TPMS

Under-inflation measurements, types, standards & rules

ISO/TC22/WG12/N120

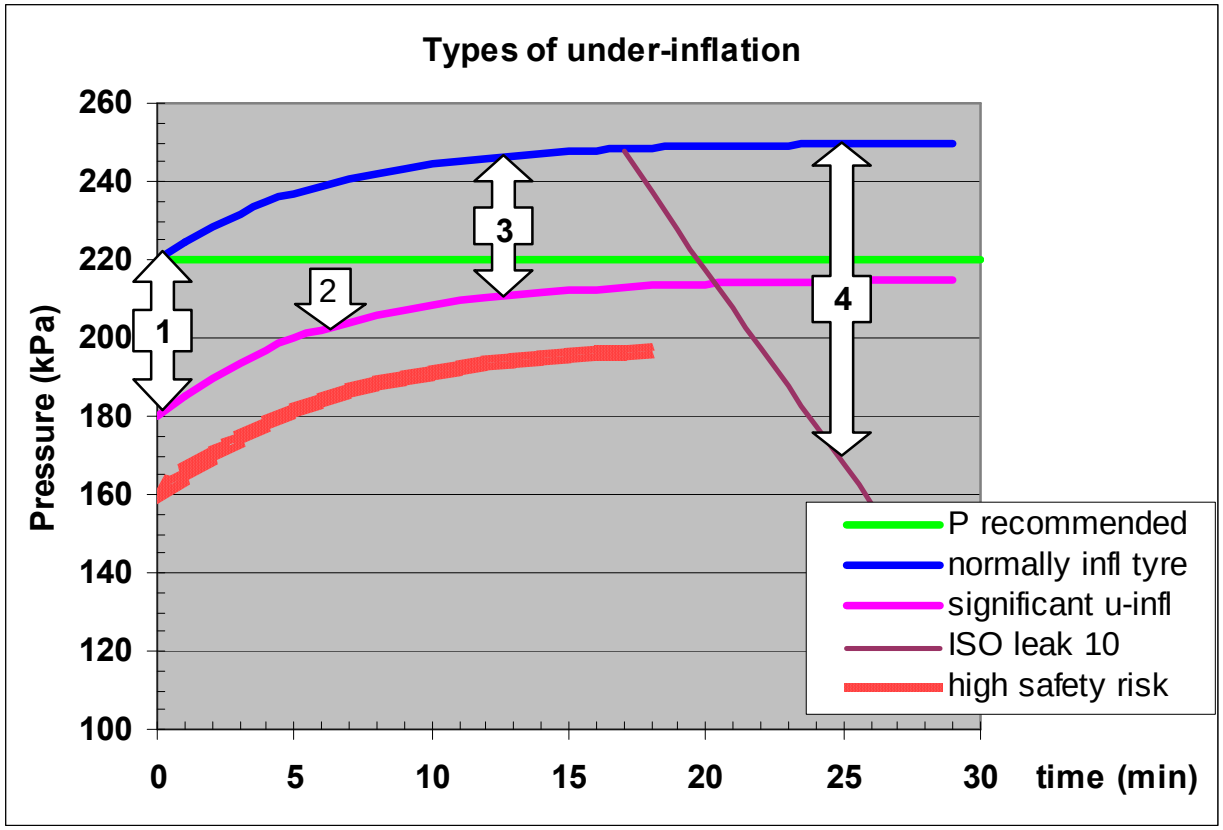
agenda

- What is under-inflation ?
- Notions that must be distinguished
- Some causes and consequences
- Existing S & R on TPMS
- What can they detect ?

What is under-inflation ?

When a tyre starts rolling, its pressure goes up.

4 types of under-inflation can be defined, measured or detected:



Which under-inflation ?

- Under-inflation **ΔP1** (of 1 up to 4 tyres) is the closest to definition, because it is measured on “cold” tyres
- Under-inflation **ΔP2**, from the comparison of a ‘warming’ tyre with the ‘cold’ reference more than 5 min after start, may be seriously misleading because the pressure vs time increase during rolling depends on several parameters (speed, load, camber, ambient temperature, …) ;
  note that ΔP2 can be either positive or negative
- Under-inflation **ΔP3** is measured between tyres
- Under-inflation **ΔP4** represents a fast leak, for example after a nail has been ejected

Depending on the TPMS technical principles, those under-inflations can be detected more or less easily.

Notions that **must** be distinguished

Normal tyres / **Run-Flat** tyres

- They are different in terms of performances and of hazards during use

Safety function / pressure **maintenance**

- Safety of the user primarily requires short alarm delays
- Pressure maintenance, to optimize tyre performances, rather requires accurate TPMS, but …

Some causes and consequences

Hazard	May happen with "normal" tyres	May happen with "Run-Flat" tyres
Fast leak during driving: 10-20 kPa/min (e.g. after nail ejection)	- *Tread failure* (if high load, speed, ambient temp., ..) - *Handling control loss* - *Tyre unseating*	- *Sidewall failure* (if high load, speed, ..) *handling control loss*, *fire*, …
Cold start on exceedingly under-inflated tyre(s) (P<140 kPa, P<<P_{rec}, or ΔP>60)	- *Tread failure*, - *Handling control loss* - *Tyre unseating* - *Hydroplaning* - *Unseen damage*	**Nothing**
Cold start on flat tyre (P<70 kPa)	**Very unlikely, user cannot but notice immediately**	- *Sidewall failure*, (if high load, speed,..) *handling*, *fire*, …

TPMS and RFWS do not respond to the same needs

	Normal tyre	specification for TPMS	Run-Flat tyre	specification for RFWS
P = $P_{recommended}$	(reference)		😐 rolling resistance 😐 comfort	
P = P_{rec} to P_{rec} -40 kPa	pressure maintenance for *optimization* of performances	accurate TPMS (*)		
P = P_{rec} -40 to P_{rec} -100 kPa or P ≥140 kPa	☹ rolling res., wear, … ☹ endurance : *risks* function of load / LI	accurate and reactive TPMS		
P <140 or <P_{rec}-100 to P > 70 kPa	☹ high *risks* of : road holding, bead unseating	reactive TPMS	☹ wear ☹ endurance	
and, if V>70% of the tyre max speed	*outside the functional domain of normal radial tyres*		☹ degradation of sidewall	RFWS must detect a 100 kPa pressure loss in 5 min
P < 70 kPa			Flat run mode => limited tyre life : 1h at 80 km/h	

(*) *but "reactivity" is obviously a plus because the actual objective is to detect ΔP1*

Existing S & R on TPMS

- **Standard ISO 21750 :2006**
  describes 3 types of TPMS (TPAS, TPWS, TLAS) and the principles of 2 test methods
  but stopped short of specifying thresholds
- **NHTSA's Rule FMVSS 138**
  makes TPMS compulsory on new PC & LT in USA,
  sets alarm threshold ("-25%") and alert delay ("20 min")
  describes a test procedure to approve TPMS
- **UN ECE Regulation R64**
  makes TPMS compulsory on passenger cars equipped with run-flat tires in ECE countries
  describes test procedures to type-approve such systems
- without forgetting **Directive 2001/95EC** on general safety of products !

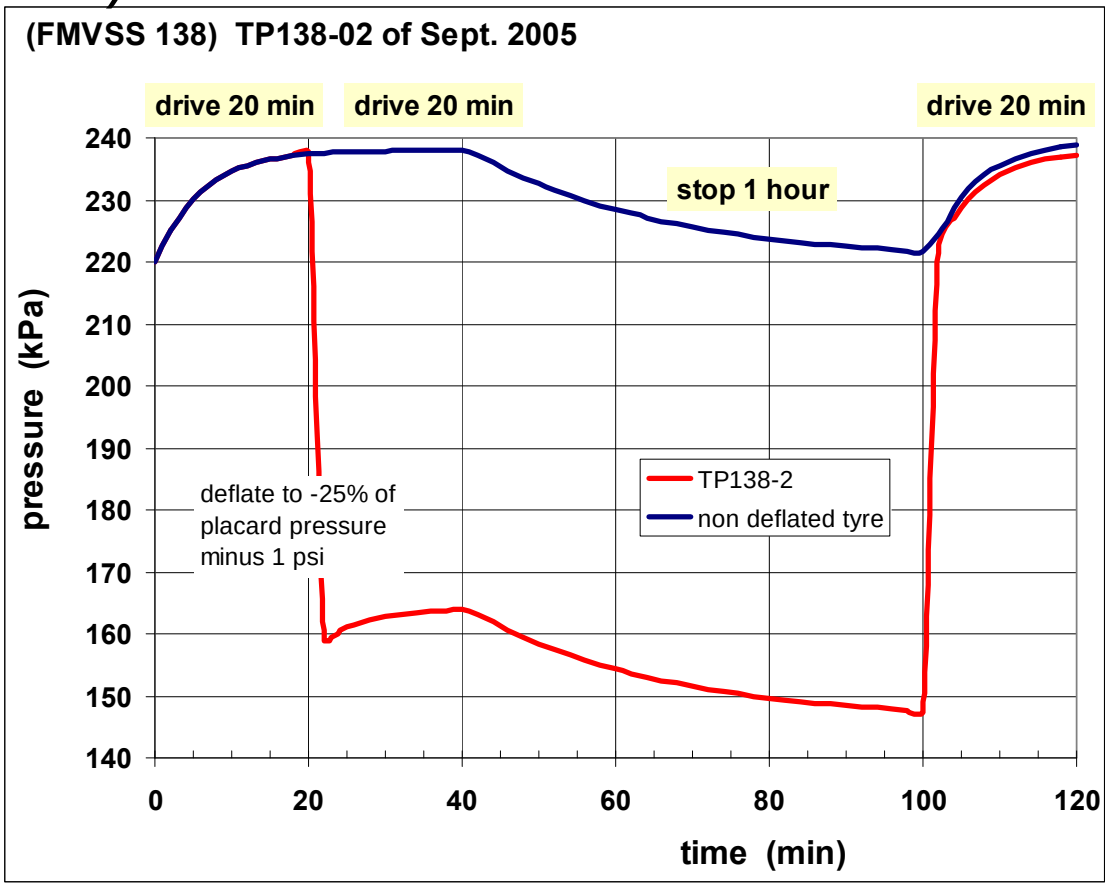
What can they detect ?

	HMI	ΔP1	ΔP2	ΔP3	ΔP4
TPWS	P display	Yes	Yes	Yes	Yes
TPAS	P display	Y (test#2)	Y	Y	Y (test#1)
TPAS	lamp	Y (test#2)	nuisance	Y	Y (test#1)
TLAS	lamp	No	No	Y	Y (test#1)
T.P/L.AS with reset error		No	No	No	Y
FMVSS138 (‘25%’,20min, lamp)		No	No	Y ?	Y

What can they detect ?

	by “direct” TPMS	by “indirect” TPMS
ΔP1	is easily detected, since the alert delay is < 2 min	cannot be detected, since the alert delay is > 5 min
ΔP2	is easily detected, but … users may be puzzled by the ΔP1-triggered alert, if the HMI is basic	cannot be detected (insufficient accuracy)
ΔP3	is easily detected (unless a “comparison” function has been forgotten)	is easily detected
ΔP4	is easily detected	can be detected (by recent generation TPMS)

FMVSS138 test method contains a questionable detail (SAE J2657 does not)



“25%” equals “33%” … and verges on the dangerous when, for ex., handling with one rear tire deflated or tire endurance are concerned

Expressing under-inflation in % of recommended pressure is questionable

If NHTSA's Rule FMVSS138 were transposed to Europe, the worst case would be :

- Maximum load, at $P_{recommended}$ = 250 kPa (cold)
- TPMS threshold = 250*0.75 -7 =180 kPa (warm!)
  => thus, cold pressure before alert could be < 165 kPa !

The difference 250-165= 85 clearly exceeds any safety limits.

Therefore, the alarm threshold should be defined in terms of absolute pressure difference, such as "-40 kPa below the recommended pressure or below the other tyres' pressure" (depending on the reactivity of the system, partial correction of pressure evolution should be contemplated).

Further issues

- Manual reset :

  if the TPMS must be manually reset, the user should be made aware of the risk of setting a biased (usually low) reference pressure into the system because of the lack of maintenance of pressure gauges at service stations

- Human Machine Interface :

  although some dashboards tend to have too many dials already, it has been recognized that the lighting of a single lamp is not recognized by ordinary users as a sign of danger ;
  in the same way, yellow lamp colour, lamp blinking, may be misinterpreted, and the ISO symbol of deflated tyre is misunderstood.

Thank you for your attention