



Machining Accuracy

STEM4inclusive schools
WP2 – Toolbox

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Mechanical processing

- The dimensions and shape of the parts cannot be obtained at the nominal values.
- Deviations in dimensions and shape depend on the factors that generate them.

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The main causes of deviations

- Precision of machine tools.
- Precision of devices.
- Precision of measuring instruments.
- Tool wear.
- Thermal gradient.
- Unevenness of machining allowance.
- Inhomogeneity of material.





Statistical control

- Random deviations can be controlled using statistical and probability theory methods.
- The limits of deviations resulting from the machining of a part can be calculated.





Tracking processing deviations

Numerical characteristics of the distribution of processing deviations:

- deviation amplitude $\omega = x_{\max} - x_{\min}$;
- weighted average value of dimensions $M(x_i) = \sum_{i=1}^n x_i \cdot p(x_i)$;
 $p(x_i) = \frac{n_i}{N}$ relative frequency of dimension xi.

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- root mean square deviation $\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n}}$.



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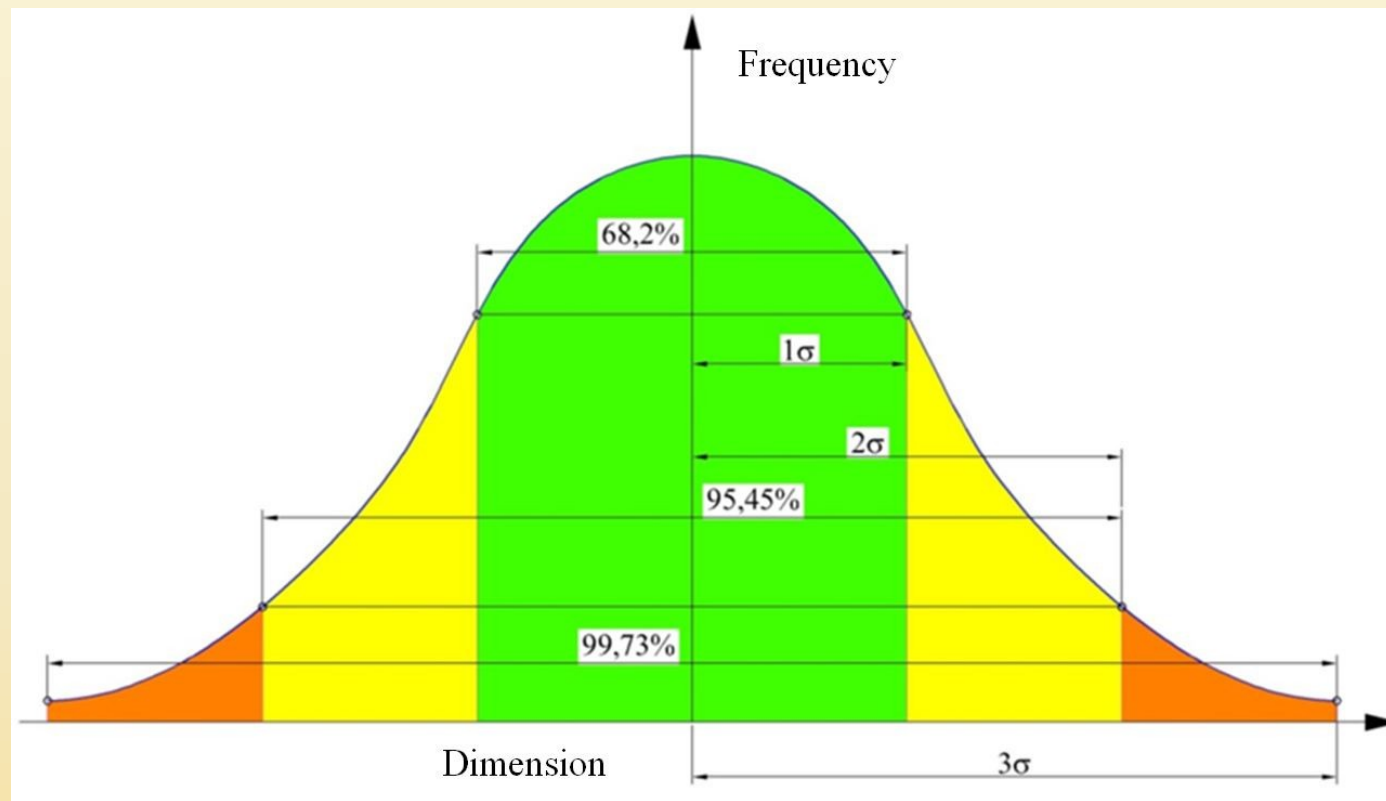


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Gauss distribution law

$$f(x) = \frac{1}{\sigma \cdot \sqrt{2 \cdot \pi}} \cdot e^{\frac{-(x-\bar{x})^2}{2 \cdot \sigma^2}}$$



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Interpreting the Gauss curve

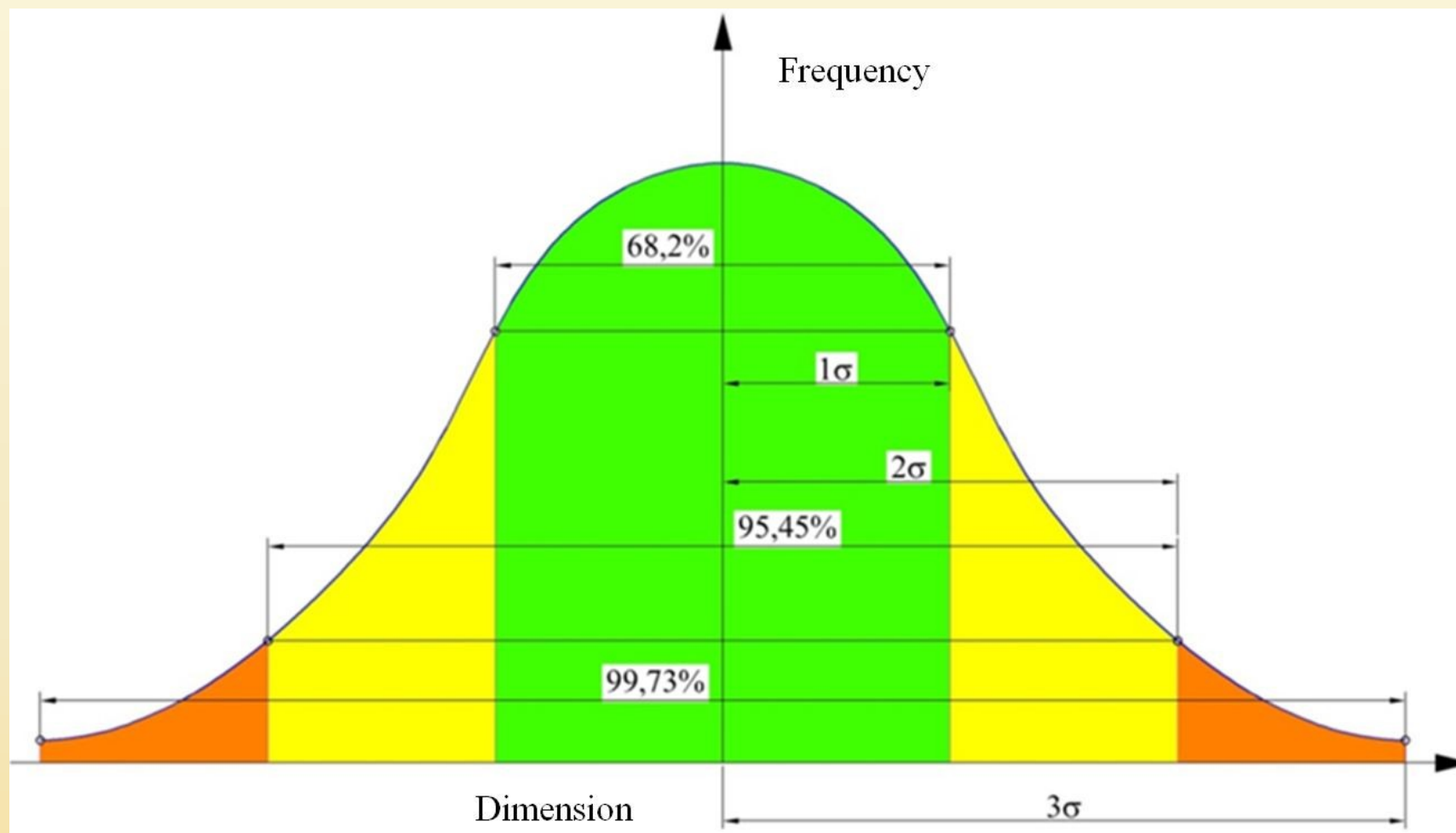
- Geometrically, σ represents the distance from the axis of symmetry of the curve to the point of inflection.
- The area limited by the curve and the abscissa represents the total number of deviations of the dimensions and is equal to unity:

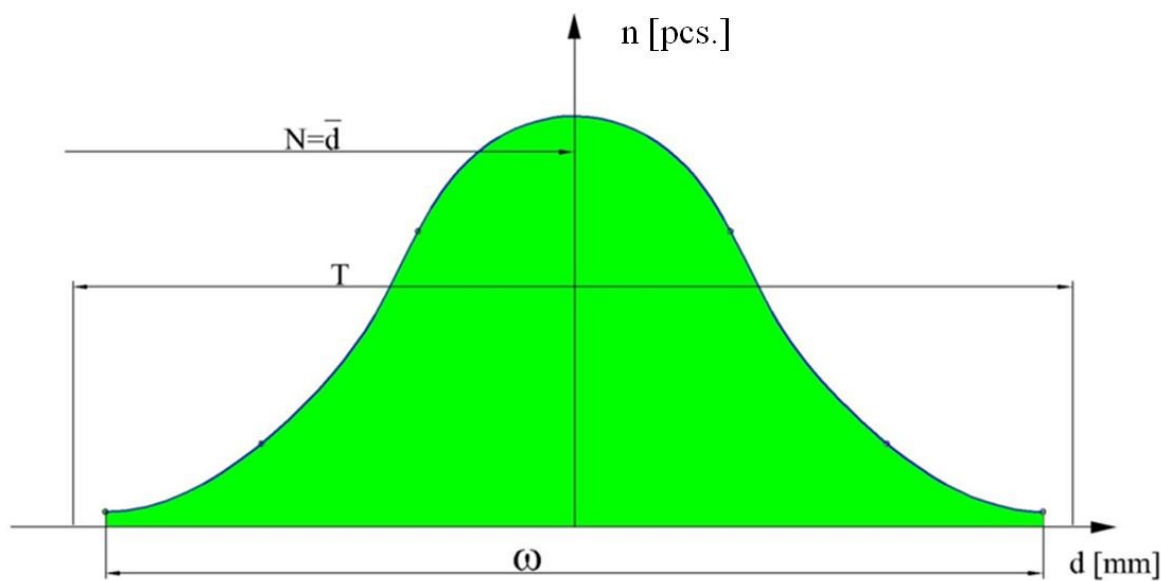
$$S(x) = \frac{1}{\sigma \cdot \sqrt{2 \cdot \pi}} \cdot \int_{-\infty}^{+\infty} e^{-\frac{x^2}{2 \cdot \sigma^2}} dx = 1 \quad \left\{ \begin{array}{l} \Rightarrow S(x) = \frac{1}{\sqrt{2 \cdot \pi}} \cdot \int_{-\infty}^{+\infty} e^{-\frac{z^2}{2}} dz = 1. \\ \frac{x}{\sigma} = z \end{array} \right.$$





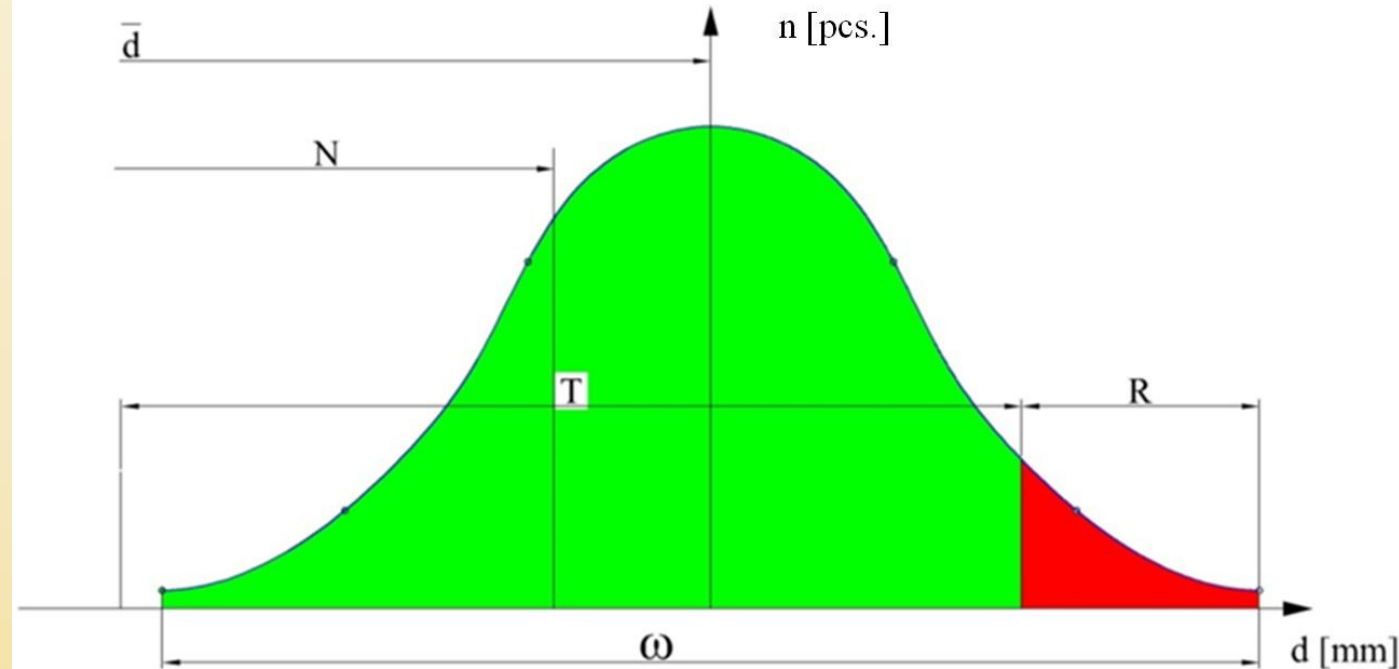
$$T \geq \omega = 6 \cdot \sigma$$





The condition $T \geq 6\sigma$ is not sufficient.
In addition, the axis of symmetry of the error distribution curve must coincide with the middle of the tolerance field.

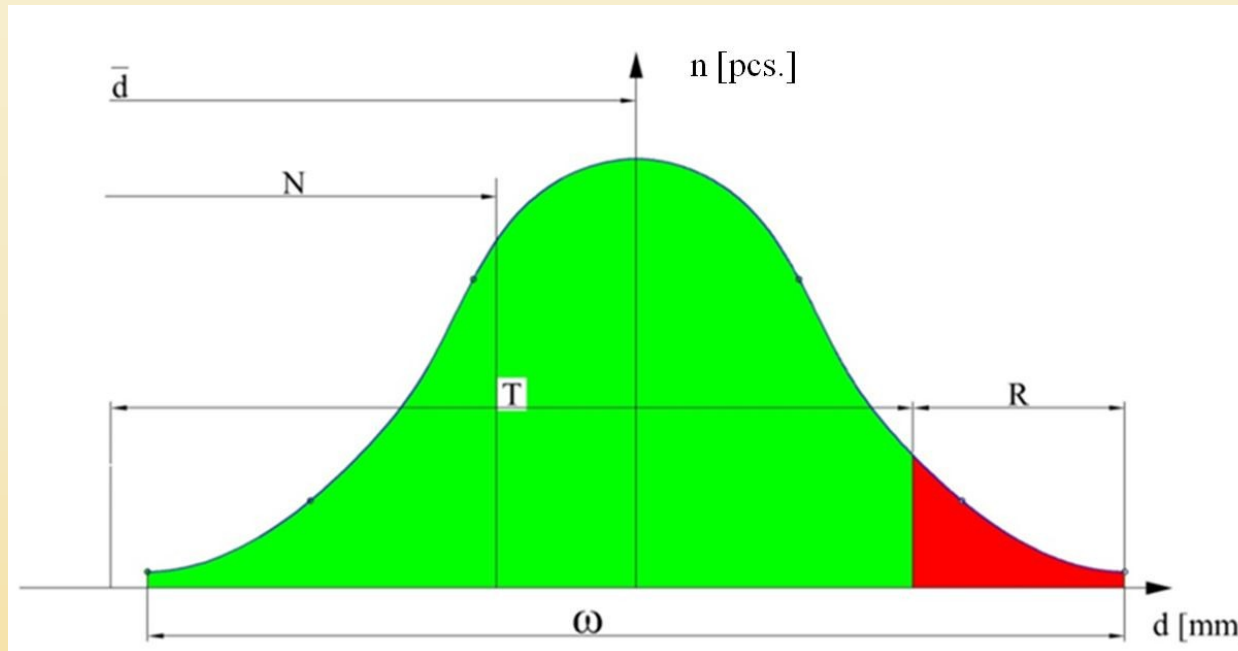
If the axis of symmetry is shifted from the center of the tolerance field by an amount called the adjustment error, then a percentage of rejected parts, R [%], results.





$$R = \left(0,5 - \varphi \left(\frac{\frac{T}{2} - E}{\sigma} \right) \right) \cdot 100$$

$$T < 6 \cdot \sigma \Rightarrow R = (R_1 + R_2) \cdot 100 = \left(1 - \varphi \left(\frac{\frac{T}{2} - E}{\sigma} \right) + \varphi \left(\frac{\frac{T}{2} + E}{\sigma} \right) \right) \cdot 100$$



To avoid errors, is necessary that:

$$T \geq 6 \cdot \sigma$$

$$2 \cdot E \leq T - 6 \cdot \sigma$$

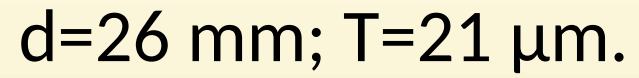


The values of the function $\varphi(z)$



z	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
$\varphi(z)$	0,0389	0,0793	0,1179	0,1554	0,1915	0,2257	0,2580	0,2881	0,3159	0,3413
z	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0
$\varphi(z)$	0,3643	0,3849	0,4032	0,4192	0,4332	0,4452	0,4554	0,4641	0,4713	0,4772
z	2,1	2,2	2,3	2,4	2,5	2,6	2,7	2,8	2,9	3,0
$\varphi(z)$	0,4821	0,4861	0,4893	0,4918	0,4938	0,4953	0,4965	0,4974	0,4974	0,4986





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