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PROJECT REPORT SUMMARY CPR 2161 v2

Suspension performance testing in PTI

Support service under the Engineering advice for Vehicle Standard Issues framework

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Prepared for: Road Safety Authority, Ireland

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Quality approved:

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Contents amendment record

This report has been amended and issued as follows:

Version	Date	Description	Editor	Technical Referee
1.1	08/01/2016	Rewording of a sentence (language check)	SH	PB
2	19/04/2016	Additional section in Appendix B: Letter of advice – addendum	SH	PB

1 Introduction

RSA is seeking support pertaining to suspension performance testing in PTI with the following areas of advice:

1. Overview of current operations within EU/Various Member States pertaining to Suspension Performance Testing
    a. What manner of test is being carried out
    b. What the pass/fail rates are
    c. The impact of the testing (where implemented) to improving Member State's safety statistics
    d. The suitability of the test criteria as set out in the Roadworthiness Directive.
2. Assessment of the suitability of the suspension performance testing that is carried out during NCT.
3. Review of advice sought from Motor Engineer/Assessor pertaining to the impact of the Imbalance Testing, carried out at NCT to a specific road collision case study.
    a. Understanding of what technical circumstances, if any, whereby vehicles shock absorbers could be worn equally on both sides of a vehicle at a similar rate and passing the imbalance test.

Due to the specific nature of the required advice, the findings in this report are organised in two sections:

Appendix A: Suspension performance testing at PTI (NCT), covering points 1. and 2. from the list above.

Appendix B: Letter of advice regarding point 3 from the list above

2 Main findings

Suspension performance testing at PTI (NCT) within EU/Various Member States:

- Ireland's NCT meets all the minimum European regulatory requirements for suspension testing at PTI and is one of the few member states which performs a damping efficiency related test using special equipment.
- Today, there is no agreement on a single method for testing suspension performance. This is because measurement of suspension performance without dismantling (which is not permitted in PTI) is a highly complex problem owing to measurements being influenced by many factors such as tyre stiffness (e.g. run-flat tyres) and wheel load. However, there are two fundamental methods for suspension shakers, the BOGE method which measures travel of the base plate and the EUSAME method which measures the force on the base plate.
- Methods for testing of suspension performance are in a state of flux in the EU with work ongoing to devise methods which give a good indication of the

efficiency of the damper (shock absorber) and are not influenced too much by vehicle design factors such as tyre stiffness and wheel load.

- It is unlikely that a 'perfect' method will be developed, so the likely outcome is that several methods will be developed, each with its advantages and disadvantages. Individual member states will have to choose which to use if they wish to perform a damping efficiency related test.

Review of advice sought from Motor Engineer/Assessor pertaining to the impact of the Imbalance Testing, carried out at NCT to a specific road collision case study:

- The MAHA MSD 3000 suspension test equipment used in the NCT test is designed as a test of the balance of the suspension across the axle rather than at the wheel. The test procedure is done to assess the interaction between the two shock absorbers on the axle and it is a fact that, in circumstances where the suspension units have deteriorated or failed to the same extent, no imbalance will be detected and the vehicle will pass this part of the test.
- Along with the imbalance test, the NCT procedure requires a visual inspection of the shock absorber units. In this case, there was no evidence of any fresh fluid leakage or obvious wear or damage to the dampers and the vehicle passed the imbalance test. The unexceptional suspension test results and the lack of any visible clues as to the condition of the dampers would not give any cause for the NCT examiner to believe that a problem existed or that further investigation was necessary.
- As unpalatable as this may appear, the complete and independent failure of both damper units is such a rare occurrence that it is understandable that an examiner, on the evidence presented, would have no reason to suspect coincidental component failures.
- A check of the Driver and Vehicle Standards Agency vehicle recall service indicates no inherent or recorded issues with the suspension of Mazda 121 cars within the relevant age range.

Appendix A Suspension performance testing at PTI (NCT)

Suspension performance testing in PTI

This document constitutes the briefing notes requested by RSA in email communication dated 15th December 2015. It compares the Periodic Technical Inspection (PTI) requirements for suspension testing within National Car Testing (NCT) in Ireland with the requirements in other EU Member States.

1 Summary

- Ireland's NCT meets all the minimum European regulatory requirements for suspension testing at PTI and is one of the few member states which performs a damping efficiency related test using special equipment.
- Today, there is no agreement on a single method for testing suspension performance. This is because measurement of suspension performance without dismantling (which is not permitted in PTI) is a highly complex problem owing to measurements being influenced by many factors such as tyre stiffness (e.g. run-flat tyres) and wheel load. However, there are two fundamental methods for suspension shakers, the BOGE method which measures travel of the base plate and the EUSAME method which measures the force on the base plate.
- Methods for testing of suspension performance are in a state of flux in the EU with work ongoing to devise methods which give a good indication of the efficiency of the damper (shock absorber) without being influenced too much by vehicle design factors such as tyre stiffness and wheel load.
- It is unlikely that a 'perfect' method will be developed, so the likely outcome is that several methods will be developed, each with its advantages and disadvantages. Individual member states will have to choose which to use if they wish to perform a damping efficiency related test.

2 European Requirements

Minimum requirements for periodic technical inspection (PTI) for motor vehicles and their trailers and technical roadside inspection of commercial vehicles are specified in European Directives. Current requirements for PTI are specified in Commission Directive 2010/48/EU which adapts to technical progress (i.e. updates) Directive 2009/40/EC. It should be noted that:

- Further updates are in the pipeline for the future and these are specified in Directive 2014/45/EU which repeals Directive 2009/40/EC.
- Recommendations for the assessment of defects found during PTI are given in Commission Recommendation 2010/378/EU. Note that this is not mandatory because it is a recommendation.

The current EU minimum requirements for suspension testing are shown in Annex 1 **Table 1**. For each EU requirement, reference to the relevant section where it can be found in the National Car Test (NCT) manual 2014 is given[1].

There are mandatory visual based inspection requirements for:

[1] **Reference:** http://www.rsa.ie/Documents/NCT/NCT%20Manual%20Revise%20JULY%202014.pdf

- springs and stabilizers,
- shock absorbers,
- torque tubes, radius arms wishbones and suspension arms,
- suspension joints
- air suspension.

Note that visual based inspection also includes, if relevant, handling and movement of parts with application of the force necessary to identify excessive play and other potential faults. However, dismantling is not permitted.

In relation to shock absorbers, a damping efficiency test (suspension performance test) using special equipment, which compares left/right differences and/or absolute values given by manufacturers, is recommended but not mandatory.

Suspension performance testing is carried in Ireland but not in a large number of EU Member States, e.g. the UK. The reasons for this are discussed in detail in the section below but mainly are:

- There is not a single recognised method for how to perform it,
- The cost of the special equipment to perform it is quite high.
- It not a mandatory requirement.

3 Suspension performance testing in the EU

3.1 Requirement

The performance of a vehicle's suspension is important for its safety. For example, worn shock absorbers can increase a car's stopping distance, especially on uneven roads (experiments have shown an increase of 70% for braking on un-even roads) and the probability of a rollover can be increased (probability doubled in case of emergency manoeuvre– ISO track test, double lane change manoeuvre).

In short, a vehicle's suspension is important for safety because it determines the quality of wheel-surface contact. This is particularly important for modern braking systems (e.g. anti-lock (ABS), stability control (ESC), because these operate on wheel speed sensor signals which are dependent on optimal wheel – surface contact.

3.2 Methods

For evaluation of suspension performance an inspection method and pass / fail limit values are required. Today, there is no agreement on a single method. Instead, a number of methods and associated limit values exist. These are largely based on two test bench principles, the BOGE resonance method used in MAHA equipment and the EUSAMA method used in ACTIA MULLER and VTEQ equipment.

The BOGE method measures the amplitude / travel of the base plate whereas the EUSAMA method measures the vertical tyre force on the base plate.

The problem is that each method can produce different performance ratings for the same suspension because they are measuring different parameters, so comparability of results between methods is limited.

To attempt to overcome this problem, the European Garage Equipment Association (EGEA) are currently leading the development of suspension test methods based on the damping ratio according to Lehr (commonly known as the Theta method). They hope that this method can be implemented for both test bench principles and will give comparable results for the different types of test benches. However, some stakeholders believe that they may not be successful. This is because measurement of suspension performance without dismantling (which is not permitted in PTI) is a highly complex problem because measurements are influenced by many factors including:

- Wheel load
- Tyre pressure
- Wheel position on the test bench
- Stiffness of the tyre
- Mass of wheel / tyre combinations.

At present the situation is in a state of flux with the following methods available:

- **EUSAMA (adhesion efficency)**: The EUSAMA value is a measure of the adhesion of the tyre to the road surface. It is not a direct measure of the suspension damping (shock) efficiency but obviously the two are related. It is defined as the minimum percentage of remnant vertical tyre contact force between the tyre and the platform during vertical oscillation of the wheel.

$$\text{EUSAMA VALUE (\%)} = \frac{\mathbf{Ni,j\ dyn\ min}}{\mathbf{Ni,j\ Static}} * 100\ (\%)$$

  The European Shock Absorber Manufacturers Association (EUSAMA) established the following guidelines for adhesion:

Adhesion Measured	EUSAMA Interpretation
61% to 100%	Excellent dynamic wheel contact
41% to 60%	Good dynamic wheel contact
21% to 40%	Fair dynamic wheel contact
1% to 20%	Poor dynamic wheel contact
0%	Bad dynamic wheel contact

  On this basis, failure criterion of less than 20% was used generally.

- **Minimum phase shift (GOCA)**: To resolve problems with the EUSAMA method GOCA (Belgium PTI authority) developed the minimum phase shift method. These problems included:
    - Some light vehicles with good dampers recorded EUSAMA values less than 20%.
    - Vehicles with run flat tyres with good dampers recorded EUSAMA values less than 20%.
    - Some light vehicles with good dampers recorded EUSAMA values less than 20%.

The minimum phase shift φ_{min} is the lowest value of the phase shift φ, determined during the test, between the sprung and unsprung mass resonant frequencies. It is more related to the performance of the damper than the EUSAMA adhesion efficiency method.

An absolute failure limit of less than 35 deg is used together with an imbalance (left to right difference on an axle) of greater than 50%.

- **BOGE (oscillation amplitude):** The BOGE method calculates the maximum oscillation amplitude of the wheel to evaluate the axle damping.

  An imbalance failure limit of greater than 30% is used.

- **BOGE (Lehr):** MAHA has developed a method to calculate the Lehr damping ratio based on the BOGE principle, the amplitude / travel of the base plate and taking into consideration other factors such as axle weight and attenuation constant.

  An absolute failure criterion of less than 0.1 together with an imbalance left/right criterion of greater than 40% are suggested.

- **Damping Coefficient (VTEQ):** VTEQ in collaboration with the University of Madrid have developed a method to calculate a damping coefficient based on the EUSAMA principle.

  An absolute failure limit of 0.12 has been proposed which has been shown to be valid for 99.87% of the car population analysed.

- **FSD test:** FSD is a government controlled organisation in Germany with the purpose to help develop the future of PTI. FSD has developed a simple suspension damping test based on driving the vehicle over a speed bump and measuring its body motion. Note that the German PTI includes a short drive of the vehicle.

3.3 Testing in the European Union

Information available from CITA[2] (mainly the results of a worldwide survey) has been analysed to help determine the current situation related to suspension performance testing in the EU. The results of this analysis can be found in Annex 1, **Table 2**. It should be noted that the CITA survey results only contained responses from PTI organisations in 17 EU member states and some responses were unclear.

In summary it was found that:

- In 5 EU Member States (MS) testing of suspension performance is obligatory. These MS are Belgium, France, Greece, Ireland and Portugal.
- In 2 EU MS testing of suspension performance is performed by some PTI organisations, but it is not obligatory. These MS are Germany and the Slovak Republic.

As far as can be determined, Belgium is the only MS which has failure limits for suspension performance imbalance (left/ right difference on an axle) and absolute limits for each wheel position. However, it should be noted that the absolute limits for each wheel position were implemented very recently, July 2015.

[2] CITA: International Motor Vehicle Inspection Committee: http://www.cita-vehicleinspection.org/

1 Annex 1: Detailed Information

Table 1: European Directive (2010/48/EU) requirements for suspension inspection at PTI.

Item Reference Directive 2010/48/EU Annex 1:	Item description	Method	Failure	Reference NCT 2014 manual
5.3.1	Springs and stabilizer	Visual inspection with vehicle over pit or on a hoist	(a) Insecure attachment of springs to chassis or axle (b) Damaged or fractured spring component (c) Spring missing (d) Inappropriate repair or modification	Item 45: Front springs Item 56: Rear springs
5.3.2	Shock absorbers	Visual inspection with vehicle over pit or on a hoist or using special equipment if available	(a) Insecure attachment of shock absorbers to chassis or axle (b) Damaged shock absorber showing signs of severe leakage or malfunction	Item 48: shock absorber condition
5.3.2.1	Efficiency testing of damping **	Use special equipment and compare left/right differences and/or absolute values given by manufacturers	(a) Significant difference between left and right (b) Given minimum values not reached	Items 19 (& 20): Front (Rear) axle suspension performance
5.3.3	Torque tubes, radius arms, wishbones and	Visual inspection with vehicle over pit or on a hoist	(a) Insecure attachment of component to chassis or axle (b) A damaged, fractured or excessively corroded component (c) Inappropriate repair or modification	Item 46: Front suspension Item 55: Rear suspension

Item Reference Directive 2010/48/EU Annex 1:	Item description	Method	Failure	Reference NCT 2014 manual
	suspension arms			
5.3.4	Suspension joints	Visual inspection with vehicle over pit or on a hoist	(a) Excessive wear in swivel pin and/or bushes or at suspension joints (b) Dust cover missing or seriously deteriorated	Item 46: Front suspension Item 55: Rear suspension
5.3.5	Air suspension	Visual inspection	(a) System inoperable (b) Any component damaged, modified or deteriorated in a way that would adversely affect the functioning of the system (c) Audible system leakage	Item 45: Front springs Item 56: Rear springs

** Note: Item related to the condition of the vehicle and its suitability for use on the road but not considered essential in a periodic technical inspection.

Table 2: Suspension performance testing in EU member states.

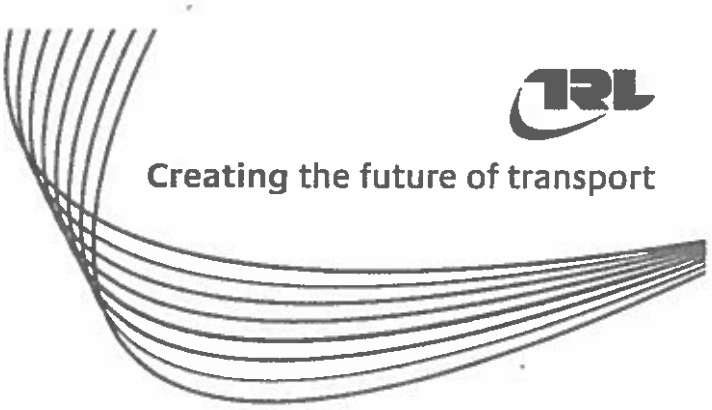
	EU Member State	Suspension Performance Testing?	Method / comment / limits
1	Austria	No	
2	Belgium	Yes - obligatory	EUSAMA (minimum phase shift) Limits for both imbalance (left/right) and individual side performance are used.
3	Denmark	No	
4	Estonia	No	
5	France	Yes – obligatory	EUSAMA (efficiency) Phase shift also allowed. Unsure what limits are used.
6	Germany	Yes – allowed but not obligatory – some test organisations perform it	DEKRA use BOGE, both oscillation amplitude and Lehr damping. FSD have designed new simple method which involves driving over speed bump and measuring vehicle body motion.
7	Greece	Yes – obligatory	EUSAMA (efficiency). Unsure what limits are used.
8	Ireland	Yes – obligatory	BOGE (oscillation amplitude) Limits for imbalance, fail > 30% imbalance.
9	Italy	No	
10	Latvia	No	
11	Luxemburg	No	
12	Portugal	Yes – obligatory	BOGE. Unsure if oscillation amplitude or Lehr used.
13	Slovak Republic	Yes – not obligatory	
14	Spain	No	Some PTI centres have equipment and are able to do it
15	Sweden	No	

	EU Member State	Suspension Performance Testing?	Method / comment / limits
16	Netherlands	No	
17	United Kingdom	No	

Appendix B Letter of advice

Our Ref 11108863/T06
Your Ref:

7 January 2016



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Dear [redacted]

As requested I have carried out an assessment of the provided papers relating to the reported suspension fault with the Mazda 121 motor car, registration number 95D25534, driven by Ms Amanda O'Flaherty (now deceased) when involved in a road collision on 29 December 2012.

I present this memorandum as initial advice in this matter, provided in isolation to any other information that exists or which may subsequently come to light when additional facts are established.

The primary sources of information that I have been given are the assessor's report of Mr Liam Cotter, on behalf of Ms Paula Murphy, Ms O'Flaherty's mother, two NCT test reports in respect of the Mazda, some press cuttings, a spreadsheet of NCT data and a copy of email correspondence between MAHA and RTE. Of the NCT reports, the first is dated 11/07/09 and the most recent 31/05/12, seven months prior to the collision date.

The condition of the Mazda 121

Both the police and Mr Cotter state that, after the collision, the Mazda's rear suspension was found to be defective, and Mr Cotter's investigation suggests that there was no damping oil remaining in either of the rear suspension struts. Mr Cotter also states that there was no evidence of recent fluid leaks from the dampers, implying that their failure had been long-standing. His conclusion is that the dampers were defective not only before the collision, which appears undeniable, but that they must also have been defective 'well before the NCT as well.'

In essence, I have to agree with this comment, although there has to be a possibility, however remote, that the struts failed between the dates of the NCT and the collision. I will return to the subject of the failure of the dampers later.

The shock absorber/suspension strut

The shock absorber is, strictly speaking, misnamed since the unit does not actually absorb shock at all, that is the job of the coil springs. The purpose of the shock absorber is to damp the oscillations created by the springs' absorption of the vehicle's movement. Without dampers, the body of the vehicle (the sprung weight) would oscillate significantly on anything but the smoothest roads.

At the foot of this letter I include a link to an online YouTube video clip, originally produced by the Open University, which demonstrates this effect.

Discussion of NCT and testing equipment

Since June 2011, the NCT requires that all cars over 10 years old must be tested every year. The Mazda in this incident, which I understand was a 1995 model, would fall into this category.

The suspension test which is the relevant issue in this investigation is carried out using MAHA MSD 3000 test equipment. It is important to note that this equipment is designed as a test of the suspension across the axle rather than at the wheel. Therefore, the equipment is operating and reporting correctly and within its specification when it measures the balance of the suspension – it is simply not required, as part of the NCT, to quantify the effectiveness of the suspension at any individual wheel.

Mr Cotter has made the error of assuming that the suspension test figures, given in units of 'Mm', refer to millimetres. In fact the unit Mm means MAHA-metres, a nominal reference value invented by the equipment manufacturer which, although it may, effectively, equate closely to millimetres, is not truly intended as a measurement of suspension travel. It is simply a method of determining the imbalance between the shock absorbers at each end of the axle.

It should also be remembered that different cars, even of the same type, will have different suspension settings which will give differing readings on the test reports. This can be either as a matter of design and manufacture or of driver/owner modification.

For instance, a car with firmer, lowered or sports suspension will give differing figures to one with a softer more comfortable ride. Some cars have manually or electronically adjustable suspension and for others the alterations might be owing to the fitting of new coil springs, dampers, anti-roll bars or other equipment. Additionally, an owner might choose to replace worn parts with non-standard, cheaper items or components purchased from a vehicle breaker. In either case the performance of the individual component cannot be guaranteed to match that of the manufacturer's originally specified equipment.

The suspension test results obtained in the NCT test preceding the collision, in May 2012, give MAHA-metre readings of 96Mm and 94Mm for the rear nearside and offside of the Mazda. This is in contrast to the 2009 NCT readings of 51Mm and 45Mm, respectively.

It is suggested by Mr Cotter that the 2012 readings should have been a sufficient enough reason for the vehicle to fail the test. In fact, analysis of the NCT tests of 29 different 1995 model Mazda 121s tested between 2011 and 2013 suggests otherwise.

The rear suspension readings for this batch of examples range between 58-123Mm at the nearside and 55-131Mm at the offside, with the 50th percentile being at 90Mm on both sides and the 85th percentile at 96Mm and 99Mm. It appears, therefore, that the readings obtained in the NCT test of Ms O'Flaherty's Mazda in May 2012 were not, in themselves, remarkable and, since the test was carried out at a different station and by a different examiner, there was no reason for the 2012 examiner to find the test unusual.

There is no standardised or official basis for evaluation of the shock absorber test values and an NCT examiner would, therefore, only build up a picture of what figures to expect from the test based upon experience. In this case, it appears that the figures recorded by the test would, in all likelihood, be at or within the expected range for this vehicle.

For all of the above reasons, it is clear that the balance of the shock absorbers across an axle is not an exact science and that the MAHA-metre figures in this case, although appearing significant, would not, in the circumstances of a positive test result for balance, be likely to flag up an issue to the NCT examiner.

Simultaneous/coincidental failure of dampers

It is difficult to define the expected life of dampers/shock absorbers – manufacturers will recommend replacement at around 60,000 miles and, from a study in Germany, failure was mostly recorded in a range of 40,000 to 110,000 miles.

The actual life expectancy of the units is largely determined by the usage of the vehicle. For example, a vehicle that does large mileages on motorway quality roads will place much less stress on its dampers than vehicles that are regularly travelling on potholed country roads or urban roads with lots of speed humps.

The mileage of the Mazda was around 68,000 miles, meaning that, if the units fitted to the car were the manufacturer's original equipment, they were at a stage at which necessary replacement might not be surprising.

That said, the simultaneous or concurrent complete failure of both rear dampers is an extremely rare and unusual occurrence. Logic would suggest that this failure could only be by the loss of damping oil from the struts over a long period of time; it is hard to think of a mechanical reason which would cause both rear dampers to fail and lose all of their fluid quickly at the same time.

For example, had the failure been of the front suspension struts, it might suggest that the vehicle had been driven aggressively over speed bumps or along rough roads. This, however, would be unlikely to explain the failures at the rear, since the front end of the vehicle would generally be subjected to higher and more immediate stress.

Although Mr Cotter describes the defective rear shock absorbers, he does not offer a reason as to how or why the damping fluid was lost.

I note that Mr Cotter's description of the Mazda's history suggests that it may have been 'stood up' for a lengthy period of time prior to Ms O'Flaherty's purchase of it. This suggests that neglect and poor/non-existent maintenance of the vehicle may have contributed to the failure of the dampers. It is possible that, because of the lack of

regular use of the vehicle, the damper seals may have perished and failed, allowing the fluid to escape. Mr Cotter does not mention the condition of the seals.

The coincidental failure of both rear dampers also suggests the possibility of an underlying mechanical issue. This could be through the fitting of inappropriate aftermarket components, such as unsuitable replacement coil springs or damper units, which might have placed undue stress on the dampers themselves.

Summary

The MAHA MSD 3000 suspension test equipment used in the NCT test is designed as a test of the balance of the suspension across the axle rather than at the wheel. The test procedure is done to assess the interaction between the two shock absorbers on the axle and it is a fact that, in circumstances where the suspension units have deteriorated or failed to the same extent, no imbalance will be detected and the vehicle will pass this part of the test.

Along with the imbalance test, the NCT procedure requires a visual inspection of the shock absorber units. In this case, there was no evidence of any fresh fluid leakage or obvious wear or damage to the dampers and the vehicle passed the imbalance test. The unexceptional suspension test results and the lack of any visible clues as to the condition of the dampers would not give any cause for the NCT examiner to believe that a problem existed or that further investigation was necessary.

As unpalatable as this may appear, the complete and independent failure of both damper units is such a rare occurrence that it is understandable that an examiner, on the evidence presented, would have no reason to suspect coincidental component failures.

A check of the Driver and Vehicle Standards Agency vehicle recall service indicates no inherent or recorded issues with the suspension of Mazda 121 cars within the relevant age range.

Addendum from 19 April, 2016

On 15 April 2016 I was provided with test reports from the RSA which assist with providing some clarification and expansion of the points already made.

The reports describe a number of tests of vehicles with shock absorbers presented in a variety of states of repair, including used, new and defective condition (with no damping oil present).

Two independent AA reports were provided, one in respect of a Mazda 121 and the other in respect of a Skoda Octavia.

Using MAHA NCT equipment, the Mazda 121 report quotes widely varying readings of suspension travel, ranging from the high 60s for used and new shock absorbers to over 200Mm for those with no damping oil.

In the Skoda Octavia report the results obtained ranged from the high 30s for new condition, mid-50s for used and around 220Mm for those with no oil.

These results suggest two things:

i. The MAHA readings obtained from the NCT tests of the collision Mazda 121 motor car, registration number 95D25534, driven by Ms Amanda O'Flaherty (of 51/45 in 2009 and 96/94 in 2012) are unremarkable. With the readings of both of the tested, undamped vehicles being over 200Mm, the collision Mazda's readings do not appear excessive enough to support the claim that the condition of the vehicle as presented at its NCT should necessarily have prompted further inspection.

ii. In my original letter of advice above, I commented that *'[Mr Cotter's] conclusion is that the dampers were defective not only before the collision, which appears undeniable, but that they must also have been defective 'well before the NCT as well.' In essence, I have to agree with this comment, although there has to be a possibility, however remote, that the struts failed between the dates of the NCT and the collision.'* It should be remembered that I have not seen either the original vehicle or its dampers and that, therefore, I have had to rely upon Mr Cotter's assessment of their condition. I have previously acknowledged that the Mazda's dampers may have been defective at the time of its NCT although I am not, and never have been, in possession of sufficient evidence to comment upon their precise condition at that time. The independent evidence from the AA's tests, and the other documents supplied by the RSA, now suggests that, at the time of the NCT, the Mazda's shock absorbers may not have been defective at all, and almost certainly not to the point of being completely drained of oil.

If I can be of further assistance, please don't hesitate to ask,

Yours sincerely

Simon Hall

Senior Consultant

Incident Investigation and Reconstruction Group

Engineering and Technology

TRL

Video Clip demonstrating undamped suspension:

https://www.youtube.com/watch?v=EbkWaNDyFOQ