Document	SCM-1.3-GL4_Quality Capability Statistics For Suppliers		
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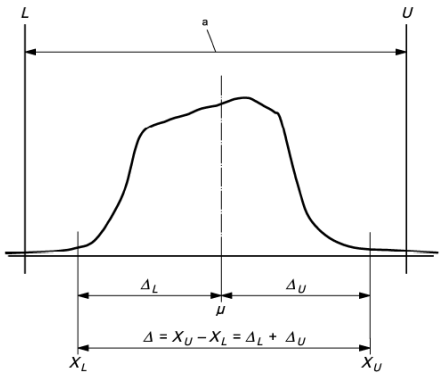
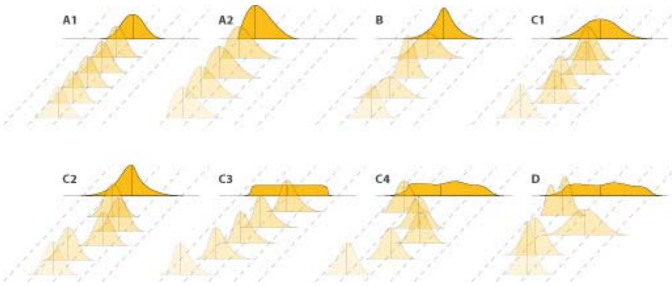
Determination of Quality Capability Statistics

Short-term capability study

Process capability study

(Version for Suppliers)





Keywords **short-term capability, machine capability, ,process capability process performance, quality capability, quality capability statistics, process performance, C_m, C_{mk}, P_p, P_{pk}, C_p, C_{pk}**

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1 Preface

These guidelines are not a replacement for a basic knowledge of statistical issues which is essential in order to be able to understand them in full and to be able to check the plausibility of and interpret the results. The use of suitable statistics software for process qualification is essential for full analysis (recommended: qs-STAT).

In addition, Appendix 3 is only a summary of key facts and formulas on the subject of quality capability statistics. A complete description of all important facts and information is reflected in the following guidelines:

- Guidelines for the determination of quality capability statistics , Part 2
  Short-term capability study

- Guidelines for the determination of quality capability statistics , Part 3
  Process capability study

2 Chronological order of the different capability studies

Part 1	Part 2	Part 3	→ start of series prod.	Part 3	Part 3
Step ①	Step ②	Step ③		Step ④	Step ⑤
Process analysis prior to start of series production				Process analysis after start of series production	

Gage R&R study ↓ Measuring capability	Short-term process analysis ↓ Short-term capability	Preliminary process analysis ↓ Process performance	Quality Control Chart & Long-term process analysis ↓ Process capability
Minimum quantity 50 pieces or as appropriate to the process	Minimum quantity 50 pieces or as appropriate to the process	Minimum quantity 100 pieces or as appropriate to the process. To keep the requisite control chart, a minimum of 20 individual random samples are necessary	An appropriate period under normal series conditions, during which it can be assured that all influential factors can take effect. (standard value: 20 production days); total random sample size ≥ 125
C_g / C_{gk}, Gage R&R Indicator for the measurement quality before commencement of data acquisition	C_m / C_{mk} Indicator of a process under short-term, ideal conditions	P_p / P_{pk} Indicator of a process under real-life conditions (influence of 5M factors), which has not yet been proven to be in a state of statistical control	C_p / C_{pk} Indicator of a process under series production conditions (full influence of 5M factors), which has previously been proven to be in a state of statistical control

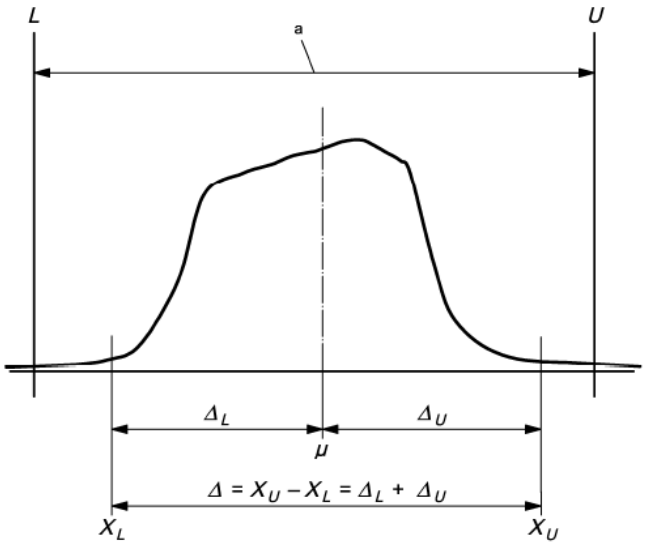
→ Time →

Figure 1 Chronological order of the different capability studies

3 Summary

3.1 Process spread

The process spread is described by means of the quantile $X_{0.99865} \triangleq 99.865\%$ point and the quantile $X_{0,00135} \triangleq 0.135\%$ point of the distribution. The so-called quantile method is therefore applicable for all distribution models.



with

U	= upper specification limit
L	= lower specification limit
a	= specified tolerance U - L
μ	= process location
Δ	= process spread
	= $X_U - X_L$
	= $\Delta_L + \Delta_U$
	(= 99.73% of the distribution)
Δ_L	= lower process variation
Δ_U	= upper process variation
X_L	= lower variation range limit $X_{0,135\%}$
X_U	= upper variation range limit $X_{99,655\%}$

Figure 2 Process spread in accordance with the quantile method acc. to DIN ISO 21747

3.2 Short-term capability studies

Objectives

The objective of a short-term capability study is a standardised documentation as to whether the machine in question permits reliable production of an observed characteristic under short-term, ideal process conditions.

Reason / Situation

- Initial sample inspection
- Procurement of new processing facilities
- Transfer of products to different plants
- Design changes
- Machinery updates
- Introduction of new raw materials
- Extended shutdowns

Hilti specification

Short-term capability index	H and N feature	K feature
$C_{m(LIMIT)}$	≥ 1.67	≥ 2.00
$C_{mk(LIMIT)}$	≥ 1.33	≥ 1.67

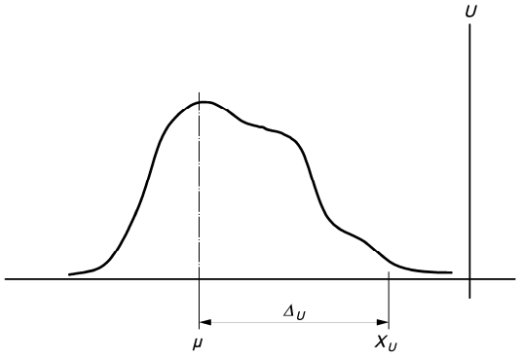
Table 1 Hilti specification for short-term capabilities

3.3 Formulae for short-term capability studies

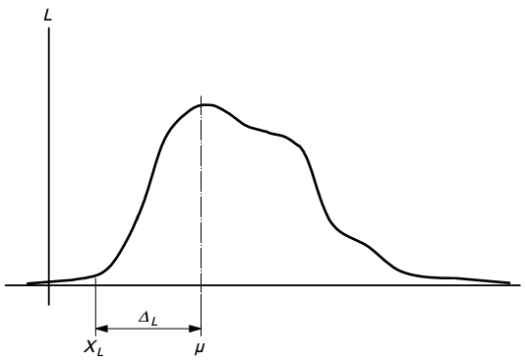
Method $M1_{I,6}$	Short-term capability index	$C_m = \frac{U - L}{\Delta}$	3-1
	Lower short-term capability index	$C_{mkL} = \frac{\mu - L}{\Delta_L}$	3-2
	Upper short-term capability index	$C_{mkU} = \frac{U - \mu}{\Delta_U}$	3-3
	Minimum short-term capability index	$C_{mk} = \min \{ C_{mkL}; C_{mkU}$	3-4

Figure 3 Short-term capability for two-sided limits acc. to DIN ISO 21747

In the case of features with an upper or lower specification limit, the following relationships apply:



Features with a upper specification limit



Features with a lower specification limit

Upper short-term capability index	$C_{mkU} = \frac{U - \mu}{\Delta_U}$	3-5	Lower short-term capability index	$C_{mkL} = \frac{\mu - L}{\Delta_L}$	3-6
Minimum short-term capability index	$C_{mk} = C_{mkU}$	3-7	Minimum short-term capability index	$C_{mk} = C_{mkL}$	3-8

Figure 4 Short-term capability for one-sided limits acc. to DIN ISO 21747

3.4 Process capability studies

Objective

The objective of process capability studies is a standardised documentation as to whether a specific feature can be produced in a consistent manner within the prescribed specifications over a sufficiently long period of time. Here, all influences should be acting on the production process during the study.

Reason / Situation

- On-going verification of process capability
- Initial sample inspection
- Procurement of new processing facilities
- Transfer of products to different plants
- Design changes
- Machinery updates
- Introduction of new raw materials
- Extended shutdowns

Hilti specification

Process capability index	H- und N-Merkmal	K-Merkmal
$P_{p(LIMIT)}$ / $C_{p(LIMIT)}$	≥ 1.33	≥ 1.67
$P_{pk(LIMIT)}$ / $C_{pk(LIMIT)}$	≥ 1.00	≥ 1.33

Table 2 Hilti specification for process performance and process capability

3.5 Formulae for process capability studies

Naming matrix in accordance with [2] as follows:

Study on	stable (in a state of statistical control)	unstable (not in a state of stat. control)
Long-term capability	C_p / C_{pk}	P_p / P_{pk} (T_p / T_{pk})
Preliminary process capability	P_p / P_{pk}	P_p / P_{pk}

Table 3 Difference between P_p / P_{pk} and C_p / C_{pk}

Method $M1_{I,6}$	Process performance index	$P_p = \frac{U - L}{\Delta}$	3-9
	Lower process performance index	$P_{pkL} = \frac{\mu - L}{\Delta_L}$	3-10
	Upper process performance index	$P_{pkU} = \frac{U - \mu}{\Delta_U}$	3-11
	Minimum process performance index	$P_{pk} = \min \left\{ P_{pkL} ; P_{pkU} \right.$	3-12

Figure 5 Process performance for two-sided limits acc. to DIN ISO 21747

In the case of features with an upper or lower specification limit, the following relationships apply:

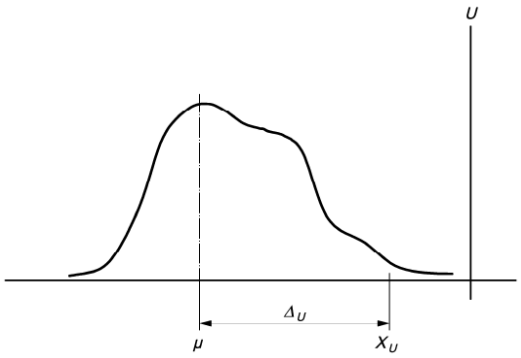
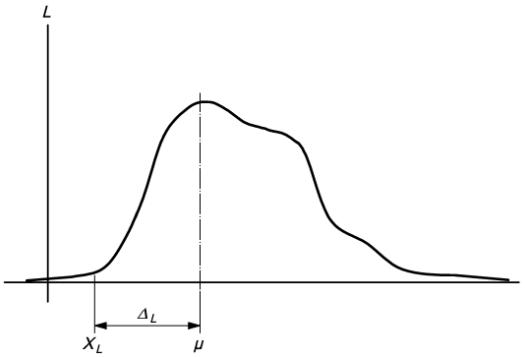
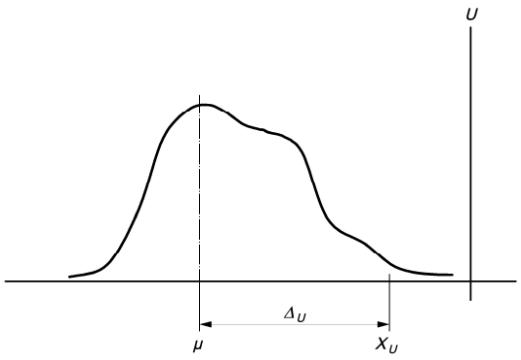
	
Features with a upper specification limit	Features with a lower specification limit
Upper process performance index $P_{pkU} = \frac{U - \mu}{\Delta_U}$ 3-13	Lower process performance index $P_{pkL} = \frac{\mu - L}{\Delta_L}$ 3-14
Minimum process performance index $P_{pk} = P_{pkU}$ 3-15	Minimum process performance index $P_{pk} = P_{pkL}$ 3-16

Figure 6 Process performance reference figures for one-sided limits acc. to DIN ISO 21747

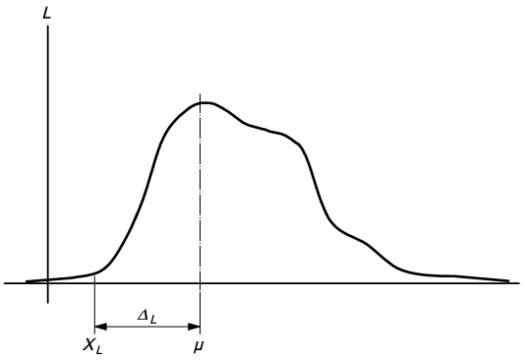
If a process is proven to be in a state of statistical control, a process capability index can be assigned:

Method $M1_{I,6}$	Process capability index $C_p = \frac{U - L}{\Delta}$	3-17
	Lower process capability index $C_{pkL} = \frac{\mu - L}{\Delta_L}$	3-18
	Upper process capability index $C_{pkU} = \frac{U - \mu}{\Delta_U}$	3-19
	Minimum process capability index $C_{pk} = \min\left\{C_{pkL}; C_{pkU}\right.$	3-20

Figure 7 Process capability for two-sided limits acc. to DIN ISO 21747



Features with a upper specification limit



Features with a lower specification limit

Upper process capability index	$C_{pkU} = \frac{U - \mu}{\Delta_U}$	3-21	Lower process capability index	$C_{pkL} = \frac{\mu - L}{\Delta_L}$	3-22
Minimum process capability index	$C_{pk} = C_{pkU}$	3-23	Minimum process capability index	$C_{pk} = C_{pkL}$	3-24

Figure 8 Process capability for two-sided limits acc. to DIN ISO 21747