Check stability before capability

Calculate and interpret Cp and Cpk from explicitly supplied stable-normal parameters while keeping evidence prerequisites and acceptance authority separate.

A good-looking index is not a qualification record

Fictional case: a width process is supplied as stable and approximately normal with mean 10.01 mm and sigma .02 mm. Specifications are 9.90-10.10 mm. These parameters and the existing native distribution remain unchanged. Engineer Asha must explain why Cp and Cpk differ and whether either number authorizes production acceptance.

Your role and the reference condition

Quality engineer with the customer-requirements owner
Normal: Distribution, stability, measurement fitness, sampling and specification authority are established for the intended use before a capability conclusion is applied.
Gap: A slide presents 1.667 as a universal passing score and treats the six-point SPC illustration from another lesson as proof of this process's stability.

Work within these conditions

1. The parameters are supplied synthetic assumptions, not estimates from customer production.

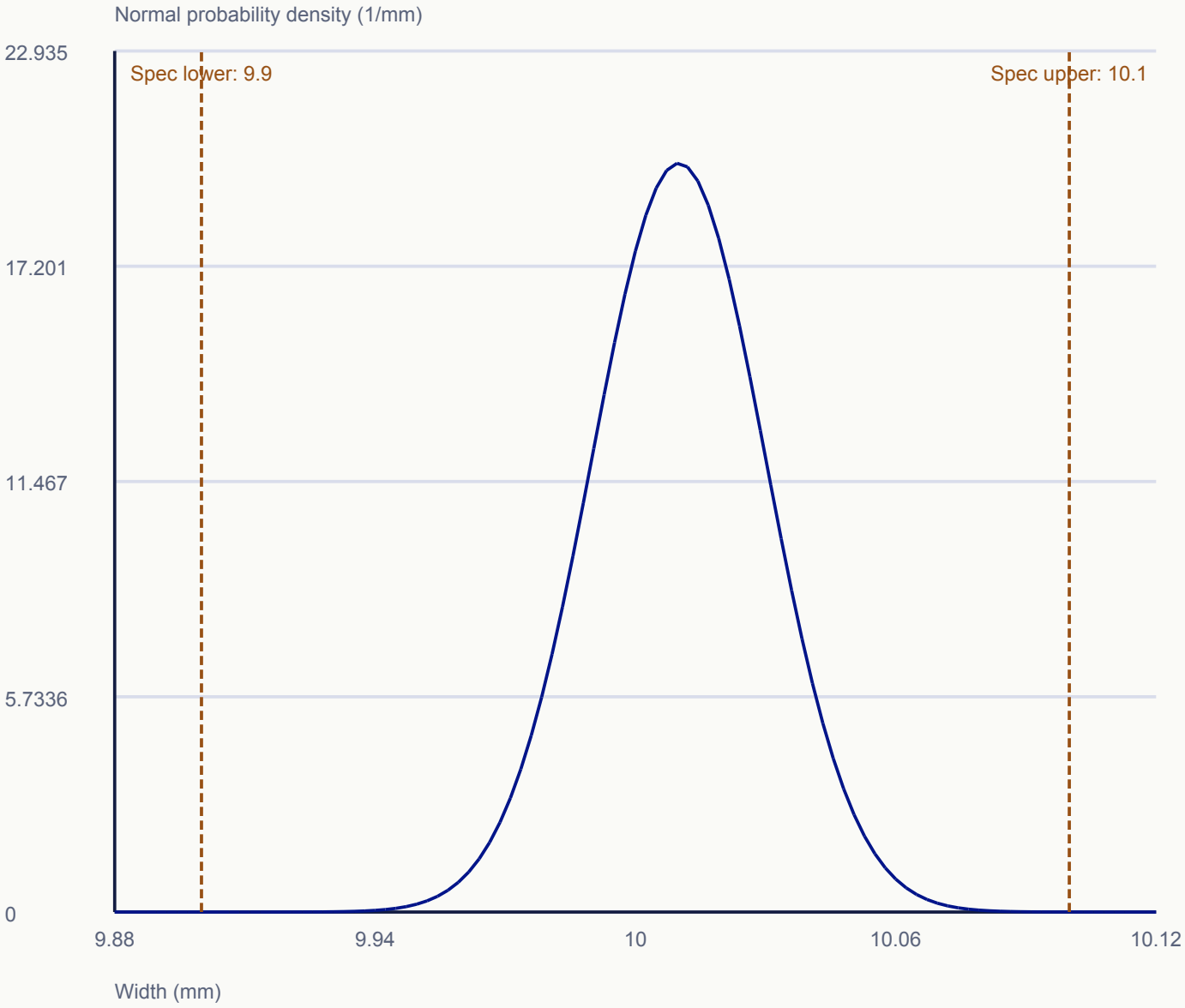
2. No universal acceptance threshold, confidence bound or customer approval is supplied.

Fictional teaching case. Supplied observations support the exercise; proposed actions are not verified customer results.

See how the method works

Capability compares a process distribution with stated specification limits. First establish that measurement is fit for the decision and that the process behaviour supports the chosen analysis. Cp compares specification width with six estimated standard deviations; Cpk also reflects how far the mean lies from the nearer specification. An attractive number does not cure instability, establish an applicable customer threshold or remove sampling uncertainty. State the estimator, distribution assumptions and study conditions when reporting results. This example supplies stable-normal parameters solely to demonstrate arithmetic. It is not evidence that a real process is qualified, approved or certain to produce no nonconforming output.

Supplied stable normal model / mean 10.01, sigma 0.02



Cp = (10.1 - 9.9) / (6 x 0.02) = 1.667

Cpk = min(10.1 - 10.01, 10.01 - 9.9) / (3 x 0.02) = 1.500

Synthetic supplied stable-normal parameters. Specification lines only; this is not an SPC chart. No universal pass threshold.

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Follow the evidence and decisions

Inspect the supplied case inputs

Parameter	Supplied value
Lower / upper specification	9.90 /10.10 mm
Process mean	10.01 mm
Sigma estimate	.02 mm
Assumed model	Stable normal process for this calculation exercise
Qualification decision	Not supplied

01 / Separate requirements from process estimates

Asha identifies specification width 10.10−9.90=.20 mm and records where the actual product requirements would come from. Mean and sigma describe the supplied process, not allowable product limits.

Why: The process distribution and customer tolerance are different authorities. Substituting control limits for specifications would make capability self-referential.

Evidence / check: The record names LSL, USL, mean and sigma separately.

02 / Check the interpretation prerequisites

She labels stable/normal/measurement-suitable as supplied exercise assumptions and lists the actual evidence needed before a real claim. She does not invent a baseline study.

Why: A calculated ratio remains arithmetic even when prerequisites are absent; its predictive capability interpretation would then be unsupported.

Evidence / check: A prerequisite checklist distinguishes given assumptions from verified workplace records.

03 / Calculate potential width ratio

Cp=.20/(6x.02)=1.6667, approximately 1.667. This compares specification width with the supplied six-sigma process spread.

Why: Cp alone does not locate the mean within the tolerance. A narrow distribution could still be shifted toward or beyond a specification.

Evidence / check: The formula retains millimetres in numerator and denominator before cancellation.

04 / Calculate the nearer-side ratio

Upper distance is 10.10−10.01=.09 mm; lower distance is 10.01−9.90=.11 mm.
Cpk=min(.09,.11)/(3x.02)=1.50.

Why: The upper side is closer. The smaller Cpk reflects this off-center mean without changing the supplied spread.

Evidence / check: The worked record identifies the limiting side and preserves both distances.

05 / Write a bounded decision

Asha reports the two indices under the stated assumptions and requests applicable acceptance requirements and appropriate uncertainty/evidence before a production decision.

Why: Neither number is a universal pass threshold. A capability calculation does not replace process control, customer conditions or the authorized release record.

Evidence / check: The report states synthetic calculation only and separates interpretation from acceptance.

Completed capability interpretation record

Calculation	Result	Interpretation
Specification width	.20 mm	External requirement range
Cp	.20/.12=1.667	Spread-only comparison
Nearer mean-to-limit distance	.09 mm upper side	Mean is off-center
Cpk	.09/.06=1.500	Nearer-side comparison
Acceptance	Not established	Applicable criteria and evidence required

The same spread drifts toward the upper limit

In a hypothetical comparison the mean becomes 10.07 mm while sigma remains .02 mm and specifications stay unchanged.

Decision

Cp remains 1.667; Cpk becomes .03/.06=.50. Treat any real drift through process investigation rather than celebrating the unchanged Cp.

Reasoning

The spread-only ratio cannot reveal loss of centering. A changing real process also challenges the stable-distribution premise.

What would change the decision?

The comparison identifies changed mean, unchanged spread and reduced nearer-side margin.

Practise with a changed case

A changed supplied distribution

New synthetic stable-normal parameters are mean 10.02 mm, sigma .025 mm and the same 9.90-10.10 mm specifications.

Parameter	Value
Mean	10.02 mm
Sigma	.025 mm
LSL / USL	9.90 /10.10 mm

Your task

1. Calculate Cp and Cpk and identify the limiting side.
2. Explain why a real unstable dataset should not receive the same interpretation.
3. Name the authority needed for a pass/fail decision.

Use the next page to record your reasoning before reading the answer.

Your practice worksheet

A changed supplied distribution

Assumptions and evidence

Tolerance width

Two mean-to-limit distances

Indices

Decision boundary

Complete your reasoning before turning to the answer. Use the separate learner workbook for group practice.

Check your reasoning and transfer it

1. Cp=.20/(6x.025)=1.3333. Cpk=min(.08,.12)/(.075)=1.0667; the upper side limits the result.

2. These are calculations under supplied assumptions. A real unstable process lacks the fixed-distribution basis of this simple interpretation; acceptance still depends on applicable customer/organizational requirements and suitable evidence.

Suggested completed record

Index	Calculation	Rounded result
Cp	.20/.15	1.333
Cpk	.08/.075	1.067

Plausible wrong turns

1. Cp does not account for centering.

2. A synthetic normal curve is not a measured qualification.

Evidence of a sound answer

1. Use the nearest specification distance.

2. Preserve sigma and specification meanings.

3. Avoid inventing a universal passing value.

Take the learning back to work

Commitment	Agreed follow-through
Owner	Capability-study owner with customer quality
Record	Study scope, measurement/baseline evidence, indices and applicable decision
Review	Before qualification and after material process changes
Verification evidence	Traceable data, suitable assumptions and authorized acceptance basis
If unresolved	Resolve instability or measurement gaps before using a capability index as decision evidence.

Help someone else apply the method

Prepare

1. Parameter cards
2. Calculator
3. Prerequisite/decision record

Minutes	Activity and coaching prompt
5	Identify the two authorities Which numbers come from requirements and which from the process?
8	Calculate both indices Why is the upper side limiting?
10	Work the changed case What does the calculation still not prove?
5	Debrief drift Why can Cp stay constant while risk changes?

Debrief

1. Require the learner to name the supplied assumptions.
2. Do not award a pass/fail verdict without stated applicable criteria.

Individual or remote practice

Draw the two mean-to-limit distances before calculating Cpk.

Connect the method and check its boundaries

Before application

1. Fit measurement and justified stability
2. Stated specifications and distribution/estimator assumptions

Outside this lesson

1. A universal customer threshold
2. Qualification of an unstable process

NIST: Process capability

NIST: Process capability

Capability compares a stable process distribution with specification limits; common indices require explicit distribution and sampling assumptions.

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Open this lesson and its visual aids