

Process Capability: Statistical Evidence of Stable Manufacturing Processes

Process capability describes the ability of a manufacturing process to consistently and reproducibly meet defined tolerance limits over an extended period. It is expressed statistically using indices such as Cp and Cpk and is a central form of evidence within quality assurance between customer and supplier. For technical buyers, process capability is an important evaluation criterion in supplier approval, start of production and ongoing quality monitoring.

Key facts

- Process capability measures how reliably a process meets the agreed tolerances.
- The key indices are Cp (potential) and Cpk (critical process position).
- In practice, $Cpk \geq 1.33$ is often considered the minimum requirement for ongoing series production processes.
- The assessment requires a stable, statistically controlled process (normal distribution).
- Evidence is typically provided via short-term capability at the start of production and long-term capability during ongoing operations.
- In procurement, process capability is a component of supplier evaluation and quality agreements.

Definition: Process Capability

Process capability is the qualitative property of a manufacturing process of producing within its natural variation in conformity with the required tolerance limits. It is calculated using statistical process control (SPC) and stated as a capability index.

Distinction from Machine Capability

Machine capability (cm/cmk) considers only the pure performance of the equipment over a short measurement sequence without any process disruptions such as changes of personnel, material or environment. Process capability, by contrast, maps the overall system of machine, tool, material, method and person over a representative period. During the start-of-production phase, machine capability is therefore often demonstrated first, before full process capability is demonstrated over several production weeks.

Significance in Industrial Procurement

For buyers, process capability is not merely a specialist quality topic but a procurement criterion: a capable process reduces the likelihood of scrap, blocked stock, 100% inspection and complaints. In supplier selection and as part of the supplier landscape analysis, capability-related evidence serves as an objective comparison criterion. Even during ongoing series deliveries, such evidence forms part of the usual scope of quality agreements.

Normative and Contractual Framework

Process capability is typically required under standards such as ISO 9001 and industry standards such as IATF 16949 (automotive) or similar industry-specific requirements. The specific target values are agreed between customer and supplier contractually or in drawing/control plan coordination.

Procurement should ensure that the requirements are clearly anchored in drawings, control plans and supplier agreements.

Methods and Approach for Determination

The determination follows a standardised procedure: define the sample size, define the characteristics, verify the measurement system, collect the data and evaluate them statistically.

Characteristic Selection and Measurement System Analysis

Before any capability study, the characteristics to be assessed must be defined, usually via key characteristic features from the control plan. The measurement system analysis (MSA) ensures that the measuring instruments and measurement methods are themselves capable, otherwise measurement variation distorts the indices. In practice, the Gage R&R analysis is used for this purpose.

Short-Term and Long-Term Capability

Short-term capability is determined at the start of production using a small, consecutive sample (frequently 25 to 125 parts). Long-term capability is based on data from ongoing operations over several weeks or months and also captures shift, batch and material variation. Both indices feed into the assessment of a process, with the long-term view providing the realistic picture.

Interpretation of the Results

A high C_p value without a sufficient C_{pk} shows that the process has low variation but is incorrectly centred. In this case, the process can usually be helped by a setting or adjustment. A low C_p indicates structural sources of variation that can only be reduced through technical root cause management. The evaluation should always be carried out in conjunction with the control chart (SPC chart).

Key KPIs for Process Capability

The assessment is carried out using standardised indices that capture both dimensions – variation and central position.

C_p: Process Potential

C_p describes the potential of a process if it were perfectly centred. It compares the tolerance width with the natural process variation (6-sigma width). C_p ignores the actual position of the process and is therefore not sufficient on its own.

C_{pk}: Critical Process Position

C_{pk} takes into account the actual position of the process between the tolerance limits. In practice, $C_{pk} \geq 1.33$ is considered the usual guideline value for ongoing series production processes, while safety-critical or complex characteristics frequently have to be evidenced with $C_{pk} \geq 1.67$ or higher. Higher requirements such as $P_{pk} \geq 2.0$ are typically agreed for safety-relevant characteristics.

Further Related Key Figures

In addition, the defect rate (ppm), OEE (Overall Equipment Effectiveness) and the variation of sample characteristics are often consulted. Looking at process capability and defect rates together provides a realistic picture of delivery quality. These key figures feed into procurement's regular supplier evaluation.

Risks and Controls in the Procurement Context

Missing or merely purported process capability carries considerable procurement risks. Controls must therefore be effective from supplier selection through to ongoing series support.

Risk: Incomplete or Fabricated Evidence

Some providers document capability studies retrospectively or use unfavourable sample selections. A realistic verification approach includes the on-site walk-through, review of the measurement systems and comparison of the study data with the complaint history. Such gaps can be uncovered as part of a supplier audit.

Risk: Excessive Requirements Without Economic Review

Unrealistically high Cpk requirements for non-critical characteristics can drive up prices unnecessarily, as the supplier factors in additional effort for containment, inspection and process control. Procurement should prioritise the requirements together with quality and a cost-benefit analysis. Not every characteristic requires the same capability evidence.

Controls and Escalation

Proven control mechanisms include ongoing SPC data delivery, response upon limit violations, 8D reports in the event of deviations and a defined requalification after process changes. Escalation levels such as improvement plans with target deadlines or contractually agreed consequences (for example within the framework of termination for convenience) should be laid down in the supplier agreement.

Process Capability in the Start of Production and Supplier Development

The practical implementation is demonstrated above all at the start of production, in supplier qualification and in ongoing quality support.

Start of Production and Run at Rate

At the start of production, process capability is documented using defined samples, frequently supplemented by evidence of performance as part of a Run at Rate. This also verifies whether the supplier can realistically achieve the agreed quantities and cycle times. Together, these form a solid basis for release for series production.

Supplier Development and Ongoing Support

With recurring deviations in capability values, supplier development comes into play: root cause analysis, optimisation planning and requalification are the usual steps. Procurement helps steer this process and should feed the results into the supplier evaluation. For processes that remain permanently incapable, the question of alternative sourcing or supplier consolidation arises.

Digitalisation of the Evidence Process

Modern systems capture measurement data automatically and calculate capability indices on an ongoing basis. Through ERP integration, quality data can be linked with order, call-off and complaint data. This creates a genuine real-time overview instead of one-off paper studies.

Current Developments: Data Quality, Data Density and Forward-Looking Quality Management

Process capability is increasingly shifting from a one-off study request to continuous, data-based quality management across the entire value chain.

Continuous Rather Than One-Off Evidence

Customer and supplier are increasingly agreeing the ongoing transmission of SPC data instead of one-off study documentation. This allows both parties to identify trends and shifts at an early stage. The advantage: quality is managed preventively rather than reactively through complaints.

Automated Data Analysis and AI

Advances in data capture and analysis now also permit the monitoring of unstructured data sources such as sensor and process parameter data. Automated analysis is also gaining ground in procurement in the context of e-procurement and digital supplier evaluations. However, the foundation always remains a clean and traceable data basis.

Sustainability and ESG Linkage

Process capability reduces scrap and material consumption and thus contributes directly to sustainability and efficiency goals. Topics such as the PPWR declaration of conformity or CO2 data collection draw on the same clean process and data discipline. Procurement and quality should coordinate their activities in this respect.

Typical metrics

Cpk (short-term capability, start of production): ≥ 1.67

common guideline value for new processes at the start of production

Cpk (long-term capability, series production): ≥ 1.33

commonly agreed minimum value for ongoing series production processes

Ppk: ≥ 1.67

common in practice for safety-critical characteristics

Measurement system analysis (Gage R&R): $< 10\%$

proportion of measurement variation in the total variation; a value below 10% is considered acceptable

Defect rate: < 100 ppm

a common target level in the automotive and precision engineering industries

Practical Example

A medium-sized mechanical engineering company procures a high-precision machined component. After release for series production, the complaint rate rises even though the supplier had submitted a valid capability study. An audit reveals that the study was carried out with an unfavourable sample

selection and without shift changes. Only a long-term capability study over four production weeks reveals the actual variation.

- Contractually anchored SPC data delivery in the call-off and quality process
- Mandatory long-term capability after the start of production instead of only short-term evidence
- On-site verification of measurement systems (MSA) as part of the supplier audit
- Linking quality data to supplier evaluation via ERP integration

Conclusion

Process capability is far more than a formal quality document: it shows whether a supplier can reliably meet the agreed tolerances over time. For procurement, this translates into a direct influence on scrap costs, delivery reliability and the long-term stability of the supply chain. What matters are realistic requirements, a sound sampling methodology and ongoing rather than merely one-off evidence. Those who systematically embed process capability in supplier selection, start of production and ongoing evaluation demonstrably reduce procurement risks. The coordination between procurement, quality and supplier is the decisive success factor in this.

Frequently asked questions

What does process capability mean in simple terms?

Process capability shows whether a manufacturing process can reliably meet the specified tolerance limits over an extended period. It is expressed using indices such as Cp and Cpk. A capable process produces hardly any deviations or scrap.

Which Cpk values are common in industry?

In practice, a $Cpk \geq 1.33$ is often considered the minimum value for ongoing series production processes. Safety-critical or complex characteristics are typically required to achieve $Cpk \geq 1.67$ or higher. The specific values are agreed contractually or in the control plan between customer and supplier.

What is the difference between Cp and Cpk?

Cp describes the pure spread potential of the process if it were perfectly centred. Cpk additionally takes into account the actual position of the process within the tolerance limits. This is why Cpk is always less than or equal to Cp and is more realistic.

When is a process capable and when merely controlled?

A controlled process is statistically stable and shows no special causes of variation, but does not necessarily have to be within tolerance. A capable process is controlled and additionally meets the required tolerance limits with a sufficient Cpk. Only the combination of both guarantees stable series quality.

How many measured values are needed for a process capability study?

For short-term capability, 25 to 125 consecutive measured values are often used. Long-term capability is typically based on data from ongoing operations over several weeks or months. The sample size should reflect real process conditions such as shift and batch changes.

What should procurement pay attention to in capability studies?

Procurement should anchor the requirements clearly in contracts and in the control plan, and should verify the methodology (sampling, measurement system analysis). In practice, a mere document review is often not sufficient. On-site audits and linking the results to supplier evaluation significantly increase the validity of the assessment.