Submitted by the expert from Italy

Informal document **GRRF-79-30**
(79th GRRF, 16 – 20 February 2015,
agenda item 6)

# Proposal to introduce requirements for the approval of replacement brake discs for L-category vehicles in UN Regulation No. 90

79° GRRF
16 February 2015

# Preamble

At the 78° session of GRRF held on 16 Sept 2014, ITALY had tabled a proposal (doc **ECE/TRANS/WP.29/GRRF/2014/23**)

It was aimed at including in UN-R 90 a set of new requirements for the approval of replacement brake discs for L-category vehicles, taking into consideration the latest technologies available in the market.

GRRF agreed to ask ITALY to revise the proposal and submit at 79° GRRF session, taking into account all the comments received.

To this extent, ITALY has forwarded the following documents for today's discussion:

- Working document **ECE/TRANS/WP.29/GRRF/2014/23/Rev.1**
- Informal document **GRRF-79-11e**
- Informal document **GRRF-79-13e**

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

**Comment raised during 78° GRRF:**
Need to exclude L6 and L7 categories.

**Revision:**
We have included reference to $L_1$, $L_2$, $L_3$, $L_4$, $L_5$ throughout the document, excluding $L_6$ and $L_7$

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

**Comment raised during 78° GRRF:**

Need to modify the definition of both ″Original replacement brake discs for category L ″ (2.3.3.1.2) and ″Identical brake discs for category L ″ (2.3.3.2.2), for competitive reasons.

**Revision:**

The original definitions are restored, same as for M, N and O categories.

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

## Comment raised during 78° GRRF:

*Paragraph 5.3.3.1.1.*, amend to read:

"5.3.3.1.1. For discs the following maximum values shall be met:

| | $M_1$, $N_1$, $O_1$, $O_2$ | $M_2$, $M_3$, $N_2$, $N_3$, $O_3$, $O_4$ | **$L_1$, $L_2$, $L_3$, $L_4$, $L_5$** |
|---|---|---|---|
| Thickness variation | 0.015 mm | 0.030 mm | **0.020 mm** |
| Cheek thickness variation (for ventilated disc only) | 1.5 mm | 2.0 mm | --- |
| Lateral run-out friction surface | 0.050 mm* | 0.150 mm* | **0.150 mm*** ** |
| Location bore variation | H9 | H9 | **D10 or H11 ****** |
| "Top hat" parallelism | 0.100 mm | 0.100 mm | --- |
| Location face flatness | 0.050 mm | 0.050 mm | **0.100 mm** |
| Friction surface roughness** | 3.2 µm | 3.2 µm | **1.6 µm** |

* n/a in the case of a floating disc.

** Ra-value according to ISO 1302:2002.

*** **0.100 mm for maximum straightness for "full floating" disc (without elastic constraints between bell and braking ring)**

**** **n/a for vehicles categories L1, L2, L3, L4, L5**

***** **Location bore variation where applicable, related to manufacturing process."**

**Italy proposal (1):** the DTV is modified from 0,015 to 0,020 mm in order to consider the standard of production adopted at international level

Why no values for L ??

Not applicable to L, since no application with vent discs exist

Both D10 and H11 tolerances are widely adopted in OEM, depending from production process

Not applicable to L, since the disk is always mounted externally on the wheel rim, and not interposed between the wheel hub and the rim

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

**Comment raised during 78° GRRF:**

May the definition of a list of stainless steel materials pose problem of design restriction?

We confirm that the list can be regarded as exhaustive of the materials used in production (Example: JIS SUS **420** is included in X20Cr13)

*Add a new paragraph 5.3.3.2.2.*, to read:

"**5.3.3.2.2 Martensitic stainless steel for braking ring of categories L1, L2, L3, L4 and L5. In order to be considered "Equivalent" the replacement brake disc shall be from the same material subgroup as the original brake disc. Five original part material subgroups are defined.**

| | *Test standard* | *Subgroup 1 JIS SUS 410* | *Subgroup 2 X 10 Cr 13 EN 10088/2* | *Subgroup 3 X 12 Cr 13 EN 10088/2* | *Subgroup 4 X 20 Cr 13 EN 10088/2* | *Subgroup 5X 30 Cr 13 EN 10088/2* |
|---|---|---|---|---|---|---|
| **Carbon Content (per cent)** | | **0.02-0.10** | **0.08-0.12** | **0.08-0.15** | **0.16-0.25** | **0.26-0.35** |
| **Silicon Content (per cent)** | | **Max 0.80** | **Max 1.00** | **Max 1.00** | **Max 1.00** | **Max 1.00** |
| **Manganese Content (per cent)** | | **0.50-2.50** | **Max 1.00** | **Max 1.50** | **Max 1.50** | **Max 1.50** |
| **Chromium Content (per cent)** | | **10.00-14.50** | **12.00-14.00** | **11.50-13.50** | **12.00-14.00** | **12.00-14.00** |
| **Iron Content (per cent)** | | **rest** | | | | |
| **Hardness HRC** | **ISO 6508-1:2005** | **30-40** | **30-40** | **30-40** | **30-40** | **30-40** |

**Italy proposal (2):** HRC is changed from (32-38) to (30-40) in order to be adapted with the OEM standard and production process

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

**Comment raised during 78° GRRF:**

Need to define a better classification, not based on commercial definition

**Table A14/2.2.5.**

| *Application* | *Front disc* | *Rear disc* |
|---|---|---|
| | *Tangential force F [kN] MIN* | |
| **Sport, Tourer and Road Enduro** | **14** | **12** |
| **Custom** | **10** | **15** |
| **Scooter** | **12** | **10** |
| **Off-road** | **12** | **7** |

A new classification is proposed, based on disc DIAMETER and THICKNESS

**Table A14/2.2.5.**

| *Disc Diameter [mm]* | *Spessore disco [mm]* | *Tangential force F [kN] MIN* |
|---|---|---|
| ≥ 150 < 200 | ≤ 4 | ≥ 8 |
| | > 4 | ≥ 10 |
| ≥ 200 < 250 | ≤ 3 | ≥ 8 |
| | >3 ≤ 4 | ≥ 10 |
| | > 4 | ≥ 12 |
| ≥ 250 < 300 | ≤ 3 | ≥ 8 |
| | > 3 ≤ 4 | ≥ 10 |
| | > 4 | ≥ 12 |
| ≥ 300 < 350 | ≤ 4 | ≥ 8 |
| | > 4 ≤ 5 | ≥ 11 |
| | > 5 | ≥ 14 |

Notes:
- No groups defined for peripherical discs (> 350)
- Fixed, floating and composed discs have all a diameter < 3 50 mm
- In current production , max of 330 mm is reached

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

## Italy proposal (3):

In Annex 14 (new), the **thermal FATIGUE test** has been modified for both front and rear discs.

**FRONT DISC**

5.1.3. Front disc

5.1.3.1. Test programme

5.1.3.1.1. Burnishing

According Table A14/5.1.3.1.1.

Table A14/5.1.3.1.1.

**TUV Directive**

| *Burnishing* | | | | |
|---|---|---|---|---|
| *Step* | *Initial speed [km/h]* | *Final speed [km/h]* | *Acceleration (+) and deceleration (–) [m/s²]* | *Step duration [s]* |
| 1 | 80 | 40 | – 3 | 3.7 |
| 2 | 40 | 80 | + 3 | 3.7 |
| 3 | 80 | 80 | --- | 20 |
| Steps 1 to 3 = 1 cycle; repeating 19 times the cycle for a total of 20 cycles | | | | |

5.1.3.1.2. Emergency stop

According Table A14/5.1.3.1.2.

Table A14/5.1.3.1.2.

| *Emergency stop* | | | | |
|---|---|---|---|---|
| *Step* | *Initial speed % of Vmax (a) [%]* | *Final speed % of Vmax (a) [%]* | *Acceleration (+) and deceleration (–) [m/s²]* | *Step duration (b) [s]* |
| 1 | 80 | 5 (km/h) | – 10 | 0.078 * Vmax |
| 2 | 5 (km/h) | 80 | + 3 | 0.258 * Vmax |
| 3 | 80 | 80 | --- | 240 |

(a) Vmax in km/h

(b) Vmax in m/s

5.1.3.1.3. Fatigue test

According Table A14/5.1.3.1.3.

Table A14/5.1.3.1.3.

**TUV Directive**

| *Fatigue test* | | | | |
|---|---|---|---|---|
| *Step* | *Initial speed % of Vmax (a) [%]* | *Final speed % of Vmax (a) [%]* | *Acceleration (+) and deceleration (–) [m/s²]* | *Step duration (b) [s]* |
| 1 | 80 | 40 | – 8 | 0.05 * Vmax |
| 2 | 40 | 80 | + 6 | 0.067 * Vmax |
| 3 | 80 | 20 | – 8 | 0.075 * Vmax |
| 4 | 20 | 80 | + 6 | 0.1 * Vmax |
| 5 | 80 | 40 | – 8 | 0.05 * Vmax |
| 6 | 40 | 60 | + 6 | 0.033 * Vmax |
| 7 | 60 | 40 | – 6 | 0.033 * Vmax |
| 8 | 40 | 60 | + 6 | 0.033 * Vmax |
| 9 | 60 | 40 | – 6 | 0.033 * Vmax |
| 10 | 40 | 80 | + 6 | 0.067 * Vmax |
| 11 | 80 | 60 | – 8 | 0.025 * Vmax |
| 12 | 60 | 60 | --- | 10 |
| 13 | 60 | 40 | – 6 | 0.033 * Vmax |
| 14 | 40 | 80 | + 6 | 0.067 * Vmax |
| Steps 1 to 14 = 1 cycle; repeating 29 times the cycle for a total of 30 cycles | | | | |

5.1.3. Front disc

5.1.3.1. Test programme

5.1.3.1.1. Burnishing

According Table A14/5.1.3.1.1.

**OEM procedure:** longer test for a better /pad/disc alignment

Table A14/5.1.3.1.1.

| *Burnishing* | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Step* | *Vehicle gross weight [kg]* | *Initial speed [km/h]* | *Final speed [km/h]* | *Deceleration [m/s²]* | *Starting temperature before the braking [°C]* | *Brakings quantity [---]* | *Rotation speed of the cooling fan [min⁻¹]* |
| 1 | 75% | 80 | 30 | 4 | 100 | 60 | 3,000 |

5.1.3.1.2. Fatigue test

According Table A14/5.1.3.1.2.

Table A14/5.1.3.1.2.

| *Thermal fatigue test* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Step* | *Vehicle gross weight [kg]* | *Initial speed [km/h]* | *Final speed [km/h]* | *Deceleration [m/s²]* | *Starting temperature before the brakings [°C]* | *Time between 2 following brakings [s]* | *Brakings quantity [---]* | *Rotation speed of the cooling fan [min⁻¹]* |
| 1 thermal | 75% / discs q.ty | 50% Vmax | 5 | 7 | 100 (a) | 30 | 5 | 2,000 |
| 2 functional | 75% / discs q.ty | 80% Vmax | 5 | 8 | 200 | --- | 1 | 3,000 |
| 3 mechanic | 100% / discs q.ty | 60% Vmax | 5 | 10 | 200 | --- | 2 | 3,000 |
| Steps from 1 to 3 = 1 cycle; repeating for a total of 20 cycles (= 160 brakings) | | | | | | | | |

(a) Starting temperature of the 1° braking only

- **Emergency stop has been included into fatigue test and improved.**
- **TUV fatigue test is too severe (at first cycle, T was > 800 °C !!)**

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

**Italy proposal (3):**

In Annex 14 (new), the **thermal FATIGUE test** has been modified for both front and rear discs.

**REAR DISC**

5.1.4. Rear disc

5.1.4.1. Test program

5.1.4.1.1. Burnishing

According Table A14/5.1.3.1.1.

Table A14/5.1.4.1.1.

| *Burnishing* | | | | |
|---|---|---|---|---|
| *Step* | *Initial speed [km/h]* | *Final speed [km/h]* | *Acceleration (+) and deceleration (–) [m/s²]* | *Step duration [s]* |
| 1 | 80 | 40 | – 2 | 5.56 |
| 2 | 40 | 80 | + 3 | 3.7 |
| 3 | 80 | 80 | --- | 20 |
| Phases 1 to 3 = 1 cycle; repeating 19 times the cycle for a total of 20 cycles | | | | |

5.1.4.1.2 Emergency stop

According Table A14/5.1.4.1.2.

Table A14/5.1.4.1.2.

| *Emergency stop* | | | | |
|---|---|---|---|---|
| *Step* | *Initial speed % of Vmax (a) [%]* | *Final speed % of Vmax (a) [%]* | *Acceleration (+) and deceleration (–) [m/s²]* | *Step duration (b) [s]* |
| 1 | 50 | 5 (km/h) | – 5 | 0.095 * Vmax |
| 2 | 5 (km/h) | 50 | + 3 | 0.16 * Vmax |
| 3 | 50 | 50 | --- | 240 |

a) Vmax in km/h

b) Vmax in m/s

5.1.4.1.3 Fatigue test

According Table A14/5.1.4.1.3.

Table A14/5.1.4.1.3.

| *Fatigue test* | | | | |
|---|---|---|---|---|
| *Step* | *Initial speed % of Vmax (a) [%]* | *Final speed % of Vmax (a) [%]* | *Acceleration (+) and deceleration (–) [m/s²]* | *Step duration (b) [s]* |
| 1 | 50 | 20 | – 3 | 0.1 * Vmax |
| 2 | 20 | 50 | + 6 | 0.05 * Vmax |
| 3 | 50 | 10 | – 3 | 0.14 * Vmax |
| 4 | 10 | 50 | + 6 | 0.067 * Vmax |
| 5 | 50 | 20 | – 3 | 0.1 * Vmax |
| 6 | 20 | 40 | + 6 | 0.033 * Vmax |
| 7 | 40 | 10 | – 2 | 0.15 * Vmax |
| 8 | 10 | 40 | + 6 | 0.05 * Vmax |
| 9 | 40 | 10 | – 2 | 0.15 * Vmax |
| 10 | 10 | 50 | + 6 | 0.067 * Vmax |
| 11 | 50 | 20 | – 3 | 0.1 * Vmax |
| 12 | 20 | 40 | + 6 | 0.033 * Vmax |
| 13 | 40 | 10 | – 2 | 0.15 * Vmax |
| 14 | 10 | 50 | + 6 | 0.067 * Vmax |
| Steps 1 to 14 = 1 cycle; repeating 29 times the cycle for a total of 30 cycles | | | | |

5.1.4. Rear disc

5.1.4.1. Test program

5.1.4.1.1. Burnishing

According Table A14/5.1.4.1.1.

Table A14/5.1.4.1.1.

| *Burnishing* | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Step* | *Vehicle gross weight [kg]* | *Initial speed [km/h]* | *Final speed [km/h]* | *Deceleration [m/s²]* | *Starting temperature before the brakings [°C]* | *Brakings quantity [---]* | *Rotation speed of the cooling fan [min⁻¹]* |
| 1 | 55% | 60 | 30 | 2 | 100 | 60 | 3,000 |

5.1.4.1.2 Fatigue test

According Table A14/5.1.4.1.2.

Table A14/5.1.4.1.2.

| *Thermal fatigue test* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Step* | *Vehicle gross weight [kg]* | *Initial speed [km/h]* | *Final speed [km/h]* | *Deceleration [m/s²]* | *Starting temperature before the braking [°C]* | *Time between 2 following braking [s]* | *Brakings quantity [---]* | *Rotation speed of the cooling fan [min⁻¹]* |
| 1 thermal | 55% | 40% Vmax | 20% Vmax | 3 | 100 (a) | 30 | 5 | 2,000 |
| 2 functional | 55% | 50% Vmax (b)<br>60% Vmax (c)<br>75% Vmax (d) | 5 | 4 | 200 | --- | 1 | 3,000 |
| 3 mechanic | 100% | 40% Vmax (b)<br>48% Vmax (c)<br>60% Vmax (d) | 5 | 5 | 200 | --- | 2 | 3,000 |
| Steps from 1 to 3 = 1 cycle; repeating for a total of 20 cycles (= 160 brakings) | | | | | | | | |

(a) Starting temperature of the 1° braking only
(b) Disc diameter < 240 mm
(c) Disc diameter ≥ 240 < 280 mm
(d) Disc diameter ≥ 280 mm

# ECE/TRANS/WP.29/GRRF/2014/23/Rev.1

**Italy proposal (3):**

In Annex 14 (new), the **thermal FATIGUE test** has been modified for both front and rear discs.

5.1.5. Test result (brake disc thermal fatigue test)

The test is regarded as having been passed if the cycles prescribed in:

(a) Tables A14/5.1.3.1.1. – 5.1.3.1.2. for front discs

(b) Tables A14/5.1.4.1.1. – 5.1.4.1.2. for rear discs

are completed without damage or failure.

If less than 20 cycles, according to "Thermomechanical Fatigue test" in Tables A14/5.1.3.1.2. and A14/5.1.4.1.2., but more than 15 are completed without damage or failure, then the test must be repeated on a new replacement part.

Under these circumstances both tests must complete more than 15 cycles without damage or failure for the part to have passed the test.

If less than 15 cycles are completed before damage or failure, then a test should be conducted on the original part and the results compared.

If the damage of failure point is no worse than the quantity of cycles of the original part – 10 per cent, then the test is regarded as having been passed.

Instead of 30

Instead of 20

The number of cycles have been slightly reduced, BUT the severity of brakins have been also increased.

# GRRF-79-11e (informal doc)

In Annex 14, "Requirements for replacement brake discs for vehicles of categories L1, L2, L3, L4 and L5“

Paragraph 2.2.4. , correct to read:

"2.2.4. Apply the force F, specified in Table ~~2.1.2.5.~~ **A14/2.2.5**., as shown in Fig.1“

***Justification**: editorial*

# GRRF-79-13e (informal doc)

*[AMENDMENT 1]: Include a note (b) in Table A14/5.1.3.1.3 as follows:*

5.1.3.1.3. Fatigue test

According Table A14/5.1.3.1.3.

Table A14/5.1.3.1.3.

| Thermal fatigue test | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Step | Vehicle gross weight [kg] | Initial speed [km/h] | Final speed [km/h] | Decele-ration [$m/s^2$] | Starting temperature before the brakings [°C] | Time between 2 following brakings [s] | Brakings quantity [---] | Rotation speed of the cooling fan [$min^{-1}$] |
| 1 thermal | 75% / discs q.ty | 50% Vmax | 5 | 7 | 100 (a) | 30 | 5 | 2.000 |
| 2 functional | 75% / discs q.ty | 80% Vmax | 5 | 8 | 200 | --- | 1 | 3.000 |
| 3 mechanic | 100% / discs q.ty | 60% Vmax | 5 | 10 | 200 | --- | 2 | 3.000 |
| Steps from 1 to 3 = 1 cycle; repeating for a total of 20 cycles (= 160 brakings) **(b)** | | | | | | | | |

(a) Starting temperature of the 1° braking only

**(b) In case of early wear of the friction material of the pads, the use of another pads set is allowed; in this case, before completing the test, the new pads set must be burnished according to paragraph 5.1.3.1.1., always using the brake disc under test.**

***Justification****: The note has been introduced in order to allow the operator to carry out and conclude the test in case of premature wear of the friction material of the pads.*

# GRRF-79-13e (informal doc)

*[AMENDMENT 2]: Modify Table A14/5.1.4.1.1 as follows:*

5.1.4. Rear disc

5.1.4.1. Test program

5.1.4.1.1. Burnishing

According Table A14/5.1.4.1.1.

Table A14/5.1.4.1.1.

| Burnishing | | | | | | | |
|---|---|---|---|---|---|---|---|
| Step | Vehicle gross weight [kg] | Initial speed [km/h] | Final speed [km/h] | Decele-ration [$m/s^2$] | Starting temperature before the braking [°C] | Brakings quantity [---] | Rotation speed of t cooling fan [$min^{-1}$] |
| 1 | **50%** | 60 | 30 | 2 | 100 | 60 | 3.000 |

***Justification**: the % of the "vehicle gross weight" has been reduced from 55% to 50% in conformity with what is foreseen in par 5.1.4.1.3.*

# GRRF-79-13e (informal doc)

*[AMENDMENT 3]: Include a paragraph 5.1.4.1.2 as follows:*

**5.1.4.1.2. Fade test**

**According Table A14/5.1.4.1.2.**

**Table A14/5.1.4.1.2.**

| Fade test | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Step** | **Vehicle gross weight [kg]** | **Initial speed [km/h]** | **Final speed [km/h]** | **Decele-ration [m/s$^2$]** | **Starting temperature before the braking [°C]** | **Time between 2 following brakings [s]** | **Brakings quantity [---]** | **Rotation speed of cooling fan [min$^{-1}$]** |
| **1** | **50%** | **40%Vmax** | **20%Vmax** | **2** | **100** | **30** | **15** | **800** |

***Justification***: *the proposed "Fade" test has the aim of stabilising the friction coefficient of pads.*
*The Fade test has the target of spilling the gas out from friction material, otherwise these gases leak during the "Fatigue" test causing a reduction of the friction coefficient.*
*This could bring to the need of an increase of braking pressure up to excessive values, so that a sudden consumption of the friction material may happen.*
*This phenomenon is typical for organic friction material, while pads with sintered friction material are less subject to it.*

# GRRF-79-13e (informal doc)

*[AMENDMENT 4]: Modify Table A14/5.1.4.1.3 as follows:*

5.1.4.1.3 Fatigue test

According Table A14/5.1.4.1.3.

Table A14/5.1.4.1.3.

| Thermal fatigue test | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Step | Vehicle gross weight [kg] | Initial speed [km/h] | Final speed [km/h] | Decele-ration [m/s$^2$] | Starting temperature before the brakings [°C] | Time between 2 following brakings [s] | Brakings quantity [---] | Rotation spee of the cooling fan [min$^{-1}$] |
| 1 thermal | **50%** | 40% Vmax | 20% Vmax | 3 | 100 (a) | 30 | 5 | 2.000 |
| 2 functional | **50%** | 50% Vmax (b) | 5 | 4 | 200 | --- | 1 | 3.000 |
| | | 60% Vmax (c) | | | | | | |
| | | 75% Vmax (d) | | | | | | |
| 3 mechanic | **90%** | 40% Vmax (b) | 5 | 5 | 200 | --- | 2 | 3.000 |
| | | 48% Vmax (c) | | | | | | |
| | | 60% Vmax (d) | | | | | | |
| Steps from 1 to 3 = 1 cycle; repeating for a total of 20 cycles (= 160 brakings) **(e)** | | | | | | | | |

(a) Starting temperature of the 1° braking only

(b) Disc diameter **≤ 245** mm

(c) Disc diameter **> 245** < 280 mm

(d) Disc diameter ≥ 280 mm

**(e) In case of early wear of the friction material of the pads, the use of another pads set is allowed; in this case, before completing the test, the new pads set must be burnished according to paragraphs 5.1.4.1.1. – 5.1.4.1.2., always using the brake disc under test.**

***Justification 1**: the % of "vehicle gross weight" has been reduced from 55% to 50% (for step 1 and 2) and from 100 to 90% (for step 3), in order to optimize the mechanical stress on the brake disc, so as to reach a Tmax of around 500 °C , instead of 660 °C*

***Justification 2**: the threshold for the diameter of the rear discs has been modified from 240mm to 245mm in order to take into account a typology of rear discs typically used on sport motorcycles*

***Justification 3**: This note is added to allow the operator to finalize the test in case of premature wear of the friction material of the pads*

# GRRF-79-13e (informal doc)

*[AMENDMENT 5]: Amend definition paragraph 2.3.2 as follows:*

"*Identification code*" identifies the brake discs or brake drums covered by the braking system approval according to Regulations Nos. 13, ~~and~~ 13-H **and 78**

***Justification**: a reference to UN-R78 is needed for braking system of vehicles of category L*

# GRRF-79-13e (informal doc)

*[AMENDMENT 6 editorial]:* for consistency with R.E.3, modify L1, L2, L3, L4, L5 with: $L_1$, $L_2$, $L_3$, $L_4$, $L_5$, throughout the document.

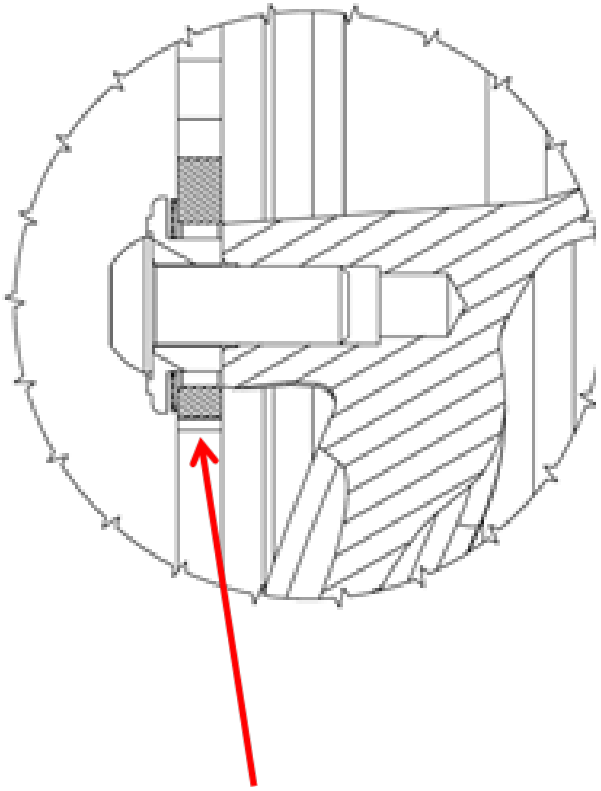
*[AMENDMENT 7 editorial]:* in Table A14/2.2.5, change the heading “spessore disco” with: “disk thickness”.

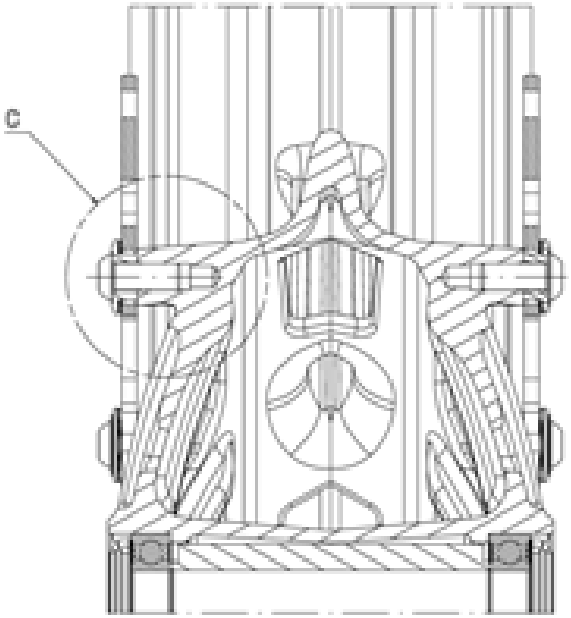
*[AMENDMENT 8 editorial]:* in paragraph 3.4.2.1, change “part C” with capital “Part C”.

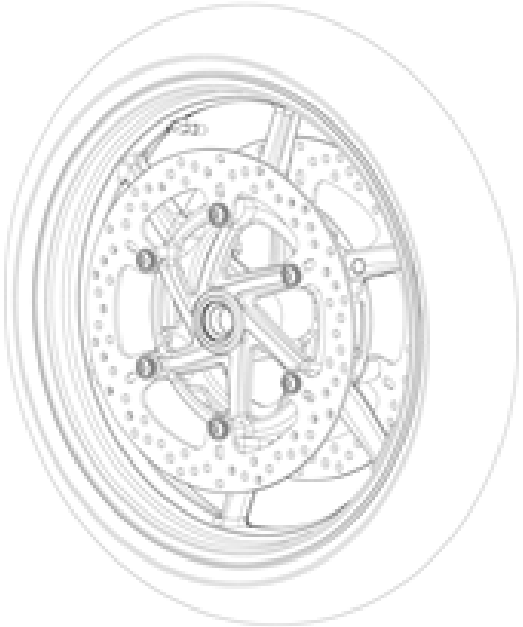
***Justification**: all editorial*

**Thank you**
**for**
**the attention**
**!!!**

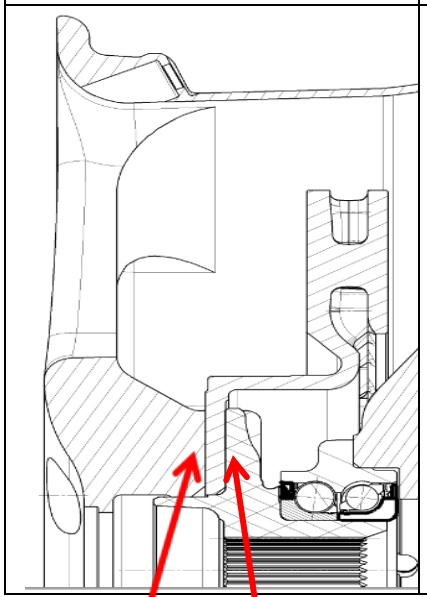
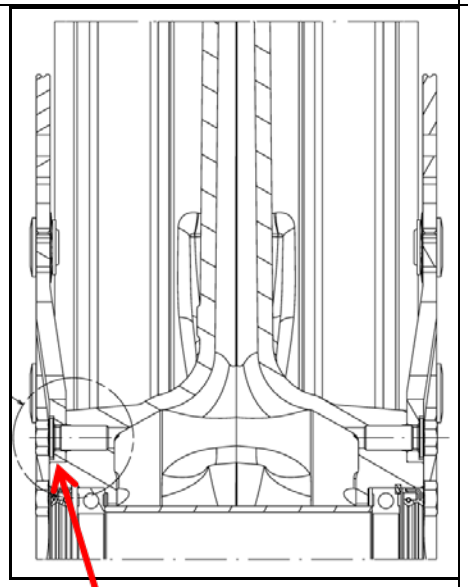
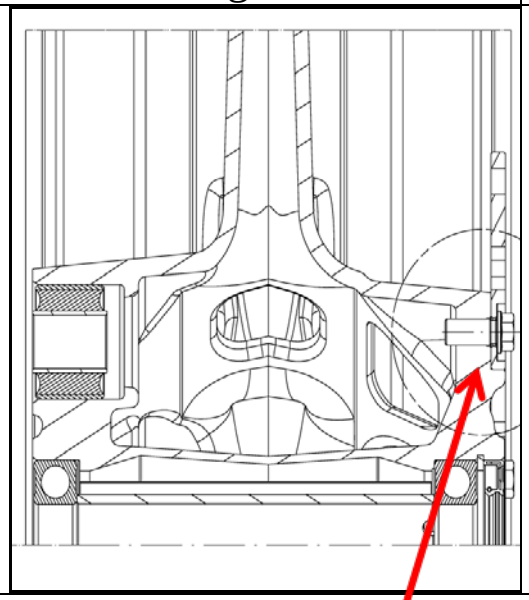
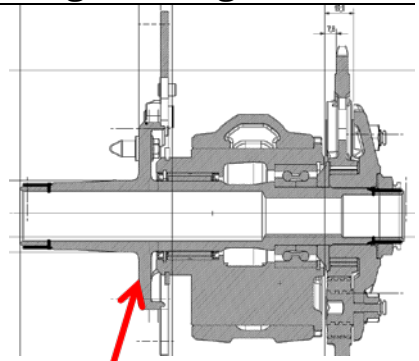
# Back up slides – location bore



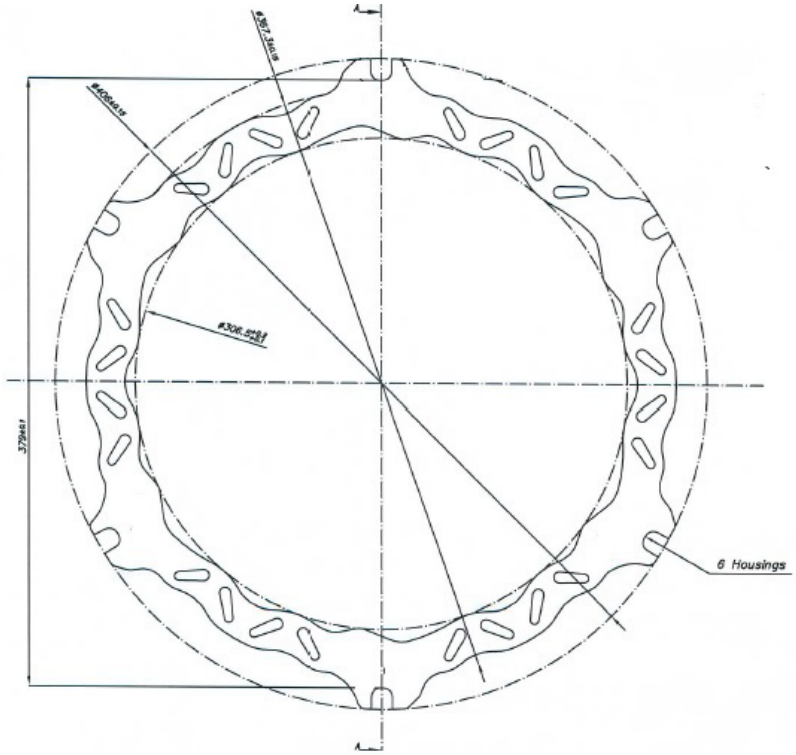


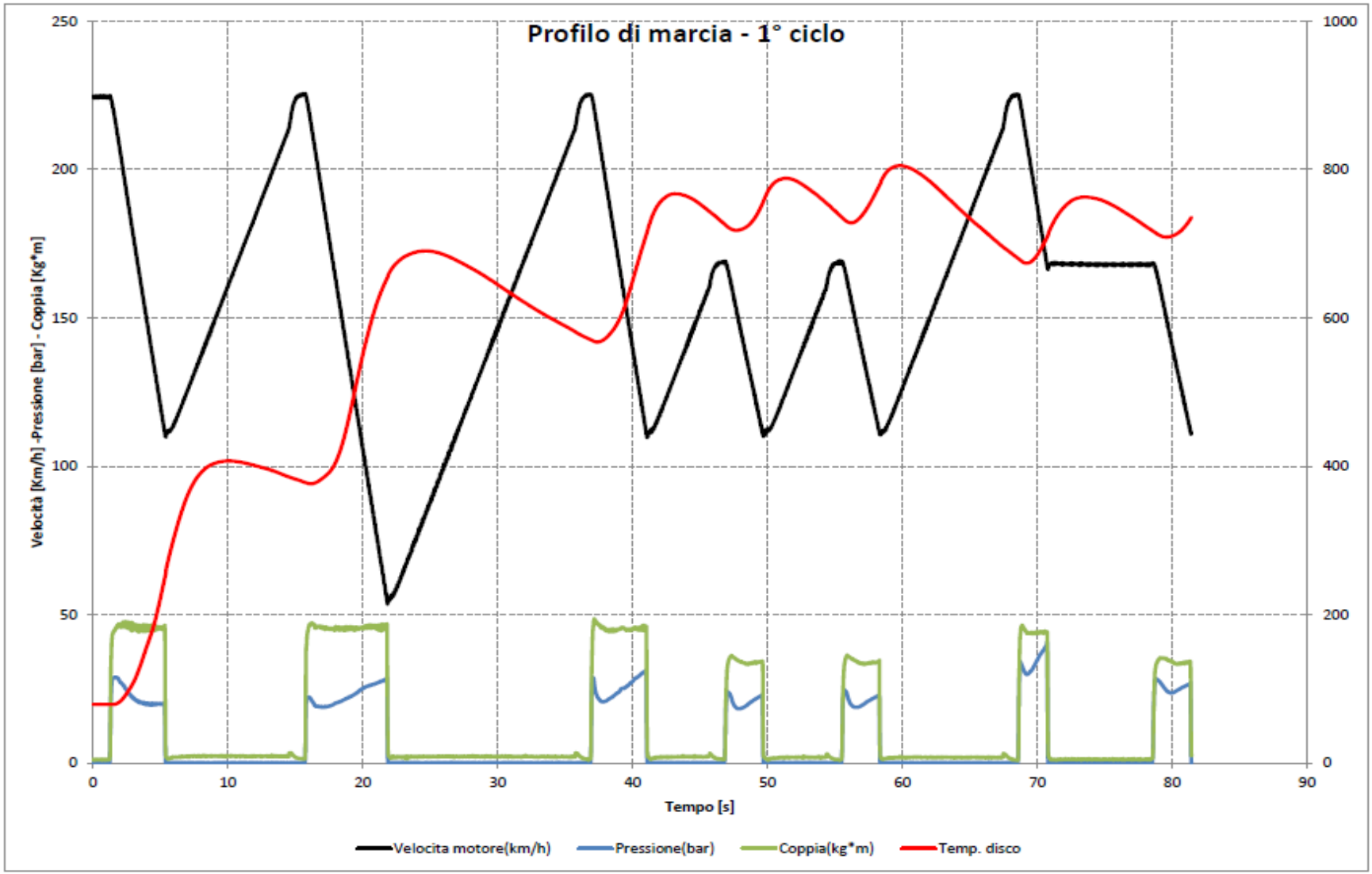
# Back up slides – top hat parallelism

| CAR example | MOTORCYCLE (FRONT WHEEL) | MOTORCYCLE (REAR WHEEL) double swing arm | MOTORCYCLE (REAR WHEEL) single swing arm |
|---|---|---|---|
|  |  |  |  |

# Back up slides – peripherical disc




# Back up slides – TUV Fatigue test



# Back up slides – New Fatigue test