Tyre abrasion test by Indoor Drum Method

PMP IWG meeting 54th session

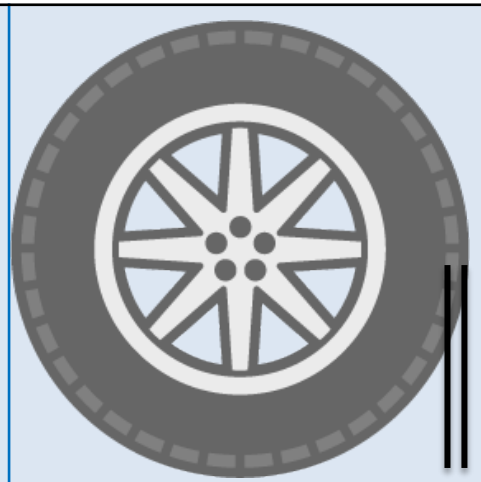
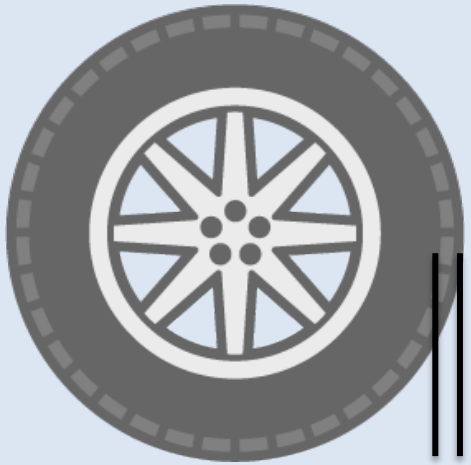
9th January 2024

JAPAN AUTOMOBILE STANDARDS INTERNATIONALIZATION CENTER

What to measure

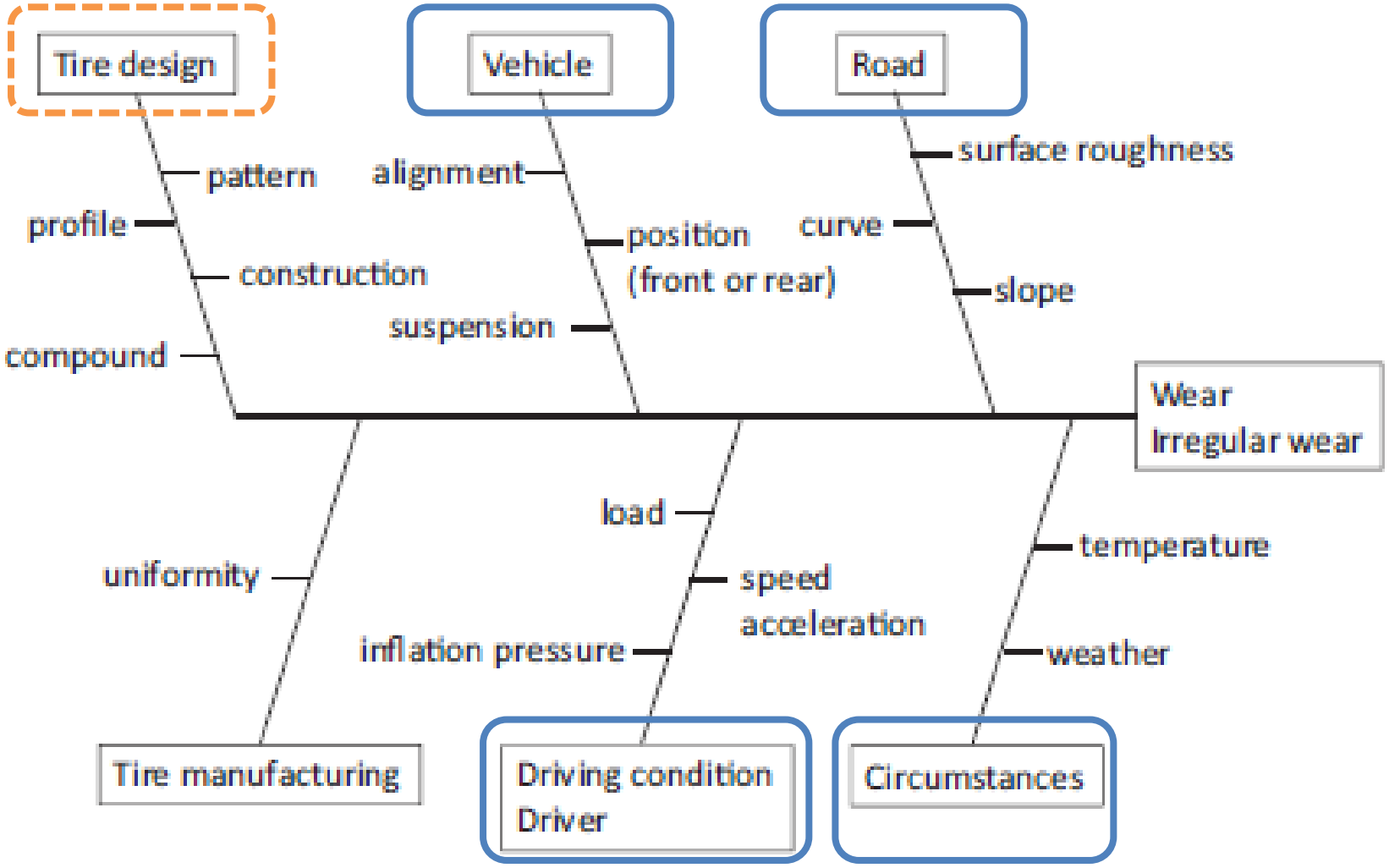
Tyre abrasion rate [mg/km] is the relevant indicator to quantify tyre wear particle

Example

		 6 mm Tread Depth	 9 mm Tread depth
Tread depth (at new)		6 mm	9 mm
Tread weight (at new)	(a)	1.0 kg	1.8 kg
Tyre life (mileage)	(b)	50,000 km	60,000 km
Abrasion rate / km	**(a)/(b)**	**20 mg/km**	**30 mg/km**

✓ To develop test methods for abrasion rate are necessary

Factors affecting tyre abrasion

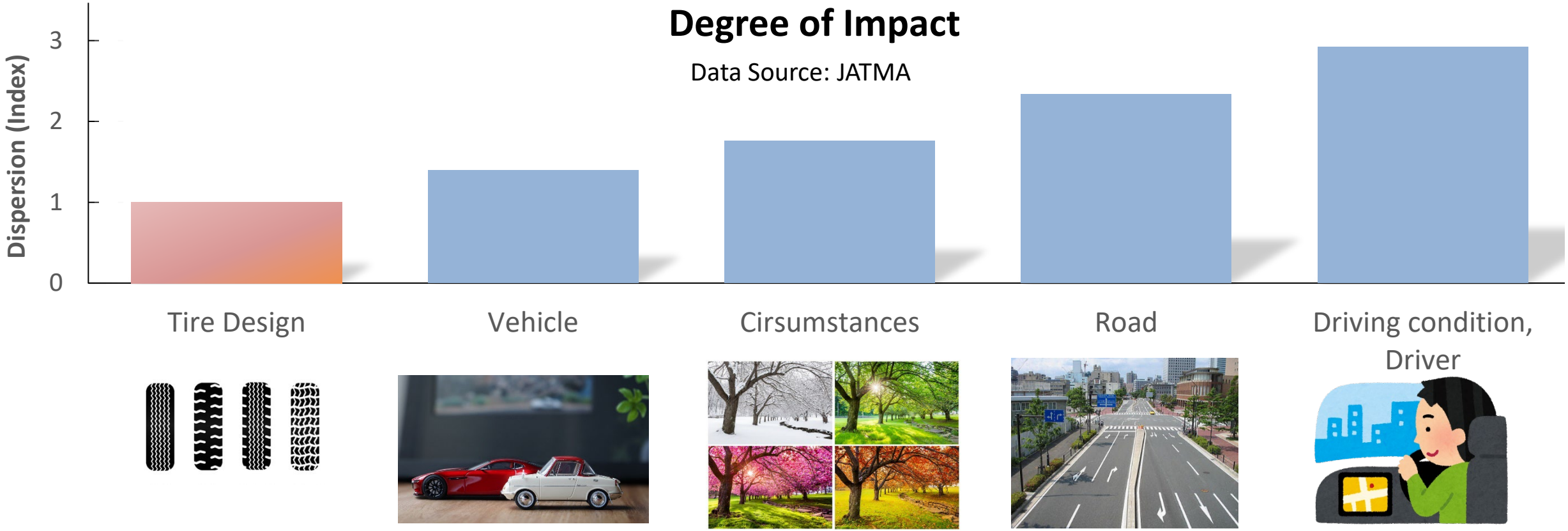


Source: "Current Studies on Wear Mechanics of Tire",, JOURNAL OF THE SOCIETY OF RUBBER SCIENCE AND TECHNOLOGY, JAPAN Vol. 88, No. 2 (2015)

✓ There are four factors affecting tyre abrasion, other than tyre design

Factors affecting tyre abrasion

Vehicle, Circumstance (weather, temperature…) , Road and Driving conditions and Driver are known as factors affecting tyre abrasion



- These 4 factors affect tyre abrasion greater than tyre design
- Test methods need to control these 4 factors

✓ Indoor Drum method can control these variances

Test conditions for Indoor Drum Method

- Test machine
- Running condition
  - Force condition
  - Others
- Drum Surface
  - Texture & Material
- Environment
- Test program
- Validation
- Measurement
- Evaluation

Test machine :

- ☐ Test Drum: External Drum
- ☐ Drum diameter, width : [1.7]m or above, more than tyre width

Running condition

- ☐ Tyre Load : 80% of the tyre LI

- ☐ Tyre inflation pressure :
  - ✓ Standard Load : 210kPa
  - ✓ Reinforced, Extra load : 250kPa

- ☐ Force condition : Condition proposed based on WLTC → Next page
  - ✓ 1 test cycle is 250km. Repeat 20 times.

- ☐ Running distance : 5000km

- ☐ Running velocity : Constant speed (100km/h for flat road , 60km/h for curve/slope)

Table A1. – Input of test cycle

T [s]	v [kph]	G(x)	G(y)
0	100	0.000	0
50	100	0.000	0.000
373.2	100	0.025	0.005
388.4	100	0.025	0.185
418.7	100	0.055	-0.175
446.5	100	0.085	0.155
471.7	100	0.115	-0.115
491.9	100	0.145	0.125
509.6	100	0.175	-0.085
522.3	100	0.205	0.065
532.4	100	0.235	-0.025
540.0	100	0.265	0.035
545.0	100	0.295	0.005
547.5	100	0.325	0.005
556.8	100	0.025	0.005
574.5	100	0.025	-0.205
602.3	100	-0.005	0.155
620.0	100	-0.035	-0.085
632.6	100	-0.065	0.065
645.2	100	-0.095	-0.055
657.9	100	-0.125	0.065
662.9	100	-0.155	0.005
668.8	100	0.025	0.005
678.9	100	0.025	0.125
699.1	100	0.055	-0.115
719.3	100	0.085	0.095
737.0	100	0.115	-0.085
	100		0.065

Force for indoor drum test

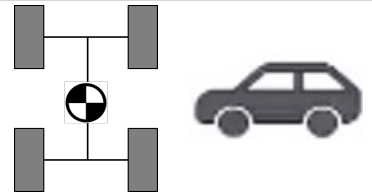
Force mode Concept

- Drum running mode based on **WLTC**
- **"Curve and Slope"** running mode is added as lateral force is a necessary element for tyre abrasion

Measurement Vehicle data

***selecting representative public road**

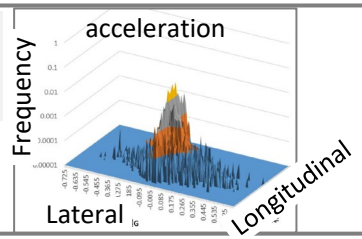
speed, m/s²
steering angle
gradient
• • •



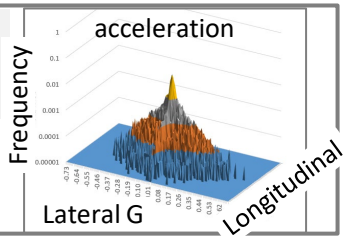
Conversion to tyre input acceleration

***using the vehicle models**

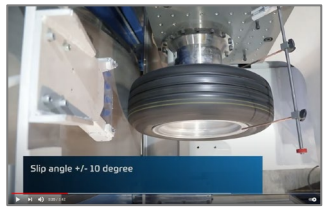
WLTC (Normal road)



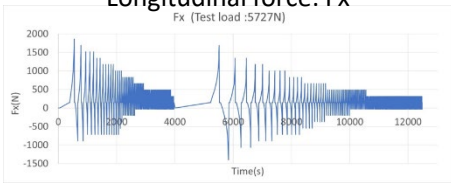
Curve & Slope (Winding road)



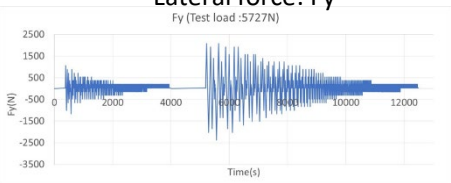
Conversion to drum testing conditions



Longitudinal force: Fx



Lateral force: Fy



- ✓ **Drum running mode developed by contract research to JARI, a core member of developing WLTP / GTR-15**
- ✓ **Converting the vehicle driving conditions representing the world into the test conditions of indoor drums**

*JARI: Japan Automobile Research Institute

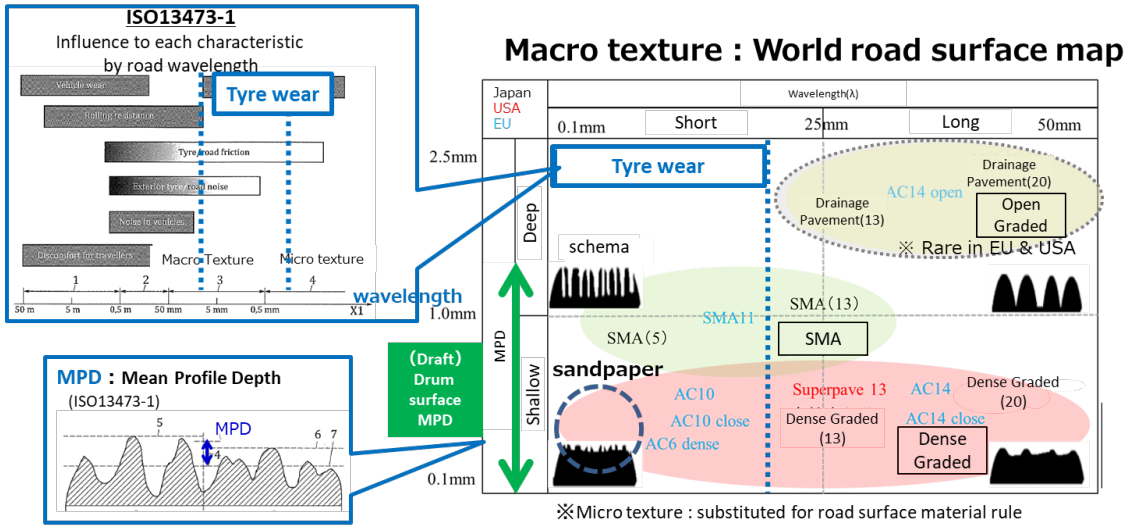
Drum Surface

☐ Texture : The range of surface shape MPD

- ✓ Measure MPD before and after the test

☐ Material : Sand or stone or substitute materials shall be the constituent elements of a drum surface

Mapping world road surface by wavelength and MPD to define drum surface shape as tyre wear depends on road surface characteristics



※Micro texture : substituted for road surface material rule

MPD is used in ISO 10844* as the definition of road surface roughness. (*Test track for noise)

Drum surface is defined by road surface shape MPD

Environment

- ☐ Preparation : 3-hour conditioning

- ☐ Ambient Temperature : 25°C +/- 5°C

- ☐ Adhesion prevention system
  - ✓ Tread wear test equipment shall be equipped with the powder distribution system to spray a controlled volume of such material (e.g., talc) on the test surface near the test tyre contact patch so that abrasion fragments does not adhere to the tyre surface or the test drum surface.

Test program

- ☐ 2 position drum: Test both SRTT and candidate at the same time
  - ✓ Tyre position shall be exchanged at 2500km

- ☐ 1 position drum: Test SRTT and Candidate tyres alternately
  - ✓ SRTT 1000km → Cand. 2000km → SRTT 2000km → Cand. 2000km → SRTT 2000km → Cand. 1000km

Validation

- ☐ Abrasion rate of reference tyre
  - ✓ SRTT17S : 50 mg/km/t to 190 mg/km/t
  - ✓ SRTT17W : 35 mg/km/t to 165 mg/km/t

- ☐ Record actual force level
  - ✓ Root Mean Square RMS of Gx & Gy : +/- 5%

Measurement

- ☐ Mass loss : Measure mass of the before and after test

Evaluation

- ☐ Abrasion rate : Mass loss per kilometer normalized by tyre load (mg/km/t)

- ☐ Abrasion index : Abrasion rate of candidate compared to abrasion rate of SRTT

Indoor drum test result

Verification

- ✓ **Test campaign results**

Correlation

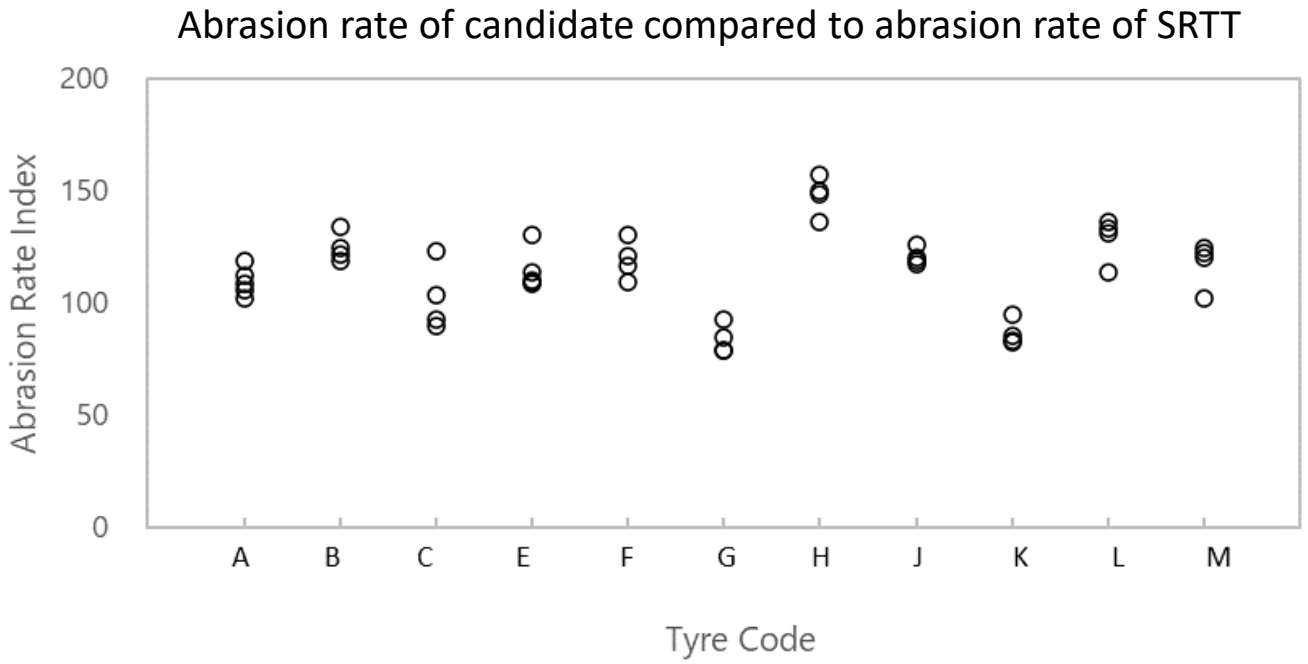
- ✓ **Test result of vehicle test & indoor drum test**

Specifications of evaluation for indoor test method

Tire Size	LI/SS	Category	Abrasion rate	Rim	Test periond (week)	Test procedure			
						1st time	2nd time	3rd time	4th time
155/65R14	75H	Normal	low abrasion	5	2				
155/65R14	75T	3PMSF	low abrasion	5	2				
205/55R16	94W	Normal	high abrasion	6.5	2				
205/55R16	91V	Normal	high abrasion	6.5	2				
205/55R16	91V	M+S	low abrasion	6.5	2				
205/55R16	91V	M+S	high abrasion	6.5	2				
205/55R16	91H	3PMSF	high abrasion	6.5	2				
235/55R19	105Y	Normal	low abrasion	7.5	2				
235/55R19	105V	M+S	low abrasion	7.5	2				
235/55R19	105H	3PMSF	high abrasion	7.5	2				
235/65R17	108T	Special Use	high abrasion	7.5	2				
225/45R17	94V	Reference(Normal)	–	7.5	2				
225/45R17	94H	Reference(3PMSF)	–	7.5	2				

✓ **11 candidate tyres has been tested with 4 repetitions by JASIC.**

✓ Indoor drum test results (4 repetitions & 2 additional data: total 46 data) has been summarized.

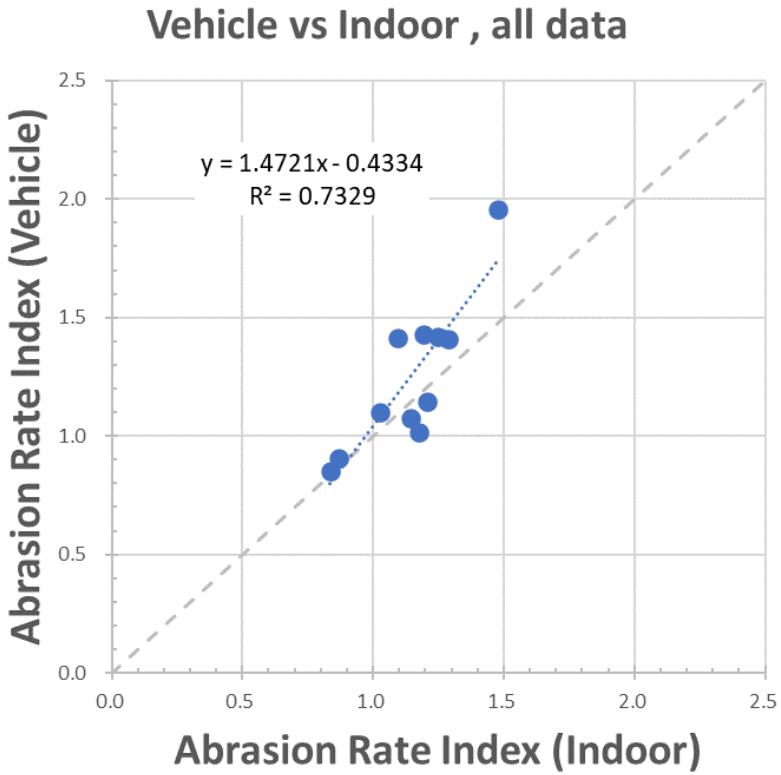


Candidate tyres evaluated by SRTT16 are adjusted according to correction factors.

✓ **These test results show sufficient test accuracy.**
✓ **Indoor drum test method is verified based on test campaign results.**

Test result of vehicle test & indoor drum test : correlation

Correlation between vehicle test & indoor drum test.



R: correlation coefficient

R^2: coefficient of determination

Slope : 1.47

R : 0.86

R^2 : 0.73

✓ **Correlation factor R is more than 0.8**

Further correlation will be studied based on market assessment data (ca. 200 tyres)