Notes for UN ECE Informal GRRF Ad-Hoc TPMS WG Meeting in Bonn on Nov 28 & 29, 2007

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A/ Why TPMS fitment is also relevant to Europe & Asia ?

- EU Commission has introduced an aggressive plan to reduce CO2 emissions in Europe and one area for improvement is passenger cars
  - Target of 120mg CO2/km by 2012 (CARS 21)
- One effective way to reduce CO2 emissions on such vehicles is to ensure tire pressures are as near optimum as possible (to minimise Rolling Resistance).
  - Fuel consumption and therefore CO2 emissions of a passenger car can increase temporarily by up to 13 % when tyres are severely under-inflated (Quattroruote August 2006)
- TPMS is a significant aid to effective tire pressure management and thereby contributes directly to lower CO2 emissions.
- This has been clearly demonstrated in the real world as significant reduction in the occurrence of vehicles having under-inflated tires has been achieved since the wide spread introduction of TPMS in the US.
  - Cars driven with under-inflated tires reduced from ~ 26% to 1.9% (SAE presentation to ISO 21750 WG – 2007).
- Furthermore TPMS fitment would also improve safety by timely informing the driver when tires are in “under-inflated” or “punctured” conditions and thereby would contribute to reduce related accidents.

A/ Why TPMS fitment is <u>also</u> relevant to Europe & Asia ?

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- Technology exists today to have TPMS included as a standard feature for vehicles used in the European & Asian markets.

- All OEMs in Europe & Asia already fit TPMS systems as standard to vehicles exported to the USA and most also offer TPMS as standard or as an option to vehicle sold in Europe & Asia.
  - Fitting latest generation of TPMS sensors to a vehicle rim does not require any major design changes to rim and in many cases does not require any rim modification at all.
  - TPMS does not require design changes to tires.

- Production capacity is readily available in the automotive supplier base if there was a regulation to make TPMS a requirement in Europe & Asia.

- For latest generation of TPMS, costs models shows a clear cost saving to vehicle owners.
  - Reducing fuel consumption (e.g.: by 4% for an under-inflation of 0.6bar)
  - Increasing tire life (e.g.: by 30% for an under-inflation of 0.6bar)

    ⇒ **Payback of TPMS can be as short as 6 months !**

    (cost model in Appendix 1)

Appendix 1 – Cost Benefit Model

Distance travelled per annum	12,000	miles	19200	Kms	1.6	Km /miles
Fuel consumption ave (no tpms)	35	mpg	8.0	L/100kms	4.5	Litres / gallon
Fuel Price	1.00	£ / litre	1.5	Euros/litre	1.5	Euros/£
Annual Fuel Costs	£1,543		2,314 €			

Tire Life	25,000	40000 Kms
Tire Cost	£80	120 €

Typical TPMS System Cost	£30	45 €

Driver does not check tire pressure			
Under-Inflation average	0.6	bar	(assumption for the purpose of this calculation)
Increase in fuel consumption	4	%	
Increase in tire wear	30	%	(this % varies with tire type and driving style)
Increased Cost due to under-inflation per annum			
Fuel	£61.71		92.6 €
Tires	£46.08		69.1 €
Total	£107.79		161.7 €

TPMS system fitted and tires filled at "advice warning on"			
Under-Inflation average	0.175	bar	(50% of 0.35bars)
Increase in fuel consumption	1	%	
Increase in tire wear	10	%	(this % varies with tire type and driving style)
Increased Cost due to under-inflation per annum			
Fuel	£15.43		23.1 €
Tires	£15.36		23.0 €
Total	£30.79		46.2 €

TPMS Cost Benefit per annum	**£77.01**	**115.5 €**

Lifetime of TPMS sensor electronics (including battery) is typically 10 years or 160,000 Km.

B/ Proposed TPMS Performance Criteria to help reduce CO2 & Improve safety

- There should be two requirements for any TPM system:
  - A/ “Advise”

    Inform the driver when the tire(s) needs to be re-inflated to restore it to the correct recommended tire pressure.

    Suggest that when this condition occurs the driver is informed as an “information message”
    - e.g. - “Low tire pressure - Add Air”
  - B/ “Action”

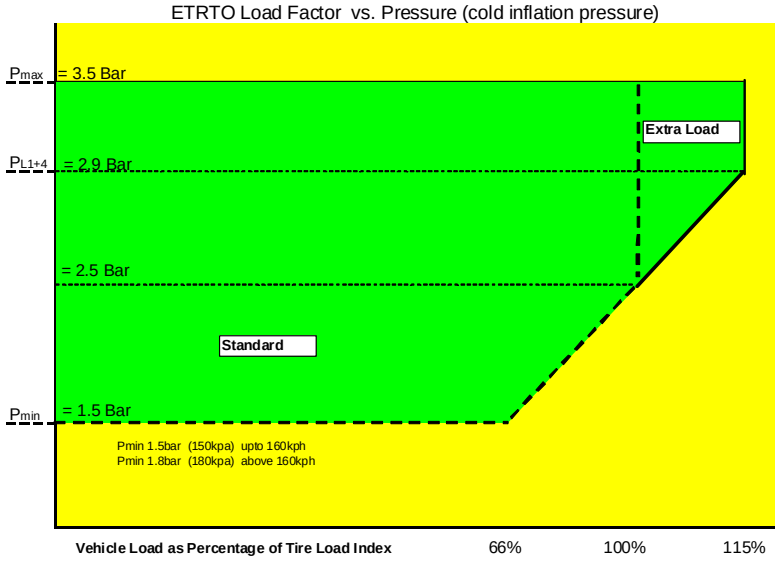
    Inform the driver when there is a puncture or “very under-inflated” tire(s) and that the driver must perform an action as the vehicle is, or soon will be, not safe to drive.

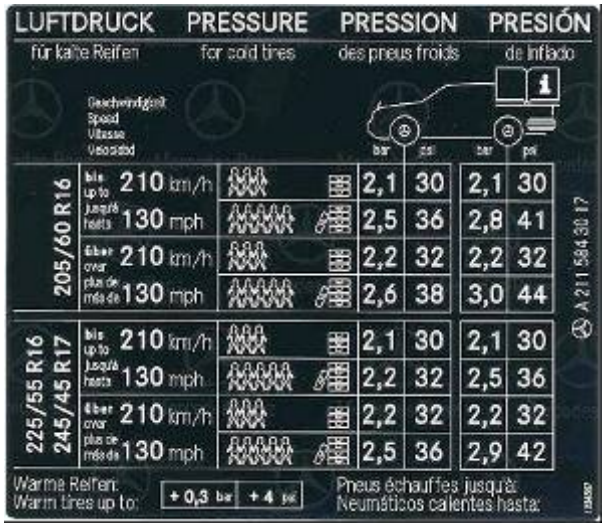
    Suggest that when this condition occurs the driver is informed as an “action message”
    - e.g. - “Very low tire pressure – make a safe stop”
- Those two requirements should refer to TPMS Performance Criteria.

B/ Proposed TPMS Performance Criteria to help reduce CO2 & Improve safety

Basis for TPMS Performance criteria:

- There are already in existence technical standards for tires showing when a tire is “under-inflated” (ETRTO) based, in particular, on tire Pressure and Load. These requirements can and should be part of any TPMS system’s requirements. OEM’s convert these requirements into Placard Plates.





- The Tire Industry has recently published data on RunFlat tires and their performance when used in “runflat mode” – this data should also be considered.

- ISO and UN ECE already have started discussions on TPMS Performance Criteria.

B/ Proposed TPMS Performance Criteria to help reduce CO2 & Improve safety

Proposed TPMS Performance Criteria – Warning thresholds:

- A/ “Advise“ - Pressure Maintenance
  - Inform the driver when the tire(s) needs to be re-inflated to restore them to the correct recommended tire pressures. – “Low tire pressure - Add air”
    - Under-Inflated tires start to increase fuel consumption when tire pressure is about 0.2bar (20kpa) or more under-inflated.
    - Suggestion is to “advise” driver when tire pressure has dropped by 0.35bar.
      We believe 0.35bar represents the minimum detection threshold which meets the combined requirements of TPMS stability (driver trust) and CO2 reduction requirements. This value allowing for some changes in ambient temperature and general diffusion in tire.
- B/ “Action” - Safety
  - Inform the driver when there is a puncture or “very under-inflated” tire(s) and that the driver must perform an action. e.g. – “Very low tire pressure – make a safe stop”
    - Under-Inflated – when tire pressure dropped by 0.5bar (50kpa) below recommended pressure *or*
    - Under – Inflated at ETRTO min of 1.5bar *or*
    - Load Factor Limit (Load rating x tire pressure)
      - Which ever of these is the highest pressure value (see Appendix 2).

B/ Proposed TPMS Performance Criteria to help reduce CO2 & Improve safety

Proposed TPMS Performance Criteria – Reaction time:

- Once the warning thresholds are defined, there is then a need to define time to trigger warnings.

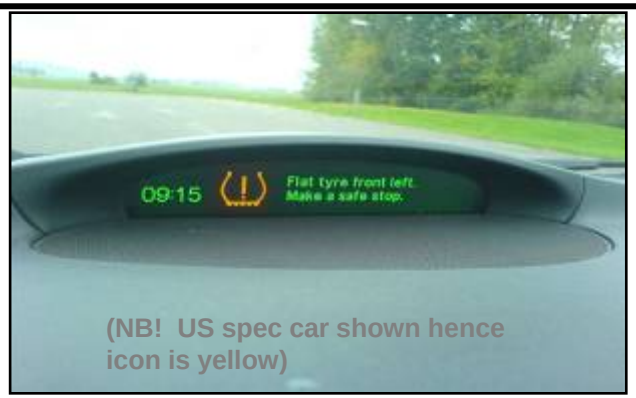
Condition	Min Detect Speed	Time to detect	Threshold	Advise / Action	Icon Colour	Text
Slightly Under-inflated	> 25Kph	10 mins max	Prec - 0.35bar	Advise		Low tire pressure - add air
Under-inflated	> 25Kph	10 mins max	Prec - 0.5bar Or 1.5bar min Or Load Factor Calculation (whichever is highest pressure)	Action		Very low tire pressure - Make a safe stop
Puncture	> 25Kph		with a leak of 0.1 bar/min or greater the warning telltale shall be on before a 1 bar loss max (1)	Action		Puncture - make a safe stop
System Malfunction	> 25Kph	10 mins max	Loss of RF signal from TPMS sensor or electrical malfunction	Advise		TPMS system malfunction - contact dealer
RF interference	> 25kph	10 min max	if there is a temporary RF interference strong enough to block TPMS signals	Advise		TPMS system temporarily unavailable

Criteria - based on ISO21750, UN ECE R64 and Tire Makers report of RunFlat Tires to EU
Aim - to harmonise any regulations and to use ISO 21750 as origin of requirements
(1) Blowout condition exempt from this requirement

NB! Any warning set are to be based on temperature compensated pressures when and as appropriate

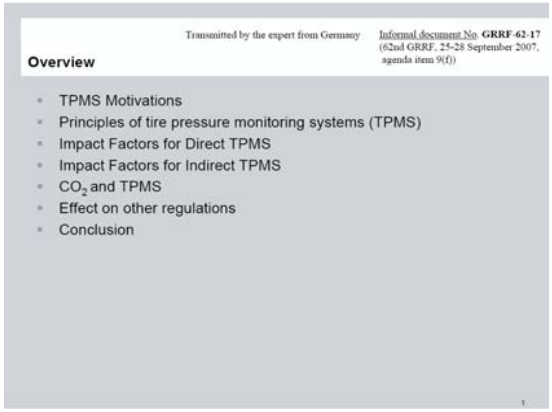
B/ Proposed TPMS Performance Criteria to help reduce CO2 & Improve safety

Very Important to make sure driver is given clear messages
(e.g.: SAAB 9-3 MY 08)

Visual Aid		
Description of Visual Aid	TPMS Telltale Integrated into LCD cluster display	Alert Location + Driver message into infotainment display
Delivery of Pressure Warning and System Fail	Low pressure Alert: Telltale + specific message on infotainment display Puncture Warning: Telltale + specific message System failure Alert: Telltale + specific message	
Sound alert (if any)		

C/ Summarized review of GRRF-62-17 report

- Overall the GRRF-62-17 report details the possible benefits & issues of having mandatory TPMS in Europe & Asia, however many of the perceived technical issues in this report have already been overcome by several TPMS suppliers (e.g.: smaller & lighter TPMS sensors have been introduced, RF transmission robustness has been increased, HMI has been greatly clarified…).


Transmitted by the expert from Germany

Informal document No. GRRF-62-17 (62nd GRRF, 25-28 September 2007, agenda item 9(f))

Overview

- TPMS Motivations
- Principles of tire pressure monitoring systems (TPMS)
- Impact Factors for Direct TPMS
- Impact Factors for Indirect TPMS
- CO_2 and TPMS
- Effect on other regulations
- Conclusion

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- Important point is that this report does not propose TPMS Performance criteria. This should now become the 1st Priority to allow Europe & Asia to also benefit from TPMS advantages to:
  - Help in reducing excessive CO2 emissions due to under-inflated tires
  - Improve Safety
  - Reduce fuel & tire consumption.

D/ Discuss next steps required

Suggestions:

- Discuss & agree the TPMS Performance Criteria
  - Should then be updated in ISO 21750.
- Discuss & agree the corresponding TPMS Test Procedure
  - Should then be updated in ISO 21750.
- TimeLine
  - Suggested target for draft of updated ISO 21750 - July 2008 for discussion.

E/ Conclusion

- Europe & Asia do not have TPMS regulation, unlike the US, and therefore do not benefit as they should from TPMS proven benefits to:
  - Help in reducing CO2 emissions
  - Improve safety
  - Reduce fuel & tire consumption.
- TPMS technology is available and affordable due to economies of scale.
- TPMS is already in wide spread use in the US with no major issues reported (provided driver information is clear and informative)
- Finally, fitting TPMS generates a cost benefit to vehicle owner.

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Appendix 1 – Cost Benefit Model - data

Source of data	Under-inflation	% increase in fuel consumption
Continental	0.2bar	1%
	0.4bar	2%
	0.6bar	4%
Beru	0.4bar	4%
Michelin	1.0bar	6%
Quattroroute	see table	
(aug 2006)		

Quattroruote / Alfa 159 2.4 20v JTDm / Compared fuel consumptions on test track for same driving conditions.

Kph	Correct	-1.0 bar	-1.0 bar %
60	21.1	18.8	10.90%
70	20.2	17.7	12.38%
80	19.1	16.5	13.61%
90	17.7	15.3	13.56%
100	16.2	14.1	12.96%
110	14.6	12.9	11.64%
120	13.0	11.8	9.23%
130	11.6	10.8	6.90%

Appendix 1 – Cost Benefit Model - data

Source of data	Under-inflation	% increase in Tire wear
NHTSA	0.2bar	15%
	0.4bar	30%
	0.6bar	45%
Beru	0.2bar	10%
	0.4bar	25%
	0.6bar	50%
GRRF (report 62-17)	0.2bar	5%
	0.4bar	10%
	0.6bar	15%
Pirelli	20%	15%
	40%	55%

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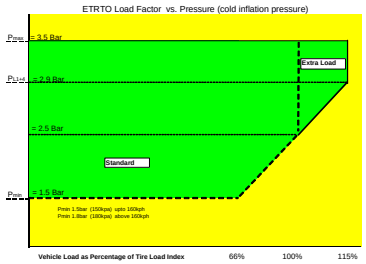
Appendix 2/ Tire Load Factor – example

ETRTO Load Factor Equation (2007 Engineering Design Information Manual PC14 & PC15)

Under-Inflation condition exists when the tire load carrying capability is equal to or less than the load applied by the vehicle it is mounted on. A driver should be warned of this **dangerous** condition and should either add air to tire or replace wheel as appropriate. The min inflation of a tire is defined:

ETRTO formulas work based on pressure in Kpa, (100kpa = 1bar)

Referance Load capacity according to Load Index	Qt
Tyre load in practice (0.5 x axle load) kg	Qr
Referance Inflation Pressure	Pt
Max speed of vehicle	V
Camber Angle (degrees)	Y
Camber Factor	Ks
Load capacity dependant on speed (kg) (for V, W, Y - tyres)	Qv
Minimium Inflation Pressure	**P**
OEMs Placard Pressure Value	Pp



P >= 150kpa (1.5bar)
and

$$P = Ks\ Pt \frac{Qr}{Qt} 1.25$$

Example

Low Speed up to 160kph

Vehicle weighs	850	kgs / axle	425	kgs / corner	
Tire 225/45 R18	90	Load Factor	V	Speed Rating	
Load factor	90	Load Index	535	kgs at 250 kPa	
Vehicle OEM wants to use Pp	250	Kpa upto	160	kph	
	280	Kpa upto	240	kph	
Camber factor	1		2	degrees of camber	

$$P = \frac{1 \quad 250}{425 \quad 535} 1.25$$

P = 250 kpa x 0.750 = **187.493** kpa

Pressure Margin **63** Kpa below Placard
(when warning should be illuminated)

High Speed

Min Pressure value is calculated using a modified formula

$$P = Ks\ (Pt + 30) \frac{Qr}{Qv} 1.25$$

Qv = [1-0.003(v-210)]Qt
Qv = 487

$$P = \frac{1}{} \quad 280 \quad \frac{425}{487} 1.25$$

P = 280 kpa x 0.873 = 244.428 **Kpa**

Pressure Margin **36** Kpa below Placard
(when warning should be illuminated)