

Proposal for amendments to informal document GRBP-83-32 to ensure robust tyre abrasion measurements regardless of the test method used

The text reproduced below was prepared by the experts from the European Commission to introduce the procedure for demonstrating the equivalence of test facilities (Vehicle and Indoor Drum) and determining the Transfer Function for Indoor Drum facilities. The modifications to the text of the draft Regulation (GRBP-83-32) are marked **in bold** for new or ~~striketrough~~ for deleted characters.

I. Proposal

Paragraph 6.1., amend to read:

"6.1. The abrasion level of the tyre, determined in accordance with the test method specified in Annex 3, shall be measured using a test facility (circuit or indoor drum) that **has demonstrated equivalence according to the procedure described in Annex 4.**"

Annex 3, insert a new paragraph 1.4., to read:

"1.4. **Prior to conducting any testing for Type Approval, the test facility (whether indoor drum or circuit) shall have successfully completed the equivalence assessment specified in Annex 4 and established its status as an Equivalent Circuit (EC) or Equivalent Drum (ED).**"

Annex 3, amend paragraph 2.8., to read:

"6.1. Processing of Measurement Results

The calculation method for the abrasion index and the abrasion level shall follow the equations:

$$MIT = MT_b - MT_a$$

$$MIR = MR_b - MR_a$$

Where:

MIT is the mass loss of the candidate tyre, in grams

MIR is the mass loss of the reference tyre, in grams

MT_b is the mass of the candidate tyre before test cycle, in grams

MT_a is the mass of the candidate tyre after test cycle, in grams

MR_b is the mass of the reference tyre before test cycle, in grams

MR_a is the mass of the reference tyre after test cycle, in grams

The abrasion index (AICT) shall be calculated according to the following equation:

$$AICT = \frac{ALCT}{ALRT} - A_{\text{margin}}$$

$$AICT = a \left(\frac{ALCT}{ALRT} - 1 \right) + 1 - A_{\text{margin}}$$

Where:

a is the coefficient of the transfer function for the drum as defined in Annex 4, paragraph 2.17,

ALCT is the abrasion level (mg/(km·t)) of the candidate tyre,

$$ALCT = 1000 \text{ (mg/kg)} \times MIT \text{ (g)}/DT\text{(km)}/Fz,T\text{(t)}$$

ALRT is the abrasion level (mg/(km·t)) of the reference tyre,

$$ALRT = 1000 \text{ (mg/kg)} \times MIR \text{ (g)}/DR\text{(km)}/Fz,R\text{(t)}$$

DT is the testing mileage of candidate tyre (km)

DR is the testing mileage of the reference tyre (km)

Fz,T is the test load of the candidate tyre (t)

Fz,R is the test load of the reference tyre (t)

A_{margin} is the dimensionless abrasion margin, which accounts for the complexities of the abrasion level measurement methods, and is equal to [0.22]."

Annex 3, Appendix 6 (Example of a test report for indoor drum test method), insert new items 1.1. to 1.4., to read:

"1. Facility Equivalence Status

1.1. Has the test facility demonstrated equivalence according to Annex 4? Yes / No

(If 'No', the test results are not valid for Type Approval)

1.2. Reference to the Equivalence Test Report (Unique ID/Date):

1.3. Transfer function applied (Drum Method Only):

Generic

Specific

Transfer function with no effect (transfer function coefficient $a = 1.00$)

If 'generic' or 'specific' transfer function is applied, indicate value of transfer function coefficient a (value between 0.95 and 2.00):

1.4. Verification of Test Parameters (Drum Method Only):

Parameter	Value in Equivalence Report	Value in Current Test	Compliant?
Surface Texture	(e.g. specific sandpaper grit)	Yes / No
Third Body Type	(e.g. silica)	Yes / No
Powder Delivery Rate [g/h]		Yes / No
Third Body Distribution System	(description of nozzle type, position, and pulse frequency)	Yes / No

"

Insert a new Annex 4, to read:

Annex 4

Procedure for Demonstrating Equivalence of Vehicle Test and Indoor Drum Test Facilities for Tyre Abrasion and Determining the Transfer Function for Indoor Drum Test Facilities

1. Scope and Purpose

- 1.1 This Annex sets out a procedure to demonstrate that the results of a tyre abrasion test carried out at a facility are equivalent to those obtained with other facilities. The aim is to ensure that, facilities yield equivalent abrasion performance results, so that approvals based on any facility or method remain comparable and mutually recognised.
- 1.2 The procedure provides a structured approach for selecting test tyres and facilities, establishing a baseline and evaluating facilities. It applies to both indoor drum and vehicle test facilities.
- 1.3 Furthermore, this procedure establishes the methodology for determining the transfer function, which mathematically relates the results obtained from the indoor drum test method to those of the vehicle test method. The procedure allows for the establishment of either a generic transfer function applicable to any indoor drum test facility or a specific transfer function applicable to a single indoor drum test facility.

2. Definitions

For the purposes of this Annex, the following definitions apply.

- 2.1 "Facility" means a testing centre, carrying out either vehicle tests at a circuit or indoor drum tests.
- 2.2 "Circuit" means the specific test route on public roads selected for the execution of the vehicle test method in accordance with Annex 3.
- 2.3 "Indoor Drum" means the test machine and associated equipment used for the execution of the indoor drum test method in accordance with Annex 3.
- 2.4 "Inter-facility equivalence exercise" means the coordinated testing campaign described in this Annex, involving the testing of a common set of exercise tyres by the facility under assessment and participating facilities, used to demonstrate equivalence and, where applicable, to determine the transfer function coefficient a .
- 2.5 "Coordinating body" means the technical service, Type Approval Authority, the facility under assessment, an Equivalent facility or other entity responsible for organising the inter-facility equivalence exercise, collecting the test data, and issuing the final equivalence report.
- 2.6 "Equivalent Drum (ED)" means an indoor drum test facility that proved equivalence to a Type Approval Authority in a previous inter-facility equivalence exercise.
- 2.7 "Equivalent Circuit (EC)" means a circuit that proved equivalence to a Type Approval Authority in a previous inter-facilities exercise.
- 2.8 "Assessed Drum (AD)" means a drum facility undergoing evaluation in the current inter-facility equivalence exercise to prove equivalence.

- 2.9 "Assessed Circuit (AC)" means a circuit undergoing evaluation in the current inter-facility equivalence exercise to prove equivalence.
- 2.10 "Facility under assessment" means the Assessed Drum (AD) or Assessed Circuit (AC) participating in the inter-facility equivalence exercise for the purpose of demonstrating equivalence.
- 2.11 "Participating facilities" means the designated facilities, other than the facility under assessment, selected to test the exercise tyres for the purpose of establishing the baseline values according to paragraph 4.1.2.1 of this Annex.
- 2.12 "Reference tyre" means the Standard Reference Test Tyre (SRTT) specified in the vehicle test method or indoor drum test method of Annex 3, used to normalize the abrasion level of the exercise tyres.
- 2.13 "Exercise Tyres (ET)" are the candidate tyres used for the equivalence assessments. These tyres shall be tested by the participating facilities and the facility under assessment and fulfil the requirements of paragraph 4.1.1 of this Annex.
- 2.14 "Baseline value" of an exercise tyre is the average Abrasion Level Index (*ALI*) obtained from all participating facilities as defined in paragraph 2.11 of this Annex. It represents the value against which under assessment facilities are compared to demonstrate equivalence.
- 2.15 "Abrasion Level Index (*ALI*)" means the abrasion performance of a tyre, expressed as the ratio of the Exercise tyre's abrasion level (ALCT) to that of a reference tyre (ALRT), without subtraction of any test-specific abrasion margin and without applying regulatory limits.
- 2.16 "Equivalence" means that a facility produces *ALI* results for the exercise tyres that are statistically consistent with the baseline values fulfilling the requirements of paragraph 4.3.2 of this Annex.
- 2.17 "Transfer function" means a linear relationship used to relate indoor drum test results to vehicle test results. The transfer function is expressed as:

$$ALI_{vehicle} \approx ALI_{drumTF} = a (ALI_{drum} - 1) + 1$$

where the transfer function coefficient *a* may either take a value of 1 (causing the transfer function to have no effect upon indoor drum test results), a generic value of [reserved] or a specific value for a given indoor drum. The specific transfer function coefficient *a* takes a value between [0.95 and 2] which shall be determined during the inter-facility equivalence exercise.

ALI_{vehicle} is the Abrasion Level Index of the candidate tyre that would be obtained using the vehicle test method in accordance with Annex 3, *ALI_{drum}* is the Abrasion Level Index obtained using the indoor drum test method, and *ALI_{drumTF}* is the approximation of *ALI_{vehicle}* obtained through the applications of the transfer function.

- 2.18 "Generic transfer function" means a transfer function where the transfer function coefficient *a* is a fixed value established by a statistical analysis of multiple facilities, intended for use by any drum facility.
- 2.19 "Specific transfer function" means a transfer function where the transfer function coefficient *a* is determined individually by a specific drum facility through a dedicated equivalence exercise, valid only for that specific facility and its operational conditions.

3. Organisation of an inter-facility equivalence exercise

- 3.1 The equivalence exercise shall be organised by a coordinating body as defined in paragraph 2.5 of this Annex.
- 3.2 Upon completion of the tests, each participating facility shall submit the data resulting from the application of the procedure described in paragraph 4.3 of this Annex to the coordinating body. The abrasion levels of the reference tyres shall also be reported; for

circuit facilities, the abrasion level normalised to the relevant reference temperature shall be included.

- 3.3 The coordinating body shall compile the results, calculate the baseline values according to paragraph 4.2 of this Annex, determine the specific transfer function for the drum under assessment, if applicable, and issue an Equivalence Report for the facility under assessment.

4. Equivalence procedure outline

The equivalence procedure consists of three main steps.

- 4.1 Step 1: Selection of exercise tyres and facilities
- 4.1.1 Exercise tyres selection (Step 1a)
- 4.1.1.1 At least [six] tyres shall be selected so that
- (i) they cover an *ALI* range of at least [0.5] units, with an even distribution across the range and
 - (ii) they are a mix of normal and 3PMSF tyres with a ratio between 1:2 and 2:1.
- 4.1.1.2 If a facility under assessment is designed for testing only normal or 3PMSF tyres, the equivalence of the facility shall be restricted to the corresponding tyre category and the requirement under paragraph 4.1.1.1 (ii) of this Annex shall not apply.
- 4.1.2 Selection of participating facilities (Step 1b)
- 4.1.2.1 The participating facilities shall be selected according to the type of assessment being performed:
- (a) Assessment of a Circuit or Indoor Drum with transfer function coefficient $a = 1$ (transfer function with no effect): In addition to the facility under assessment, the participating facilities shall include either:
 - (i) At least [one] Equivalent Circuit (EC), with any number of additional equivalent circuits or equivalent indoor drums, as long as the number of equivalent circuits is equal or higher than the number of equivalent indoor drums; or
 - (ii) At least [three] circuits (regardless of equivalence status), with no participating indoor drums.
 - (b) Assessment of an Indoor Drum using a Specific Transfer Function: If the AD intends to determine a specific transfer function coefficient a , the participating facilities shall include either:
 - (i) At least [two] Equivalent Circuits (EC), with any number of additional equivalent circuits or equivalent indoor drums, as long as the number of equivalent circuits is equal to or higher than the number of equivalent indoor drums; or
 - (ii) At least [three] circuits (regardless of equivalence status), with no participating indoor drums.
 - (c) Assessment of an Indoor Drum using a Generic Transfer Function: If the AD intends to use a Generic Transfer Function (as defined in paragraph 2.18 of this Annex) the participating facilities shall include either:
 - (i) At least [one] Equivalent Circuit (EC), with any number of additional equivalent circuits or equivalent indoor drums, as long as the number of equivalent circuits is equal to or higher than the number of equivalent indoor drums; or
 - (ii) At least [one] Equivalent Indoor Drum (ED), with any number of additional equivalent circuits or equivalent indoor drums, provided that all equivalent indoor drums use the same Generic Transfer Function.

(iii) At least [three] circuits (regardless of equivalence status), with no participating indoor drums.

4.2 Step 2: Establishment of baseline values

4.2.1 All facilities shall carry out the tests according to Annex 3 of this Regulation. Each participating facility shall test each exercise tyre at least once.

4.2.2 The results of each Equivalent Indoor Drum facility shall be adjusted using the transfer function defined in paragraph 2.17 of this Annex.

4.2.3 For each exercise tyre, if more than one test result is available, the baseline value shall be the arithmetic mean of the *ALI* results reported by the participating facilities as defined in paragraph 2.11. The calculation of the baseline requires a minimum of two data points, if at least two participating facilities are required according to paragraph 4.1.2.

4.2.4 Any result whose absolute difference from the mean exceeds [0.25] shall be excluded and a new mean shall be calculated with the remaining results. Such exclusions shall be applied iteratively until all remaining results lie within $\pm[0.25]$ of their mean. If fewer than two valid data points remain after exclusion, data from an additional facility shall be added or an additional tyre shall be tested.

4.3 Step 3: Demonstration of equivalence of a facility

4.3.1 The facility under assessment (AC or AD) shall compare its measurements with the baseline values.

4.3.2 Before comparing to the baseline values according to paragraph 4.3.3 of this Annex, the results of a drum facility under assessment shall be adjusted using the transfer function defined in paragraph 2.17.

4.3.3 Drum facilities under assessment using a generic transfer function shall apply the value of the generic transfer function coefficient *a*. Indoor drum facilities under assessment with transfer function coefficient *a* = 1 (transfer function with no effect) shall assign the transfer function coefficient *a* the value of 1.

4.3.4 The facility under assessment shall demonstrate equivalence by fulfilling the following criteria:

(i) For each exercise tyre, the *ALI* result of the facility under assessment (adjusted by the transfer function, if applicable) differs from the baseline value by no more than $\pm[0.25]$; and

(ii) The root mean square deviation between baseline and under assessment facility for each exercise tyre shall be equal or lower than [0.10];

(iii) For the case that a specific transfer function is calculated, for all exercise tyres, the correlation coefficient (R^2) between the results of the facility under assessment and the baselines shall be greater than [0.85]. The correlation coefficient shall be calculated using the Ordinary Least Squares (OLS) method between the results of the facility under assessment and the baseline values, according to the following formula:

$$R^2 = 1 - \frac{\sum_i (ALI_{drum,TF,i} - ALI_{baseline,i})^2}{\sum_i \left(ALI_{baseline,i} - \frac{\sum_j ALI_{baseline,j}}{n} \right)^2}$$

Where *i* is the exercise tyre index and *n* the total number of exercise tyres tested.

4.3.5 For drum facilities under assessment determining a specific transfer function, the value of the transfer function coefficient *a* shall be calculated based on the results of the inter-facility equivalence exercise.

The calculation method is the Least Squares regression on the shifted coordinates.

Let:

$$m = ALI_{drum} - 1$$

$$n = ALI_{vehicle} - 1$$

The coefficient a_{calc} is calculated as:

$$a_{calc} = \frac{\sum_i(m_i \cdot n_i)}{\sum_i(m_i)^2}$$

The final Transfer Function coefficient a used for type-approval tests shall be determined as follows:

If $a_{calc} < 0.95$, then $a = 0.95$

If $a_{calc} > 2.00$, then $a = 2.00$

Otherwise, $a = a_{calc}$

- 4.3.6 Indoor drum test facilities that prove equivalence under this procedure (whether using a transfer function with no effect), a specific transfer function, or a generic transfer function) are recognised for the specific test parameters used during the exercise.

The following parameters shall be recorded in the equivalence test report and shall remain fixed for all subsequent Type Approval or Conformity of Production testing: (i) The surface texture (e.g., specific sandpaper grit or surface reference); (ii) The third body type and specification; (iii) The third body flow rate [g/h]; (iv) The method of third body distribution (e.g., nozzle type, position, and pulse frequency); (v) the transfer function applied.

Any significant change to the constructive characteristics (such as the powder distribution system) or significant deviation in the operational parameters shall require a new demonstration of equivalence.

- 4.3.7. Reference Parameters for Vehicle Test Facilities

The equivalence status of a vehicle test facility (circuit) is established based on the specific test circuit route used during the equivalence exercise. To ensure the consistency of the test results, the following parameters shall be recorded in the test report:

(a) The Test Circuit Route: The specific set of roads, defined by GPS coordinates or a detailed map, including the proportion of test severities (e.g., urban, extra-urban, motorway);

(b) The Test Vehicles: The vehicle class (defined by segment, powertrain architecture, and driven axle) used to test the Exercise and Reference tyres.

- 4.3.8 The test reports and analysis shall be made available to the Type Approval Authority.

5. Recognition of Historical Validation Data

- 5.1. Notwithstanding the requirements of paragraph 4.1, certain facilities that participated in the inter-facility campaign used to develop this Regulation are recognized as having demonstrated equivalence, on the basis of the measurement data provided during said campaign which served to establish the abrasion limits and test procedures of this Regulation.
- 5.2. The list of such facilities and their established Transfer Function coefficients is referenced in the Guidance document on the Procedure for Demonstrating Equivalence of Vehicle Test and Indoor Drum Test Facilities for Tyre Abrasion and Determining the Transfer Function for Indoor Drum Test Facilities [[UN Document Identifier](#)].
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