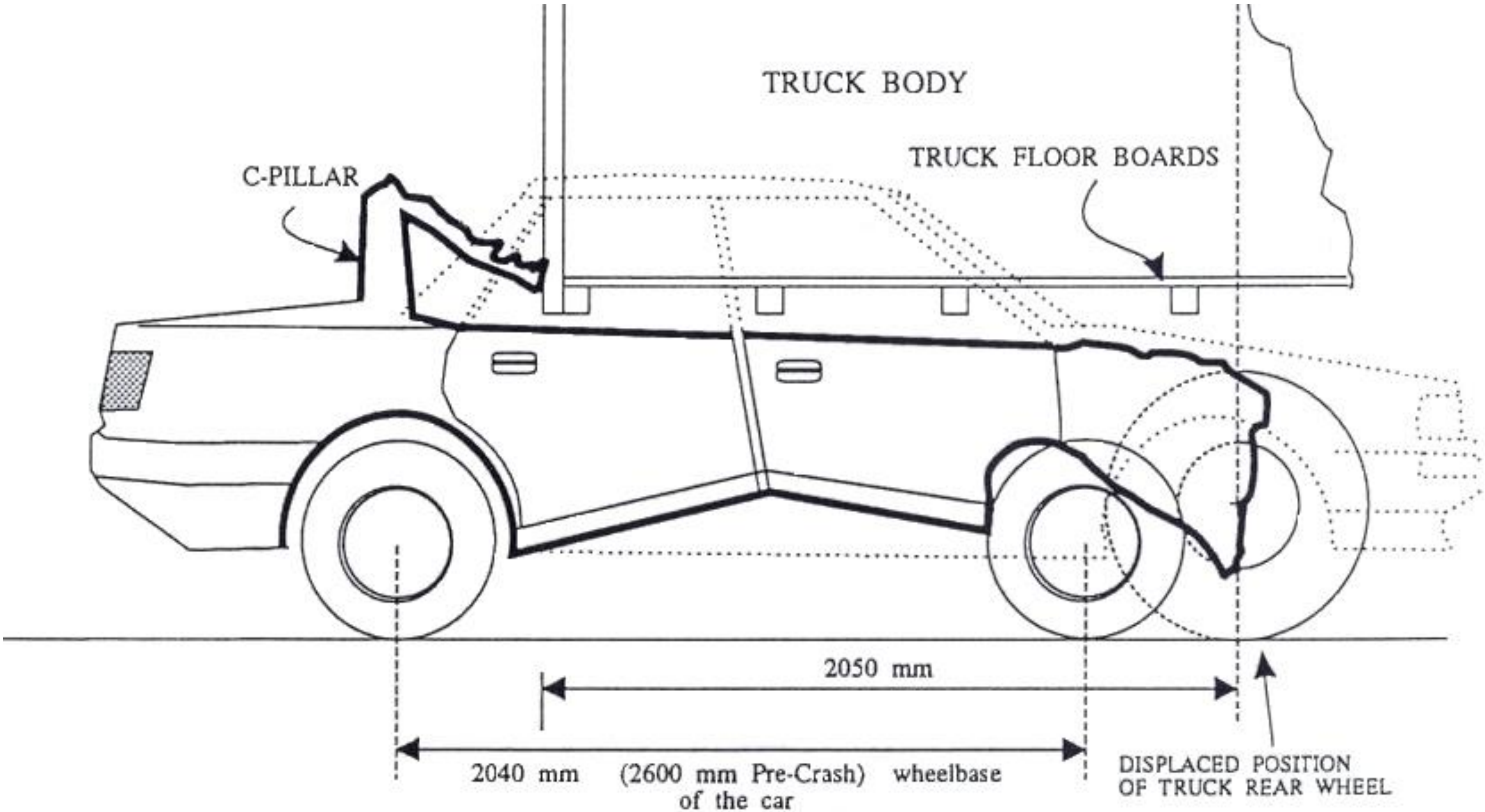
Rechnitzer & Grzebieta, Crashworthy System – a paradigm shift in road safety design (part I), Transport Engineering in Australia, IEAust, Vol. 7, Nos. 1&2, Dec 2001.

Truck underride in Australia – 50 km/h

Rechnitzer, Powell & Sayer, Performance Criteria, Design And Crash Tests Of Effective Rear Underride Barriers For Heavy Vehicles, Proceedings of the 17th International Technical Conference On The Enhanced Safety Of Vehicles, Amsterdam 2001, 4-7 June 2001

Truck underride in Australia – 50 km/h

Negates all on-board crashworthiness systems – airbags, seat belt pretensioners



Rechnitzer & Grzebieta, Crashworthy System – a paradigm shift in road safety design (part I), Transport Engineering in Australia, IEAust, Vol. 7, Nos. 1&2, Dec 2001.

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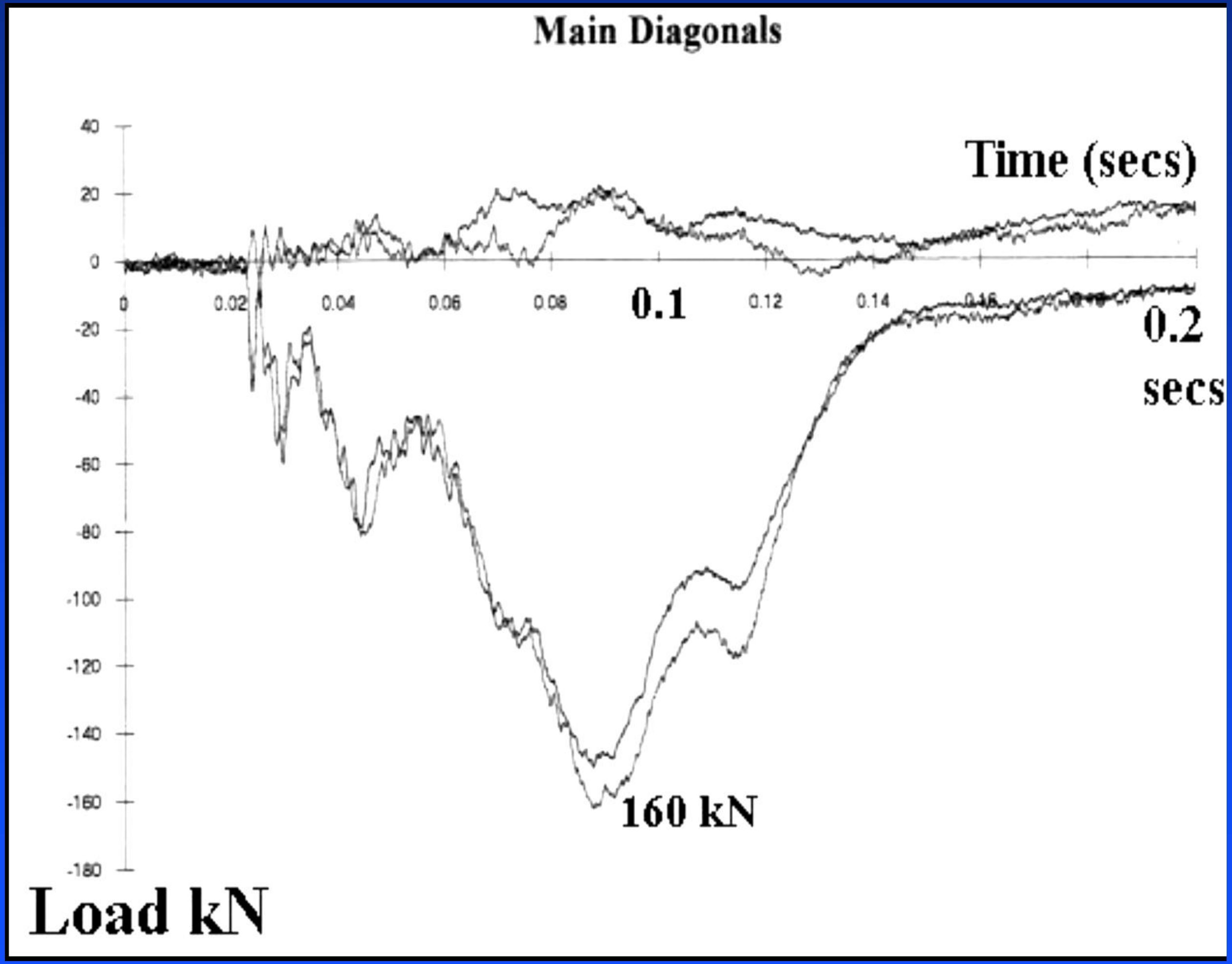
Designed Rigid Underride Barrier

Rigid Underride Crash (10 tonne truck & handbrake on – 50 km/h)

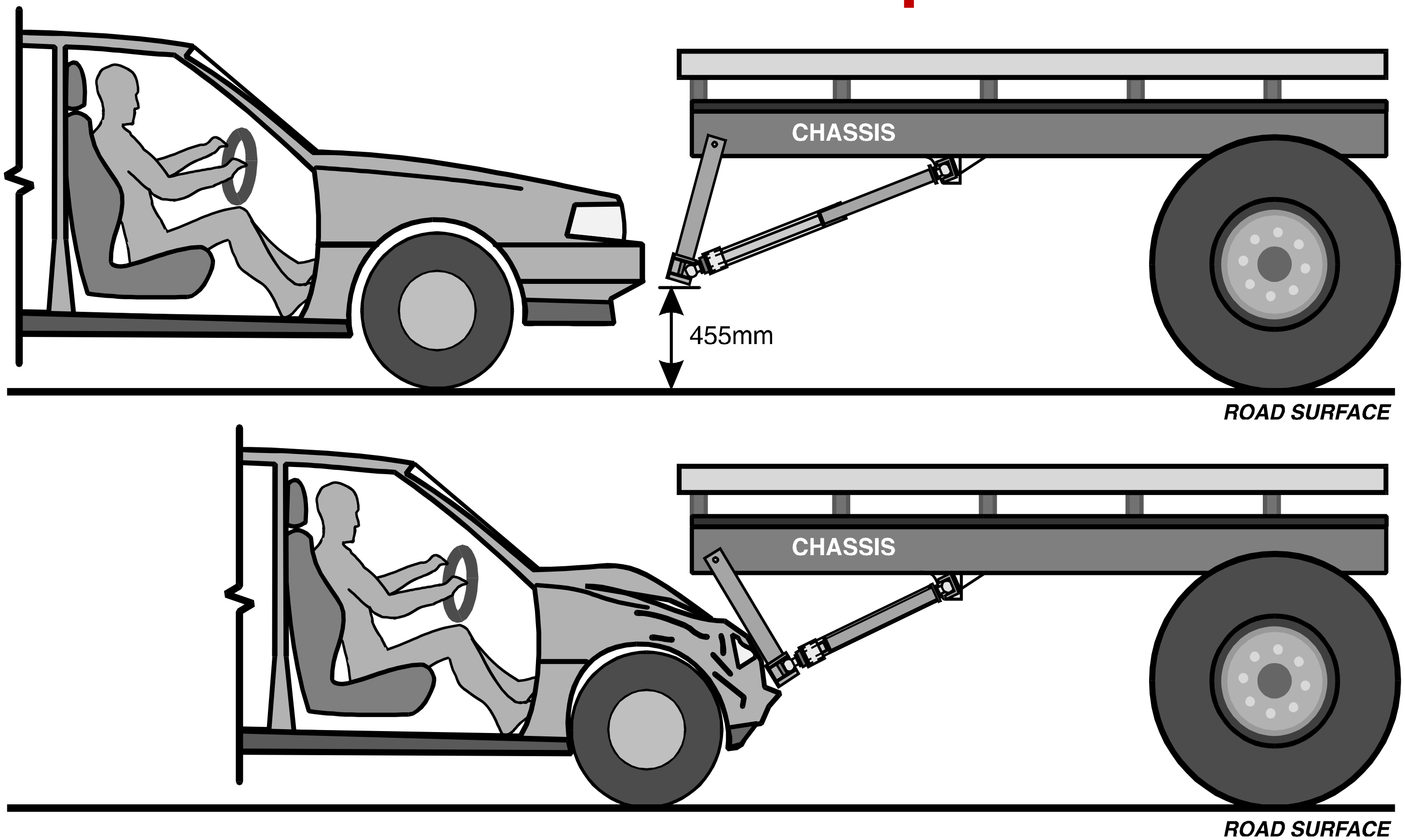
Forces in struts (Rigid system)



Rigid, 50% offset (48km/h)

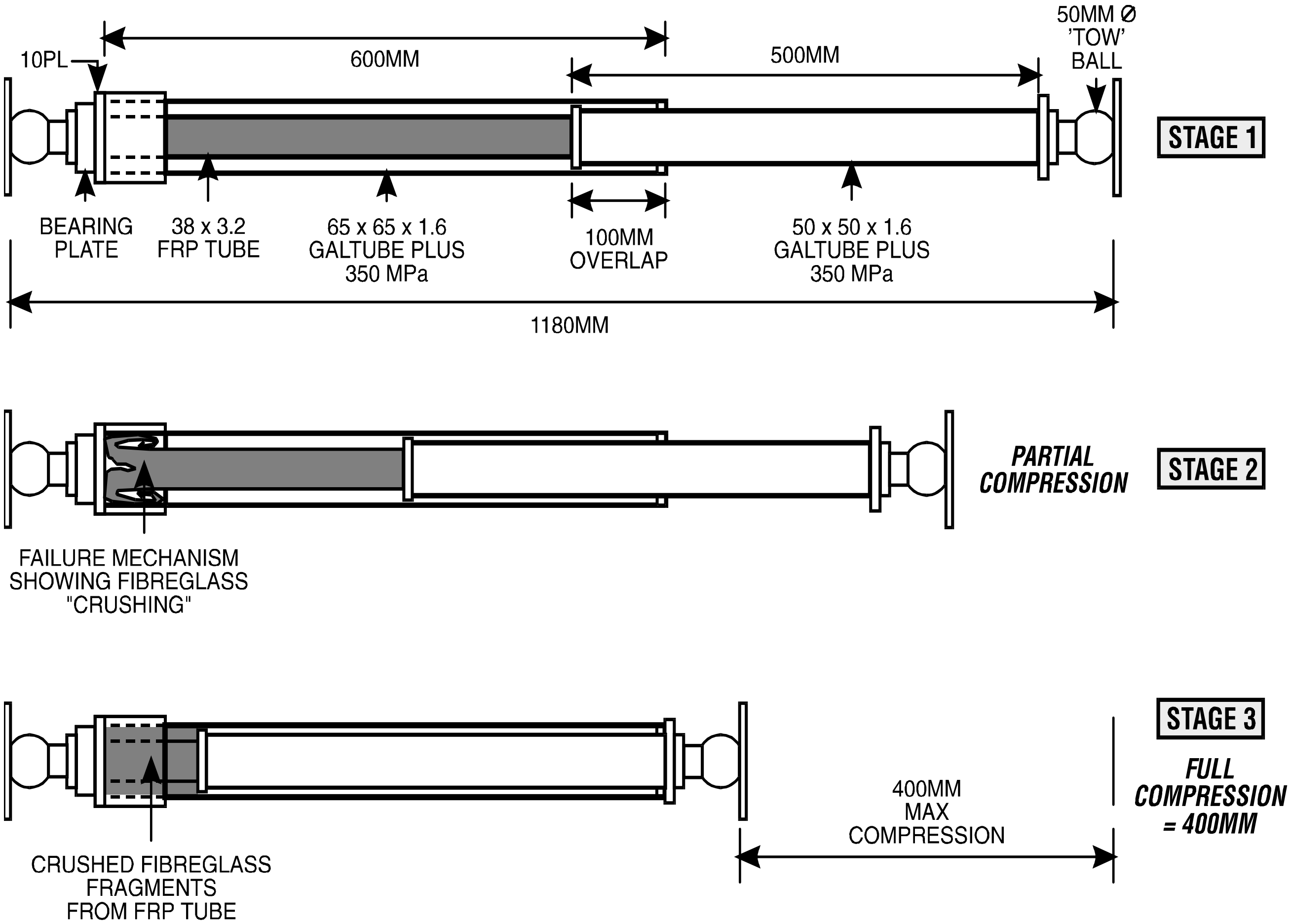
Rigid, 50% offset (48km/h)

Illustration of energy absorbing rear underride barrier system on rear of truck before & after impact



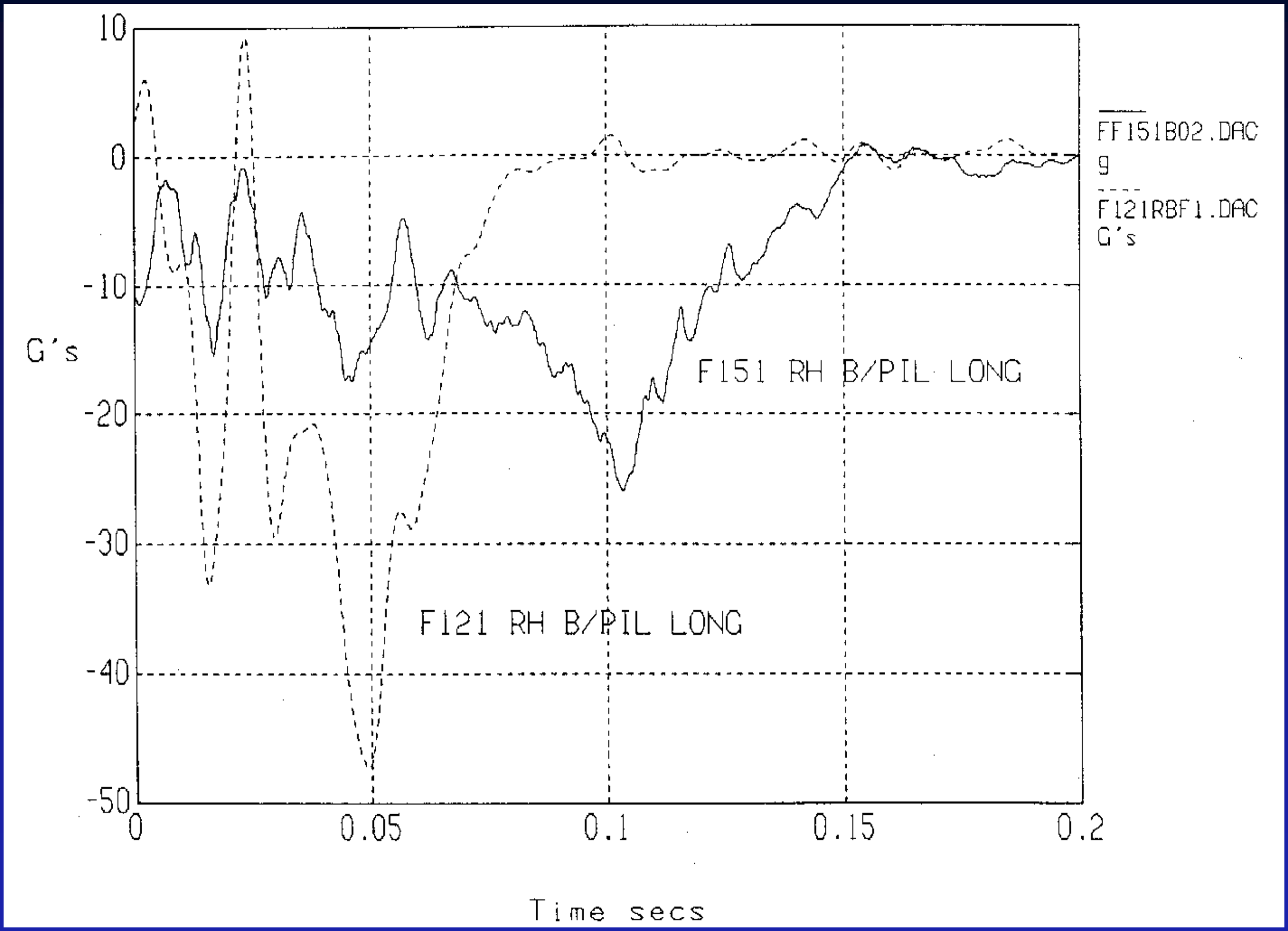
Rechnitzer, Powell & Sayer, Performance Criteria, Design And Crash Tests Of Effective Rear Underride Barriers For Heavy Vehicles, Proceedings of the 17th International Technical Conference On The Enhanced Safety Of Vehicles**,** Amsterdam 2001, 4-7 June 2001

Schematic of the energy absorbing tube-in-tube system



Crash Test 4, Energy absorbing, centred (48km/h)

Energy dissipating results



Dashed line – Full frontal concrete barrier
Solid line – With energy absorbertar

Energy absorbing, centred, 50km/h

Energy absorbing, 50% offset, 50km/h

Buckled tubes in offset test

Modified energy absorbing system

Grzebieta & Rechnitzer, Crashworthy Systems – a paradigm shift in road safety design (part II), Transport Engineering in Australia, IEAust, Vol. 7, Nos. 1&2, Dec 2001.

Modified energy absorbing system
75 km/h

Modified energy absorbing system 75 km/h

Results comparison - vehicle crash into concrete wall vs energy absorbing system

	NCAP centred impact m=1320kg 56km/h		Centred impact; m=1350kg 75km/h impact (9.1 t truck with energy absorbing barrier)	
Injury Criterion	Driver HIII	Passenger HIII	Driver HIII	Passenger HIII
Head (HIC)	1499	1223	1842	1205
Femur (kN)	L 9.41 R 1.93	3.16 1.05	14 4.1	2.56 6.57
Chest 3ms clip	59.6g	49.1	56.2g	48.2g

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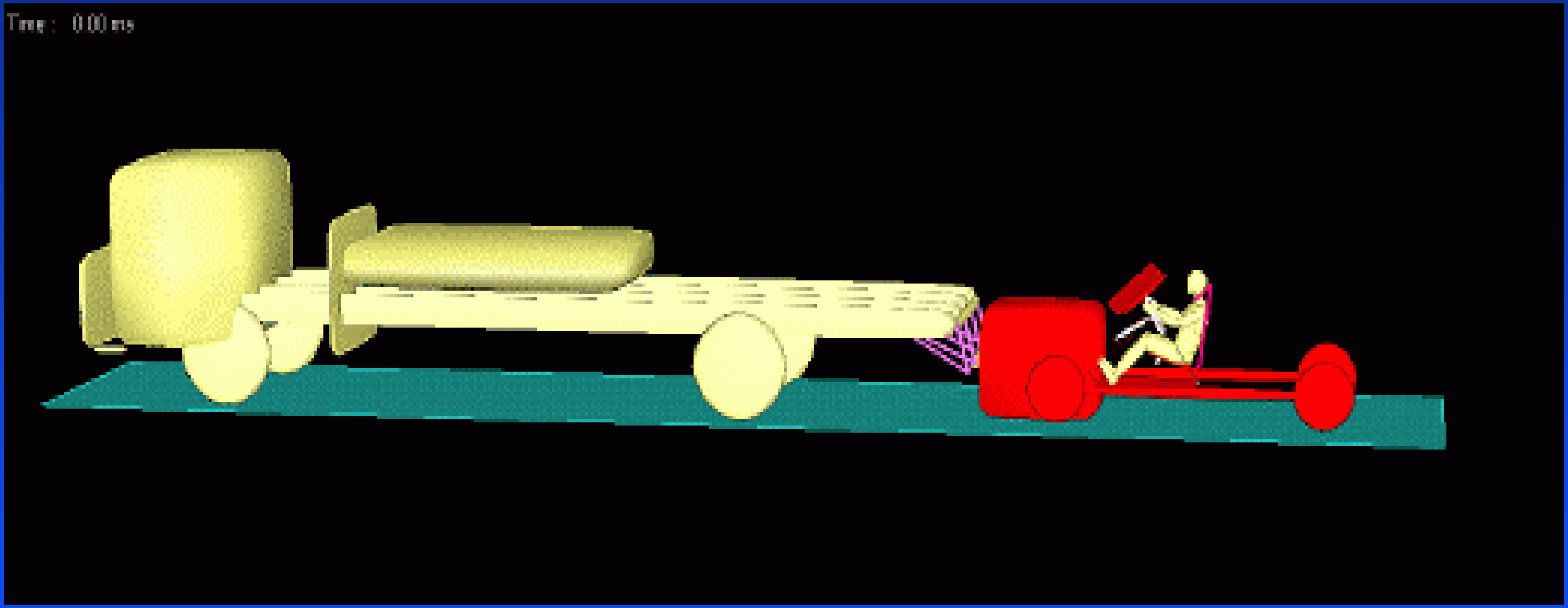
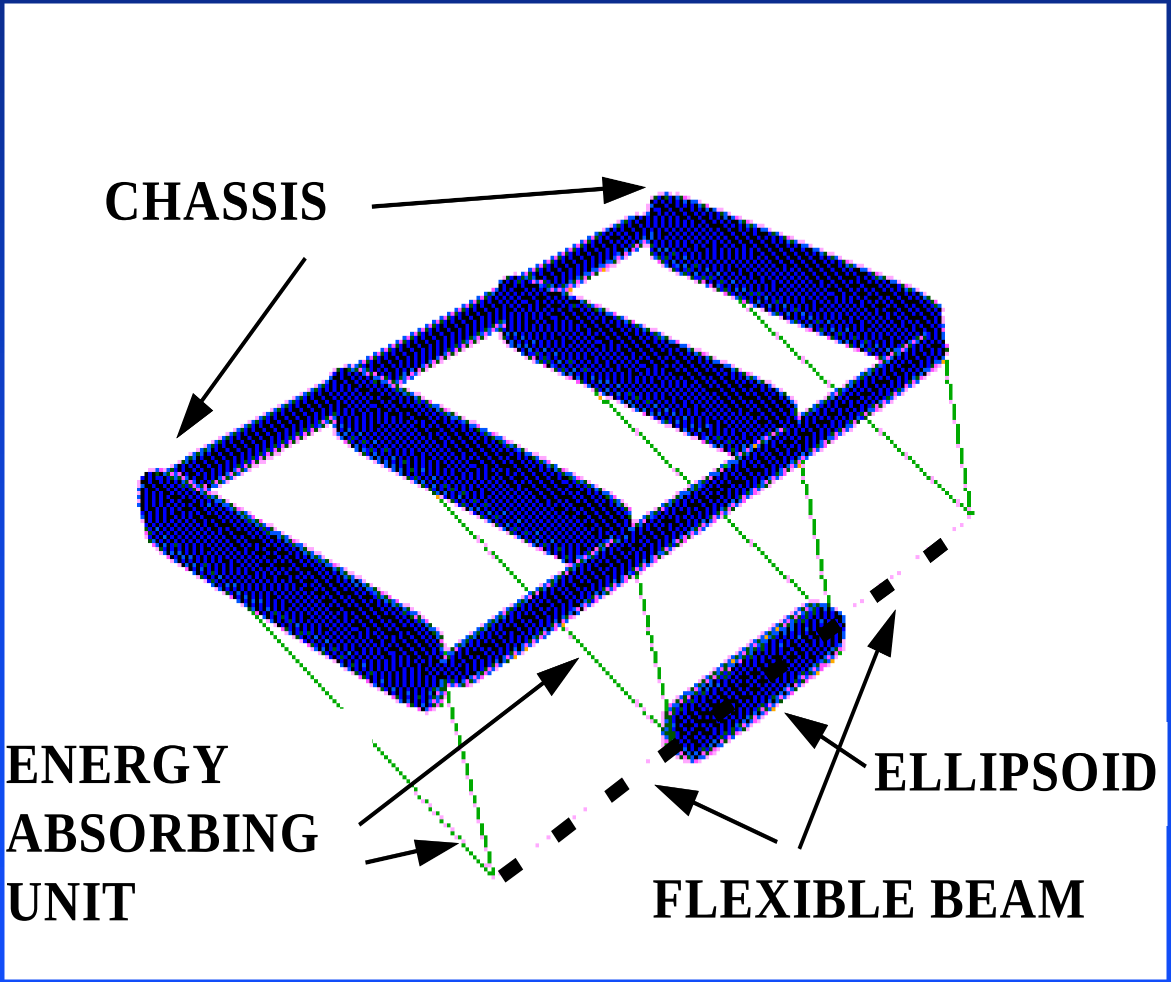
Model set-up for truck underride simulation

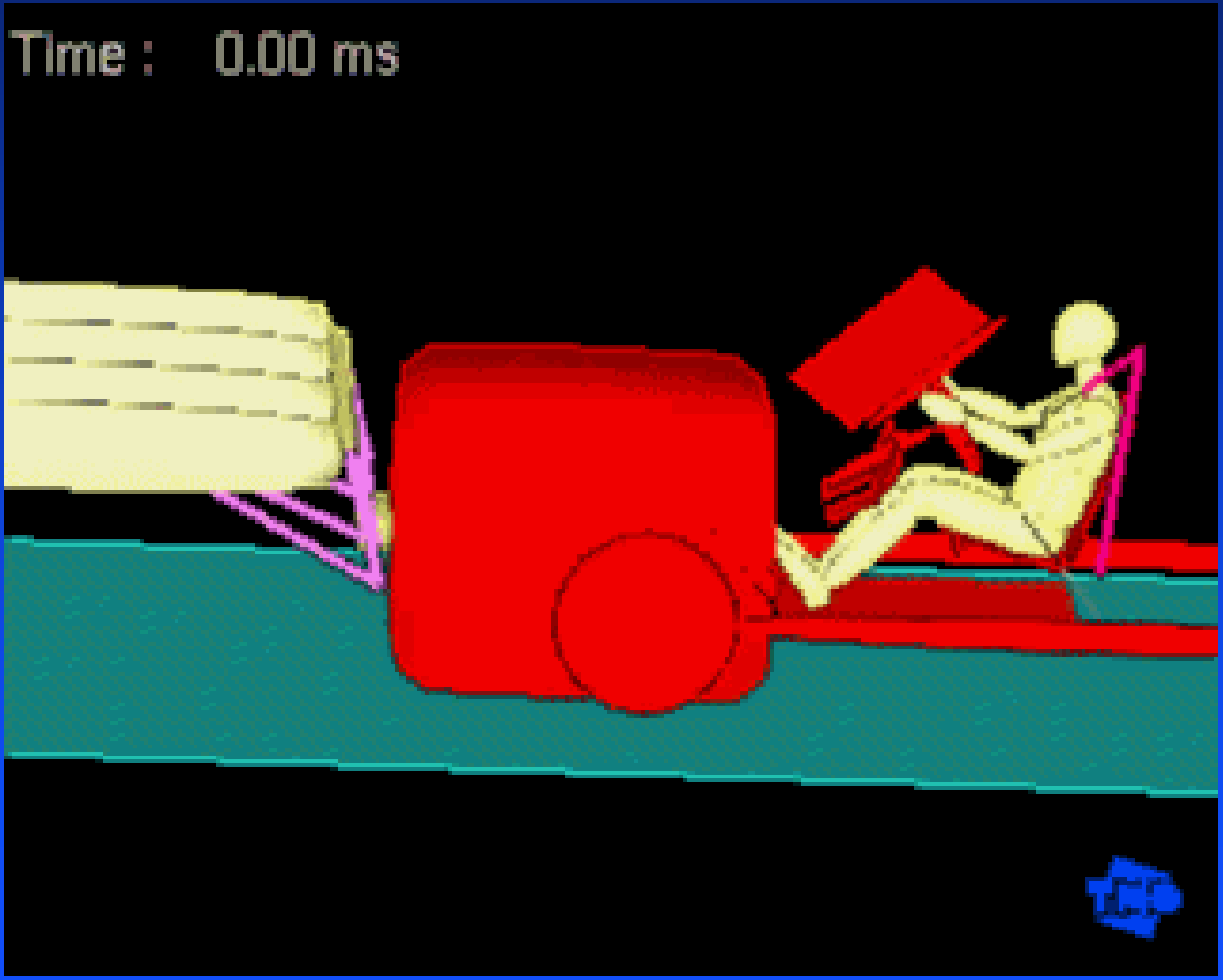


Energy absorbing underride barrier model



SIMULATION RESULTS

– no driver airbag



Injury outcomes from the MADYMO simulation compared with the crash test – without airbag

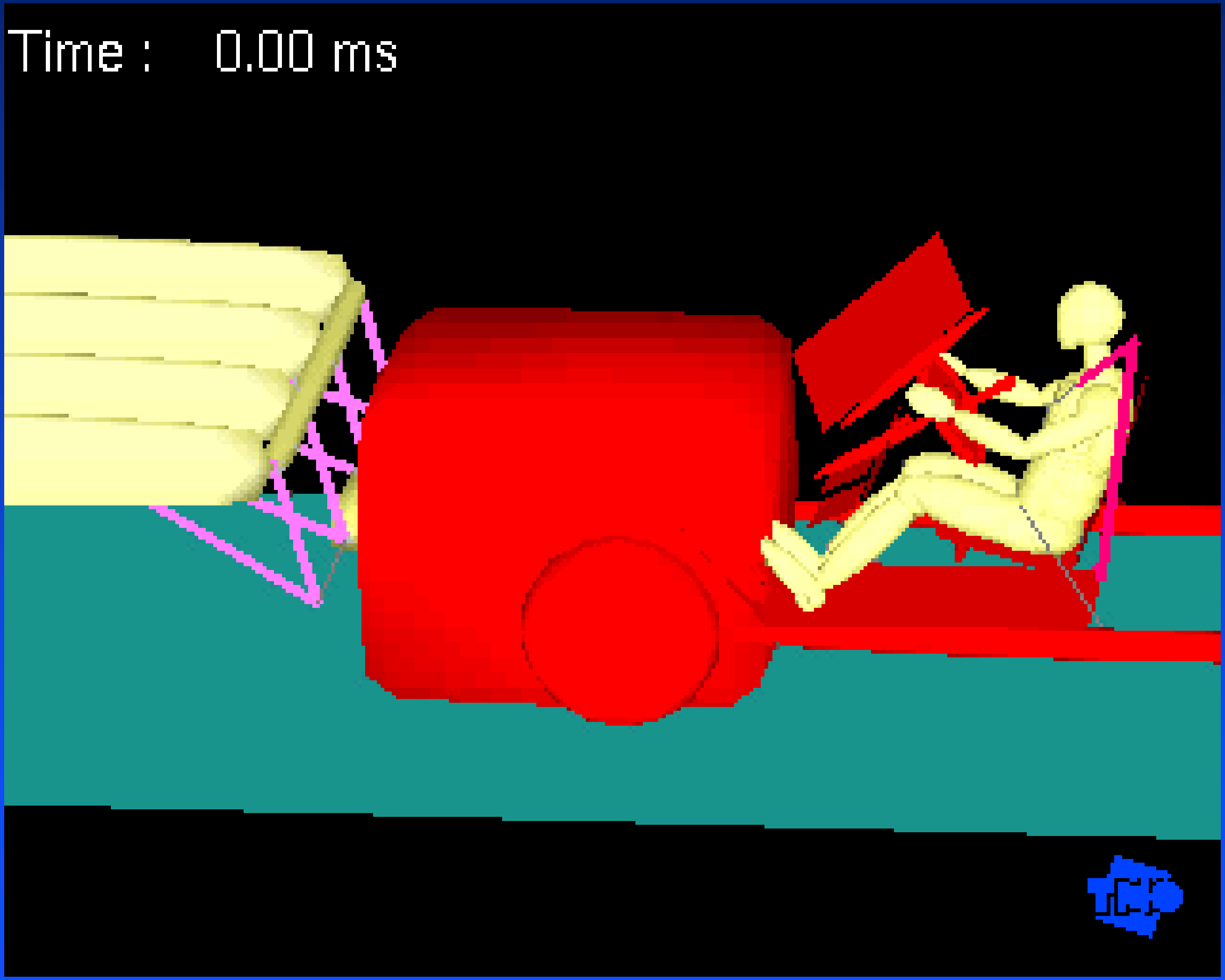
	Madymo Simulation	Crash Test
Head Injury (HIC 36) - Critical value 1000	1913	1842
Chest Injury (3ms clip) - Critical value 60g	62g	56g
Max. Femur compressive load (kN)	Left 1.2 Right 2.1	14 4.1

Summary key results for MADYMO simulation & comparison with crash test

	Madymo Simulation	Crash Test
Car (CG) Result Deceleration	41 G	40 G
Resultant car-barrier force	542kN	529kN
Total peak strut force (4 struts)	474kN	500kN

SIMULATION RESULTS

– with a driver airbag



Injury outcomes from the MADYMO simulation compared with the crash test – with airbag

Injury Criteria	Crash Test	Madymo Sim. No airbag	Madymo Sim. With airbag
Head Injury (HIC 36) - Critical Value 1000	1842	1913	869
Chest Injury (3ms) - Critical Value 60g	56g	62g	52g
Maximum Femur Compressive Load (kN) Critical Value 10 kN	14.0 4.1	Left 1.2 Right 2.1	Left 1.2 Right 2.1

http://www.unece.org/trans/main/wp29/wp29regs41-60.html

The 02 series of amendments - Date of entry into force: 11 July 2008

UNECE

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UNECE TRANSPORT AREAS OF WORK / VEHICLE REGULATIONS / AGREEMENTS AND REGULATIONS / UN REGULATIONS (1958 AGREEMENT) / REGS 41-60

- Transport
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- Meetings and Events
- Working Parties and Documents
  - World Forum for Harmonization of Vehicle Regulations (WP.29)
  - Working Party on Noise (GRB)
  - Working Party on Lighting and Light-Signalling (GRE)
  - Working Party on Pollution and

UN Vehicle Regulations - 1958 Agreement

Addenda to the 1958 Agreement (Regulations 41-60)

Important Note:

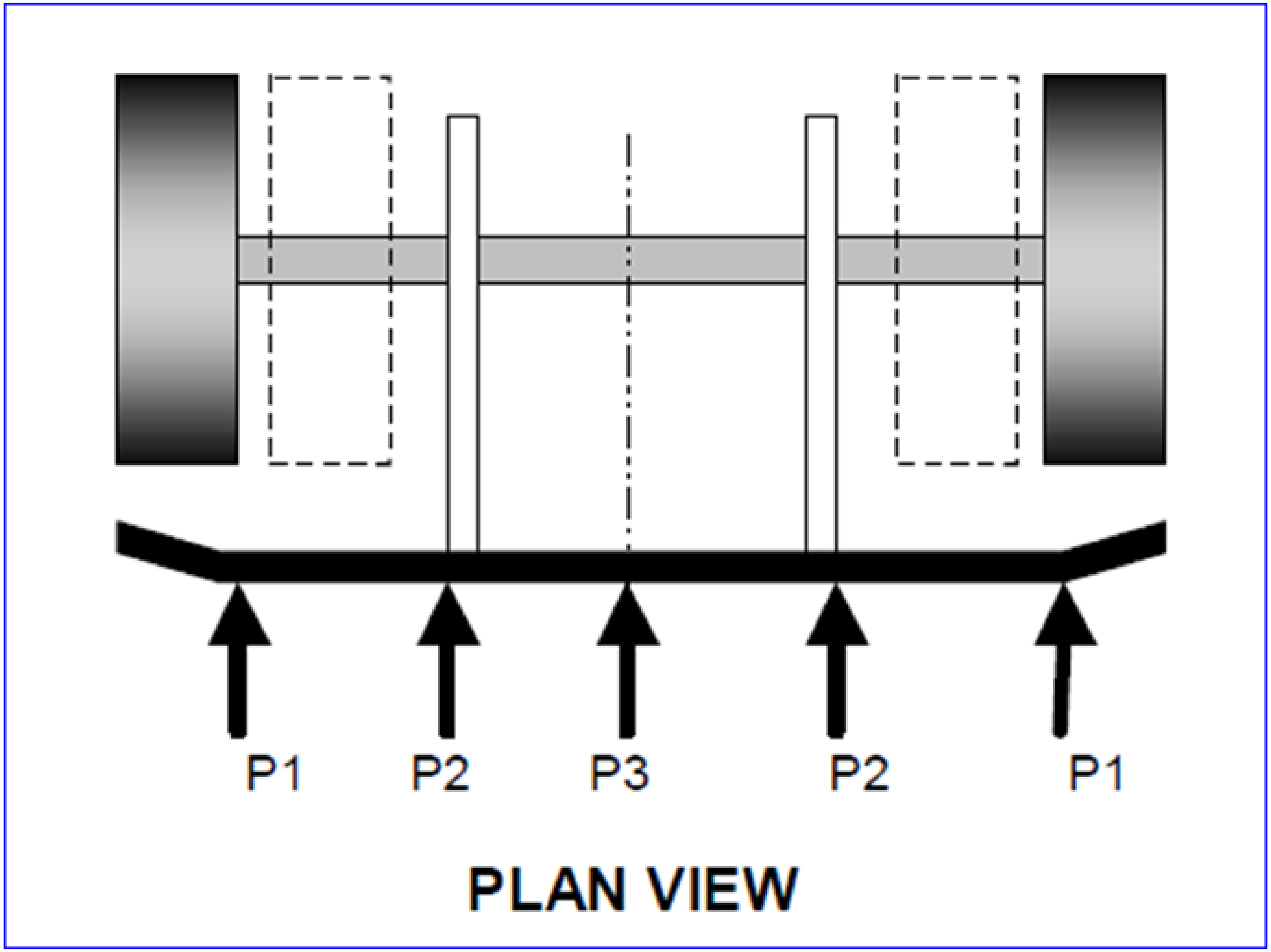
1. Some of the regulations presented in electronic format on this Website use WordPerfect fonts. If these fonts are not available on your system, certain symbols and equations may not display correctly. Click here

41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

Regulation No. 58 - Rev.2 - Rear underrun protective devices (RUPDs)

English	DOC	PDF
French	DOC	PDF
Russian	DOC	PDF

ECE R58 RUPD Test requirements



Performance criteria - Comparison with Regulations – barrier test forces

Load position	E.C.E R 58 maximum	USA (FMVSS 223/224)	Brazil	Recommended
	Test Load kN			
Outer P_1	50	50	100	200
Off centre P_2	100	100	150	200
Centre P_3	50	50	100	100

Actual loads from crash tests 160 kN

Performance criteria – Caution! Can result in weak TUB for light truck

P1 = 25% of mass vehicle mass or 50kN which ever is less

P2 = 50% of mass vehicle mass or 100kN which ever is less.

P3 = 25% of mass vehicle mass or 50kN which ever is less.

100 kN (10 tonne) truck

P1 & P2 = 25kN and P3 = 50kN !

If ECE Reg is being considered then:

- *Upgraded performance requirements for rear underride barriers needed and are feasible.*
- *Barrier test forces:*

P1 (Outer Edge)	P2 (Off Centre)	P3 (Centre)
200 kN	200 kN	100 kN

- *Height:* *400mm (not 550 mm)*
- *Width:* *within 100mm of side*
- *Energy absorption:* *50kJ minimum*
- *Maximum distance from rear of vehicle including deformation 400 mm or less*

- In 1977 Heavy Vehicle Safety report the House of Representatives Standing Committee on Road Safety concluded after hearing arguments for and against underride barriers that:

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What has happened since then?

Before1997

- Man landed on the moon (1969)
- Web browser & Search Engine (1990)
- Wifi (1991), GPS (1994), DVD (1995)

Post 1997

- Google Maps (2003)
- Human Genome (2003)
- Google Car (2005)
- MARS lander (used big airbags) (2004)
- Iphone (2007)
- Rosetta spacecraft landed on comet (2014)

Australian Standard – revision (public comment)

AS/NZS 3845.2 - Road safety barrier systems and devices

SECTION 7 TRUCK UNDERRUN BARRIERS

7.1 SCOPE

This Section sets out the requirements for Truck Underrun Barriers (TUB's) that are installed on the rear of a truck or trailer.

The performance requirements set out in this Section for TUB's may be equally applied to any truck or trailer of an articulated truck that operates on any public road and are used to protect the occupants in a vehicle that runs into the back of the truck or trailer. TUBs are permanently fixed to such vehicles.

NOTE:TUB's for any truck or trailer including the trailer on an articulated truck are discussed in the commentary in Appendix G.

7.2 GENERAL

Subject to the noted modifications of section 7.3, MASH shall be the basis of testing procedures for TUBs in accordance with Clause 4.3.

Australian Standard – revision (public comment)

AS/NZS 3845.2 - Road safety barrier systems and devices

- Performance requirements for TUB's intended for trucks servicing work sites and maintenance
- A similar function to TMA's but with reduced energy dissipating capacity, i.e. decelerate vehicles over much shorter distance and rely mostly on the crashworthiness of the vehicle
- Are mainly used to protect the occupants inside the vehicle striking back of truck or trailer and occupants of the truck in any road environment
- Are permanently fixed to the truck or trailer

Australian Standard – revision (public comment)

AS/NZS 3845.2 - Road safety barrier systems and devices

Based on MASH terminology & test protocols

– Vehicles, impact speed and criteria

TABLE 7.1
TEST MATRIX FOR TRUCK UNDERRUN BARRIERS

Test Level	Feature	Test designation	Impact conditions			Impact point	Evaluation Criteria (see Table 5.1 of MASH)[c]
			Vehicle	Nominal Speed[a] (km/h)	Nominal Angle[a] θ deg.		
2	Truck Underrun Barrier	2-51	2270P	70	0	(a)	C,D,F
		2-52	2270P	70	0	(b)	C,D,F
		2-54	1500A	70	0	(a)	C,D,F
		2-55	1500A	70	0	(b)	C,D,F

Australian Standard – revision (public comment)

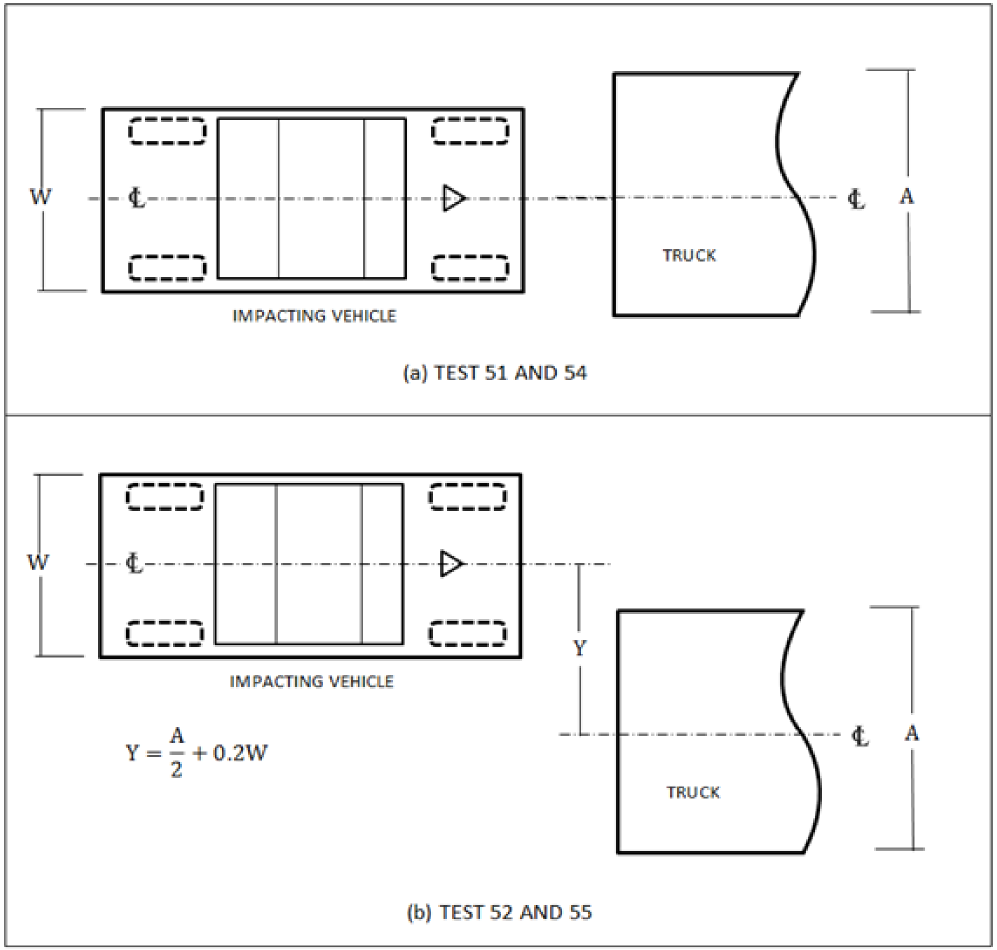

Figure 7.1

Center impact

30% overlap

$$Y = \frac{A}{2} + 0.2W$$

Australian Standard – revision (public comment)

Tests 51, 52, 54 and 55

maximum allowable truck weight and truck should be placed in second gear and the parking brake set

OR rigidly blocked support truck for unlimited weight. Support truck placed in 2nd gear and parking brake set and blocked to prevent forward or lateral motion.

OR surrogate structure that replicates the rear back portion of the truck type to which the TUB will be used when in service. Surrogate structure fixed against a crash test block replicating a rigidly blocked support truck for unlimited support weight.

Australian Standard – revision (public comment)

Tests 51, 52, 54 and 55

- TUB fixed to rear of the truck in the same way as would be installed in service.
- Maximum rearward displacement of the TUB beyond the face of the rear of the truck not to exceed 500 mm.
- TUB may deform under the impact loading but no joint failures or buckling of TUB's key support structures or of the support truck structure allowed.

Summary

- **Possible to design an underride barrier which gives equivalent deceleration characteristics to impact into a rigid wall or offset barrier**
- **ECE regulation exists but not adopted internationally – need to increase load demand to 200 kN and reduce clearance to 400 mm**
- **AS/NZS 3845.2 barrier standard contains underride crash test based on US MASH crash testing for Australia and New Zealand**

Further References

- **Papers can be downloaded from:**

  http://www.georgerechnitzer.com.au/downloads/

- **A/Prof. George Rechnitzer's PhD**

  https://www.filesanywhere.com/fs/v.aspx?v=8b6a69875e67767ca2a4

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Road Safety – it's a matter of design

Questions?

DECADE OF ACTION FOR ROAD SAFETY 2011-2020

Together we can save lives.