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Laboratory Regulatory Tire Testing of Two -Wheelers: A Review

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ABSTRACT: Tire being crucial for the road safety, comfort and fuel economy/efficiency of vehicles needs to undergo comprehensive and rigorous testing in the laboratory to evaluate and ensure its adequate performance. Tire performance is required to be evaluated via tests like dimension test, plunger test, load-speed performance test, endurance test, and dynamic growth test. Various tire testing standards are used worldwide to assure vehicle/rider's as well as pedestrian's safety. The main objective of this work is to explain the test methods and procedures in order to get the certification of two-wheeler tires for commercial use along with some suggestions for amendments. This study shall help the policymakers in a way that they can use the points mentioned in this review in the future amendments of different tire testing standards.

Keywords: Tire Testing, Tire Performance, Dimension Test, Plunger Test, Load/Speed Performance Test, Endurance Test, Dynamic Growth Test

I. INTRODUCTION:

Benchmarking and the performance of pneumatic tires has always been very vital for the safety of passengers in vehicles and pedestrian. Pneumatic tires should be capable to perform well on asphalt/road in different conditions like wet, dry and muddy. The requirements can vary according to the different application areas as per different conditions, segments and variants. The performance of pneumatic tires mainly depends on the structure, tread structure/pattern, mixing material, ply strength, etc. Pneumatic tires are safety critical components and thus it requires special approval before getting usage in vehicles. Almost every country has some standards for tire testing that ensures the safety of passengers as well as pedestrians. In order to be eligible for road-worthiness the requirements mentioned in these standards should be met by the pneumatic tires before getting approval for road readiness in India by BIS accredited labs.

This work explains the parameters and tests that are required to be checked in pneumatic tires in order to get approval from concerned authorities. The tests involved are explained briefly here along with it laboratory conditions are also explained. Some examples of tire testing standards are Indian Standards (IS) 15627:2005, Federal Motor Vehicle Safety Standards (FMVSS) 119 and European Economy Community (ECE) Standards R75. This study will be helpful for understanding laboratory testing methods and conditions of two-wheeler tires and suggests some amendments in tire testing limits for above mentioned Indian tire testing standard i.e. [IS 15627 up to Amendment number 03, June 2017]. The discussion is strictly restricted to the class of two-wheelers only.

General Terms

1. Bead: The inner part below the tire sidewall having a group of strands whose shape and structure enables it to fit and hold the rim tightly
2. Carcass: It is the inner skeleton on the tire apart from tread and sidewall bear the circumferential load.
3. Tread: The topmost part of the tire comes in contact with external surfaces when roll.
4. Ply: Fabric strands in-lined with carcass either in radial direction or diagonally.

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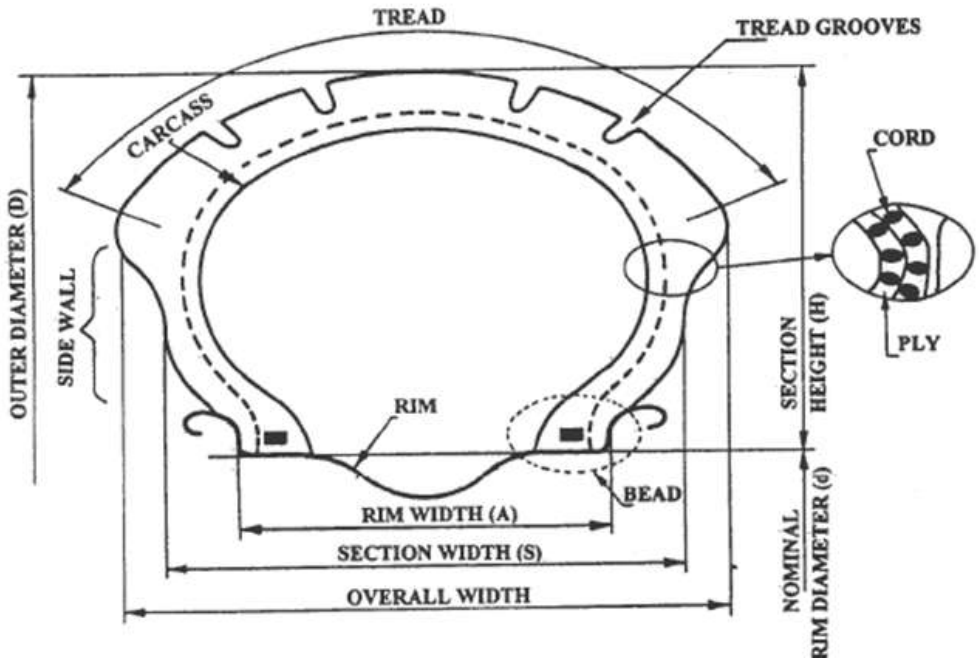


Fig.1-Basic Structure of Radial Tire

Laboratory Tire Performance Testing Parameters

1. The main criteria that are used to evaluate tire performance are mentioned below:

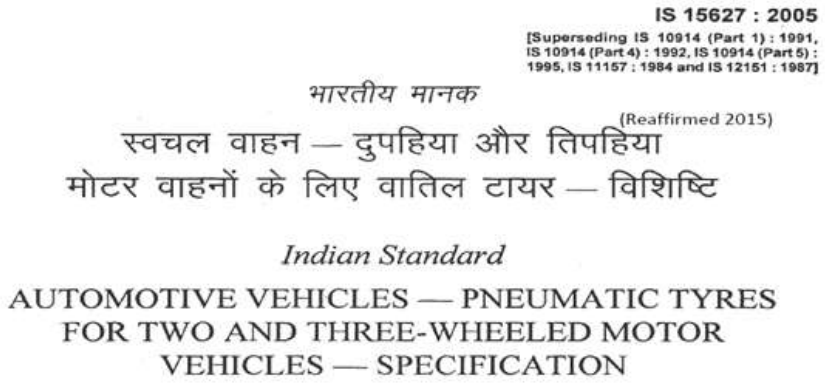
a) Dimension and marking: Tire is checked for tread wear indicator (TWI), section width and outer diameter, and some important markings that provide tire characteristics to the user.

b) Strength of tire: Resistance against puncture is checked by applying external load through a plunger rod of specified dimension.

c) Service Life/Endurance: Tire rim assembly is made to run continuously with a constant speed for a long duration of time in loaded condition.

d) Load speed performance: Tire rim assembly is subjected to higher speed and load simultaneously.

e) Dynamic Growth: Effect of centrifugal force on radial elongation/growth of tire is observed.


IS 15627 : 2005
[Superseding IS 10914 (Part 1) : 1991, IS 10914 (Part 4) : 1992, IS 10914 (Part 5) : 1995, IS 11157 : 1984 and IS 12151 : 1987]

भारतीय मानक

(Reaffirmed 2015)

स्वचल वाहन — दुपहिया और तिपहिया मोटर वाहनों के लिए वातिल टायर — विशिष्टि

Indian Standard

AUTOMOTIVE VEHICLES — PNEUMATIC TYRES FOR TWO AND THREE-WHEELED MOTOR VEHICLES — SPECIFICATION

Fig.2 –Front page IS 15627

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Various Tire Tests

1. Tire Dimension Test/ Marking

In this test tire-rim assembly is conditioned for 24 hours at ambient temperature at the pressure specified by the manufacturer otherwise as per given in standard [1]. After the conditioning period is over assembly is checked whether there is any pressure leakage or not. After checking the pressure, three parameters need to be checked i.e, section width, outer diameter, and tread wear indicator.

The measured values of section width and outer diameter should be within the mentioned range [2] of the value which is specified in the standard (it varies with the size of tires) and there should be at least six equally spaced TWI marks around the tire circumference in case of diameter less than 12 inches and at least 4 in case of diameter more than 12 inches. Tread Wear Indicator (TWI) should be between 0.8mm to 1.4mm [3]. If measured values are not within the ranges mentioned in standard then tire will be considered failed.

Tire shall also have all the essential markings embraced on the tire sidewall and also markings should be within the dimensional range as mentioned in the standard [13].

Fig.3 –Circumferential Gauge used for measuring Tire Diameter

2. Plunger Test

In this test tire-rim assembly is conditioned for 03 hours at the pressure specified by the manufacturer otherwise given in standard [1]. Conditioning temperature should be approximately equal to the ambient temperature. Five equally spaced markings are to be made on tire circumference. On these marks plunger of specified dimension is forced with a travel rate of 50±1.5mm/min [4]. Plunger energy varies for different sizes of tires, as per their application and ply strength. Table for plunger size requirement & break energy requirement for diagonal ply, bias ply and ISO designated tires can be found in the standard [5].

The Breaking Energy shall be calculated as [6]

$$W = \frac{F*P}{2} \times 10^{-3}$$

Where,
W = Break Energy in Joules
F = Break Force in Newtons
P = Penetration at break (mm)

If tire successfully bears the penetration force and do not get punctured, it is considered complianed for the certification.

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Fig.4 –Tire plunger testing setup

3. Endurance Test

In this test tire-rim assembly is conditioned for 03 hours at the pressure specified in the standard [7]. Conditioning temperature should be between 20°C to 40°C. After the conditioning period is over tire-rim assembly is checked for pressure leakage. The assembly is then mounted on a machine having a circular drum of width more than the width of tire-rim assembly. The diameter of the test drum is 1.7 ± 1 or 2.0 ± 1 in meters. The tire-rim assembly is pressed against the face of the drum with a load specified in the standard. The test is carried out in three stages which vary according to the application category of tires. The first stage is of 04 hours, second is of 10 hours and last stage is of 24 hours. Load varies in each of these stages as mentioned in the standard. Detailed information about the load and speed of various stages can be referred from the standard [8].

At the end of each stage run tire pressure is to be monitored. Additionally, after three hours from the start of the test a pressure check is to be made and during the later stages the value of pressure should not be less than the pressure reading taken after three hours.

After the completion of the test, the tire is cut and examined for broken cords, tread separation, ply & bead separation and sidewall damage [8]. If everything is fine tire fulfills the criteria for certification for use in commercial purposes.

Fig.5 –Tire endurance testing setup

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4. Load/Speed Performance Test

In this test tire-rim assembly is conditioned for 03 hours at the pressure specified by the manufacturer otherwise as given in standard [7]. Conditioning temperature should be between 20°C to 40°C. After the conditioning, the period is over tire-rim assembly is checked for pressure leakage. The assembly is then mounted on the machine having a circular drum of width more than the width of tire-rim assembly. The diameter of the test drum is 1.7 ± 1 or 2.0 ± 1 in meters. In this test tire-rim assembly is pressed against the face of the drum at a load of 65 percent of which marked on the tire (for 1.7m ± 1 drum diameter). In the case of mopeds tire involving drum diameter of 2.0m ± 1 this load becomes 67 percent of what marked on the tire. The test is run in five stages with the first stage having a duration of 20 minutes and later stages of 10 minutes each. Maximum test speed for 1.7m ± 1 drum diameter is ten kmph less than that marked on the tire. While for 2.0 m ± 1 drum diameter maximum test speed is equal to that of speed marked on the tire. For detailed information about the load and speed of various stages standard can be referred to [9].

For speeds above 210 kmph applied load is different and it is mentioned clearly in the standard [10]. For higher speeds, i.e. above 240 kmph two load/speed performance tests are carried out for which maximum load is specified by the manufacturer. The test cycle is specified in standard [11].

Fig.6 –Tire LSP test machine schematic diagram

5. Dynamic Growth Test

This test is carried out on Diagonal ply or Bias-ply tires only. It is for tires with a speed index of more than P (150 kmph). It is carried out on tires that have successfully passed the Load/Speed performance test. The pressure of the tire-rim assembly is adjusted as given in the standard [12] Tire-rim assembly is conditioned between 20°C to 40°C or higher as per customer specification for 3 hours after that is it mounted on the axle and entire assembly is accelerated to corresponding maximum speed within 5 minutes (warming-up). After this assembly is allowed to run at maximum speed for 5 minutes a check is made that the tire should not exceed enveloping curve and hence considered test compliance.

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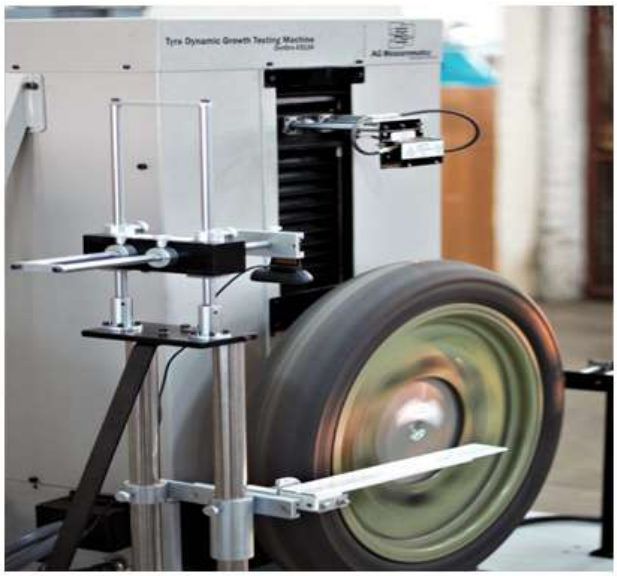

Fig.7 –Tire Dynamic growth test machine Setup

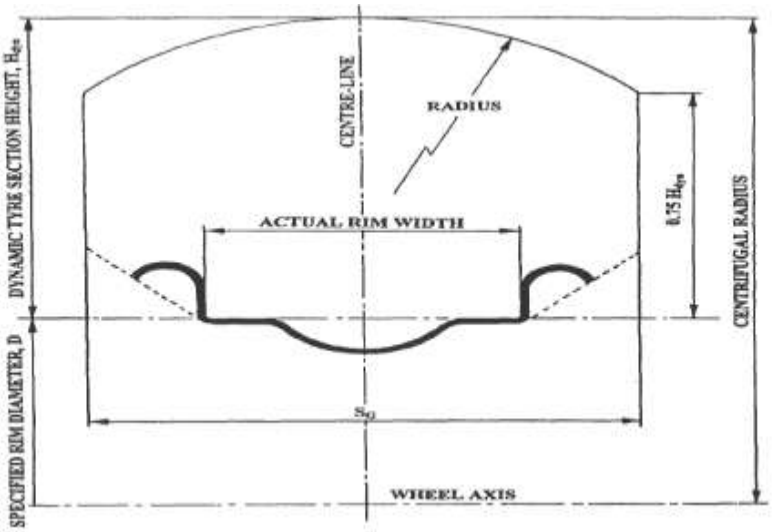

Fig.8 –Enveloping curve for tire dynamic growth

II. SUGGESTION FOR AMENDMENTS

1. Compulsion use of textured/rough roller surface equivalent to asphalt grade in the Endurance and Load/Speed Performance (LSP) test machines to simulate realistic conditions during testing.

It was observed in laboratory which is equipped with an Endurance test machine having smooth steel surface roller, various passenger car radial tire samples were tested on machine as per the reference standard for 40000 km and it was found that the difference in Non-Skid-Depth before and after the test was just in the range of 1.2-1.6% whereas the tires are generally worn out after running 40000-50000 km [15] on the road surface. The major factor is because the smooth steel roller surface of the Endurance test rig during tire endurance testing can only simulate after effect of long duration cyclic load on the tire, whereas heat generation due to tire and surface (roadbed) friction is among the major factor of tire failure on road.

So with the above-said amendment, of using the textured surface roller in the existing machines, the accredited laboratories can evaluate tire failures due to heat generation along with the long duration cyclic load (Endurance Test), high-speed test (LSP Test), and tire wear which would help in better benchmarking of commercial tires.

2. Inclusion of tire wet grip testing in regulatory standards.

III. CONCLUSION

This study helps the user to get a brief knowledge about testing and performance of existing Indian 2W and 3W tire standard i.e. IS 15627.

For policymakers, the inclusion of the above-mentioned amendments in the existing regulatory standard can help industry and regulatory bodies in improving the near future tires and eventually making tires safer, better performer in terms of handling, heat resistance, tire wear, and tire traction.

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