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METROLOGICAL CONTROL OF TYRE PRESSURE GAUGES: A CASE STUDY OF KINONDONI MUNICIPAL COUNCIL, TANZANIA

Julius Kitalile Mwakyoma,
Department of Legal and Industrial Metrology, College of Business Education (CBE), P.O.Box 1968, Dar es Salaam, Tanzania
.E-mail: j.kitalile@cbe.ac.tz
&

Jailos Mrisho Nzumile,
Department of Legal and Industrial Metrology, College of Business Education (CBE), P. O Box 1968, Dar es Salaam, Tanzania.
E-mail: mrishojailos@ymail.com

ABSTRACT

Abstract

Monitoring the inflation of tyre pressure plays a significant role in ensuring safety of motor vehicle users both private and public. Accurate measurement of tyre inflation pressure requires a tyre pressure gauge, which is consistent and that complies with other metrological characteristics. Proper metrological control of the manufactured and imported gauges is paramount to measure the accuracy of the tyre pressure. The control of conformity to metrological characteristics for new and those in use is still uncertain, their accuracy is also not known to both users and their customers who inflate pressure in their motor vehicle tyres. This study assessed the legal metrological control of the tyre inflation pressure gauges in Dar es Salaam. The assessment was done by taking a sample of 255 bus drivers, 159 inflation pressure gauge users and also 159 inflation pressure gauges located in Kinondoni. The results reveal that users are aware of calibration and verification of their gauges. It was indicated that 89.9% of 159 respondents had no idea of calibrating their instruments while 10.1% were aware, 96.9% never attended any training regarding calibration. About 98.1% had never been visited by any regulatory authority for calibration and verification. It was observed that only 18.2% of 159 tested instruments were accurate while the remaining were deviating from 40 % and 30% for positive and negative deviation respectively. The government should consider adding the instruments in the list of those subjected to legal metrological control to have accurate tyre pressure inflation gauge. The additional of the instruments will enable the regulatory authorities to carry out calibration and verification to the manufactured and imported tyre pressure inflation gauges in the country and getting rid of counterfeit and inaccurate instruments.

Keywords: *Metrological Control, Pressure Gauge, Tyre Pressure, Calibration, Verification*

INTRODUCTION

Background Information

Vehicle tyre inflation has become widely known and sensitive in road safety across the world. Over inflation and under inflation have negative effects on tyres. Effects associated with over inflated includes, the decrease in the rolling resistance, ride comfort and the centre of the tyre wears more than it should. While underinflated rolling resistance increases fuel consumption, tyre overheating and premature tread wear (Hillier and Coombes, 2004). Therefore, it is important to inflate the tyre pressure as per recommendation from vehicle manufacturer. The tyre inflation pressure gauges play an important role in ensuring accurate inflation of pressure in vehicle tyres due to the fact that confidence in the measured results derives principally from the ability of the equipment to deliver correct measurements under variable measurement and environmental conditions. From the experience in our daily life, people always inflate their car tyre in the station without even knowing whether the pressure gauge being used displays a correct amount or not. This might end up with the tyre being over or under inflated and eventually leading to the fore mentioned outcomes.

Globalization and free market have influenced the importation of different brands and types of tyre inflation pressure gauges in local market. However, some of the gauges are counterfeit and substandard leading to errors when inflating tyres. This has resulted to some of the customers as noted by researchers to complain regarding errors on the inflated pressure in their car tyres. This may cause several measurement errors and eventually end up with uncountable effects for both civilian, government as well as business owner. Accurate tyre inflation pressure measurement requires a tyre pressure gauge which is accurate, consistent and conforming to other metrological characteristics. The control of conformity to metrological characteristics for both new gauges and those in use is still uncertain, their accuracy is also not known to both users and their customers who inflate pressure in their motor vehicle tyres. In view of this gap, this study intends to assess the legal metrological control of the tyre inflation pressure gauges in Kinondoni municipal council in Dar es Salaam City.

Objective

Assessing metrological control of tyre inflation pressure gauges

Significance of the study

The results of the study will inform the government and the general public of the status of tyre inflation pressure gauges used in garages and tyre service centres in terms of their functional performance. The study will help the users to know the importance of verification and calibration of tyre inflation pressure gauges. The study will further help the government to see the need for executing metrological control of tyre inflation pressure gauges as it is for other equipment of weights and measures.

LITERATURE REVIEW

Metrology is defined as the science of measurement and its applications, which includes all theoretical and practical aspects of measurement (OIML, 2013). Likewise, legal metrological control means whole of legal metrology activities, which contribute to metrological assurance that includes legal control of measuring instruments, metrological supervision and metrological expertise (OIML, 2013). Generally, metrological activities are divided into three levels of control including; type approval and initial verification, subsequent verification and surveillance. Type approval represents the compliance of the device to constructive characteristics in order to guarantee that the instrument is manufactured or imported according to the national regulations. Initial verification checks if the instrument is in accordance to the approved features. The subsequent verification represents the level of control of the instruments after entering in the market, testing periodically or after a repair if the device fulfils the requirements. Finally, surveillance is the level of control focused mainly on identifying metrological frauds and misuse of the instruments in the market. These activities may be conducted by public or private bodies according to each country's necessity (OIML, 2013).
In practice, subsequent verification can assume the following two forms which are verification after repair and mandatory periodic verification (OIML, 1988). Subsequent verification is applicable to any measuring instrument under regulation when it is repaired due to failure or maintenance operation, for these cases, the measuring instrument has to be re-verified. In case of mandatory periodic re-verification, the periods for verification are legally fixed for protection of public interest. Measuring instruments are of different types and purposes, not all types are subjected to legal control. Most of the countries specify measuring instruments used for trade, safety protection, medical treatment and health and environmental monitoring to be subjected to legal control. Following this, it is undeniably that tyre pressure gauge is also one of the measuring instruments for safety protection and therefore should be subjected to legal control by most of the countries for example European Union countries(CEN, 2014).

Weights and measures agency are responsible for controlling all types of measuring instruments in Tanzania. It is unfortunate that the current Weights and Measures Act cap 340 (RE 2002) (URT, 1982) with its regulations does not deal with other types of measuring instruments than those in trade use. Other measuring instruments used in safety protection, medical treatment and health and environmental monitoring are not covered. Tyre pressure gauge, which is not used for trade transactions is among the measuring instruments not covered by weights and measures Act cap 340 RE 2002 with its regulations (URT, 2002). Therefore, it is not subjected to legal metrological control. Importers and users are not bound to observe the conformity to metrology requirements.

An appropriate tyre pressure is very significant in the sense that the inflated air act as an ideal compressible elastic support for the tyre structure. Also the amount of air needed inside the tyre is directly determined by the vertical load

capacity for which the tyre is designed. Friction coefficients, both static and kinetic, are mildly affected by inflation pressure on dry roads, while on wet surfaces inflation pressure is a crucial factor to improve both friction coefficients (Gillespie, 1992). The maximum inflation pressure branded on the tire's sidewall is not appropriate inflation tyre pressure as it indicates the pressure needed to meet the tire's full rated load carrying capacity. The technical reason for properly inflated tyre is to distribute the vehicle load evenly across the tyre footprint by providing good contact with the road, passenger comfort, responsive handling and uniform tyre wear. When vehicle tyres are inflated to their correct pressure, the safety of occupants is guaranteed, the fuel economy is enhanced and the passenger comfortability is achieved (Reimpell and Stoll, 1996).
With regards to tyre pressure measuring instruments and monitoring systems, International Organisation for Legal metrology (OIML, 1975) describes three categories of tyre pressure gauges as follows:
Pressure gauges used in "fixed" or mobile installations in service stations and intended for checking pressure while the tyres are being inflated;

Hand-held pressure gauges from vehicle tool-kits intended for periodic checks of tyre pressure
Pressure gauges fixed on vehicle dashboards and intended for continuous checking of vehicle-tyre pressure while the vehicle is moving.

Moreover in July 2009, the EU Council and European Parliament adopted a new regulation (EC 661/2009), which aimed at improving road safety and energy efficiency by requiring accurate tyre pressure monitoring systems (TPMS) to be fitted in all new cars (EC,2009). Since November 2014, all new cars sold in Europe must be equipped with a system that continuously monitors tyre pressure and warns the driver when the tyre pressure is too low. In Tanzania however hand-held pressure gauges, and fixed or mobile installations at service stations are the most common and widely used tyre pressure measurement instruments. Accurate tyre inflation pressure measurement requires tyre pressure gauge which is accurate and consistent. According to Reed and Reid (2000), inaccurate tyre pressure gauge and incorrect reading by the operator are among major causes of over-inflation.

So far various studies have been done on tyre inflation pressure , some of areas covered are effect of tyre pressure on vehicle performance(Alhassan, 2011), effect of tyre pressure on rolling loss in cars(Ramesh et al., 2015), relationship between vehicle manufacturers recommended tyre pressure and tyre pressure used by vehicle owners (Alhassan et al., 2014), effect of tyre pressure on fuel consumption, vehicle handling and ride quality(Varghese, 2013), monitoring operational conditions of vehicle tyre pressure levels and tread depths in Kumasi metropolis, Ghana (Bawa et al., 2015). However, in Tanzania, the studies related to tyre inflation pressure have not been done, also the studies on whether tyre pressure gauges contribute to under inflation or over inflation has not been undertaken. In view of this identified research gap, this study seeks to identify different types of tyre inflation pressure gauges used in Dar es Salaam at Kinondoni as a case study, assess the status of tyre inflation pressure gauges currently used in garages and tyre service centres and establish practice for metrological control of tyre inflation pressure gauges.

RESEARCH METHODOLOGY

The study was conducted in Kinondoni; all twenty wards of Kinondoni council were included in this study.
While collecting information, a combination of both primary and secondary data were used. In collecting primary data, both structured and unstructured interviews, questionnaires, observations and measurements were used. Structured questionnaires were administered to respondents selected randomly while structured and unstructured interviews were conducted to selected regulatory authorities. Secondary data were collected from literature review including relevant articles, similar researches, existing standards and regulations. Data were collected by considering elements such as sampling design, design and preparation of data collection tools and techniques.

Sampling Design

Population refers to the entire group of people, events, or things of interest that the researcher wishes to investigate (Sekaran, 2003). The population of this study included:
Tyre inflation pressure gauges used in Kinondoni garages and tyre service centres,
The total number of tyre inflation pressure gauges were counted and obtained to be two hundred sixty-three (263) in Kinondoni.

Users of tyre inflation pressure gauges in Kinondoni garages and tyre service centres. These are the owners or any employee working in the station who regularly use tyre inflation pressure gauge.
Since there are 263 inflation pressure gauges in Kinondoni, there also 263 users of inflation pressure gauges.
Drivers of commuter buses in Makumbusho bus stand.
According to the management there were seven hundred (700) drivers of commuter buses
Regulatory bodies which were two such as Weight and Measures Agency (WMA) and Tanzania Bureau of Standards (TBS).

Sample size calculation
As pointed out by Yamane (1967), a sample size for a population less than ten thousands (10,000) is calculated by employing the formula shown in equation (1);

$$n = \frac{N}{1+Ne^2} \qquad (1)$$

Also, the confidence level was taken to be 95%.
Where n is the sample size, N is the population size, e is the sampling error and 1 is a constant. Based on the above formula, the following sample size were calculated by substituting each population size in equation (1) above as shown below;

i. Sample for commuter bus drivers in Makumbusho bus stand

$$n = \frac{700}{1 + 700(0.05^2)}$$

$$= \mathbf{255}$$

ii. Sample for users of tyre inflation pressure gauges in Kinondoni

$$n = \frac{263}{1 + 263(0.05^2)}$$

$$= \mathbf{159}$$

iii. Sample for tyre inflation pressure gauges in Kinondoni

$$n = \frac{263}{1 + 263(0.05^2)}$$

$$= \mathbf{159}$$

Calibration of pressure gauge
Pressure gauge calibration is done by comparing the output from a standard pressure gauge with the one in use followed by the adjustment of the one in use if there exist discrepancies with the standard gauge. To accomplish this, a digital tyre pressure gauge of range 0-200 pound per square inch (psi) and readability accuracy of 0.1 psi was purchased and taken to the metrology laboratory of Tanzania Bureau of Standards for calibration in order to ascertain its accuracy. The tyre pressure gauge was calibrated and issued a certificate of calibration Number 29827 thereafter. The calibrated gauge was then used for comparison with the gauges available in various centres.

Data Analysis
The collected data was coded using Statistical Package for Social Sciences (SPSS) and Microsoft Excel and analysed using frequency tables, histograms and pie charts.

RESULTS AND DISCUSSION
During data collection the respondents were categorized into three groups such as commuter bus drivers who covers sixty one point three percent (61.3%), users of tyre pressure gauges covers thirty eight point two percent (38.2%) as well as members from regulatory authorities who covers zero point five percent (0.5%) as shown in Figure 1.

Figure 1. Percentage of the respondents

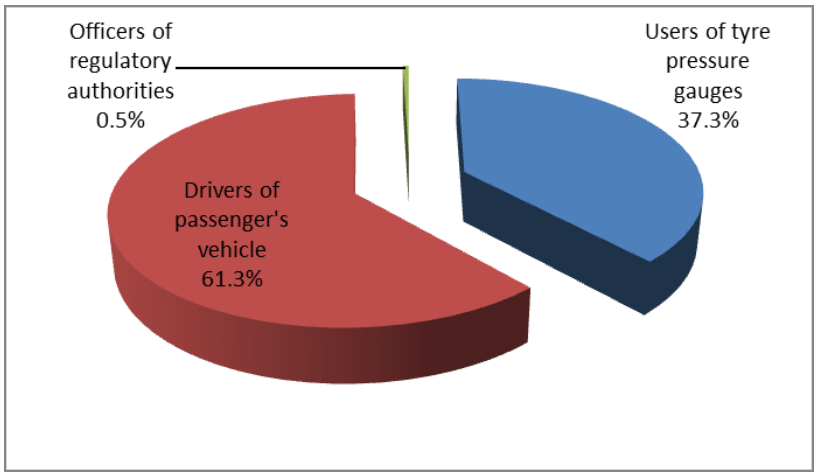


Figure 1. Percentage of the respondents

The respondents' status during data collection are shown in Table 1 especially for pressure gauge users and drivers.

Table 1. Respondents' profile

Group	Variable	Category	Frequency	Percent (%)
Drivers	Level of education	Primary level	133	52.2
		Secondary level	72	28.2
		College	49	19.2
		University	1	0.4
	Experience as drivers	0-3 years	11	4.3
		4-6 years	57	22.3
		7-10 years	69	27.1
		Over 10 years	118	46.3

Users of tyre pressure gauges	Level of education	Primary level	85	53.5
		Secondary level	50	31.4
		College	16	10.1
		University	8	5
	Years of garage or centre in business	0-5 years	33	20.8
		6-10 years	70	44
		Over 10 years	56	35.2
	Experience of respondent in using tyre pressure gauges	Below 1 year	6	3.8
		1-4 years	35	22
		5-10 years	62	39
		Over 10 years	56	35.2

Table1 indicates that 52.2% of 255 driver had primary level of education, 28.2% attained secondary education, 19.2% had college level and 0.4% had University education. It also shows that 95.7% of drivers had experience of more than three years; only 4.3% of the 255 driver respondents had experience of three years or less. About 96.2% of the users had experience of using tyre pressure gauges for more than one year, only 3.8% of the 159 users had experience of less than one year. Most of users had primary education (53.5%) and secondary education (31.4%).

The results related to the monitoring of an inflated pressure in the tyres using the pressure gauge designed is provided in Table 2.

Table 2. General practice of checking an inflated pressure in vehicle tyres

Practice	**Frequency**	**Percentage**
Vehicles fitted with TPMS	2	0.8
Vehicles not fitted with TPMS	253	99.2
Drivers knowing recommended pressure of their vehicle tyres	244	95.7
Drivers not knowing the recommended pressure of their vehicle tyres	11	4.3
Drivers with own tyre pressure gauges	7	2.7
Drivers without tyre pressure gauges	248	97.3
Drivers preferring garages	40	15.7
Drivers preferring tyre service centres	215	84.3

Table 2 shows that 0.8% of 255 vehicles were fitted with tyre pressure monitoring system (TPMS). From these results it is obvious that tyre inflation pressure gauges remain the major measuring instrument for checking inflation pressure in vehicle tyres in Dar es Salaam. Findings of this study revealed that most of drivers (95.7%) were aware of recommended pressure for their vehicle tyres. It was further noticed that 2.7% of driver had their tyre pressure gauges

for routine checking of inflation pressure to their vehicle tyres while 97.3% did not have tyre pressure gauges. Those who did not have tyre pressure used unreliable methods for checking their tyre pressure by observation and hitting the tyre with a spanner or other metal rods. The study further revealed that 100% of drivers were not aware about the pressure inflation facilities such as compressors. It is evident that when the tyre pressure of their vehicles became low, drivers use tyre pressure gauges available at garages or tyre service centres for inflation of pressure in their vehicle tyres. Moreover, results revealed that 15.7% of drivers preferred to inflate their tyres in garages while 84.3% preferred in tyre service centres. Table 3 shows the frequency of checking an inflated pressure in vehicle tyre by drivers. It was found that 33.7% of drivers preferred to check an inflated pressure in vehicle tyre on weekly.

Table 3. Drivers routine checking of inflation pressure in vehicle tyre

Routine	Frequency	Percent
Daily	41	16.1
Weekly	86	33.7
Monthly	25	9.8
When pressure seems low	45	17.6
When the vehicle is serviced	29	11.4
Others	29	11.4
Total	255	100

The study also pointed out that 89.9% users had never heard about verification/calibration of tyres pressure gauges. About 96.9% had never attended any training or seminar relating to tyre pressure gauges, and 98.1% had never been visited by any regulatory authority dealing with verification or calibration of tyre pressure gauges as shown in Table 4.

Table 4. Awareness and Training for Verification and Calibration of Tyre Pressure Gauges

Awareness/Training questions	**Frequency**	
	Attended	**Not attended**
Have you ever attended training about verification / calibration of tyre pressure gauges?	16 (10.1%)	143 (89.9%)
Have you ever attended training or awareness seminar relating to tyre pressure gauges?	5 (3.1%)	154 (96.9%)
Have you ever been visited by any regulatory authority for verification/calibration of tyre pressure gauges?	3 (1.9%)	156 (98.1%)

The interviews conducted to Tanzania Bureau of Standards (TBS) and Weight and Measures Agency (WMA) officers revealed that neither training nor awareness seminars had been done to importers, suppliers and users of tyre pressure gauges. Findings imply that tyre pressure gauge users were lacking elementary knowledge needed during selecting, purchasing, using, handling, and maintaining the accuracy of tyre pressure gauges. It is clear that the users had poor response to voluntary calibration of their tyre pressure gauges as they are not aware of the importance of calibration.

Findings indicate that regulatory authorities had not done enough to train pressure gauge users on the importance of calibration.

The study also identified different types of tyre inflation pressure gauges used in garages located in Kinondoni as presented in Figure 2.

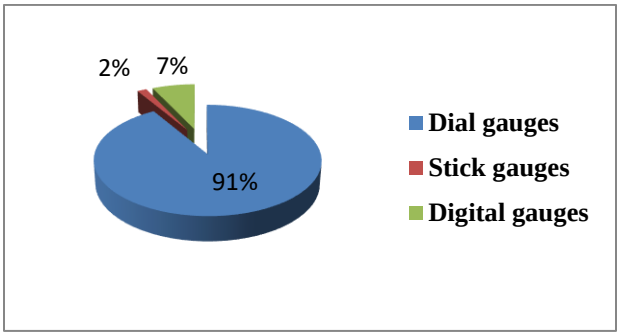


Figure 2. Percentage of types of tyre pressure gauges used in Kinondoni

The study identified the status of tyre inflation pressure gauges used in service centre and garages. Results indicated that 93.1% had significant knowledge but have not calibrated their tyre pressure gauges while 6.9% claimed to have calibrated them but were not able to show calibration certificate as shown in Figure 3.

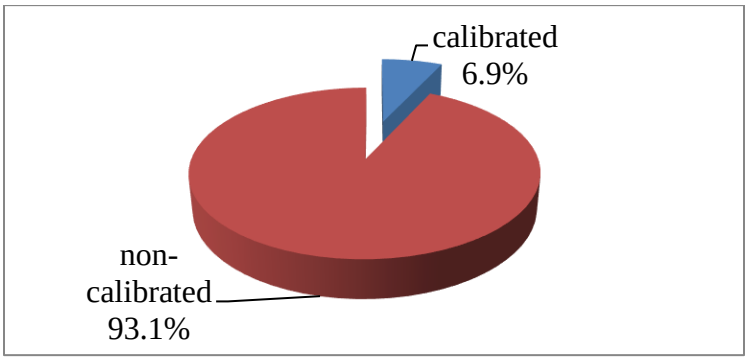


Figure 3. Calibration status of used tyre pressure gauges in last five years

The results from comparison of gauge pressure measurements conducted at different garages and tyre service centres in Kinondoni indicated that 18.2 % of the gauges gave exactly the same reading as the calibrated tyre pressure gauge when they were used to measure the tyre having a pressure of 60 psi. The rest of the gauges had negative deviation up to 30% and positive deviation up to 40% as indicated in Table 5 and Figure 4.

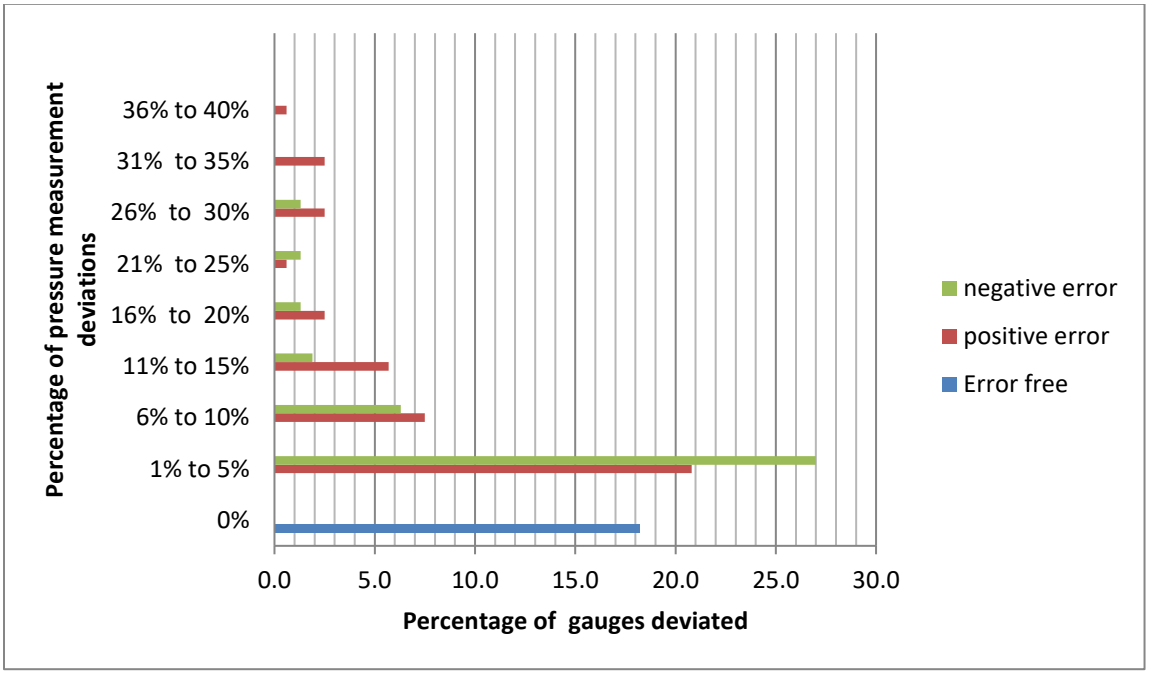
Table 5. Comparison of Gauge Pressure Measurement

Deviation (%)	Number of pressure gauges	Percentage
-26 to -30	2	1.3
-21 to -25	2	1.3
-16 to -20	2	1.3

-11 to -15	3	1.9
-6 to -10	10	6.3
-1 to -5	43	27.0
0	29	18.2
1 to 5	33	20.8
6 to 10	12	7.5
11 to 15	9	5.7
16 to 20	4	2.5
21 to 25	1	0.6
26 to 30	4	2.5
31 to 35	4	2.5
36 to 40	1	0.6
Total	159	100

The study also revealed that in Dar es Salaam and Tanzania at large there was no accredited metrology laboratory offering calibration and adjustment services to tyre pressure gauges used in garages and tyre service centres.

Figure 4. Gauges pressure measurement deviations



CONCLUSION AND RECOMMENDATIONS

Conclusion

The study revealed that tyre pressure gauges used in garages and tyre service centres in Kinondoni as a case study did not conform to various metrological aspects. Most of them were not verified or calibrated. Therefore, it is obvious that there is inadequate legal metrological control on tyre inflation pressure gauge used in Dar es Salaam specifically in Kinondoni.

Recommendations

Considering the observation on the tyre inflation pressure gauges, for both users and customers (drivers), a large percentage of the users never attended any training regarding calibration and verification of gauges. Therefore, the regulatory bodies such as Tanzania Bureau of Standards and Weight and Measures Agency require to provide more training and encourage users to participate for increasing their awareness. Since the gauges are currently not subjected to legal control, it will be healthier for the regulatory bodies to at least conduct inspection to check whether they deliver accordingly or with errors for the time being. Nevertheless, driver's awareness on the tyre inflation pressure gauges should be increase by providing them with training so that to monitor the inflated pressure on their tyres during the process rather than using traditional method such as hitting the tyres with spanner to check the inflated pressure. It is also recommended that; the government should encourage the establishment of private calibration laboratories that will be used to carryout calibration and verification activities of metrological equipment.

Also, to combat the importation of fake, counterfeit and substandard gauges it is important for the regulatory authorities such as Tanzania Bureau of Standards (TBS) and Weight and Measures Agency (WMA) to undertake calibration, initial verification as well as inspection at a particular interval of time as presented in the table in appendix 1.

Acknowledgement

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REFERENCES

Alhassan, T., (2011)."The effect of tyre pressure on vehicle performance". (Unpublished thesis): Kwame Nkrumah University of Science and Technology.

Alhassan, T., Andoh, P., Owusu-ansah, P., and Frimpong, J. A., (2014) "Relationship between Vehicle Manufacturers Recommended Tyre Pressure and Tyre Pressure Used by Vehicle Owners". Research Journal of Applied Sciences, Engineering and Technology DOI: 10.19026.

Bawa, S., Sarpong, K. & Larbi,J. (2015). "Monitoring Operational Conditions of Vehicle Tyre Pressure Levels and Tread Depths in Kumasi Metropolis". Journal of Applied Science & Technology. 20 44-49.

European Committee for Standardization (2014). Tyre pressure measuring instruments. Devices for inspection of pressure and/or inflation / deflation of tyres for motor vehicles. Metrology, requirements and testing.

Gillespie, T., (1992). Fundamentals of Vehicle Dynamics. Warrendale: Society of Automotive Engineering.

Hillier, V., & Coombes, (2004). Hillier's Fundamentals of Motor Vehicle Technology (5th Ed).Cheltenham: Nelson Thornes Ltd.

OIML. (1988). "Initial and subsequent verification of measuring instruments and processes". International Document D 20. Paris: OIML.

OIML. (2013). International vocabulary of terms in legal metrology. Paris: OIML.

Ramesh, G., Mallesham, M. & Gangadhar, V. (2015). "Analysis of Effect of Tyre Overload and Inflation Pressure on Rolling Loss in Cars ". International Journal of Engineering Research and Applications.5(8) 01-08.

Reed, P. & Reid, V. (2000). Motor Vehicle Technology for Mechanics London: Macmillan.

Reimpell, J. & Stoll H. (1996). The Automotive Chassis: Engineering Principles. 2nd ed., London: Arnold.

Sekaran, U (2003). Research Methods for Business. A skill Building Approach (4th Ed).New York: John Wiley.

URT. (1982). The Weights and Measures Act Cap 340.

Varghese, A. (2013). "Influence of Tyre Inflation Pressure on Fuel Consumption, Vehicle Handling and Ride Quality". (Unpublished Thesis): Chalmers University of Technology.

Yamane,T (1967). Statistics, an Introductory Analysis, 2nd Ed., New York: Harper and Row.

Appendix 1: The Summary of Proposed Practice for Metrological Control of Tyre Pressure Gauge
S/No Actions Purpose When Responsible

Appendix 1: *The Summary of Proposed Practice for Metrological Control of Tyre Pressure Gauge*

S/No	Actions	Purpose	When	Responsible
1	Submission of valid documents related to type approval to WMA	Assuring that a gauge conforms to requirements and that it is adequate for use	Before importation or manufacturing	Importer or manufacturer of tyre pressure gauge
2	Initial verification	Assessment of conformity to type	Upon arrival	Importer or manufacturer of tyre pressure gauge
3	Annual calibration and adjustment	Maintaining the accuracy of tyre pressure gauges	At interval not exceeding 12 months	WMA or Any accredited laboratory
4	Inspection	Metrological supervision.	Regularly	WMA