

UN Regulation Nos.13 / 13-H

Braking (Test procedures)

NTSEL

National Traffic Safety and Environment Laboratory

Takuya WATANABE

6th February 2020

1

Outline

1. Facility & equipment

1-1. Facility

1-2. Equipment

1-3. Calibration

2. Test procedure

2

Outline

1. Facility & equipment

1-1. Facility

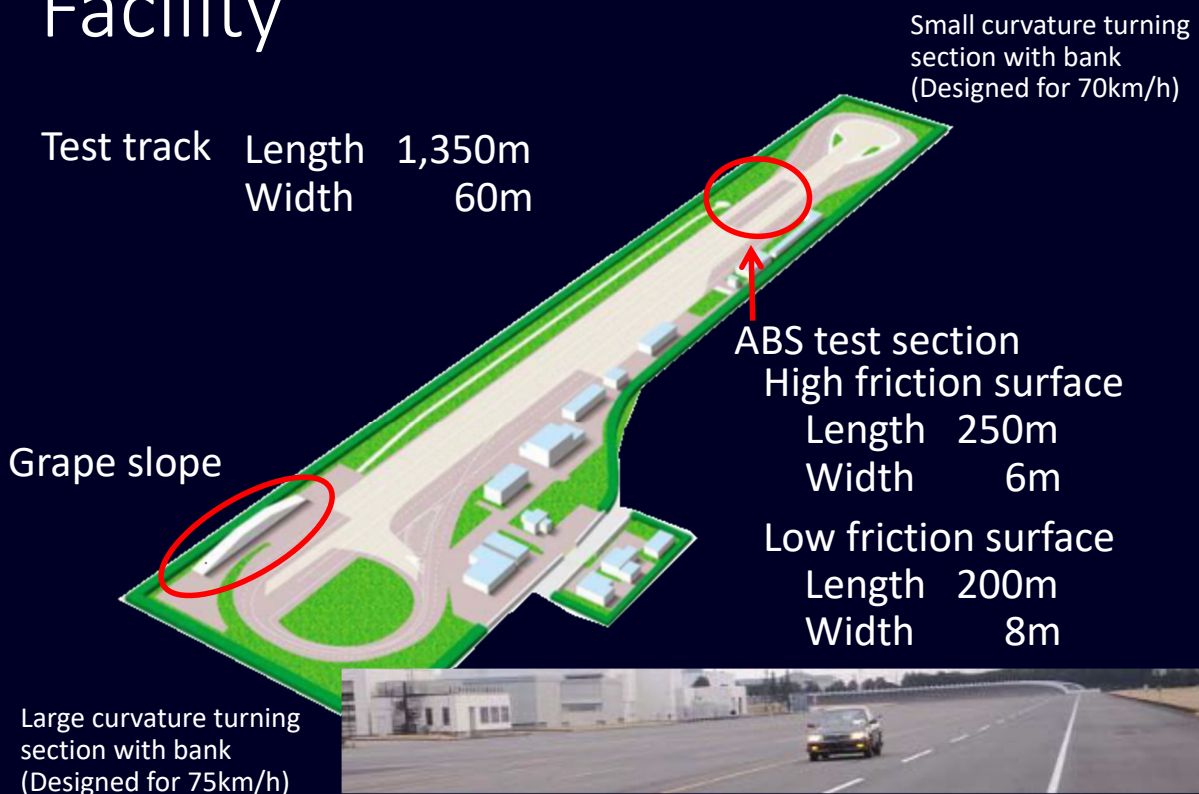
1-2. Equipment

1-3. Calibration

2. Test procedure

3

Facility



4

Test track



- Road surface affording good adhesion
- Flat and level, straight-line pavement
- Suitable road width and lane marker for braking points



5

ABS test section

**High friction surface**

Friction coefficient 0.8

Low friction surface

Friction coefficient 0.3

Low friction surface



Basalt tile pavement



6

Grape slope

R13H

20% grade slope

R13

18% grade slope for Truck

12% grade slope for Trailer



7

Grape slope

R13H

20% grade slope

R13

18% grade slope for Truck

12% grade slope for Trailer



8

Outline

1. Facility & equipment

1-1. Facility

1-2. Equipment

1-3. Calibration

2. Test procedure

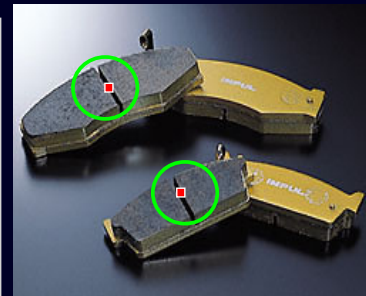
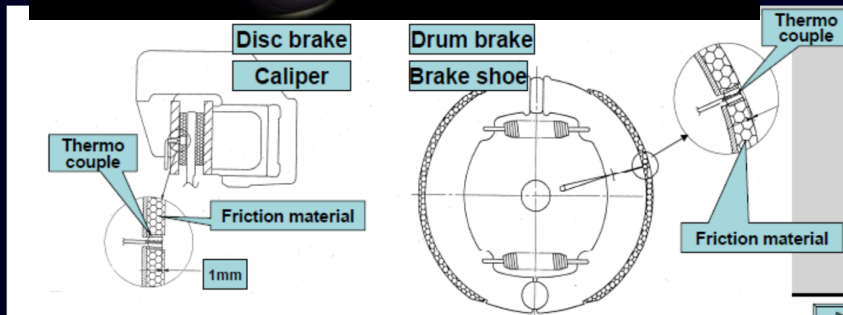
9

Equipment

Check points	Service braking and braking with failure	Parking braking	ABS	Equipment
Braking temperature before braking	✓	✓	✓	Thermocouples
Initial braking speed and stopping distance	✓	✓	✓	Speed sensor (G sensor)
Mean fully developed deceleration	✓	✓	✓	"
Force applied to control	✓	✓	✓	Measuring guage of control force
Wheel lockup at speeds exceeding 15 km/h	✓		✓	Wheel speed sensor
Vehicle behavior	✓		✓	Visual check
Deceleration time			✓	Measuring unit (Generated from data)
Control angle			✓	Steering angle sensor

10

Thermocouple



11

Speed sensor

Fifth wheel type



Non-contact type



12

Speed sensor

GPS type



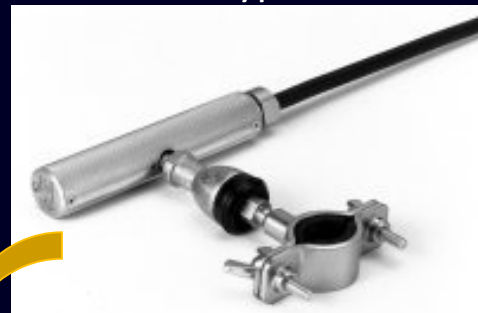
13

Measuring gauge of control force

Brake pedal type



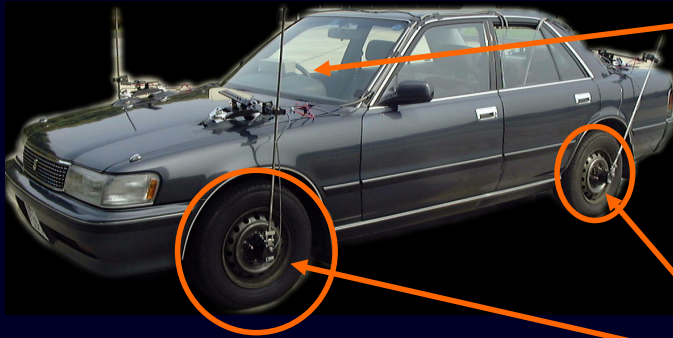
Hand brake type



14

Steering angle sensor Wheel speed sensor

Steering angle sensor



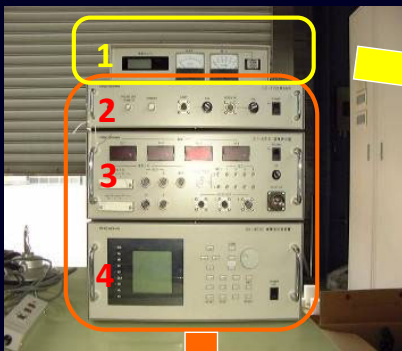
Wheel speed sensor



15

Measuring unit

- In case of fifth wheel



- 1 Display of Vehicle speed/deceleration/control force
- 2 Amplifier for fifth wheel onboard measuring unit
- 3 Temperature monitor
- 4 Main display & Main body of the onboard measuring unit

16

Measuring unit

- In case of GPS



Display and meters

- Deceleration
- Control force
- Vehicle speed

Measurement unit

- Deceleration time
- MFDD
- Temperature before braking
- Stopping distance



GPS Head unit

17

Outline

1. Facility & equipment

1-1. Facility

1-2. Equipment

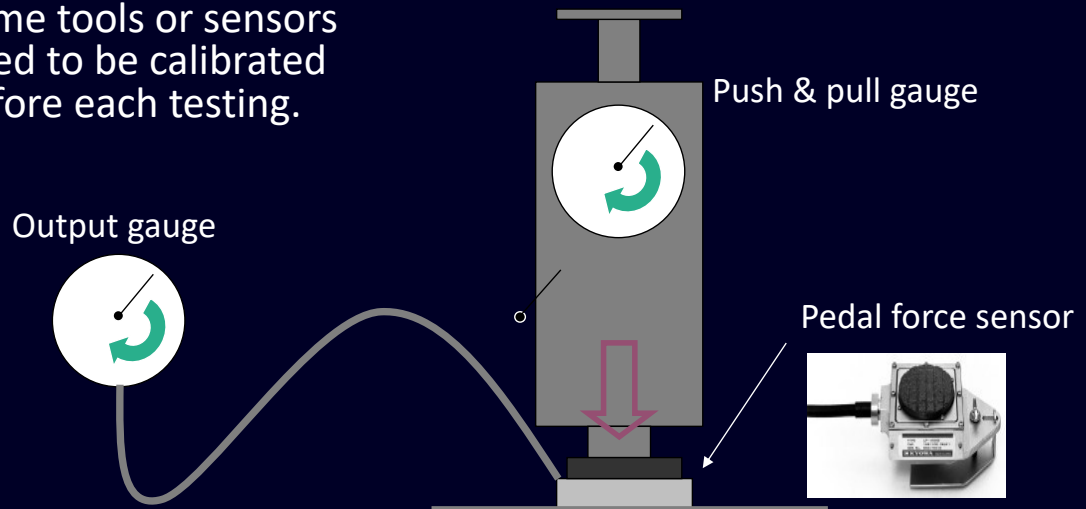
1-3. Calibration

2. Test procedure

18

Calibration of pedal force

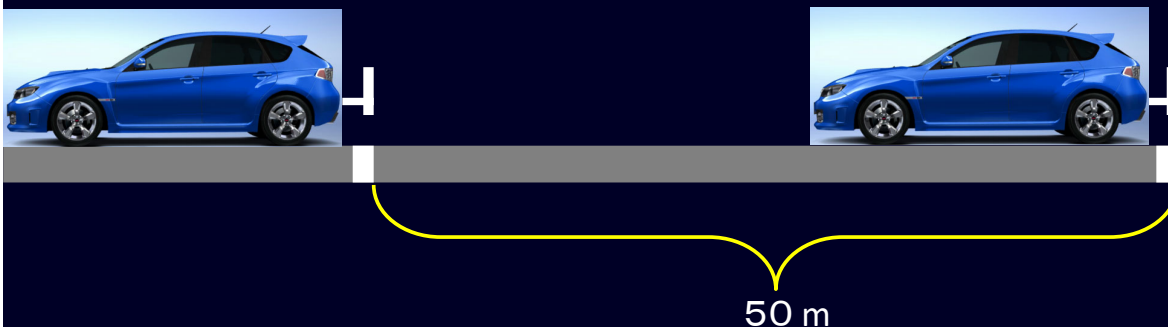
- Some tools or sensors need to be calibrated before each testing.



- Calibrate at several points from 0N to 500N
- Confirm the accuracy between the push & pull gauge and output

19

Calibration of vehicle speed



- In case of fifth wheel or non-contact sensor, calibrate its pulse output from 0m to 50m
- In case of GPS, the calibration is not necessary. Only check its accuracy.
- Confirm the accuracy within $\pm 1\%$ according to R13H Annex3 1.1.2

20

Outline

1. Facility & equipment

1-1. Facility

1-2. Equipment

1-3. Calibration

2. Test procedure

21

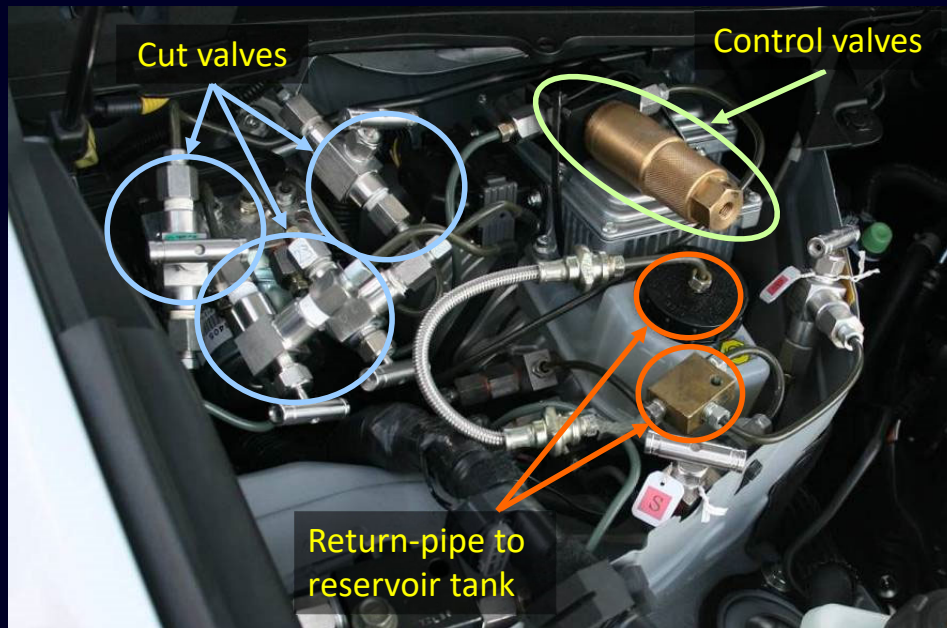
Checking points before testing

- Confirmation of testing vehicle
 - Vehicle type and number
 - Type of engine
 - Tire size and inflation pressure
 - Measurement equipment and its calibration
 - Confirmation of testing vehicle braking parts / modified parts for testing
 - Measurement mass
- Confirmation item of test condition
 - Weather conditions
 - State of testing road surface



22

Confirmation of testing vehicle (Modified parts / brake pipes)



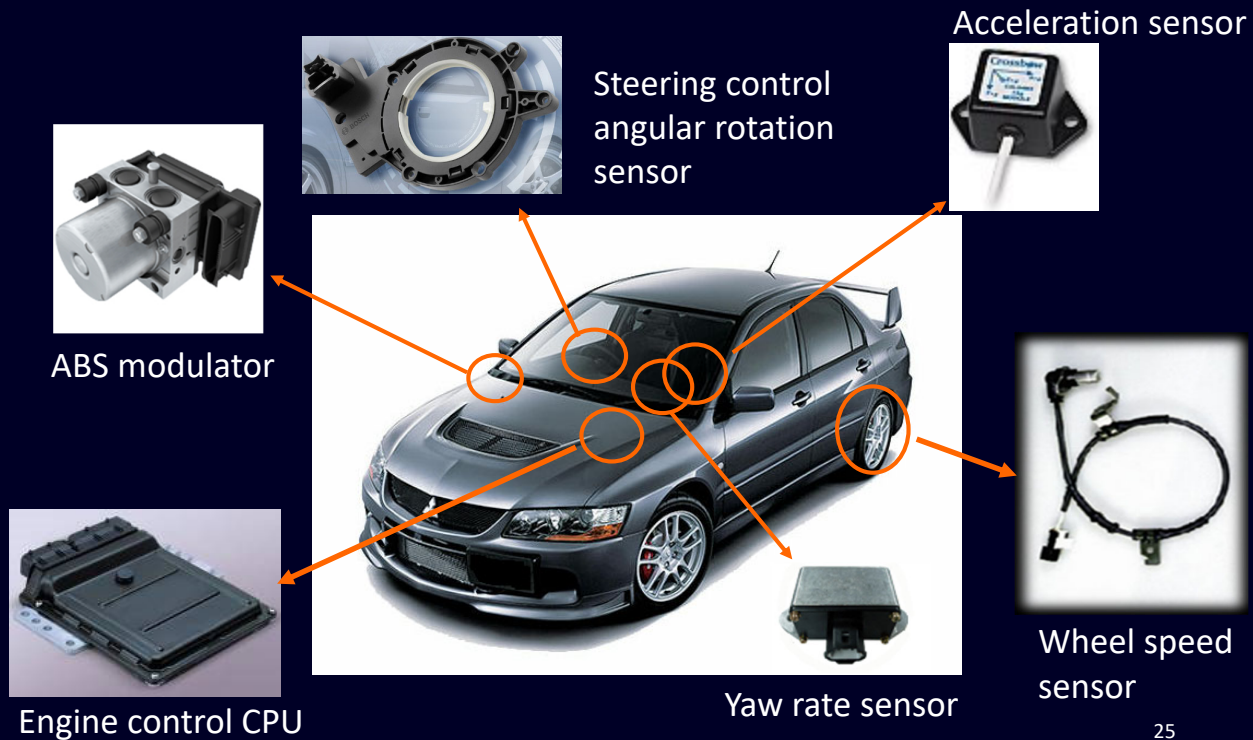
23

Confirmation of testing vehicle (Braking parts)



24

Confirmation of testing vehicle (Braking parts)



Contents

R13H

Annex 3	Braking tests and performance of braking systems
Annex 4	Provisions relating to energy sources and energy storage devices (energy accumulators)
Annex 5	Distribution of braking among the axles of vehicles
Annex 6	Test requirements for vehicles fitted with anti-lock systems
Annex 7	Inertia dynamometer test method for brake linings
Annex 8	Special requirements to be applied to the safety aspects of complex electronic vehicle control systems
Annex 9	Electronic stability control systems and brake assist systems

Test item of Annex 3

- Type-0 test
- Type-I test
- Secondary braking system test
- ABS failure test
- Dynamic parking brake test
- Static parking brake test

27

Requirements (behaviour of the vehicle during braking)

Target		Check item	Requirement
Brake lining or braking path of the disc or drum		Temperature	65 - 100 degrees C
Steering correction	Initial 2 seconds	Angular rotation	≤ 120 degrees
	in all	//	≤ 50 daN

28

Requirements (test condition)

Control force	Service brakes	foot control	6.5 - 50 daN
	Parking brakes	manual device	≤ 40 daN
		foot control device	≤ 50 daN
Initial speed			≥ 98 % of the prescribed speed

29

Requirements (behaviour of the vehicle during braking)

Vehicle behaviour	Without locking of the wheel at speed exceeding 15 km/h
	Without deviation of the vehicle from a 3.5 m lane
	Without exceeding a yaw angle of 15 degrees
	Without abnormal vibration



30

Requirements (behaviour of the vehicle during braking)

Vehicle behaviour	Without locking of the wheel at speed exceeding 15 km/h
	Without deviation of the vehicle from a 3.5 m lane
	Without exceeding a yaw angle of 15 degrees
	Without abnormal vibration



31

Test item of Annex 3

- **Type-0 test**
- Type-I test
- Secondary braking system test
- ABS failure test
- Dynamic parking brake test
- Static parking brake test

32

Type-0 test (in cold and disconnect)

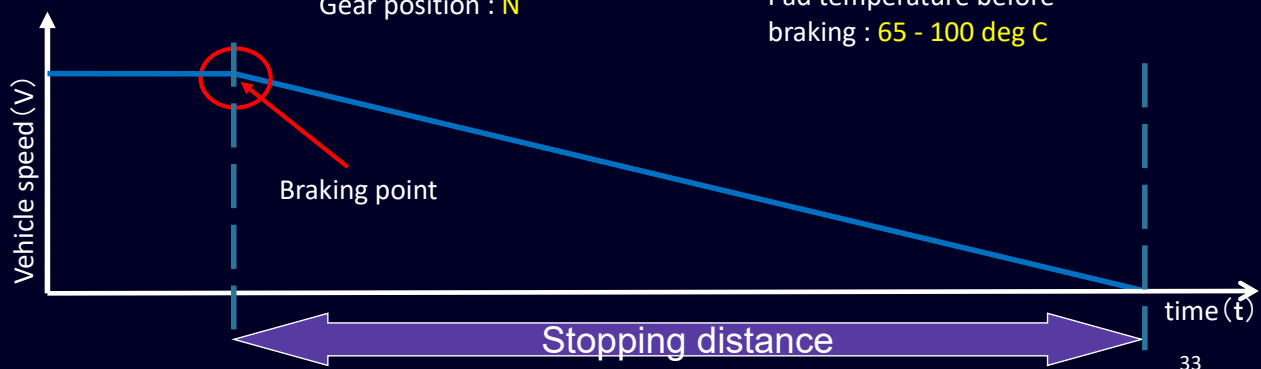
Test item	Service brake system condition	Engine connection	Test vehicle loading condition (kg)	Test speed V (km/h)	MFDD dm (m/s ²)	Stopping distance (m)
Type-0 test	Normal	Disconnected	Laden Unladen	100	≥ 6.43	$\leq 0.1 + 0.0060 V^2$ (70 m)



Gear position : N



Pad temperature before braking : 65 - 100 deg C



Type-0 test (in cold and connect)

Test item	Service brake system condition	Engine connection	Test vehicle loading condition (kg)	Test speed V (km/h)	MFDD dm (m/s ²)	Stopping distance (m)
Type-0 test	Normal	Connected	Laden Unladen	80 % Vmax (144*)	≥ 5.76	$\leq 0.1 + 0.0067 V^2$ (153.33*)

* e.g. Vmax = 180km/h



Gear position : D



Pad temperature before braking : 65 - 100 deg C



Test item of Annex 3

- Type-0 test
- **Type-I test**
- Secondary braking system test
- ABS failure test
- Dynamic parking brake test
- Static parking brake test

35

Type-I fade and recovery test

Sequence

Heating up procedure to put brakes in hot condition



Fade test

(Check the brake performance under hot condition)



Cooling down procedure to put brakes in recovery condition



Recovery test

(Check the brake performance under recovery condition)

36

Type-I fade and recovery test (Heating)



Pad temperature
before braking :
65-100 deg.C (First time only)

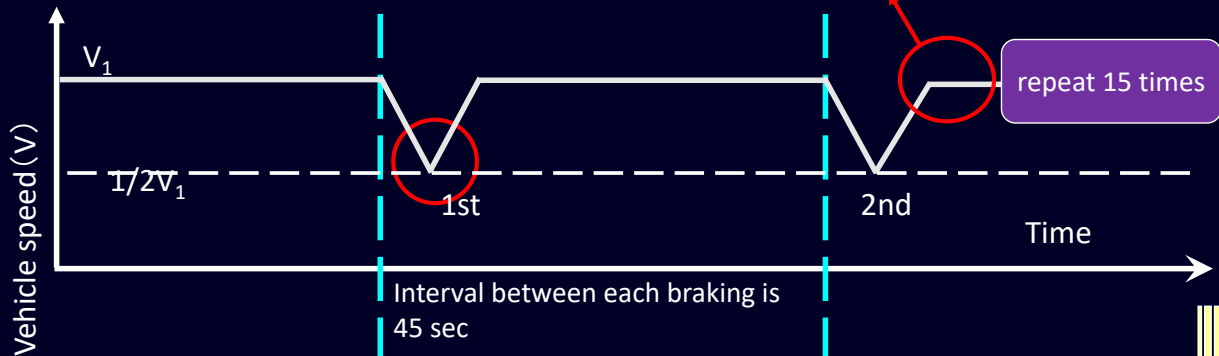


Gear position : D



Deceleration
3.0m/s² or more

Initial speed of braking :
 $V_1 = 80\% V_{max} \leq 120 \text{ km/h}$



37

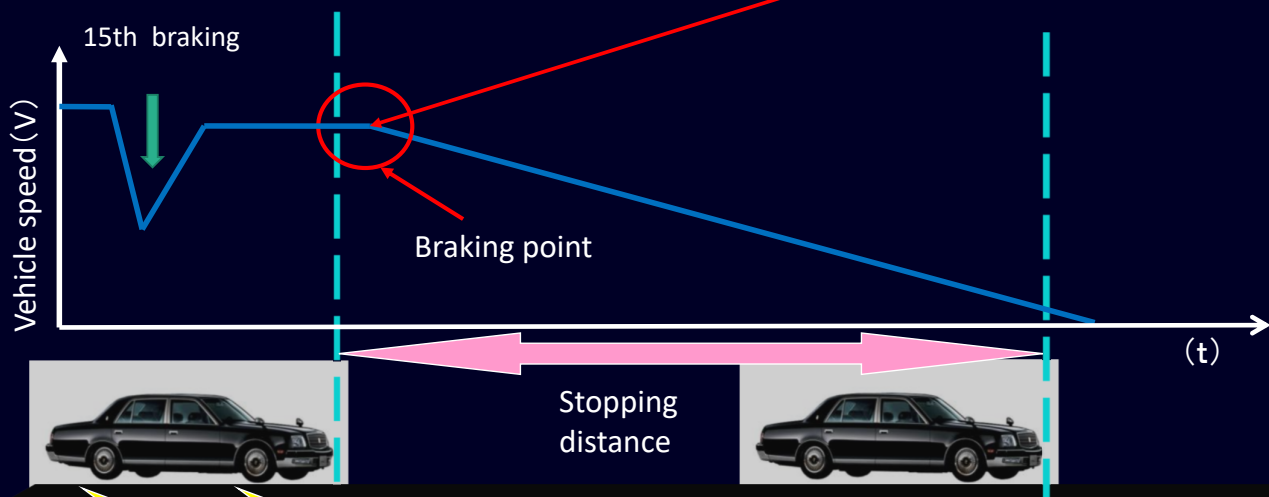
Type-I fade and recovery test (Fade test)



Gear position : N



Initial speed of
braking : 100km/h



38

Type-I fade and recovery test (Fade test)

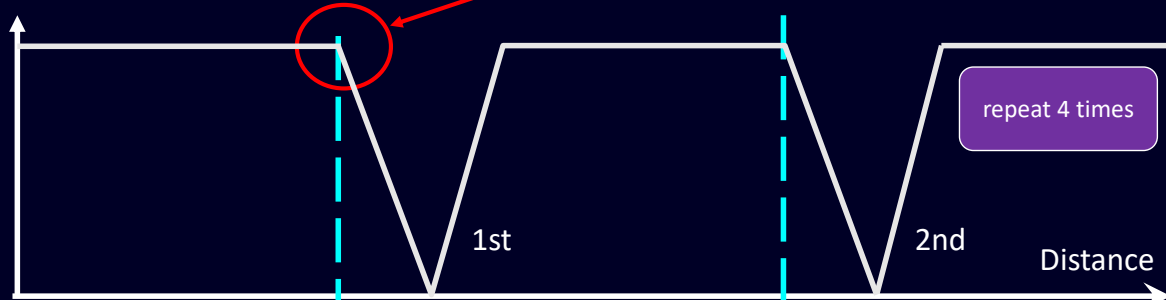
Braking speed	98% or exceeding 100 km/h
Stopping distance	75% requirement : $0.1V + 0.0080v^2$ or less 60% requirement : Result of Type-0 normal of 60% or more
MFDD	75% requirement : 4.82m/s^2 or more 60% requirement : Result of Type0 normal of 60% or more
Control force	Same as Result of Type0 normal
Vehicle behavior	Without locking of the wheel at speed exceeding 15km/h Without deviation of the vehicle from a 3.5m lane Without exceeding a yaw angle of 15° Without abnormal vibration

39

Type-I fade and recovery test (Cooling)



Gear position : D

Deceleration
 3.0m/s^2 or moreInitial speed of braking : 50km/h 

40

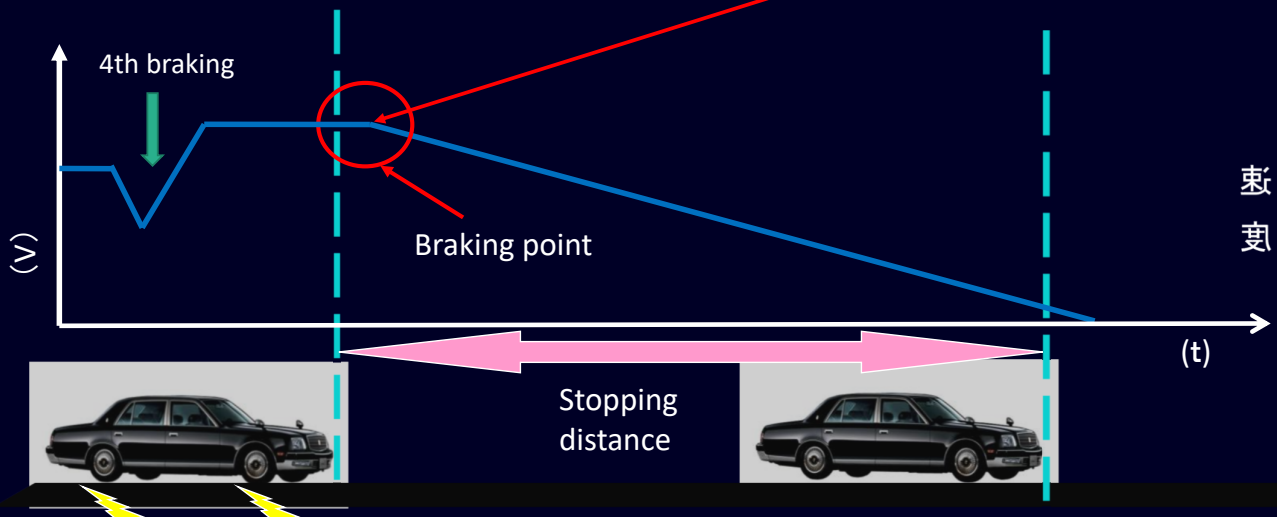
Type-I fade and recovery test (Recovery test)



Gear position : N



Initial speed of braking : 100km/h



41

Type-I fade and recovery test (Recovery test)

Braking speed	98% or exceeding 100 km/h
Stopping distance	Result of Type0 normal From 70 to 150%
MFDD	Result of Type0 normal From 70 to 150%
Control force	Same as Result of Type0 normal
Vehicle behavior	Without locking of the wheel at speed exceeding 15km/h
	Without deviation of the vehicle from a 3.5m lane
	Without exceeding a yaw angle of 15°
	Without abnormal vibration

42

Test item of Annex 3

- Type-0 test
- Type-I test
- **Secondary braking system test**
- ABS failure test
- Dynamic parking brake test
- Static parking brake test

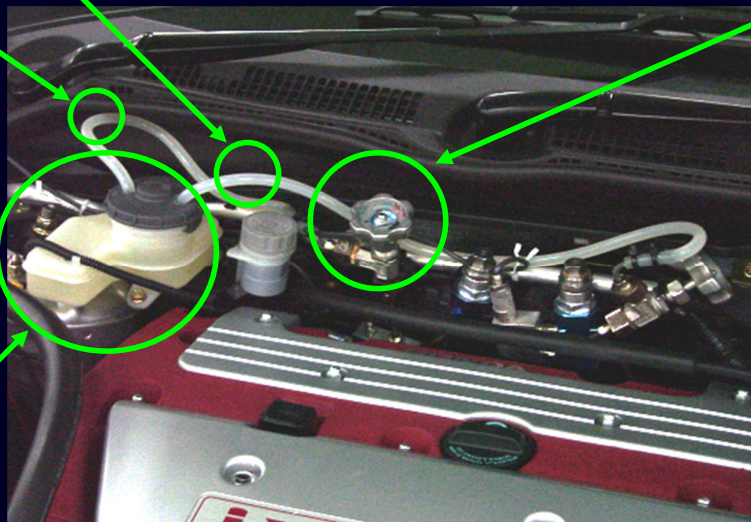
43

Secondary braking system test (Brake fluid leakage)

Return pipe

Cut valve

Reservoir



44

Secondary braking test (Brake fluid leakage)

Test item	Service brake system condition	Engine connection	Test vehicle loading condition (kg)	Test speed V (km/h)	MFDD dm (m/s ²)	Stopping distance (m)
Secondary braking system test	Front / FL-RR failure	Disconnected	Laden	100	≥ 2.44	≤ 168.0 ($0.1 + 0.0158 V^2$)
			Unladen			
	Rear / FR-RL failure		Laden			
			Unladen			



Gear position : N



Pad temperature before braking : 65 - 100 deg C



Secondary braking test (Energy failure)



The vacuum hose is pulled out, and then the mastering power becomes defective

Secondary braking system test (Energy failure)

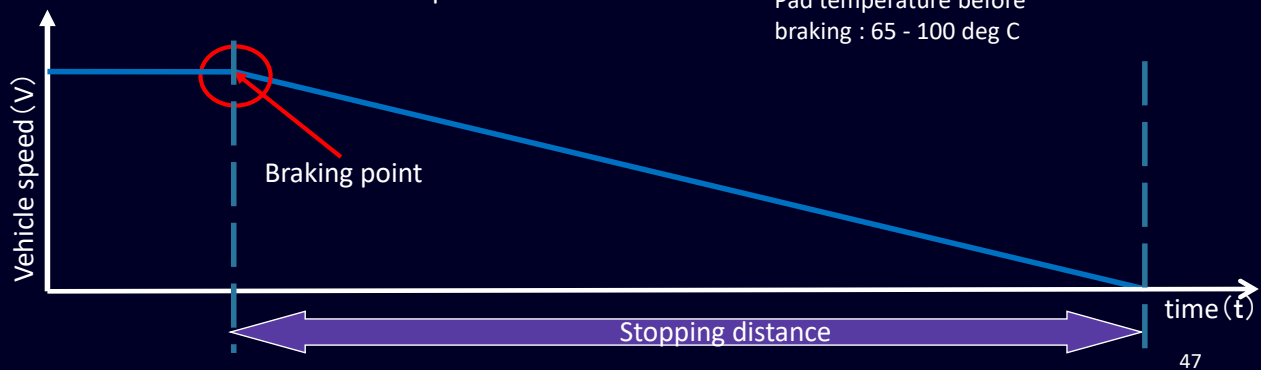
Test item	Service brake system condition	Engine connection	Test vehicle loading condition (kg)	Test speed V (km/h)	MFDD dm (m/s ²)	Stopping distance (m)
Secondary braking system test	Vacuum booster failure	Disconnected	Laden	100	≥ 2.44	≤ 168.0 ($0.1 + 0.0158 V^2$)
			Unladen			



Gear position : N



Pad temperature before braking : 65 - 100 deg C

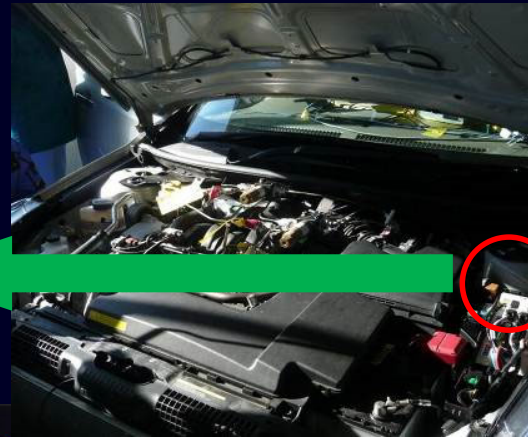
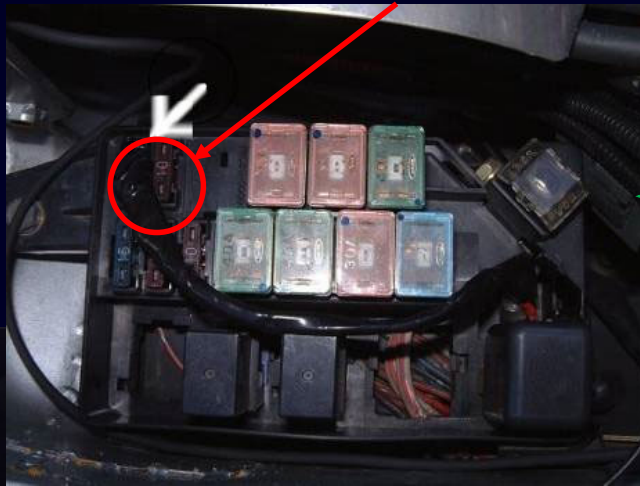


Test item of Annex 3

- Type-0 test
- Type-I test
- Secondary braking system test
- **ABS failure test**
- Dynamic parking brake test
- Static parking brake test

ABS failure test

Disconnect ABS Fuse



Confirm ABS failure indicator lamp is turned on

* The failure mode is different according to the vehicle.

49

ABS failure test

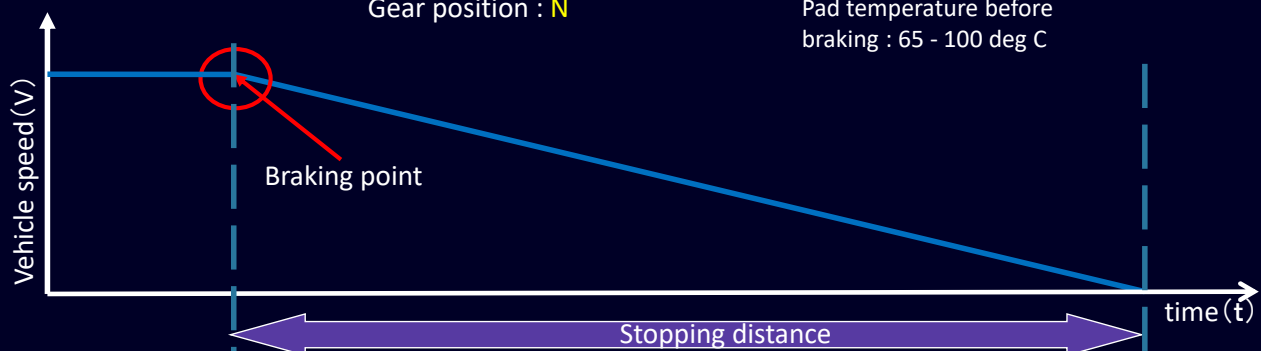
Test item	Service brake system condition	Engine connection	Test vehicle loading condition (kg)	Test speed V (km/h)	MFDD dm (m/s ²)	Stopping distance (m)
ABS failure test	ABS failure	Disconnected	Laden	100	≥ 5.15	≤ 85.0 ($0.1 + 0.0075 V^2$)
			Unladen			



Gear position : N



Pad temperature before braking : 65 - 100 deg C



50

Test item of Annex 3

- Type-0 test
- Type-I test
- Secondary braking system test
- ABS failure test
- **Dynamic parking brake test**
- Static parking brake test

51

Dynamic parking brake test

Test item	Service brake system condition	Engine connection	Test vehicle loading condition (kg)	Test speed V (km/h)	MFDD dm (m/s ²)	Stopping distance (m)
Dynamic parking brake test	Nomal	Disconnected	Laden	30	≥ 1.5	≤ 26.1 ($0.1V + 0.0257 V^2$)



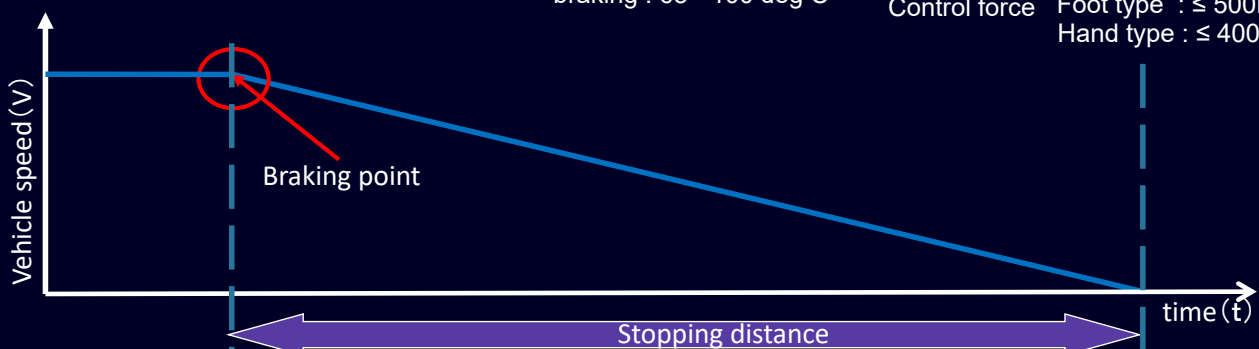
Gear position : N



Pad temperature before braking : 65 - 100 deg C



Control force
Foot type : $\leq 500N$
Hand type : $\leq 400N$



52

Test item of Annex 3

- Type-0 test
- Type-I test
- Secondary braking system test
- ABS failure test
- Dynamic parking brake test
- **Static parking brake test**

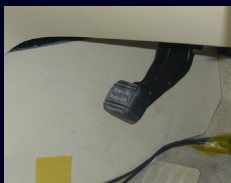
53

Static parking brake test

Control force

Foot type :500N or less

Hand type :400N or less



Gear position : **N**



Up

Inclination of
20%

Down

54

Confirmation of warning lamp of parking brake



<Hand brake type>



<Foot brake type>



Check the warning lamp is on

55

ABS testing

- Purpose

To confirm the braking force utilization rate and other data during ABS intervention by using road surfaces of different adhesion coefficients.

- Road surface: Definitions

- (i) High μ surface : A road surface having an adhesion coefficient of about 0.8
- (ii) Low μ surface : A road surface having an adhesion coefficient of 0.3 or less
- (iii) Split μ surface : A road surface where the left and right wheels have different adhesion utilization coefficients



56

ABS testing

Test item	Contents
(1) ABS failure braking test and confirmation of warning lamp	Confirmation of braking ability and operation of warning lamp in the ABS failure
(2) Z_{AL} measurement	Measurement of braking rate of the vehicle with the ABS in operation
(3) Z_{MALS} measurement	Measurement of Z_{AL} of the power driven vehicle on a split surface
(4) k measurement	Measurement of Adhesion coefficient between tire and road surface
(5) Additional check ABS	
(a) Confirmation of wheel lock	Confirmation no wheel lock in ABS operation
(b) High $\mu \rightarrow$ Low μ test	Confirmation vehicle behavior from high- μ surface to low- μ surface
(c) Low $\mu \rightarrow$ High μ test	Confirmation vehicle behavior from low- μ surface to high- μ surface
(d) Split μ test	Confirmation vehicle behavior on a split- μ surface

57

The marking on the tires for Visual check of lock

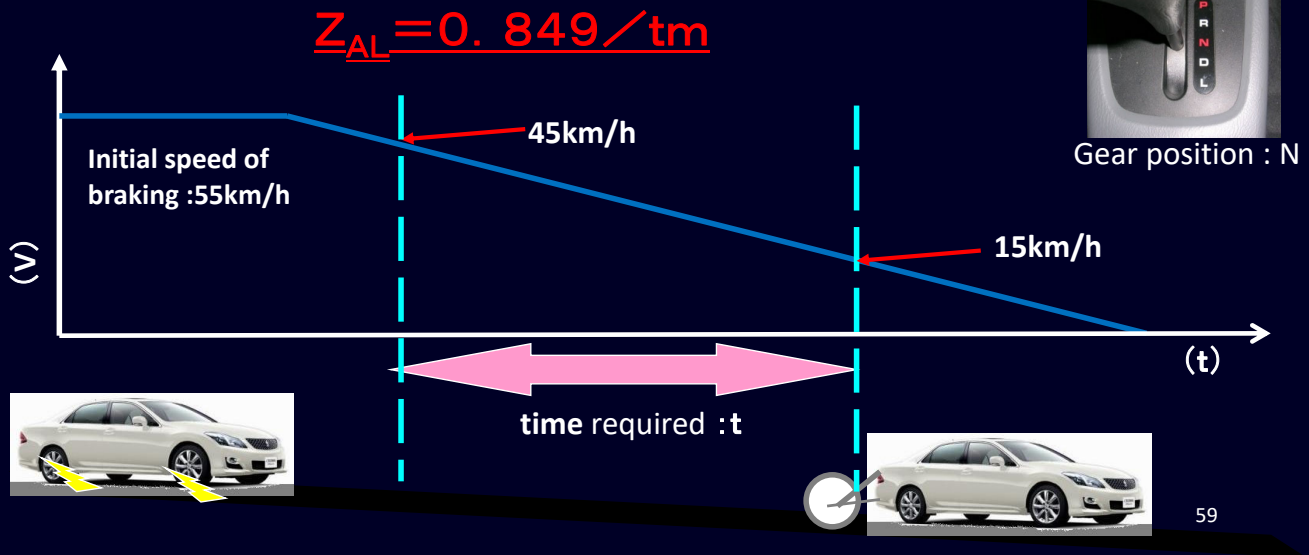


Mark on the
tires to check
wheel rotation
visually

58

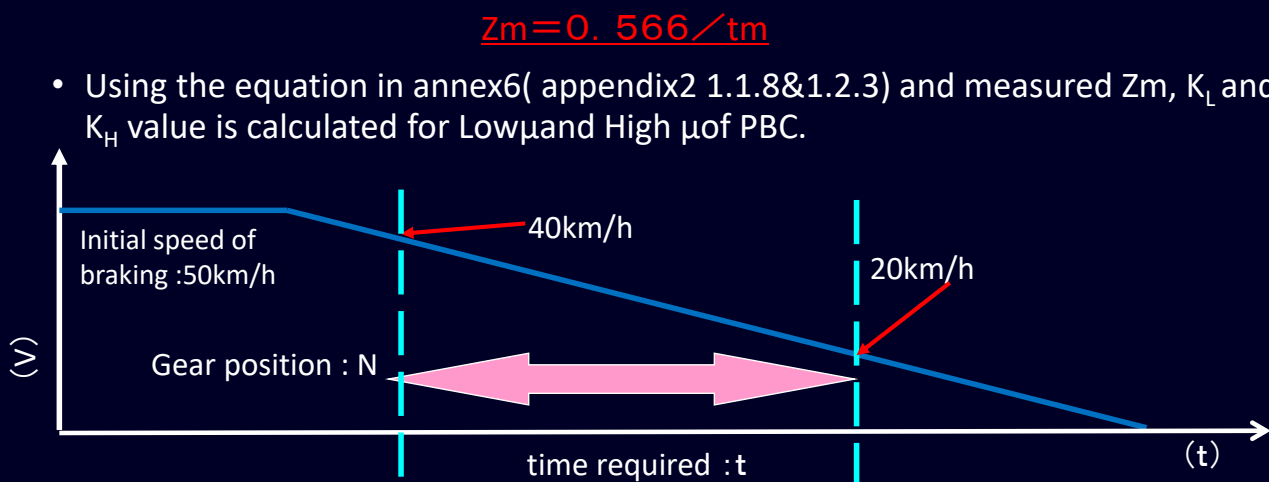
ABS testing (Z_{AL} measurement)

- These tests are executed on Low μ road and high μ road.
- ABS system is available.
- It is executed three times, and the average time (t_m) is calculated.
- Maximum braking rate (Z_{AL}) is calculated from the following expressions (t_m) between the calculated mean time.



ABS testing (K value measurement)

- These tests are executed on Low μ road and high μ road.
- These tests are executed on each axle.
(Front axle braking only and rear axle braking only)
- ABS system is NOT operative
- Three t within 5% of minimum measurements (t_{min}) is measured and mean value (t_m) is calculated.
- Using the equation in annex6(appendix2 1.1.8&1.2.3) and measured Z_m , K_L and K_H value is calculated for Low μ and High μ of PBC.



ABS testing (The adhesion utilized : ϵ calculated)

- These values are calculated for Low μ road and high μ road.
- The adhesion utilized for the vehicle is quotient of the maximum braking rate with the ABS operative (Z_{AL}) and the coefficient of adhesion (K_M).

$$\epsilon = Z_{AL} / K_M$$

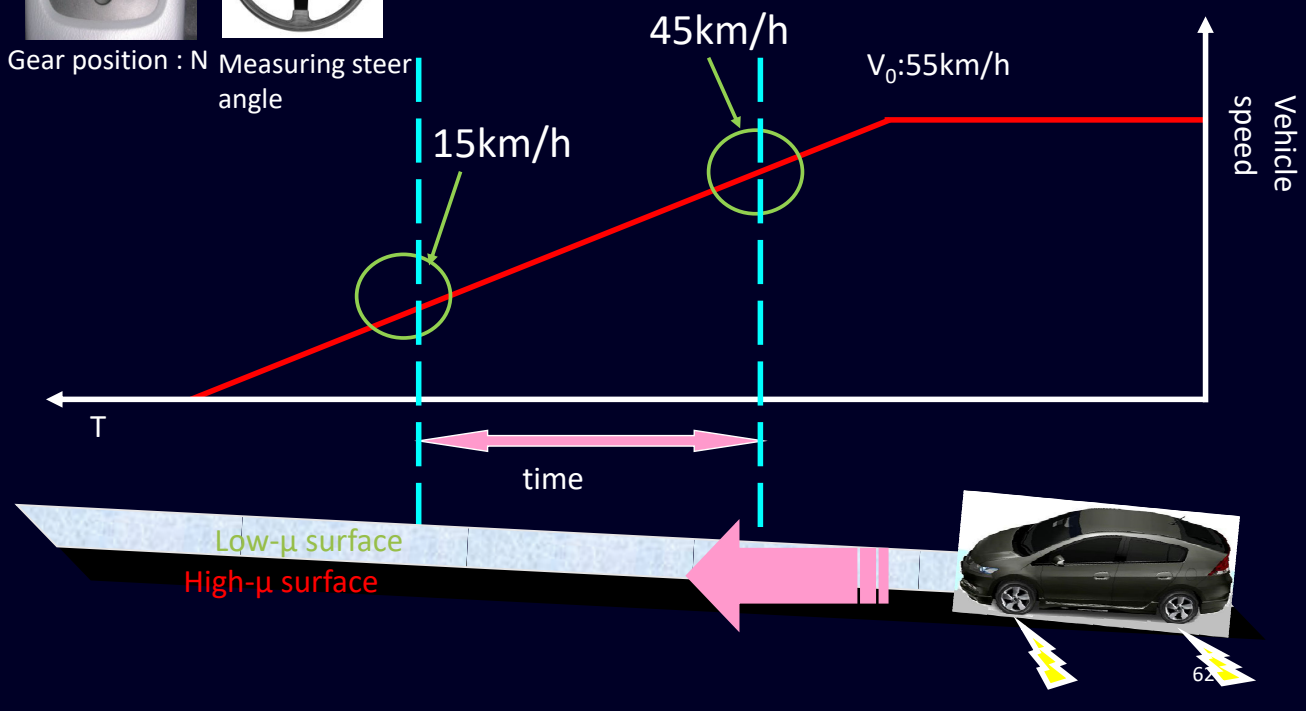
$$\epsilon \geq 0.75$$

61

ABS testing (Z_{MALS} measurement)



Gear position : N
Measuring steer angle



ABS testing (Z_{MALS} measurement)

- The right and left wheels of the vehicle are situated on the high μ road and the low μ road surfaces and braking is applied.
- It is executed three times, and the average time (t_m) is calculated.
- Braking ratio (Z_{MALS}) is calculated from (t_m) between the calculated mean time.

$$Z_{\text{MALS}} = 0.849 / t_m$$

- Braking ratio (Z_{MALS}) must satisfy the following expressions.

$$Z_{\text{MALS}} \geq 0.75 \times \left(\frac{4K_L + K_H}{5} \right)$$

$$Z_{\text{MALS}} \geq K_L$$

63

Additional ABS testing

- Purpose

To confirm the following under various road surface conditions:

- The wheels do NOT lock up
- The vehicle behavior is stable



64

Additional ABS testing (check item)

Criteria to be checked	High μ surface	Low μ surface	From high μ surface to low μ surface	From low μ surface to high μ surface	Split μ surface
Test speed	40 and 120km/h	40 and 120km/h	40 and 120km/h	50km/h	40km/h
The wheels do not lock up at speeds exceeding 15km/h	✓	✓	✓	✓	✓
The yaw angle does not exceed 15 degrees	✓	✓	✓	✓	✓
The vehicle does not deviate from a 3.5m-wide lane	✓	✓	✓	✓	✓
The steering angle does not exceed 120 degrees during the first two seconds and 240 degrees throughout the test					✓
The vehicle does not cross the border line on the road surface					✓

Test movies

- Type-O test
- ABS test
- (Reference) ABS failure on Low friction surface
- ESC tyre conditioning (R13H)
- ESC test (R13H)
- EVSC off test (R13)
- EVSC test (R13)

Thank you for your attention !