Process capability study — bore diameter, part 4471

All records

CAPSULEM8
CM8-291 · Process Capability Study
August 9, 2026

READINGS USED
11
1 excluded · 12 recorded · provisional only

MEAN AND SIGMA
25.0086
s 0.00832 overall · 0.00551 within subgroups

CPK (OVERALL SIGMA)
0.86
Not capable · minimum acceptable 1.33 · two-sided

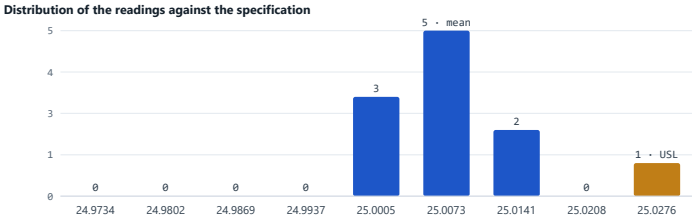
CP (OVERALL SIGMA)
1.20
Cp minus Cpk shows the centring loss: 0.35

OUT OF SPECIFICATION
1 of 11
9.1 % of the readings used — the empirical check on the index

ESTIMATED DEFECTS
5,129 ppm
estimate from the normal model · observed 90,909 ppm

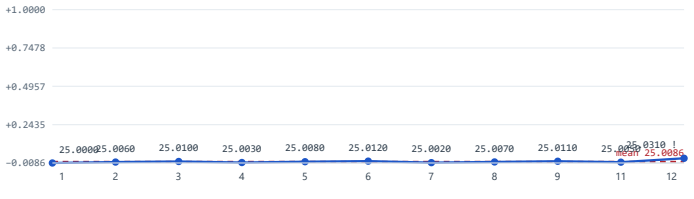
12 of 12 record(s) included. All records. Amounts in USD.

Distribution of the readings against the specification



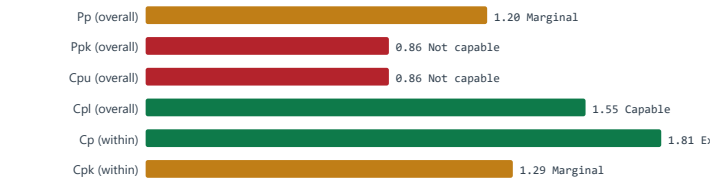
Read this before you believe any index. Bin midpoints along the bottom, count of readings up the side. LSL 24.9700. USL 25.0300. Mean 25.0086. Bins lying wholly outside a limit are red, a bin a limit falls inside is amber and names it, everything inside is blue. A single hump with the limits well clear of the tails is what the indices assume; two humps, a long tail or a wall at one end means the arithmetic below is describing a distribution your process does not have.

Every reading in sample order



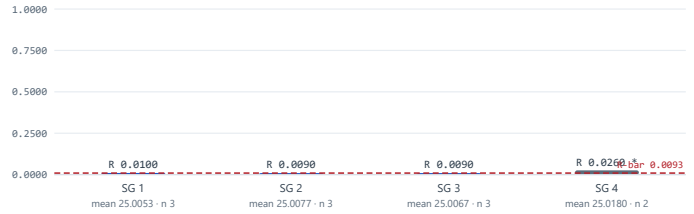
The drift a histogram hides. Sample number along the bottom, the reading's distance from the mean up the side; the dashed line is the mean itself and each point is labelled with its actual value. A histogram cannot show order, so a process that has walked steadily from one end of the tolerance to the other looks merely wide in it. A trend, a step or a run of points on one side here means the process is not stable, and a capability index computed from an unstable process describes a period rather than a process. Readings marked with an exclamation mark fell outside a specification limit. Excluded readings are not plotted.

The capability indices side by side



Every index this study can compute, in one place. Overall indices use the sample standard deviation of every reading, s = 0.00832 — long-term capability, which is properly called Pp and Ppk. Within-subgroup sigma is 0.00551, from R-bar divided by d2 over 3 subgroups of 3 — short-term capability, properly called Cp and Cpk. The gap between the two pairs is what the process does between subgroups: drift, tool wear, setting changes, shift and batch effects. Bars are red below 1.00, amber below 1.33 and green above it.

Subgroup spread, or the specification split



The variation the within-subgroup sigma is built from. The height of each bar is that subgroup's range — its largest reading minus its smallest — with the subgroup mean and size printed underneath. The dashed line is R-bar, the average range over the 3 subgroups of 3 readings, 0.0093; divided by d2 = 1.693 it gives the within-subgroup sigma 0.00551 that the within Cp and Cpk use. Grey bars marked with an asterisk are subgroups of a different size and are left out of R-bar, because d2 depends on the size. Ranges that jump about mean the subgroups are not describing one process; subgroup means that walk up or down while the ranges stay small mean the process is drifting between subgroups, which is exactly the difference between Cpk and Ppk.

Capability summary

MEASURE	VALUE	HOW IT WAS WORKED OUT
Readings used	11	1 reading(s) excluded and left out of every index
Process mean	25.0086	Sum of the readings divided by 11
Overall sigma (s)	0.00832	Sample standard deviation of all 11 readings, divisor n − 1
Within-subgroup sigma	0.00551	R-bar 0.00933 ÷ d2 1.693 from 3 subgroups of 3
Lower specification limit	24.9700	From Settings
Nominal or target	25.0000	Mean is +0.0086 from nominal
Upper specification limit	25.0300	From Settings
Tolerance width	0.0600	USL − LSL
Pp — overall potential	1.20	(USL − LSL) ÷ 6s — spread only, centring ignored
Ppk — overall actual	0.86	The lower of Cpu and Cpl below · Not capable · minimum acceptable 1.33
Cpu — upper side (overall)	0.86	(USL − mean) ÷ 3s
Cpl — lower side (overall)	1.55	(mean − LSL) ÷ 3s
Cp — within-subgroup	1.81	(USL − LSL) ÷ 6 × within-subgroup sigma
Cpk — within-subgroup	1.29	The lower of the two within-subgroup sides · Marginal
Cpu — within-subgroup	1.29	(USL − mean) ÷ 3 × within-subgroup sigma
Cpl — within-subgroup	2.34	(mean − LSL) ÷ 3 × within-subgroup sigma
Estimated defective parts per million	5,129	Normal model: the tail area beyond each limit at this mean and sigma. An estimate, and only as good as the assumption that the distribution is normal
Readings observed outside the limits	1 of 11	9.1 % — 90,909 ppm observed, against 5,129 ppm estimated
Verdict	Not capable — below your minimum	Based on the overall Ppk, which this tool also reports as Cpk on the tiles

Readings

SAMPLE	DATE	READING	DEV. FROM NOMINAL	SPECIFICATION	SUBGROUP	EXCLUDED	REASON
1	2026-07-31	25.0000	+0.0000	In spec	1		
2	2026-07-31	25.0060	+0.0060	In spec	1		
3	2026-07-31	25.0100	+0.0100	In spec	1		
4	2026-08-01	25.0030	+0.0030	In spec	2		
5	2026-08-01	25.0080	+0.0080	In spec	2		
6	2026-08-01	25.0120	+0.0120	In spec	2		
7	2026-08-02	25.0020	+0.0020	In spec	3		
8	2026-08-02	25.0070	+0.0070	In spec	3		
9	2026-08-02	25.0110	+0.0110	In spec	3		
10	2026-08-03	25.0380	+0.0380	Out of spec	4	✓	Bore gauge not zeroed on the setting ring after the shift change; reading is about 0.03 mm high.
11	2026-08-03	25.0050	+0.0050	In spec	4		
12	2026-08-03	25.0310	+0.0310	Out of spec	4		

Measured readings

STUDY	CHARACTERISTIC	PROCESS	READING	SAMPLE	DATE	OPERATOR	SUBGROUP	EXCLUDED	REASON	DEVIATION FROM NOMINAL	OUT OF SPECIFICATION	EXCLUDED
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0000	1	2026-07-31	A. Bergström	1	No	—	0.0000	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0060	2	2026-07-31	A. Bergström	1	No	—	0.0060	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0100	3	2026-07-31	A. Bergström	1	No	—	0.0100	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0030	4	2026-08-01	A. Bergström	2	No	—	0.0030	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0080	5	2026-08-01	A. Bergström	2	No	—	0.0080	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0120	6	2026-08-01	A. Bergström	2	No	—	0.0120	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0020	7	2026-08-02	P. Nakamura	3	No	—	0.0020	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0070	8	2026-08-02	P. Nakamura	3	No	—	0.0070	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0110	9	2026-08-02	P. Nakamura	3	No	—	0.0110	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0380	10	2026-08-03	P. Nakamura	4	Yes	Bore gauge not zeroed on the setting ring after the shift change; reading is about 0.03 mm high.	0.0380	Out of spec	Excluded
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0050	11	2026-08-03	P. Nakamura	4	No	—	0.0050	In spec	–
Bore diameter capability, part 4471	Bore diameter (mm)	CNC lathe 3, op 20 reamed bore	25.0310	12	2026-08-03	P. Nakamura	4	No	—	0.0310	Out of spec	–

Notes

Sample study — twelve readings is provisional, not a finished capability study; thirty or more taken across several set-ups is the usual minimum. Note that the mean sits well above the nominal, which is why Ppk is far below Pp, and that one reading is genuinely outside the upper limit while the normal model predicts far fewer. Replace every reading with your own before relying on anything here.

A capability index is a model, not a measurement. Cp, Cpk, Pp, Ppk and the parts-per-million figure all assume the readings come from one stable process with a roughly normal distribution — and a skewed, bimodal, drifting or out-of-control process breaks that assumption without changing the number the arithmetic produces. The histogram and the count of readings actually outside the limits are the reality check: if they disagree with the index, trust the data and not the index. Nothing here can tell you whether the process was stable while you measured, whether the gauge was capable of the resolution you recorded, or whether the specification is the one the customer holds you to. This is a calculation and record-keeping aid, not an engineering judgement, and it is not a substitute for a control chart, a measurement systems analysis or a competent statistician where the decision is a costly one.