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The importance of metrology for quality control in a metal stopper factory in the City of Manaus, AM

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Abstract*— *Companies that aim to participate in the current global market face several challenges, such as, agility, productivity, quality of their products or services, innovation and flexibility. However, in order to meet all these requirements, it is essential that these organizations invest in standardization, quality and define an efficient metrological base capable of obtaining accurate information and that assist in the decision making process based on calibrations, samples and tests. The present research has as general objective to evaluate the importance of the applicability of metrology in the quality control of a factory of metallic stoppers located in the City of Manaus. The applied methodology consists of a bibliographic research complemented by a case study in the focus company. The basis of any production process that aims for quality is rooted in metrology, without it is not possible to ensure that that product is within the specified. So in every company that seeks quality products, it is necessary to implement metrology management to show how quality can be achieved through this tool. The metal stopper factory has periodic calibration guidelines in the factory, it has instruments and measurement systems that certify the uncertainties inherent in metrological processes, ensuring the process of traceability of measurements, using corrections to reduce errors, generating improvements in the quality of results which consequently leads to increased confidence in the actions and decisions taken.

Keywords*— *Calibration, Measurement, Test, Sample.

I. INTRODUCTION

The implementation and knowledge of Metrology in Brazil is still recent, as it is only now being observed the importance in the country's development, in which Metrology has a strategic role in supporting the competitiveness of the national productive sector as well as in the health, environment, security and defense of Brazil [1].

From this point of view, Metrology is presented as a fundamental support for technological growth and innovation, promoting competitiveness and creating an environment favorable to industrial and scientific development throughout the country [2].

Metrology is the science of measurement, whose main foundation is to promote reliability, credibility, universality and quality in measurements. It is known that measurements are present, directly or indirectly, in practically all industrial production processes of decision making, making metrology immense and involving industry, commerce, health, safety and the environment. [1].

CONMETRO - National Council for Metrology, Standardization and Industrial Quality reported in the document of strategic guidelines for Brazilian metrology in 2012 that an estimated 4 to 6% of the national GDP of industrialized countries are the most dedicated to measurement processes, since it is a science that encompasses theoretical and practical aspects related to measurement, ensuring that quality control is present in all stages of manufacturing a product. Because through metrology it is possible to gain confidence from those who sell and those who buy the product, because its essence is to guarantee the accuracy of the production processes [3].

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It is notable that the Brazilian industry is currently growing consistently, addressing greater volume and higher quality of its products and services, so it is necessary that companies are increasingly prepared to deliver quality products to their customers. So, for the cork stopper it is no different, so for that it uses metrology as a way to benefit to reduce costs with jobs and rework and helps to maintain the quality of its products, thus adding credibility to its customers and partners.

This work has as general objective to clarify on the applicability of metrology in the quality control of a factory of metallic stoppers. With specific objectives to report on the importance of metrology for quality control and present the main advantages of metrology for the factory of metallic stoppers.

Due to globalization, in the last thirty years, standardization has become part of various aspects of human routines, facilitating the commercial and technical exchange that is sought to meet the needs of the current economic scenario to which the global industry finds itself [4].

The concepts of measurement and metrology have a similar relationship. However, the concept of measurement has been rooted in culture since the dawn of civilization. Being considered the connection between the universe of abstract concepts and the universe of empirical phenomena. For this reason, measurement consists of the fundamentals of knowledge through experimental results [5].

According to LIRA (2002, p. 3), metrology has its origin since the oldest trades, where instruments were used as exchange currencies:

In some ways, small changes have been made from those times to the present day, except that today's coins are rarely gold. In the past, as now, sellers and buyers should agree with the exchange units. But, unlike the old days, in which the fluctuation between exchange rates and unit of measurement values occurred entirely without any criteria or standardization, today there is agreement about a stable system of units of measurement that is recognized worldwide [6].

Historically, the first governmental action in the area of metrology was the adoption by Brazil, through a decree of D. Pedro II, of the decimal metric system created by the Metro Convention, signed in 1875. Another relevant record of government participation in the field of metrology, normalization and quality was the creation, in 1921, of the Experimental Fuel and Mineral Station in Rio de Janeiro. At that same time, in São Paulo, the Materials Testing Laboratory of the Polytechnic School of Engineering was created. It should be noted that the attention of both initiatives was focused on testing imported products [7].

Although ABNT was founded on the initiative of government agencies, the facts that culminated in its creation, and in its performance, are due more to the isolated actions of the scientists and technicians that made it up than to the deliberate action of the Brazilian State. Institutionally, the existing metrology framework at INT and standardization at ABNT was maintained until the formation of the National Institute of Weights and Measures (INPM), with Law No. 4048, of December 29, 1961, which regulated the creation of the Ministry of Industry and Trade (MIC). In this act, the Metrology Division and the Metrology Commission of INT, whose competences passed to INPM [8], were extinguished.

The National Institute of Weights and Measures (INPM) was founded in the mid-1960s with the responsibility to act in everything that involved the standardization of measurement systems, making its activities and competences extremely unique, and for the creation of a government organization involving broader skills. After Brazil went through its economic development, the institute was replaced and its activities passed to the National Institute of Metrology, Quality and Technology (INMETRO), which also became responsible for technical standardization and the standardization of industrial quality, INMETRO remains in this role today [8].

Companies that intend to participate in the globalized market must face many challenges, among them, product quality, agility, flexibility and capacity for innovation. In order for these requirements to be met, it is necessary to invest in standardization, quality and in the establishment of a metrological base capable of transforming samples, calibrations, and tests into reliable information for the decision-making process [9].

Its focus is to guarantee the credibility, reliability, quality of measurements and their universality. Because of this, it is possible to guarantee that metrology has a broader scope than expected, considering that directly or indirectly and in basically all decision-making processes involve this factor. According to the author, 4 to 6% of the national GDP of industrialized countries is directed to the measurement and calibration processes [10].

Decisions are exemplified by the release of a production batch after an approval test or trial; the outcome related to the causes of a problem with an impact on quality, after a study involving tests and measurements planned for evaluation according to statistical techniques;

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a failed batch after an inspection; a product approved in search of certification by an external body after an audit.

Among the procedures directly related to industrial metrology, there is quality control. Where all products need to absolutely comply with the parameters and specifications required for the project, in order to comply with the quality of the functions for which they were designed [1].

The result will not be complete and, consequently, the measurement will not have acceptable reliability, if it is not associated with the indications about the values that can certainly be measured, that is, associating the uncertainty with the measurement results. This uncertainty added to the result gives a qualitative idea for the measurement, since it is not possible to establish a true value of a measurement due to the absence of good conditions for measurement. Imperfections in instruments and measurement systems, conditions related to the environment (temperature, vibrations, noise, humidity, pressure, etc.) and errors caused by handling the instrument or method applied to achieve the measurement that impact the measurement result and that influence uncertainty, impacting the measurement reliability [1].

II. MATERIALS AND METHODS

The present research took place through bibliographic research where its base is developed using material already elaborated, as of books and scientific articles, referring to the theme and the research problem, through theoretical presentation referring to the themes related to the history and concept about the themes addressed [11].

To complement the work, a descriptive research was used, where according to Prodanov and De Freitas (2013), the researcher's role is to record and describe the facts observed without interfering with what is being observed [12]. This research model seeks to describe the characteristics of a given population or phenomena, or even to establish a relationship between variables, which can be carried out through questionnaires and systematic observations.

The analyzed data are considered qualitative because it is characterized in the qualification of collected data, during the identification of the problem. The research project will take place through a case study, defined as an empirical investigation focusing on the contemporary phenomenon, based on the early development of theories to conduct data collection and analysis [11].

The company chosen to carry out this project is Ambev - Brewery from the Amazon Metal Stoppers unit, located at Avenue Constantino Nery, 2575, Flores.

The foundation of AmBev - Company de Drinks of the Americas took place on July 1, 1999, after the merger of the two largest Brazilian companies in the sector: Company Antarctica Paulista and Company Brewery Brahma. The main objective was to create a global Brazilian company, strong enough to compete in the international market.

With activities in 18 countries on the American continent, the brewery remains a leader in the Latin American beer sector. Being created in 1999, with the union of the Brahma and Antarctica breweries, a member of the Anheuser-Busch InBev group (AB InBev). Its enterprise is based on the production and sale of beers, soft drinks and non-alcoholic and non-carbonated drinks. Its main Brazilian brands are Skol, Antarctica, Brahma, Original, Bohemia and Guarana Antarctica, and in other countries the main brands are Pilsen, Labatt Blue, Quilmes, President, Paceña, Alexander Keith's and Kokanee. The company is also a major independent bottler for PepsiCo. Responsible for the production, sale and distribution in Brazil and other Latin American countries, brands such as Pepsi, Lipton Ice Tea, H2OH!, and the isotonic Gatorade under license from PepsiCo (AMBEV, 2018).

III. RESULTS AND DISCUSSION

Metrology, when inserted in the context of the production process, is responsible for monitoring and controlling the variables and attributes of products, it has the function of stimulating production with quality, acting in the process, giving conditions for companies to be increasingly competitive in the business world, attributing to the products better added value and quality of consumption in the market.

Metrology adds benefits to production systems, as it is possible to reduce labor and rework costs and directly influence the quality of products and services, in addition to adding credibility to the companies that adopt them. In the metrology systems of companies specifically, it is very common to see the application of calibration and the evaluation of uncertainty, thus guaranteeing the quality of the instruments and standards of the production process [1].

Metrological reliability of measurement systems is the main motivation for carrying out calibrations, as it is possible to acquire benefits everywhere. For the final

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customer who consumes the product, for the one who produces and controls and, mainly, for the economy more generally. The lack of calibration can result in immeasurable losses in products, processes, services and in the image of the company, because without calibration the loss can occur both on the part of the supplier and on the part of the product buyer [12].

Metrology is the physical basis of quality control, as it is fundamental for the competitiveness of industries and technological development in the country, not being the work of chance that makes the most developed countries in the world invest in metrological operations, being the elements that impact the company's competitiveness, quality, metrology and productivity.

Thus, it is noted that metrology is exactly linked to quality, as it contributes to companies having a well-defined process, paying attention to quality standards, regardless of the area. In addition, metrology is linked to the practice of continuous improvement as it leads those involved to pay more attention to details and seek new ways to improve their process.

The company in question is fully committed to fully meet all the specifications of its products at each stage of production until the final product, and for that purpose it defines a process control system using statistical tools necessary for monitoring and checking process capabilities. For that, it has a data policy, in which it informs that the responsibility of all the members of the teams that produce, analyze and report data is responsible. Reliable and accurate documentation is critical and eliminates any possibility of erroneous data.

It was verified that the meters are classified as follows: a) Product - involved in direct or indirect measurement or evaluation of the product. Meters that measure weights, dimensions etc. or evaluate the visual aspects of the product would be classified as product meters. b) Process - involved in the measurement of the process associated with the production of the product used in the measurement checks. This can include pH meters, special pressure or temperature meters, etc. c) Others - offline meters not directly involved with the production or process. An example would be the tool room gauges.

When a meter control measurement exceeds the specified limits (control limits, specifications, etc.) it is a must to carry out a documented reaction plan to address the root cause of the problem. It is not acceptable to double check the meter, unless an exception is specifically granted for the quality of the zone - the plant must retain the exception. The root cause and corrective action must be documented electronically or via the system. In all cases, this information must be easily accessible. In the event that the meter is outside the acceptable measurement range, all products produced since the last acceptable measurement check will be considered suspect. Containment (blocking) of this product and appropriate disposal activities must take place.

All meters must have procedures that document the proper use, sample size and calibration / control frequency, as well as reaction plans and containment potential, if the meter is not working properly, called a service standard. All team members who use the meter must be formally trained in the use of the meter by plant policies associated with the training.

The new meters must have a formal study of measurement performance before using in production. Depending on the meter, it can be a potential, short or long term study, or a combination of these studies. The results of these studies will be published and retained in accordance with document management policies. Primary meters should be maintained / serviced / certified periodically, as appropriate. The frequency should be based on the supplier's recommendations as well as the risk assessment.

In this company it was observed that all areas have a secure, controlled and traceable data management system. Non-compliant results are recorded immediately upon identification. If the process is corrected, the results after corrective measures will also be recorded and they all impact on performance indicators (KPIs), non-compliant items must be justified by the operation and have provision by the Supervision, to discover the root cause of the problem.

The reliability of the data management system must be guaranteed, as it is the basis of any analysis to control the process. Reliable data cannot be repeated all the time (for example, data repeated within the specification limit) or have records at fixed times. The use of statistical tools requires valid data, depending on adherence to this policy. Make sure the data makes sense.

Calibration must be performed on all critical equipment according to the list of metrological plans (attached in this standard), which is updated periodically by the metrology specialist at ZBS.

The calibration points must be defined according to the equipment's process range. The process range must be acquired via PTP (inside the PTP there are the upper and lower process ranges specified by the types of products manufactured). If it is not possible via PTP, the equipment's process must be monitored, and its lower and

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upper range measured together with the equipment operator.

The calibration points must be created as follows: point 1: 20% below the lower limit of the process range; point 2: lower limit of the process range; point 3: middle of the process range; point 4: upper limit of the process range; point 5: 20% above the upper limit of the process range. When a device has only one point to be calibrated, the same calibration point must be entered 3 times. When an equipment has only 3 points to be calibrated, only points 1, 3 and 5 apply. The associated standard instrument must always be from the same unit of measurement as the equipment, for its correct calibration.

The calibration must be performed as follows: The instrumentalist receives the Maintenance Order, verifies which points should be calibrated, and already performs the LEP (Permissible Error Limit) calculation to assist him in the field calibration time. . In the field, you should check the physical condition of the equipment, request the area to perform the calibration. Remove the equipment and check if it is possible to perform the mesh calibration. It is necessary to check if the measurements of the points are within the LEP, if not, it is necessary to make an adjustment on the field instrument and, once the adjustment is made, make a calibration again and note the points.

The diffusion of scientific metrology occurs through RBC, consisting of a chair of approximately 500 laboratories registered and qualified by INMETRO. One of the ramifications of this area is Legal Metrology, responsible for meeting legal, administrative and technical requirements for measurement units, measuring instruments and material measures. It has a purpose in commercial transactions, where measurements are indispensable for the prospects of accuracy [1]

The author adds that the technical regulations and laws are enacted by the government that direct the activities of legal metrology, especially with regard to the metrological aspects of the instruments that involve these operations. The structuring of this regulation is based on the guidelines of the International Organization for Legal Metrology (OIML) and counts on the assistance of those responsible for the manufacture of instruments and consumers [1].

Metrology confidence encompasses numerous steps, such as: correct parameters of measuring instruments, statistical control, training and awareness of those involved in the activity, traceability of measurements and control of these instruments. Because of their importance, the organizations responsible for national and international standardization, such as: INMETRO, International Organization for Standardization - ISO, International Electrotechnical Commission - IEC, Brazilian Association of Technical Standards - ABNT, using specific standards (such as: NBR ISO 9001, ISO 17025, NBR ISO 10012 and NR-13) metrological quality management being a prerequisite for the recognition of the quality of processes and Certification of the Quality System [9].

In this way, the production systems benefit from metrological management systems, reducing costs with any necessary rework, in addition to the benefits with a direct impact on the quality of services provided and products, adding credibility to the process and image of the organization that adopt this tool . Specific points such as calibration and uncertainty assessment provide the quality of metrology applied to instruments and the production process [1]

Therefore, one must take into account the calibration history of the measurement medium, as well as the standard used in the last calibration of the same. Regarding the technical point of view, the result will be better in proportion to the reduction in the uncertainty of the calibration standard. However, when the standard's uncertainty decreases, the cost increases. A technical economic balance is then sought for the situation. The ideal is to seek a condition in which the standard has an uncertainty of one tenth of the uncertainty of the medium to be calibrated. It is necessary to highlight that this ideal point changes depending on the measurement system that will be calibrated. It is acceptable that in a calibration, this uncertainty is at least one third of the medium to be calibrated [14].

IV. CONCLUSION

Through metrology, the complete evaluation of new products is carried out before they are placed on the market. It is also important in the evaluation of processes and measuring instruments, in order to ensure that equipment makes the correct measurements of products. Thus, one of the great benefits is the standardization of measurement methods and the maintenance of the precision and accuracy of these methods. Metrology processes, when efficient and effective, lead to the minimization of inspection costs. They also contribute to reducing the cost of tailings and rework, using statistical quality control techniques.

Metrology is at the root of every production process that seeks quality, without it it is not possible to ensure that that product is within the specified. So in every company that seeks quality products, a metrological verification

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system is needed to show how quality can be achieved. Metrological proof or reliability of measurements is only achieved through Calibration and Traceability.

The metal stopper factory has periodic calibration guidelines at the factory, it has measurement instruments and systems that ensure the uncertainties required in metrological processes, ensuring the traceability of measurements, reducing errors through corrections, generating improvements in the quality of results, increasing the reliability of actions and decisions.

As the consumer market is more and more demanding, it was necessary for this factory in Manaus to adapt to what is required, because this way it can implement processes of proven quality to be qualified as a supplier to many other companies and also to enjoy the advantage of having processes quality and remain with a reliable and ethical image of your product in the market.

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