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# DETERMINING THE TOTAL DISPERSION ZONE FOR MICROMETER $S_M$ MEASURING EQUIPMENT

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## Abstract

*The aim of the total dispersion zone for measuring equipment $S_M$ is to define if three workers A, B, C can achieve the same values of measurement using the same measuring equipment. Before estimating the total dispersion zone for measuring equipment $S_{M.}$ the calibration of the micrometer was carried out. The values were obtained by measuring the width of clip anchor. It is necessary to calculate the average values $\overline{X}_A, \overline{X}_B, \overline{X}_C$ and to calculate standard deviations $s_{\Delta A}, s_{\Delta B}, s_{\Delta C}$ for three workers. Finally, the total dispersion zone $S_M$ will be calculated and the results will be interpreted.*

## Key words

*measuring equipment, average value, standard deviation, dispersion zone*

## Introduction

Requirements for quality have been lately widened to such a degree where they become a significant factor in company management. To manufacture some quality products, it is necessary to detect not just the capability of processes or the production facilities but also the capability of the measuring equipment.

The aim was to prove the capability of a micrometer and to meet the given requirement for the measuring system of the pressing process.

The capability of measuring equipment predicates of the operational capability of measuring tools and considers also the influence of the operators and the place of use [1].

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***The functionality of measuring tools is expressed by indexes $C_{gm}$ and $C_{gmk}$***

- Index $C_{gm}$ is the ratio 0.2 x sign tolerance $T$ to six times of standard deviation repeated measurements $s_{w}$.,
- Index $C_{gmk}$ is the ratio 0.1 x sign tolerance $T$ to three times of standard deviation $s_w$ , taking into account the position $\overline{X}_a$ measured by the tools.

*Implementation:*

The examination of measuring tools has to be done on the assumed place of use. Before the examination, it is necessary to calibrate the measuring tools. Normally the measurement has to be performed in the same place and the same position. At least 25 repeated measurements have to be done; the values are recorded in a form.

***Defining the total dispersion of measuring tools $S_M$***

*Procedure:*

Before the examination, the operator has to calibrate the measuring tools. Ten serial manufactured products, which have to be numbered, and measured twice, in the same order and place like before, have to be used. The measurement will be done by the operator A; 10 equivalent products will be measured by operators B and C. Values are recorded in the form. The differences between lines 1 and 2 will be calculated.

## Materials and methods

As requested by MEVIS Slovakia s.r.o., Insize micrometer was used for total dispersion zone of measuring equipment $S_{M,}$. The monitored feature – the width of the clip anchor with dimensions 7.5 ± 0.2 mm – was measured using this measurement tool. Three workers conducted the measurements, each of them measured 10 products, while the measurement was conducted twice.

Identification of measuring tool: Micrometer INSIZE 3104-80
Range of measuring tool: 50 - 80 mm
Product name: LEGRAND
Measured feature: width of handles
Feature value: 7.500 mm
Tolerance: USL = 7.700 mm
LSL = 7.300 mm
Real value: Xr = 7.500 mm
Operating staff: 3 workers
The amount of measured products: 10.

Before starting the examination of total scatter $S_M$ it is necessary to prove the capability using the index $C_{gmk,}$ the value of which has to be $C_{gmk} \geq 1.33$ [3]. If the index $C_{gmk} < 1.33$; afterwards will be proposed corrective measures, which will eliminate the cause of the detected non-compliance or other unwanted situations (changes in the surrounding temperature, adjust production equipment, collection of products, used material, human factor…).

$$C_{gm} = \frac{0.2.T}{6.s_w} \tag{1}$$

$C_{gmk}$ = lower value from

$$C_{gmk} = \frac{(X_r + 0.1.T) - \overline{X}_a}{3.s_w} \tag{2}$$

or

$$C_{gmk} = \frac{\overline{X}_a - (X_r - 0.1.T)}{3.s_w} \ , \tag{3}$$

where: $s_W$ - standard deviation,
$\overline{X}_a$ - average value,
$X_r$ - conventional true value,
$T$ - sign tolerance.

***Evaluation according to the methods s***

Average values $\overline{X}_A, \overline{X}_B, \overline{X}_C$ and standard anomalies $s_{\Delta A}, s_{\Delta B}, s_{\Delta C}$ for each operator will be calculated.

*Total scatter area $S_M$ will be calculated as follows:*

- average standard deviation of the measuring device

$$\bar{s}_\Delta = (s_{\Delta A} + s_{\Delta B} + s_{\Delta C}).\left(1/3\right) , \tag{4}$$

$$\bar{s} = \frac{\bar{s}_\Delta}{\sqrt{2}} \ , \tag{5}$$

- standard deviation $s_v$ caused by the operators and calculated from of three average values $\overline{X}_A, \overline{X}_B, \overline{X}_C$
- total scatter zone of the measuring device $S_M$:

$$S_M = \sqrt[6]{\bar{s}^2 + s_v^{\ 2}} \ , \tag{6}$$

$$S_M \% = \frac{S_M}{T}.100 \ , \tag{7}$$

where: T – sign tolerance.

*We regard $S_M$% as follows:*

$S_M$% = 0 to 20 % good.
$S_M$% = 21 to 30 % limited usable.
$S_M$% = more than 30 % unacceptable [2].

EVALUATION OF THE TOTAL DISPERSION ZONE $S_M$ (according to method s)

Table 1

| | | | |
|---|---|---|---|
| **MEVIS SLOVAKIA, s.r.o.** | **Form for evaluation of total dispersion zone $S_M$ (according to method *s*)** | | **Method 2**<br>**Level Nr: 1/1** |
| Nr. of facility<br>M 13458 | Measuring equipment<br>MICROMETER INSIZE 3104-80 | Year of production | |

| **Data about product** | **Data about normal line** | **Data about product** |
|---|---|---|
| Name: Legrand | Name: standard | Cgm: 1.93 |
| Sign: width of clip anchor | Nr: 15 | Cgmk: 1.87 |
| Real value: 7.500 mm | Real value: Xr = 7.500 | Prepared: Kudičová |
| USL = 7.700<br>LSL = 7.300 | | Date: 20.02.2011 |

**Measurement conditions:**

**Measuring data** : **Measure**: mm **Value deviation**:

| **Worker** | **A** | | | **B** | | | **C** | | |
|---|---|---|---|---|---|---|---|---|---|
| Product | Line 1 | Line 2 | (1-2) | Line 1 | Line 2 | (1-2) | Line 1 | Line 2 | (1-2) |
| 1 | 7.499 | 7.498 | 0.001 | 7.499 | 7.501 | 0.002 | 7.500 | 7.499 | 0.001 |
| 2 | 7.497 | 7.498 | 0.001 | 7.499 | 7.500 | 0.001 | 7.499 | 7.499 | 0.000 |
| 3 | 7.501 | 7.499 | 0.002 | 7.498 | 7.498 | 0.000 | 7.497 | 7.498 | 0.001 |
| 4 | 7.498 | 7.498 | 0.000 | 7.500 | 7.500 | 0.000 | 7.499 | 7.499 | 0.000 |
| 5 | 7.496 | 7.497 | 0.001 | 7.501 | 7.500 | 0.001 | 7.501 | 7.500 | 0.001 |
| 6 | 7.498 | 7.499 | 0.001 | 7.501 | 7.500 | 0.001 | 7.500 | 7.501 | 0.001 |
| 7 | 7.500 | 7.501 | 0.001 | 7.497 | 7.499 | 0.002 | 7.498 | 7.499 | 0.001 |
| 8 | 7.500 | 7.500 | 0.000 | 7.497 | 7.498 | 0.001 | 7.499 | 7.498 | 0.001 |
| 9 | 7.502 | 7.499 | 0.003 | 7.499 | 7.499 | 0.000 | 7.498 | 7.497 | 0.001 |
| 10 | 7.502 | 7.501 | 0.001 | 7.500 | 7.501 | 0.001 | 7.498 | 7.498 | 0.000 |

$s_{\Delta A}$= 0.000831 $s_{\Delta B}$= 0,0007 $s_{\Delta C}$= 0.000458

$\overline{X}_A$ = 0.0011 $\overline{X}_B$ = 0.0009 $\overline{X}_C$ = 0.0007

**1. Average standard deviation of measuring equipment $\overline{s}$ :**

Average standard deviation of difference Measure: mm

$$\overline{s}_\Delta = (s_{\Delta A} + s_{\Delta B} + s_{\Delta C}).(1/3) = 0.000662973$$

$$\overline{s} = \overline{s}_\Delta / \sqrt{2} = 0.000468793$$

**2. Standard deviation $s_v$ of average values $\overline{X}_A$, $\overline{X}_B$, $\overline{X}_C$ (handling effect)**

$s_v$ = 0.0001632993

**3. Total dispersion zone of measuring equipment $S_M$**

$$S_M = 6.\sqrt{\overline{s}^2 + \overline{s}_v^2} = 0.079180207$$

$S_M$ % = ($S_M$ /T).100 = **19.79 %**

| **4. Results** | **$S_M$ 0 – 20 %** | 21 – 30 % | > 30 % |
|---|---|---|---|
| | **(good)** | (delimited) | (deficient) |

Remark: Date: 20.02.2011 Department: Q Name: Kudičová

## Results and discussion

The first worker performed two consecutive measurements of one screw and then measured other nine products in the same way. Other two workers measured the same ten pressings in the same way as the first worker.

Revised screws were numbered and each worker carried out the measurements in the same order and the same place in the production hall. Measured data ($s_{\Delta A}$, $s_{\Delta B}$, $s_{\Delta C}$) were recorded in Table 1 for evaluation of the total dispersion zone of the measuring equipment $S_M$. Twenty values were measured for each worker. From these values were calculated: medium values $\overline{X}_A = 0.0011\ mm$, $\overline{X}_B = 0.0009\ mm$, $\overline{X}_C = 0.0007\ mm$ and further standard deviations for each worker $s_{\Delta A} = 0.000831\ mm$, $s_{\Delta B} = 0.0007\ mm$, $s_{\Delta C} = 0.000458\ mm.$ Basically were calculated average medium standard deviations $\overline{s} = 0.000468793\ mm$ and handling effect deviation $s_v = 0.0001632993\ mm.$ Finally, the total dispersion zone for micrometer $S_M = 19.79\ \%$ was calculated. If this value was in the zone from 0 to 20 %, the measuring equipment was qualified as good. All measured data as well as the calculated values are shown in the form for the evaluation of the total dispersion zone $S_M$ in the Table of the total dispersion zone $S_M$ (Table 1).

## Summary

Determining the total dispersion zone for measuring equipment $S_M$ according to the method *s* proved that the measuring equipment can be qualified as good because the value was in the zone from 0 to 20 %. ($S_M$ = 19.79 %).

Similarly, the values of capability indexes $C_{gm}$ = 1.93 and $C_{gmk}$ = 1.87 proved that the measuring equipment, a micrometer, is capable. Based on these data, we can calculate their capability indexes and evaluate the process capability. This information signals the organisation a necessity of quality improvement, and simultaneously provides an evidence for a customer about the stability of production conditions.

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