MATERION

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TECHNICAL TIDBITS

MATERION PERFORMANCE ALLOYS

PROCESS CAPABILITY

What does it mean for a process to be capable?

In Capable Hands? –
A brief discussion of what it means for a process to be capable and what you can expect for material properties from such capable processes.

- Process Capability
- Process Potential (Cp)
- Process Capability Index (Cpk)
- Bilateral
- Unilateral

It is a measure of how reliably a given process can achieve the desired outcome. There are several aspects to **process capability** and we will discuss two of them. The first is how well the results of the process falls within the specification limits (the **process potential**). The second is how close the process results come to hitting the nominal (targeted) values (the **process capability index**).

Typically, the **nominal** value would be the center of the specification limits. This makes sense, since it is easier to hit a target if you aim for the center than if you aim for one of the edges. However, there may be cases where more customers desire having a particular property at the upper end of the range (of course they would be made aware of the tradeoffs involved), so the actual target may be offset from the center. For our purposes, we will discuss the case where the nominal value is the mean of the specification limits.

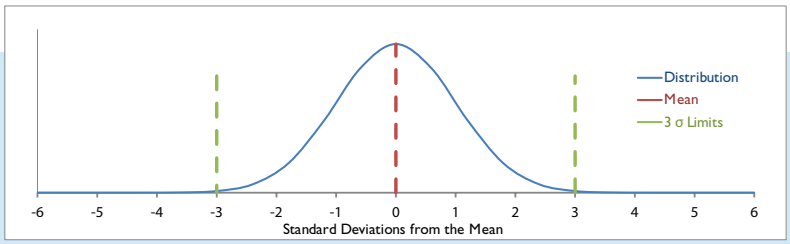

Figure 1. Illustration of Process Spread.
99.73% of all measurements fall between +3 standard deviations and -3 standard deviations from the mean. Therefore, six standard deviations (6x) is considered the spread of the process.

Process Potential (Cp)

The process potential is calculated by the following equations. If there is both an upper specification limit and a lower one, the process is considered **bilateral** and the process spread is 6 standard deviations. If there is only an upper limit or only a lower limit (**unilateral** case), you will only be concerned with the side of the distribution closest to the spec limit and the process spread is 3 standard deviations. The process capability is a ratio of the allowable spread (based on specification limits) to the actual spread. If 6 standard deviations fit exactly within the specification limits, the process potential (Cp) is equal to one. (99.73% of all outputs would be within specification), and fewer than 0.3% would fall outside the specification. Cp numbers greater than one indicate a higher percentage within the specification range, and numbers less than one indicate a higher percentage outside the specification range. A Cp equal to 2.0 shows 12 standard deviations between the specification limits, and only 2 failures per billion opportunities.

$$C_p = \frac{USL - LSL}{6\sigma}$$ (Bilateral case, both maximum and minimum property values specified)

$$C_p = \frac{USL - \mu}{3\sigma}$$ (Unilateral case, maximum property value specified)

$$C_p = \frac{\mu - LSL}{3\sigma}$$ (Unilateral case, minimum property value specified)

Where: USL = Upper Specification Limit
LSL = Lower Specification Limit
σ = standard deviation
μ = process mean
Nominal = the targeted result, usually the midpoint of the specification range

The next issue of Technical Tidbits will discuss other statistical measures for material properties.

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PROCESS CAPABILITY (CONTINUED)

Process Capability Index, (Cpk)

This index measures the ability of a process to produce product within specification. The capability index measures the degree of centering of the actual process spread with respect to the allowable spread. The figure κ below is the distance between the nominal (target) value and the process mean. Divide that distance by half of the specification range to get a ratio to the off-center distance. A perfectly centered process would have a ratio κ equal to zero and the Cpk would then be equal to the Cp. If the process mean is on one of the specification limits, then half of the outputs would be out of specification. The σ ratio would be one and the Cpk would be zero.

$$C_{pk} = C_p(1-\kappa) \quad Where: \quad \kappa = \frac{|Nominal - \mu|}{(USL - LSL)/2}$$

Condition 1: Distribution mean centered on nominal specification
Cp = A/B = 2.0 Cpk = C/0.5B = 2.0

Condition 2: Same distribution with mean shifted 1.5 σ from the nominal specification
Cp = A/B = 2.0 Cpk = C/0.5B = 1.5

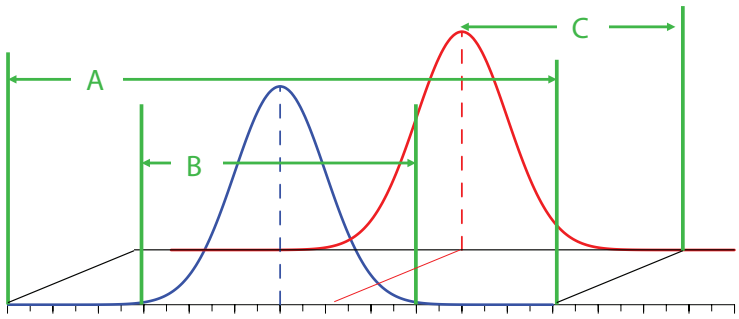

Figure 1. Illustration of Process Spread. The output of the blue process is perfectly centered within the specification limits, and the process mean is identical to the target. This is an ideal situation. The output of the red process has the same distribution, but the process mean is offset by1.5 sigma from the target. The process potential is the same, but the capability is lower in the red process.

The Cpk value essentially is a deration of the Cp value to account for deviations from the target. Cpk will always be less than or equal to Cp, so it is a more conservative measure of process capability. The specification minimums and ranges on Materion Performance Alloys data sheets are derived with a minimum Cpk of 1. This means that at least 99.7% of all produced material will fall within the data sheet limits, meaning the probability of having to rework is 0.3%

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References:

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e-Handbook of Statistical Methods, http://www.itl.nist.gov/div898/handbook/pmc/section1/pmc16.htm, 28 July 2016

Connector Engineering Design Guide Brush Wellman Inc. 2008

Please contact your local sales representative for further information on material hardness or other questions pertaining to Materion or our products.

Health and Safety

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Performance Alloys or your local representative..

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