Machine for development impact tests in sports seats and similar

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Abstract. This paper describes the stages of development of a machine to perform impact tests in sport seats, seats for spectators and multiple seats. This includes reviews and recommendations for testing laboratories that have needs similar to the laboratory where unfolded this process. The machine was originally developed seeking to meet certain impact tests in accordance with the NBR15925 standards; 15878 and 16031. The process initially included the study of the rules and the election of the tests for which the machine could be developed and yet all reports and outcome of interaction with service providers and raw materials. For operating facility, it was necessary to set entirely the machine control, which included the concept of dialogue with operator, the design of the menu screens and the procedures for submission and registration of results. To ensure reliability in the process, the machine has been successfully calibrated according to the requirements of the Brazilian network of calibration. The criticism to this enterprise covers the technical and economic aspects involved and points out the main obstacles that were needed to overcome.

1. Introduction
This work originated from the chance that the test laboratory Rhodes [1] faced, in search of sporting seats certification for supply to football stadiums for the 2014 World Cup to be held in Brazil. The big challenge was started from the study and thorough interpretation of the standards to be used. To go deeper in the interpretation of these standards, we participate with the Technical Committee CB-15 ABNT-Brazilian Association of technical standards. Through this study it was possible to reconcile the development of a same equipment with ability to perform impact tests and meet the requirements of standards NBR15925-plastic Furniture for sporting events [2], NBR15878-Seats for spectators [3] and NBR16031 – multiple Seats [4]. The equipment has earned the designation of MT-006-impact Testing machine. This equipment underwent a severe assessment regarding the attendance of the requirements laid down by the impact of the standards tests. During and after construction, the non-conformities identified are analyzed with the objective of guaranteeing quality and reliability in the results of tests conducted there. The following sections describe various aspects of the development of this equipment, establish their potential, operating facility, types of tests and the economic aspects of the project and summary at the end, what was achieved for this experience.
2. Development of the machine

2.1 Basic and accessory Structures

To meet the requirements of the tests proposed by NBR15925 standards, 15878 16031, equipment and passed initially by a dimensional analysis. Mechanical devices have been created to ensure the positioning and the application of loads on specific points of the specimens to be tested. Accessories have been developed called the standards as "impact test device of the seat and pendulum of impact". They are used for the application of loads during the test. According to the rules, these accessories must meet the dimensional criteria for the specific mass and must be calibrated. Figures 1 and 2 show the impact devices.

![Figure 1. a) Device to impact seat test.](image1)

a) Device for seat impact test – circular body, with 200 mm diameter, separated from the impact plan by coil springs and free to move in a line perpendicular to the plane of the central area of impact. The body and the associated parties with the exception of the springs must be fitted with a mass of 17 kg ± 0, 1 kg and all appliances including the mass and the impact surface shall have a mass of 25 kg ± 0, 1 kg. See Figure 3.

![Figure 2. b) Pendulum impact.](image2)
b) Pendulum impact - cylindrical object having mass ± 6,5kg 0,07kg, supported by one pin through a steel tube 38mm ± 2mm diameter and 2mm wall thickness. The distance between the pin and the center of gravity of the pendulum must be 1 m. The pendulum has on its end a 50IRHD rubber with a radius of 67mm. See Figures 4 and 5.

**Figure 3.** Impact on the seat.

**Figure 4.** Impact on the backrest.
2.2 Electropneumatic System

The electro pneumatic command of this equipment was achieved through joint work with suppliers of equipment for industrial automation. Automatron Industrial Technology companies [5] and Festo Automation Ltda. [6] had important performance in this step. The equipment is controlled by a PLC-Programmable logic controller, see Figure 6. The operation is semi-automatic equipment, must be initialized via operator. Data such as number of cycles, height of drop, drop angle of impact device and pendulum, can be viewed through the HMI-Human machine Interface and can be parameterized and initialized according to the types of tests and requirements, this configuration can be seen in Figure 7.
In order to use the device to impact test of the seat, there is a valve for pneumatic actuation of control ascent and descent of two-cylinder actuators. With the aid of electromagnet, this system allows you to trigger the device up and down. The course or free fall height of the impact device on the seat are capable of programming and controlled by means of sensors, see Figure 8.

The pendulum of impact is driven by a stepper motor coupled to a clutch by means of two gears and transmission chain, as shown in Figure 9. This setting allows the command of appropriate tilt angle and free fall of the pendulum, in addition to meeting the values established by the standards.
The figures 10 and 11 allow better understand the design philosophy that guided this intervention, and the results that were obtained here. Figure 10 highlights the buttonhole that is provided with the Programmable Logic Control which was adopted. As you can see, it includes, in a certain standard format, texture and color, a conventional numeric keypad to ten digits, data entry keys and return, and directional navigation keys to two orthogonal axes. According to a consistent pattern, but in a different color, there is another field with six function keys. The held programming can be seen in the PLC screen that allows you to track the entry of all data provided.
This command arrangement complies with current regulations in the literature, understood in Ergonomics, based on principles that seek the efficiency and safety in operation, and the minimum wear of the operator [7]. Correspondingly, the construction of the dialogue to be established between the machine and the operator as well as their presentation on the screen, should be based on ergonomic principles, which are also regulated by international technical standards [8, 9]. The names used for the measuring, their acronyms, and the sequence of presentation of grandeur were chosen in order to optimize the operation. With the same goal, were exploited the presentation graphics capabilities of the system screens offered.

As well as in Figure 11, the remaining arrangements for the presentation of Visual information always were prepared in order to provide clarity, ease of interpretation and cognitive reference comfortable. An evaluation of these results, made by skilled technician, indicated that they are perfectly in line with the recommendations of contemporary literature, and even more robustly established principles, such as those of the Gestalt theory [10].

3. Technical and operational data of test equipment

The following is a description of the technical characteristics of the machine after built for purposes of evaluation of the results of the project:

This is an outfit usually called impact Testing machine, dedicated to tests of sports seats, seats for spectators, multiple seats and their similar ones. Is a semi-automatic equipment, with supply voltage of 220Vac, 60 Hz frequency, power consumption 120W. She is endowed with a processor "Dakol V12022T38" (registered trademarks here eventually cited are the property of their legal owners).

The testing machine was calibrated as to its characteristics liable to calibration. The certificate was issued by [11] calibration laboratory accredited by the general coordination of Accreditation which is the Brazilian Government authority that provides accreditation in accordance with norm NBR ISO/IEC17025-General requirements for the competence of testing and calibration laboratories [12].

The equipment is capable of performing the tests whose descriptions follow below. These descriptions were transcribed or summarized technical norms NBR 15925, 15878 and 16031 already mentioned.

Impact tests of seat:
Are tests that evaluate the ability of the body-of-proof resist the freefall of impact of 25 ± 0, 1 kg at a height of 300 mm on the seat for 10 cycles.

Impact tests on the backrest:
Are tests that evaluate the ability of the body-of-proof resist the free fall of the pendulum of impact of 6, 5 kg ± 0, 07kg at a height of 620 mm or 68° angle on the outer rear edge of the backrest for 10 cycles.
An important feature of the system logic is highlighted below. The tests can be selected in programmed screen by pressing F4 = MENU, which belongs to the human machine interface already mentioned earlier. However, they cannot be changed during execution, once the program is inserted into the internal memory of the PLC (Programmable logic controller) is password protected. Therefore the operator has access only to the functions of start, finish and pause the test. This feature addresses explicitly the requirements of NBR ISO/IEC 17025 already mentioned in the chapter in which this standard deals with the integrity of data collected or handled by computerized systems. Generally, this feature helps ensure reliability test results, and this is an aspect very carefully observed in the process of accreditation of a laboratory.

4. Economic aspects of the project
Beyond the purely technical aspects regarding the report of the development of equipment in order to meet the requirements of the standards, that treated all the previous text, fits make a brief comparison of costs between the scenarios of this development. This analysis is justified, since this whole process if entered in the company's strategic plan Rhodes, manufacturer of components and accessories for the furniture industry, which has, among its goals, the permanent search for the quality. This search has indicated, on the one hand, the desirability of providing the company of an accredited testing laboratory as competent. On the other hand, it was necessary to harmonize this proposal with the availabilities and the company's expectations regarding the economic aspect of the investment.

The numbers shown below allow you to establish comparisons on which to draw a conclusion as to the relevance of the business.

Impact Testing machine:
Enterprise value = $ 48,363 .00
Ability of testing-types = 3 essays
Total value of a battery of 3 external laboratories tests = $ 6,000 .00
Number of tests that have already been carried out in a period of 12 months = 15 essays.
As for the value of the equipment, in a period of one year of tests the numbers indicate a reasonable estimate: the total cost of the project was $ 48,363 .00, therefore, in terms of equity, the balance was positive with return on investment at about $ 41,637 .00 or 86% of the amount invested.
As for the ability to perform tests: the machine is extremely versatile, meets the tests of three technical standards of following furniture. In addition, when it is obtained the accreditation of the laboratory for these tests by the Government authority, the lab will expand greatly its ability to provide compliance testing services to third parties, which may constitute a new source of revenue to the company.

5. Conclusion
This venture has been subjected to a comprehensive initial assessment, focused on basal issue: the need to impose certain rules of procedure in a productive activity, and the results observed as a result of this enforcement [13]. This evaluation indicated that a favorable balance was obtained.
The construction and development of impact test equipment met the requirements established by the rules NBR15925, 15878 and 16031. In addition, allowed the test laboratory Rhodes ease of interrelation with operator trials machine, calibration facility for issuance of the certificate RBC-Brazilian network of calibration.
As previously demonstrated, the project achieved a good result, in terms of return on investment.
Experience has shown the convenience of close cooperation between technical staff from both parties: providers and consumers of laboratory equipment. Also showed that there were gains for both parties, when company executives who participated in the study, as well as review and preparation of technical standards.
Noting also that this work was paramount to meeting deadlines agreed with internal and external clients, reduced cost of tests externally and mainly to guarantee Laboratory's competence in conveying reliability and quality in the results of the tests, giving an essential step to its accreditation by the Government authority, and the resulting benefits which may be derived.
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