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Inner tubes for tires - Requirements and testing methods

Tire inner tubes — Requirements and testing methods

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Foreword

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The ABNT NBR 15557 was drafted at the Brazilian Tires and Rims Committee (ABNT/CB-45), by the Inner Tubes for Tires Study Commission (CE-45:000.02). The Project circulated for National Consultation according to Public Notice Nr 05, from 05.23.2014 to 06.21.2014, with Project number ABNT NBR 15557.

The Scope of this Brazilian Standard in English is as follows:

Scope

This Standard establishes requirements and test methods for tubes intended for tires.

This Standard applies to the following groups:

a) *group 1: inner tubes for tires of cars, vans and their towed;*

b) *group 2: inner tubes for tires of truck, minibuses, utilities and their towed (including trailers);*

c) *group 3: inner tubes for tires for buses, trucks and their towed (including recessed platform trailers);*

d) *group 4: inner tubes for tires for industrial vehicles and industrial trucks;*

e) *group 5: inner tubes for tires off-road earthmoving equipment, loaders machines, graders, compactors machines and forklifts to move containers;*

f) *group 6: inner tubes for tires for tractors, micro-tractors, harvesters, cultivators, agricultural implements and removal of wood;*

g) *group 7: inner tubes for tires of motorcycles, scooters, mopeds, bicycles, trikes and quads*

Inner tubes for tires - Requirements and testing methods

1 Scope

This Standard sets out the requirements and testing methods for inner tubes intended for tires. This Standard applies to the following groups:

a) group 1: inner tubes for automobile, pickup trucks tires and their towed equipment;
b) group 2: inner tubes for pickup trucks, minibus, utility vehicles tires and their towed equipment (including *trailers*);
c) group 3: inner tubes for bus, trucks tires and its respective towed equipment (including low-loading trailers);
d) group 4: inner tubes for industrial vehicles and forklift trucks tires;
e) group 5: inner tubes for off-the-road tires of earth moving machinery, wheel loaders, graders, road roller and forklift trucks to move containers;
f) group 6: inner tubes for tires of tractors, microtractors, combines, cultivators, agricultural and timber removal implements;
g) group 7: inner tubes for motorcycle, motor scooters, mopeds, bicycles, tricycles and quadricycles tires.

2 Terms and definitions

For the purposes of this document, the following terms and definitions shall apply.

2.1
adhesion to the valve base
the percent elongation obtained of the test specimen, at the beginning of the detachment (or separation) of the valve from the inner tube test specimen

2.2
metal-rubber adhesion
the percent elongation obtained of the test specimen, at the beginning of the detachment (or separation) between the metal insert and the body (rubber) of the valve.

2.3
elongation at break
the percent deformation of specimen at the moment of rupture

2.4
inner tube
element consisting of elastomers for tire sustentation, tubular shaped body, in closed ring and provided with a valve, with the role to contain, with maximum tightness, the fluid under pressure inside it

2.5

test specimen
sample taken from the inner tube, with pre-established dimensions and positions (see Figure 1), used for conducting the tests

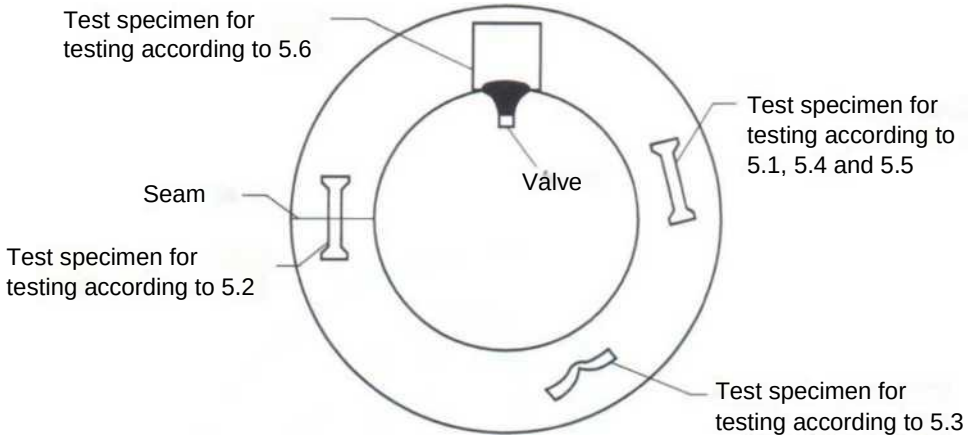

Figure 1 - Schematic location of the test specimens

2.6
permanent deformation
percent residual deformation of the specimen after maintained, under pre-established conditions of static elongation, temperature and time, and measured after a given final rest period

2.7
modulus at 100 %
traction force per area unit of the original cross section of the test specimen corresponding to an elongation of 100%

2.8
loss of resistance after aging
percent loss of yield strength of the test specimen after aging (i.e., after maintained under predetermined temperature and time conditions, and measured after a given rest period), in relation to the yield strength obtained from not aged test specimen

2.9
tearing resistance
traction force per original thickness unit of the test specimen, at the moment of tearing

2.10
yield strength
traction force per area unit of the original cross section of the test specimen, at the moment of rupture

2.11
yield strength of the seam
traction force per unit area of the original cross section of the test specimen, obtained from the seam region, at the moment of rupture

2.12
valve
element of the inner tube through which it is possible to inflate or deflate the tire

3 Requirements

The inner tubes shall be tested according to the methods described in Section 5, and the results shall be in accordance with the requirements set out on Table 1.

Table 1 - Limit values of the physical properties

Requirements	Specification			Section of the testing method
	Group 3	Group 7	Other groups of inner tubes	
Minimum yield strength in the specimen, in MPa	7,0	7,0	7,0	5.1
Minimum elongation in the specimen, in %	350,0	350,0	350,0	5.1
Maximum Modulus at 100% in the specimen, in MPa	2,0	Not applicable	2,0	5.1
Minimum yield strength of the seam, in MPa	3,5	3,5	3,5	5,2
Minimum tearing resistance, in N/mm	22,0	18,0	18,0	5.3
Maximum permanent deformation, in %	22,0	Not applicable	Not applicable	5.4
Maximum loss of resistance after aging, in %	10,0	Not applicable	Not applicable	5.5
Minimum adhesion to the valve base, in %	200.0	200.0	200.0	5.6
Minimum valve metal-rubber adhesion, in %	200,0	200,0	200,0	5.6

4 Sampling

4.1 Ambient temperature of the testing room

The ambient temperature of the testing room shall be (23 ± 2)°C, and the test specimens shall be pre-conditioned to this environment for at least 3 hours before the start of the testing. Whenever the temperature of the testing environment is outside this range, it shall be noted for the record, with the results, the corresponding temperature.

4.2 Marker

4.2.1 The marker shall be capable of printing in the test specimen two parallel marks, with maximum width of 0.5 mm, with distance from center to center of (25.0 ± 0.5) mm. The used marking cannot affect (physically or chemically) the test specimen.

4.2.2 In the case of testings of adhesion to the valve base and valve metal-rubber adhesion, the marking shall be made so as to contain the region of union between the edge of the valve and the inner tube test specimen (approximately 5 mm under the valve base and 20 mm under the inner tube test specimen).

NOTE: There is no need for marking the test specimen, in the case of using an automatic extensometer.

4.3 Thickness Gauge

The device shall have a 0.01 mm graduated display and flat, circular base probe, capable of applying pressure between 0.020 MPa and 0.025 to the test specimen.

4.4 Devices for obtaining the test specimens

4.4.1 Cutting device for testings of yield strength, elongation of the test specimen and modulus at 100% of the test specimen, yield strength of the seam and loss of strength after aging

The cutting devices for obtaining test specimens shall be of steel, built according to the model, international (I) (see Figure 2) or reduced (R) (see Figure 3). The devices shall have the internal faces perpendicular to the cutting edge plane. The edge should be sharp and free of irregularities.

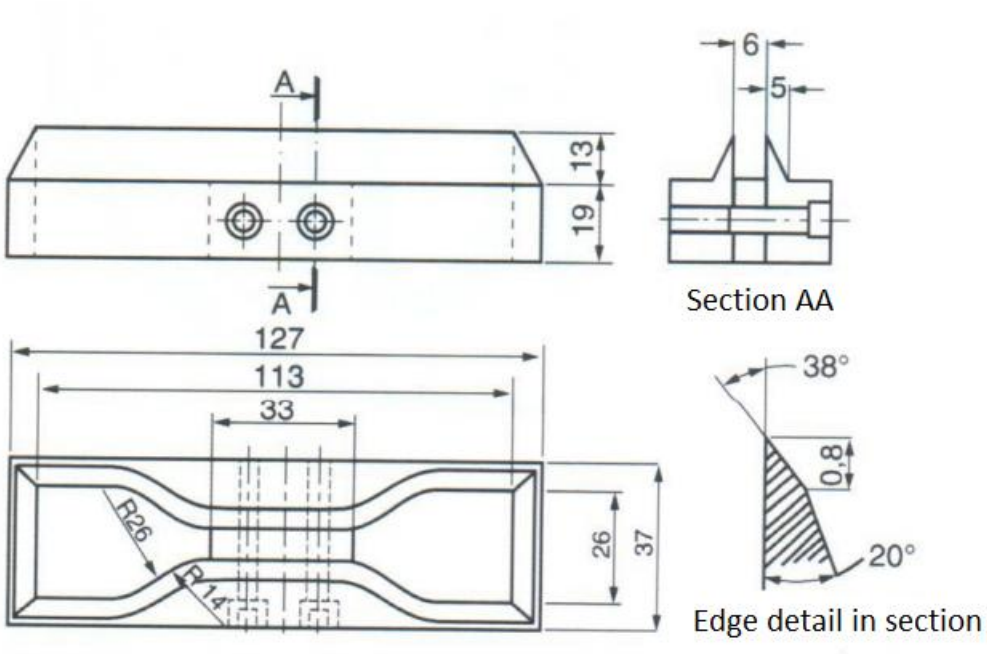

Figure 2 - Cutting device - Model I (international)

Dimensions in millimeters

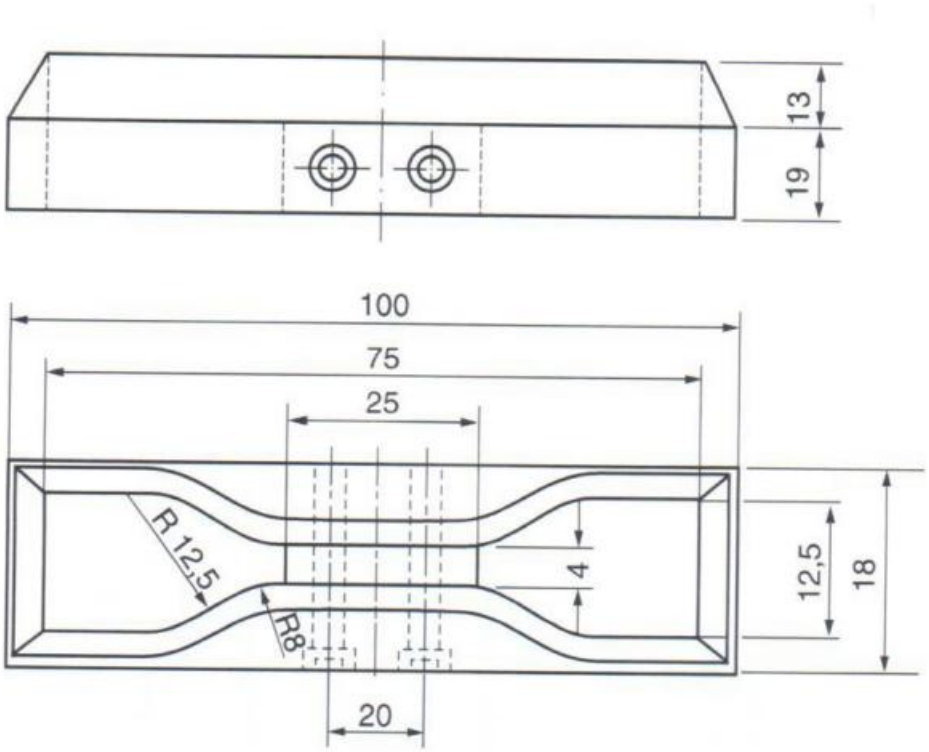

Figure 3 - Cutting device - Model R (reduced)

4.4.2 Static elongation device for testings of permanent deformation and loss of resistance after aging.

4.4.2.1 For the testing of permanent deformation, the cutting device shall comply with 4.4.1.

4.4.2.2 The device for the static elongation (tensioning or stretching) of the test specimen shall be of steel and cannot undergo deformation throughout the testing. The device shall allow attachment of the test specimens so as to ensure that the predetermined static elongation is maintained throughout the testing.

4.4.3 Cutting device for the tearing resistance testing.

The cutting device to obtain the test specimens shall be of steel, built according to the model II (see Figure 4). The device shall have the internal faces perpendicular to the cutting edge plane. The edge should be sharp and free of irregularities.

Dimensions in millimeters

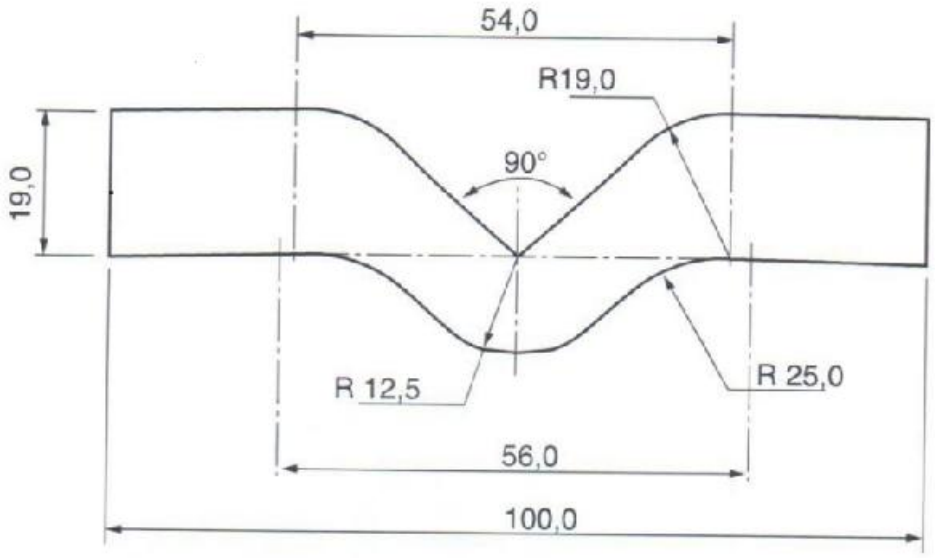

Figure 4 - Cutting device - Model II

4.4.4 Cutting device for the testing of adhesion to the valve base and valve metal-rubber adhesion

The test specimens are obtained using scissors or guillotine, by two parallel cuts and separated 5 mm to 8 mm from the valve edge. The cuts shall be free of irregularities.

4.5 Testing machine (dynamometer) for testings of yield strength, elongation, modulus, tearing resistance and loss of strength after aging

4.5.1 Provide the force dynamometer testing machine, capable of indicating or recording the applied load with an accuracy of ± 2%.

4.5.2 The jaws of the machine shall make pressure evenly distributed across the entire width of the test specimen, so that it should increase with the tensile load, preventing any slippage. The jaws cannot cause the rupture of the test specimens at their attachment region.

4.5.3 The jaws speed separation shall be (500 ± 50) mm/min. for model I (international) and II, and (200 ± 20) mm/min. for model R (reduced).

4.5.4 The course of the jaws shall allow a total minimum clearance of 750 mm.

4.5.5 The elongation measurement device, manual or automatic, shall allow reading to the nearest ± 1 mm.

4.5.6 The testing shall be disregarded if, during its implementation, the test specimen slips or comes loose from the jaws (or claws) of the testing machine.

4.6 Greenhouse for testings of permanent deformation and loss of strength after aging

The greenhouse-type equipment shall have forced air circulation, capable of maintaining a constant and homogeneous testing temperature of (105 ± 2) °C. The greenhouse internal dimensions shall allow the accommodation of the static elongation device, without it staying resting against the wall of the greenhouse.

5 Testing methods

5.1 Testing of yield strength of the specimen, elongation of the specimen and modulus at 100% of the specimen

5.1.1 Equipment

The equipment shall be according to 4.4.1 and 4.5.

5.1.2 Test specimen

5.1.2.1 The average width of the cutting device in its central section is determined from three width measurements, comprised between the cutting edges of the edges and taken of the center and at the ends of the parallel central section, by means of suitable measuring instrument, reading to the nearest 0.01 mm.

5.1.2.2 The average thickness of the test specimen is determined based on the arithmetic average of three thickness measurement, performed in the center and at the ends of the parallel central section, by means of thickness gauge, reading to the nearest 0.01 mm.

5.1.3 Procedure

5.1.3.1 Obtain three specimens in total, through the cutting device, as set out in 4.4.1, taken from the inner tube specimen in a circumferential direction (extrusion direction of the inner tube).

5.1.3.2 Do not use specimens taken from across the seam or across the vulcanization mold closing region.

5.1.3.3 Hold the specimens by the ends to dynamometer jaws, taking care to set them symmetrically, so that the tension is evenly distributed to any cross-section.

5.1.3.4 Activate the dynamometer with the speed separation as provided in 4.5.3,
continuously observing the distance between the lines centers marked on the test specimen, as set out in 4.2.

5.1.3.5 Record the corresponding strength at the moment of rupture.

5.1.3.6 Record the distance between the centers of the reference lines, marked on the test specimen, at the moment of rupture.

5.1.3.7 Record the corresponding strength at the moment of reaching a 100% elongation of the test specimen.

5.1.4 Expression of results

5.1.4.1 To calculate the yield strength of the specimen, the following expression shall be used:

$$T_r = \frac{Fr}{E \times L}$$

where

T_r is the yield strength of the test specimen, expressed in megapascals (Mpa);

F_r is the tensile strength of the test specimen, expressed in newtons (N);

E is the original average thickness of the test specimen, expressed in millimeters (mm);

L is the average width of the cutting device, expressed in millimeters (mm).

The final result shall be expressed as the average of the values obtained from the three testings performed.

5.1.4.2 To calculate the elongation at break of the test specimen, the following expression shall be used:

$$AL_r = \left(\frac{L_r - L_i}{L_i} \right)$$

where

AL_r is the elongation at break, expressed in percentage (%);

L_r is the distance between the centers of the reference lines at the moment of rupture, expressed in millimeters (mm);

L_i is the initial distance between the centers of the reference lines, expressed in millimeters (mm).

The final result shall be expressed as the average of the values obtained from the three testings performed.

5.1.4.3 To calculate the modulus at 100% of the test specimen, the following expression shall be used:

$$M_{100} = \frac{F_{100}}{E \times L}$$

where

M_{100} is the modulus at 100% of elongation, expressed in megapascals (Mpa);

F_{100} is the force corresponding to 100% of elongation, expressed in newtons (n);

E is the original average thickness of the test specimen, expressed in millimeters (mm);

L is the average width of the cutting device, expressed in millimeters (mm).

The final result shall be expressed as the average of the values obtained from the three testings performed.

5.2 Yield strength testing of the seam

5.2.1 Equipment

The equipment shall be according to 4.4.1 and 4.5.

5.2.2 Test specimen

5.2.2.1 The average width of the cutting device at its central section is determined from three width measurements, comprised between the cutting edges of the edges and taken at the center and the ends of the parallel central section, by means of suitable measuring instrument, reading to the nearest 0.01 mm.

5.2.2.2 The thickness of the specimen is determined from measurement made at the central section of the test specimen and across the seam, by means of thickness gauge reading to the nearest of 0.01 mm. In the case of overlapped seam, consider the total thickness at the central section of the test specimen.

5.2.3 Procedure

5.2.3.1 Obtain two test specimens in total, through the cutting device as set out in 4.4.1, taken from the side of the inner tube in a circumferential direction and from across the seam, so that this coincides with the center of the cutting device considered in the transverse direction.

5.2.3.2 Hold the specimens by the ends to dynamometer jaws, taking care to set them symmetrically, so that the tension is evenly distributed to any cross-section.

5.2.3.3 The dynamometer shall be activated with the speed separation as provided in 4.5.3,

5.2.3.4 Record the corresponding strength at the moment of rupture.

5.2.4 Expression of results

To calculate the yield strength of the seam, the following expression shall be used:

$$T_e = \frac{F_e}{E \times L}$$

where

T_e is the yield strength of the seam, expressed in megapascals (Mpa);

F_e is the tensile strength of the seam, expressed in newtons (N);

E is the original seam thickness of the test specimen, expressed in millimeters (mm););

L is the average width of the cutting device, expressed in millimeters (mm).

Express the final result as the average of the values obtained from the two testings performed.

5.3 Tearing resistance testing

5.3.1 Equipment

The equipment shall be according to 4.4.3 and 4.5.

5.3.2 Test specimens

The test specimens shall be obtained according to 4.4.3.

5.3.3 Procedure

5.3.3.1 Obtain three test specimens in total, through the cutting device as set out in 4.4.3, taken from the inner tube specimen in a circumferential direction (extrusion direction of the inner tube).

5.3.3.2 Do not use specimens taken from across the seam or across the vulcanization mold closing region.

5.3.3.3 Determine the thickness of the test specimen from the measurement of the thickness made at the central section, by means of a thickness gauge reading to the nearest of 0.01 mm.

5.3.3.4 Hold the specimen by the ends to dynamometer jaws, taking care to set it symmetrically, so that the tension is evenly distributed to any cross-section.

5.3.3.5 Activate the dynamometer with speed separation of (500 ± 50) mm/min.

5.3.3.6 Record the strength achieved at the moment when the test specimen tearing begins.

5.3.4 Expression of results

For the calculation of the tearing resistance, the following expression shall be used:

$$R_{rg} = \frac{F_{rg}}{E}$$

where

R_{rg} is the tearing resistance by thickness, expressed in newtons per millimeters (N/m);

F_{rg} is the maximum tearing strength, expressed in newtons (N);

E is the original thickness of the test specimen, expressed in millimeters (mm);

The final result shall be expressed as the average of the values obtained from the three testings performed.

5.4 Permanent deformation testing

5.4.1 Equipment

The equipment shall be according to 4.4.2, 4.5 and 4.6.

5.4.2 Test specimens

The test specimens shall be according to 5.1.2.

5.4.3 Procedure

5.4.3.1 Three test specimens in total shall be obtained, through the cutting device, as set out in 4.4.1, taken from the inner tube test specimen in a circumferential direction (extrusion direction of the inner tube).

5.4.3.2 Do not use specimens taken from across the seam or across the vulcanization mold closing region.

5.4.3.3 The test specimens shall be hold by the ends to the jaws of the static elongation device (as set out in 4.4.2), so as to obtain a static elongation of 50% (or 1.5 times) of the original length of the pre-selected region (as defined in 4.2).

5.4.3.4 Carry out accelerated aging in a greenhouse at (105 ± 2) ° C for 5 h.

5.4.3.5 Remove the static elongation device from the greenhouse (with the test specimens still attached to it and stretched) and let it cool down for 2 h at room temperature.

5.4.3.6 Remove the test specimens from the static elongation device, leaving them to rest (rest without stretching) at ambient temperature, between 8 h and 24 h.

5.4.3.7 Record the distance between the centers of the reference lines, marked on the test specimen.

5.4.4 Expression of results

For the calculation of the permanent deformation, the following expression shall be used:

$$D_p = \left(\frac{L_f - L_i}{L_i} \right) \times 100$$

where

D_p is the permanent deformation, expressed in percentage (%);

L_f is the final distance between the centers of the reference lines, expressed in millimeters (mm);

L_i is the initial distance between the centers of the reference lines, expressed in millimeters (mm).

The final result shall be expressed as the average of the values obtained from the three testings performed.

5.5 Testing of loss of strength after aging

5.5.1 Equipment

The equipment shall be according to 4.5.

5.5.2 Test specimen

The test specimens shall be according to 5.1.2.

5.5.3 Procedure

5.5.3.1 Using the same test specimens of the permanent deformation testing (and tested as set out in 5.4.3), carry out the yield strength testing (as set out in 5.1.3).

5.5.3.2 Record the corresponding strength at the moment of rupture.

5.5.4 Expression of results

For the calculation of the loss of resistance after aging, the following expression shall be used:

$$P_{re} = \left(\frac{F_r - F_{re}}{F_r} \right) \times 100$$

where

P_{re} is the loss of resistance after aging, expressed in percentage (%);

F_r is the tensile strength average of the three not aged test specimens (tested according to 5.1), expressed in newtons (N);

F_{re} is the tensile strength of the aged test specimen, expressed in newtons (N).

The final result shall be expressed as the average of the values obtained from the three testings performed.

5.6 Testing of adhesion to the valve base and valve metal-rubber adhesion

5.6.1 Equipment

The equipment shall be according to 4.4.4 and 4.5.

5.6.2 Test specimen

The test specimen shall be obtained as set out in 4.4.4, taken from the valve region of the inner tube. The valve shall be located at the center of the test specimen.

5.6.3 Procedure

5.6.3.1 The valve (or valve stem) shall be attached (or threaded) to the upper shaft of the dynamometer (by the use of an adapter replacing the upper jaw), whereas the two ends of the test specimen shall be attached together to the lower jaw of the dynamometer.

5.6.3.2 Care must be taken to hold the ends of the test specimen in a symmetrical way, so as to prevent the twisting of the test specimen, the inclined tractioning in relation to the valve shaft and not evenly distributed tension at its ends.

5.6.3.3 The dynamometer shall be activated with speed separation of (500 ± 50) mm / min., continuously observing the distance between the line centers marked on the test specimen as set out in 4.2.

5.6.3.4 Record the distance between the centers of the reference lines marked in the test specimen at the moment when the detachment from the valve base or the metal-rubber adhesion failure begins.

5.6.4 Expression of results

For the calculation of the adhesion to the valve base and valve metal-rubber adhesion, the following expression shall be used:

$$AD = \left(\frac{L_d - L_i}{L_i} \right) \times 100$$

where

AD is the adhesion to the valve base and valve metal-rubber adhesion, expressed in percentage (%);

L_d is the distance between the centers of the reference lines at the moment of detachment from the valve base or the metal-rubber adhesion failure begins, expressed in millimeters (mm);

L_i is the initial distance between the centers of the reference lines, expressed in millimeters (mm).

The final result is directly the value obtained from the single testing performed.

The value of the final result found is valid for the testing that caused its interruption, i.e., the beginning of detachment from the valve base or rubber-metal adhesion failure. For the other testing, the result shall be indicated, by adding the expression “larger than” (or the symbol “>”).

6 Marking and packaging

6.1 Identification

During the manufacture process, the inner tubes shall be identified at least with the following markings:

a) manufacturer's mark;

b) inner tube code and/or measures;

c) code that identifies the manufacturing period (code that identifies at least the week and year of manufacture).

6.2 Packaging

The inner tubes packages shall be individual and shall contain at least the following information:

a) manufacturer's mark;

b) inner tube code and/or measures;

c) measures of applicable tires.

NOTE Inner tubes intended for automobile manufacturer and non-motorized industrial vehicles do not require individual packaging.