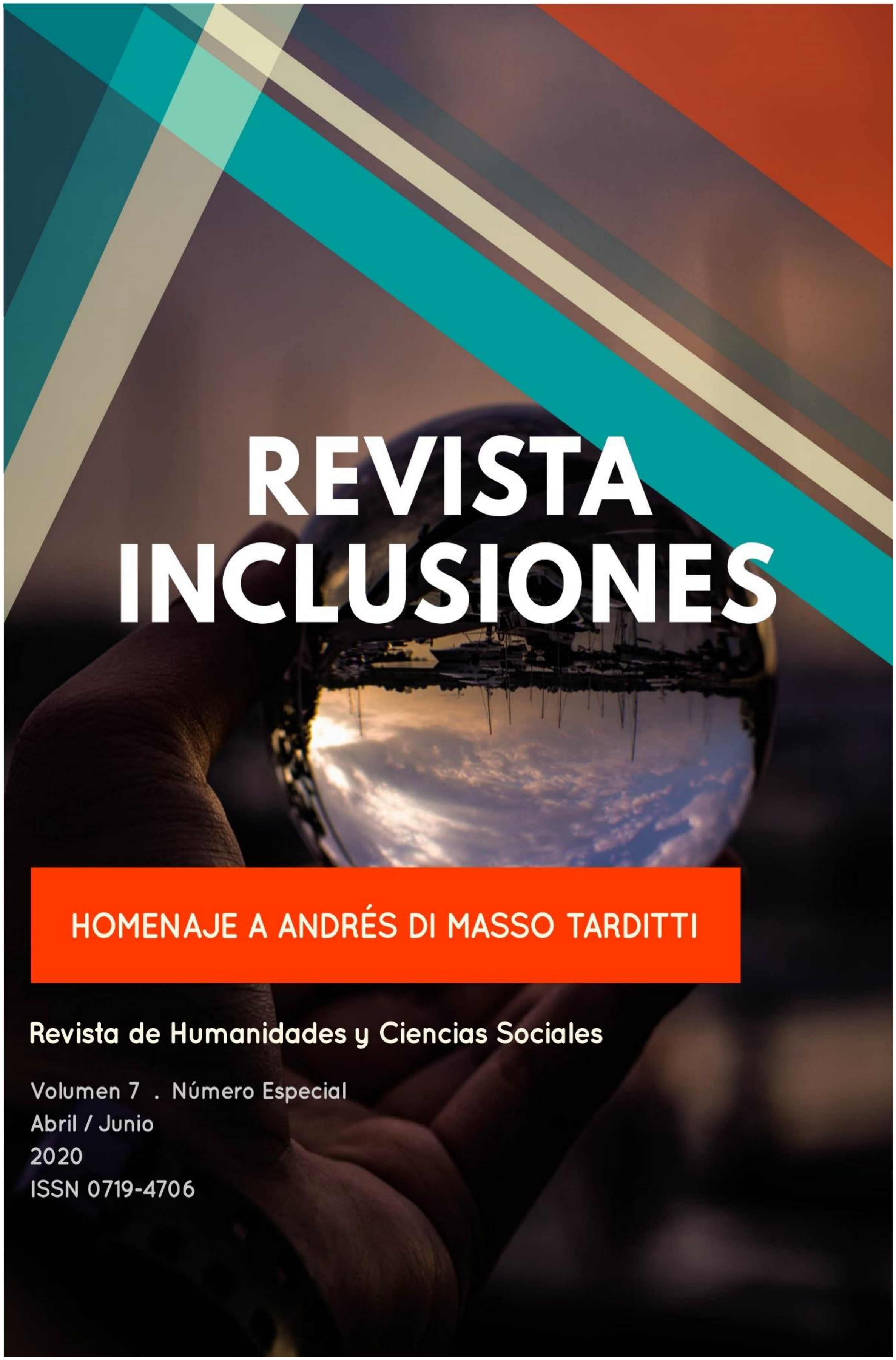

REVISTA INCLUSIONES

HOMENAJE A ANDRÉS DI MASSO TARDITTI

Revista de Humanidades y Ciencias Sociales

Volumen 7 . Número Especial
Abril / Junio
2020
ISSN 0719-4706

Editorial Cuadernos de Sofía
Santiago – Chile
Representante Legal
Juan Guillermo Estay Sepúlveda Editorial

Indización, Repositorios y Bases de Datos Académicas

Revista Inclusiones, se encuentra indizada en:

CATÁLOGO

BIBLIOTECA UNIVERSIDAD DE CONCEPCIÓN

REVISTA INCLUSIONES
REVISTA DE HUMANIDADES Y CIENCIAS SOCIALES

CUADERNOS DE SOFÍA EDITORIAL

ISSN 0719-4706 - Volumen 7 / Número Especial / Abril – Junio 2020 pp. 92-98

STATISTICAL METHODS OF TECHNICAL CONTROL OF PRODUCTION OF GAS TURBINE ENGINES

Ph. D. Tatiana V. Kochergina
Ural State University of Economics, Russian Federation
ORCID: 0000-0002-9042-8128
otdel-98@mail.ru
Ph. D. Maria S. Khokholush
Ural State University of Economics, Russian Federation
ORCID: 0000-0001-6318-6525
sports-hms@usue.ru
Ph. D. Tatiana I. Guseva
Ural State University of Economics, Russian Federation
ORCID: 0000-0003-3942-5519
t.i.guseva@yandex.ru
Ph. D. Maria V. Selezneva
Ural State University of Economics, Russian Federation
ORCID: 0000-0003-3942-5519
mvselezneva@yandex.ru

Fecha de Recepción: 19 de febrero de 2020 – **Fecha Revisión**: 28 de febrero de 2020

Fecha de Aceptación: 22 de marzo de 2020 – **Fecha de Publicación**: 01 de abril de 2020

Abstract

This article is devoted to the organization of technical control at the enterprise of the aviation industry using statistical methods. In the course of the study, the substantiation of the role of instruments for technical control of the quality of products of Aviadetal LLC is being conducted. Based on the conducted research, proposals were developed for improving the technical control toolkit. The purpose of this work is to develop recommendations for improving the organization of technical control using statistical methods.

Key Words

Technical control – Statistical methods – Quality – Gas turbine engines

Para Citar este Artículo:

Kochergina, Tatiana V.; Khokholush, Maria S.; Guseva, Tatiana I. y Selezneva, Maria V. Statistical methods of technical control of production of gas turbine engines. Revista Inclusiones Vol: 7 num Especial (2020): 92-98.

Introduction

Quality assurance includes planned and systematic actions necessary to ensure that the product will meet the specified requirements, and this is achieved by measuring the characteristics of the product to determine its compliance or non-compliance with the specified requirements.

The ISO 9000 standards and the TQM concept envisage a wide application of statistical methods for controlling production processes[1], analyzing their reproducibility, planning and conducting selective control of product quality; collecting, processing and interpreting observational data in order to transform this data into objective information necessary to make informed decisions. All of the above justifies the relevance and significance of the chosen topic.

The aim of the study is to develop recommendations for improving the organization of technical control using statistical methods of gas turbine engines.

In any quality management system, statistical methods of quality control are of particular importance and are among the most progressive methods[2]. Standards and guidelines for the application of statistical methods of quality control are given in the following documents[3].

Methodology

For in-depth analysis of quality control in the production of gas turbine engines, control charts and the histogram method are used. The histogram method is proposed by A. M. Gary in 1833. The histogram is a bar graph and is used to visualize the distribution of specific parameter values by frequency of repetition over a certain period of time (week, month, year). When applied to the graph of permissible parameter values, it is possible to determine how often this parameter falls within the permissible range, shifts within the tolerance or goes beyond its limits[4]. This method allows you to monitor the current process and identify problems to be addressed as a matter of priority. Thanks to the graphical representation of the available quantitative information, one can see patterns that are difficult to distinguish in a simple table with a set of numbers, evaluate problems and find ways to solve them[5]. The collected data serves as a source of information in the analysis process using various statistical methods and the development of measures to improve the quality of processes.

---

[1] I. Guler; M. F. Guillén & J. M. Macpherson, "Global competition, institutions, and the diffusion of organizational practices: The international spread of ISO 9000 quality certificates", Administrative science quarterly, Vol: 47 num 2 (2002): 207-232.

[2] A. Plakhin; R. Kampf; E. Ogorodnikova & A. Kokovikhin, "Localization strategies of the Czech companies on the basis of industrial-logistics parks in the Sverdlovsk region", MATEC Web of Conferences EDP Sciences Vol: 134 (2017).

[3] ISO/TR 10017 Statistical methods. Application Guide in accordance with GOST R ISO 9001; ISO 2859 Statistical methods. Procedures for sampling control on an alternative basis y ISO 3951 Standards, Statistical Methods. Sampling procedures on a quantitative basis.

[4] A. M. Azab, Integrating GIS, Remote Sensing, and Mathematical Modelling for Surface Water Quality Management in Irrigated Watersheds: UNESCO-IHE PhD Thesis. CRC Press. 2012.

[5] Schmeleva, A. N. (2017). Evaluation and improvement of the operating efficiency of enterprise quality management system (QMS): Conceptual bases. Calitatea, num 18 Vol: 160 (2017).

The disadvantages of using the histogram in the quality control process include low efficiency with small samples[6]. The second statistical quality control method was offered in 1924 by Walter Schuhart. A control card is a kind of schedule, but it differs from a regular schedule by the presence of lines, called control borders, or regulation boundaries[7]. These boundaries denote the scatter widths that are formed under normal conditions of the process. If all points of the graph enter the area bounded by the control boundaries, then this shows that the process takes place in relatively stable conditions. And vice versa, the point outflows beyond the regulation limits indicates that the process has gone wrong and it is necessary to take measures for its adjustment[8].

Control charts on a quantitative basis are double cards, one of which represents the change in the average value of the process, and the second variation of the process. The scatter can be calculated based on span ($\bar{R}$-card) or standard deviation ($\bar{X}$-card). Statistical control cards for a qualitative sign are:

1) p-card – a card for the shares of defective items. The proportion of defective items in the sample is calculated. It is used when the volume in the sample is variable.
2) np-card – a card of the number of defective items. The number of defective items in the sample is calculated, applied when the volume in the sample is constant.
3) c-card – a card of the number of defects in the sample. Count the number of defects in the sample.
4) u-card – a card of the number of defects per item. Count the number of defects per item in the sample.

Control charts are used to assess the controllability of the current process. In the case of controllability - an assessment of its reproducibility. In the case of a statistically unmanaged process, conduct a corrective impact process and test the effectiveness of the measures taken. This method is used in conjunction with histograms.

Results

Gas turbine installations were developed on the basis of aircraft engines in the 90s of the 20th century, the range of their use includes gas turbine power plants and gas pumping units. These products are characterized by such quality indicators as reliability, purpose, durability, persistence, ergonomics and maintainability. We present the results of quality control of a batch of flanges 94-05-344 using the method of histograms and control charts. As a material for the manufacture of the workpiece used alloy steel 30HGSA GOST4543-71. Next, use the quality control tool - a histogram. To do this, we process the results of monitoring the size of the hole with a diameter of 30.5 + 0.16 mm using NO 18-50-1 GOST 868-82 with a scale value of 0.01 mm.

The results of the control size of 30.5 + 0.16 mm are shown in table 1.

---

[6] J. Donald, Wheeler. Advanced Topics in Statistical Process Control: The Power of Shewhart's Charts (SPC Press: 1995).
[7] R. V. Binder, “Can a manufacturing quality model work for software?”, IEEE Software, Vol: 14 num 5 (1997): 101-102.
[8] J. C. Bou-Llusar; A. B. Escrig-Tena; V. Roca-Puig & I. Beltrán-Martín, ”An empirical assessment of the EFQM Excellence Model: Evaluation as a TQM framework relative to the MBNQA Model”, Journal of Operations Management, Vol: 27 num 1 (2009): 1-22.

X_i									
30,55	30,60	30,59	30,56	30,59	30,56	30,55	30,56	30,60	30,59
30,59	30,61	30,56	30,60	30,55	30,61	30,60	30,57	30,59	30,55
30,60	30,56	30,61	30,56	30,59	30,60	30,59	30,55	30,61	30,61
30,61	30,60	30,60	30,55	30,61	30,56	30,56	30,59	30,56	30,59
30,55	30,61	30,59	30,59	30,56	30,60	30,55	30,61	30,57	30,61
30,60	30,55	30,60	30,55	30,60	30,59	30,61	30,60	30,55	30,56
30,59	30,56	30,61	30,59	30,55	30,56	30,55	30,61	30,61	30,61
30,56	30,55	30,59	30,56	30,60	30,60	30,56	30,59	30,60	30,55

Table 1
Control results, mm.

Next, the statistical data processing for the construction of the histogram is carried out in accordance with the following procedure, table 2.

Stage name	Calculation formula	Result
1 Determination of arithmetic mean value of the measured value	$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$	$\bar{X} = \frac{2446,54}{80} = 30,58175$ mm
2 Determine the standard deviation σ by the formula	$\sigma = S_x = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n-1}}$	$\sigma = S_x = \sqrt{\frac{0,0416}{79}} = 0,022947380 \approx 0,0229$
3 Estimation of the arithmetic mean S	$S_{\bar{x}} = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n*(n-1)}}$	$S_{\bar{x}} = \sqrt{\frac{0,0416}{80*79}} = 0,002565593 \approx 0,0026$
4 Finding step *h*	$h = (y_n - y_1)/m$, y_n – the last value in the sample; y_1 – the first value in the sample; *m* – the number which is determined by special formulas.	$h = \frac{30,61 - 30,55}{5} = \frac{0,06}{5} = 0,012 \approx 0,01$ mm
5 Defining grouping intervals Δ1, Δ2, Δ3	$\Delta_1 = [y_1; y_1+h]$ $\Delta_2 = [y_1+h; y_1+2h]$ $\Delta_3 = [y_1+2h; y_1+3h]$ $\Delta_4 = [y_1+3h; y_1+4h]$ $\Delta_5 = [y_1+4h; y_1+5h]$	Δ_1 = [30,55; 30,56] Δ_2 = [30,56; 30,57] Δ_3 = [30,57; 30,59] Δ_4 = [30,59; 30,60] Δ_5 = [30,60; 30,61]
6 Counting numbers of indicators n_k measurement results of each grouping interval		n_{k1}=15; n_{k2}=16; n_{k3}=18; n_{k4}=16; n_{k5}=15
7 Calculation of the probability of getting the measurement results of each grouping interval	$P_k = \frac{n_k}{n}$	$P_{k1} = \frac{15}{80}$ =0,1875; $P_{k2} = \frac{16}{80}$ =0,2; $P_{k3} = \frac{18}{80}$ =0,225; $P_{k4} = \frac{16}{80}$ =0,2; $P_{k5} = \frac{15}{80}$ =0,1875

Table 2
Stages and results of statistical processing of measurement data

To construct a histogram on the x axis, the interval is plotted in ascending order of numbers, and a rectangle with height Pk is constructed on each interval. The polygon is a broken curve connecting the midpoints of the bases of each column of the histogram (figure 1).

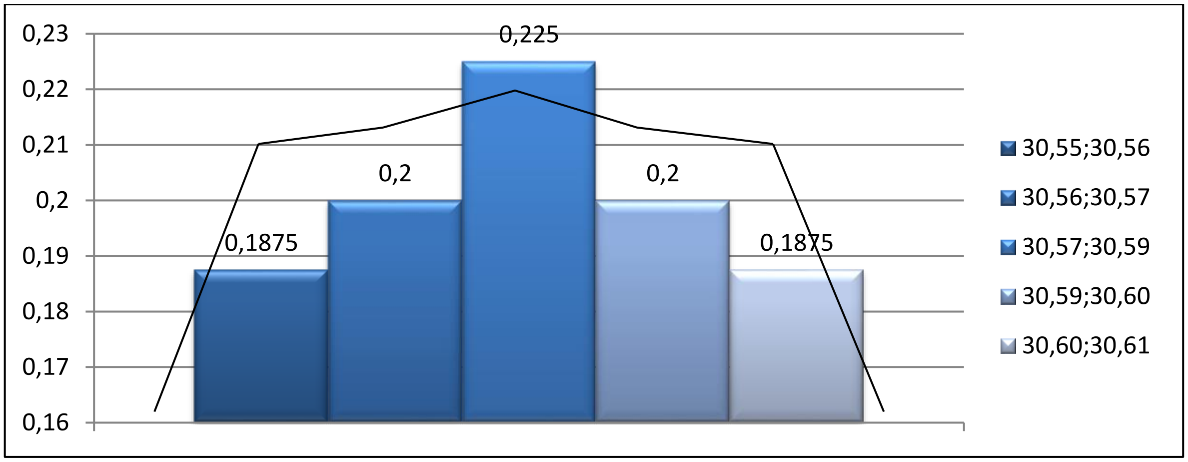

Figure 1
Histogram of probabilities of hitting the measurement results of each grouping interval

As a result of the construction of the histogram, we can conclude that the normal distribution of random error in the sample is normal.

Next, we present the result of the evaluation of the process under study using statistical control charts. Calculation of statistical control cards of the X – R type is made on the basis of the results of the control given in table 3.

I	II	III	IV	V	VI	VII	VIII	IX	X
30,55	30,60	30,59	30,56	30,59	30,56	30,55	30,56	30,60	30,59
30,59	30,61	30,56	30,60	30,55	30,61	30,60	30,57	30,59	30,55
30,60	30,56	30,61	30,56	30,59	30,60	30,59	30,55	30,61	30,61
30,61	30,60	30,60	30,55	30,61	30,56	30,56	30,59	30,56	30,59
30,55	30,61	30,59	30,59	30,56	30,60	30,55	30,61	30,57	30,61
30,60	30,55	30,60	30,55	30,60	30,59	30,61	30,60	30,55	30,56
30,59	30,56	30,61	30,59	30,55	30,56	30,55	30,61	30,61	30,61
30,56	30,55	30,59	30,56	30,60	30,60	30,56	30,59	30,60	30,55
The average span of each sample									
0,06	0,06	0,05	0,06	0,06	0,05	0,06	0,06	0,06	0,06

Table 3
Control results, mm.

Next, statistical data processing is carried out to construct a histogram in accordance with the following procedure, table 4.

Stage name	Calculation formula	Result
1 Process centerline determination	$CL = \bar{R} = \frac{\sum_{i=1}^{n} R_{xi}}{m}$ m – number of samples	$CL = \bar{R} = \frac{0,06+0,06+0,05+0,06+0,06+0,05+0,06+0,06+0,06+0,06}{10} = 0,058$
2 Determination of the upper control limit	$UCL = \bar{X} + A2 * R$	UCL = 1,864 * 0,058 = 0,108112
3 Determination of the lower control limit	$LCL = \bar{X} - A2 * R$	LCL = 0,136 * 0,058 = 0,007888

Table 4
Stages and results of building a control card

A graphic image of the control card in scope is shown in figure 2.

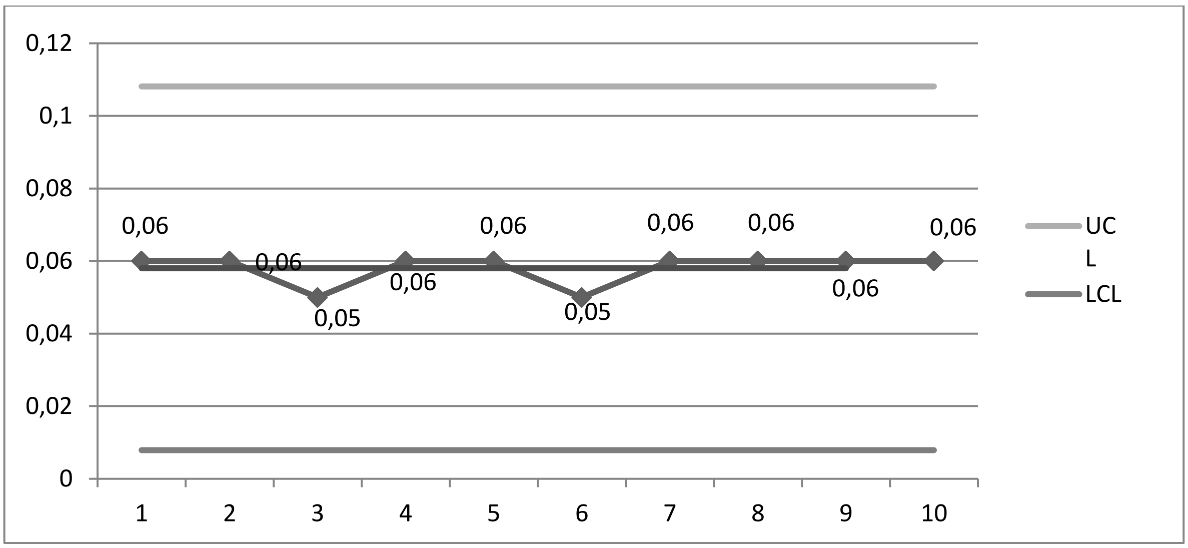

Figure 2
Graphic image of the span chart

The view of the scope control card indicates the stability of the technological process, since the points do not go beyond the limits of regulation.

The study analyzed the quality control of gas turbine engine parts using a histogram and control charts. The use of these tools on the example of a flange showed that the distribution of the sample on the histogram polygon is normal - this indicates that the quality of the batch is in a satisfactory condition. The values in the control card scope are within acceptable limits - this indicates the stability of the process.

Bibliografía

Azab, A. M. Integrating GIS, Remote Sensing, and Mathematical Modelling for Surface Water Quality Management in Irrigated Watersheds: UNESCO-IHE PhD Thesis. CRC Press. 2012.

Binder, R. V. "Can a manufacturing quality model work for software?". IEEE Software, Vol: 14 num 5 (1997): 101-102.

Bou-Llusar, J. C.; Escrig-Tena, A. B.; Roca-Puig, V. & Beltrán-Martín, I. "An empirical assessment of the EFQM Excellence Model: Evaluation as a TQM framework relative to the MBNQA Model". Journal of Operations Management, Vol: 27 num 1 (2009): 1-22.

Donald J. Wheeler. Advanced Topics in Statistical Process Control: The Power of Shewhart's Charts. SPC Press: 1995.

Guler, I.; Guillén, M. F. & Macpherson, J. M. "Global competition, institutions, and the diffusion of organizational practices: The international spread of ISO 9000 quality certificates". Administrative science quarterly, Vol: 47 num 2 (2002): 207-232.

ISO/TR 10017 Statistical methods. Application Guide in accordance with GOST R ISO 9001

ISO 2859 Statistical methods. Procedures for sampling control on an alternative basis

ISO 3951 Standards, Statistical Methods. Sampling procedures on a quantitative basis

Plakhin, A.; Kampf, R.; Ogorodnikova, E. & Kokovikhin, A. "Localization strategies of the Czech companies on the basis of industrial-logistics parks in the Sverdlovsk región". MATEC Web of Conferences EDP Sciences. Vol: 134 (2017).

Schmeleva, A. N. "Evaluation and improvement of the operating efficiency of enterprise quality management system (QMS): Conceptual bases". Calitatea, num 18 Vol: 160. (2017).

CUADERNOS DE SOFÍA
EDITORIAL