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World Forum for Harmonization of Vehicle Regulations

Working Party on Noise

Fifty-seventh session
Geneva, 2-4 September 2013
Item 6 of the provisional agenda
Regulation No. 117 (Tyre rolling noise and wet grip adhesion)

Proposal for Supplement 5 to the 02 series of amendments to Regulation No. 117

Submitted by the expert from the Russian Federation[1]

The text reproduced below was prepared by the experts from the Russian Federation to elaborate on the concept of tyre deceleration (dω/dt) in the test technology. It is based on ECE/TRANS/WP.29/GRB/2013/3, incorporating amendments as proposed in a document without symbol (GRB-57-01) distributed at the fifty-seventh session of the Working Party on Noise (GRB)(ECE/TRANS/WP.29/GRB/55, para. 18). The modifications to the existing text of the UN Regulation are marked in bold for new or strikethrough for deleted characters.

[1] In accordance with the programme of work of the Inland Transport Committee for 2010–2014 (ECE/TRANS/208, para. 106 and ECE/TRANS/2010/8, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

I. Proposal

Annex 6,

Paragraph 3.5., amend to read:

"3.5. Duration and speed.

When the deceleration method is selected, the following requirements apply:

(a) The deceleration j shall be determined in exact dω/dt or approximate Δω/Δt form, where ω is angular velocity, t – time;

If the exact form dω/dt is used, then the recommendations of Appendix 4 to this Annex are to be applied.

(b) …"

Annex 6, insert a new Appendix 4, to read:

"Annex 6 – Appendix 4

Deceleration method: Measurements and data processing for deceleration value obtaining in differential form dω/dt.

1. Record dependency "distance-time" for rotating body in a discrete form:

$$\alpha_i = i\Delta\alpha = \varphi(t_i)$$

where:

α_i is an angle of body rotation during deceleration from speed 80 to 60 km/h or 60 to 40 km/h dependent of the PC or CV tyre in radians;

i is the number of constant angle increments;

$\Delta\alpha$ is constant increment of angle of rotation in radians;

t_i is time in seconds.

***Note*: The recommended value of $\Delta\alpha$ is 2π.**

2. Insert measured data into the "deceleration calculator" downloable from www.nami.ru/upload/calculator.zip and obtain:

2.1. Constants of approximating dependency:

$$\alpha = f(t) = A \ln \frac{1}{\cos B(T_\Sigma - t)},$$

where:

A is constant in radians;

B is constant in 1/s;

T_Σ is constant in s.

2.2. The result is in accordance with the use of a speed of 80 (60) kph:

$$j = \frac{d\omega}{dt} = \frac{d^2\alpha}{dt^2} = \frac{AB^2}{\cos^2 BT_\Sigma} \text{ "}$$

II. Justification

1. The proposed principal is based on an absolutely exact formula:

$$j = \frac{d\omega}{dt} = \frac{d^2\alpha}{dt^2}$$

2. There are no real simplification or assumption between the formulae in clauses 2.1 and 2.2 of Appendix 4 because the formula in clause 2.2 is derived from the formula in clause 2.1 according to the rules of differential calculus:

$$j = \frac{d^2\alpha}{dt^2} = \frac{AB^2}{\cos^2 B(T_\Sigma - t)}$$

3. As soon as the measurements begin at 80 (60) km/h when t = 0, one can obtain the formula shown in clause 2.2 of Appendix 4. This means that the accuracy of the result j depends on a quality of approximation of empirical dependency α=f(t) by formulae in clause 2.1.

4. The "deceleration calculator" presents the estimation of the result in the form of a standard deviation σ:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}[\alpha_i - f(t_i)]^2}$$

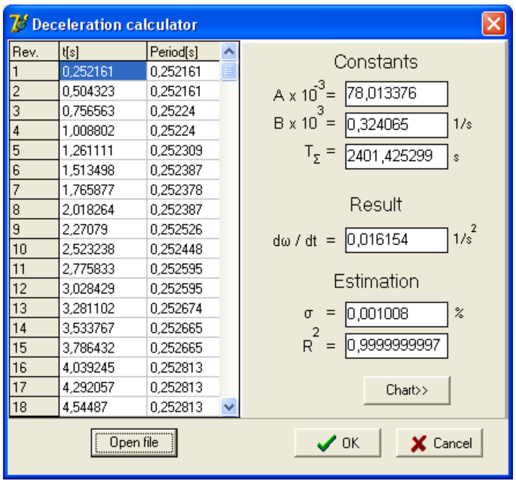
where $f(t_i)$ is approximating dependency from clause 2.1 of Appendix 4 in a discrete form, and in a form of quadrature R^2 of coefficient of correlation for non-linear approximation:

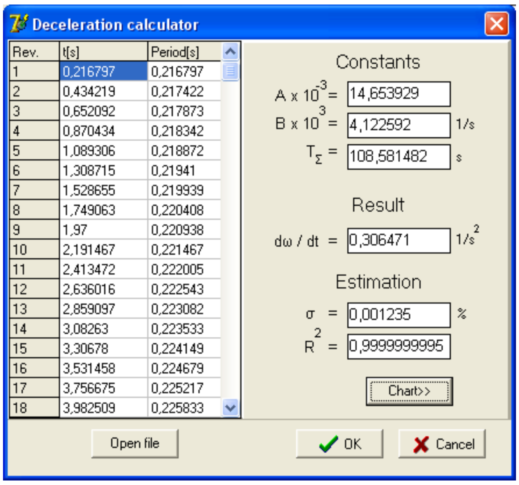
$$R = \sqrt{1 - \frac{\sum_{i=1}^{n}[\alpha_i - f(t_i)]^2}{\sum_{i=1}^{n}(\alpha_i - \overline{\alpha})^2}}$$

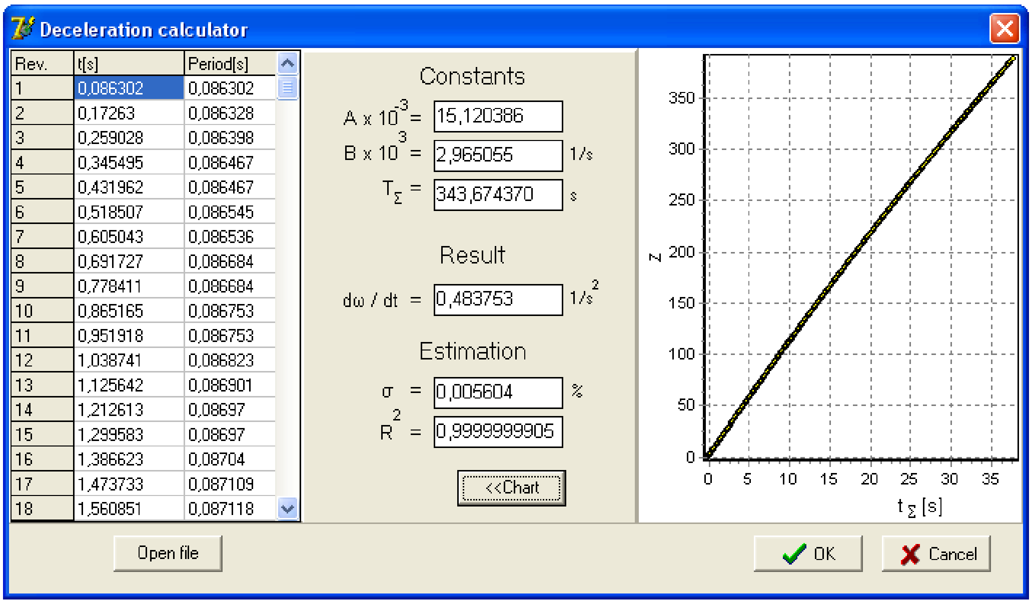
where $\overline{\alpha} = \frac{1}{n}\sum \alpha_i$

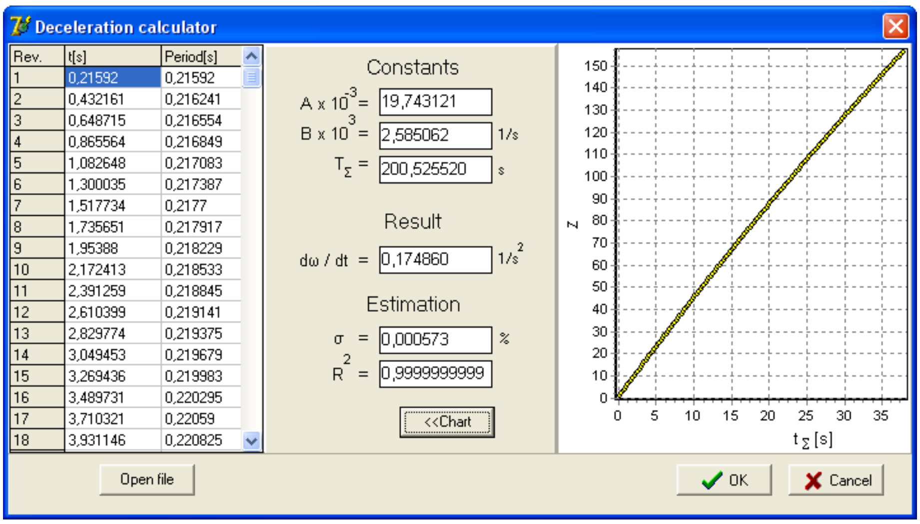
5. The measurement method together with the “Deceleration Calculator” provide for the approximation accuracy typically reached by quadrature R^2>0.9999 and by standard deviation σ<0.03%.

6. A user may also check on the button "chart" and have the graph with lens $\alpha = f(t)$ among empirical points. The examples given here after show opportunities and an exclusively high quality of approximation:


Deceleration calculator
Rev. t[s] Period[s]
1 0,252161 0,252161
2 0,504323 0,252161
3 0,756563 0,25224
4 1,008802 0,25224
5 1,261111 0,252309
6 1,513498 0,252387
7 1,765877 0,252378
8 2,018264 0,252387
9 2,27079 0,252526
10 2,523238 0,252448
11 2,775833 0,252595
12 3,028429 0,252595
13 3,281102 0,252674
14 3,533767 0,252665
15 3,786432 0,252665
16 4,039245 0,252813
17 4,292057 0,252813
18 4,54487 0,252813
Constants
A x 10-3 = 78,013376
B x 10-3 = 0,324065 1/s
TΣ = 2401,425299 s
Result
dω / dt = 0,016154 1/s2
Estimation
σ = 0,001008 %
R2 = 0,9999999997
Chart>>
Open file
OK
Cancel


Deceleration calculator
Rev. t[s] Period[s]
1 0,216797 0,216797
2 0,434219 0,217422
3 0,652092 0,217873
4 0,870434 0,218342
5 1,089306 0,218872
6 1,308715 0,21941
7 1,528655 0,219939
8 1,749063 0,220408
9 1,97 0,220938
10 2,191467 0,221467
11 2,413472 0,222005
12 2,636016 0,222543
13 2,859097 0,223082
14 3,08263 0,223533
15 3,30678 0,224149
16 3,531458 0,224679
17 3,756675 0,225217
18 3,982509 0,225833
Constants
A x 10-3 = 14,653929
B x 10-3 = 4,122592 1/s
TΣ = 108,581482 s
Result
dω / dt = 0,306471 1/s2
Estimation
σ = 0,001235 %
R2 = 0,9999999995
Chart>>
Open file
OK
Cancel


Deceleration calculator
Rev. t[s] Period[s]
1 0,086302 0,086302
2 0,17263 0,086328
3 0,259028 0,086398
4 0,345495 0,086467
5 0,431962 0,086467
6 0,518507 0,086545
7 0,605043 0,086536
8 0,691727 0,086684
9 0,778411 0,086684
10 0,865165 0,086753
11 0,951918 0,086753
12 1,038741 0,086823
13 1,125642 0,086901
14 1,212613 0,08697
15 1,299583 0,08697
16 1,386623 0,08704
17 1,473733 0,087109
18 1,560851 0,087118
Constants
A x 10-3 = 15,120386
B x 10-3 = 2,965055 1/s
TΣ = 343,674370 s
Result
dω / dt = 0,483753 1/s2
Estimation
σ = 0,005604 %
R2 = 0,9999999905
<<Chart
N
350
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35
tΣ [s]
Open file
OK
Cancel


Deceleration calculator
Rev. t[s] Period[s]
1 0,21592 0,21592
2 0,432161 0,216241
3 0,648715 0,216554
4 0,865564 0,216849
5 1,082648 0,217083
6 1,300035 0,217387
7 1,517734 0,2177
8 1,735651 0,217917
9 1,95388 0,218229
10 2,172413 0,218533
11 2,391259 0,218845
12 2,610399 0,219141
13 2,829774 0,219375
14 3,049453 0,219679
15 3,269436 0,219983
16 3,489731 0,220295
17 3,710321 0,22059
18 3,931146 0,220825
Constants
A x 10-3 = 19,743121
B x 10-3 = 2,585062 1/s
TΣ = 200,525520 s
Result
dω / dt = 0,174860 1/s2
Estimation
σ = 0,000573 %
R2 = 0,9999999999
<<Chart
N
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0 5 10 15 20 25 30 35
tΣ [s]
Open file
OK
Cancel