Relationship of Process Capability and R&R

For this particular section, the following relationships apply:

σ_o The sigma of the observed process as determined from a capability study. This sigma should preferably come from the $\frac{\bar{R}}{d_2}$ of a control chart, it is sigma of the process based on at least 100 observations. This sigma includes the variation of the actual process and measurement.

σ_a The sigma of the actual process without the measurement variation. It is not directly measurable.

$\sigma_{R\&R}$ The sigma from an R&R study. This sigma indicates the variation due to measurement.

$$\sigma_o^2 = \sigma_a^2 + \sigma_{R\&R}^2, \text{ and}$$

$$C_p = \frac{tolerance}{6\sigma_o} = observed\ C_p, \text{ then}$$

$$\sigma_o = \frac{tolerance}{6C_p}$$

Let %R&R = X%, but

$$\%R\ \&\ R = \left(\frac{5.15\ \sigma_{R\&R}}{tolerance}\right) * 100 = X\%, \text{ then}$$

$$X = \frac{5.15\ \sigma_{R\&R}}{tolerance}, \text{ thus}$$

$$\sigma_{R\&R} = \frac{X\ (tolerance)}{5.15}$$

Using $\sigma_o^2 = \sigma_a^2 + \sigma_{R\&R}^2$ and the formula for σ_o and $\sigma_{R\&R}$,

$$\sigma_a = \sqrt{\sigma_o^2 - \sigma_{R\&R}^2}$$

$$\sigma_a = \sqrt{\left(\frac{tolerance}{6\ C_p}\right)^2 - \left(\frac{(X)\ (tolerance)}{5.15}\right)^2}$$

$$\sigma_a = tolerance\sqrt{\left(\frac{1}{6\ C_p}\right)^2 - \left(\frac{X}{5.15}\right)^2}, \text{ then}$$

$$C_{pA} = Actual\ C_p = \frac{tolerance}{6\ \sigma_a}, \text{ and}$$

$$C_{pA} = \frac{tolerance}{6\left\{tolerance\sqrt{\left(\frac{1}{6\,C_p}\right)^2 - \left(\frac{X}{5.15}\right)^2}\right\}}, =$$

$$C_{pA} = \frac{1}{6\sqrt{\left(\frac{1}{6\,C_p}\right)^2 - \left(\frac{X}{5.15}\right)^2}}$$

C_{pA}, the actual C_p, can be calculated for each combination of the observed C_p and X (the proportion of R&R to the tolerance). Note that some combinations of X and observed C_p are impossible.

These results are shown in table 10.

Table of Actual C_p for Combination of Observed C_p and % R&R

%R&R

Observed C_p	0%	10%	20%	30%	40%	50%	60%	70%
0.50	0.50	0.50	0.50	0.51	0.51	0.52	0.53	0.55
0.60	0.60	0.60	0.61	0.61	0.62	0.64	0.66	0.69
0.70	0.70	0.70	0.71	0.72	0.74	0.77	0.80	0.85
0.80	0.80	0.80	0.81	0.83	0.86	0.90	0.96	1.06
0.90	0.90	0.90	0.92	0.95	0.99	1.06	1.16	1.33
1.00	1.00	1.01	1.03	1.07	1.13	1.23	1.40	1.73
1.10	1.10	1.11	1.14	1.19	1.28	1.43	1.72	2.49
1.20	1.20	1.21	1.25	1.32	1.45	1.68	2.20	5.83
1.30	1.30	1.32	1.36	1.46	1.63	1.99	3.11	
1.40	1.40	1.42	1.48	1.61	1.85	2.42	6.81	
1.50	1.50	1.52	1.60	1.76	2.10	3.08		
1.60	1.60	1.63	1.72	1.93	2.40	4.41		
1.70	1.70	1.73	1.85	2.11	2.79			
1.80	1.80	1.84	1.98	2.32	3.31			
1.90	1.90	1.95	2.12	2.54	4.09			
2.00	2.00	2.06	2.26	2.80	5.52			

Table 1