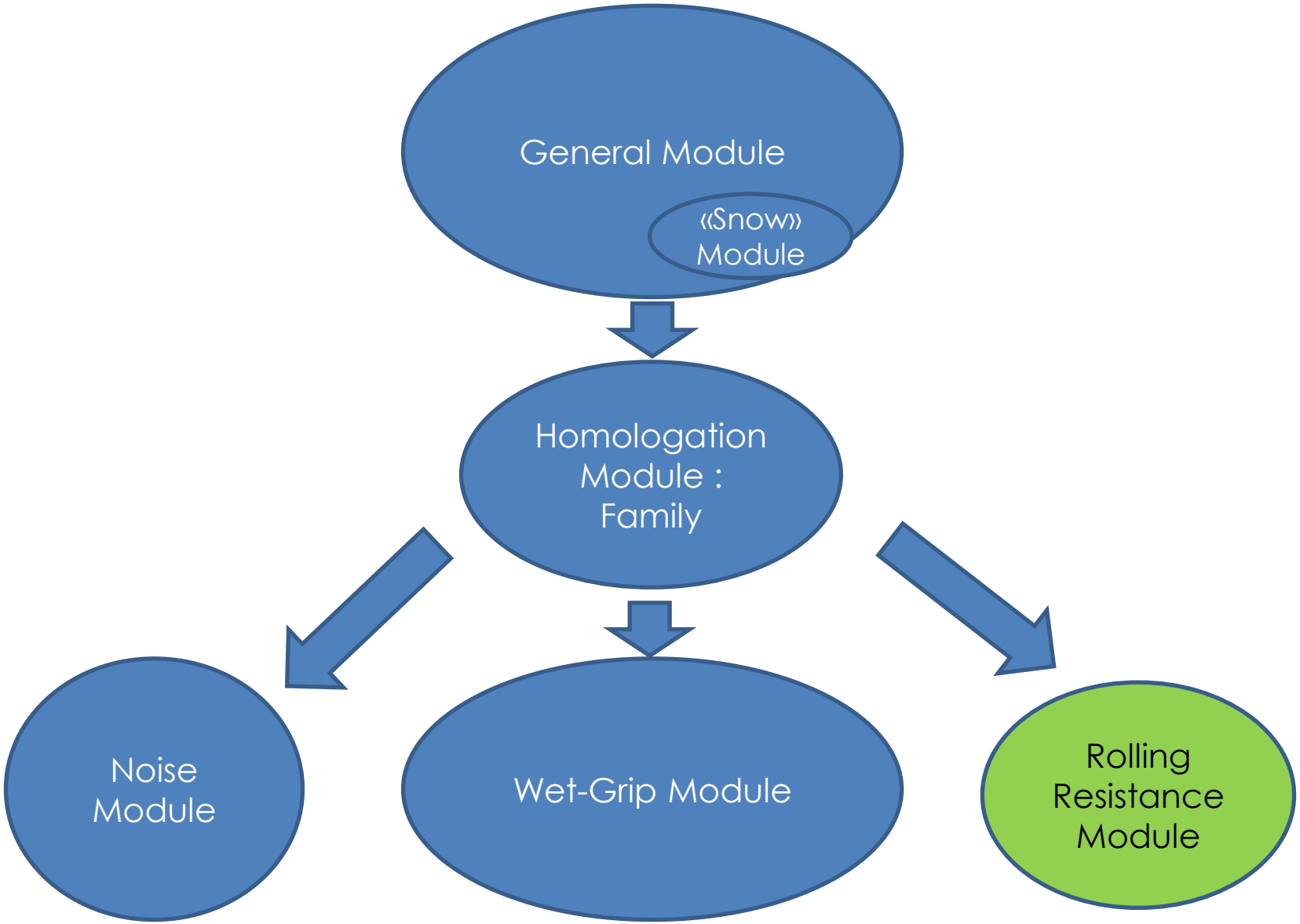
ROLLING RESISTANCE (RR) MODULE

APPROVAL AND LABELLING FOR EUROPEAN TIRES


General Module
«Snow»
Module
Homologation
Module :
Family
Noise
Module
Wet-Grip Module
Rolling
Resistance
Module

HOW TO MESURE THE ROLLING RESISTANCE ? (the machine)

⇨ On one or (several) Dedicated(s) Rig(s): Roller bench ingrate in a air-conditioned room

⇨ Tires Classes : C1, C2 and C3

Environment air-conditioned at 25°C

C1/C2 Tires on the left spindle head

C3 Tires on the right spindle head

1.7 or 2 m drum
Slick and hard-faced (≤ 6.3 µm)
or texturize (Depth 180 µm : nominal grain 80)

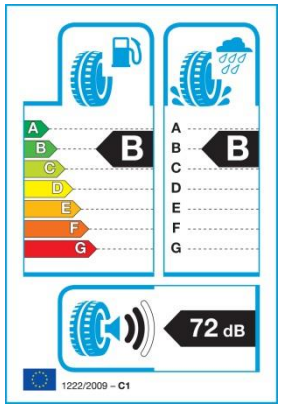
⇨ Tire lining up: CAMBER ≤ 2 mrad and STEERING ≤ 1mrad.

⇨ Load Application: Perpendicular to the contact surface ≤ 1mrad or ≤ 5 mrad according to method.

Example of Rig suppliers : MTS (United States of America), ZF (Germany) , …

HOW TO MESURE THE ROLLING RESISTANCE ? (the methods)

Following the Protocol defined in annex 6 of regulation ECE 117 (Homologation and Labelling case) with an addition of the annex IVb UE 1235/2011 for Labelling (Laboratory alignement).



4 measurements methods possible : Force, Torque, Deceleration and Power.

- **FORCE** : Reaction force measured or converted at the tire spindle.
- **TORQUE*** : Torque input measured at the test drum.
- **DECELERATION** : Deceleration of the test drum & tire assembly.
- **POWER** : Measurement of the power input to the test drum.

**UTAC CERAM Recognized method*

HOW TO MESURE THE ROLLING RESISTANCE ? (Prerequisite)

Method description: (Tire preparation)

✓ **Fitting:**

The tire shall be mounted on a steel or light alloy measuring rim Following; ISO 4000-1-2010 or ISO 4209-1-2001, otherwise standards organizations recognized.

✓ **Inflation:**

For C1; **2,1 bars** (**N**ormal-**L**oad category), **2,5 bars** (**E**xtra-**L**oad category).

For C2 and C3; Inflation **pressure marked on sidewall**, or if not marked on sidewall, as specified in applicable tire standards manuals corresponding to maximum load capacity for single application.

✓ **Thermal conditioning:**

The inflated tire shall be placed in the thermal environment of the test location for a minimum of : **3h for C1** and **6h for C2/C3**. After thermal conditioning, the inflation pressure shall be adjusted to the test pressure, and verified 10 minutes after the adjustment is made.

HOW TO MESURE THE ROLLING RESISTANCE ? (Test Procedure)

Method description: (Warm up, rolling and measurements)

Warm-up duration by category of tires, Load-Index and wheel size:

- 0h30 for all C1 tire
- 0h50 for C2/C3 tires with Load-Index ≤ 121
- 2h30 for C3 with Load-Index > 121 and wheel < 22.5 ''
- 3h00 for C3 with Load-Index > 121 and wheel ≥ 22.5 ''

The Rolling is realized at:

- 80 km/h for C1, C2 and C3 with Load-Index ≤ 121
- 60 km/h for C3 with Load-Index > 121 if the speed index ≤J
- 80 km/h for C3 with Load-Index > 121 if the speed index ≥ J

HOW TO MESURE THE ROLLING RESISTANCE ? (Test Procedure)

The measurement is made under 2 configurations of vertical load:

- ✓ **SKIM TEST** reading, during this step the load is reduce to maintain the tire at the speed without slippage:
  - For **C1** recommanded at **100N** (maxi 200N),
  - for **C2** recommanded at **150N** (maxi 200N) if on C1 machine or **500N** if on a C2/C3 machine,
  - then for **C3** recommanded at **400N** (maxi 500N).

    ⇨ **Appreciation of the parasitic losses (Friction and aerodynamic): F_{pl}**

- ✓ **UNDER LOAD** reading, during this step a load coresponding to the Load index is applyed :
  - For **C1 = 80%** of the Load index,
  - for **C2/C3 = 85%** of the load corresponding to maximum load capacity for single application.

    ⇨**Appreciation of the Rolling resistance (Total resistance) : F_{rt}**

HOW TO MESURE THE ROLLING RESISTANCE ? (Calculation)

Method description: (Rolling resistance calculation)

Rolling resistance Force: **Fr** = **F T**otal **r**esistance – **F p**arasitic **l**osses

Test Load = **Lm** is the load applied during rolling resistance measurement

Rolling **R**esistance **C**oefficient : **RRC = Fr*/ Lm**

*: Drum diameter correction (nominal 2 m) and temperature correction (nominale 25°C)

Drum diameter correction :

$Fcor_d = K \,.\, Fr$ avec $K = [(R_1 / R_2) \times (R_2 + r_T) / (R_1 + r_T)]^{0.5}$

R1 is the radius of drum 1, R2 is the radius of drum 2. rT is one-half of the nominal design tire diameter, (all values in meter).

Temperature correction:

$Fcor_{25} = Fr \times [1 + K(t_{amb} - 25)]$

(mesured between 0,15 meter and 1 meter of tire side wall)

HOW THE MEASURES CAN BE GUARANTEE ?

✓ **Use of resources with defiened specifications:**

- Range and limits of tolerances of the Equipements and systems used to mesure: Tire load, inflation pressure, the force, the torque, the distance, the speed, the temperature, the time.
- Radial roundness and wheel buckling limits
- Angular positioning limits
- Limits on tolerances regarding average values of the tires load, the inflation pressure, the speed, the time.

✓ **One requirement for test reproducibility:**

- $\sigma m < 0.075$ N/kN (for C1/C2)
- $\sigma m < 0.060$ N/kN (for C3)

✓ **A monthly monitoring of the machine measurments:**

- Periodic test with a referenced tire (control)

HOW THE MEASURES CAN BE GUARANTEE ?

In addition of the Labelling: (Interlaboratory)

Interlaboratory tests solutions :

- Define and set-up universal referenced values
- Set up and adjusting machines from the differents laboratory (referents and candidates).

Aim of the protocol:

✓ Gather N laboratory call « reference » (σ_m < **0.05 N/kN** instead of **0.075**)

✓ Select N batch of 10 types of tires (5 C1/C2 et 5 C3) covering the RRC range.

✓ Sending to each laboratory 1 set of 10 tires. (pre-tests)

✓ Each laboratory measured the RRC of every tires he received (4 times by tires for the repetability)

HOW THE MEASURES CAN BE GUARANTEE ?

In addition of the Labelling: (Interlaboratory)

Aim of the protocol (next):

- ✓ Bring together all the values and make statistic analysis (possible rejection of values)
- ✓ Define the values call « reference value » for each single tire (average on all laboratory)
- ✓ Establish for each laboratory the correlation with the referenced values by the determination of the linear regression between the values of the laboratory and the values of the group.

In 2011 and 2014: The experts group (EGLA) mandatory by the European Commission and chair by France (UTAC) with Germany copresidency have manage the interlaboratory tests.

- → Study reports : http://ec.europa.eu/energy/en/topics/energy-efficient-products-and-labels/tyres
- → Publication of the laboratory in the UE official journal,
- → Annexe IVbis of the regulation UE 1235/2011 writing for the explaination of the rolling resistance alignement procedure for laboratory **Applicable rules for all** candidate laboratory.

LESSON LEARN ON ROLLING RESISTANCE PROCEDURE

Detail of Influence factor on finale RRC Value :

- ✓ Error of load applyed during the test and the skim-load measurement.
  ⇨*Make sure to use the appropriate pourcentage of the referenced load. (page 6 of this presentation)*
- ✓ Mistake on tire test inflation (Pressure = Load)
  ⇨*Applyed the right pressure required by the R117/R1222*
- ✓ Respect the frame time conditionning
  ⇨*To garantee the good positionning of the tire and carcass stretching*
- ✓ Use the appropriate wheel width (conformity to ISO and standards)
  ⇨*To avoid any modification of the contact tire surface and tire side wall stiffness*
- ✓ Verify the ambiante temperature of the test room and correction factor
  ⇨*This is an important point to avoid any drifted values (± 2°C)*
- ✓ Use the correct tire rotation pattern requirement for the test in accordance to drum rotation
  ⇨*Essential to avoid any wrong RRC values due to backward rotation*