PROCESS CAPABILITY

Process capability is a measure of the producer's capability to produce a product which will meet a customer's tolerances. Usually it refers to one specific dimension which is critical to the performance of the product.

Process capability compares the customer's tolerance range, (maximum – minimum) to the producer's distribution width, 6 σ **,** where $\boldsymbol{\sigma}$ is the producers standard deviation.

In this discussion it is assumed that the producer's process is under statistical control, and that the key dimension is normally distributed.

The process capability index, Cp = (Customer's tolerance range) / 6 σ .

If the process σ is unknown, it can be estimated from control chart data using either of the formulas below:

Estimate of σ = RBAR / d2 or SBAR / c4

If Cp is < 1.0, 6 σ is greater than the customer's tolerance range, so there is no way that the producer can satisfy the customer's requirements. This is illustrated by the Figure 1 below.

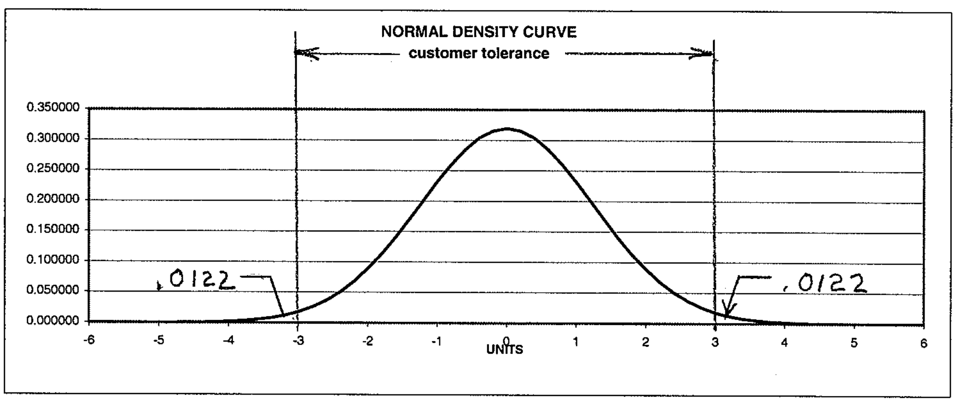

Figure 1

In figure 1, σ = .0013, 6 σ = .008, Customer Tolerance Range = .006 and Cp = 0.75

If the Cp = 1.0, the producer's distribution width is exactly equal to the customer's tolerance range, and the producer can meet the customer's tolerances **only if the process mean is maintained exactly on the center of the tolerance range.**

This is illustrated by Figure 2 below.

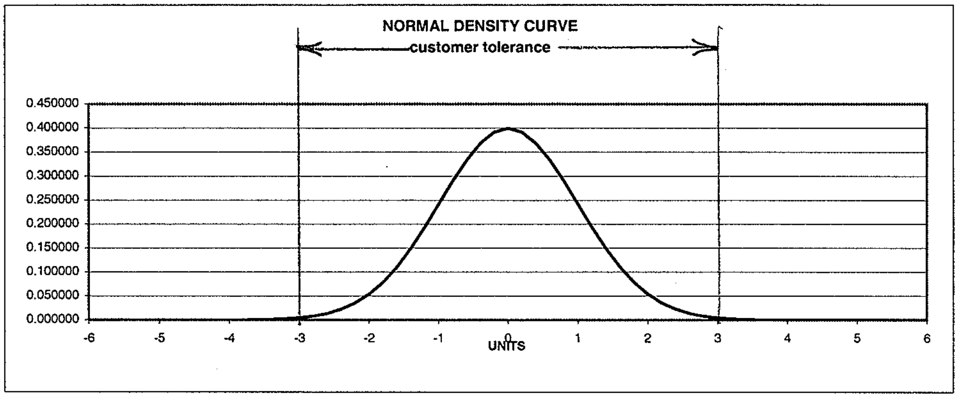

Figure 2
In figure 2, σ = .001, 6 σ = .006, Customer tolerance range = .006 and Cp = 1.0

A Cp of 1.0 is usually not acceptable to the customer because it means there is no allowance for a drift in the process mean. Such a drift would result in some product which would go outside the tolerance range on either the high side or the low side.

The automotive industry requires a Cp of 1.33 so that there is a small allowance for the mean to shift before some product goes out of tolerance. This is illustrated in Figure 3 below.

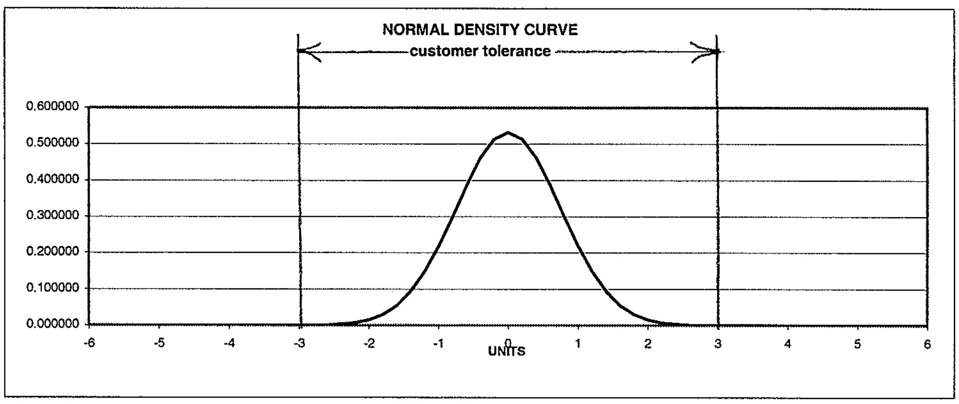

Figure 3
In figure 3, σ = .00075, 6 σ = .0045, Customer tolerance range = .006 and Cp = 1.33

The producer's process width is now only ¾ of the customer's tolerance range, or to say it another way, the customer's tolerances are now equivalent to plus / minus 4 σ above and below the center of the range. This allows a small drift of the process mean without any product going out of tolerance.

The above three figures show that in order to achieve a higher Cp, the producer must reduce the process σ.

The producer must maintain the process under statistical control by using control charts to monitor the process mean and variation, such as XBAR – RANGE, or XBAR – STD DEVIATION.

Although a satisfactory Cp shows the producer is **capable** of meeting the customer's tolerances, it does not show whether the product **actually** meets the customer's tolerance. Something is needed to show whether the producer controlled the process mean at the center of the customer's tolerance range.

The process capability index, Cpk, takes the centering of the process into account. It looks at how close the process mean is to the customer's upper tolerance and to the lower tolerance. It takes the **lesser of these** and divides this by 3 σ, which is half of the process width.

Cpk = (separation between the process mean and nearest tolerance limit) / 3 σ .

The Cpk will equal the Cp when the process mean is exactly equal to the center of the customer's tolerance.

But when the process mean is **not** exactly equal to the center of the customer's tolerance, the Cpk will be **lower** than the Cp. Figure 4 below shows that the process mean has drifted downward 0.75 units below the target and the lower tail is just touching the customer's lower limit. In this situation the Cp still equals 1.33, but the Cpk = 1.00

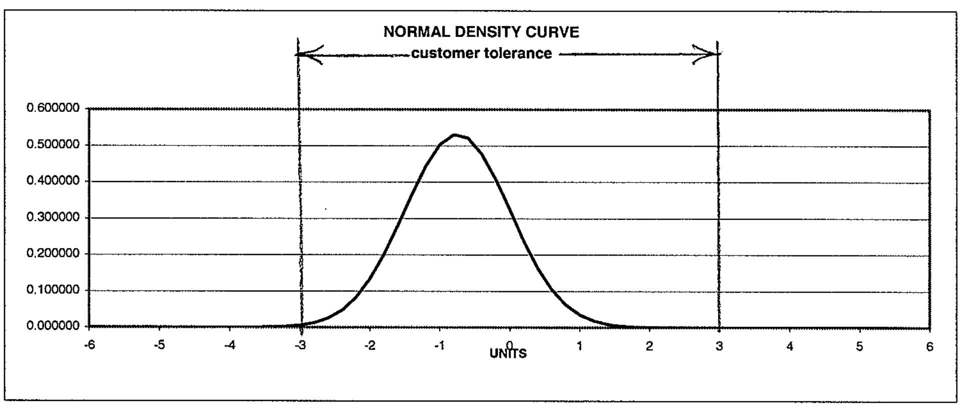

Figure 4

In figure 4, σ = .00075, 6 σ = .0045, Customer tolerance range = .006, Cp = 1.33 but Cpk = 1.00

If the process mean drifts any lower, some parts will be below the customer's lower limit.

Figure 5 below shows a situation where the process mean had drifted .002 below the target and approximately 9.18% of the parts produced will be below the customer's lower limit.

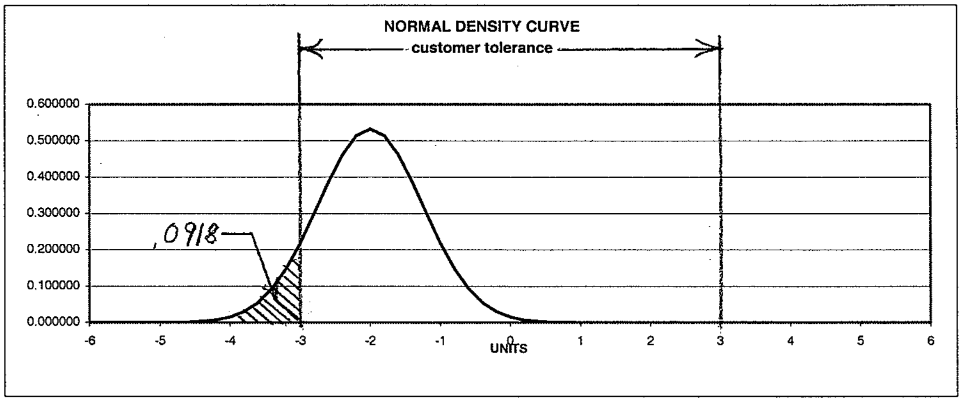

Figure 5

In figure 5, σ = .00075, 6 σ = .0045, Customer tolerance range = .006, Cp = 1.33 but Cpk = 0.44

This is obviously unsatisfactory since some parts will be out of tolerance.

The Cpk shows what was **actually** done vs what could have been done.

To be a successful supplier the Cpk must be 1.00 or higher as in Figure 4, and there must be control charts which demonstrate that the process was under statistical control during production of the parts.

The automotive industry requires a Cpk of 1.33 or higher, as in Figure 3, in order to have greater assurance of compliance to specifications.