

ISO tolerance *grades*.

ISO 286 tolerance reference — **IT grade values** across nominal size ranges, plus **common hole and shaft fits** (H7, h6, k6, n6, etc.) with actual dimensional values. The system everyone in metric machining uses, demystified.

IT grade values by size range

Each "IT grade" defines the *total tolerance band width* for a given nominal size. Lower numbers = tighter tolerance. IT5 is precision-ground; IT7 is standard machining; IT11 is rough casting. All values in micrometers (μm).

NOMINAL SIZE	IT5	IT6	IT7	IT8	IT9	IT10	IT11
≤ 3 mm	4 μm	6 μm	10 μm	14 μm	25 μm	40 μm	60 μm
3–6 mm	5 μm	8 μm	12 μm	18 μm	30 μm	48 μm	75 μm
6–10 mm	6 μm	9 μm	15 μm	22 μm	36 μm	58 μm	90 μm
10–18 mm	8 μm	11 μm	18 μm	27 μm	43 μm	70 μm	110 μm
18–30 mm	9 μm	13 μm	21 μm	33 μm	52 μm	84 μm	130 μm
30–50 mm	11 μm	16 μm	25 μm	39 μm	62 μm	100 μm	160 μm
50–80 mm	13 μm	19 μm	30 μm	46 μm	74 μm	120 μm	190 μm
80–120 mm	15 μm	22 μm	35 μm	54 μm	87 μm	140 μm	220 μm
120–180 mm	18 μm	25 μm	40 μm	63 μm	100 μm	160 μm	250 μm

NOMINAL SIZE	IT5	IT6	IT7	IT8	IT9	IT10	IT11
180–250 mm	20 μm	29 μm	46 μm	72 μm	115 μm	185 μm	290 μm

Common fits at Ø25 mm (worked example)

Same tolerance grade gives different actual dimensions depending on the nominal size. Below are the most-used hole and shaft tolerances *worked out at Ø25* — copy the pattern and re-derive for your nominal size using the IT grade table above.

TOLERANCE	TYPE	UPPER Δ	LOWER Δ	ACTUAL SIZE AT Ø25	USE
H7	Hole	+21	0	25.000 to 25.021	Standard ground hole. The reference for most fits.
H8	Hole	+33	0	25.000 to 25.033	Machined hole, looser tolerance.
H9	Hole	+52	0	25.000 to 25.052	Coarser machined hole, free fit.
H11	Hole	+130	0	25.000 to 25.130	Cast or rough hole. Drilled-only OK.
h6	Shaft	0	-13	24.987 to 25.000	Precision shaft, ground.
h7	Shaft	0	-21	24.979 to 25.000	Standard ground shaft.
h9	Shaft	0	-52	24.948 to 25.000	Turned shaft.
g6	Shaft	-7	-20	24.980 to 24.993	Slight clearance. Used for sliding fit.
f7	Shaft	-20	-41	24.959 to 24.980	Free running with lubrication.
k6	Shaft	+15	+2	25.002 to 25.015	Transition fit, light press.
n6	Shaft	+28	+15	25.015 to 25.028	Medium press fit, requires arbor press.
p6	Shaft	+35	+22	25.022 to 25.035	Press fit, permanent assembly.

TOLERANCE	TYPE	UPPER Δ	LOWER Δ	ACTUAL SIZE AT Ø25	USE
s6	Shaft	+48	+35	25.035 to 25.048	Heavy press / shrink fit, requires heating.

Reading the system. Each tolerance is two parts: a *letter* for the position of the tolerance band relative to nominal (uppercase H, K, N for holes; lowercase h, k, n for shafts) and a *number* for the IT grade (the band's width). So "H7" is a hole with the band starting at nominal, IT grade 7 wide. "h7" is a shaft with the band ending at nominal, IT grade 7 wide. "H7/h7" describes a clearance fit of 0 to 21 μm at Ø10–18 mm, or 0 to 21 μm at Ø18–30 mm — wider at larger nominal sizes.

Common fits and what they're for

FIT DESIGNATION	TYPE	USE CASE
H11/c11	Loose running	Rough applications, large clearance, e.g. agricultural shafts
H9/d9	Free running	Standard journal bearing fit
H8/f7	Close running	Precision running fit with light load and lubrication
H7/g6	Sliding	Easy to assemble, no significant force; locating slides
H7/h6	Locational clearance	Easy assembly, can rotate freely; gauge blocks
H7/k6	Transition (light press)	Press-on assembly, removable with arbor press
H7/n6	Transition (medium press)	Light interference; small motor / pulley fit
H7/p6	Press	Permanent assembly, requires substantial force

FIT DESIGNATION	TYPE	USE CASE
H7/s6	Heavy press / shrink	Shaft heated for assembly; gear hub on shaft

Common pitfalls

- **Uppercase and lowercase aren't optional.** H7 (hole) and h7 (shaft) are different tolerances. A drawing that says just "7" is ambiguous and wrong.
- **The same fit gives different clearance at different sizes.** H7/h7 at Ø10 is up to 18 μm of clearance; at Ø250 it's up to 92 μm. Don't memorize "H7/h7 = 21 μm" — that's only true at Ø18–30 mm.
- **Hole-basis (H) is the standard.** Industry convention is to use H as the hole tolerance and adjust the shaft. Hole tools (reamers, broaches) come in standard sizes; shafts are easier to grind to size.
- **"Press fit" depends on materials and surface finish.** A theoretically valid press fit (e.g. H7/p6) can still gall, score, or seize if the surface finish is rough or the materials are similar (steel-on-steel without lubrication). The tolerance band alone doesn't guarantee success.
- **ISO 286 isn't the same as ANSI/ASME Y14.5 GD&T.** ISO 286 is for size tolerances on cylindrical features. GD&T is the broader system for geometric tolerances (flatness, parallelism, true position). They're complementary, not competing.

Common questions

What does 'H7/g6' mean on an engineering drawing?

It's an ISO 286 hole/shaft fit. H7 is the hole tolerance — the upper-case letter (H) sets the position relative to nominal size (H = lower limit at nominal), the number (7) sets the precision class. g6 is the shaft tolerance — lower-case g positions the shaft slightly below nominal, grade 6 is tighter. Together H7/g6 creates a 'sliding fit' with small clearance.

What's the difference between IT6 and IT7?

IT (International Tolerance) grades define the size of the tolerance zone in micrometers. IT6 is tighter than IT7. For a 30 mm dimension, IT6 = 13 μm, IT7 = 21 μm. Lower IT numbers are tighter, achievable through better machining processes. IT5 and below typically need grinding; IT11+ can be done with rough turning.

How tight is 'press fit' vs 'sliding fit'?

Press fit (typical H7/p6) has interference — the shaft is slightly bigger than the hole, requiring force to assemble. Sliding fit (H7/g6) has small clearance — fits by hand, slides smoothly. Loose running fit (H11/c11) has large clearance for thermal expansion or rough manufacturing. Choose based on whether you need motion, location, or torque transmission.

Why are tolerances asymmetric — why not just ± 0.05 ?

ISO basic-hole and basic-shaft systems use one-sided tolerances because most fits work by adjusting one part to match a standard. A H7 hole is always at nominal-or-larger, never smaller. Choosing matching shaft tolerances (g6, h6, k6, p6, etc.) controls whether the fit is clearance, transition, or interference. This is more rigorous than symmetric tolerances for assembly.

Can I just use ± 0.05 instead of looking up ISO tolerances?

For prototypes or non-critical parts, yes. For production parts that need to interchange, ISO tolerances are how machinists, suppliers, and inspectors communicate. A drawing with ± 0.05 doesn't specify which limit matters most — a shaft 30.05 may be unacceptable in one assembly but fine in another. ISO codes make intent unambiguous.

Sources

- **IT grade values:** ISO 286-1:2010 — Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 1: Basis of tolerances, deviations and fits, Table 1.
- **Fundamental deviations:** ISO 286-1:2010, Tables 2-6 (shaft and hole deviations).
- **Recommended fits:** ISO 286-2:2010 — Tables of standard tolerance classes and limit deviations for holes and shafts.
- **US equivalent:** ANSI B4.2 (preferred metric limits and fits) uses the same ISO 286 system; ANSI B4.1 (older inch system) does not.

Disclaimer. Tolerance values shown are nominal per ISO 286-1:2010. For production drawings, always verify against the current standard and confirm with your manufacturer that the specified tolerance is achievable with their process.