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CONFORMITY EVALUATION OF BICYCLE INNER TUBES NEGOTIATED IN MANAUS ACCORDING TOSTANDARD ABNT NBR15557

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ABSTRACT:
The purpose of this article was to evaluate compliance tire inner tubes in three identified manufacturers, labeled A, B and C, which are being marketed in the city of Manaus-AM, Brazil. In the methodology was used the standards NBR 15557:2014[12]which covers the Requirements and Testing Methods for tires inner tubes and the Brazilian version of the publication EA-4/02[14]-Expression of Uncertainty in Measurement in Calibration, this way it was associated the uncertainty of measuring instruments used in the tests to the results of measurements. In addition to these aforementioned standards, it was used the ABNT NBR ISO/IEC 17025[13]whichnormatizes the general requirements for testing and calibration laboratory competence. The results ensure that manufacturers A and C met all the requirements of NBR 15557: 2014[12]standard, however the B manufacturer did not meet the requirements of items 3 and 6, so it is not compliant.

KEYWORDS: *NBR 15557, tire inner tubes, bicycle.*

1. INTRODUCTION

The ordinance of the INMETRO - Metrology National Institute, Quality and Technology number 656 of December 17th of 2012[1] establish the criteria for Conformity Evaluation Program for Adult Use Bicycle Components through the compulsory certification mechanism, meeting the established technical requirements aiming the accidents prevention and providing security for the consumer.[2] The ordinance states that from 18 (eighteen) months from the date of publication of the decree, the bicycle components adult use should be manufactured and imported only in accordance with approved requirements and duly registered with the INMETRO.

The requirements apply to the following bicycle parts of adult use: Rim, inner tube, brake assembly, cordage, fork, suspension fork, handlebars, nipple, pedal, crank, frame, lightning and handlebar support. It is noteworthy that the set up adult bicycle are dispensed of certification, only its components are certified.

In 2010, IFAM - Federal Amazonas Institute was selected by INMETRO International Joint General Coordination to participate in a project within the ECONORMASscope "Support Deepening the economic integration process and the sustainable development of Mercosul" which is part of the actions of European Union cooperation with the Southern Common Market (MERCOSUL) comprising a line of action for harmonization of technical standards and regulations for the MERCOSUL in aspects related with quality and product safety, as well as the creation of regional capacities for evaluation the conformity of products, stimulating the strengthening of testing laboratories.[3]In this context the IFAM was awarded with equipment purchased within the ECONORMAS to implement an accredited laboratory tests and conformity of parts and bicycle models. Among these given equipment are: Universal testing machine, dynamic testing machine,brake testing machine, pedals fatigue testing machine. [4]

Since the first scientific paper on Butyl rubber [5]was presented, numerous publications have described the properties and compounding technique of this polymer. Although Butyl has been referred to as a specialty rubber, it can also be used to replace natural rubber in many applications. Butyl was found to be a remarkable barrier to the passage of gases, including air. The polymer also deteriorated very little on aging and had excellent tear resistance. Because of these properties Butyl was first considered for inner tubes, and in this application Butyl has found its largest commercial acceptance.[6] Automobile inner tubes were first made experimentally in September, 1940. With Butyl made in the Standard Oil pilot plant this experimental work continued until April, 1943, when the first government plant began producing Butyl commercially. From that time until the present Butyl has been used successfully to manufacture all types and sizes of inner tubes ranging from bicycle tubes of 1¼-inch cross-section to earth-mover tubes of 24-inch cross-section. Butyl tubes were first used by the United States Army for service in the European war theater in May, 1944. The following month Butyl was used in essential civilian trucks; but not until September, 1945, was sufficient Butyl available for civilian automobile tube[7].

Butyl rubber (chemically a copolymer of isobutylene and isoprene) has very good properties including low gas permeability, good thermal and oxidative stability, and excellent moisture and chemical resistance. It has been used in a wide variety of tyre and non-tyre applications such as inner tubes, tyre inner liners and tyre curing bladders due to its low unsaturation (generally less than 3%).

The inner tubes shall be manufactured from an appropriate rubber compound and vulcanized to anend less annular ring shape and shall be with a valve or spud. The tube shall be uniform in thickness, free fromflaws and designed to fit in a tyre of the corresponding nominal size.

In 2010, He et al [8] proposed another materials butyl rubber for rubber/silicate layer nanocomposites may be used as a substitute material in general rubber products, such as seal ring, packing seal, hose, shoe sole and other daily necessities. Rubber/silicate layer nanocomposites prepared by the latex compounding method possess low cost/ performance ratio and desirable properties, such as excellent tensile strength, superior gas barrier property, improved flame retardant property, outstanding antifatigue properties, etc. This novel and valuable material can be applied in tire inner tube, tire inner liner, OTR tire tread, conveyer belts, and so on.

Karaagac et al [9] described the effects of gamma irradiation on the recycling of used inner tubes. It has been concluded that gamma irradiated inner tubes are compatible with butyl rubber and gamma irradiated used inner tubes can be recycled within butyl based rubber compounds.

In this work was done bicycle tube compliance analysis according to NBR 15557:2014[12] tire tube - Requirements and test methods, bicycles tubes fall in group 7, for this group were performed the following tests: minimum breaking stress, minimum elongation, minimum breakdown voltage on the mend, tear strength, minimum grip on the valve seat, minimum membership valve rubber-metal, marking and packaging

The results showed that the B manufacturer did not meet the requirements of items 3 and 6, so is not as according to standard.

2 - MATERIALS AND METHODS

In this work the following equipment was used: universal testing machine with 1% accuracy load cell, displacement sensor, digital micrometer with 0.001 mm resolution, digital caliper with a resolution of 0.01mm, cutting devices for obtaining proof bodies.The speed of claws distance in the universal testing machine was 500 mm / min, it wasused a data acquisition and control software for static testing SCM3000 and was development a calculation sheet in Microsoft excel where was input the sample parametrs and obtained all the results of testing and uncertainty.

2.1 – Obtaining samples

The samples were from four different domestic manufacturers, that, in this work will be identified by: Manufacturer A Manufacturer B Manufacturer C.

The specimens were removed of tire tubeas shown in Figure 1. The sample were placed in the environment for 3 hours at a temperature of 24°C, the NBR 15557:2014[12] establishes that the temperature should be 23 ± 2° C.

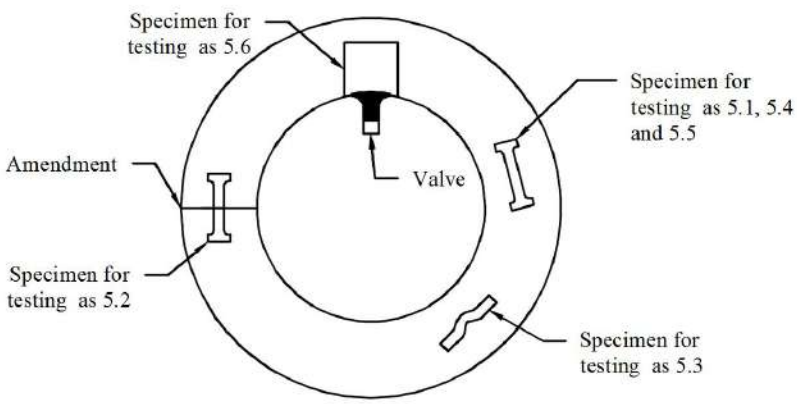


Figure 1.Schematic Location of specimens. Source: NBR 15557:2014[6] tire tube - Requirement and test methods according Table 1.

The section of the test method is listed, as provided in the standard Table 1 shows the minimum valued physical properties as established in the NBR 15557: 2014[12].

Table 1.Limit values of physical properties. Source: Adaptedfrom NBR 15557: 2014[6]..

REQUIREMENTS	SPECIFICATION GROUP 7	SECTION OF THE TEST METHOD
Minimum rupture stress in the body, in MPa	7	5.1
Minimum elongation in the body, in%	350	5.1
Maximum modulus at 100% in the body, MPa	-----	5.1
Minimum rupture stressin the amendment in MPa	3.5	5.2
Minimum Tear resistance, N / mm	18	5.3

Maximumpermanentdeformation in %	-----	5.4
Loss of maximum strength after aging, in %	-----	5.5
Minimum adhesion on the valve base in%	200	5.6
Minimum adhesion rubber-metal valve, in %	200	5.6

For the specimens of test methods 5.1, 5.2 was used international model cutting device as shown inFigure 2 (Model I).For the specimens of test methods 5.3 Model II it was used cutting device as shown in Figure 3.

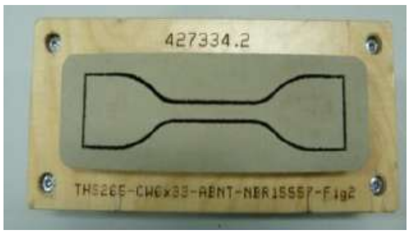


Figure 2 - Cutting device Model I

Figure 3 - Cutting device - Model II

The specimens were mounted into claws as shown in the Figures 4a and 4b. The a Figure 4a. shows the device with specimen for testing of 5.1 and 5.2 of the norm items. Figure 4b shows the device to obtain the samplefor testing the items 5.3.

Figure 4a.Samples 5.1 and 5.2

Figure 4b. Sample 5.3

2.2 - Physical parameters calculations

The sample was made according to NBR 15557/2014[12]. For each measurementoflength were done three measurements on each specimen. The final result of each test it was expressed as the average of the values obtained.

2.2.1 - Section of the test method 5.1. For this test it took 3 specimens.

Calculating the stress resistance:

$$T_r = \frac{F_r}{E \cdot L} \tag{1}$$

Where: T_r: rupture stress, F_r: breaking strength in the body,E: average thickness of the test piece, L average width of the cutting insert.

Calculation of rupture elongation:

$$AL_r = \left(\frac{L_r - L_i}{L_i}\right) \tag{2}$$

Where: AL_r: elongation at rupture, L_r: distance between the centers of the reference lines at the instant of rupture, L_i: initial distance between the centers of the reference lines[colocarumafiguramostrandoestadistância entre oscentros de referência] at the instant of rupture.

The universal testing machine used for this test had a displacement sensor without the need to dial in the specimen. The value of $(L_r - L_i)$ was determined by the displacement of the machine to breakdown and L_i value was determined by measuring the distance between the claws. As the ruptures forces of chambers are low, it was discarded the deformations in the load cells.

2.2.2 - Section of the test method 5.2. To carry out this test is used two sample.

$$T_e = \frac{F_e}{E \cdot L} \tag{3}$$

Where: $T_e$rupture stress on the mend, F_e: rupture strength in the amendment,E: average thickness of the test piece, L: average width of the cutting device.

2.2.3 – Section 5.3 of the test method. To carry out this test is used tree sample.

$$R_{rg} = \frac{F_{rg}}{E} \tag{4}$$

Where: R_{rg}: resistance by tearing thickness, F_{rg}: maximum tear force, E: average thickness of the test piece.

2.2.4 - Section of the test method5.6. Performed with only one sample.

$$D_p = \left(\frac{L_f - L_i}{L_i}\right) x100 \tag{5}$$

Where: D_p: permanent deformation, L_r: distance between the centers of the reference lines at the instant of rupture, L_i: initial distance between the centers of the reference lines at the instant of rupture.

For this test it was not made references signalized and was used aequipment displacement sensor. The final result value found is valid for the test caused interruption, ie, the beginning of the displacement of the valve seat or rubber metal bond failure. To perform another test, the result should be indicated by adding the phrase "greater than" (or the symbol ">").

2.3 - Marking and packaging

The analysis of markings on chamber and packaging were made by visually observing if contained information of: manufacturer brand, code and measure of the chamber, the period of production, measures to tires applicable.

2.4 - Calculation of measurement uncertainties

Uncertainty is a parameter associated with the result of a measurement that characterizes the dispersion of values that can be reasonably attributed to the measurand (Lira, 2008) [10].
According to ISO 17025[10]should be determined uncertainty of the measurements done and identified the factors that may affect the result of a measurement. For the uncertainty calculations were considered as the main sources to the dispersion of the results, the uncertainty of the measuring equipment and the temperature variation, in accordance with by EA-4/02[14]..

The dispersion of the results was calculated by the following equation 6:

$$u = \frac{s}{\sqrt{n}} \quad (6)$$

Where: s: standard deviation of the measurements, n: number of measurements performed.
Uncertainty of the measuring equipment, this parameter is obtained by Equation 7. The value of a is deducted from the calibration certificates for measuring devices used to determine the results of the tests.

$$u = \frac{a}{\sqrt{3}} \quad (7)$$

Where: *a*: half the width of the gap in which greatness is supposed to be contained.
For the temperature effect it was considered that the temperature variation (ΔT) it will be at most 2°C, taking into account any ambient temperature changes within the test chamber. Using a rectangular distribution, there is an estimate of the uncertainty associated with the variation of temperature given by equation 8.

$$u = \frac{\Delta T}{\sqrt{3}}.\alpha\ .L_0 \quad (8)$$

Where: ΔT: temperature variation, α coefficient of thermal expansion, L0: measured length.
The estimated uncertainty involves only the addition or subtraction of a series of measurements x1, x2, …xn, hen the combined uncertainty associated with y, u(y), it was determined by the Equation 9.

$$u(y) = \sqrt{(u(x_1)^2 \times c_1^2 + u(x_2)^2 \times c_2^2 + \ldots + u(x_n)^2 \times c_n^2)} \quad (9)$$

Where: u: (x_1) is the uncertainty associated with the parameter x_1, c_1 it is the sensitivity coefficient of the parameter x_1, etc.

The expanded uncertainty, U, is determined by multiplying the combined uncertainty, u, the expansion factor, k, to a normal distribution for a 95% probability is equal to 2. Determined by the Equation 10.

$$U = k \times u = 2 \times u \tag{10}$$

The uncertainty of the area to rectangular specimen was calculated by Equation 11:

$$u_{S_0} = \sqrt{(b_0)^2 \times u_{a_0}^2 + (a_0)^2 \times u_{b_0}^2} \tag{11}$$

Where: a0 and b0 average dimensions of the cross section of the specimen, uaoandubo measurement uncertainty.

The uncertainty of the stress was calculated by equation 12:

$$u_{R_m} = \sqrt{\left(\frac{1}{S_0}\right)^2 u_{F_m}^2 + \left(\frac{F_m}{S_0^2}\right)^2 u_{S_0}^2} \tag{12}$$

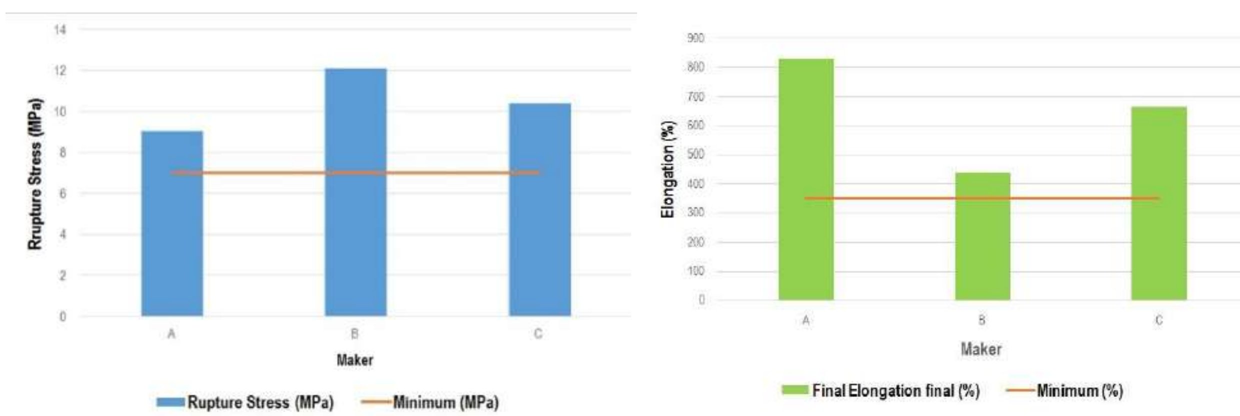
Where: F_m maximum force, S_0 area of the cross section of the specimen, u_{Fm}eu_{So} measurement uncertainty.

The calculation of the uncertainty of elongation and adhesion is similar to stress and can be determined by equation 12.

3.RESULTS AND DISCUSSIONS

3.1 Tests Item 5.1

All manufacturers attended this item from the normthat stablish minimum rupture stress in the body is 7.0 MPa. Best results for rupture stress to the B manufacturer as can be seen in figure 5a and in figure 5b it can be seen greater elongation for the manufacturer A.



(a) (b)

Figure 5. (a)rupture stress results. (b) Stretching Results.

3.2 Tests item 5.2

All manufacturers responded to this standard item as shown in Figure 6.The standardNBR 15557/2014[12]stablishminimum rupture stress in the amendment is 3.5MPa.

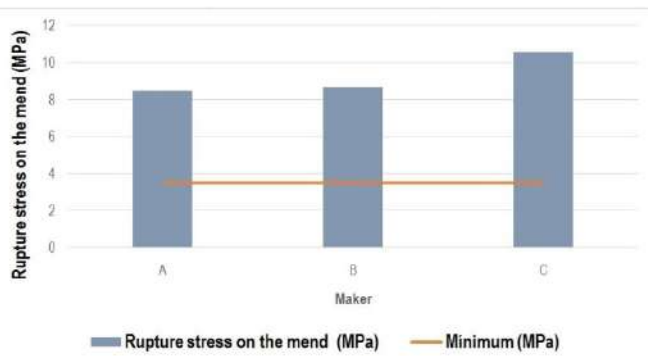


Figure 6 - Results rupture stress on the mend.

3.3 Tests item 5.3

The figue 7 show that manufacturers A and C met this requirement of the standardNBR 15557/2014[12], in which stablishminimum tear resistance is 18.0 N /mm.

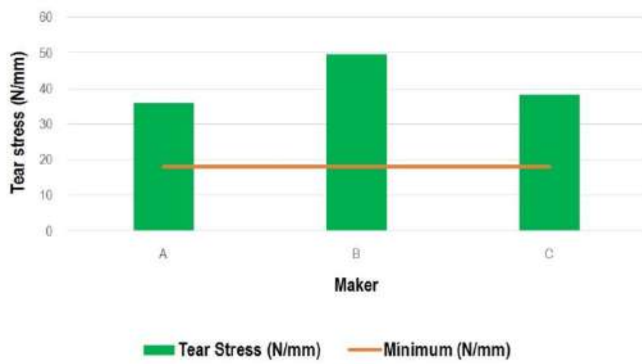


Figure 7 - Results tear test.

The chamber of the manufacturer B had a mean tearing stress of 49.63 N / mm greater than the minimum allowed by the standard is which 18 N / mm, but with a measurement uncertainty of 37.8 N / mm, the difference between average value of stress and measurement uncertainty was 11.8 N/mm lower than 18 N/mm, and is considered not conformed.

This high value of uncertainty due to non-uniformity in the thickness of the inner tube, in the measurements of thickness values it was obtained ranging from 0.85 mm to 1.49 mm, a variation of 75%, this dispersion influenced the measurement uncertainty the thickness of the area produced high dispersion results in the voltage ranging from 33.71 N / mm and 61.24 N / mm, variation of 81.67%. In anotheres countries as India and Japan the standards IS 13098/2012[9]andJIS D 4231/1995[10]respectively stablish a uniformity in the thickness: except for the region at or near lap or splice, thethickness of the tube, when measured along thelongitudinal direction of the tube, shall not vary from the arithmetic mean of the readings by ±17.5 percent at any point.

3.4 Item 5.6 Testing

In this test, the standardNBR 15557/2014[6]stablishtheminimum adhesion on the valve base is 200 %. The results of test show that are according with the standard the manufacturers A and C, A manufacturer presenteddisplacement in the valve base, as shown in Figure 8b, the C manufacturer has failed rubber-metal adhesion, as shown in Figure 8c. The manufacturer B had less adherence than specified by the norm, showing displacement in the valve base.

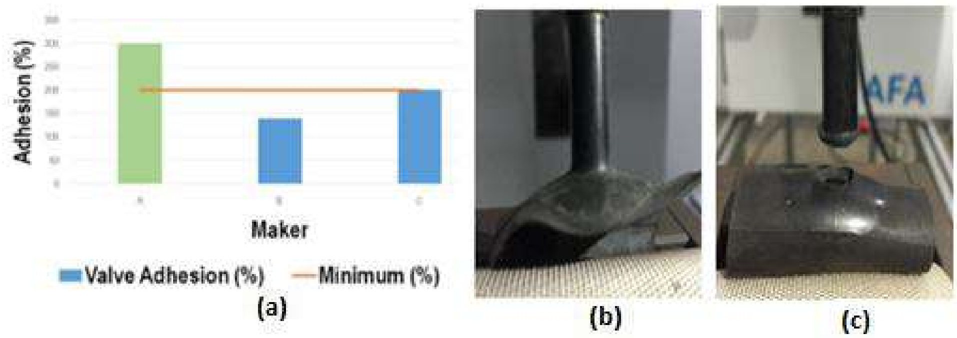


Figure 8- (a)Result adhesion test, (b) Displacement the valve base, manufacturer's test A, (c) Failure rubber-metal adhesion, C. manufacturer's test.

3.5 Item 6 Testing

All manufacturers were accordingNBR 15557/2014[12]in this item.

4 CONCLUSION

Given the results presented in the tests, it can be concluded that:

i) B manufacturer of tube It is not in accordance, did not meet the items 5.3 and 5.6 of NBR 15557/2014[6]standard, which states that to be according the product must present compliance in all items of submitted tests.A probable cause was a variation of 75% in the thickness, although the NBR 15557/2014[12] standard, it does not stablish values for this property.

ii) - Manufacturers A and C met allthe requirements ofNBR 15557/2014[12]standard.

iii) - Using the methodology presented in this article, with the equipment and devices installed in the laboratory of the IFAM-IDMC, may be tested all the requirements of NBR 15557/2014[12] of the tube for bicycle tires, marketed in Manaus -AM and / or other cities in Brazil.Text paragraph.

5 ACKNOWLEDGMENTS

LECCOMB - Bicycle Component Conformance Test Laboratory IFAM-IDMC.

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