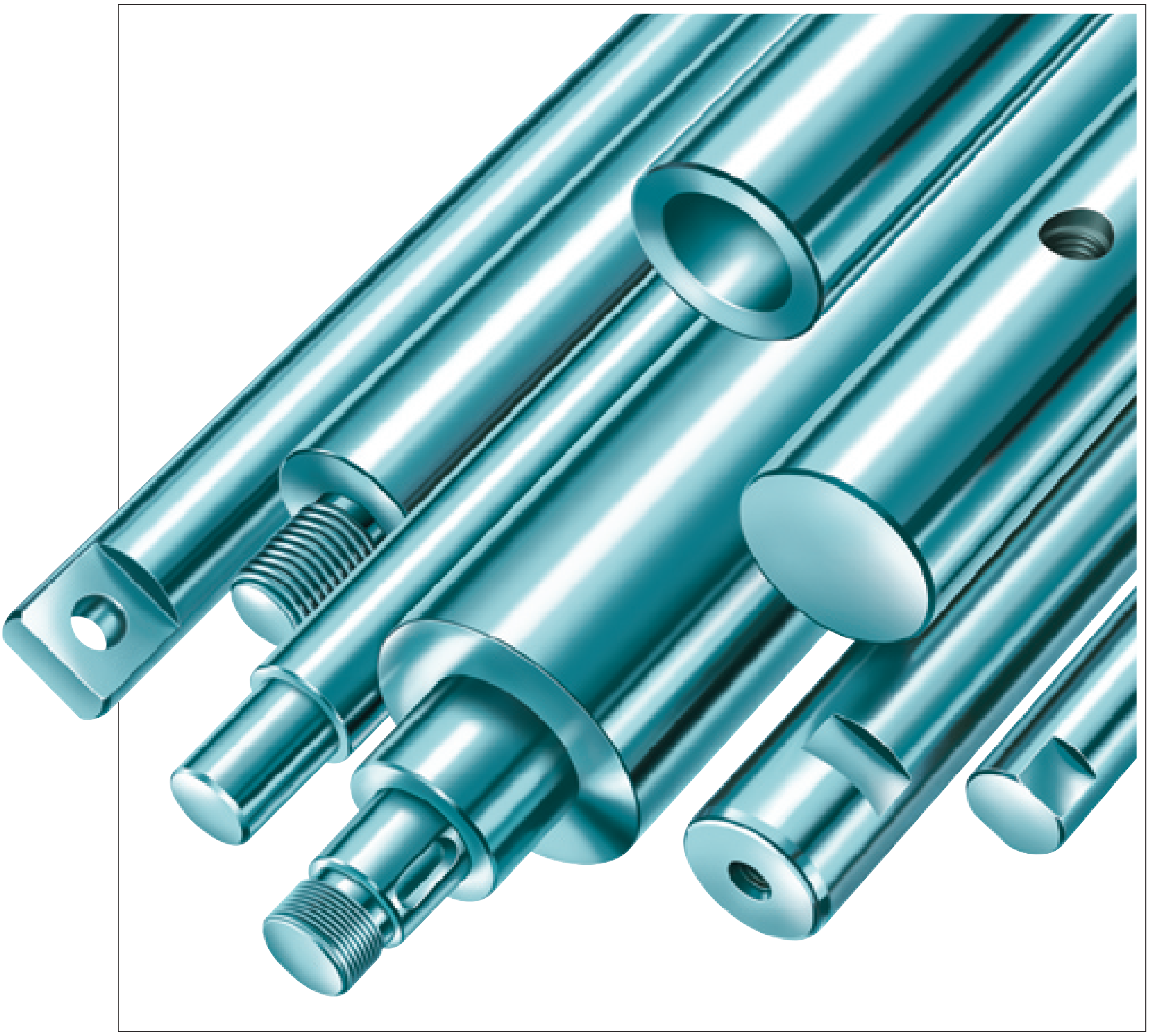


Solid Shafts
and Hollow Shafts

Technical Product Information TPI 79

Solid Shafts and Hollow Shafts

metric, inch sizes

Features

Shafts

- consist as standard of tempered steel with high surface hardness and low surface roughness
  - hardness and low surface roughness ensure ideal running characteristics
  - the uniform effective hardness depth ensures a continuous transition from the hardened surface layer to the tough core
  - the shaft core is soft (normalized), allowing it to absorb bending stresses
- possess a uniformly high quality standard thanks to comprehensive quality tests and strict test standards
- have high load carrying capacities
- are well suited for use as a precision raceway for linear ball bearings due to their high material quality, their dimensional and geometrical accuracy (roundness and parallelism) and their surface hardness and low surface roughness
- are also used as
  - guide rods for bushings
  - drawing and straightening rollers
  - shafts and axles in many applications
  - in the construction of fixtures and machines
- are manufactured
  - as solid shafts with metric and inch dimensions. Solid shafts are available with radial and axial threaded fixing holes (see *threaded holes* and *dimension table*)
  - as hollow shafts for lower-weight designs in metric dimensions
  - with flat ends with and without threaded holes
  - in one-piece lengths up to 6 000 mm; longer shafts assembled from several shafts available on request
- permit rigid, accurate, ready-to-mount and economical linear guidance systems with high load carrying capacities in combination with linear ball bearings, yoke type track rollers, ball type track rollers and ball type grooved profile track rollers.

Solid shafts – metric

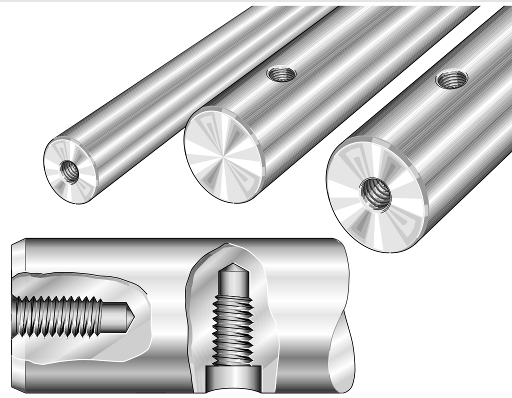
W

120 368

8

- precision solid shaft, shell hardened, ground
  - surface hardness 670 +170 HV (59 +6 HRC)
- alternatively of corrosion resistant steel X 46 Cr 13 (material No. 1.4034)
  - surface hardness 550 +70 HV (52 +4 HRC)
- standard tolerance, quality h6
- one-piece length up to 6 000 mm (depending on the diameter)
- diameters ranging from 4 mm to 80 mm

Threaded holes

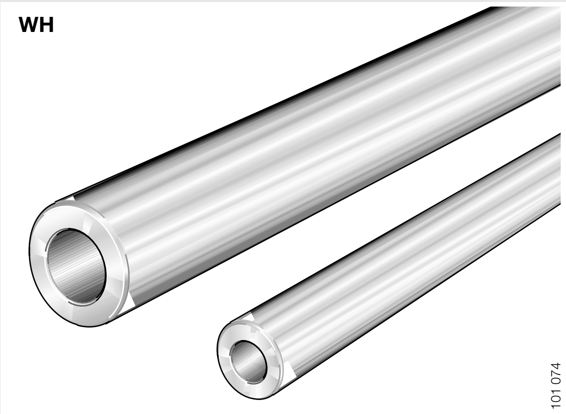


120 410

- radial and axial threaded holes for fixing precision solid shafts W
- holes possible for shaft diameters from 8 mm to 80 mm

Hollow shafts – metric

WH

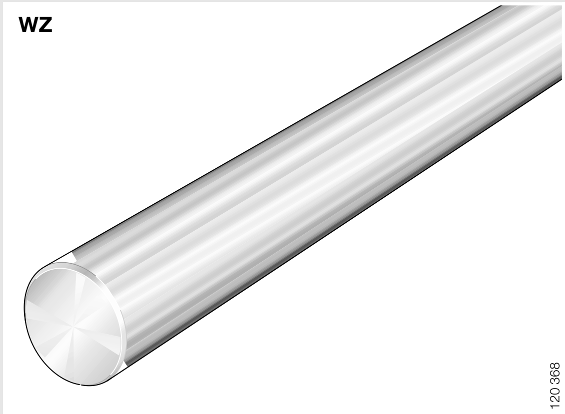


10

- precision hollow shaft, shell hardened, ground
  – surface hardness 670 +170 HV (59 +6 HRC)
- standard tolerance, quality h7
- one-piece up to 6 000 mm length
- diameters ranging from 16 mm to 80 mm

Solid shafts – inch sizes

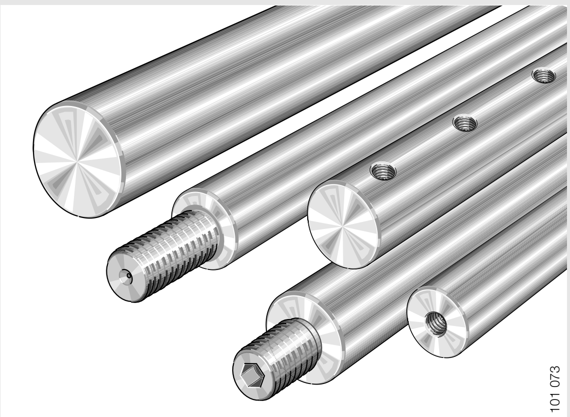
WZ



11

- precision solid shaft, shell hardened, ground
  – surface hardness 670 +170 HV (59 +6 HRC)
- standard tolerance, quality grade “L”
- one-piece up to 4 000 mm length
- diameters from 1/4 inch to 3 inches

Shaft ends



7

- special design of shaft ends

Design and safety information

Minimum hardening depth

In the case of Hertzian contact, a minimum hardening depth Ht must be met in addition to adequate surface hardness in order to ensure reliable functioning of the bearing arrangement:

- this is the case depth Eht for case hardening
- this is the surface hardening depth Rht for flame or induction hardening.

The required minimum hardening depth essentially depends upon:

- the rolling element diameter D_w
- the loading on the material
- the core strength of the material
- the hardening method.

Hardness curves

Figure 1 shows:

- the hardness curves for
  - flame or induction hardening ①
  - case hardening ②
- the curve of the required hardness ③

A steep hardness gradient, which can occur especially during flame or induction hardening, leads to expansion of the deformation zone with the same nominal hardening depth.

Minimum surface hardening depths

The minimum surface hardening depths Rht for INA shafts – depending on the shaft diameter – are specified in Table 1.

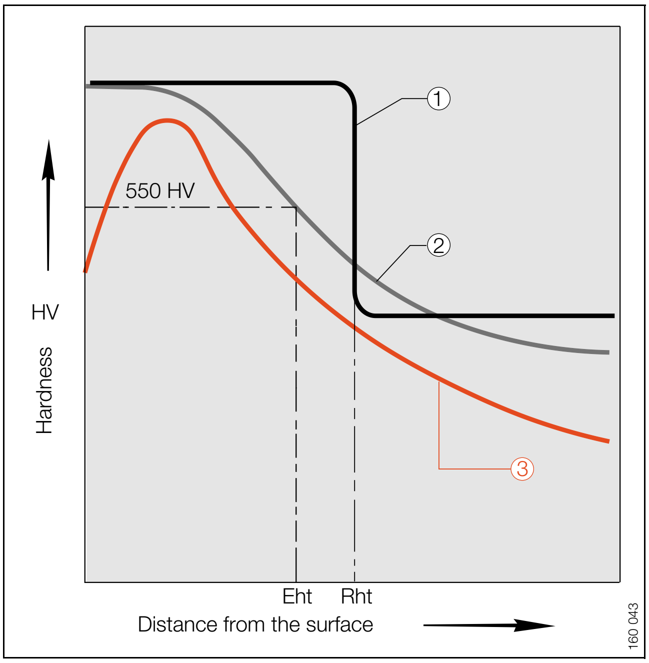


Figure 1 · Hardness curves

Table 1 · Surface hardening depths Rht according to ISO/TC 4/SC 11

Shaft diameter d_{LW} mm		Surface hardening depth Rht mm
over	to	min.
–	10	0,4
10	18	0,6
18	30	0,9
30	50	1,5
50	80	2,2

Raceway hardness with special steels

In addition to the standard tempered-steel shafts, INA also supplies shafts of the following materials:

- X 46 Cr 13 (material No. 1.4034)
- X 90 CrMoV 18 (material No. 1.4112).

If these shafts are used as a raceway for linear roller bearings, the dynamic and static load ratings C and C_0 of the bearings are decreased due to the lower raceway hardness of the shafts.

Effective static and dynamic load ratings

The effective static and dynamic load ratings C_{0H} and C_H with reduced shaft hardness are calculated using (see equations):

- the static and dynamic hardness factors f_{H0} and f_H according to Figure 2 and
- the static and dynamic load ratings C_0 and C according to *dimension table* for the linear ball bearings.

$$C_{0H} = f_{H0} \cdot C_0$$

$$C_H = f_H \cdot C$$

C_{0H}, C_H, N
effective static and dynamic load ratings with reduced raceway hardness (shaft)

f_{H0}, f_H –
static and dynamic hardness factor (Figure 2)

C_0, C N
static and dynamic load rating of the bearing.

Further information about the load carrying capacity is contained in INA publication *LIF*.

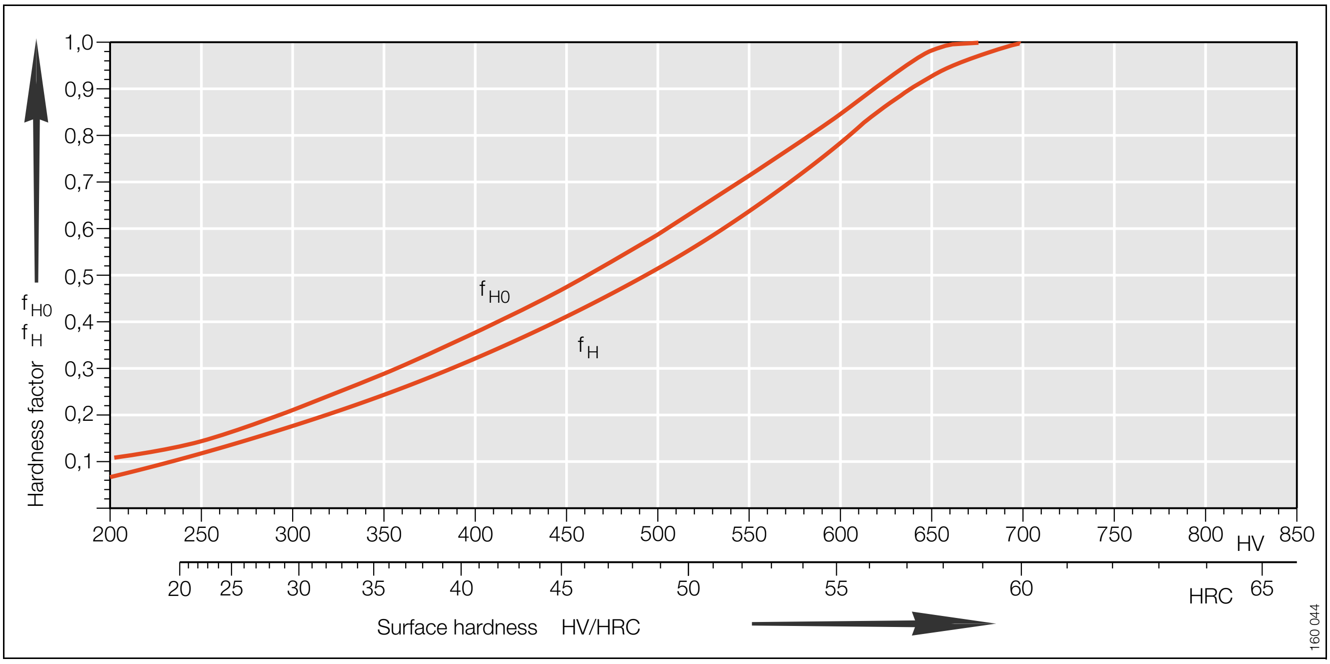


Figure 2 · Static and dynamic hardness factors with reduced raceway hardness

Solid Shafts and Hollow Shafts

metric, inch sizes

Accuracy

Quality grades

INA shafts are available in the quality grades stated in Table 2.

Table 2 · Quality grades of shafts

Series designation	Shaft	Quality
W	metric solid shaft	h6
WH	metric hollow shaft	h7
WZ	solid shaft in inch sizes	Grade “L”

Length tolerances

Table 3 shows the length tolerances for shafts that are cut to length.

Table 3 · Length tolerances

Shaft length L mm		Tolerance mm
over	to	max.
–	400	±0,5
400	1000	±0,8
1000	2000	±1,2
2000	4000	±2
4000	6000	±3

Chamfers at shaft ends

Both shaft ends are chamfered after the shafts are cut to length (Figure 3, Table 4), but the shafts are also available without chamfers.

Table 4 · Chamfer design

Shaft diameter d_{LW} mm	Chamfer x mm
$d_{LW} \leqq 10$	1^{+1}
$10 < d_{LW} \leqq 30$	$1{,}5^{+1}$
$30 < d_{LW} \leqq 80$	$2{,}5^{+1}$

Roundness, parallelism, surface hardening depth

These values depend on the shaft diameter d_{LW} and are listed in the *dimension tables*.

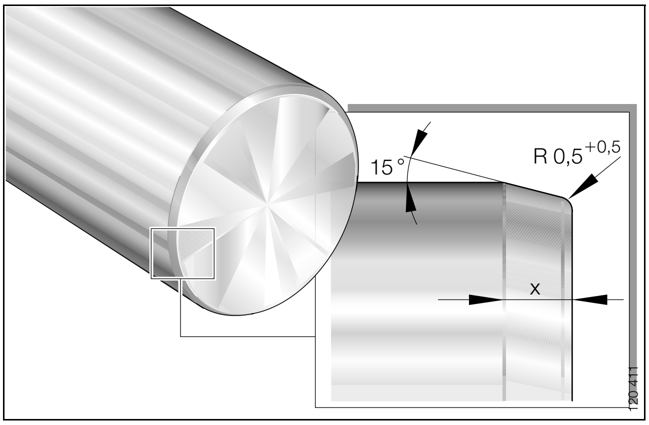


Figure 3 · Design of shaft ends

Spec.

Special design

Special designs are possible on request:

- shafts of design type W consist of X 90 CrMoV 18 (material No. 1.4112)
- chrome-plated shafts
- shafts protected against corrosion with INA special coating Corrotect®
- unhardened shafts
- shafts with special heat treatment
  - e.g. hardness, effective hardness depth, hardening zones, hardening method
- shaft ends with (Figure 4)
  - ① axial thread
  - ② radial thread
  - ③ external thread and hexagonal socket
  - ④ reduced, smooth stud
  - ⑤ reduced, threaded stud
  - ⑥ profiled undercut
  - ⑦ milled surfaces and centering hole
  - ⑧ milled surfaces and transverse hole

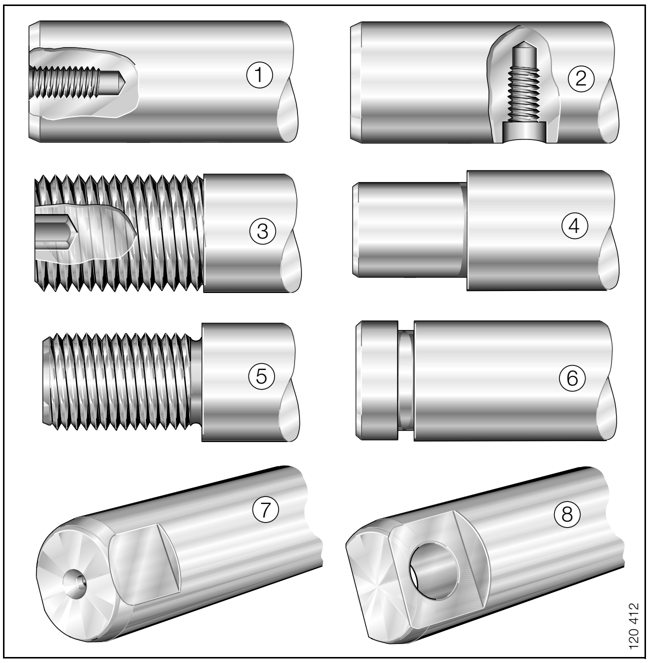


Figure 4 · Shaft ends – special designs according to customer drawing

Sample order and order code designation

- metric solid shaft W
- shaft diameter d_{LW} 25 mm
- quality h6
- hole pattern for fixing bores 05
  - axial thread M8 (K_6 according to *dimension table*)
  - radial thread M8 (K_7 according to *dimension table*)
  - distance 120× (C_4 according to *dimension table*)
- length 2 000 mm.

Order code designation: **W 25h6 05M8M8-120×2000** (Figure 5).

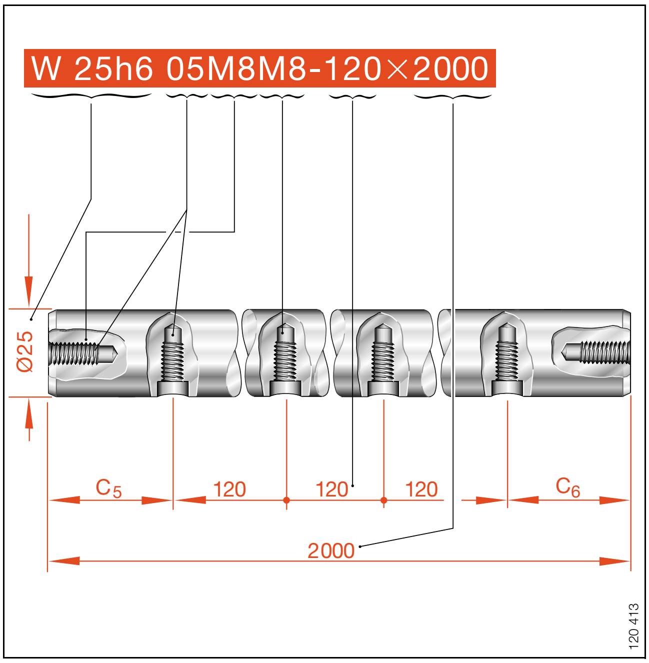
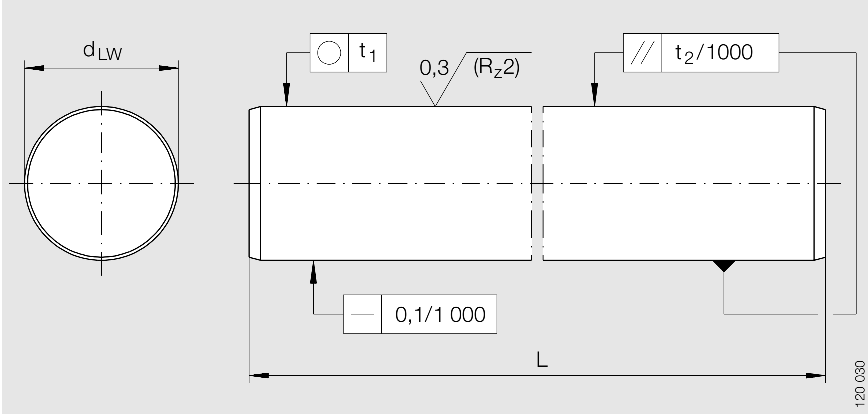


Figure 5 · Sample order and order code designation

Solid shafts

metric

Design type W



W

Dimension table · Dimensions in mm

Shaft diameter	Series designation	Weight	Length	Materials[1]			Tolerance	Roundness	Parallelism	Surface hardening depth
				Tempered steel	Corrosion-resistant steel[4]		h6	t_1	t_2[2]	Rht[3]
					X 46 Cr 13	X 90 CrMoV 18				min.
d_{LW}		kg/m	L_{max}				µm	µm	µm	mm
4	**W 4**	0,1	2 500	●	–	●	0– 8	4	5	0,4
5	**W 5**	0,15	3 600	●	–	–	0– 8	4	5	0,4
6	**W 6**	0,22	4 000	●	●	●	0– 8	4	5	0,4
8	**W 8**	0,39	4 000	●	●	●	0– 9	4	6	0,4
10	**W 10**	0,61	4 000	●	●	●	0– 9	4	6	0,4
12	**W 12**	0,89	6 000	●	●	●	0–11	5	8	0,6
14	**W 14**	1,21	6 000	●	●	●	0–11	5	8	0,6
15	**W 15**	1,37	6 000	●	●	●	0–11	5	8	0,6
16	**W 16**	1,57	6 000	●	●	●	0–11	5	8	0,6
17	**W 17**	1,78	6 000	●	–	–	0–11	5	8	0,6
18	**W 18**	1,98	6 000	●	●	●	0–11	5	8	0,6
20	**W 20**	2,45	6 000	●	●	●	0–13	6	9	0,9
24	**W 24**	3,55	6 000	●	●	●	0–13	6	9	0,9
25	**W 25**	3,83	6 000	●	●	●	0–13	6	9	0,9
30	**W 30**	5,51	6 000	●	●	●	0–13	6	9	0,9
32	**W 32**	6,3	6 000	●	●	●	0–16	7	11	1,5
35	**W 35**	7,56	6 000	●	–	–	0–16	7	11	1,5
40	**W 40**	9,8	6 000	●	●	●	0–16	7	11	1,5
50	**W 50**	15,3	6 000	●	●	●	0–16	7	11	1,5
60	**W 60**	22,1	6 000	●	●	●	0–19	8	13	2,2
80	**W 80**	39,2	6 000	●	●	●	0–19	8	13	2,2

1) Shafts consist of tempered steel as standard.
Corrosion-resistant steels only on request or as a special design.

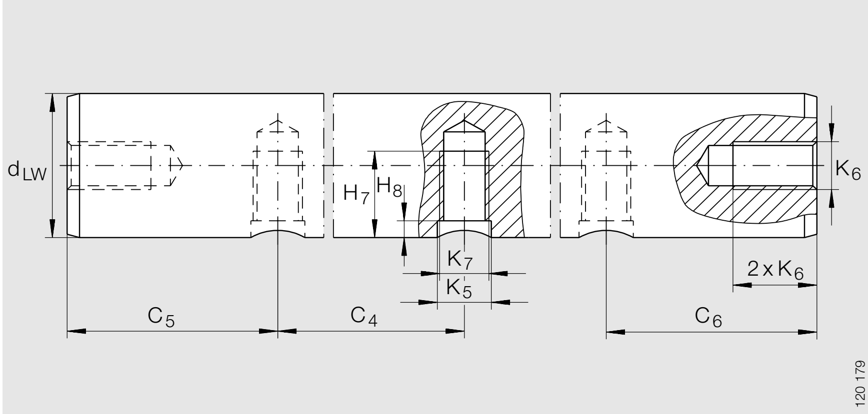
2) Measured diameter variation.

3) According to DIN 6 773-3.

4) Reduction in load rating for linear ball bearing due to lower shaft hardness (see *Raceway hardness with special steels*, Page 5).

Recommended threaded holes

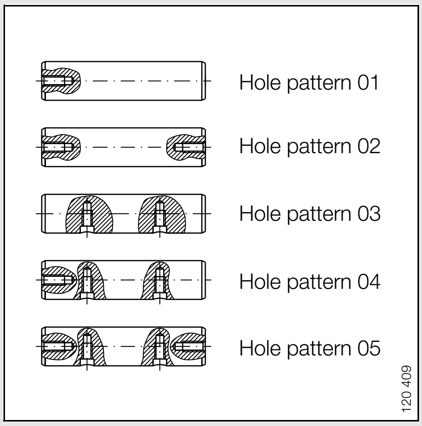
for shafts W



Threaded holes

Dimension table · Dimensions in mm

Series designation[1]	Axial thread										Radial thread								
											Dimensions								
	K_6										C_4			$C_{5\ min}$[2], $C_{6\ min}$[2] Hole pattern		H_7	H_8	K_5	K_7
														03	04–05				
W 8	M3	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–
W 10	M3	M4	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–
W 12	–	M4	M5	–	–	–	–	–	–	–	75		120	10		7	2	5	M4
W 14	–	M4	M5	M6	–	–	–	–	–	–	–	–	–	–		–	–	–	–
W 15	–	–	M5	M6	M8	–	–	–	–	–	–	–	–	–		–	–	–	–
W 16	–	–	M5	M6	M8	–	–	–	–	–	75	100	150	15		10	2,5	6	M5
W 18	–	–	–	M6	M8	M10	–	–	–	–	–	–	–	–		–	–	–	–
W 20	–	–	–	–	–	–	–	–	–	–	–	–	150	15		12,5	3	6	M5
W 20	–	–	–	M6	M8	M10	–	–	–	–	75	100	150	15		11	3	7	M6
W 24	–	–	–	–	M8	M10	M12	–	–	–	–	–	–	–		–	–	–	–
W 25	–	–	–	–	–	–	–	–	–	–	–	–	150	15	see footnote[3]	15	3	7	M6
W 25	–	–	–	–	M8	M10	M12	–	–	–	75	120	150	15		15	3	9	M8
W 30	–	–	–	–	–	–	–	–	–	–	–	–	150	15		15	3,5	7	M6
W 30	–	–	–	–	–	M10	M12	M16	–	–	100	150	200	20		17	3,5	11	M10
W 32	–	–	–	–	–	M10	M12	M16	–	–	–	–	–	–		–	–	–	–
W 40	–	–	–	–	–	M10	M12	M16	–	–	150	200	300	20		25	4	11	M10
W 40	–	–	–	–	–	M10	M12	M16	–	–	100	–	–	20		21	4	13	M12
W 50	–	–	–	–	–	–	–	–	–	–	–	–	150	20		19	4	11	M10
W 50	–	–	–	–	–	–	M12	M16	M20	–	–	200	300	20		21	4	13	M12
W 50	–	–	–	–	–	–	M12	M16	M20	–	100	–	–	20		25	4	15	M14
W 60	–	–	–	–	–	–	–	M16	M20	M24	–	–	–	–		–	–	–	–
W 80	–	–	–	–	–	–	–	M16	M20	M24	–	–	–	–		–	–	–	–



Hole patterns for fixing holes

[1] See Page 8 for dimensions.

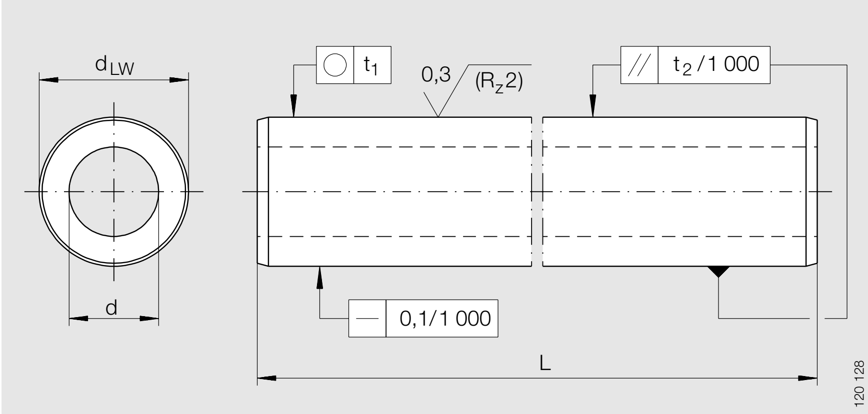
[2] C_5 and C_6 depend on the shaft length.

[3] Take the axial thread into account for designs with hole patterns 04 and 05 (see Figure *Hole patterns for fixing holes*):
$C_{5\ min} = C_{6\ min} = 3 \times K_6 + K_7$.

Hollow shafts

metric

Design type WH



WH

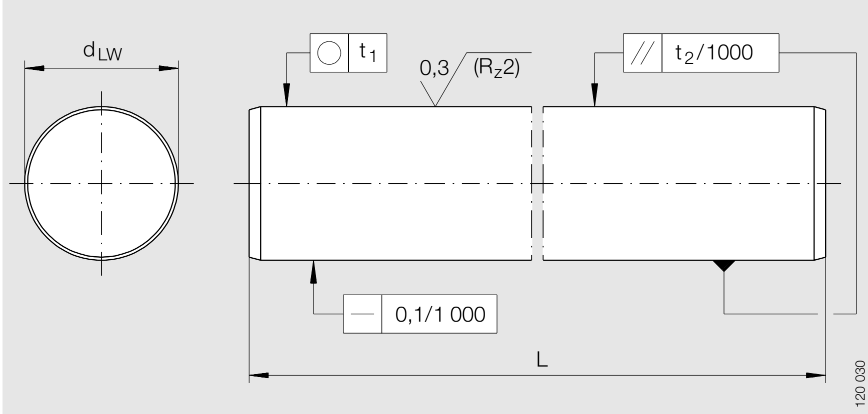
Dimension table · Dimensions in mm									
Outside diameter	Series designation	Weight	Length	Inside diameter	Materials Tempered steel	Tolerance	Roundness	Parallelism	Surface hardening depth
			L	d[1]		h7	t_1	t_2[2]	Rht[3]
d_{LW}		kg/m				µm	µm	µm	min. mm
16	**WH 16**	1,28	6 000	7	●	0–18	5	8	0,9
20	**WH 20**	1,25	6 000	14	●	0–21	6	9	0,9
25	**WH 25**	2,35	6 000	15,6	●	0–21	6	9	0,9
30	**WH 30**	3,5	6 000	18,2	●	0–21	6	9	0,9
40	**WH 40**	4,99	6 000	28,1	●	0–25	7	11	1,5
50	**WH 50**	9,97	6 000	29,7	●	0–25	7	11	1,5
60	**WH 60**	14,2	6 000	36	●	0–30	8	13	2,2
80	**WH 80**	19,5	6 000	56,9	●	0–30	8	13	2,2

1) Wall-thickness tolerance of the starting material ±4%.
2) Measured diameter variation.
3) According to DIN 6 773-3.

Solid shafts

inch sizes

Design type WZ



WZ

Dimension table · Dimensions in mm

Shaft diameter d_{LW}		Series designation	Weight	Length[5] L_{max}	Materials[1]		Tolerance Grade “L”	Roundness t_1	Parallelism t_2[2]	Surface hardening depth Rht[3]
					Tempered steel	Corrosion-resistant steel[4] X 46 Cr 13				
inch	mm		kg/m				µm	µm	µm	min. mm
1/4	***6,35***	**WZ 04**	0,25	4 000	●	–	–13–25	4	5	
3/8	***9,525***	**WZ 06**	0,56	4 000	●	●	–13–25	4	6	
1/2	***12,7***	**WZ 08**	0,99	4 000	●	●	–13–25	5	8	
5/8	***15,875***	**WZ 10**	1,55	4 000	●	●	–13–25	5	8	
3/4	***19,05***	**WZ 12**	2,24	4 000	●	●	–13–25	6	9	
7/8	***22,22***	**WZ 14**	3,05	4 000	●	–	–13–25	6	9	
1	***25,4***	**WZ 16**	3,97	4 000	●	●	–13–25	6	9	
1 1/8	***28,575***	**WZ 18**	4,11	4 000	●	–	–13–25	7	11	
1 1/4	***31,75***	**WZ 20**	6,22	4 000	●	●	–13–25	7	11	
1 3/8	***34,95***	**WZ 22**	7,51	4 000	●	–	–15–28	7	11	
1 1/2	***38,1***	**WZ 24**	8,95	4 000	●	●	–15–28	7	11	
2	***50,8***	**WZ 32**	15,91	4 000	●	–	–15–33	7	11	
2 1/2	***63,525***	**WZ 40**	24,85	4 000	●	–	–18–38	8	13	
3	***76,225***	**WZ 48**	35,79	4 000	●	–	–20–43	8	13	

1) Shafts consist of tempered steel as standard.
Corrosion-resistant steels only on request or as a special design.

2) Measured diameter variation.

3) According to DIN 6 773-3.

4) Reduction in load rating for linear ball bearing due to lower shaft hardness (see *Raceway hardness with special steels*, Page 5).

5) Longer lengths available on request.

INA Lineartechnik oHG

Postfach 15 45
66406 Homburg (Saar) · Germany
www.ina.com

Germany:
Phone 0180 / 5 00 38 72
Fax 0180 / 5 00 38 73

Other Countries:
Phone +49 / 68 41 / 7 01-1 00
Fax +49 / 68 41 / 7 01-6 25

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