Slidura

Cast bronze bushings · sleeve · flanged · thrust washers

Cast Bronze Bushings – Design and Lubrication Guide

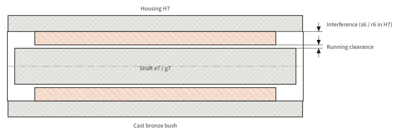
ISO fits · interference · clearance · installation · grease, oil and groove patterns G1 – G8

A press-fitted bronze bush is a chain of three tolerances: the housing bore, the bush outside diameter and the bush bore, closed by the shaft. Interference between housing and bush holds the bush; the same interference shrinks the bore; what is left between shrunk bore and shaft is the running clearance. Get the chain wrong at any link and the bush either walks, seizes or wears out early.

Standard fit guidelines (ISO)

ISO 4379 fixes the fit system for copper-alloy bushes and it is what we machine to unless the drawing says otherwise. The housing is H7, the bush outside diameter s6 to Ø120 mm and r6 above (the larger the diameter, the smaller the relative interference), the bore E6 – deliberately wide so that after pressing it lands near H8 – and the shaft e7 for general duty or g7 where a smaller clearance is wanted. In inch practice the same fit is described as "0.0005 – 0.001 in of interference per inch of diameter" and "0.001 in of clearance per inch of shaft".

For your enquiry: Send your housing and shaft tolerances – we machine the bush to fit them, not the other way round.



Housing H7 · bush outside s6 / r6 · bore E6 closing to approx. H8 · shaft e7 / e8 / g7. Interference holds the bush; what is left between the closed bore and the shaft is the running clearance.

Element	ISO 4379	Purpose	Inch rule of thumb
Housing bore	H7	reference; chamfered edge, Ra max. 1.6 µm	nominal +0.0005 … +0.0015 in
Bush outside Ø	s6 (max. Ø120) · r6 (> Ø120)	press fit that holds under load and heat	OD = housing + 0.0005 … 0.001 in per inch
Bush bore as delivered	E6	closes to approx. H8 when pressed	finish bore 0.001 – 0.002 in oversize
Shaft	e7 general · e8 heavy / hot / dirty · g7 precision	sets the running clearance	0.001 in per inch of shaft (0.0015 – 0.002 heavy)
Flange Ø	d11	clearance in the counterbore	—
Length	h13	turned faces	—

How much interference – by diameter

The table below is calculated from the ISO 286-2 deviations: s6 / r6 bush in an H7 housing. Read it as the range you will get with standard parts; a specific pair of measured parts lands somewhere inside it. The relative interference falls from 14 – 48 µm at Ø20 (0.07 – 0.24 %) to 31 – 106 µm at Ø200 (0.015 – 0.05 %), which is what a bronze bush needs: enough to stay put under the load and the thermal expansion of bronze (18×10^{-6} /K, 50 % more than steel), not so much that a thin wall yields.

Adjust when: the wall is thin (D/d < 1.15 – take the low end or p6), the housing is aluminium (expands with the bush – use r6 / s6 fully and add a keeper for heat), the housing is a thin ring that would stretch (reduce), or the position runs above 100 °C (bronze expands more than the steel housing and tightens further – the fit can be lighter). "Is 0.002 in a good press fit?" – for a 1 – 2 in bush, yes: 0.05 mm is inside the s6 / H7 band at Ø40 (18 – 59 µm); for a 4 in bush (Ø100: 36 – 93 µm) it is at the low end, for a 1/2 in bush (Ø12: 10 – 39 µm) too much.

For your enquiry: Give the housing material and the operating temperature if either is unusual.

Bore d	Outside D medium wall	Housing H7 µm	Bush D s6 / r6 µm	Interference µm	Relative % of D
10	14	+18 / 0	+39 / +28	10 – 39	0.071 – 0.28 %
12	16	+18 / 0	+39 / +28	10 – 39	0.063 – 0.24 %
16	20	+21 / 0	+48 / +35	14 – 48	0.07 – 0.24 %
20	24	+21 / 0	+48 / +35	14 – 48	0.058 – 0.20 %
25	30	+21 / 0	+48 / +35	14 – 48	0.047 – 0.16 %
30	36	+25 / 0	+59 / +43	18 – 59	0.05 – 0.16 %
35	41	+25 / 0	+59 / +43	18 – 59	0.044 – 0.14 %
40	48	+25 / 0	+59 / +43	18 – 59	0.037 – 0.12 %
50	58	+30 / 0	+72 / +53	23 – 72	0.04 – 0.12 %
60	70	+30 / 0	+78 / +59	29 – 78	0.041 – 0.11 %
70	80	+30 / 0	+78 / +59	29 – 78	0.036 – 0.10 %
80	90	+35 / 0	+93 / +71	36 – 93	0.04 – 0.10 %
100	115	+35 / 0	+101 / +79	44 – 101	0.038 – 0.09 %
120	135	+40 / 0	+88 / +63	23 – 88	0.017 – 0.07 %
150	165	+40 / 0	+93 / +68	28 – 93	0.017 – 0.06 %
180	200	+46 / 0	+106 / +77	31 – 106	0.015 – 0.05 %
200	220	+46 / 0	+109 / +80	34 – 109	0.015 – 0.05 %

ISO 286-2 deviations, upper / lower, for the nominal size of D. Standard parts land anywhere in the range; measured parts can be calculated on request.

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The bore closes after pressing

A pressed bush transfers most of its interference to the bore: for a thin wall (D/d approx. 1.1 – 1.2) reckon 80 – 100 % of the diametral interference, for a thick wall (D/d > 1.5) 50 – 70 %. Example: Ø40 × Ø48 × 40 bush, s6 in H7 – interference 18 – 59 µm, so the bore closes by roughly 15 – 55 µm. Delivered at E6 (Ø40: +50 … +66 µm) it lands at about 0 … +50 µm, close to H8 (0 … +39) – which is why ISO 4379 tolerances the bore E6 in the first place.

For a position where several bushes must line up, or the clearance must be closer than the sum of these bands allows, order the bore with 0.1 – 0.3 mm stock and ream or bore it in place after pressing. Machining a solid bronze bush in place is routine; a lined or sintered bush cannot be treated this way.

Running clearance

Cast bronze under grease wants more clearance than a rolling bearing engineer expects: 0.1 – 0.3 % of the shaft diameter, i.e. 40 – 90 µm at Ø30 and 100 – 250 µm at Ø100. Too little and the grease film cannot form, heat has nowhere to go and the bush seizes as the bronze expands; too much and the load concentrates on a narrow strip and the shaft hammers. The table below gives the clearance of a bore at about H8 after fitting against an e7 shaft; take e8 (about 50 % more) for hot positions, misalignment and dirty grease, g7 for oil-lubricated precision spindles.

"How much clearance for a bronze bushing?" – start at 0.001 in per inch of shaft (0.1 %), add 50 % for heat, dirt or an aluminium bronze / C86300 bush, which do not conform. Never run a bronze bush at zero clearance.

Running clearance by diameter – bore approx. H8 after fitting

calculated from ISO 286-2 · e7 general duty · e8 heat, dirt, misalignment · g7 oil-lubricated precision

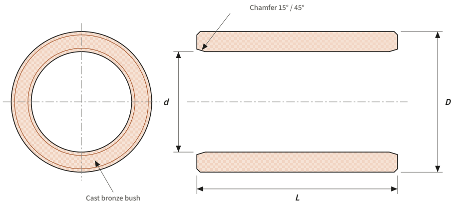
Bore d	Bore E6 as delivered, µm	Bore approx. H8 after pressing, µm	Shaft e7 µm	Clearance e7 µm	Clearance e8 µm	Clearance g7 µm	e7 relative % of d
10	+34 / +25	+22 / 0	−25 / −40	**25 – 62**	25 – 69	5 – 42	0.25 – 0.62 %
12	+43 / +32	+27 / 0	−32 / −50	**32 – 77**	32 – 86	6 – 51	0.267 – 0.64 %
16	+43 / +32	+27 / 0	−32 / −50	**32 – 77**	32 – 86	6 – 51	0.2 – 0.48 %
20	+53 / +40	+33 / 0	−40 / −61	**40 – 94**	40 – 106	7 – 61	0.2 – 0.47 %
25	+53 / +40	+33 / 0	−40 / −61	**40 – 94**	40 – 106	7 – 61	0.16 – 0.38 %
30	+53 / +40	+33 / 0	−40 / −61	**40 – 94**	40 – 106	7 – 61	0.133 – 0.31 %
35	+66 / +50	+39 / 0	−50 / −75	**50 – 114**	50 – 128	9 – 73	0.143 – 0.33 %
40	+66 / +50	+39 / 0	−50 / −75	**50 – 114**	50 – 128	9 – 73	0.125 – 0.28 %
50	+66 / +50	+39 / 0	−50 / −75	**50 – 114**	50 – 128	9 – 73	0.1 – 0.23 %
60	+79 / +60	+46 / 0	−60 / −90	**60 – 136**	60 – 152	10 – 86	0.1 – 0.23 %
70	+79 / +60	+46 / 0	−60 / −90	**60 – 136**	60 – 152	10 – 86	0.086 – 0.19 %
80	+79 / +60	+46 / 0	−60 / −90	**60 – 136**	60 – 152	10 – 86	0.075 – 0.17 %
100	+94 / +72	+54 / 0	−72 / −107	**72 – 161**	72 – 180	12 – 101	0.072 – 0.16 %
120	+94 / +72	+54 / 0	−72 / −107	**72 – 161**	72 – 180	12 – 101	0.06 – 0.13 %
150	+110 / +85	+63 / 0	−85 / −125	**85 – 188**	85 – 211	14 – 117	0.057 – 0.13 %
180	+110 / +85	+63 / 0	−85 / −125	**85 – 188**	85 – 211	14 – 117	0.047 – 0.10 %
200	+129 / +100	+72 / 0	−100 / −146	**100 – 218**	100 – 244	15 – 133	0.05 – 0.11 %

Never run a cast bronze bush at zero clearance. The e7 column is the range to expect with standard parts; for aluminium bronze and C86300, which do not conform, take the e8 column. Where the shaft is the given part, we adjust the bore.

Wall thickness, chamfers and lead-in

ISO 4379 gives three walls per bore: at Ø25 the outside diameters are 28, 30 and 32 (walls 1.5, 2.5 and 3.5 mm), at Ø100 they are 110, 115 and 120 (5, 7.5 and 10 mm), at Ø200 they are 210, 220 and 230. The thin wall suits space-limited housings and thin-wall pressing; the medium and thick walls carry heavier housings, edge loading, grooves and re-machining allowance. Below about 1.5 mm a cast bronze bush is difficult to press without collapse; above about 0.15 × d the bush stops conforming and the housing must be accurate.

Chamfers: 45° × 0.3 – 2 mm on the outside for lead-in, 15° × 1 – 5 mm on the bore to guide the shaft and keep grease from being wiped out (values per ISO 4379). Chamfer the housing edge too – a sharp housing edge shaves the bush and starts a crack. Press from the chamfered end, with the flange side first on flanged bushes.



ISO 4379 Type C: three outside diameters per bore; chamfers 45° outside (c 0.3 – 2 mm) and 15° inside (1 – 5 mm).

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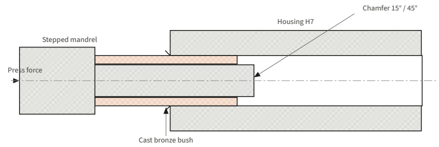
Installation methods: press, shrink fit, adhesive

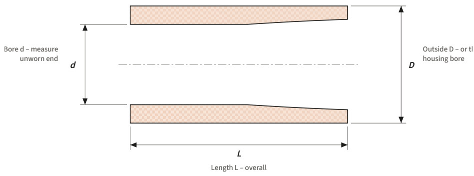
Press fit: a hydraulic or arbor press with a stepped mandrel that pilots in the bore and pushes on the end face; align the bush square before it enters; press steadily, never hammer on the bronze (it flares the end and cracks the wall). Press force estimate: F approx. $\mu \times p \times \pi \times D \times L$, with μ approx. 0.15 for dry bronze on steel and p the contact pressure from the interference – we calculate it for your sizes on request; light oil on the outside diameter halves the force and does not loosen the fit.

Shrink fit: heat the housing (steel: up to 150 °C is harmless; 100 °C at Ø100 opens the bore by 0.12 mm) or cool the bush in dry ice (−78 °C shrinks a Ø100 bronze bush by about 0.18 mm) and drop the bush in; the fit is then the full interference without any pressing damage – the usual method above Ø150 mm. Do not heat a bronze bush above 250 °C.

Adhesive: an anaerobic retaining compound can replace part of the interference (a slide fit plus adhesive) for thin housings, aluminium housings or repairs of oversize bores; it does not survive above about 150 °C or repeated shock and is not a substitute for a proper press fit on a heavily loaded pin. Anti-rotation: the flange, a dowel or a grub screw in a drilled spot when the fit alone is doubtful.



Stepped mandrel piloting in the bore, force on the end face, bush square to the housing. Light oil on the outside halves the press force.



Replacing a worn bush without a drawing: measure the bore at the unworn end, the outside diameter (or the housing bore) and the overall length; note grooves and holes.

Shaft: hardness and surface finish

The shaft must be the harder partner. Leaded tin bronze and gunmetal (55 – 75 HB) run on unhardened or quenched-and-tempered steel of 150 – 200 HB; tin and phosphor bronzes (90 HB) want 250 HB or better; aluminium bronze and C86300 (150 – 225 HB) need a hardened and ground shaft of 300 HB minimum, typically 45 – 55 HRC, or hard chrome. Surface finish Ra 0.8 µm or finer, Ra 0.4 for the hard alloys at higher speed; a rough shaft acts as a file on the bronze, a polished shaft carries the grease film. Stainless shafts run well on gunmetal and tin bronze; on aluminium bronze they gall unless hardened.

Large-diameter bushings above Ø200 mm

Above the ISO series the relative interference keeps falling (r6 in H7 gives 0.015 – 0.05 %) and shrink fitting replaces pressing. Large bushes are machined with a wall of 5 – 10 % of the bore, the outside to r6 or to a slide fit with a keeper, and the bore often finished in place after the housing is bored. Walls flex during transport: measure the bush and the housing before fitting, and expect a Ø500 bush to be 0.1 – 0.2 mm out of round when unrestrained – it becomes round in the housing. Half bearings and segmented rings are made where a one-piece bush cannot be fitted.

Important things to remember

1. Housing H7, bush s6 / r6, bore E6 as delivered, shaft e7 / e8 – or say what you use instead
2. Chamfer the housing edge and press from the chamfered / flanged end with a mandrel – never hammer
3. Expect the bore to close by 50 – 100 % of the interference; measure it after pressing on precision positions or order it for finishing in place
4. Running clearance 0.1 – 0.3 % of the diameter; more for heat, dirt and hard alloys
5. Shaft harder than the bush: plain steel for 660 and LG2, hardened 300 HB+ for aluminium bronze and C86300
6. Shaft Ra 0.8 µm or better; a rough shaft destroys any bronze
7. Oil hole and grooves outside the load zone; relubricate before the old grease is gone
8. Above Ø150 shrink-fit instead of pressing; above Ø200 consider finishing the bore in place

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Is bronze self-lubricating? No. Sintered oil-impregnated bronze, graphite-plugged bronze and metal-polymer bushes are self-lubricating because lubricant is stored inside the material; a machined cast bronze bush has no reservoir and depends on external grease or oil. In return it carries three to four times the load of a sintered bush and can be re-machined, re-grooved and re-greased for decades.

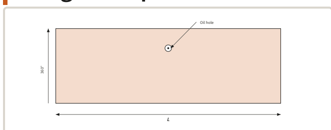
Grease or oil?

Types and principles, not brands: any major lubricant maker has a product in each row. Confirm compatibility with seals and with the previous grease before changing.

Duty	Lubricant type	Selection principle	Groove pattern
Slow oscillation, intermittent, outdoors, dirt	Grease, NLGI 2, lithium or lithium-complex, base oil ISO VG 150 – 460	High base-oil viscosity for the film, EP additives above ~10 N/mm^2, water-resistant thickener outdoors	G1 short bushes · G2 straight · G4 figure-eight
Heavy shock load, low speed	Grease NLGI 1 – 2 with EP and solid additives (MoS_2, graphite)	Solid additives bridge boundary contacts at start-up and under shock	G5 double figure-eight · G8 pockets
Continuous rotation, moderate speed	Oil, ISO VG 68 – 220, circulating or oil bath / wick	Viscosity for the speed–load combination; film thickness first, then cooling	G6 spiral · G3 circumferential with pressure feed
High temperature 120 – 250 °C	High-temperature grease (polyurea / bentonite, synthetic base oil) or oil with suitable flash point	Above ~150 °C most greases oxidise fast – shorten the interval or consider a graphite-plugged bush	G3 · G4 with generous reservoirs
Water, seawater, wet product	Water-resistant grease (calcium sulfonate, aluminium complex) or medium lubrication	Choose a wash-out resistant grease; alloy matters as much – LG2 or aluminium bronze	G2 · G4; consider medium-lubricated plain bore
Food, drink, pharma	H1 food-grade grease or oil	Same principles, registered lubricant; lead-free alloy (CuSn12, aluminium bronze)	G1 · G2

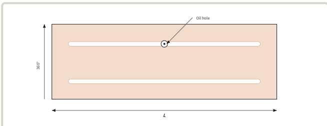
Oil groove patterns and when to use each

code on the drawing or in the order code suffix, e.g. 660-404840-G2



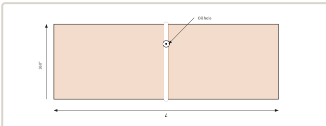
G1 Plain bore – no grooves

Short bushes (L max. d), grease-packed on assembly, low speed; also bores finished in place. Grease is held by the running clearance and the chamfers.



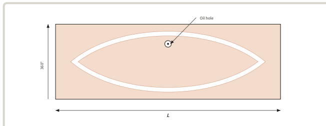
G2 Straight axial grooves

Oscillating pins and long bushes; one to four grooves in the unloaded zone, stopping short of the ends. Spreads grease along the length, easy to machine, the default for excavator and agricultural pins.



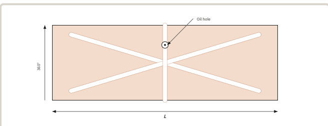
G3 Circumferential groove

One ring groove at mid-length, fed by the oil hole; for rotation with a load direction that changes and for pressure-fed oil, since the ring distributes to the whole circumference. Not for grease-only oscillation (the grease sits in the ring).



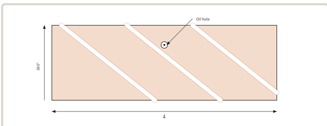
G4 Figure-eight (crossed) grooves

The all-round grease pattern for rotating and oscillating bushes: two crossing diagonal grooves distribute grease both axially and around the bore and wipe fresh grease into the load zone at each stroke.



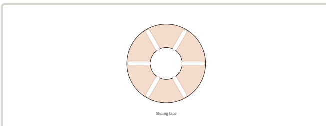
G5 Double figure-eight / X-and-ring

Figure-eight plus a ring groove or a second X for heavily loaded, intermittently moving bushes under boundary lubrication – more reservoir volume and more edges to redistribute grease; for large bores above Ø80.



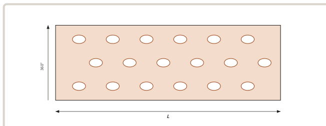
G6 Spiral (helical) groove

Continuous rotation in one direction, oil lubricated: the helix pumps oil along the bore from the feed end. Also used to carry grease through long rotating bushes. Hand of the helix follows the shaft rotation.



G7 Radial face grooves (thrust washers, flange faces)

Four to eight radial grooves on a sliding face, from the bore towards the outside without breaking through, so that grease is carried under the rotating counterface. Standard on thrust washers and on the flange face of bushes that take axial load.



G8 Grease pockets (dimples)

Drilled or milled pockets in the unloaded half of the bore act as separate reservoirs for slow, very heavily loaded bushes – crane pivots, press bushes, mould guides – where a groove would cut the bearing area too much.

Codes G2 – G8 are the order-code suffix (660-404840-G2). Groove size default: width approx. 0.1 × d (min. 2 mm), depth approx. half the width; edges rounded. A groove in the load zone halves the bearing area and pumps grease out – keep it in the unloaded half unless the load rotates.

Oil holes and grease fittings

The oil hole enters from the housing side, in the unloaded zone, and meets the groove or the plain bore; its diameter is 1/8 to 1/6 of the bore for grease (3 mm minimum), smaller for oil. The hole is deburred and chamfered on the inside so the edge does not scrape the shaft. The grease fitting (Zerk / hydraulic nipple, or a grease cup) sits in the housing, not in the bush, and the housing hole is aligned with the bush hole before pressing – mark the bush position or use the flange as the reference. A relief hole or an open groove end lets old grease and grit escape on positions that are greased often.

Suffix H in the order code adds one oil hole in the middle of the length; give the angular position relative to the load or to a flange feature if it matters, or say "hole at 90° to the load zone" and we place it.

Relubrication interval

The interval depends on load, speed, temperature, contamination and sealing more than on the bush, so no single number is right. The principle: relubricate before the old grease is displaced or dried – the bush must never run on the residue. Start with the machine maker's schedule or the interval used on comparable positions; halve it above 80 °C, in water or dust, and for pins that move in one direction under load; extend it where grease still purges clean at the joint. Purge until fresh grease shows at the seal; wipe the excess so that dirt does not stick.

Dry running: a cast bronze bush with the grease gone heats within minutes, the bronze smears and the shaft is scored; a seized bush then spins in the housing and ruins that too. If a position cannot be relubricated on schedule, a graphite-plugged bush or a metal-polymer bush is the right part, not a larger grease reservoir.

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