MOTORCYCLE BRAKES GTR - SUMMARY/CHANGES/ACTIONS/TECHNICAL JUSTIFICATION TABLE

*Document aligned with GRRF Informal Document 59-24 on **06/02/23***

<table>
<tr><th>GTR SECTION</th><th>GTR CONTENT IN SUMMARISED FORM / CHANGES SINCE DOC 2006/4</th><th>TECHNICAL JUSTIFICATION/ACTIONS REMAINING</th></tr>
<tr><td>1. SCOPE & PURPOSE</td><td>This gtr specifies the requirements for service brake and, where applicable, parking brake systems.
It applies to vehicles in category 3 (two and three-wheeled vehicles) as summarised in the following table: (Table not shown in gtr)
<table><tr><th>CATEGORY</th><th>DESCRIPTION</th></tr><tr><td>3-1</td><td>2 wheels, engine < 50cc and max speed < 50 km/h</td></tr><tr><td>3-2</td><td>3 wheels, engine < 50cc and max speed < 50 km/h</td></tr><tr><td>3-3</td><td>2 wheels, engine > 50 cc or max speed > 50 km/h</td></tr><tr><td>3-4</td><td>3 wheels – symmetrical, engine > 50 cc or max speed >50 km/h .</td></tr><tr><td>3-5</td><td>3 wheels – asymmetric, engine > 50 cc or max speed > 50 km/h (motorcycle + sidecar)</td></tr></table>Note:
- Does not include vehicles with a V max. of < 25 km/h, and those equipped for disabled drivers.</td><td>.

Categories taken from SR1</td></tr>
<tr><td>2. DEFINITIONS</td><td>Listed at the end of this table</td><td></td></tr>
<tr><td>3. GENERAL REQUIREMENTS</td><td></td><td></td></tr>
<tr><td>3.1 Brake system requirements

3.1.1</td><td>Each vehicle must meet the relevant requirements</td><td></td></tr>
<tr><td>3.1.2</td><td>Service brake control operation - rider seated normally with both hands on steering.</td><td>Based on ECE R78</td></tr>
<tr><td>3.1.3</td><td>Secondary brake control operation - rider seated normally with one hand on steering.</td><td>Based on ECE R78</td></tr>
<tr><td>3.1.4</td><td>Parking brake system - where fitted, must hold vehicle on prescribed slope with a separate control and locked in position by mechanical means. Operated with rider seated normally</td><td>Based on ECE R78</td></tr>
<tr><td>3.1.5</td><td>2 wheelers (3-1 + 3-3) shall have 2 separate service brake systems or a split service brake system – at least 1 brake operates on front wheel, 1 on rear.</td><td>Same content as ECE R78</td></tr>
<tr><td>3.1.6</td><td>Category 3-5 (motorcycle + sidecar) shall be as 3.1.5. A sidecar brake is not required if the performance requirements can be met.</td><td>Same content as ECE R78</td></tr>
</table>

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	3.1.7	3 wheelers of category 3-2 shall have: - a parking brake + one of the following: - 2 service brake systems (excluding CBS) which when applied together brake all wheels OR - a split service brake system that operates on all wheels OR - a CBS that actuates the brakes on all wheels and a secondary brake that may be the parking brake.	Based on ECE R78.
	3.1.8	3 wheelers of category 3-4 shall have: - a parking brake + : - a foot operated service brake system which operates on all wheels using either: - a split service brake system OR - a CBS and a secondary brake that may be the parking brake.	Based on ECE R78
	3.1.9	Where 2 separate service brake systems are installed, there may be a common brake provided failure in 1 system does not affect the performance of the other.	Same content as ECE R78
	3.1.10	Master cylinders shall have: - a separate sealed, covered, reservoir for each brake system - 1.5 x the fluid displacement required from new to fully worn brake linings - a visible fluid level.	The fluid level checking requirement is taken from ECE R78 whilst the other 2 requirements are from FMVSS 122, thus creating a comprehensive requirement.
	3.1.11	Vehicles equipped with a split braking system shall be fitted with a red warning lamp to signify hydraulic failure or low fluid level.	Same content as FMVSS 122
	3.1.12	Vehicles with ABS shall be fitted with a clearly visible yellow warning lamp to signify control signal failures	Content based on ECE R78 but with a clearer description of the requirement and the lamp
3.2 Durability			
	3.2.1	Brake wear shall be taken account of automatically or manually.	Same content as ECE R78
	3.2.2	Friction material thickness shall be visible or able to be checked with a specific device.	This requirement is taken from FMVSS 122 but with an additional statement to cover instances where the lining is not visible.
	3.2.3	During tests, no friction material detachment or fluid leakage.	Same content as FMVSS 122
3.3 Dynamic performance results		These may be presented in 3 ways – specified in respective tests :	
	3.3.1 MFDD	Mean Fully Developed Deceleration	Taken from ECE R78

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	3.3.2 Stopping distance	Based on the basic equations of motion : $S = 0.1\ V + (X)\ V^2$ where : S = stopping distance V = vehicle speed X = a variable based on test requirement. To calculate the corrected stopping distance using the actual vehicle speed, the following formula is used : $S\ s = 0.1\ Vs + (Sa - 0.1\ Va)\ x\ Vs^2/Va^2$ Where: S s = corrected stopping distance in metres Vs = specified vehicle test speed in km/h Sa = actual stopping distance in metres Va = actual vehicle test speed in km/h	Based on ECE R78 / JSS 12-61. NHTSA and TC representatives also required a stopping distance alternative to MFDD. The formulae used in the gtr are based on the standard equations of motion. The corrected stopping distance equation is included in order to take account of differences between actual test speed and specified test speed. (Taken from JSS 12-61).
	3.3.3 Continuous Deceleration Recording	Continuous deceleration recording for tests such as Wet brake and Heat fade – heating procedure.	This method of performance measurement is necessary for these tests. For example, the Wet brake test requires an analysis of vehicle deceleration during the period 0.5 to 1.0 seconds after brake control application.
4. TEST CONDITIONS, PROCEDURES, AND PERFORMANCE REQUIREMENTS			
4.1 General			
	4.1.1: Test surfaces	4.1.1.1 Dynamic brake tests (excluding low friction ABS tests): Test area to be clean, dry and with a level road surface. Gradient ≤ 1%. Test surface shall have a nominal PBC (peak braking coefficient) of 0.9 unless otherwise stated.	ECE R78/JSS 12-61 does not mention a friction value but it is specified in FMVSS 122. It was considered that it should be specified in the gtr in order to understand any test result anomalies. For example, a lower friction surface could result in premature wheel lock before the required vehicle brake performance was reached. Conversely, an unsatisfactory system may be made to comply by the use of an unrealistically high friction surface. It is difficult to derive a repeatable value for PBC as it varies with ambient temperature, tyres used, etc. A common test procedure is not specified in the gtr.
		4.1.1.2 Low friction ABS tests: Test area to be clean, and with a level road surface. Gradient ≤ 1%. PBC ≥ 0.3, ≤ 0.45	Same note as above. The lowest value PBC (0.3) is used to derive the ABS stopping performance requirement – para 4.9.4.2 ($0.3x\ 0.7x\ 9.8 = 2.05\ m/s^2$)
		4.1.1.3 Parking brake tests: A clean, dry, non deformable surface with the specified slope.	This paragraph is included in the gtr to prevent a potential failure to comply due to the vehicle's locked wheels sliding down the test hill. The text is based on FMVSS 122 with "non deformable" added as the surface (eg. loose gravel) could assist in retaining the vehicle.
		4.1.1.4 Test lane width: - 2.5 m for 2 wheeled motorcycles. - vehicle width plus 2.5 m for 2 wheeled motorcycles with sidecar or 3 wheeled motorcycles.	The lane width is used as part of the vehicle stability assessment. The text is taken from ISO 8710.

<table>
<tr><th colspan="2">GTR SECTION</th><th>GTR CONTENT IN SUMMARISED FORM / CHANGES SINCE DOC 2006/4</th><th>TECHNICAL JUSTIFICATION/ACTIONS REMAINING</th></tr>
<tr><td></td><td>4.1.2:
Ambient temperature</td><td>4° - 45° C</td><td>Only FMVSS 122 specifies an ambient temperature (0-38° C)
To avoid a frozen surface, a minimum 4° was added.
India insisted on 45°</td></tr>
<tr><td></td><td>4.1.3:
Wind speed</td><td>Not more than 5 m/s</td><td>To prevent wind assisted stopping performance or vehicle instability caused by cross winds, this text was taken from JSS 12 – 61.</td></tr>
<tr><td></td><td>4.1.4:
Test speed tolerance</td><td>± 5 km/h</td><td>Taken from JSS 12-61 and included in order to improve test repeatability as well as complying with the stopping distance equation tolerance in 3.3.2.</td></tr>
<tr><td></td><td>4.1.5:
Auto transmission</td><td>These vehicles shall complete engine connected and disconnected tests.
If transmission has a neutral, this shall be used for engine disconnected tests.</td><td>This paragraph is based on ECE R78 but with a text addition to cover a vehicle type that is on the market.</td></tr>
<tr><td></td><td>4.1.6:
Vehicle position and wheel lock</td><td>- Vehicles shall begin each stop in the middle of the test lane
- Stops shall be made without the wheels passing outside the test lane and without wheel lock.</td><td>This section is applicable during the analysis of vehicle stability during a stop. It is based on FMVSS 122 but modified to specify that the “wheels” should not go outside the lane (was “vehicle”) for better definition.</td></tr>
<tr><td></td><td>4.1.7:
Test sequence</td><td><table><tr><th>TEST ORDER</th><th>SECTION</th></tr><tr><td>1. Dry Stop - single brake control actuated</td><td>4.3</td></tr><tr><td>2. Dry Stop - all service brake controls actuated</td><td>4.4</td></tr><tr><td>3. High Speed</td><td>4.5</td></tr><tr><td>4. Wet Brake</td><td>4.6</td></tr><tr><td>5. Heat Fade</td><td>4.7</td></tr><tr><td>6. If fitted:</td><td></td></tr><tr><td>6.1 Parking Brake</td><td>4.8</td></tr><tr><td>6.2 ABS</td><td>4.9</td></tr><tr><td>6.3 Partial failure test, for a split-brake system</td><td>4.10</td></tr><tr><td>6.4 Power assisted braking system failure</td><td>4.11</td></tr></table>Note that Heat Fade is always the final test.</td><td>Based on FMVSS 122, it is important that a test order is used in order to improve overall test repeatability.

The test order was chosen as it was considered that each test was unlikely to have a significant effect on the following one.

The test most likely to have a significant effect on a subsequent test is the Fade test and so this shall always be the final test.</td></tr>
<tr><td colspan="2">4.2 Preparation</td><td></td><td></td></tr>
<tr><td></td><td>4.2.1: Engine idle speed</td><td>Manufacturers specification</td><td>This note is taken from FMVSS 122 and is to minimise the effect of engine braking and give repeatability to the results.</td></tr>
<tr><td></td><td>4.2.2: Tyre pressures</td><td>Manufacturer’s specification</td><td>This standard note appears in other regulations and helps to assure consistent results eg. tyre to road adhesion.</td></tr>
</table>

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	4.2.3: Control lever application point and direction	Hand control: Input force applied 50 mm from the outer end of the lever. Foot control: Input force applied in the centre of and at right angles to the pedal.	This specification is important as it defines the input force provided by the rider's hand or foot to the brake system. Regarding the hand control, FMVSS 122 specifies a dimension from the end of the hand grip whilst ECE R78/JSS 12-61 measures from the end of the control lever. Although it may appear that the FMVSS method is the more representative of normal use, a survey of various vehicles showed that this was not practical because sometimes, the lever did not coincide with the specified application point. Therefore, it was decided to base the requirement on the ECE/JSS philosophy but using a modified ISO 8710 text for clarity.
	4.2.4: Brake Temperature measurement	Based on a determination by each contracting party, the temperature is measured in the centre of the braking path of the disc or drum using: a. rubbing thermocouple OR b. thermocouple embedded in friction material	These are the 2 types of measurement methods commonly used by both manufacturers and authorities. There are pros and cons with each method. For example: Rubbing type: - Difficult to use with drilled discs. - Rubbing friction = small increase in temperature - Requires careful setting up Embedded: - Difficult to install - Requires brake pad to be modified. - Slower to react to temperature change. It is considered that the choice of method will make no difference in practice.
	4.2.5: Brake burnishing	The brakes must be burnished prior to testing. This procedure may be completed by the manufacturer. - Vehicle unladen - Initial speed ≥ 50 km/h for 3-3, 3-4, 3-5 vehicles (0.8 Vmax for 3-1, 3-2 vehicles) - Reacceleration speed 5-10 km/h - Vehicle deceleration – CBS = 3.5-4.0 m/s^2 - Vehicle deceleration - front separately = 3.0-3.5 m/s^2 for 3-3, 3-4, 3-5 vehicles (1.5-2.0 m/s^2 for 3-1, 3-2 vehicles) - Vehicle deceleration - rear separately = 1.5-2.0 m/s^2 - 100 brake applications per brake system - Engine disconnected - Initial brake temperature before each brake application ≤100°C	In order to obtain consistent and repeatable results, the brake linings must be burnished. A burnishing procedure is specified in FMVSS 122 but not in ECE R78/JSS 12-61 - in this case it is the manufacturer's responsibility to supply the vehicle in a burnished condition. Therefore, to cover type approval or self certification, the procedure outlined in the gtr shall be used. This procedure was established following a survey of the major motorcycle manufacturers.

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4.3 Dry Stop Test– single brake control actuated	Summary: - Applicable to all vehicle categories - Laden vehicle only but where CBS fitted, also tested lightly loaded. - Engine disconnected - Initial brake temperature: ≥55°C and ≤100°C - Test speed: 40 km/h for 3-1, 3-2. 60 km/h for 3-3, 3-4, 3-5 vehicles or 0.9 Vmax - Separate tests for each service control - Brake actuation force – Hand ≤ 200N. Foot ≤ 350N for 3-1, 3-2, 3-3, 3-5.≤ 500 for 3-4 vehicles - 6 stops maximum Requirements :MFDD or equivalent s. distance based on $S = 0.1V + (X)V^2$ Minimum MFDD : Front brake : 3-1 = 3.4 m/s^2 ; 3-2 = 2.7 m/s^2 ; 3-3 = 4.4 m/s^2 ; 3-5 = 3.6 m/s^2 Rear brake: 3-1 = 2.7 m/s^2 ; 3-2 = 2.7 m/s^2 ; 3-3 = 2.9 m/s^2 ; 3-5 = 3.6 m/s^2 CBS and SSBS: 3-1,3-2 = 4.4 m/s^2 ; 3-3 = 5.1 m/s^2 ; 3-4 = 5 m/s^2 ; 3-5 = 5.4 m/s^2 CBS secondary brake = 2.5 m/s^2 for all vehicle types.	This test is based on ECE R78 (and JSS 12-61). A severity comparison test was carried out by IMMA using a range of motorcycles. Brake control forces for FMVSS v ECE procedures were compared. Result: - For front braking, FMVSS and ECE required similar control force. - For rear braking, more control force required to meet ECE requirement. - The test vehicle would not meet the ECE requirement if the FMVSS brake control forces were applied. Therefore, it was considered that the ECE test was marginally more stringent than the FMVSS test. Tests were also carried out by TC/NHTSA but the results suggested that the FMVSS test was slightly more stringent. The concept of using single brake control tests (ECE/JSS) instead of both controls together (FMVSS) was chosen because: - It improves repeatability. It is difficult for the test rider to apportion between front and rear when separate controls are used at the same time. - It may be possible to make an unsatisfactory brake “acceptable” by biasing the braking away from that brake. - The ultimate achievable brake performance is higher. Eg. Front + Rear brake together = 1.0 G Front alone = >0.9 G. Rear alone = >0.4G Theoretical total = >1.3G ie +30% Some minor changes have been incorporated into the ECE/JSS test procedure as follows: - IBT : ≥55°C and ≤100°C instead of ≤100°C in order to improve result repeatability. - The scope was enlarged to include those vehicles fitted with Split Service Brake systems.

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4.4 Dry Stop Test- all service brake controls actuated.	Summary: - Applicable to category 3-3, 3-4, 3-5 only - Lightly loaded vehicle test. - Stops with engine disconnected - Test speed = 100 km/h or 0.9 V max whichever is lower. - Stops performed with all service brake controls activated at the same moment - Brake actuation force – Hand ≤ 250N. Foot ≤ 400N (≤500N for 3-4) - 6 stops maximum Requirements: Stopping distance: For test speeds < 80.5 km/h, $S =\leq 0.0055\ V^2$ For test speeds ≥ 80.5 km/h, $S =\leq 0.0060\ V^2$	The conditions for this test simulate what is considered to be a normal riding situation ie medium speed, rider only, with both service brake controls being applied simultaneously. This will also check for overall vehicle stability. The test is taken directly from FMVSS 122. As in FMVSS 122, the performance requirement is expressed as a maximum stopping distance only.
4.5 High Speed Test	Summary: - Applicable to 3-3, 3-4, & 3-5 vehicles with a Vmax of ≥ 125 km/h - Lightly loaded vehicle test. - Stops with engine connected, highest gear - Test speed = 0.8 v max for vehicles with Vmax ≥ 125, ≤ 200 km/h 160 km/h for vehicles with Vmax ≥ 200 km/h - Stops performed with all service brake controls activated at the same moment - Brake actuation force – Hand ≤ 200N. Foot ≤ 350N for 3-3, 3-5. ≤ 500N for 3-4 - 4 stops maximum Requirement: - MFDD ≥ 5.8 m/s^2 or stopping distance $S \leq 0.1V + 0.0067V^2$	This test evaluates the complete service braking system from elevated test speeds. A high speed test is included in FMVSS 122, ECE R78, and JSS 12-61. All these tests apply similar test conditions but there are differences in areas such as test speed, and required brake performance. A severity test comparing the above 3 procedures was carried out by IMMA using various motorcycles. Braking force and kinetic energy were the main items evaluated. The conclusions were that FMVSS was more severe due the higher test speed and JSS more severe due to a higher brake performance requirement. (The ECE test does not include a brake performance requirement) Tests were also carried out by TC/NHTSA with similar results It was thus decided to base this test on the JSS parameters with a limit of 160 km/h in the interests of rider safety.A maximum of 4 stops is used in order to limit any effect that this test may have on subsequent tests.

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4.6 Wet Brake Test **- Base line** **- Wet brake**	Summary - Each brake to be tested is fitted with spray equipment. - For all vehicle categories. - Drum brakes exempt unless ventilation or inspection ports present. - Laden vehicle only (CBS, where fitted, also tested unladen) - Stops with engine disconnected - Initial speed = 40 km/h for 3-1, 3-2 and 60 km/h for 3-3, 3-4, and 3-5 vehicles - Separate tests for front brake, rear brake, and CBS (where fitted) - Not applicable to parking brake unless it is the secondary brake - Perform a Dry Stop test – single brake control actuated (as 4.3) but measure the control force to achieve an average deceleration of 2.5- 3.0 m/s^2 3 stops performed and the average control force used for the Wet Brake stop. - Repeat the Baseline stop after the brake has been continuously wetted at a flow rate of 15 l/h for > 500 m. Requirement, with a wet brake: - Using the same baseline average control force, the deceleration recorded between 0.5 and 1 sec after brake application shall be: - ≥ 60% and ≤120% of the average baseline deceleration until the vehicle stops.	This test is taken from ECE R78 (and JSS 12-61). It was developed in the UK 20+ years ago in order to deal with problems in the field where the braking performance of motorcycles with exposed disc brakes was significantly reduced when ridden in heavy rain. This coincided with the large scale adoption of disc brakes on motorcycles. The test therefore simulates the above conditions by wetting the discs using water spray equipment. The FMVSS 122 wet test applies a different philosophy to ECE R78 above. This is a static test where the brake assembly is immersed in water in order to simulate passing slowly through deep water. To assess the severity of ECE v FMVSS tests, IMMA used a large motorcycle for comparison testing: The results showed that the first of the FMVSS recovery stops was similar to the ECE test. FMVSS allows 5 recovery stops and by the 5^{th}, the brakes were dry. Therefore, the ECE test was judged to be more severe. Tests were also carried out by TC/NHTSA with similar results The ECE R78 spray type test was thus included in the gtr because: a. It simulates a potential problem in real life conditions. Brake performance after passing through deep water has not been an issue in practice. b. It appears to be more severe than the alternative – FMVSS 122 test c. There are practical problems when immersing the brake in deep water. eg engine/transmission function. Drum brakes have always been exempt from the ECE R78 test because they have not been problematic during wet road riding. However, based on a paragraph included in JSS 12-61, an extra test for drum brakes with ventilation or inspection holes is included in the gtr. Some other minor changes have also been included in the gtr: - The test now applies to all vehicle categories (L5 exempt in ECE) - The test procedures and requirements are more clearly defined for improved repeatability and understanding.

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4.7 Heat Fade Test	Summary: - 3-3,3-4, and 3-5 vehicles only - All with laden vehicle - Separate test for each brake system - If CBS fitted, test only CBS (not secondary system) Test in 3 parts - performed consecutively for each brake system:	This test evaluates each service braking system when it is operating at an elevated brake temperature. A Fade test is included in FMVSS 122 and ECE R78/ JSS 12-61. Although they both apply a similar test philosophy, there are significant differences in aspects of vehicle loading condition, and brake application. (FMVSS =lightly loaded, all controls, ECE = laden, single control) A severity test comparing the above 2 procedures was carried out by IMMA using a 600 cc motorcycles. The measure of severity was to compare the maximum recorded brake temperature for each procedure. The result was that the front and rear brake temperatures were higher when the ECE Fade test was used and so it was concluded that the ECE test was more severe. Tests were also carried out by TC/NHTSA with similar results Therefore, due to the result of the above severity test and repeatability concerns detailed under test 4.3, it was decided to use the test conditions and requirements from ECE R78.
Base line	- Perform a single Dry stop test-single brake actuated, as in para 4.3 and record control force	
Heating Procedure	- Perform 10 repeated stops as quickly as possible - Speeds – Front + CBS = 100 km/h or 70% v max whichever is lower - Rear = 80 km/h or 70 % v max whichever is lower - Braking interval = 1000 m - Engine connected with the highest gear engaged for 50% of stop, disconnected for the remaining stops. - For the first stop, deceleration = 3 – 3.5 m/s^2 with constant control force and the same force is applied for the remaining 9 stops (vehicles that are unable to meet this deceleration shall use the relevant values from the table in 4.3.3.)	
Hot Brake Stop	- Repeat Baseline stop within 1 minute after completion of Heating Procedure with a control force <baseline force. Requirement : The single Hot Brake Stop shall have a performance ≥ 60% of Baseline test performance or if based on stopping distance, $S_2 \leq 1.67\ S_1 - 0.67 \times 0.1V$	
OPTIONAL / IF FITTED		
4.8 Parking Brake System Test	Summary :- - Applicable to 3-2, 3-4, 3-5 vehicles (3 wheelers) - Static test - Laden vehicle - Engine disconnected - 18% slope, up and down - control forces: hand ≤400N; foot ≤500 N Requirement : - Vehicle remains stationary on slope during a period of 5 minutes.	This static test is only applicable to vehicles which are equipped with a parking brake. FMVSS 122 and ECE R78 include a parking brake test. For FMVSS, the slope is steeper and the vehicle is unladen but for ECE, the vehicle is laden but the slope is less steep. It was considered that the ECE test, being laden, was more realistic and so it was decided to retain all the test conditions for the gtr test.

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4.9 ABS Tests			
	4.9.1 General information	- Applicable to category 3-1 + 3-3 only - Wheel lock shall be allowed provided that the stability of the vehicle is not affected to the extent that it requires the rider to release the control and the vehicle stays in the test lane. List of ABS tests: — Para a. Stops on a high friction surface – as in 4.1.1.1 — 4.9.3 b. Stops on a low friction surface – as in 4.1.1.2 — 4.9.4 c. Wheel lock checks on high and low friction surfaces. — 4.9.5 d. Wheel lock check - high to low friction surface transition. — 4.9.6 e. Wheel lock check - low to high friction surface transition. — 4.9.7 f. Stops with an ABS electrical failure. — 4.9.8	These tests are based on ECE R78 (and JSS 12-61). There are no ABS tests in other regulations. ABS tests will be carried out on vehicles during 2006 to validate these procedures and requirements. Special attention will given to items marked in **bold.** Compared to ECE R78, some general minor changes and improvements have been incorporated in the gtr. eg. brake application rate specified, tolerances applied, and the EMI test removed as this is included in the total vehicle evaluation of Electro Magnetic Compatibility.
	4.9.2 Vehicle condition	- Lightly loaded vehicle only (apart from test f which is laden) - Engine disconnected. (Applicable to all tests: - Initial brake temperature: ≥55°C and ≤100°C **- Brake actuation force – Hand = 200N ± 20%. Foot = 350N ± 20%.** **These forces may be increased in order to ensure that the ABS is fully cycling during the stop.)**	Higher forces are required to ensure the correct validation of the ABS system.
	4.9.3 Stops on a high friction surface	- Test speed = 60 km/h or 0.9 V max whichever is lower. - Stops performed with all service brake controls activated at the same moment **- If no ABS on 1 wheel, apply a control force lower than the wheel lock value** - 6 stops maximum Requirements: **- Stopping distance ≤ $0.0063V^2$ or MFDD > 6.17 m/s^2** - No wheel lock, vehicle wheels must stay in test lane.	Based on RDW idea of 0.9 PBC x 0.7 ECE R78 efficiency requirement x 9.8 to convert to m/s^2
	4.9.4 Stops on a low friction surface	- As paragraph 4.9.3 but with low instead of high friction surface. Requirements: **- Stopping distance ≤ $0.0188V^2$ or MFDD > 2.05 m/s^2** - No wheel lock, vehicle wheels must stay in test lane.	Based on RDW idea of 0.3 PBC (lowest value) x 0.7 ECE R78 efficiency requirement x 9.8 to convert to m/s^2
	4.9.5 Wheel lock checks on a high and low friction surface	- Tests on high and low friction surfaces - Test speed: High friction = 80 km/h or 0.8 V max whichever is lower. Low friction = 60 km/h or 0.8 V max whichever is lower. - Stops performed with all service brake controls activated at the same moment plus each control applied separately. - 6 stops maximum Requirements: - No wheel lock, vehicle wheels must stay in test lane.	

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	4.9.6 Wheel lock check – high to low friction surface transition	- Tests on a high friction surface immediately followed by a low friction surface. - Test speed: 50 km/h or 0.5 V max at the surface transition point. - Stops performed with all service brake controls activated at the same moment plus each control applied separately. - 3 stops maximum Requirements: - No wheel lock, vehicle wheels must stay in test lane.	
	4.9.7 Wheel lock check - low to high friction surface transition	- Tests on a wet low friction surface followed by a wet high friction surface >0.8 PBC. - Test speed: 50 km/h or 0.5 V max at the surface transition point. - Stops performed with all service brake controls activated at the same moment plus each control applied separately. - 3 stops maximum Requirements: - No wheel lock, vehicle wheels must stay in test lane. - After passing over the surface transition point, **the vehicle deceleration shall increase.**	The description of the performance requirement has been changed. ECE R78 states that the "vehicle deceleration must rise to the appropriate high value within a reasonable time". As this cannot be defined, the current text was provided. However, NHTSA would like to see response time and amount of deceleration increase specified.
	4.9.8 Stops with an ABS electrical failure	- With the ABS electrical system disabled, perform a Dry Stop test – single brake control actuated (paragraph 4.3) Requirement: - Stopping distance or MFDD shall be as specified for "single brake system, rear wheel braking only" – as in paragraph 4.3.3.	
4.10 Partial Failure		Only applicable to a "Split service brake system" – In the event of a hydraulic failure, the remaining sub- system must meet the relevant performance requirement. - Applicable to 3-3, 3-4, 3-5 vehicles. - Lightly loaded vehicle - Engine disconnected - Test speed: 50 km/h and 100 km/h or 0.8 Vmax -Brake actuation force: Hand ≤ 250N. Foot ≤ 400N Requirement: - Minimum MFDD = 3.3 m/s^2 or s = ≤ $0.1V + 0.0117V^2$	It is important that a test is included to evaluate the brake performance of an SSB (car type) system if there is a failure in one of the hydraulic circuits. However, a test of this type is not included in either ECE R78 or JSS 12-61 regulations. Therefore, after confirmation that the test conditions and requirements of the FMVSS 122 procedure was satisfactory, it was agreed that this test should be included in the gtr.
4.11 Power assisted braking system failure		Test is applicable to all vehicle categories but is not required when the vehicle is fitted with another separate service brake system. Perform a Dry Stop test – single brake control activated (as 4.3) with the power assistance disabled. Requirements: - For CBS or SSB systems, MFDD ≥2.5 m/s^2 or the stopping distance $S \leq 0.1V + 0.0154V^2$ using each control separately that operates the power assistance. - For single brake systems, use the "Single brake system, rear wheel(s) only" section of the table in 4.3.3.	There are no similar tests required in other motorcycle regulations. However, with servo equipped motorcycles now on the market, a test was considered necessary.(as it is for passenger cars) This new test is based on the Dry Stop test – with single brake control activated (4.3).

DEFINITIONS – where appropriate, taken from SR1.

TERM	DEFINITION	SOURCE
Antilock Brake system (ABS)	A system which senses wheel slip and automatically modulates the pressure producing the braking forces at the wheel(s) to limit the degree of wheel slip.	Based on ISO 611:2003 - to exclude poor systems.
Baseline test	A stop or a series of stops carried out in order to confirm the performance of the brake prior to subjecting it to a further test e.g. Heating procedure or Wet brake stop.	IMMA
Brake	Parts of the brake system in which the forces opposing the movement of the vehicle are developed.	ISO 1710:1995, ECE R78
Brake system	Combination of parts (excluding the engine) whose function is progressively to reduce the speed of a moving vehicle, bring it to a halt, and keep it stationary if already halted. The system consists of the Control, the Transmission, and the Brake.	ISO 12364, ECE R78
Combined Brake System (CBS)	For categories 3-1 and 3-3, a brake system where at least two brakes on different wheels are actuated by the operation of a single control. Category 3.2 & 3.4: a brake system where the brakes on all wheels are actuated by the operation of a single control. Category 3.5: a brake system where the brakes on at least the front and rear wheels are actuated by the operation of a single control. (Where the rear wheel and sidecar wheel are braked simultaneously, this is regarded as the rear brake.)	Based on ECE R78 with SR1 categories included.
Control	Part actuated directly by the rider in order to supply the energy to the transmission required for braking the vehicle.	ISO 12364, ECE R78
Driver mass	The nominal mass of a driver that shall be 75 kg. (subdivided into 68 kg occupant mass at the seat and 7 kg luggage mass)	SR1
Engine disconnected	When the engine is no longer connected to the driving wheels.	IMMA
Initial Brake Temperature	Temperature of the hottest brake before any brake application.	FMVSS 122
Laden*	The maximum mass of the fully laden solo vehicle based on its construction and design performances, as declared by the manufacturer. This shall be less than or equal to the sum of the maximum axles' (group of axles) capacity.	SR1
Lightly loaded	mass in running order plus 15 kgs for test equipment including outriggers, or the laden condition, whichever is less. In the case of ABS tests on a low friction surface (paragraphs 4.9.4 - 4.9.7), the mass for the test equipment is increased to 30 kg to account for the outriggers.	Informal Group
Mass in running order	The sum of the unladen* vehicle mass and the driver mass.	SR1

Peak Braking Coefficient (PBC)	The friction of the test surface, measured in accordance with the method specified in national legislation.	Informal Group
Power assisted braking system	A braking system in which the energy necessary to produce the braking force is supplied by the physical effort of the driver assisted by one or more energy supplying devices, for example vacuum assisted (with vacuum booster)	ISO 611:2003
Secondary braking system	The second service brake system on a vehicle equipped with a combined brake system.	IMMA
Service brake system	A brake system which is used for slowing the vehicle when in motion.	IMMA
Single brake system	A brake system which acts on only one axle	IMMA
Split service brake system	A brake system that actuates the brakes on all wheels consisting of two or more subsystems actuated by a single control designed so that a single failure in any subsystem (such as a leakage type failure of a hydraulic subsystem) does not impair the operation of any other subsystem.	FMVSS 122
Stopping distance	Distance travelled by the vehicle from the point of application of the control to the point at which the vehicle reaches a full stop.	FMVSS 122
Test speed	Vehicle speed measured at the moment the rider begins to actuate brake system control(s)	ISO 12364
Transmission	Combination of components which provide the functional link between the control and the brake.	ISO 1710:1995, ECE R78
V max	Means the highest speed attainable by accelerating at a maximum rate from a standing start for a distance of 1.6 km on a level surface, with the vehicle lightly loaded.	FMVSS 122
Wheel lock	The condition that occurs when there is a slip ratio of 1.00.	ISO 12364