

# Failure of Indirect Tyre Pressure monitoring systems puts drivers and road users at risk

Independent tests show indirect TPMS pass the regulatory test but fail to work on the road

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A briefing by



## Summary

Tyre pressure monitoring systems (TPMS) designed to alert the driver when their tyres are deflating or at a dangerously low pressure have been mandatory on passenger cars in Europe since 2014. There are two systems on the market today – direct and indirect TPMS; with carmakers increasingly choosing to equip their vehicles with indirect systems due to their lower price.

T&E has long been aware that indirect TPMS fails to deliver in real-world driving conditions, and is concerned that such systems could be optimised to pass the regulatory test but fail to perform appropriately on the road. We have commissioned a set of tests on two vehicles equipped with such indirect systems to check their effectiveness. Both cars failed to pass most of the tests that slightly diverged from the prescribed protocol, pointing to 1) serious safety concerns for drivers using indirect TPMS and 2) manufacturers calibrating the systems to only pass the test and not deliver on the road.

Following the #Dieselgate scandal manufacturers are also suspected of cheating on safety tests as well as those for emissions. More in-depth investigation by national regulators is necessary. Urgent regulatory action is also necessary at EU level to ensure TPMS delivers in real-world conditions; this must be mandated for all vehicles and apply also to replacement tyres no later than 2018. Lives should not be put in danger for the sake of tiny cost savings for carmakers.

## 1. Tyre pressure monitoring systems up until now

### 1.1. TPMS Regulation

Maintaining optimal pressure of vehicle tyres is crucial for road safety; it also improves fuel efficiency. It is estimated that at least one in four vehicles is running on under-inflated tyres.<sup>1</sup>

Severe tyre under-inflation contributes to road accidents affecting the braking and handling performance of the vehicle, particularly on wet surfaces. Under-inflated tyres also wear more quickly. Overall speed related accidents, including inability to brake in time, account for around one fifth of all truck accidents,<sup>2</sup> and TNO estimates that properly maintaining tyre pressure could reduce that number by 4% to 20%.<sup>3</sup>

Tyre pressure monitoring systems (TPMS) can reduce the problem of underinflated tires by continuously measuring tyre pressure and warning the driver if any of the tyres are under-inflated or deflating and therefore potentially dangerous. While primary aim of TPMS is to avoid unsafe tyre pressure, this also

<sup>1</sup> <http://www.tirerack.com/tires/tiretech/techpage.jsp?techid=44>

<sup>2</sup> TNO report, [http://ec.europa.eu/clima/policies/transport/vehicles/heavy/docs/tno\\_2013\\_final\\_report\\_en.pdf](http://ec.europa.eu/clima/policies/transport/vehicles/heavy/docs/tno_2013_final_report_en.pdf)

<sup>3</sup> Ibid.

improves fuel economy by optimizing the energy necessary to drive a vehicle. The overall fuel reduction is relatively small (less than 1%) and the highest potential has been observed for heavy goods vehicles.<sup>4</sup>

EU Regulation EC/661/2009<sup>5</sup> mandates TPMS on all passenger cars from November 2014. This legislation transposes the UNECE regulation R64, which stipulates that:

- A warning signal shall appear no later than **10 minutes** after the pressure in **one tyre** is reduced by 20% or drops to 1.5bar
- A warning signal shall illuminate no later than **60 minutes** if **any of the tyres' (up to 4)** pressure is reduced by 20%
- A separate **malfunction warning** shall appear no later than **10 min** after any malfunction in the operation of TPMS occurs (e.g. vehicle's TPMS systems doesn't work or identify the tyre under-inflation properly).

## 1.2. Direct and indirect TPMS

Two systems to monitor tyre pressure and alert drivers have been designed to date: direct and indirect TPMS. **Direct systems** (dTPMS) use pressure sensors located in each wheel to directly measure the pressure in each tyre and warn the driver, through dashboard, when the air pressure in any of their tyres drops to dangerous levels. Because direct TPMS have a real-time pressure sensor in each wheel, they generate accurate warnings and can alert the driver promptly (between a few seconds and a few minutes depending on the rate of deflation). Such systems detect gradual air loss over time.

**Indirect TPMS** (iTPMS) is a software-based device that estimates pressure difference between tyres by comparing rotational speeds (and tyre vibrations in more advanced systems) of one tyre in relation to others. Such systems are cheaper than dTPMS but have a number of shortcomings, notably:

- iTPMS are unable to accurately measure tyre pressure in real time
- iTPMS rely on regularly calibration by the driver, which makes them vulnerable to improper tuning
- A vehicle must be moving for the iTPMS to work and thus cannot be used to check inflation levels at a petrol station (where drivers often inflate their tyres)
- Because many parameters can influence a wheel's rotational speed and cause vibration (road surface, temperature, environment, tyre type, etc) such systems are predisposed to generate frequent false warnings. For example, false warnings may occur when the tyres spin on wet, icy and snow-covered roads, or if the road surface is bumpy; confusing the driver and undermining the effectiveness of the system.

The EU law doesn't differentiate between direct and indirect TPMS provided they can meet the type approval test requirements. Manufacturers of both systems today successfully pass the specified homologation (type approval) tests in line with the protocol agreed at UNECE level. The use of indirect systems is growing because they are cheaper despite their inaccuracy and failures.

T&E has been concerned by the inability of iTPMS to deliver safety benefits in real-world driving conditions, due to its reliance on rotational and vibratory differences which on the road are influenced by many factors apart from tyre pressure. To investigate the issue further we commissioned independent tests to check the effectiveness of iTPMS on the road and particularly how tests are being conducted.

## 2. Testing results point to iTPMS failure<sup>6</sup>

T&E commissioned an independent testing service to test two vehicles equipped with indirect TPMS: a VW Golf 7 and Fiat 500L. The vehicles used different tyre manufacturers and were rented from nearby rental

<sup>4</sup> Ibid.

<sup>5</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:200:0001:0024:en:PDF>

<sup>6</sup> Summary of testing results for the two vehicles can be found in the Annex ; full reports are published alongside this briefing

companies. All the technical specifications and detailed testing results can be found in the two reports published alongside this briefing. Each vehicle performed 11 tests: involving a combination of different driving situations with one or more under-inflated tyres. The tests were repeated twice for repeatability and the results are summarised below.

## 2.1. Under-inflation of one tyre

T&E asked the testing lab to perform two tests where one tyre is under-inflated to critical levels according to the regulations.<sup>7</sup> In the first instance (test P-00), both VW and Fiat were driven strictly in accordance with the test protocol used at type approval to verify compliance, and in both cases the warning appeared within the 10 minute limit set in legislation.

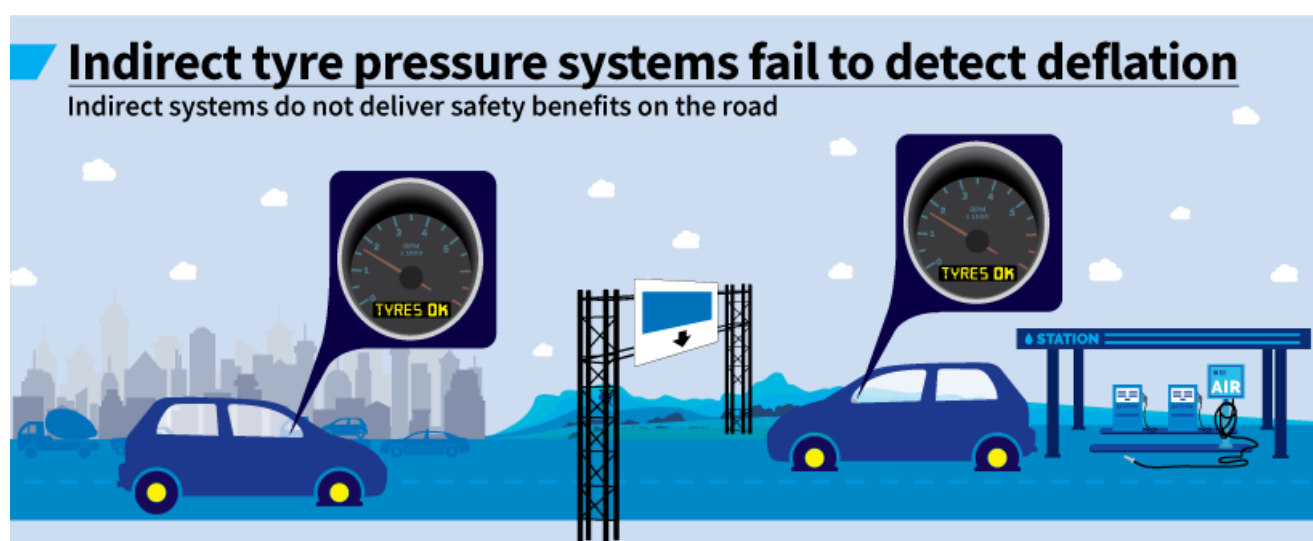
In the second test (P-01) both cars were driven freely on the test track with one tyre on purpose calibrated at 1.4 bar (below the legal threshold of -20% pressure reduction) for 70 mins. iTPMS failed to issue a warning in either the VW or Fiat, pointing to a clear failure to meet the safety standard on the road. The tests were repeated twice.

## 2.2. Under-inflation of all tyres

T&E also asked the testing service to perform a number of tests with more than one tyre under-inflated (all four in most cases) to see if iTPMS will send timely warnings in line with the law. The regulatory test (D-00) was performed with both vehicles successfully alerting the driver within the 60 min limit.

However, **the iTPMS on both VW Golf and Fiat 500L failed to issue a timely under-inflation warning in at least 5 of the six tests performed in which the test conditions slightly deviated from the official test.** Each of these tests aimed to represent driving conditions that can reasonably be encountered on the road and included the following situations:

- A trip involving suburb roads and motorways at different speeds from 45km/h to above 90km/h with all tyres under-inflated by over 20% (test D-01)
- A typical situation of driving 20 mins in a city at low speeds and then going to a motorway (around 100km/h) with all tyres under-inflated by over 20% (test D-02)
- Driving at high speeds above 100km/h with all tyres under-inflated by over 20% (on a German motorway for example) (test D-03)
- Repeating the exact type approval test but on tyres with short and medium mileages of 400km and 800km accordingly with all tyres under-inflated by over 20% (tests D-04 and D-05)



<sup>7</sup> UNECE regulation R64, <https://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/r064r1e.pdf>

- Driving with all four tyres calibrated at a critical level of 1.4bar (for example when renting a car and not checking tyre pressure/how it was reset if no gauge is available) (test D-06)

In 5 out of 6 of the above tests, that on purpose diverge from the prescribed test cycle, the TPMS warning signal failed to illuminate in either VW Golf or Fiat 500L. In the case of repeating the prescribed test but on an older vehicle, the warning time has equally failed to respect the 60 min limit; e.g. well over two hours in the case of Fiat. This demonstrates a complete failure of indirect TPMS to perform the task for which it is intended in various driving situations thereby potentially putting the driver and other road users at risk.

### 2.3. Malfunction warning

T&E also included tests to verify the compliance with the last part of TPMS regulations, the malfunction warning. This is designed to notify the driver that their TPMS system is not functioning properly and cannot recognize dangerous under-inflation so that action is sought to repair it. In both tests – with one tyre calibrated at 1.4bar and with four tyres at 1.4bar – the iTPMS failed to recognize and notify the driver of its defect (malfunction) on either of the vehicles within the 10 min limit (tests M-01 and M-02 respectively).

This is particularly worrying, as this means that the driver feels safe and is not aware that their iTPMS system is dysfunctional and will not alert them in case of critical pressure levels.

## 3. Conclusions and recommendations

The test results of the two vehicles equipped with indirect TPMS clearly demonstrate failure of such systems to deliver in the real-world driving situations outside of the test prescribed by the regulation. The driver – knowing the tyre safety systems is present in the car and not seeing any warning - is left to believe that their tyres are safe and at the right pressure as there is 1) no under-inflation warning and 2) no malfunction warning. This is unacceptable, as pressure lower than 1.5 bar is critical for safety, with a tyre starting to detach from its rim, for example when braking.

In summary the tests commissioned by T&E show:

- Both VW Golf and Fiat 500L equipped with indirect TPMS demonstrate compliance within the narrow test specifications of UNECE R64 homologation test conditions
- Both cars show very poor performance in the other real-world driving conditions chosen (outside of the type approval test conditions)
- **Out of the 16 “real-world” tests (i.e. diverging from the test protocol) performed by the testing lab, VW Golf has failed 14 and Fiat 500L – all 16**
- Not a single Malfunction Warning was issued to inform the driver of the unsafe situation they were in.

The tests not only demonstrate the clear failure of iTPMS to deliver required safety and fuel efficiency benefits, but also suggest optimisation of indirect systems that are calibrated to pass the type approval test but not be operational when used on the road. The major increase in warning time when older tyres are used to repeat the regulatory test is particularly suspicious, and points to a possible de-sensitification of the iTPMS.

Such optimisation can be explained by manufacturers’ desire to avoid many false warnings that iTPMS would otherwise produce, confusing the driver and undermining its very purpose. Because iTPMS don’t measure actual tyre pressure relying instead on rotational speeds and vibrations, many real-world driving conditions such as road surface, temperature, weather conditions, etc, would cause its warning alerts. To avoid this, manufacturers might be choosing to only sensitize iTPMS during the narrow conditions of the regulatory tests. This is similar to the use of defeat devices to detect emissions tests and reduce this

emissions only under these conditions. Similar findings on the performance of indirect systems were earlier revealed by TNO<sup>8</sup>, Dutch research organization. **More in-depth investigation is necessary to analyse that.**

The failure of indirect systems has already been acknowledged by UNECE, and its working group W29 has recently passed amendments clarifying that TPMS systems must operate “over a wide range of road and environmental conditions” (instead of in accordance with the test procedure only) and that a malfunction warning time cannot be ignored due to “external conditions” that manufacturers are currently allowed to use as a derogation (similar to the abuse of loopholes for switching off exhaust treatment systems to protect the engine).

T&E welcomes this amendment and calls on the EU – in its upcoming review of the General Safety Regulation (GSR) – to strengthen European TPMS provisions, specifically:

1. The new TPMS requirements agreed at UNECE must be **swiftly implemented into EU law with an ambitious timetable**, 2017 for new types and **2018 for all new passenger cars**
2. Operational requirements for TPMS to deliver in real-world driving conditions should be **extended to all tyres**, including after-market replacement ones. Drivers will change tyres more than once in their vehicle’s lifetime and safety must be guaranteed throughout. This includes the switchover to winter tyres.
3. TPMS must be made **mandatory for all vehicle categories**, including vans, trucks and buses (All M and N categories)
4. A robust “**safety net**” should be included to **prevent incorrect TPMS calibrations** in the future.

As part of the current negotiations on the new Type Approval Framework Regulation (TAFR), TPMS systems (as other vehicle safety and emission systems) should be **checked for their performance on the road over the lifetime of the vehicle** by the national market surveillance authorities and the Commission. Any failure to comply with the requirements on the road should be investigated and appropriate remedy action, such as recalls, pursued.

The current Dieselgate scandal has shown how carmakers are optimizing their vehicles to only pass the emissions test by turning down emission controls on the road. This recent testing data shows that this behaviour might go beyond emissions and involves safety systems like iTPMS as well. The performance of such systems degrades considerably over time with no malfunction warning to alert the driver. While cars equipped with iTPMS pass the regulatory tests, they suspiciously fail to meet the safety requirements on the road and are therefore largely ineffective in protecting drivers and other road users.

## Further information

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<sup>8</sup> TNO study, [http://ec.europa.eu/transport/road\\_safety/pdf/vehicles/study\\_tyres\\_2014.pdf](http://ec.europa.eu/transport/road_safety/pdf/vehicles/study_tyres_2014.pdf)

## Annex: results summary

<b>VW Golf 7</b>	
<b>Benchmark tests of iTPMS</b>	
<b>TEST ID</b>	<b>Time of TPMS warning ON [min]</b>
P00-1	1
P00-2	2
P01-1	NO WARNING
P01-2	NO WARNING
D00-1	8
D00-2	7
D01-1	18
D01-2	9
D02-1	NO WARNING
D02-2	NO WARNING
D03-1	NO WARNING
D03-2	NO WARNING
D04	78
D05	71
D06-1	NO WARNING
D06-2	NO WARNING
M01-1	NO WARNING
M01-2	NO WARNING
M02-1	NO WARNING
M02-2	NO WARNING

<b>Fiat 500L</b>	
<b>Benchmark tests of iTPMS</b>	
<b>TEST ID</b>	<b>Time of TPMS warning ON [min]</b>
P00-1	4
P00-2	3
P01-1	NO WARNING
P01-2	NO WARNING
D00-1	10
D00-2	9
D01-1	NO WARNING
D01-2	NO WARNING
D02-1	NO WARNING
D02-2	NO WARNING
D03-1	NO WARNING
D03-2	NO WARNING
D04	151
D05	137
D06-1	NO WARNING
D06-2	NO WARNING
M01-1	NO WARNING
M01-2	NO WARNING
M02-1	NO WARNING
M02-2	NO WARNING