

VIGO DRIVE™

# GH SERIES

Precision Gearheads



Nabtesco



ISO 9001  
JQA-1190

# ***GH SERIES Gearheads for High-precision Control taking your servomotor performance to the limit***

*The GH SERIES Gearheads are based upon the highly successful, high-precision RV Series Reduction Gears. The high-performance RV has over 2 million units in service in various applications around the world today. The GH SERIES are high-precision servomotor gearheads that provide significant advantages in terms of ease-of-use and cost for performance.*

**GH 7**



**GH 17**



**GH 24**



**GH 40**



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# Features and Configurations

## High shock load capability

## High rigidity

## High precision

## High speed

The double-end support design and unique pin gear mechanism provide the following advantages:

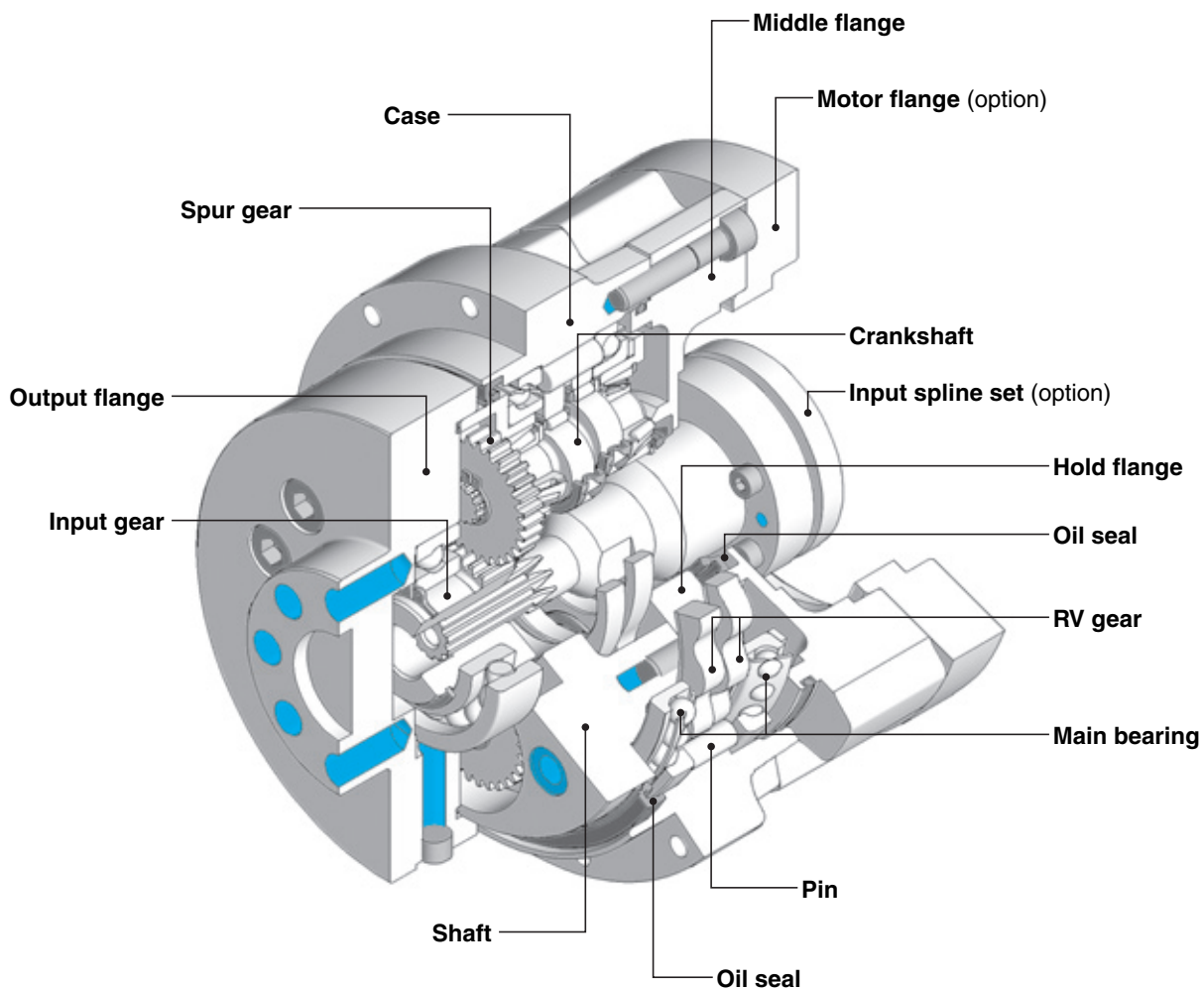
- (1) Capable of 7 times the rated torque
- (2) High rigidity as well as small backlash [6 arc.min]
- (3) Capable of high output speed with low reduction ratio (1/11 to 1/31)
- (4) High torque density

## Heavy load support

A set of internal main bearings (large angular ball bearings) enables complete support of heavy external loads.

## Maximum ease of use

- (1) Pre greased
- (2) Easy motor mounting



**Rotation direction** The rotation direction of the output shaft is same as that of the input spline.



# Principle of Operation

1. Rotation of the servomotor is transmitted through the input gear to the spur gears, and the speed is reduced accordingly with the gear ratio between the input gear and the spur gears. This is the first reduction section <Fig. 1>.
2. Since they are directly connected, the crankshafts have the same rotational speed as the spur gears <Fig. 1>.
3. Two RV gears are mounted around the needle bearings on the eccentric region of the crankshaft. (In order to balance the equal amount of force, two RV gears are mounted) <Fig. 2>.
4. When the crankshafts rotate, the RV gears mounted on the eccentric sections also revolve eccentrically around the input axis (crank movement) <Fig. 2>.
5. Pins are arrayed in a constant pitch in the grooves inside the case. The number of pins is just one larger than the number of RV teeth <Fig. 3>.
6. As the crankshafts revolve one complete rotation, the RV gears revolve eccentrically one pitch of a pin (crank movement), with all the RV teeth in contact with all of the pins <Fig. 3>.
7. The rotation is then transmitted to the shaft (output shaft) via the crankshaft. At this time, the shaft rotation speed can be reduced in proportion to the number of pins against the crankshaft <Fig. 3>.
8. The total reduction ratio is the product of the first reduction ratio multiplied by the second reduction ratio.

Fig. 1 First reduction section

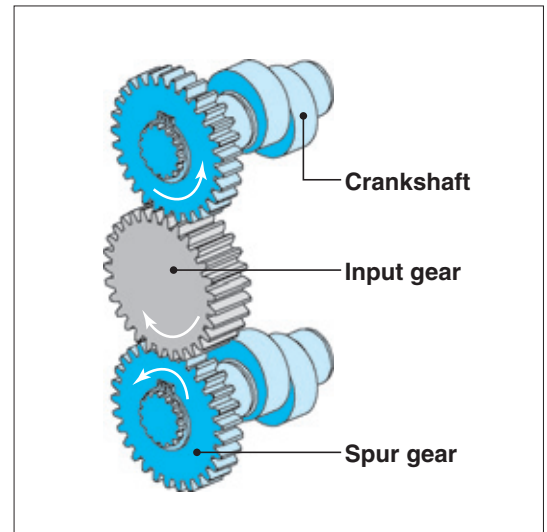


Fig. 2 Crankshaft section

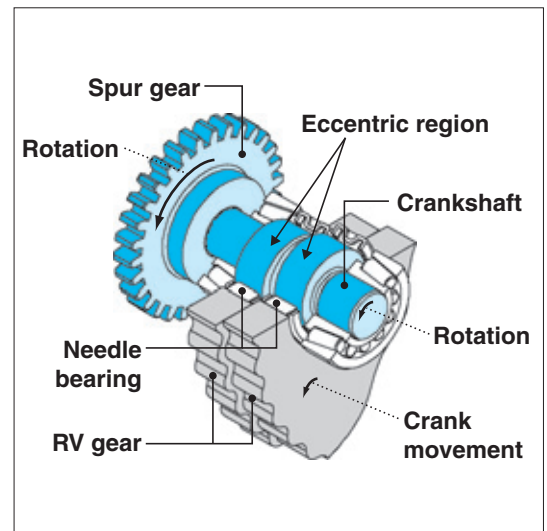
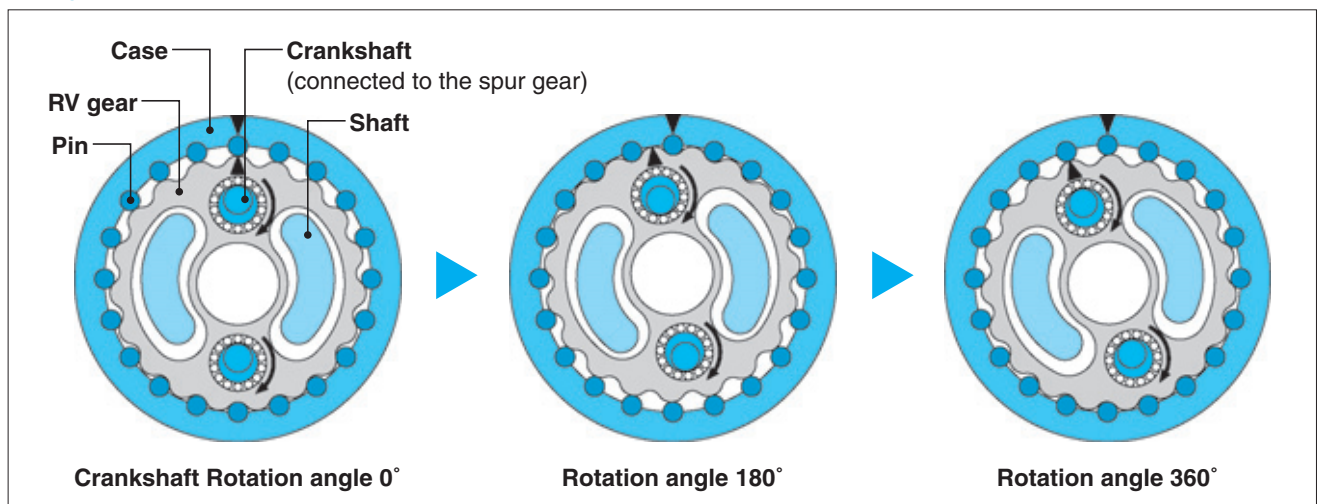


Fig. 3 Second reduction section



# Specifications

**Rating Table** (\*1)

| Model Code | Ratio Code | Ratio  | Rated Torque (To)<br>N-m (Kgf-m) | Rated Output Speed (No)<br>r.p.m. | Allowable Torque                                |   | Allowable Output Speed (*2)    |                                  | Backlash<br>arc.min | Inertia Moment I (I=GD <sup>2</sup> /4)<br>Input Shaft Equivalent (*3)<br>Kg-m <sup>2</sup> | Mass (Kg) |
|------------|------------|--------|----------------------------------|-----------------------------------|---|---|--------------------------------|----------------------------------|---------------------|---|-----------|
|            |            |        |                                  |                                   | Acceleration/Deceleration Torque<br>N-m (Kgf-m) | Momentary Maximum Torque<br>N-m (Kgf-m) | Continuous Operation<br>r.p.m. | Intermittent Operation<br>r.p.m. |                     |   |           |
| GH7        | 11         | 461/41 | 69<br>(7)                        | 50                                | 206<br>(21)                                     | 480<br>(49)                             | 150                            | 270                              | 6                   | 0.440 x 10 <sup>-4</sup>  | 8         |
|            | 21         | 21     |                                  |                                   |   |   |                                |                                  |                     | 0.233 x 10 <sup>-4</sup>  |           |
|            | 31         | 153/5  |                                  |                                   |   |   |                                |                                  |                     | 0.173 x 10 <sup>-4</sup>  |           |
| GH17       | 11         | 11     | 167<br>(17)                      | 50                                | 500<br>(51)                                     | 1166<br>(119)                           | 150                            | 270                              | 6                   | 1.751 x 10 <sup>-4</sup>  | 15.5      |
|            | 21         | 21     |                                  |                                   |   |   |                                |                                  |                     | 0.960 x 10 <sup>-4</sup>  |           |
|            | 31         | 31     |                                  |                                   |   |   |                                |                                  |                     | 0.806 x 10 <sup>-4</sup>  |           |
| GH24       | 11         | 11     | 235<br>(24)                      | 50                                | 706<br>(72)                                     | 1646<br>(168)                           | 150                            | 250                              | 6                   | 1.410 x 10 <sup>-4</sup>  | 15.5      |
|            | 21         | 21     |                                  |                                   |   |   |                                |                                  |                     | 0.618 x 10 <sup>-4</sup>  |           |
|            | 31         | 31     |                                  |                                   |   |   |                                |                                  |                     | 0.444 x 10 <sup>-4</sup>  |           |
| GH40       | 11         | 419/39 | 392<br>(40)                      | 50                                | 1176<br>(120)                                   | 2744<br>(280)                           | 150                            | 250                              | 6                   | 0.711 x 10 <sup>-3</sup>  | 35.5      |
|            | 21         | 21     |                                  |                                   |   |   |                                |                                  |                     | 0.451 x 10 <sup>-3</sup>  |           |
|            | 31         | 723/23 |                                  |                                   |   |   |                                |                                  |                     | 0.219 x 10 <sup>-3</sup>  |           |
| GH100      | 21         | 20.375 | 980<br>(100)                     | 50                                | 2942<br>(300)                                   | 6865<br>(700)                           | 65                             | 135                              | 10                  | 1.68 x 10 <sup>-3</sup>   | 90        |
|            | 31         | 31.4   |                                  |                                   |   |   |                                |                                  |                     | 1.31 x 10 <sup>-3</sup>   |           |

Note:  
 \*1. The rating table shows the specification values of each reduction gear.  
 \*2. The allowable output speed may be limited by heat depending on the operation rate.  
 If you use this product with the operation rate per cycle exceeding 50% or allowable output speed during continuous operation, contact us.  
 \*3. For the inertia moment value, both the reduction gear and the input gear are taken into consideration. This, however, does not include the inertia moment of the input spline.

## Capacity of Main Bearing

| Model Code | Allowable Moment (Mo)<br>N-m (Kgf-m) | Maximum Thrust Load (W)<br>N (Kgf) | Dimension α1      |                  |
|------------|--------------------------------------|------------------------------------|-------------------|------------------|
|            |                                      |                                    | Flange type<br>mm | Shaft type<br>mm |
| GH7        | 460<br>(47)                          | 1372<br>(140)                      | 133.3             | 155.3            |
| GH17       | 804<br>(82)                          | 1960<br>(200)                      | 156.9             | 200.1            |
| GH24       | 843<br>(86)                          | 2940<br>(300)                      | 152.1             | 211.1            |
| GH40       | 1823<br>(186)                        | 2940<br>(300)                      | 198.1             | 277.1            |
| GH100      | 4900<br>(500)                        | 5586<br>(570)                      | 262.0             | -                |

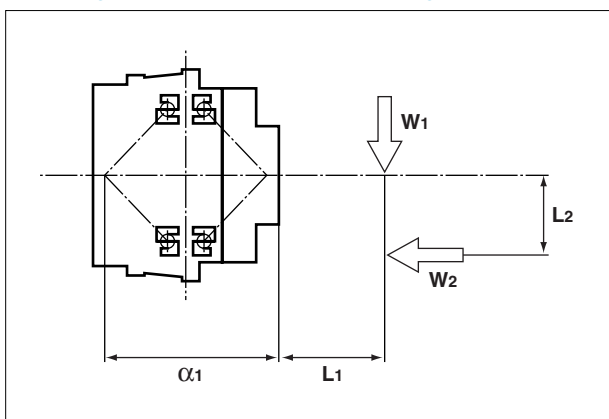
## Load moment

$$M_c = \{ W_1 \times (\alpha_1 + L_1) + W_2 \times L_2 \times 10^{-3}$$

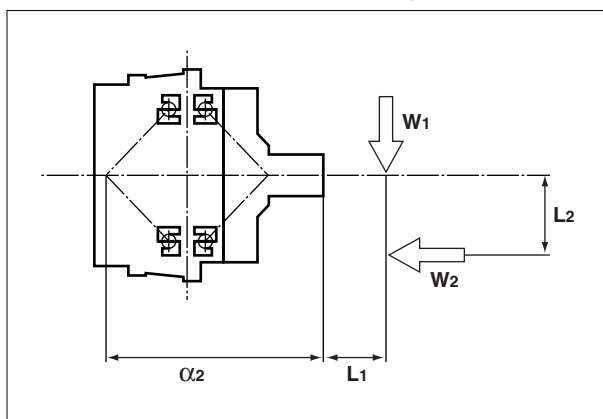
$$M_c \leq M_o$$

$M_c$  : Load moment (N-m)  
 $W_1, W_2$  : Load (N)  
 $(\alpha_1 + L_1), L_2$  : Distance to the point of load application (mm)  
 $L_1$  : Distance from the mounting surface of the output shaft to the point of load application (mm)

**Flange Type External Load Diagram**



**Shaft Type External Load Diagram**



# Glossary

## Life Rating

The lifetime resulting from the operation with the rated torque and the rated output speed is referred to as the "life rating". For the GH reduction gear, the life rating is 6,000 hours continuous.

## Allowable Acceleration/Deceleration

When the machine starts or stops, the load torque to be applied to the reduction gear is larger than the constant-speed torque due to the effect of the inertia torque of the rotation part. In such a situation, the allowable torque during acceleration/deceleration is referred to as "allowable acceleration/deceleration torque".

**Note:** Be careful that the load torque, which is applied during normal operation, does not exceed the allowable acceleration/deceleration torque.

## Momentary Maximum Allowable Torque

A large torque may be applied to the reduction gear due to execution of emergency stop or by an external shock. In such a situation, the allowable value of the momentary applied torque is referred to as "momentary maximum allowable torque".

**Note:** Be careful that the momentary excessive torque does not exceed the momentary maximum allowable torque.

## Allowable Output Speed [Intermittent]

The allowable output speed during the operation in which the maximum torque is below the rated torque of the reduction gear and also when the operation rate of the reduction gear per cycle is below 30%, it is referred to as "allowable output speed [Intermittent]".

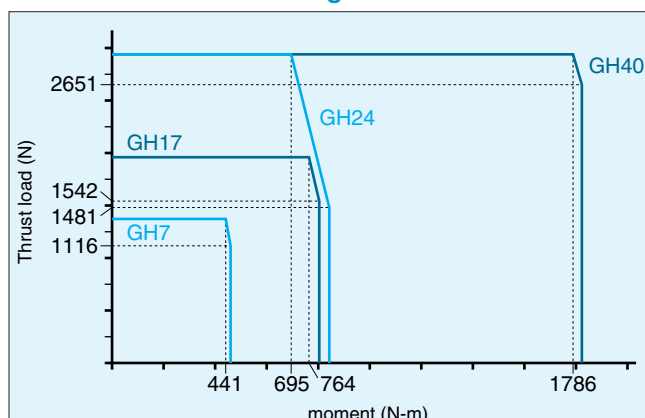
**Note:** Maintain the environment and operation conditions so that the temperature of the reduction gear case is 60°C or lower.

## Allowable Output Speed [Continuous]:

The allowable output speed when the reduction gear operation rate per cycle exceeds 50% is referred to as "allowable output speed [Continuous]".

**Note:** Maintain the environment and operation conditions so that the temperature of the reduction gear case is 60°C or lower.

## Allowable Moment Diagram

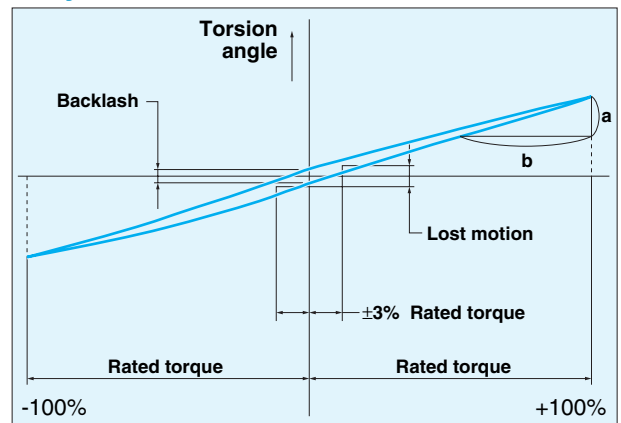


## Rigidity (Torsional Rigidity and Lost Motion) and Backlash

When torque is applied to the output shaft while the input shaft is fixed, torsion is generated on the output shaft according to the torque value and a hysteresis curve results.

- The value of  $b/a$  is referred to as "torsional rigidity".
- The torsion angle at the mid point of the hysteresis curve width at  $\pm 3\%$  of rated torque is referred to as "lost motion".
- The torsion angles when the torque indicated by the hysteresis curve is zero are referred to as "backlash".

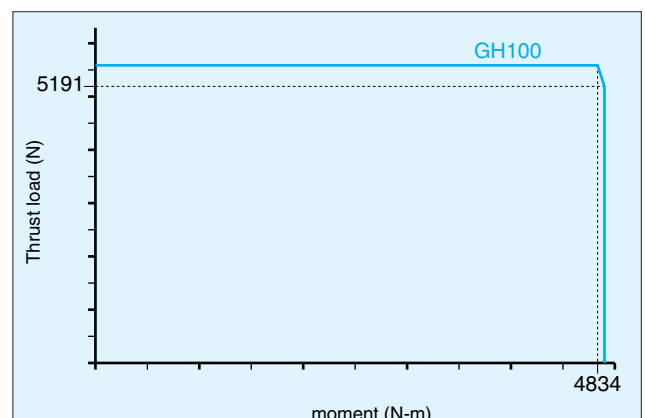
## Hysteresis Curve



## Allowable Moment and Maximum Axial Load

The external load moment may be applied to the reduction gear, and the allowable value of the external moment is referred to as "allowable moment", while the allowable value of the axial load is referred to as "maximum axial load".

**Note:** When the load moment and the axial load are applied concurrently, ensure that the reduction gear is used within the corresponding allowable moment range, which is indicated in the allowable moment diagram.



# Selection Flow Chart

(1) Study of load characteristics

Check the condition of the load torque applied to the reduction gear.  
A sample diagram is shown below.

Calculation of average load torque ( $T_m$ )  
Calculation of average output speed ( $N_m$ )

$$T_m = \frac{10}{3} \sqrt{\frac{t_1 \cdot N_1 \cdot T_1^{\frac{10}{3}} + t_2 \cdot N_2 \cdot T_2^{\frac{10}{3}} + \dots + t_n \cdot N_n \cdot T_n^{\frac{10}{3}}}{t_1 \cdot N_1 + t_2 \cdot N_2 + \dots + t_n \cdot N_n}}$$

$$N_m = \frac{t_1 \cdot N_1 + t_2 \cdot N_2 + \dots + t_n \cdot N_n}{t_1 + t_2 + \dots + t_n}$$

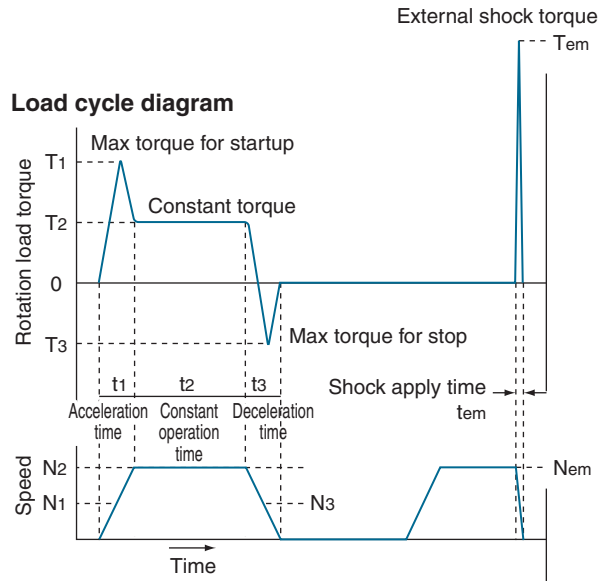
Reduce the load.

Select the reduction gear with the higher model number.

Provisionally select the model number from the Rating Table.

Calculation of life rating ( $L_h$ )

$$L_h = 6000 \times \frac{N_o}{N_m} \times \left(\frac{T_o}{T_m}\right)^{\frac{10}{3}}$$



NO  $L_h \geq$  Required life rating

YES

Study of maximum output speed

Maximum output speed  $\leq$  Allowable output speed

YES

NO

Study of acceleration/deceleration torque ( $T_1/T_3$ )

$T_1$  or  $T_3 \leq$  Allowable acceleration/deceleration torque

YES

NO

Study of external shock torque ( $T_{em}$ ) at emergency stop

$T_{em} \leq$  Momentary maximum allowable torque

YES

NO

Calculation of allowable number of apply times ( $C_{em}$ )

$$C_{em} = \frac{775 \times \left(\frac{7 \times T_o}{T_{em}}\right)^{\frac{10}{3}}}{20 \times \frac{N_m}{60} \times t_{em}}$$

Actual number of times  $\leq C_{em}$

YES

NO

Study of external shock torque ( $T_{out}$ ) when the motor shaft speed is 0

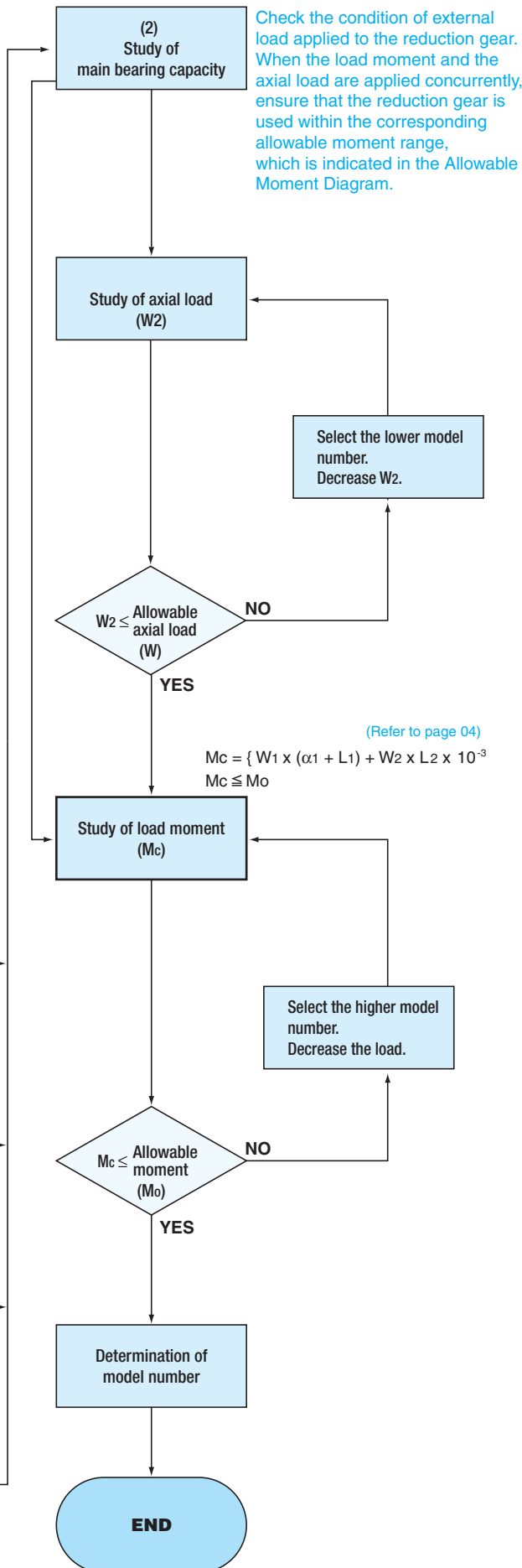
$T_{out} \leq$  Momentary maximum allowable torque

YES

NO

$T_{out}$ : Recommended value





## Selection example

### (1) Study of load characteristics

#### • Usage condition

$$T_1 = 391 \text{ N-m} \quad T_2 = 98 \text{ N-m} \quad T_3 = 193 \text{ N-m} \quad T_{em} = 2600 \text{ N-m}$$

$$t_1 = 0.1 \text{ sec} \quad t_2 = 0.15 \text{ sec} \quad t_3 = 0.1 \text{ sec} \quad t_{em} = 0.02 \text{ sec}$$

$$N_1 = N_3 = 50 \text{ r.p.m.} \quad N_2 = 100 \text{ r.p.m.} \quad N_{em} = 100 \text{ r.p.m.}$$

#### • Calculation of average load torque

$$T_m = \frac{10}{3} \sqrt{\frac{0.1 \times 50 \times 391^{\frac{10}{3}} + 0.15 \times 100 \times 98^{\frac{10}{3}} + 0.1 \times 50 \times 193^{\frac{10}{3}}}{0.1 \times 50 + 0.15 \times 100 + 0.1 \times 50}}$$

$$= 250 \text{ Nm}$$

#### • Calculation of average output speed

$$N_m = \frac{0.1 \times 50 + 0.15 \times 100 + 0.1 \times 50}{0.1 + 0.15 + 0.1} = 71.4 \text{ r.p.m.}$$

#### • Selection of tentative frame number

According to the  $T_m$  and  $N_m$  values, select GH40 tentatively.

$$250 \text{ N-m} < 392 \text{ N-m} \quad 71.4 \text{ r.p.m.} < 150 \text{ r.p.m.}$$

Rated torque of GH40

Allowable output speed of GH40

#### • Calculation of life rating

$$L_h = 6000 \times \frac{50}{71.4} \times \left( \frac{392}{250} \right)^{\frac{10}{3}} = 18818 \text{ Hr}$$

$$18818 > 10000$$

Required life rating

#### • Study of maximum output speed

$$100 \text{ r.p.m.} < 150 \text{ r.p.m.}$$

Allowable output speed of GH40 (during continuous operation)

#### • Study of torque for startup/stop

$$T_{max} = T_1 = 391 \text{ N-m} < 1176 \text{ N-m}$$

Allowable startup/stop torque of GH40

#### • Study of torque at emergency stop or external shock

$$T_{em} = 2600 \text{ N-m} < 2744 \text{ N-m}$$

Momentary maximum allowable torque of GH40

$$C_{em} = \frac{775 \times \left( \frac{7 \times 392}{2600} \right)^{\frac{10}{3}}}{20 \times \frac{100}{60} \times 0.02} = 1391 \text{ times}$$

$$150 \text{ times} < 1391 \text{ times}$$

Actual number of apply times

### (2) Study of main bearing capacity

#### • External load condition

$$W_1 = 1350 \text{ N} \quad L_1 = 200 \text{ mm}$$

$$W_2 = 900 \text{ N} \quad L_2 = 100 \text{ mm}$$

#### • Study of thrust load

$$900 \text{ N} < 2940 \text{ N}$$

Allowable axial load of GH40

#### • Verification of load moment (flange type)

$$M_c = 1350 \times \frac{(198.1 + 200)}{1000} + 900 \times \frac{100}{1000}$$

$$= 627 \text{ N-m}$$

$$627 \text{ N-m} < 1823 \text{ N-m}$$

Allowable moment of GH40

#### • GH40 is finally selected (all conditions are satisfied).

# Performance

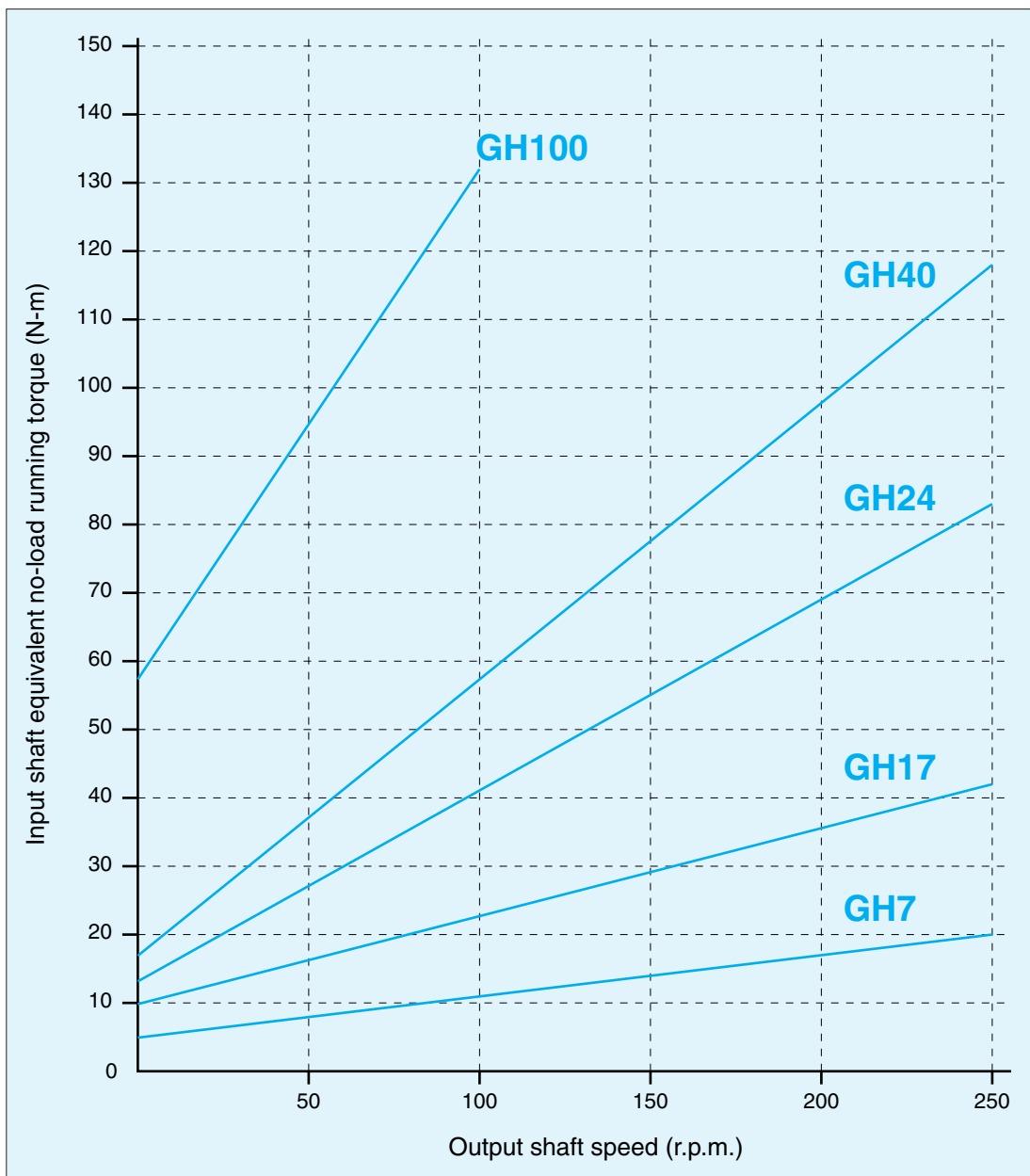
## No-load running torque

Case temperature: 20°C

Lubricant: Grease (Molywhite RE00)

The no-load running torque that is converted to the input shaft side value should be figured out according to the following equation:

$$\text{Input shaft equivalent no-load running torque (N-m)} = \frac{\text{Input shaft equivalent no-load running torque (N-m)}}{\text{Speed ratio}}$$



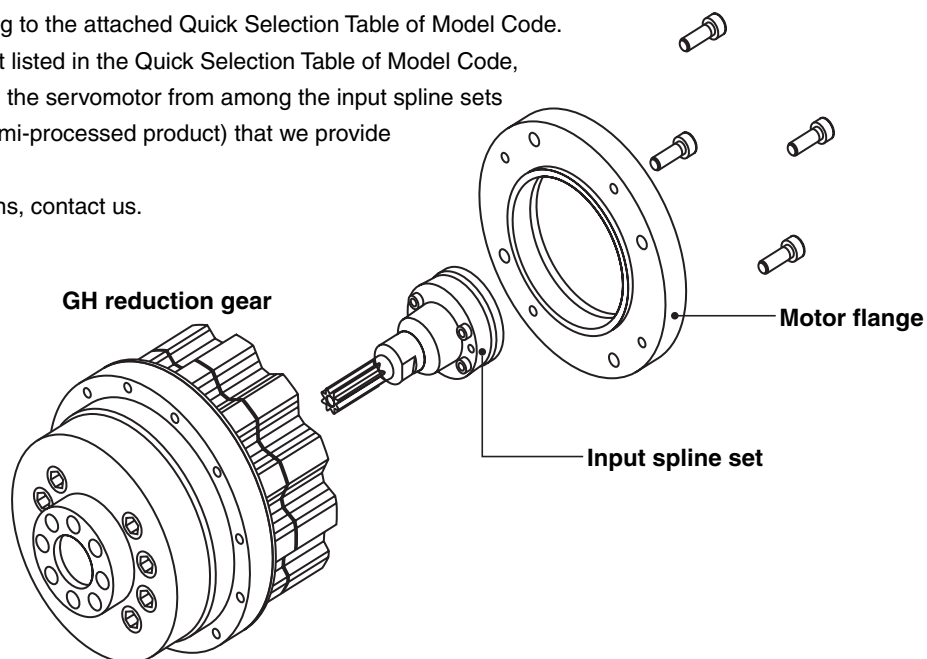
# Model Code

When ordering or making an inquiry, use the following model code.

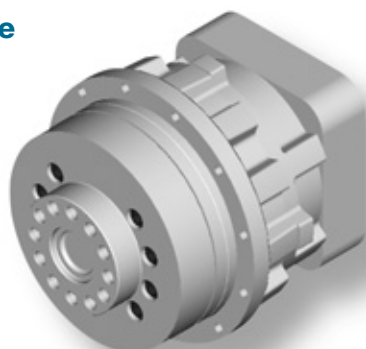
|           |                   |                   |                          |          |                          |
|-----------|-------------------|-------------------|--------------------------|----------|--------------------------|
| <b>GH</b> | <b>7</b>          | <b>21</b>         | <b>A</b>                 | <b>B</b> | <b>P</b>                 |
|           | (1)<br>Model code | (2)<br>Ratio code | (3)<br>Input spline code |          | (4)<br>Motor flange code |
|           | 7                 | 11                | Standard                 | A to ZZ  | Standard                 |
|           | 17                | 21                | Blank                    | Y1       | Blank                    |
|           | 24                | 31                | None                     | Y2       | None                     |
|           | 40                |                   |                          |          |                          |
|           | 100               |                   |                          |          |                          |
|           |                   |                   |                          |          | Output shaft type code   |
|           |                   |                   |                          |          | Flange    P              |
|           |                   |                   |                          |          | Shaft      S             |

## Selection of model code

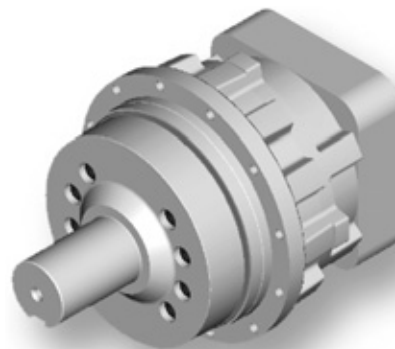
1. Only 21 and 31 can be used as the ratio code of the GH100.
2. Only the flange type output shaft is available for the GH100.
3. Select the model code according to the attached Quick Selection Table of Model Code.
4. When you use a servomotor not listed in the Quick Selection Table of Model Code, select the parts compatible with the servomotor from among the input spline sets and motor flanges (standard/semi-processed product) that we provide (refer to pages 15 to 23).
5. For the customized specifications, contact us.



## Output shaft type



Output flange type

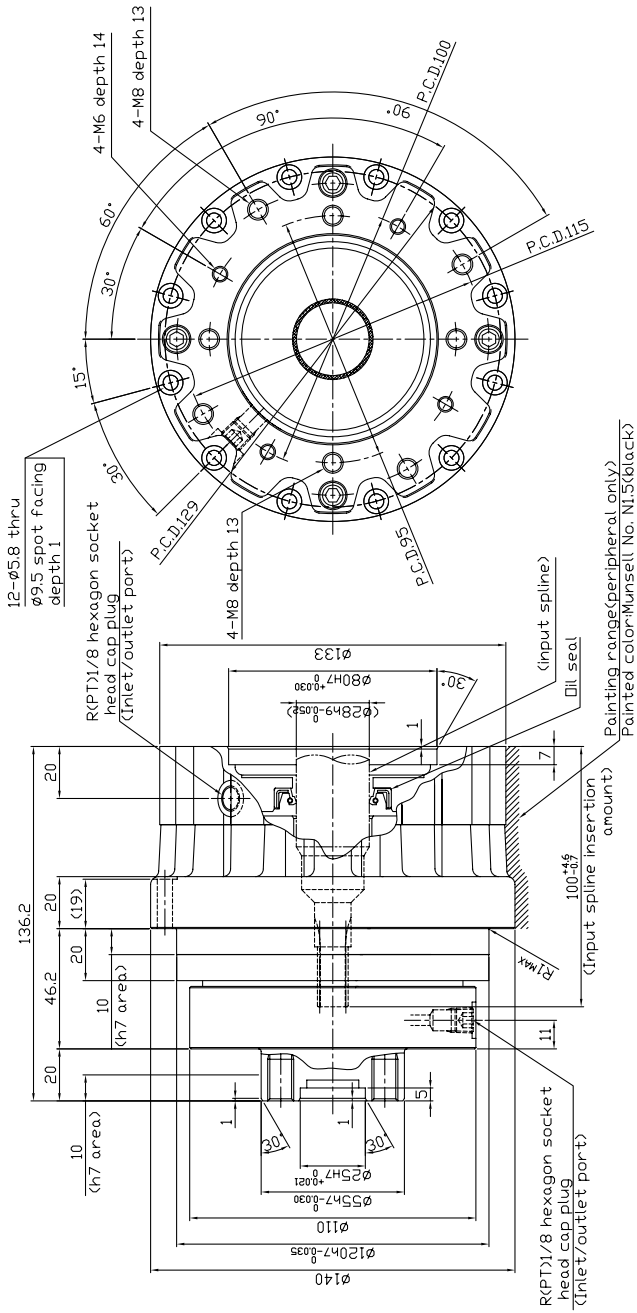


Output shaft type

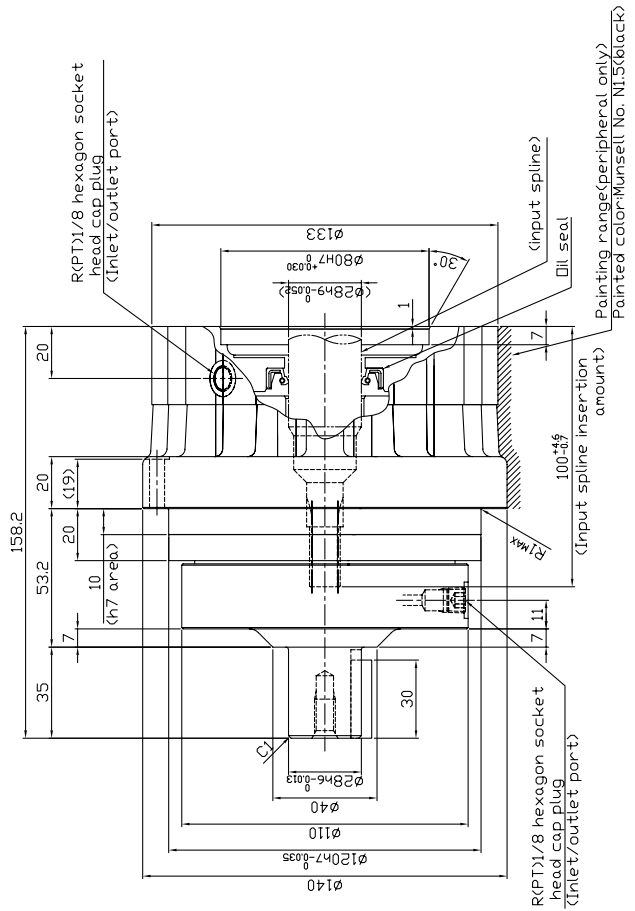
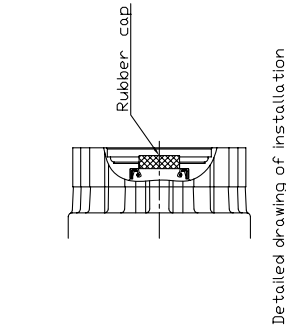
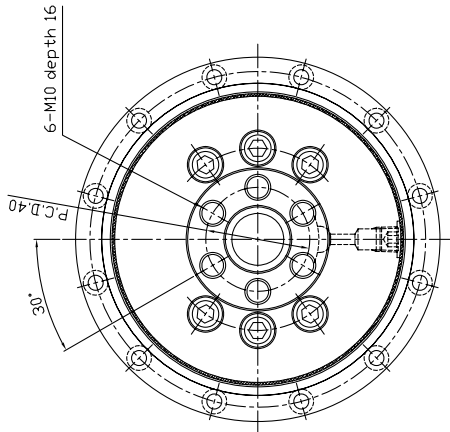
# External Dimension Drawing Reduction Gear

GH7

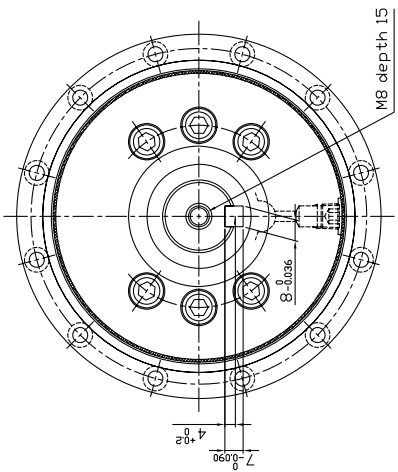
The total length does not include the length of the motor flange.



Output flange type



Output shaft type



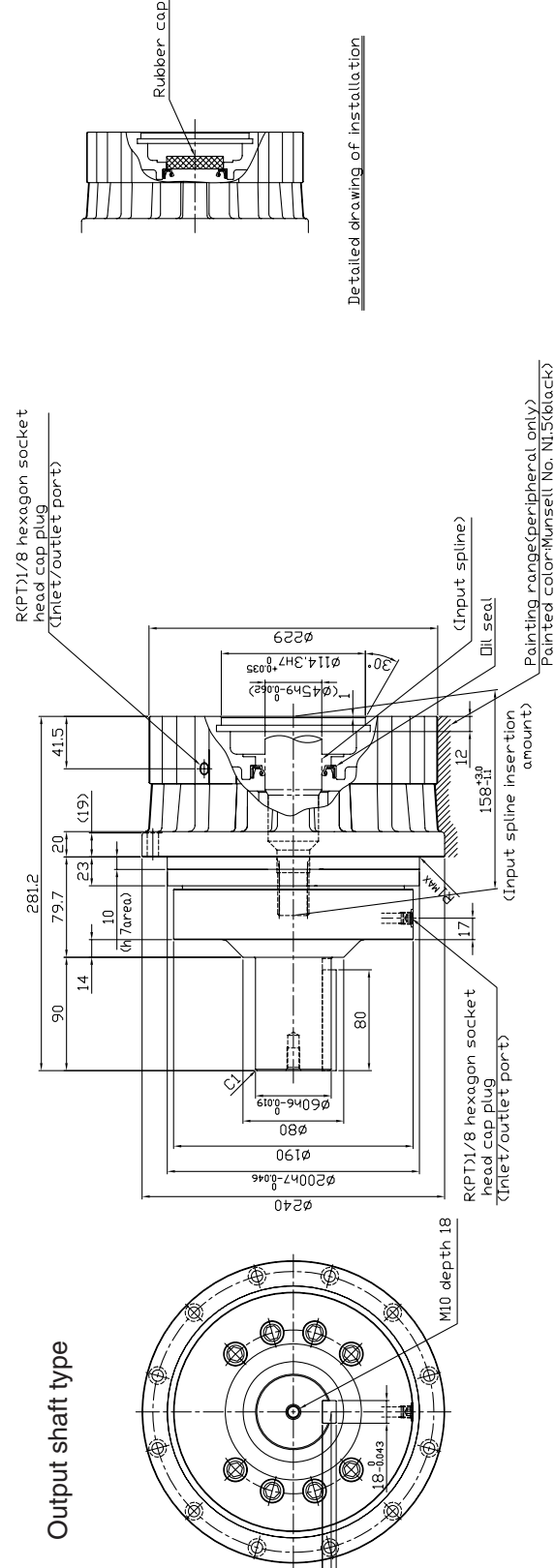
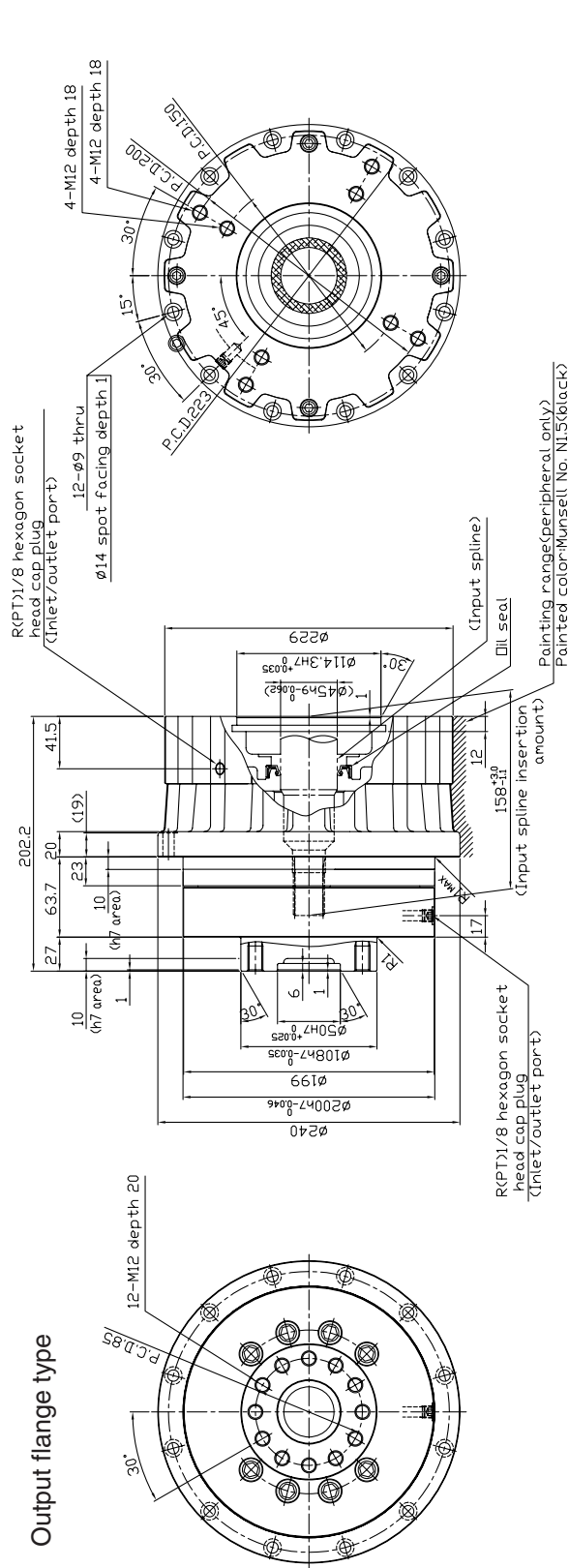






# GH40

The total length does not include the length of the motor flange.





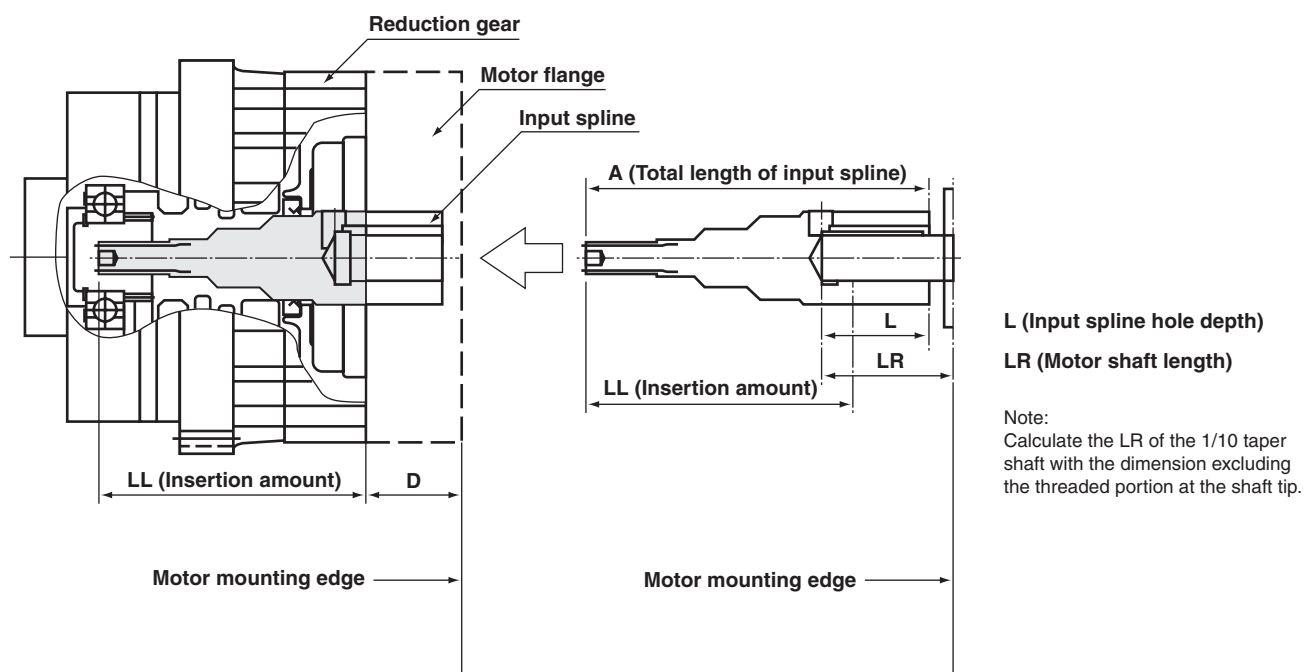
# Model Code Selection (Precautions)

1. Select the model code that is compatible with the servomotor being used according to the Quick Selection Table of Model Code.
2. If a compatible servomotor is not listed in the Quick Selection Table of Model Code, select a part that is compatible with the servomotor according to the external dimension drawings for the input spline set and motor flange attached on the following pages.

Check the thickness of the motor flange according to the following equation:

**Thickness of motor flange  $D = (A + LR - L) - LL$**

| Model Code | LL<br>Input Spline Insertion Amount (mm) |
|------------|--|
| GH7        | 100 <sup>+4.6</sup> <sub>-0.7</sub>      |
| GH17       | 122 <sup>+6.3</sup> <sub>-1.0</sub>      |
| GH24       | 106 <sup>+3.7</sup> <sub>-0.4</sub>      |
| GH40       | 158 <sup>+3.0</sup> <sub>-1.1</sub>      |
| GH100      | 202 <sup>+2.5</sup> <sub>-1.0</sub>      |

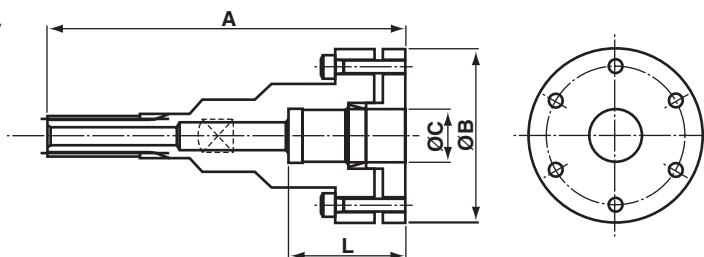


## Combination of reduction gear and servomotor

1. The combinations that satisfy the following equation are recommended.  
 $(\text{Rated torque of motor} \times 0.5) < \{ \text{Rated torque of reduction gear} / (\text{Speed ratio} \times 0.8) \} < (\text{Rated torque of motor} \times 1.5)$
2. Select the combinations that satisfy the following equation.  
 $(\text{Maximum torque of motor}) < \{ \text{Momentary maximum torque of reduction gear} / (\text{Speed ratio} \times 0.8) \}$
3. Limitation must be imposed to the motor torque when the condition indicated in 2 above cannot be satisfied.
4. For more precise motor selection, the effective torque, load inertia moment, brake torque, regenerative ability, and so forth, must also be considered.

# External Dimension Drawing Input Spline Set

For straight shaft without key



| Model | Code | Parts No. | Input Spline Dimension (mm) |    |   |    |
|-------|------|-----------|-----------------------------|----|---|----|
|       |      |           | A                           | ØB | ØC  | L  |
| GH7   | S    | 10S421-*  | 124                         | 53 | 11 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$   | 24 |
|       | A    | 10S421A*  | 124                         | 53 | 14 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$   | 29 |
|       | B    | 10S421B*  | 124                         | 53 | 16 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$   | 29 |
|       | D    | 10S421D*  | 123                         | 53 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 48 |
|       | M    | 10S421M*  | 126                         | 53 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 31 |
|       | N    | 10S421N*  | 120                         | 53 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 60 |
|       | Q    | 10S421Q*  | 144                         | 63 | 24 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 49 |
|       | R    | 10S421R*  | 114                         | 53 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 39 |
|       | T    | 10S421T*  | 124                         | 53 | 16 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$   | 34 |
|       | U    | 10S421U*  | 124                         | 48 | 14 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$   | 24 |
|       | AF   | 10S421AF* | 117                         | 53 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 33 |
|       | AY   | 10S421AY* | 105                         | 53 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 30 |
|       | AZ   | 10S421AZ* | 117                         | 53 | 10 H7 $\begin{smallmatrix} +0.015 \\ 0 \end{smallmatrix}$   | 19 |
|       | BA   | 10S421BA* | 123                         | 53 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 31 |
|       | BB   | 10S421BB* | 123                         | 53 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 38 |
| GH17  | S    | 20S421-*  | 137                         | 63 | 14 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$   | 30 |
|       | B    | 20S421B*  | 137                         | 63 | 24 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 50 |
|       | C    | 20S421C*  | 124                         | 63 | 25 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 40 |
|       | E    | 20S421E*  | 124                         | 63 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 40 |
|       | P    | 20S421P*  | 128                         | 63 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 32 |
|       | Q    | 20S421Q*  | 134                         | 63 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 32 |
|       | T    | 20S421T*  | 124                         | 63 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 40 |
|       | W    | 20S421W*  | 176                         | 68 | 35 $\begin{smallmatrix} +0.035 \\ +0.010 \end{smallmatrix}$ | 73 |
|       | AB   | 20S421AB* | 134                         | 63 | 24 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 37 |
|       | AC   | 20S421AC* | 132                         | 63 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 53 |
|       | AF   | 20S421AF* | 176                         | 68 | 35 $\begin{smallmatrix} +0.035 \\ +0.010 \end{smallmatrix}$ | 59 |
|       | AL   | 20S421AL* | 124                         | 63 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 37 |
|       | AQ   | 20S421AQ* | 132                         | 63 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 30 |
|       | AR   | 20S421AR* | 132                         | 63 | 24 $\begin{smallmatrix} +0.036 \\ +0.015 \end{smallmatrix}$ | 40 |
|       | AS   | 20S421AS* | 131                         | 63 | 16 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$   | 29 |
| GH24  | S    | 30S421-*  | 142                         | 63 | 24 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 50 |
|       | A    | 30S421A*  | 129                         | 63 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 40 |
|       | D    | 30S421D*  | 174                         | 63 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 74 |
|       | E    | 30S421E*  | 129                         | 63 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 60 |
|       | G    | 30S421G*  | 129                         | 63 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 50 |
|       | H    | 30S421H*  | 142                         | 63 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 74 |
|       | Q    | 30S421Q*  | 174                         | 68 | 35 $\begin{smallmatrix} +0.035 \\ +0.010 \end{smallmatrix}$ | 74 |
|       | T    | 30S421T*  | 137                         | 63 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 53 |
|       | U    | 30S421U*  | 139                         | 63 | 24 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 57 |
|       | W    | 30S421W*  | 129                         | 63 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 50 |
|       | AA   | 30S421AA* | 159                         | 68 | 32 H7 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$   | 43 |
|       | AB   | 30S421AB* | 126                         | 63 | 24 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$   | 47 |



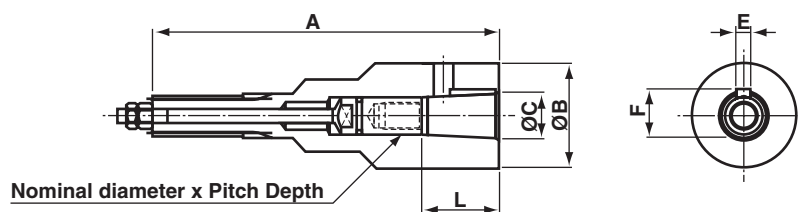
The part numbers attached with \* at the end are our revised numbers. These are subject to change without advance notice.

The shape of the part shown here is only a representation.

For this reason, the actual shape may differ from the drawing shown here.

| Model | Code      | Parts No. | Input Spline Dimension (mm) |  |  |     |
|-------|-----------|-----------|-----------------------------|--|--|-----|
|       |           |           | A                           | ØB                                     | ØC                                     | L   |
| GH24  | AH        | 30S421AH* | 138                         | 63                                     | 22 H7 <sup>+0.021</sup> <sub>0</sub>   | 31  |
|       | AL        | 30S421AL* | 174                         | 68                                     | 35 <sup>+0.035</sup> <sub>+0.010</sub> | 64  |
|       | AM        | 30S421AM* | 174                         | 68                                     | 35 <sup>+0.035</sup> <sub>+0.010</sub> | 59  |
|       | AN        | 30S421AN* | 129                         | 63                                     | 19 H7 <sup>+0.021</sup> <sub>0</sub>   | 37  |
|       | AP        | 30S421AP* | 137                         | 63                                     | 28 H7 <sup>+0.021</sup> <sub>0</sub>   | 45  |
| GH40  | S         | 40S421-*  | 163                         | 68                                     | 22 H7 <sup>+0.021</sup> <sub>0</sub>   | 38  |
|       | A         | 40S421A*  | 176                         | 68                                     | 24 H7 <sup>+0.021</sup> <sub>0</sub>   | 48  |
|       | B         | 40S421B*  | 176                         | 68                                     | 28 H7 <sup>+0.021</sup> <sub>0</sub>   | 58  |
|       | C         | 40S421C*  | 163                         | 68                                     | 35 H7 <sup>+0.025</sup> <sub>0</sub>   | 38  |
|       | D         | 40S421D*  | 177                         | 68                                     | 35 <sup>+0.035</sup> <sub>+0.010</sub> | 73  |
|       | K         | 40S421K*  | 175                         | 68                                     | 32 H7 <sup>+0.025</sup> <sub>0</sub>   | 32  |
|       | M         | 40S421M*  | 176                         | 68                                     | 24 H7 <sup>+0.021</sup> <sub>0</sub>   | 58  |
|       | N         | 40S421N*  | 177                         | 68                                     | 35 <sup>+0.035</sup> <sub>+0.010</sub> | 63  |
|       | U         | 40S421U*  | 211                         | 70                                     | 42 H7 <sup>+0.025</sup> <sub>0</sub>   | 79  |
|       | W         | 40S421W*  | 171                         | 68                                     | 28 H7 <sup>+0.021</sup> <sub>0</sub>   | 51  |
|       | AD        | 40S421AD* | 175                         | 68                                     | 32 H6 <sup>+0.016</sup> <sub>0</sub>   | 34  |
|       | AF        | 40S421AF* | 175                         | 68                                     | 32 H7 <sup>+0.025</sup> <sub>0</sub>   | 42  |
|       | AL        | 40S421AL* | 175                         | 70                                     | 32 H7 <sup>+0.025</sup> <sub>0</sub>   | 57  |
|       | AM        | 40S421AM* | 176                         | 68                                     | 28 H7 <sup>+0.021</sup> <sub>0</sub>   | 48  |
| AN    | 40S421AN* | 177       | 68                          | 35 <sup>+0.035</sup> <sub>+0.010</sub> | 58                                     |     |
| GH100 | A         | 60S421A*  | 216                         | 77                                     | 42 H7 <sup>+0.025</sup> <sub>0</sub>   | 102 |
|       | C         | 60S421C*  | 216                         | 75                                     | 35 <sup>+0.035</sup> <sub>+0.010</sub> | 68  |
|       | D         | 60S421D*  | 216                         | 77                                     | 42 H7 <sup>+0.025</sup> <sub>0</sub>   | 74  |
|       | E         | 60S421E*  | 216                         | 77                                     | 42 H7 <sup>+0.025</sup> <sub>0</sub>   | 68  |
|       | F         | 60S421F*  | 216                         | 75                                     | 35 <sup>+0.035</sup> <sub>+0.010</sub> | 53  |

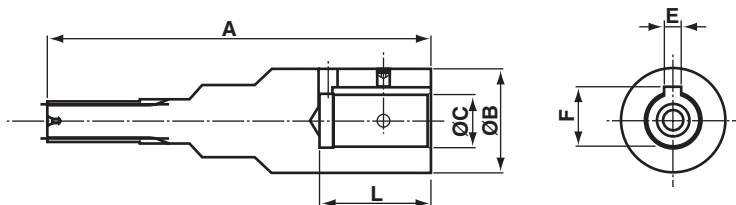
### For 1/10 taper



| Model | Code | Parts No. | Input Spline Dimension (mm) |    |                                   |    |    |       | Thread    |       |       |
|-------|------|-----------|-----------------------------|----|-----------------------------------|----|----|-------|-----------|-------|-------|
|       |      |           | A                           | ØB | ØC                                | L  | E  | F     | Nom. Dia. | Pitch | Depth |
| GH7   | G    | 10S422G*  | 86                          | 38 | 11 <sup>+0.1</sup> <sub>0</sub>   | 15 | 4  | 7     | M6        | P1.0  | 9     |
|       | H    | 10S422H*  | 112                         | 28 | 16 <sup>+0.1</sup> <sub>0</sub>   | 28 | 5  | 9.5   | M10       | P1.25 | 13    |
|       | X    | 10S422X*  | 106                         | 28 | 14 <sup>+0.1</sup> <sub>0</sub>   | 18 | 5  | 8.65  | M8        | P1.0  | 13    |
|       | AB   | 10S422AB* | 116                         | 28 | 11 <sup>+0.1</sup> <sub>0</sub>   | 15 | 4  | 7     | M6        | P1.0  | 9     |
|       | AR   | 10S422AR* | 130                         | 32 | 22 <sup>+0.1</sup> <sub>0</sub>   | 36 | 6  | 12.9  | M12       | P1.25 | 15    |
|       | AS   | 10S422AS* | 106                         | 28 | 14 <sup>+0.1</sup> <sub>0</sub>   | 18 | 4  | 8.25  | M8        | P1.0  | 13    |
| GH17  | F    | 20S422F*  | 104                         | 38 | 16 <sup>+0.1</sup> <sub>0</sub>   | 28 | 5  | 9.5   | M10       | P1.25 | 13    |
|       | R    | 20S422R*  | 124                         | 38 | 16 <sup>+0.1</sup> <sub>0</sub>   | 28 | 5  | 9.5   | M10       | P1.25 | 13    |
| GH24  | F    | 30S422F*  | 129                         | 36 | 16 <sup>+0.1</sup> <sub>0</sub>   | 28 | 5  | 9.5   | M10       | P1.25 | 13    |
|       | K    | 30S422K*  | 144                         | 42 | 30.8 <sup>+0.1</sup> <sub>0</sub> | 46 | 7  | 17.75 | M20       | P1.5  | 23    |
|       | L    | 30S422L*  | 105                         | 36 | 16 <sup>+0.1</sup> <sub>0</sub>   | 28 | 5  | 9.5   | M10       | P1.25 | 13    |
| GH40  | E    | 40S422E*  | 165                         | 45 | 16 <sup>+0.1</sup> <sub>0</sub>   | 28 | 5  | 9.5   | M10       | P1.25 | 13    |
|       | H    | 40S422H*  | 149                         | 45 | 30.8 <sup>+0.1</sup> <sub>0</sub> | 46 | 7  | 17.75 | M20       | P1.5  | 23    |
|       | X    | 40S422X*  | 248                         | 72 | 55 <sup>+0.1</sup> <sub>0</sub>   | 82 | 10 | 29.85 | M36       | P3.0  | 30    |

# External Dimension Drawing Input Spline Set

For straight shaft with key



| Model | Code      | Parts No. | Input Spline Dimension (mm) |                           |                                |    |      |      |  |
|-------|-----------|-----------|-----------------------------|---------------------------|--------------------------------|----|------|------|--|
|       |           |           | A                           | ØB                        | ØC                             | L  | E    | F    |  |
| GH7   | C         | 10S423C*  | 124                         | 28                        | 14 H7 <sup>+0.018/0</sup>      | 29 | 5    | 16.3 |  |
|       | J         | 10S423J*  | 125                         | 28                        | 16 H7 <sup>+0.018/0</sup>      | 35 | 5    | 18.3 |  |
|       | W         | 10S423W*  | 125                         | 32                        | 19 G7 <sup>+0.028/+0.007</sup> | 35 | 6    | 21.8 |  |
|       | Y         | 10S423Y*  | 112                         | 28                        | 14 H7 <sup>+0.018/0</sup>      | 28 | 5    | 16.3 |  |
|       | AC        | 10S423AC* | 120                         | 28                        | 14 H7 <sup>+0.018/0</sup>      | 45 | 5    | 16.3 |  |
|       | AD        | 10S423AD* | 133                         | 36                        | 22 H7 <sup>+0.021/0</sup>      | 41 | 6    | 24.8 |  |
|       | AH        | 10S423AH* | 112                         | 32                        | 17 H7 <sup>+0.018/0</sup>      | 29 | 5    | 19.3 |  |
|       | AK        | 10S423AK* | 134                         | 32                        | 19 H7 <sup>+0.021/0</sup>      | 39 | 6    | 21.8 |  |
|       | AM        | 10S423AM* | 134                         | 38                        | 24 H7 <sup>+0.021/0</sup>      | 39 | 8    | 27.3 |  |
|       | AN        | 10S423AN* | 133                         | 36                        | 22 H7 <sup>+0.021/0</sup>      | 28 | 6    | 24.8 |  |
|       | AP        | 10S423AP* | 125                         | 32                        | 19 H7 <sup>+0.021/0</sup>      | 30 | 6    | 21.8 |  |
|       | AQ        | 10S423AQ* | 119                         | 28                        | 14 H7 <sup>+0.018/0</sup>      | 19 | 5    | 16.3 |  |
|       | AT        | 10S423AT* | 124                         | 32                        | 17 H7 <sup>+0.018/0</sup>      | 49 | 5    | 19.3 |  |
|       | AU        | 10S423AU* | 113                         | 32                        | 16 H7 <sup>+0.018/0</sup>      | 28 | 5    | 18.3 |  |
|       | AW        | 10S423AW* | 124                         | 28                        | 11 H7 <sup>+0.018/0</sup>      | 24 | 4    | 12.8 |  |
|       | AX        | 10S423AX* | 117                         | 28                        | 10 H7 <sup>+0.015/0</sup>      | 19 | 3    | 11.4 |  |
| GH17  | G         | 20S423G*  | 137                         | 38                        | 22 H7 <sup>+0.021/0</sup>      | 50 | 6    | 24.8 |  |
|       | K         | 20S423K*  | 137                         | 38                        | 19 H7 <sup>+0.021/0</sup>      | 40 | 5    | 21.3 |  |
|       | N         | 20S423N*  | 172                         | 50                        | 35 <sup>+0.035/+0.010</sup>    | 69 | 10   | 38.3 |  |
|       | X         | 20S423X*  | 170                         | 45                        | 28 H7 <sup>+0.021/0</sup>      | 43 | 8    | 31.3 |  |
|       | Y         | 20S423Y*  | 163                         | 50                        | 35 <sup>+0.035/+0.010</sup>    | 46 | 10   | 38.3 |  |
|       | AD        | 20S421AD* | 130                         | 38                        | 22 H7 <sup>+0.021/0</sup>      | 33 | 8    | 25.3 |  |
|       | AA        | 20S423AA* | 130                         | 38                        | 24 H7 <sup>+0.021/0</sup>      | 37 | 8    | 27.3 |  |
|       | AE        | 20S423AE* | 123                         | 38                        | 17 H7 <sup>+0.018/0</sup>      | 28 | 5    | 19.3 |  |
|       | AK        | 20S423AK* | 123                         | 38                        | 19 H7 <sup>+0.021/0</sup>      | 36 | 6    | 21.8 |  |
|       | AP        | 20S423AP* | 137                         | 38                        | 19 H7 <sup>+0.021/0</sup>      | 40 | 6    | 21.8 |  |
|       | AT        | 20S423AT* | 136                         | 40                        | 22 H7 <sup>+0.021/0</sup>      | 49 | 6    | 24.8 |  |
|       | AU        | 20S423AU* | 135                         | 38                        | 19 H7 <sup>+0.021/0</sup>      | 33 | 6    | 21.8 |  |
| GH24  | AX        | 20S423AX* | 136                         | 38                        | 16 H7 <sup>+0.018/0</sup>      | 29 | 5    | 18.3 |  |
|       | AY        | 20S423AY* | 123                         | 38                        | 19 H7 <sup>+0.021/0</sup>      | 39 | 5    | 21.3 |  |
|       | B         | 30S423B*  | 159                         | 50                        | 35 <sup>+0.035/+0.010</sup>    | 58 | 10   | 38.3 |  |
|       | J         | 30S423J*  | 159                         | 42                        | 28 H7 <sup>+0.021/0</sup>      | 48 | 8    | 31.0 |  |
|       | M         | 30S423M*  | 111                         | 36                        | 22 H7 <sup>+0.021/0</sup>      | 38 | 8    | 25.3 |  |
|       | X         | 30S423X*  | 122                         | 42                        | 24 H7 <sup>+0.021/0</sup>      | 37 | 8    | 27.3 |  |
|       | Y         | 30S423Y*  | 154                         | 42                        | 28 H7 <sup>+0.021/0</sup>      | 37 | 8    | 31.3 |  |
|       | AD        | 30S423AD* | 160                         | 50                        | 28 H7 <sup>+0.021/0</sup>      | 38 | 8    | 31.3 |  |
|       | AE        | 30S423AE* | 159                         | 50                        | 32 H7 <sup>+0.025/0</sup>      | 58 | 10   | 35.3 |  |
|       | AF        | 30S423AF* | 156                         | 44                        | 28 H7 <sup>+0.021/0</sup>      | 53 | 8    | 31.3 |  |
| AG    | 30S423AG* | 129       | 42                          | 22 H7 <sup>+0.021/0</sup> | 50                             | 8  | 25.3 |      |  |

For the GH100 input spline set, contact us.

The part numbers attached with \* at the end are our revised numbers.

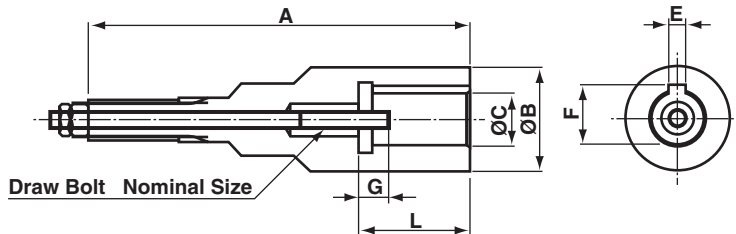
These are subject to change without advance notice.

The shape of the part shown here is only a representation.

For this reason, the actual shape may differ from the drawing shown here.

| Model | Code | Parts No. | Input Spline Dimension (mm) |    |  |    |    |      |
|-------|------|-----------|-----------------------------|----|--|----|----|------|
|       |      |           | A                           | ØB | ØC   | L  | E  | F    |
| GH40  | F    | 40S423F*  | 176                         | 45 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$      | 48 | 8  | 31.3 |
|       | G    | 40S423G*  | 194                         | 50 | 35 $\begin{smallmatrix} +0.035 \\ +0.010 \end{smallmatrix}$    | 58 | 10 | 38.3 |
|       | L    | 40S423L*  | 225                         | 60 | 42 H7 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$      | 93 | 12 | 45.3 |
|       | P    | 40S423P*  | 169                         | 45 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$      | 49 | 8  | 31.3 |
|       | R    | 40S423R*  | 169                         | 45 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$      | 49 | 10 | 31.3 |
|       | T    | 40S423T*  | 225                         | 75 | 55 H7 $\begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$      | 56 | 16 | 59.3 |
|       | Y    | 40S423Y*  | 187                         | 50 | 35 H7 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$      | 59 | 10 | 38.3 |
|       | AA   | 40S423AA* | 173                         | 45 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$      | 35 | 8  | 25.3 |
|       | AB   | 40S423AB* | 172                         | 50 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$      | 38 | 10 | 31.3 |
|       | AC   | 40S423AC* | 176                         | 50 | 28 G7 $\begin{smallmatrix} +0.028 \\ +0.007 \end{smallmatrix}$ | 58 | 8  | 31.3 |
|       | AE   | 40S423AE* | 173                         | 50 | 24 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$      | 55 | 8  | 27.3 |
|       | AG   | 40S423AG* | 172                         | 50 | 28 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$      | 38 | 8  | 31.3 |
|       | AJ   | 40S423AJ* | 194                         | 50 | 32 H7 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$      | 58 | 10 | 35.3 |
|       | AK   | 40S423AK* | 200                         | 60 | 42 H7 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$      | 68 | 12 | 45.3 |

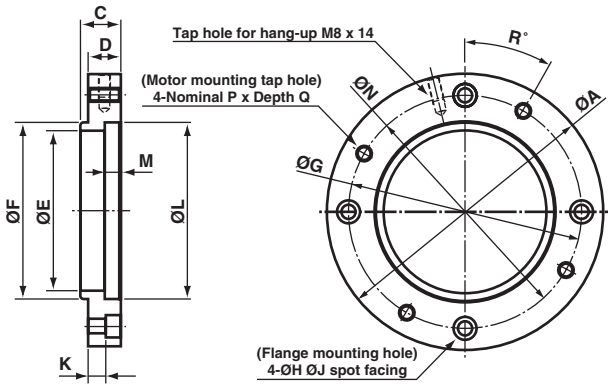
### For straight shaft with key (with draw bolt)



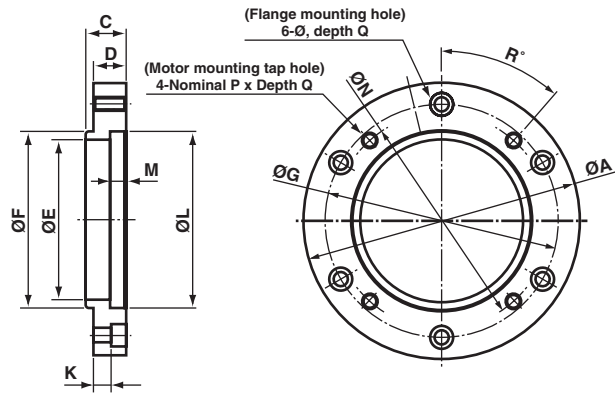
| Model | Code | Parts No. | Input Spline Dimension (mm) |    |   |      |    |      | Stud Bolt |    |
|-------|------|-----------|-----------------------------|----|---|------|----|------|-----------|----|
|       |      |           | A                           | ØB | ØC  | L    | E  | F    | Nom. Dia. | G  |
| GH7   | E    | 10S423E*  | 124                         | 28 | 16 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$ | 34   | 5  | 18.3 | M5        | 12 |
|       | F    | 10S423F*  | 94                          | 28 | 16 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$ | 29   | 5  | 18.3 | M5        | 10 |
|       | AG   | 10S423AG* | 94                          | 28 | 16 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$ | 29   | 5  | 18.3 | M5        | 10 |
| GH17  | D    | 20S423D*  | 136                         | 38 | 19 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$ | 39   | 6  | 21.8 | M6        | 12 |
|       | J    | 20S423J*  | 136                         | 38 | 16 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$ | 29   | 5  | 18.3 | M5        | 12 |
|       | AH   | 20S423AH* | 125.5                       | 35 | 17 H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$ | 42.5 | 5  | 19.3 | M6        | 16 |
|       | AJ   | 20S423AJ* | 123                         | 38 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$ | 39   | 6  | 24.8 | M5        | 11 |
| GH24  | P    | 30S423P*  | 147.5                       | 36 | 22 H7 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$ | 38   | 6  | 24.8 | M6        | 12 |
| GH40  | J    | 40S423J*  | 165.5                       | 50 | 35 H7 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$ | 39   | 10 | 38.3 | M6        | 13 |

# External Dimension Drawing Motor Flange

## Circle type



## Circle type (30S)



## Circle type

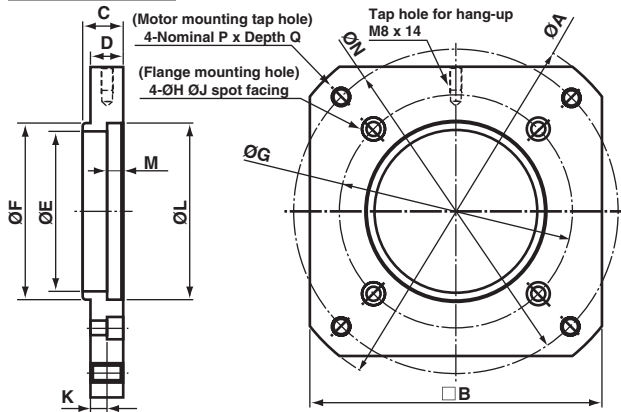
| Model          | Code     | Parts No. | Motor Flange Dimension (mm) |    |    |     | Reduction Gear Mounting Dimension (mm)                 |  |     |      |    | Motor Mounting Dimension (mm) |  |  |     |     |     |     |     |
|----------------|----------|-----------|-----------------------------|----|----|-----|--|--|-----|------|----|-------------------------------|--|--|-----|-----|-----|-----|-----|
|                |          |           | ØA                          | C  | D  | ØE  | ØF   | ØG   | ØH  | ØJ   | K  | ØL                            | M  | ØN   | P   | Q   | R°  |     |     |
| GH7            | S        | 10S203-*  | 135                         | 35 | 30 | 72  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 10                            | 95   | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 115 | M8  | 20  | 45° |
|                | D        | 10S203D*  | 135                         | 35 | 30 | 72  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 9                             | 80   | $H7 \begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$ | 10  | 100 | M6  | 15  | 45° |
|                | G        | 10S203G*  | 135                         | 35 | 30 | 60  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 9                             | 50   | $H7 \begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$ | 5   | 70  | M4  | 10  | 45° |
|                | H        | 10S203H*  | 135                         | 35 | 30 | 60  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 9                             | 70   | $H7 \begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$ | 10  | 90  | M6  | 15  | 45° |
|                | J        | 10S203J*  | 135                         | 35 | 30 | 60  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 9                             | 50   | $H7 \begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$ | 5   | 70  | M5  | 10  | 45° |
|                | N        | 10S203N*  | 135                         | 55 | 50 | 72  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 9                             | 80   | $H7 \begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$ | 12  | 100 | M6  | 15  | 45° |
|                | Q        | 10S203Q*  | 135                         | 35 | 30 | 60  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 9                             | 70   | $H7 \begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$ | 10  | 90  | M5  | 15  | 45° |
|                | X        | 10S203X*  | 135                         | 55 | 50 | 72  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 10                            | 95   | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 115 | M8  | 20  | 45° |
|                | AE       | 10S203AE* | 135                         | 25 | 20 | 70  | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 115 | 9    | 14 | 9                             | 80   | $H7 \begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$ | 10  | 100 | M6  | 15  | 60° |
| GH17           | S        | 20S203-*  | 170                         | 25 | 20 | 100 | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145 | 9    | 14 | 10                            | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 145 | M8  | -   | 30° |
|                | A        | 20S203A*  | 190                         | 25 | 20 | 100 | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150 | 9    | 14 | 10                            | 130  | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 10  | 165 | M10 | -   | 45° |
|                | B        | 20S203B*  | 170                         | 25 | 20 | 72  | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145 | 9    | 14 | 10                            | 80   | $H7 \begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$ | 10  | 100 | M6  | 12  | 45° |
|                | F        | 20S203F*  | 170                         | 25 | 20 | 80  | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145 | 9    | 14 | 10                            | 95   | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 115 | M8  | -   | 30° |
|                | K        | 20S203K*  | 190                         | 25 | 20 | 100 | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150 | 9    | 14 | 10                            | 115  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 165 | M8  | -   | 45° |
|                | L        | 20S203L*  | 170                         | 65 | 60 | 100 | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145 | 9    | 14 | 10                            | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 145 | M8  | 20  | 30° |
|                | U        | 20S203U*  | 170                         | 40 | 35 | 100 | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145 | 9    | 14 | 10                            | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 145 | M8  | 20  | 30° |
| W              | 20S203W* | 170       | 25                          | 20 | 70 | 110 | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145  | 9   | 14   | 10 | 95                            | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10   | 115 | M6  | 12  | 30° |     |
| GH24           | N        | 30S203N*  | 170                         | 65 | 60 | 100 | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145 | 9    | 14 | 8                             | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 145 | M8  | 15  | 45° |
| GH40/<br>GH100 | S        | 40S203-*  | 230                         | 30 | 25 | 100 | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 200 | 13.5 | 20 | 5                             | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 7   | 145 | M8  | 20  | 0°  |
|                | E        | 40S203E*  | 230                         | 30 | 25 | 100 | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 200 | 13.5 | 20 | 5                             | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | -   | 45° |
|                | G        | 40S203G*  | 230                         | 30 | 25 | 100 | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 200 | 13.5 | 20 | 7                             | 130  | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 10  | 165 | M10 | -   | 0°  |
|                | H        | 40S203H*  | 230                         | 48 | 43 | 100 | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 200 | 13.5 | 20 | 5                             | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | 22  | 45° |
|                | M        | 40S203M*  | 230                         | 62 | 57 | 100 | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 200 | 13.5 | 20 | 5                             | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | 25  | 45° |
|                | T        | 40S203T*  | 230                         | 92 | 87 | 100 | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 200 | 13.5 | 20 | 5                             | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | 22  | 45° |
|                | W        | 40S203W*  | 230                         | 58 | 53 | 100 | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 200 | 13.5 | 20 | 5                             | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | 22  | 45° |

## Circle type (30S)

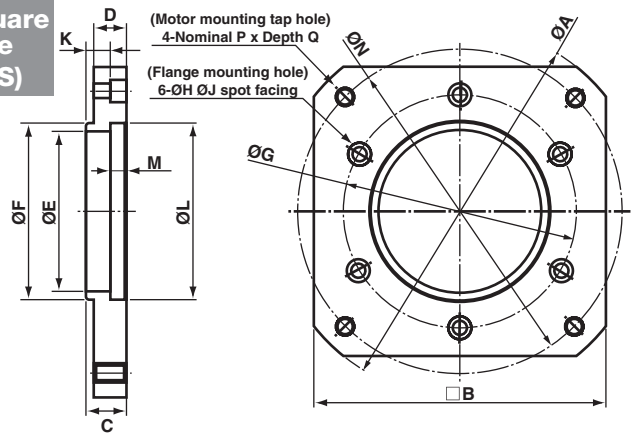
| Model | Code | Parts No. | Motor Flange Dimension (mm) |    |    |    | Reduction Gear Mounting Dimension (mm) |  |     |    |    | Motor Mounting Dimension (mm) |     |  |    |     |    |    |     |
|-------|------|-----------|-----------------------------|----|----|----|--|--|-----|----|----|-------------------------------|-----|--|----|-----|----|----|-----|
|       |      |           | ØA                          | C  | D  | ØE | ØF                                     | ØG   | ØH  | ØJ | K  | ØL                            | M   | ØN   | P  | Q   | R° |    |     |
| GH24  | L    | 30S203L*  | 170                         | 33 | 28 | 70 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 8                             | 110 | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 8  | 145 | M8 | 20 | 45° |
|       | M    | 30S203M*  | 170                         | 33 | 28 | 80 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 8                             | 95  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 8  | 115 | M8 | 17 | 45° |
|       | Q    | 30S203Q*  | 170                         | 33 | 28 | 70 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 10                            | 80  | $H7 \begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$ | 10 | 100 | M6 | 12 | 45° |
|       | R    | 30S203R*  | 170                         | 33 | 28 | 70 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 8                             | 95  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10 | 115 | M6 | 12 | 45° |

The part numbers attached with \* at the end are our revised numbers. These are subject to change without advance notice.  
The shape of the part shown here is only a representation. For this reason, the actual shape may differ from the drawing shown here.

**Square type**



**Square type (30S)**



**Square type**

| Model          | Code     | Parts No. | Motor Flange Dimension (mm) |     |     |     |       | Reduction Gear Mounting Dimension (mm)                 |  |      |      |    | Motor Mounting Dimension (mm) |  |  |     |     |     |    |
|----------------|----------|-----------|-----------------------------|-----|-----|-----|-------|--|--|------|------|----|-------------------------------|--|--|-----|-----|-----|----|
|                |          |           | ØA                          | □B  | C   | D   | ØE    | ØF   | ØG   | ØH   | ØJ   | K  | ØL                            | M  | ØN   | P   | Q   |     |    |
| GH7            | A        | 10S203A*  | 165                         | 130 | 35  | 30  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 10                            | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 11  | 145 | M8  | 20 |
|                | B        | 10S203B*  | 215                         | 165 | 35  | 30  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 9                             | 150  | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 10  | 185 | M10 | -  |
|                | C        | 10S203C*  | 190                         | 150 | 35  | 30  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 9                             | 130  | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 11  | 165 | M10 | -  |
|                | E        | 10S203E*  | 155                         | 120 | 35  | 30  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 9                             | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 130 | M8  | 20 |
|                | F        | 10S203F*  | 165                         | 130 | 55  | 50  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 10                            | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 11  | 145 | M8  | 20 |
|                | K        | 10S203K*  | 230                         | 180 | 55  | 50  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 10                            | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | 20 |
|                | L        | 10S203L*  | 230                         | 180 | 70  | 65  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 10                            | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | 20 |
|                | M        | 10S203M*  | 190                         | 150 | 55  | 50  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 10                            | 130  | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 12  | 165 | M10 | 20 |
|                | P        | 10S203P*  | 230                         | 180 | 35  | 30  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 10                            | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 12  | 200 | M12 | -  |
| GH17           | W        | 10S203W*  | 190                         | 150 | 35  | 30  | 72    | 80   | $h7 \begin{smallmatrix} 0 \\ -0.030 \end{smallmatrix}$ | 95   | 9    | 14 | 9                             | 115  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 11  | 165 | M8  | -  |
|                | C        | 20S203C*  | 230                         | 180 | 25  | 20  | 100   | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145  | 9    | 14 | 10                            | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 200 | M12 | -  |
|                | D        | 20S203D*  | 230                         | 180 | 65  | 60  | 100   | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145  | 9    | 14 | 10                            | 114.3  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 200 | M12 | 20 |
|                | E        | 20S203E*  | 270                         | 220 | 25  | 20  | 100   | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145  | 9    | 14 | 5                             | 200  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 7   | 235 | M12 | -  |
| GH24           | G        | 20S203G*  | 270                         | 220 | 65  | 60  | 100   | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145  | 9    | 14 | 10                            | 200  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 10  | 235 | M12 | 20 |
|                | H        | 20S203H*  | 270                         | 220 | 45  | 40  | 100   | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145  | 9    | 14 | 10                            | 200  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 10  | 235 | M12 | 20 |
| GH40/<br>GH100 | B        | 30S203B*  | 165                         | 130 | 46  | 41  | 100   | 110  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 145  | 9    | 14 | 8                             | 110  | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10  | 145 | M8  | 13 |
|                | A        | 40S203A*  | 250                         | 200 | 30  | 25  | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 180  | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 7   | 215 | M12 | -  |
|                | B        | 40S203B*  | 270                         | 220 | 30  | 25  | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 200  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 7   | 235 | M12 | -  |
|                | C        | 40S203C*  | 270                         | 220 | 48  | 43  | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 200  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 10  | 235 | M12 | 25 |
|                | D        | 40S203D*  | 300                         | 250 | 30  | 25  | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 230  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 7   | 265 | M12 | -  |
|                | F        | 40S203F*  | 270                         | 220 | 30  | 25  | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 200  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 7   | 250 | M8  | 20 |
|                | K        | 40S203K*  | 270                         | 220 | 95  | 90  | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 200  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 10  | 235 | M12 | 25 |
|                | L        | 40S203L*  | 250                         | 200 | 64  | 59  | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 180  | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 12  | 215 | M12 | 15 |
|                | N        | 40S203N*  | 330                         | 265 | 117 | 112 | 100   | 114.3  | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20 | 5                             | 250  | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 10  | 300 | M16 | 25 |
| X              | 40S203X* | 250       | 200                         | 30  | 25  | 100 | 114.3 | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 150  | 13.5 | 20   | 5  | 180                           | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 7  | 215 | M14 | -   |    |

**Square type (30S)**

| Model | Code | Parts No. | Motor Flange Dimension (mm) |     |    |    |     | Reduction Gear Mounting Dimension (mm) |  |     |    |    | Motor Mounting Dimension (mm) |       |  |    |     |     |    |
|-------|------|-----------|-----------------------------|-----|----|----|-----|--|--|-----|----|----|-------------------------------|-------|--|----|-----|-----|----|
|       |      |           | ØA                          | □B  | C  | D  | ØE  | ØF                                     | ØG   | ØH  | ØJ | K  | ØL                            | M     | ØN   | P  | Q   |     |    |
| GH24  | S    | 30S203-*  | 230                         | 174 | 78 | 73 | 100 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | -  | 9                             | 114.3 | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 10 | 200 | M12 | 13 |
|       | C    | 30S203C*  | 230                         | 180 | 46 | 41 | 100 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 9                             | 114.3 | $H7 \begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$ | 6  | 200 | M12 | 13 |
|       | D    | 30S203D*  | 250                         | 200 | 33 | 28 | 100 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 10                            | 180   | $H7 \begin{smallmatrix} +0.040 \\ 0 \end{smallmatrix}$ | 8  | 215 | M12 | -  |
|       | E    | 30S203E*  | 270                         | 220 | 33 | 28 | 100 | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 10                            | 200   | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 8  | 235 | M12 | -  |
|       | F    | 30S203F*  | 270                         | 220 | 65 | 60 | 95  | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 9                             | 200   | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 10 | 235 | M12 | 20 |
|       | H    | 30S203H*  | 270                         | 220 | 65 | 60 | 95  | 110                                    | $h7 \begin{smallmatrix} 0 \\ -0.035 \end{smallmatrix}$ | 138 | 9  | 14 | 9                             | 200   | $H7 \begin{smallmatrix} +0.046 \\ 0 \end{smallmatrix}$ | 10 | 250 | M8  | 20 |



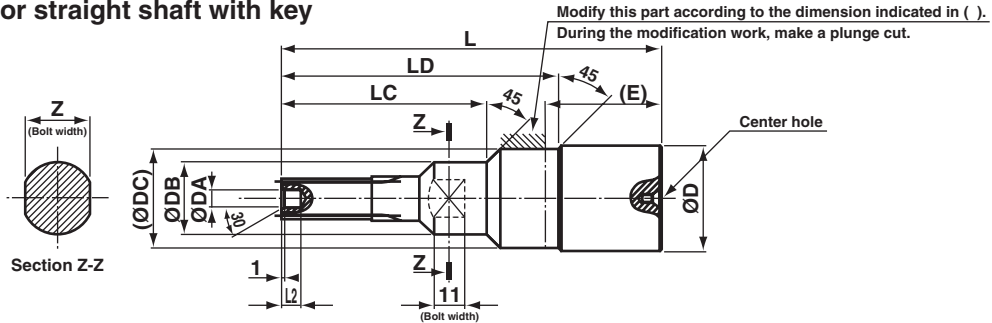
# Combination with Non-standard Product

For the combination with a nonstandard product, use a semi-processed product (for the GH100, however, a semi-processed product is not available).

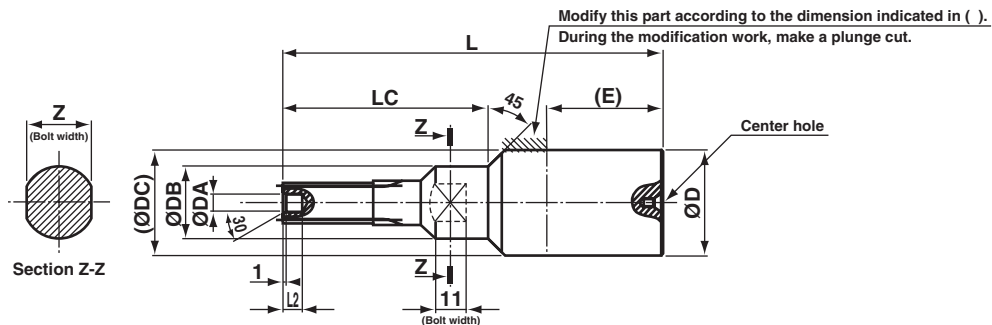
The parts numbers attached with at the end are our revised numbers. These are subject to change without advance notice.

## 1. Input spline blank

For Y1 taper shaft or straight shaft with key

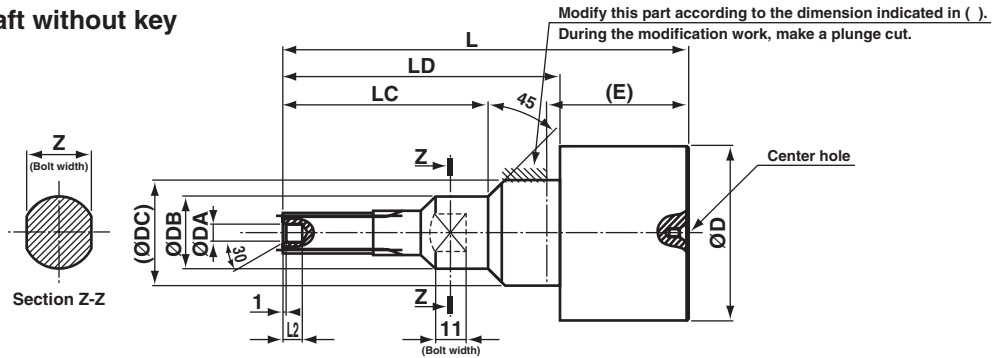


| Model | Code | Parts No. | Input Spline Dimension (mm) |     |     |                                   |      |     |    |      |       |                                 |
|-------|------|-----------|-----------------------------|-----|-----|-----------------------------------|------|-----|----|------|-------|---------------------------------|
|       |      |           | ØD                          | ØDA | ØDB | ØDC                               | (E)  | L   | L2 | LC   | LD    | Z                               |
| GH7   | Y1   | 10S140-*  | 32                          | 4.5 | 24  | 28.2 <sup>+0.1</sup> <sub>0</sub> | (52) | 137 | 5  | 58   | 94    | 21 <sup>0</sup> <sub>-0.4</sub> |
| GH24  | Y1   | 30S140-*  | 42                          | 6.6 | 32  | 36.2 <sup>+0.1</sup> <sub>0</sub> | (62) | 159 | 7  | 65   | 100   | 27 <sup>0</sup> <sub>-0.4</sub> |
| GH40  | Y1   | 40S140-*  | 50                          | 11  | 40  | 45.2 <sup>+0.1</sup> <sub>0</sub> | (70) | 194 | 8  | 95.5 | 128.5 | 34 <sup>0</sup> <sub>-0.4</sub> |



| Model | Code | Parts No. | Input Spline Dimension (mm) |     |     |                                   |      |     |    |    |    |                                 |
|-------|------|-----------|-----------------------------|-----|-----|-----------------------------------|------|-----|----|----|----|---------------------------------|
|       |      |           | ØD                          | ØDA | ØDB | ØDC                               | (E)  | L   | L2 | LC | LD | Z                               |
| GH17  | Y1   | 20S140-*  | 38.2                        | 6.6 | 26  | 38.2 <sup>+0.1</sup> <sub>0</sub> | (41) | 137 | 7  | 74 | -  | 23 <sup>0</sup> <sub>-0.4</sub> |

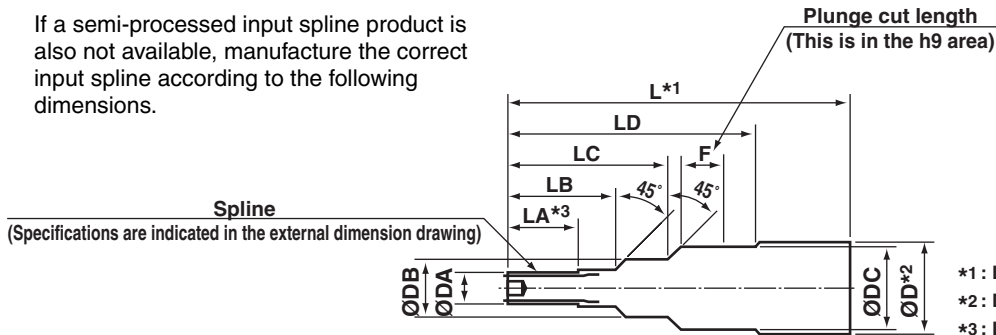
For Y2 straight shaft without key



| Model | Code | Parts No. | Input Spline Dimension (mm) |     |     |                                    |      |     |    |      |     |                                 |
|-------|------|-----------|-----------------------------|-----|-----|------------------------------------|------|-----|----|------|-----|---------------------------------|
|       |      |           | ØD                          | ØDA | ØDB | ØDC                                | (E)  | L   | L2 | LC   | LD  | Z                               |
| GH7   | Y2   | 10S140A*  | 53                          | 4.5 | 24  | 28.2 <sup>+0.1</sup> <sub>0</sub>  | (48) | 133 | 5  | 58   | 90  | 21 <sup>0</sup> <sub>-0.4</sub> |
| GH17  | Y2   | 20S140A*  | 63                          | 6.6 | 26  | 38 <sup>+0.2</sup> <sub>+0.1</sub> | (50) | 146 | 7  | 74   | 99  | 23 <sup>0</sup> <sub>-0.4</sub> |
| GH24  | Y2   | 30S140A*  | 63                          | 6.6 | 32  | 36 <sup>+0.2</sup> <sub>+0.1</sub> | (64) | 161 | 7  | 65   | 100 | 27 <sup>0</sup> <sub>-0.4</sub> |
| GH40  | Y2   | 40S140A*  | 70                          | 11  | 40  | 45 <sup>+0.2</sup> <sub>+0.1</sub> | (58) | 184 | 8  | 95.5 | 131 | 34 <sup>0</sup> <sub>-0.6</sub> |

## 2. Manufacturing of input spline

If a semi-processed input spline product is also not available, manufacture the correct input spline according to the following dimensions.



- \*1 : L must equal or exceed LD.
- \*2 : D must equal or exceed DC.
- \*3 : LA is the spline effective teeth width.

| Model | ØDA | ØDB | ØDC                                  | F(Min) | LA | LB | LC   | LD    |
|-------|-----|-----|--------------------------------------|--------|----|----|------|-------|
| GH7   | 14  | 24  | 28 h9 <sup>0</sup> <sub>-0.052</sub> | 25     | 23 | 40 | 58   | 90    |
| GH17  | 16  | 26  | 38 h9 <sup>0</sup> <sub>-0.062</sub> | 16     | 33 | 50 | 74   | 99    |
| GH24  | 18  | 32  | 36 h9 <sup>0</sup> <sub>-0.062</sub> | 30     | 20 | 40 | 65   | 100   |
| GH40  | 26  | 40  | 45 h9 <sup>0</sup> <sub>-0.062</sub> | 28     | 34 | 52 | 95.5 | 128.5 |
| GH100 | 30  | 52  | 55 h9 <sup>0</sup> <sub>-0.074</sub> | 30     | 44 | 84 | 155  | 200   |

Material: SCM415 HNR  
 Surface finishing: Carburizing and quenching  
 Surface hardness: Hrc58 to 62  
 Applicable depth of quench-hardened case: 0.3 to 0.7 mm (Hv513)

### Spline specifications

#### GH7

| Involute spline (shaft)<br>12 x 10 x 1.0 (JIS B1603 Appendix) |                   |  |
|---|-------------------|--|
| Addendum modification coefficient +0.8                        |                   |  |
| Tool  | Tooth form        | Low tooth  |
|   | Module            | 1.00   |
| Pressure angle  |                   | 20°  |
| Number of teeth   |                   | 10   |
| Pitch circle diameter   |                   | 10   |
| Face width  | Over-pin diameter |  |
|   | Pin diameter      | Ø1.80 13.564 <sup>-0.012</sup> <sub>-0.078</sub> |
| Class   |                   | Class b  |
| Remarks   |                   | Side fit   |

#### GH17

| Involute spline (shaft)<br>15 x 10 x 1.25 (JIS B1603 Appendix) |                   |  |
|--|-------------------|--|
| Addendum modification coefficient +0.8                         |                   |  |
| Tool   | Tooth form        | Low tooth  |
|  | Module            | 1.25   |
| Pressure angle   |                   | 20°  |
| Number of teeth  |                   | 10   |
| Pitch circle diameter  |                   | 12.5   |
| Face width   | Over-pin diameter |  |
|  | Pin diameter      | Ø2.25 16.954 <sup>-0.012</sup> <sub>-0.078</sub> |
| Class  |                   | Class b  |
| Remarks  |                   | Side fit   |

#### GH24

| Involute spline (shaft)<br>17 x 12 x 1.25 (JIS B1603 Appendix) |                   |  |
|--|-------------------|--|
| Addendum modification coefficient +0.6                         |                   |  |
| Tool   | Tooth form        | Low tooth  |
|  | Module            | 1.25   |
| Pressure angle   |                   | 20°  |
| Number of teeth  |                   | 12   |
| Pitch circle diameter  |                   | 15   |
| Face width   | Over-pin diameter |  |
|  | Pin diameter      | Ø2.25 19.225 <sup>-0.013</sup> <sub>-0.084</sub> |
| Class  |                   | Class b  |
| Remarks  |                   | Side fit   |

#### GH40/100

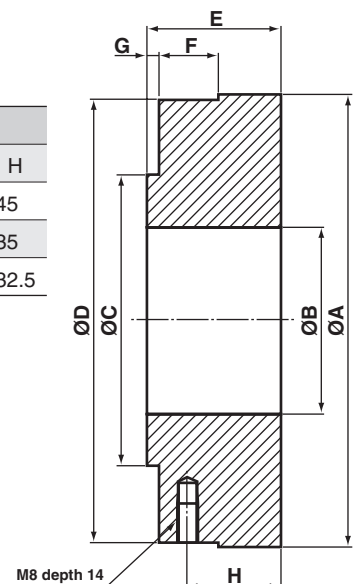
| Involute spline (shaft)<br>25 x 18 x 1.25 (JIS B1603 Appendix) |                   |  |
|--|-------------------|--|
| Addendum modification coefficient +0.8                         |                   |  |
| Tool   | Tooth form        | Low tooth  |
|  | Module            | 1.25   |
| Pressure angle   |                   | 20°  |
| Number of teeth  |                   | 18   |
| Pitch circle diameter  |                   | 22.5   |
| Face width   | Over-pin diameter |  |
|  | Pin diameter      | Ø2.25 27.183 <sup>-0.013</sup> <sub>-0.089</sub> |
| Class  |                   | Class b  |
| Remarks  |                   | Side fit   |

## 3. Motor flange blank (external dimension drawing)

When you use the following semi-processed product, while the standard product is not available, order motor flange code "Y1".

| Model | Code | Parts No. | Input Spline Dimension (mm) |     |   |     |    |    |   |      |  |
|-------|------|-----------|-----------------------------|-----|---|-----|----|----|---|------|--|
|       |      |           | ØA                          | ØB  | ØC                                      | ØD  | E  | F  | G | H    |  |
| GH7   | Y1   | 10S240-*  | 140                         | 70  | 80 h7 <sup>0</sup> <sub>-0.030</sub>    | 135 | 60 | 27 | 5 | 45   |  |
| GH17  | Y1   | 20S240-*  | 170                         | 70  | 110 h7 <sup>0</sup> <sub>-0.035</sub>   | 166 | 50 | 22 | 5 | 35   |  |
| GH40  | Y1   | 40S240-*  | 230                         | 100 | 114.3 h7 <sup>0</sup> <sub>-0.035</sub> | 266 | 50 | 22 | 5 | 32.5 |  |

\* In the designing process, determine the hole size for the motor flange mounting bolt in reference to the external dimension drawing of reduction gear.

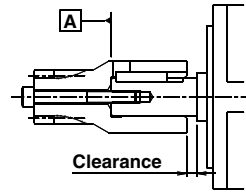


When determining the motor flange length (thickness), take the input spline dimension and the input spline insertion amount in the reduction gear into consideration (refer to page 15).

## 1. Input spline motor shaft hole design

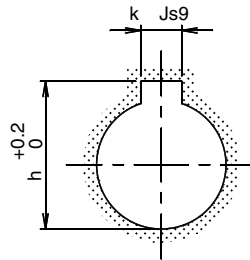
### Reference for the motor shaft edge contact (Recommended by Nabtesco Corporation)

The input gear reference mounting position is "A", which is the edge of the motor shaft. (There is a clearance between the edge of the motor shaft base and the end face of the input gear.)



### 1) Tolerance of key width and height

There are various different diameters of the motor shaft. For each shaft diameter, we define the tolerance of key width and key height as follows.



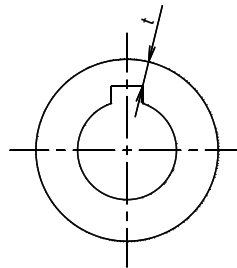
The tolerance of key width should be in compliance with "Js9" (JIS ordinary class).

The tolerance of key height should be "0" to "+0.2".

\* The tolerance of key height defined by JIS is "0" to "+0.1". However, with consideration given to the tilt of the slotter tool for the keyway, we define the dimensional tolerance as above.

### 2) Study of wall thickness between keyway and hub outside diameter

We define the wall thickness "t" between the shaft hole diameter and the outside diameter as shown on the right.



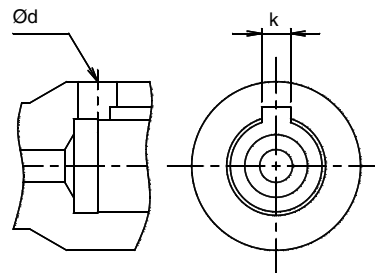
Wall thickness "t"  $\geq 3$   
(based on our past results)

\* If the wall thickness is below "t" defined here, the hardness of the core increases during quenching (carburizing), causing the core to be less likely bent or twisted, which will require a masking process. In addition, it could also cause a swell or tilt of keyway toward the shaft, invalidating the symmetry feature of keyway width.

### 3) Relief hole for processing keyway

When processing a keyway, a relief hole for chippings will be required.

We define the diameter of the relief hole (drilled hole) as follows.

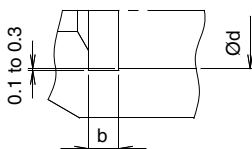


Drilled hole (Ød) = k + 2 mm

\* The above dimension is determined with consideration given to the tolerance of core misalignment during drilling.

### 4) Relief hole for shaft hole polishing and its width

For accuracy of gear and centering of the shaft hole diameter, the hole is polished. At this point, be sure to leave a relief width (polish 0.1 to 0.3 mm along the radius) at the back of the shaft hole.



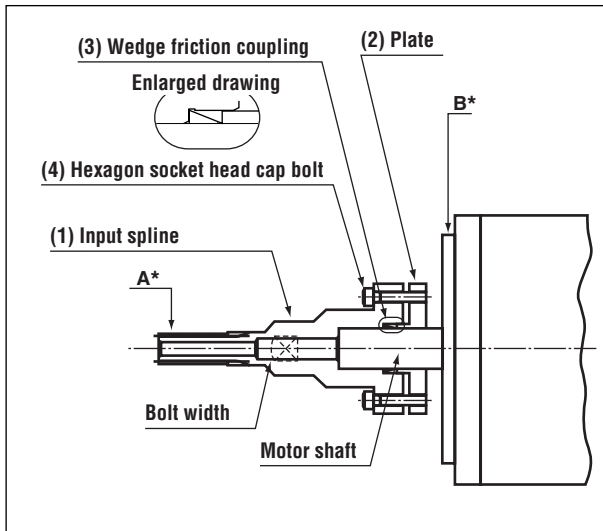
We define the relief width "b" as follows:

| Shaft diameter (Ød) | Relief width (b) |
|---------------------|------------------|
| Ød < 25 mm          | 5 mm             |
| Ød $\geq$ 25 mm     | 7 mm             |

## 5) Attachment to the servomotor

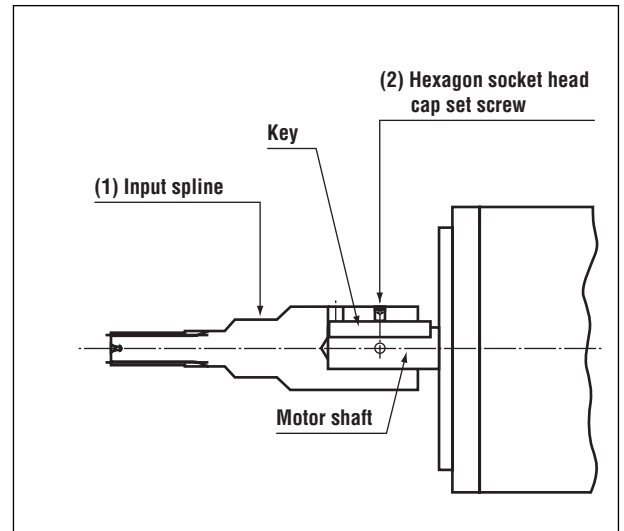
The following is a representative case for connecting an input spline to the servomotor shaft.

### (1) For straight type (without key)

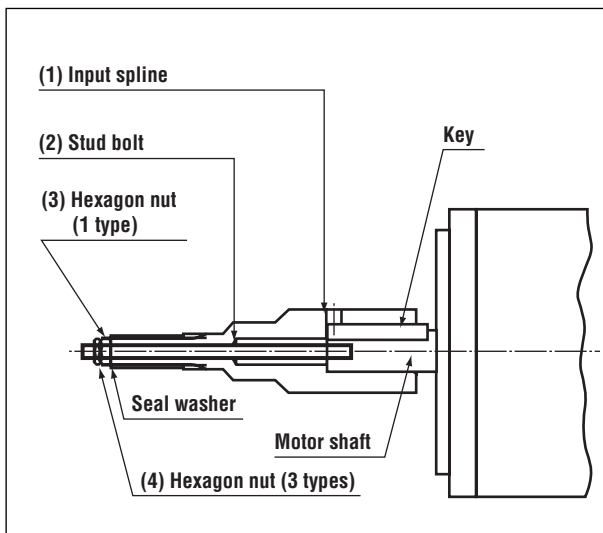


\* Adjust the deviation of "A" at the edge of the input spline to 70  $\mu\text{m}$  or less against "B" on the motor mounting pilot diameter.

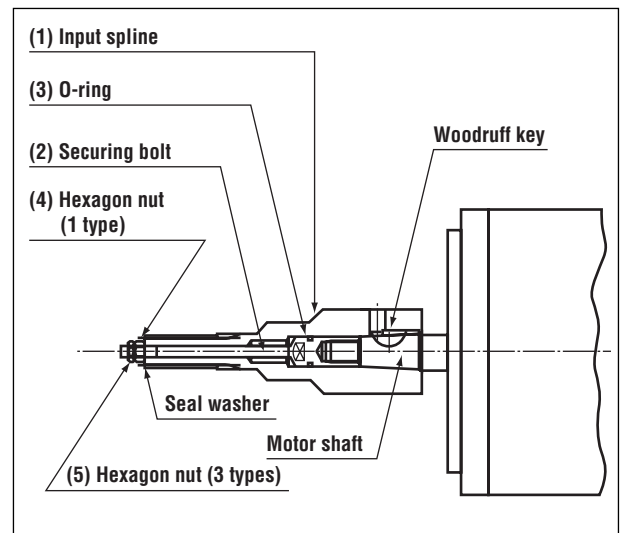
### (2) For straight type (with key)



### (3) For straight type (stud bolt with key)



### (4) For 1/10 taper



# Engineering Notes

## 2. Installation of the reduction gear and mounting it to the output shaft

When installing a reduction gear and mounting it to the output shaft, use hexagon socket head cap screws and tighten to the torque, as specified below, in order to satisfy the momentary maximum allowable torque, which is noted in the rating table. Employment of the Belleville spring washer is recommended to prevent the bolt from loosening and protect the bolt cross section from flaws.

### 1) Bolt tightening torque and tightening force

| Hexagon socket head cap screw<br>nominal size x pitch | Tightening torque<br>(N-m) | Tightening force<br>F<br>(N) | Bolt specification  |
|---|----------------------------|------------------------------|---|
| M5 x 0.8  | 9.01 ± 0.49                | 9310                         | Hexagon socket head cap screw<br>JIS B 1176 or Equivalent |
| M6 x 1.0  | 15.6 ± 0.78                | 13180                        |   |
| M8 x 1.25   | 37.2 ± 1.86                | 23960                        |   |
| M10 x 1.5   | 73.5 ± 3.43                | 38080                        | Strength class<br>JIS B 1051 12.9 or Equivalent           |
| M12 x 1.75  | 128.4 ± 6.37               | 55100                        | Thread<br>JIS B 0205 6 g or class 2 or Equivalent         |
| M14 x 2.0   | 204.8 ± 10.2               | 75860                        |   |
| M16 x 2.0   | 318.5 ± 15.9               | 103410                       |   |

- Note: 1. The tightening torque values listed are for steel or cast iron material.  
2. If softer material, such as aluminum or stainless, is used, limit the tightening torque. Also pay attention to the system requirements of the transmission torque.

### 2) Calculation of allowable transmission torque of bolts

|   |   |  |
|---|---|--|
| $T = F \times \frac{D \times 10^{-3}}{2} \times \mu \times n$ | T | Allowable transmission torque by tightening bolt (N-m)   |
|   | F | Bolt tightening force (N)  |
|   | D | Bolt mounting P.C.D (mm)   |
|   | μ | Friction factor<br>μ=0.15: When grease remains on the mating face.<br>μ=0.20: When grease is removed from the mating face. |
|   | n | Number of bolts (pcs.)   |

### 3) Serrated lock washer External teeth for hexagonal socket bolt

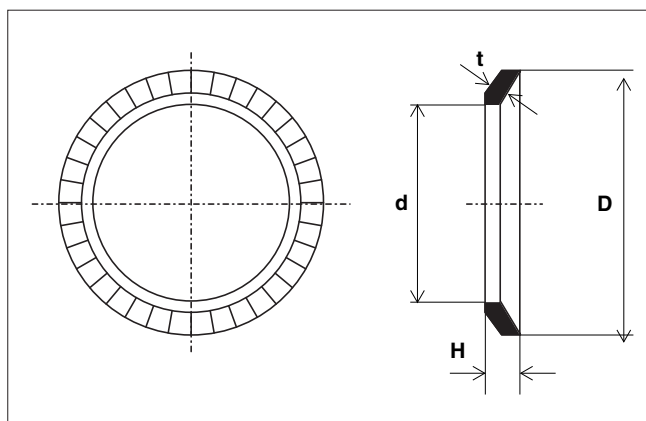
TS Corporation symbol: Bell-SW-2H (nominal size)

Material: Steel

Hardness: HRC 40 to 48

(Unit: mm)

| Nominal size | ID and OD of Belleville spring washer |     | t   | H    |
|--------------|---------------------------------------|-----|-----|------|
|              | d<br>Basic size                       | D   |     |      |
| 5            | 5.25                                  | 8.5 | 0.6 | 0.85 |
| 6            | 6.4                                   | 10  | 1.0 | 1.25 |
| 8            | 8.4                                   | 13  | 1.2 | 1.55 |
| 10           | 10.6                                  | 16  | 1.5 | 1.9  |
| 12           | 12.6                                  | 18  | 1.8 | 2.2  |
| 14           | 14.6                                  | 21  | 2.0 | 2.5  |
| 16           | 16.9                                  | 24  | 2.3 | 2.8  |



Note: When using any equivalent washer, select it with special care given to its outside diameter.

### 3. Lubrication

The standard lubrication method for the GH reduction gear is greasing.

Before shipping the reduction gear, grease recommended by Nabtesco Corporation (Molywhite RE NO 00) is filled into the product.

When a reduction gear filled with the appropriate amount of grease is operated, the standard replacement time due to grease deterioration is 20,000 hours.

When using the gear with deteriorated grease or under an inappropriate ambient temperature condition (40°C or more), check the deterioration condition of the grease and determine the appropriate replacement cycle.

#### Specified grease name

|                     |                      |
|---------------------|----------------------|
| Grease name         | Molywhite RE00       |
| Manufacturer        | Nabtesco Corporation |
| Ambient temperature | -10 to 40°C          |



# MEMO

A series of horizontal dashed lines for writing.

# Appendix

|   |           |
|---|-----------|
| <b>1. Table of SI units</b>   | <b>30</b> |
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# Appendix

## 1. Table of SI units

### 1) Comparison of SI, CGS, and gravity units

| Quantity<br>Unit System | Length L | Mass M            | Time T | Acceleration | Force | Stress     | Pressure   | Energy        |
|-------------------------|----------|-------------------|--------|--------------|-------|------------|------------|---------------|
| SI                      | m        | kg                | s      | $m/s^2$      | N     | Pa         | Pa         | J             |
| CGS System              | cm       | g                 | s      | Gal          | dyn   | $dyn/cm^2$ | $dyn/cm^2$ | erg           |
| Gravitation System      | m        | $kgf \cdot s^2/m$ | s      | $m/s^2$      | kgf   | $kgf/cm^2$ | $kgf/m^2$  | $kgf \cdot m$ |

| Quantity<br>Unit System | Power Rate      | Temperature | Viscosity         | Dynamic Viscosity | Magnetic Flux | Flux Density | Magnetic Field Strength |
|-------------------------|-----------------|-------------|-------------------|-------------------|---------------|--------------|-------------------------|
| SI                      | W               | K           | $Pa \cdot s$      | $m^2/s$           | Wb            | T            | A/m                     |
| CGS System              | erg/s           | $^{\circ}C$ | P                 | St                | Mx            | Gs           | Oe                      |
| Gravitation System      | $kgf \cdot m/s$ | $^{\circ}C$ | $kgf \cdot s/m^2$ | $m^2/s$           | —             | —            | —                       |

### 2) Basic unit prefix (JIS Z 8203)

| Multiples of<br>Unit | Prefix |        | Multiples of<br>Unit | Prefix |        |
|----------------------|--------|--------|----------------------|--------|--------|
|                      | Name   | Symbol |                      | Name   | Symbol |
| $10^{18}$            | Exa    | E      | $10^{-1}$            | Deci   | d      |
| $10^{15}$            | Peta   | P      | $10^{-2}$            | Centi  | c      |
| $10^{12}$            | Tera   | T      | $10^{-3}$            | Milli  | m      |
| $10^9$               | Giga   | G      | $10^{-6}$            | Micro  | $\mu$  |
| $10^6$               | Mega   | M      | $10^{-9}$            | Nano   | n      |
| $10^3$               | Kilo   | k      | $10^{-12}$           | Pico   | p      |
| $10^2$               | Hecto  | h      | $10^{-15}$           | Femto  | f      |
| 10                   | Deca   | da     | $10^{-18}$           | Ato    | a      |

### 3) SI-customary unit conversion table

| Quantity                       | Unit Designation                         | Symbol                    | Conversion Rate to SI   | Name of SI Unit                   | Symbol                 |
|--------------------------------|--|---------------------------|-------------------------|-----------------------------------|------------------------|
| Plane Angle                    | Degree                                   | °                         | $\pi/180$               | Radiant                           | rad                    |
|                                | Minute                                   | '                         | $\pi/10\ 800$           |                                   |                        |
|                                | Second                                   | "(sec)                    | $\pi/648\ 000$          |                                   |                        |
| Length                         | Meter                                    | m                         | 1                       | Meter                             | m                      |
|                                | Micron                                   | $\mu$                     | $10^{-6}$               |                                   |                        |
|                                | Angstrom                                 | Å                         | $10^{-10}$              |                                   |                        |
| Area                           | Square meter                             | m <sup>2</sup>            | 1                       | Square meter                      | m <sup>2</sup>         |
|                                | Are                                      | a                         | $10^2$                  |                                   |                        |
|                                | Hectare                                  | ha                        | $10^4$                  |                                   |                        |
| Volume                         | Cubic meter                              | m <sup>3</sup>            | 1                       | Cubic meter                       | m <sup>3</sup>         |
|                                | Liter                                    | ℓ(L)                      | $10^{-3}$               |                                   |                        |
| Mass                           | Kilogram                                 | kg                        | 1                       | Kilogram                          | kg                     |
|                                | Ton                                      | t                         | $10^3$                  |                                   |                        |
|                                | Kilogram force / square second per meter | kgf · s <sup>2</sup> /m   | 9.806 65                |                                   |                        |
| Time                           | Second                                   | s                         | 1                       | Second                            | s                      |
|                                | Minute                                   | min                       | 60                      |                                   |                        |
|                                | Hour                                     | h                         | 3 600                   |                                   |                        |
|                                | Day                                      | d                         | 86 400                  |                                   |                        |
| Speed                          | Meters per second                        | m/s                       | 1                       | Meters per second                 | m/s                    |
|                                | Knot                                     | kn                        | 1 852/3 600             |                                   |                        |
| Frequency and Vibration        | Cycle                                    | s <sup>-1</sup> (pps)     | 1                       | Hertz                             | Hz                     |
| Revolutions (rotational speed) | Revolutions per minute (rpm)             | r.p.m.(r/min)             | 1/60                    | Per second                        | s <sup>-1</sup>        |
| Angular Speed                  | Radians per second                       | rad/s                     | 1                       | Radians per second                | rad/s                  |
| Acceleration                   | Meters per square second                 | m/s <sup>2</sup>          | 1                       | Meters per second square          | m/s <sup>2</sup>       |
|                                | G  | G                         | 9.806 65                |                                   |                        |
| Force                          | Kilogram force                           | kgf                       | 9.806 65                | Newton                            | N                      |
|                                | Ton force                                | tf                        | 9.806 65                |                                   |                        |
|                                | Dyne                                     | dyn                       | $10^{-5}$               |                                   |                        |
| Force Moment                   | Kilogram force / meter                   | kgf · m                   | 9.806 65                | Newton meter                      | N · m                  |
| Inertia Moment                 | Kilogram force / meter / square second   | kgf · m · s <sup>-2</sup> | 9.806 65                | Kilogram / square meter           | kg · m <sup>2</sup>    |
| Stress                         | Kilogram force per square meter          | kgf/m <sup>2</sup>        | 9.806 65                | Pascal or Newton per square meter | Pa or N/m <sup>2</sup> |
| Pressure                       | Kilogram force per square meter          | kgf/m <sup>2</sup>        | 9.806 65                | Pascal                            | Pa                     |
|                                | Meter water column                       | mH <sub>2</sub> O         | 9.806 65                |                                   |                        |
|                                | Meter of mercury                         | mHg                       | 101 325/0.76            |                                   |                        |
|                                | Torr                                     | Torr                      | 101 325/760             |                                   |                        |
|                                | Atmosphere                               | atm                       | 101 325                 |                                   |                        |
|                                | Bar                                      | bar                       | $10^5$                  |                                   |                        |
| Energy                         | Erg                                      | erg                       | $10^{-7}$               | Joule                             | J                      |
|                                | IT calorie                               | cal <sub>IT</sub>         | 4.186 8                 |                                   |                        |
|                                | Kilogram force / meter                   | kgf · m                   | 9.806 65                |                                   |                        |
|                                | Kilowatt hour                            | kW · h                    | $3.600 \times 10^6$     |                                   |                        |
|                                | Metric horsepower per hour               | PS · h                    | $2.647\ 79 \times 10^6$ |                                   |                        |
| Power Rate and Power           | Watt                                     | W                         | 1                       | Watt                              | W                      |
|                                | Metric horsepower                        | PS                        | 735.5                   |                                   |                        |
|                                | Kilogram force / meter per second        | kgf · m/s                 | 9.806 65                |                                   |                        |
| Viscosity                      | Poise                                    | P                         | $10^{-1}$               | Pascal second                     | Pa · s                 |
|                                | Centipoise                               | cP                        | $10^{-3}$               |                                   |                        |
|                                | Kilogram force / square second per meter | kgf · s/m <sup>2</sup>    | 9.806 65                |                                   |                        |
| Dynamic Viscosity              | Stoke                                    | St                        | $10^{-4}$               | Square meter per second           | m <sup>2</sup> /s      |
|                                | Centistoke                               | cSt                       | $10^{-6}$               |                                   |                        |
| Temperature                    | Degree                                   | °C                        | +273.15                 | Kelvin                            | K                      |
| Radioactive                    | Curie                                    | Ci                        | $3.7 \times 10^{10}$    | Becquerel                         | Bq                     |
| Dosage                         | Roentgen                                 | R                         | $2.58 \times 10^{-4}$   | Coulombs per kilogram             | C/kg                   |
| Absorption Dosage              | Rad                                      | rad                       | $10^{-2}$               | Gray                              | Gy                     |
| Dosage Equivalent              | Rem                                      | rem                       | $10^{-2}$               | Sievert                           | Sv                     |
| Magnetic flux                  | Maxwell                                  | Mx                        | $10^{-8}$               | Weber                             | Wb                     |
| Flux density                   | Gamma                                    | γ                         | $10^{-9}$               | Tesla                             | T                      |
|                                | Gauss                                    | Gs                        | $10^{-4}$               |                                   |                        |
| Magnetic Field Strength        | Oersted                                  | Oe                        | $10^3/4\pi$             | Amperes per meter                 | A/m                    |
| Quantity of Electricity        | Coulomb                                  | C                         | 1                       | Coulomb                           | C                      |
| Potential Difference           | Volt                                     | V                         | 1                       | Volt                              | V                      |
| Electric Resistance            | Ohm                                      | Ω                         | 1                       | Ohm                               | Ω                      |
| Current                        | Ampere                                   | A                         | 1                       | Ampere                            | A                      |

# Appendix

## 2. Kgf to N conversion table

| kgf      |    | N       |
|----------|----|---------|
| 0.101972 | 1  | 9.80665 |
| 0.2039   | 2  | 19.613  |
| 0.3059   | 3  | 29.420  |
| 0.4079   | 4  | 39.227  |
| 0.5099   | 5  | 49.033  |
| 0.6118   | 6  | 58.840  |
| 0.7138   | 7  | 68.647  |
| 0.8158   | 8  | 78.453  |
| 0.9177   | 9  | 88.260  |
| 1.0197   | 10 | 98.067  |
| 1.1217   | 11 | 107.873 |
| 1.2237   | 12 | 117.680 |
| 1.3256   | 13 | 127.486 |
| 1.4276   | 14 | 137.293 |
| 1.5296   | 15 | 147.100 |
| 1.6315   | 16 | 156.906 |
| 1.7335   | 17 | 166.713 |
| 1.8355   | 18 | 176.520 |
| 1.9375   | 19 | 186.326 |
| 2.0394   | 20 | 196.133 |
| 2.1414   | 21 | 205.940 |
| 2.2434   | 22 | 215.746 |
| 2.3453   | 23 | 225.553 |
| 2.4473   | 24 | 235.360 |
| 2.5493   | 25 | 245.166 |
| 2.6513   | 26 | 254.973 |
| 2.7532   | 27 | 264.780 |
| 2.8552   | 28 | 274.586 |
| 2.9572   | 29 | 284.393 |
| 3.0591   | 30 | 294.200 |
| 3.1611   | 31 | 304.006 |
| 3.2631   | 32 | 313.813 |
| 3.3651   | 33 | 323.619 |
| 3.4670   | 34 | 333.426 |
| 3.5690   | 35 | 343.233 |
| 3.6710   | 36 | 353.039 |
| 3.7729   | 37 | 362.846 |
| 3.8749   | 38 | 372.653 |
| 3.9769   | 39 | 382.459 |
| 4.0789   | 40 | 392.266 |
| 4.1808   | 41 | 402.073 |
| 4.2828   | 42 | 411.879 |
| 4.3848   | 43 | 421.686 |
| 4.4868   | 44 | 431.493 |
| 4.5887   | 45 | 441.299 |
| 4.6907   | 46 | 451.106 |
| 4.7927   | 47 | 460.913 |
| 4.8946   | 48 | 470.719 |
| 4.9966   | 49 | 480.526 |
| 5.0986   | 50 | 490.333 |

| kgf     |     | N       |
|---------|-----|---------|
| 5.2006  | 51  | 500.139 |
| 5.3025  | 52  | 509.946 |
| 5.4045  | 53  | 519.752 |
| 5.5065  | 54  | 529.559 |
| 5.6084  | 55  | 539.366 |
| 5.7104  | 56  | 549.172 |
| 5.8124  | 57  | 558.979 |
| 5.9144  | 58  | 568.786 |
| 6.0163  | 59  | 578.592 |
| 6.1183  | 60  | 588.399 |
| 6.2203  | 61  | 598.206 |
| 6.3222  | 62  | 608.012 |
| 6.4242  | 63  | 617.819 |
| 6.5262  | 64  | 627.626 |
| 6.6282  | 65  | 637.432 |
| 6.7301  | 66  | 647.239 |
| 6.8321  | 67  | 657.046 |
| 6.9341  | 68  | 666.852 |
| 7.0360  | 69  | 676.659 |
| 7.1380  | 70  | 686.466 |
| 7.2400  | 71  | 696.272 |
| 7.3420  | 72  | 706.079 |
| 7.4439  | 73  | 715.885 |
| 7.5459  | 74  | 725.692 |
| 7.6479  | 75  | 735.499 |
| 7.7498  | 76  | 745.305 |
| 7.8518  | 77  | 755.112 |
| 7.9538  | 78  | 764.919 |
| 8.0558  | 79  | 774.725 |
| 8.1577  | 80  | 784.532 |
| 8.2597  | 81  | 794.339 |
| 8.3617  | 82  | 804.145 |
| 8.4636  | 83  | 813.952 |
| 8.5656  | 84  | 823.759 |
| 8.6676  | 85  | 833.565 |
| 8.7696  | 86  | 843.372 |
| 8.8715  | 87  | 853.179 |
| 8.9735  | 88  | 862.985 |
| 9.0755  | 89  | 872.792 |
| 9.1774  | 90  | 882.599 |
| 9.2794  | 91  | 892.405 |
| 9.3814  | 92  | 902.212 |
| 9.4834  | 93  | 912.018 |
| 9.5853  | 94  | 921.825 |
| 9.6873  | 95  | 931.632 |
| 9.7893  | 96  | 941.438 |
| 9.8912  | 97  | 951.245 |
| 9.9932  | 98  | 961.052 |
| 10.0952 | 99  | 970.858 |
| 10.1972 | 100 | 980.665 |

| kgf     |     | N        |
|---------|-----|----------|
| 10.2991 | 101 | 990.472  |
| 10.4011 | 102 | 1000.278 |
| 10.5031 | 103 | 1010.085 |
| 10.6050 | 104 | 1019.892 |
| 10.7070 | 105 | 1029.698 |
| 10.8090 | 106 | 1039.505 |
| 10.9110 | 107 | 1049.312 |
| 11.0129 | 108 | 1059.118 |
| 11.1149 | 109 | 1068.925 |
| 11.2169 | 110 | 1078.732 |
| 11.3188 | 111 | 1088.538 |
| 11.4208 | 112 | 1098.345 |
| 11.5228 | 113 | 1108.151 |
| 11.6248 | 114 | 1117.958 |
| 11.7267 | 115 | 1127.765 |
| 11.8287 | 116 | 1137.571 |
| 11.9307 | 117 | 1147.378 |
| 12.0327 | 118 | 1157.185 |
| 12.1346 | 119 | 1166.991 |
| 12.2366 | 120 | 1176.798 |
| 12.3386 | 121 | 1186.605 |
| 12.4405 | 122 | 1196.411 |
| 12.5425 | 123 | 1206.218 |
| 12.6445 | 124 | 1216.025 |
| 12.7465 | 125 | 1225.831 |
| 12.8484 | 126 | 1235.638 |
| 12.9504 | 127 | 1245.445 |
| 13.0524 | 128 | 1255.251 |
| 13.1543 | 129 | 1265.058 |
| 13.2563 | 130 | 1274.865 |
| 13.3583 | 131 | 1284.671 |
| 13.4603 | 132 | 1294.478 |
| 13.5622 | 133 | 1304.284 |
| 13.6642 | 134 | 1314.091 |
| 13.7662 | 135 | 1323.898 |
| 13.8681 | 136 | 1333.704 |
| 13.9701 | 137 | 1343.511 |
| 14.0721 | 138 | 1353.318 |
| 14.1741 | 139 | 1363.124 |
| 14.2760 | 140 | 1372.931 |
| 14.3780 | 141 | 1382.738 |
| 14.4800 | 142 | 1392.544 |
| 14.5819 | 143 | 1402.351 |
| 14.6839 | 144 | 1412.158 |
| 14.7859 | 145 | 1421.964 |
| 14.8879 | 146 | 1431.771 |
| 14.9898 | 147 | 1441.578 |
| 15.0918 | 148 | 1451.384 |
| 15.1938 | 149 | 1461.191 |
| 15.2957 | 150 | 1470.998 |

[How to read the table]

If for example you want to convert 10 kgf to N, find "10" in the middle column of the first set of columns on the right. Look in the N column directly to the right of "10", and you will see that 10 kgf equals 98.066 N. Oppositely, to convert 10 N to kgf, look in the kgf column to the right of "10" and you will see that 10 N equals 1.0197 kgf.

### 3. Inch-millimeter conversion table

| Inch     |          | 0"     | 1"     | 2"     | 3"      | 4"      | 5"      | 6"      | 7"      | 8"      | 9"      |
|----------|----------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|
| Fraction | Decimal  |        |        |        |         |         |         |         |         |         |         |
| 1/64     | 0.015625 | 0.397  | 25.400 | 50.800 | 76.200  | 101.600 | 127.000 | 152.400 | 177.800 | 203.200 | 228.600 |
| 1/32     | 0.031250 | 0.794  | 25.797 | 51.197 | 76.597  | 101.997 | 127.397 | 152.797 | 178.197 | 203.597 | 228.997 |
| 3/64     | 0.046875 | 1.191  | 26.194 | 51.594 | 76.994  | 102.394 | 127.794 | 153.194 | 178.594 | 203.994 | 229.394 |
| 1/16     | 0.062500 | 1.588  | 26.591 | 51.991 | 77.391  | 102.791 | 128.191 | 153.591 | 178.991 | 204.391 | 229.791 |
| 5/64     | 0.078125 | 1.984  | 26.988 | 52.388 | 77.788  | 103.188 | 128.588 | 153.988 | 179.388 | 204.788 | 230.188 |
| 3/32     | 0.093750 | 2.381  | 26.988 | 52.784 | 78.184  | 103.584 | 128.984 | 154.384 | 179.784 | 205.184 | 230.584 |
| 7/64     | 0.109375 | 2.778  | 27.381 | 53.181 | 78.581  | 103.981 | 129.381 | 154.781 | 180.181 | 205.581 | 230.981 |
| 1/8      | 0.125000 | 3.175  | 27.781 | 53.578 | 78.978  | 104.378 | 129.778 | 155.178 | 180.578 | 205.978 | 231.378 |
| 9/64     | 0.140625 | 3.572  | 28.178 | 53.975 | 79.375  | 104.775 | 130.175 | 155.575 | 180.975 | 206.375 | 231.775 |
| 5/32     | 0.156250 | 3.969  | 28.575 | 54.372 | 79.772  | 105.172 | 130.572 | 155.972 | 181.372 | 206.772 | 232.172 |
| 11/64    | 0.171875 | 4.366  | 28.972 | 54.769 | 80.169  | 105.569 | 130.969 | 156.369 | 181.769 | 207.169 | 232.569 |
| 3/16     | 0.187500 | 4.763  | 29.369 | 55.166 | 80.566  | 105.966 | 131.366 | 156.766 | 182.166 | 207.566 | 232.966 |
| 13/64    | 0.203125 | 5.159  | 29.766 | 55.563 | 80.963  | 106.363 | 131.763 | 157.163 | 182.563 | 207.963 | 233.363 |
| 7/32     | 0.218750 | 5.556  | 30.163 | 55.959 | 81.359  | 106.759 | 132.159 | 157.559 | 182.959 | 208.359 | 233.759 |
| 15/64    | 0.234375 | 5.953  | 30.559 | 56.356 | 81.756  | 107.156 | 132.556 | 157.956 | 183.356 | 208.756 | 234.156 |
| 1/4      | 0.250000 | 6.350  | 30.956 | 56.753 | 82.153  | 107.553 | 132.953 | 158.353 | 183.753 | 209.153 | 234.553 |
| 17/64    | 0.265625 | 6.747  | 31.353 | 57.150 | 82.550  | 107.950 | 133.350 | 158.750 | 184.150 | 209.550 | 234.950 |
| 9/32     | 0.281250 | 7.144  | 31.750 | 57.547 | 82.947  | 108.347 | 133.747 | 159.147 | 184.547 | 209.947 | 235.347 |
| 19/64    | 0.296875 | 7.541  | 32.147 | 57.944 | 83.344  | 108.744 | 134.144 | 159.544 | 184.944 | 210.344 | 235.744 |
| 5/16     | 0.312500 | 7.938  | 32.544 | 58.341 | 83.741  | 109.141 | 134.541 | 159.941 | 185.341 | 210.741 | 236.141 |
| 21/64    | 0.328125 | 8.334  | 32.941 | 58.738 | 84.138  | 109.538 | 134.938 | 160.338 | 185.738 | 211.138 | 236.538 |
| 11/32    | 0.343750 | 8.731  | 33.338 | 59.134 | 84.534  | 109.934 | 135.334 | 160.734 | 186.134 | 211.534 | 236.934 |
| 23/64    | 0.359375 | 9.128  | 33.734 | 59.531 | 84.931  | 110.331 | 135.731 | 161.131 | 186.531 | 211.931 | 237.331 |
| 3/8      | 0.375000 | 9.525  | 34.131 | 59.928 | 85.328  | 110.728 | 136.128 | 161.528 | 186.928 | 212.328 | 237.728 |
| 25/64    | 0.390625 | 9.922  | 34.528 | 60.325 | 85.725  | 111.125 | 136.525 | 161.925 | 187.325 | 212.725 | 238.125 |
| 13/32    | 0.406250 | 10.319 | 34.925 | 60.722 | 86.122  | 111.522 | 136.922 | 162.322 | 187.722 | 213.122 | 238.522 |
| 27/64    | 0.421875 | 10.716 | 35.322 | 61.119 | 86.519  | 111.919 | 137.319 | 162.719 | 188.119 | 213.519 | 238.919 |
| 7/16     | 0.437500 | 11.113 | 35.719 | 61.516 | 86.916  | 112.316 | 137.716 | 163.116 | 188.516 | 213.916 | 239.316 |
| 29/64    | 0.453125 | 11.509 | 36.116 | 61.913 | 87.313  | 112.713 | 138.113 | 163.513 | 188.913 | 214.313 | 239.713 |
| 15/32    | 0.468750 | 11.906 | 36.513 | 62.309 | 87.709  | 113.109 | 138.509 | 163.909 | 189.309 | 214.709 | 240.109 |
| 31/64    | 0.484375 | 12.303 | 36.909 | 62.706 | 88.106  | 113.506 | 138.906 | 164.306 | 189.706 | 215.106 | 240.506 |
| 1/2      | 0.500000 | 12.700 | 37.306 | 63.103 | 88.503  | 113.903 | 139.303 | 164.703 | 190.103 | 215.503 | 240.903 |
| 33/64    | 0.515625 | 13.097 | 37.703 | 63.500 | 88.900  | 114.300 | 139.700 | 165.100 | 190.500 | 215.900 | 241.300 |
| 17/32    | 0.531250 | 13.494 | 38.100 | 63.897 | 89.297  | 114.697 | 140.097 | 165.497 | 190.897 | 216.297 | 241.697 |
| 35/64    | 0.546875 | 13.891 | 38.497 | 64.294 | 89.694  | 115.094 | 140.494 | 165.894 | 191.294 | 216.694 | 242.094 |
| 9/16     | 0.562500 | 14.288 | 38.894 | 64.691 | 90.091  | 114.491 | 140.891 | 166.291 | 191.691 | 217.091 | 242.491 |
| 37/64    | 0.578125 | 14.684 | 39.291 | 65.088 | 90.488  | 115.888 | 141.283 | 166.688 | 192.088 | 217.488 | 242.888 |
| 19/32    | 0.593750 | 15.081 | 39.688 | 65.484 | 90.884  | 116.284 | 141.684 | 167.084 | 192.484 | 217.884 | 243.284 |
| 39/64    | 0.609375 | 15.478 | 40.084 | 65.881 | 91.281  | 116.681 | 142.081 | 167.481 | 192.881 | 218.281 | 243.681 |
| 5/8      | 0.625000 | 15.875 | 40.481 | 66.278 | 91.678  | 117.078 | 142.478 | 167.878 | 193.278 | 218.678 | 244.078 |
| 41/64    | 0.640625 | 16.272 | 40.878 | 66.675 | 92.075  | 117.475 | 142.875 | 168.275 | 193.675 | 219.075 | 244.475 |
| 21/32    | 0.656250 | 16.669 | 41.275 | 67.072 | 92.472  | 117.872 | 143.272 | 168.672 | 194.072 | 219.472 | 244.872 |
| 43/64    | 0.671875 | 17.066 | 41.672 | 67.469 | 92.869  | 118.269 | 143.669 | 169.069 | 194.469 | 219.869 | 245.269 |
| 11/16    | 0.687500 | 17.463 | 42.069 | 67.866 | 93.266  | 118.666 | 144.066 | 169.466 | 194.866 | 220.266 | 245.666 |
| 45/64    | 0.703125 | 17.859 | 42.466 | 68.263 | 93.663  | 119.063 | 144.463 | 169.863 | 195.263 | 220.663 | 246.063 |
| 23/32    | 0.718750 | 18.256 | 42.863 | 68.659 | 94.059  | 119.459 | 144.859 | 170.259 | 195.659 | 221.059 | 246.459 |
| 47/64    | 0.734375 | 18.653 | 43.259 | 69.056 | 94.456  | 119.856 | 145.256 | 170.656 | 196.056 | 221.456 | 246.856 |
| 3/4      | 0.750000 | 19.050 | 43.656 | 69.453 | 94.853  | 120.253 | 145.653 | 171.053 | 196.453 | 221.853 | 247.253 |
| 49/64    | 0.765625 | 19.447 | 44.053 | 69.850 | 95.250  | 120.650 | 146.050 | 171.450 | 196.850 | 222.250 | 247.650 |
| 25/32    | 0.781250 | 19.844 | 44.450 | 70.247 | 95.647  | 121.047 | 146.447 | 171.847 | 197.247 | 222.647 | 248.047 |
| 51/64    | 0.796875 | 20.241 | 44.847 | 70.644 | 96.044  | 121.444 | 146.844 | 172.244 | 197.644 | 223.044 | 248.444 |
| 13/16    | 0.812500 | 20.638 | 45.244 | 71.041 | 96.441  | 121.841 | 147.241 | 172.641 | 198.041 | 223.441 | 248.841 |
| 53/64    | 0.828125 | 21.034 | 45.641 | 71.438 | 96.838  | 122.238 | 147.638 | 173.038 | 198.438 | 223.838 | 249.238 |
| 27/32    | 0.843750 | 21.431 | 46.038 | 71.834 | 97.234  | 122.634 | 148.034 | 173.434 | 198.834 | 224.234 | 249.634 |
| 55/64    | 0.859375 | 21.828 | 46.434 | 72.231 | 97.631  | 123.031 | 148.431 | 173.831 | 199.231 | 224.631 | 250.031 |
| 7/8      | 0.875000 | 22.225 | 46.831 | 72.628 | 98.028  | 123.428 | 148.828 | 174.228 | 199.628 | 225.028 | 250.428 |
| 57/64    | 0.890625 | 22.622 | 47.225 | 73.025 | 98.425  | 123.825 | 149.225 | 174.625 | 200.025 | 225.425 | 250.825 |
| 29/32    | 0.906250 | 23.019 | 47.622 | 73.422 | 98.822  | 124.222 | 149.622 | 175.022 | 200.422 | 225.822 | 251.222 |
| 59/64    | 0.921875 | 23.416 | 48.019 | 73.819 | 99.219  | 124.619 | 150.019 | 175.419 | 200.819 | 226.219 | 251.619 |
| 15/16    | 0.937500 | 23.813 | 48.416 | 74.216 | 99.616  | 125.016 | 150.416 | 175.816 | 201.216 | 226.616 | 252.016 |
| 61/64    | 0.953125 | 24.209 | 48.813 | 74.613 | 100.013 | 125.413 | 150.813 | 176.213 | 201.613 | 227.013 | 252.413 |
| 31/32    | 0.968750 | 24.606 | 49.213 | 75.009 | 100.409 | 125.809 | 151.209 | 176.609 | 202.009 | 227.409 | 252.809 |
| 63/64    | 0.984375 | 25.003 | 49.609 | 75.406 | 100.806 | 126.206 | 151.606 | 177.006 | 202.406 | 227.806 | 253.206 |
|          |          |        | 50.006 | 75.803 | 101.203 | 126.603 | 152.003 | 177.403 | 202.803 | 228.203 | 253.603 |

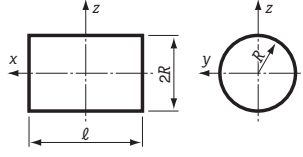
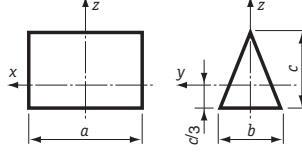
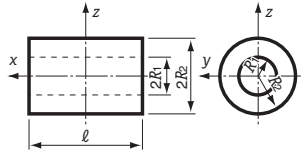
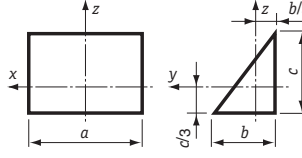
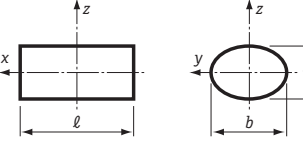
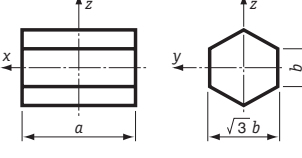
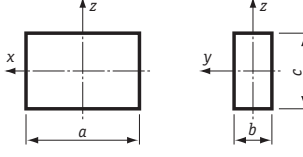
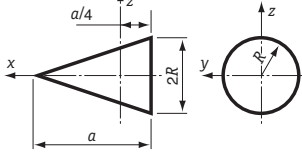
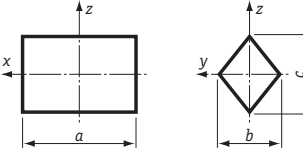
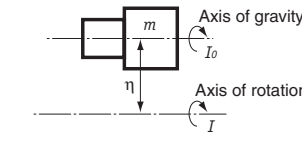


# Appendix

## 4. Industrial material property table

| Material                   | Gravity      | Young's Modulus<br><i>E</i> (GPa) | Shear Modulus<br><i>G</i> (GPa) | Coefficient of<br>Thermal Expansion<br>$\times 10^{-6}/^{\circ}\text{C}$<br>(20°C) | Tensile Strength<br>(MPa)    | Yield Point<br>(MPa)        | Elongation<br>(%)         | Hardness<br>(HB)       |
|----------------------------|--------------|-----------------------------------|---------------------------------|--|------------------------------|-----------------------------|---------------------------|------------------------|
| Mild Steel                 | 7.85 to 7.8  | 206.8                             | 82.3 to 82.5                    | 11.16 to 11.28   | 490 to 590                   | 274                         | 20                        | 140 to 150             |
| Dead Soft Steel            | 7.85 to 7.86 | 205.8                             | 79.4                            | 11.28 to 11.60   | 245                          | 108                         | 60                        | 60 to 70               |
| Hard Steel                 | 7.84 to 7.85 | 204.8                             | 81.9                            | 10.72 to 10.73   | 607 to 640                   | 320                         | 19                        | 200                    |
| Blackheart Malleable Iron  | 7.35         | 171                               | 85.8                            | 11.55  | 294 to 392                   |                             | 8 to 20                   | 109 to 145             |
| Gray Iron                  | 7.05 to 7.30 | 73.5 to 127                       | 28.4 to 39.2                    | 9.2 to 11.8  | 440                          |                             |                           | 230                    |
| Nodular Graphite Cast Iron | 7.1          | 150                               | 78.4                            | 10   | 450 to 680                   |                             |                           | 140 to 200             |
| Chrome Steel               | 7.84         | 201 to 211                        | —                               | 11.2   | > 784                        |                             | 15                        | 217 to 302             |
| Nickel Chrome Steel        | 7.8          | 204                               | —                               | 13.3   | > 833                        | > 686                       | 18                        | 248 to 302             |
| Stainless Steel            | 7.6 to 7.75  | 203 to 208                        | —                               | 11.0   | 690 to 930                   |                             |                           | 210                    |
| Aluminum                   | 2.7          | 62                                |                                 | 23.9   | 48 (Soft)<br>114 (Hard)      |                             | 49 (Soft)<br>6 (Hard)     | 17 (Soft)<br>27 (Hard) |
| Aluminum Alloy             | 2.79         | 68.6                              | 26.5                            | 22.6   | 480                          |                             | > 10                      | 75                     |
| Super Aluminum Alloy       | 2.8          | 73.6                              | 26.0                            | 22.8   | 569                          |                             | > 4                       | 90                     |
| Copper                     | 8.96         | 108                               | 57                              | 16.5   | 225 (Soft)<br>340 (Hard)     |                             | 6 to 45<br>(Hard) (Soft)  |                        |
| Aluminum Bronze            | 7.6          | 110                               | —                               | 17   | 617 to 725                   | 411                         | 12 to 25                  | 125 to 160             |
| Alpha Brass                | 8.54         | 108                               | 41                              | 19   | 323 to 519                   | 108 to 431<br>(Soft) (Hard) | 8 to 62<br>(Hard) (Soft)  | 49 to 80               |
| Beta Brass                 | 8.39         | 1.03                              | 38                              | 18.4   | 372 to 480<br>(Soft) (Hard)  | 15 to 35<br>(Soft) (Hard)   | 10 to 45<br>(Hard) (Soft) | 49 to 80               |
| Phosphor Bronze            | 8.78         | 110                               | —                               | 18.4   | 382 to 637<br>(Soft) (Hard)  | 147 to 500<br>(Soft) (Hard) | 10 to 70<br>(Hard) (Soft) | 70 to 130              |
| Nickel Brass               | 8.3 to 8.7   | 108                               | 39                              | 18 to 21   | 350 to 590<br>(Soft) (Hard)  | 128 to 520<br>(Soft) (Hard) | 4 to 46<br>(Hard) (Soft)  |                        |
| Beryllium Copper           | 8.2          | 110                               | —                               | 16.6   | 490 to 1300<br>(Soft) (Hard) | 880                         | 2 to 50<br>(Hard) (Soft)  |                        |
| Polycarbonate              | 1.2          | 2.3                               |                                 |  | 62 to 73                     |                             | 60 to 100                 | M70                    |
| Reinforced Glass Fiber     | 1.52         | 8.9                               |                                 |  | 137                          |                             | 1.7                       |                        |
| Nylon (6-6)                | 1.13 to 1.15 | 0.3                               |                                 |  | 81                           |                             | 60                        | R118                   |
| Epoxy Resin                | 1.1 to 2.0   | 2.45                              |                                 |  | 27 to 89                     |                             | 1 to 6                    | M80 to 120             |
| Natural Rubber             | 1.9          | 0.02 to 0.4                       |                                 |  | 1.5 to 3.4                   |                             |                           | HS30 to 100            |

## 5. Inertia moment formula

| Object Shape   | $I$ (Inertia Moment), $m$ (Mass)  | Object Shape   | $I$ (Inertia Moment), $m$ (Mass)   |
|--|---|--|--|
| <p>1</p>    | $I_x = \frac{1}{2} m R^2$ $I_y = \frac{1}{4} m \left( R^2 + \frac{l^2}{3} \right)$ $I_z = I_y$ $m = \pi R^2 l \rho$   | <p>6</p>                           | $I_x = \frac{1}{12} m \left( \frac{b^2}{2} + \frac{2}{3} c^2 \right)$ $I_y = \frac{1}{12} m \left( a^2 + \frac{2}{3} c^2 \right)$ $I_z = \frac{1}{12} m \left( a^2 + \frac{b^2}{2} \right)$ $m = \frac{1}{2} a b c \rho$   |
| <p>2</p>    | $I_x = \frac{1}{2} m (R_1^2 + R_2^2)$ $I_y = \frac{1}{4} m \left\{ (R_1^2 + R_2^2) + \frac{l^2}{3} \right\}$ $I_z = I_y$ $m = \pi (R_2^2 - R_1^2) l \rho$   | <p>7</p>                           | $I_x = \frac{1}{36} m (b^2 + c^2)$ $I_y = \frac{1}{12} m \left( a^2 + \frac{2}{3} c^2 \right)$ $I_z = \frac{1}{12} m \left( a^2 + \frac{2}{3} b^2 \right)$ $m = \frac{1}{2} a b c \rho$  |
| <p>3</p>  | $I_x = \frac{1}{16} m (b^2 + c^2)$ $I_y = \frac{1}{4} m \left( \frac{c^2}{4} + \frac{l^2}{3} \right)$ $I_z = \frac{1}{4} m \left( \frac{b^2}{4} + \frac{l^2}{3} \right)$ $m = \frac{\pi}{4} l b c \rho$ | <p>8</p>                         | $I_x = \frac{5}{12} m b^2$ $I_y = \frac{1}{12} m \left( a^2 + \frac{5}{2} b^2 \right)$ $I_z = I_y$ $m = \frac{3\sqrt{3}}{2} a b^2 \rho$  |
| <p>4</p>  | $I_x = \frac{1}{12} m (b^2 + c^2)$ $I_y = \frac{1}{12} m (a^2 + c^2)$ $I_z = \frac{1}{12} m (a^2 + b^2)$ $m = a b c \rho$   | <p>9</p>                         | $I_x = \frac{3}{10} m R^2$ $I_y = \frac{3}{80} m (4R^2 + a^2)$ $I_z = I_y$ $m = \frac{\pi}{3} R^2 a \rho$  |
| <p>5</p>  | $I_x = \frac{1}{24} m (b^2 + c^2)$ $I_y = \frac{1}{24} m (c^2 + 2a^2)$ $I_z = \frac{1}{24} m (b^2 + 2a^2)$ $m = \frac{1}{2} a b c \rho$   | <p>10 Parallel axis theorem</p>  | $I = I_0 + m \eta^2$ <p><math>I_0</math> : Inertia moment of the object related to the axis of gravity</p> <p><math>I</math> : Inertia moment of the object related to the axis of rotation that is parallel to the axis of gravity</p> <p><math>\eta</math> : Distance between the axis of rotation and the axis of gravity</p> |

# Appendix

## 6. Basic tolerance

### 1) Dimensional tolerance for shafts

(Unit:  $\mu\text{m}$ )

| Diameter division<br>(mm)<br>over or less |      | a13   |       | c12  |       | d6   |       | e6   |       | e13  |       | f5   |     | f6   |      | g5   |     | g6   |      |
|---|------|-------|-------|------|-------|------|-------|------|-------|------|-------|------|-----|------|------|------|-----|------|------|
| high                                      | low  | high  | low   | high | low   | high | low   | high | low   | high | low   | high | low | high | low  | high | low | high | low  |
| 3   | 6    | -270  | -450  | -70  | -190  | -30  | -38   | -20  | -28   | -20  | -200  | -10  | -15 | -10  | -18  | -4   | -9  | -4   | -12  |
| 6   | 10   | -280  | -500  | -80  | -230  | -40  | -49   | -25  | -34   | -25  | -245  | -13  | -19 | -13  | -22  | -5   | -11 | -5   | -14  |
| 10  | 18   | -290  | -560  | -95  | -275  | -50  | -61   | -32  | -43   | -32  | -302  | -16  | -24 | -16  | -27  | -6   | -14 | -6   | -17  |
| 18  | 30   | -300  | -630  | -110 | -320  | -65  | -78   | -40  | -53   | -40  | -370  | -20  | -29 | -20  | -33  | -7   | -16 | -7   | -20  |
| 30  | 40   | -310  | -700  | -120 | -370  | -80  | -96   | -50  | -66   | -50  | -440  | -25  | -36 | -25  | -41  | -9   | -20 | -9   | -25  |
| 40  | 50   | -320  | -710  | -130 | -380  | -100 | -119  | -60  | -79   | -60  | -520  | -30  | -43 | -30  | -49  | -10  | -23 | -10  | -29  |
| 50  | 65   | -340  | -800  | -140 | -440  | -120 | -142  | -72  | -94   | -72  | -612  | -36  | -51 | -36  | -58  | -12  | -27 | -12  | -34  |
| 65  | 80   | -360  | -820  | -150 | -450  | -145 | -170  | -85  | -110  | -85  | -715  | -43  | -61 | -43  | -68  | -14  | -32 | -14  | -39  |
| 80  | 100  | -380  | -920  | -170 | -520  | -170 | -199  | -100 | -129  | -100 | -820  | -50  | -70 | -50  | -79  | -15  | -35 | -15  | -44  |
| 100                                       | 120  | -410  | -950  | -180 | -530  | -190 | -222  | -110 | -142  | -110 | -920  | -56  | -79 | -56  | -88  | -17  | -40 | -17  | -49  |
| 120                                       | 140  | -460  | -1090 | -200 | -600  | -210 | -246  | -125 | -161  | -125 | -1015 | -62  | -87 | -62  | -98  | -18  | -43 | -18  | -54  |
| 140                                       | 160  | -520  | -1150 | -210 | -610  | -230 | -270  | -135 | -175  | -135 | -1105 | -68  | -95 | -68  | -108 | -20  | -47 | -20  | -60  |
| 160                                       | 180  | -580  | -1210 | -230 | -630  | -260 | -304  | -145 | -189  | -    | -     | -    | -   | -76  | -120 | -    | -   | -22  | -66  |
| 180                                       | 200  | -660  | -1380 | -240 | -700  | -290 | -340  | -160 | -210  | -    | -     | -    | -   | -80  | -130 | -    | -   | -24  | -74  |
| 200                                       | 225  | -740  | -1460 | -260 | -720  | -320 | -376  | -170 | -226  | -    | -     | -    | -   | -86  | -142 | -    | -   | -26  | -82  |
| 225                                       | 250  | -820  | -1540 | -280 | -740  | -350 | -416  | -195 | -261  | -    | -     | -    | -   | -98  | -164 | -    | -   | -28  | -94  |
| 250                                       | 280  | -920  | -1730 | -300 | -820  | -390 | -468  | -220 | -298  | -    | -     | -    | -   | -110 | -188 | -    | -   | -30  | -108 |
| 280                                       | 315  | -1050 | -1860 | -330 | -850  | -440 | -1070 | -480 | -1110 | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 315                                       | 355  | -1200 | -2090 | -360 | -930  | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 355                                       | 400  | -1350 | -2240 | -400 | -970  | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 400                                       | 450  | -1500 | -2470 | -440 | -1070 | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 450                                       | 500  | -1650 | -2620 | -480 | -1110 | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 500                                       | 560  | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 560                                       | 630  | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 630                                       | 710  | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 710                                       | 800  | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 800                                       | 900  | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 900                                       | 1000 | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 1000                                      | 1120 | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 1120                                      | 1250 | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 1250                                      | 1400 | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |
| 1400                                      | 1600 | -     | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -   | -    | -    | -    | -   | -    | -    |

| Diameter division<br>(mm)<br>over or less |      | j5   |     | js5   |       | j6   |     | js6   |       | j7   |     | k4   |     | k5   |     | k6   |     | m5   |     |
|---|------|------|-----|-------|-------|------|-----|-------|-------|------|-----|------|-----|------|-----|------|-----|------|-----|
| high                                      | low  | high | low | high  | low   | high | low | high  | low   | high | low | high | low | high | low | high | low | high | low |
| 3   | 6    | +3   | -2  | +2.5  | -2.5  | +6   | -2  | +4    | -4    | +8   | -4  | +5   | +1  | +6   | +1  | +9   | +1  | +9   | +4  |
| 6   | 10   | +4   | -2  | +3    | -3    | +7   | -2  | +4.5  | -4.5  | +10  | -5  | +5   | +1  | +7   | +1  | +10  | +1  | +12  | +6  |
| 10  | 18   | +5   | -3  | +4    | -4    | +8   | -3  | +5.5  | -5.5  | +12  | -6  | +6   | +1  | +9   | +1  | +12  | +1  | +15  | +7  |
| 18  | 30   | +5   | -4  | +4.5  | -4.5  | +9   | -4  | +6.5  | -6.5  | +13  | -8  | +8   | +2  | +11  | +2  | +15  | +2  | +17  | +8  |
| 30  | 40   | +6   | -5  | +5.5  | -5.5  | +11  | -5  | +8    | -8    | +15  | -10 | +9   | +2  | +13  | +2  | +18  | +2  | +20  | +9  |
| 40  | 50   | +6   | -7  | +6.5  | -6.5  | +12  | -7  | +9.5  | -9.5  | +18  | -12 | +10  | +2  | +15  | +2  | +21  | +2  | +24  | +11 |
| 50  | 65   | +6   | -9  | +7.5  | -7.5  | +13  | -9  | +11   | -11   | +20  | -15 | +13  | +3  | +18  | +3  | +25  | +3  | +28  | +13 |
| 65  | 80   | +7   | -11 | +9    | -9    | +14  | -11 | +12.5 | -12.5 | +22  | -18 | +15  | +3  | +21  | +3  | +28  | +3  | +33  | +15 |
| 80  | 100  | +7   | -13 | +10   | -10   | +16  | -13 | +14.5 | -14.5 | +25  | -21 | +18  | +4  | +24  | +4  | +33  | +4  | +37  | +17 |
| 100                                       | 120  | +7   | -16 | +11.5 | -11.5 | +16  | -16 | +16   | -16   | +26  | -26 | +20  | +4  | +27  | +4  | +36  | +4  | +43  | +20 |
| 120                                       | 140  | +7   | -18 | +12.5 | -12.5 | +18  | -18 | +18   | -18   | +29  | -28 | +22  | +4  | +29  | +4  | +40  | +4  | +46  | +21 |
| 140                                       | 160  | +7   | -20 | +13.5 | -13.5 | +20  | -20 | +20   | -20   | +31  | -32 | +25  | +5  | +32  | +5  | +45  | +5  | +50  | +23 |
| 160                                       | 180  | -    | -   | -     | -     | -    | -   | +22   | -22   | -    | -   | -    | -   | -    | -   | +44  | 0   | -    | -   |
| 180                                       | 200  | -    | -   | -     | -     | -    | -   | +25   | -25   | -    | -   | -    | -   | -    | -   | +50  | 0   | -    | -   |
| 200                                       | 225  | -    | -   | -     | -     | -    | -   | +28   | -28   | -    | -   | -    | -   | -    | -   | +56  | 0   | -    | -   |
| 225                                       | 250  | -    | -   | -     | -     | -    | -   | +33   | -33   | -    | -   | -    | -   | -    | -   | +66  | 0   | -    | -   |
| 250                                       | 280  | -    | -   | -     | -     | -    | -   | +39   | -39   | -    | -   | -    | -   | -    | -   | +78  | 0   | -    | -   |
| 280                                       | 315  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 315                                       | 355  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 355                                       | 400  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 400                                       | 450  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 450                                       | 500  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 500                                       | 560  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 560                                       | 630  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 630                                       | 710  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 710                                       | 800  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 800                                       | 900  | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 900                                       | 1000 | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 1000                                      | 1120 | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 1120                                      | 1250 | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 1250                                      | 1400 | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |
| 1400                                      | 1600 | -    | -   | -     | -     | -    | -   | -     | -     | -    | -   | -    | -   | -    | -   | -    | -   | -    | -   |

(Unit:  $\mu\text{m}$ )

| h4   |     | h5   |     | h6   |     | h7   |      | h8   |      | h9   |      | h10  |      | h11  |      | h13  |      | js4  |      | Diameter division<br>(mm)<br>over or less |
|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|
| high | low | high | low | high | low | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  |   |
| 0    | -4  | 0    | -5  | 0    | -8  | 0    | -12  | 0    | -18  | 0    | -30  | 0    | -48  | 0    | -75  | 0    | -180 | +2   | -2   | 3 6                                       |
| 0    | -4  | 0    | -6  | 0    | -9  | 0    | -15  | 0    | -22  | 0    | -36  | 0    | -58  | 0    | -90  | 0    | -220 | +2   | -2   | 6 10                                      |
| 0    | -5  | 0    | -8  | 0    | -11 | 0    | -18  | 0    | -27  | 0    | -43  | 0    | -70  | 0    | -110 | 0    | -270 | +2.5 | -2.5 | 10 18                                     |
| 0    | -6  | 0    | -9  | 0    | -13 | 0    | -21  | 0    | -33  | 0    | -52  | 0    | -84  | 0    | -130 | 0    | -330 | +3   | -3   | 18 30                                     |
| 0    | -7  | 0    | -11 | 0    | -16 | 0    | -25  | 0    | -39  | 0    | -62  | 0    | -100 | 0    | -160 | 0    | -390 | +3.5 | -3.5 | 30 40                                     |
| 0    | -8  | 0    | -13 | 0    | -19 | 0    | -30  | 0    | -46  | 0    | -74  | 0    | -120 | 0    | -190 | 0    | -460 | +4   | -4   | 40 50                                     |
| 0    | -8  | 0    | -13 | 0    | -19 | 0    | -30  | 0    | -46  | 0    | -74  | 0    | -120 | 0    | -190 | 0    | -460 | +4   | -4   | 50 65                                     |
| 0    | -10 | 0    | -15 | 0    | -22 | 0    | -35  | 0    | -54  | 0    | -87  | 0    | -140 | 0    | -220 | 0    | -540 | +5   | -5   | 65 80                                     |
| 0    | -10 | 0    | -15 | 0    | -22 | 0    | -35  | 0    | -54  | 0    | -87  | 0    | -140 | 0    | -220 | 0    | -540 | +5   | -5   | 80 100                                    |
| 0    | -12 | 0    | -18 | 0    | -25 | 0    | -40  | 0    | -63  | 0    | -100 | 0    | -160 | 0    | -250 | 0    | -630 | +6   | -6   | 100 120                                   |
| 0    | -12 | 0    | -18 | 0    | -25 | 0    | -40  | 0    | -63  | 0    | -100 | 0    | -160 | 0    | -250 | 0    | -630 | +6   | -6   | 120 140                                   |
| 0    | -12 | 0    | -18 | 0    | -25 | 0    | -40  | 0    | -63  | 0    | -100 | 0    | -160 | 0    | -250 | 0    | -630 | +6   | -6   | 140 160                                   |
| 0    | -12 | 0    | -18 | 0    | -25 | 0    | -40  | 0    | -63  | 0    | -100 | 0    | -160 | 0    | -250 | 0    | -630 | +6   | -6   | 160 180                                   |
| 0    | -14 | 0    | -20 | 0    | -29 | 0    | -46  | 0    | -72  | 0    | -115 | 0    | -185 | 0    | -290 | 0    | -720 | +7   | -7   | 180 200                                   |
| 0    | -14 | 0    | -20 | 0    | -29 | 0    | -46  | 0    | -72  | 0    | -115 | 0    | -185 | 0    | -290 | 0    | -720 | +7   | -7   | 200 225                                   |
| 0    | -14 | 0    | -20 | 0    | -29 | 0    | -46  | 0    | -72  | 0    | -115 | 0    | -185 | 0    | -290 | 0    | -720 | +7   | -7   | 225 250                                   |
| 0    | -16 | 0    | -23 | 0    | -32 | 0    | -52  | 0    | -81  | 0    | -130 | 0    | -210 | 0    | -320 | 0    | -810 | +8   | -8   | 250 280                                   |
| 0    | -16 | 0    | -23 | 0    | -32 | 0    | -52  | 0    | -81  | 0    | -130 | 0    | -210 | 0    | -320 | 0    | -810 | +8   | -8   | 280 315                                   |
| 0    | -18 | 0    | -25 | 0    | -36 | 0    | -57  | 0    | -89  | 0    | -140 | 0    | -230 | 0    | -360 | 0    | -890 | +9   | -9   | 315 355                                   |
| 0    | -18 | 0    | -25 | 0    | -36 | 0    | -57  | 0    | -89  | 0    | -140 | 0    | -230 | 0    | -360 | 0    | -890 | +9   | -9   | 355 400                                   |
| 0    | -20 | 0    | -27 | 0    | -40 | 0    | -63  | 0    | -97  | 0    | -155 | 0    | -250 | 0    | -400 | 0    | -970 | +10  | -10  | 400 450                                   |
| 0    | -20 | 0    | -27 | 0    | -40 | 0    | -63  | 0    | -97  | 0    | -155 | 0    | -250 | 0    | -400 | 0    | -970 | +10  | -10  | 450 500                                   |
| -    | -   | -    | -   | 0    | -44 | 0    | -70  | 0    | -110 | 0    | -175 | 0    | -280 | 0    | -440 | -    | -    | -    | -    | 500 560                                   |
| -    | -   | -    | -   | 0    | -44 | 0    | -70  | 0    | -110 | 0    | -175 | 0    | -280 | 0    | -440 | -    | -    | -    | -    | 560 630                                   |
| -    | -   | -    | -   | 0    | -50 | 0    | -80  | 0    | -125 | 0    | -200 | 0    | -320 | 0    | -500 | -    | -    | -    | -    | 630 710                                   |
| -    | -   | -    | -   | 0    | -50 | 0    | -80  | 0    | -125 | 0    | -200 | 0    | -320 | 0    | -500 | -    | -    | -    | -    | 710 800                                   |
| -    | -   | -    | -   | 0    | -56 | 0    | -90  | 0    | -140 | 0    | -230 | 0    | -360 | 0    | -560 | -    | -    | -    | -    | 800 900                                   |
| -    | -   | -    | -   | 0    | -56 | 0    | -90  | 0    | -140 | 0    | -230 | 0    | -360 | 0    | -560 | -    | -    | -    | -    | 900 1000                                  |
| -    | -   | -    | -   | 0    | -66 | 0    | -105 | 0    | -165 | 0    | -260 | 0    | -420 | 0    | -660 | -    | -    | -    | -    | 1000 1120                                 |
| -    | -   | -    | -   | 0    | -66 | 0    | -105 | 0    | -165 | 0    | -260 | 0    | -420 | 0    | -660 | -    | -    | -    | -    | 1120 1250                                 |
| -    | -   | -    | -   | 0    | -78 | 0    | -125 | 0    | -195 | 0    | -310 | 0    | -500 | 0    | -780 | -    | -    | -    | -    | 1250 1400                                 |
| -    | -   | -    | -   | 0    | -78 | 0    | -125 | 0    | -195 | 0    | -310 | 0    | -500 | 0    | -780 | -    | -    | -    | -    | 1400 1600                                 |

| m6   |     | n5   |     | n6   |     | p5   |     | p6   |      | r6   |      | r7   |      | Basic tolerance |      |     |      | Diameter division<br>(mm)<br>over or less |
|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|-----------------|------|-----|------|---|
| high | low | high | low | high | low | high | low | high | low  | high | low  | high | low  | IT2             | IT3  | IT5 | IT7  |   |
| +12  | +4  | +13  | +8  | +16  | +8  | +17  | +12 | +20  | +12  | +23  | +15  | +27  | +15  | +1.5            | +2.5 | +5  | +12  | 3 6                                       |
| +15  | +6  | +16  | +10 | +19  | +10 | +21  | +15 | +24  | +15  | +28  | +19  | +34  | +19  | +1.5            | +2.5 | +6  | +15  | 6 10                                      |
| +18  | +7  | +20  | +12 | +23  | +12 | +26  | +18 | +29  | +18  | +34  | +23  | +41  | +23  | +2              | +3   | +8  | +18  | 10 18                                     |
| +21  | +8  | +24  | +15 | +28  | +15 | +31  | +22 | +35  | +22  | +41  | +28  | +49  | +28  | +2.5            | +4   | +9  | +21  | 18 30                                     |
| +25  | +9  | +28  | +17 | +33  | +17 | +37  | +26 | +42  | +26  | +50  | +34  | +59  | +34  | +2.5            | +4   | +11 | +25  | 30 40                                     |
| +25  | +9  | +28  | +17 | +33  | +17 | +37  | +26 | +42  | +26  | +50  | +34  | +59  | +34  | +2.5            | +4   | +11 | +25  | 40 50                                     |
| +30  | +11 | +33  | +20 | +39  | +20 | +45  | +32 | +51  | +32  | +60  | +41  | +71  | +41  | +3              | +5   | +13 | +30  | 50 65                                     |
| +30  | +11 | +33  | +20 | +39  | +20 | +45  | +32 | +51  | +32  | +60  | +41  | +71  | +41  | +3              | +5   | +13 | +30  | 65 80                                     |
| +35  | +13 | +38  | +23 | +45  | +23 | +52  | +37 | +59  | +37  | +73  | +51  | +86  | +51  | +4              | +6   | +15 | +35  | 80 100                                    |
| +35  | +13 | +38  | +23 | +45  | +23 | +52  | +37 | +59  | +37  | +73  | +51  | +86  | +51  | +4              | +6   | +15 | +35  | 100 120                                   |
| +40  | +15 | +45  | +27 | +52  | +27 | +61  | +43 | +68  | +43  | +88  | +63  | +103 | +63  | +5              | +8   | +18 | +40  | 120 140                                   |
| +40  | +15 | +45  | +27 | +52  | +27 | +61  | +43 | +68  | +43  | +88  | +63  | +103 | +63  | +5              | +8   | +18 | +40  | 140 160                                   |
| +40  | +15 | +45  | +27 | +52  | +27 | +61  | +43 | +68  | +43  | +88  | +63  | +103 | +63  | +5              | +8   | +18 | +40  | 160 180                                   |
| +46  | +17 | +51  | +31 | +60  | +31 | +70  | +50 | +79  | +50  | +106 | +77  | +123 | +77  | +7              | +10  | +20 | +46  | 180 200                                   |
| +46  | +17 | +51  | +31 | +60  | +31 | +70  | +50 | +79  | +50  | +106 | +77  | +123 | +77  | +7              | +10  | +20 | +46  | 200 225                                   |
| +46  | +17 | +51  | +31 | +60  | +31 | +70  | +50 | +79  | +50  | +106 | +77  | +123 | +77  | +7              | +10  | +20 | +46  | 225 250                                   |
| +52  | +20 | +57  | +34 | +66  | +34 | +79  | +56 | +88  | +56  | +126 | +94  | +146 | +94  | +8              | +12  | +23 | +52  | 250 280                                   |
| +52  | +20 | +57  | +34 | +66  | +34 | +79  | +56 | +88  | +56  | +126 | +94  | +146 | +94  | +8              | +12  | +23 | +52  | 280 315                                   |
| +57  | +21 | +62  | +37 | +73  | +37 | +87  | +62 | +98  | +62  | +144 | +108 | +165 | +108 | +9              | +13  | +25 | +57  | 315 355                                   |
| +57  | +21 | +62  | +37 | +73  | +37 | +87  | +62 | +98  | +62  | +144 | +108 | +165 | +108 | +9              | +13  | +25 | +57  | 355 400                                   |
| +63  | +23 | +67  | +40 | +80  | +40 | +95  | +68 | +108 | +68  | +166 | +126 | +189 | +126 | +10             | +15  | +27 | +63  | 400 450                                   |
| +63  | +23 | +67  | +40 | +80  | +40 | +95  | +68 | +108 | +68  | +166 | +126 | +189 | +126 | +10             | +15  | +27 | +63  | 450 500                                   |
| +70  | +26 | -    | -   | +88  | +44 | -    | -   | +122 | +78  | +194 | +150 | +220 | +150 | -               | -    | -   | +70  | 500 560                                   |
| +70  | +26 | -    | -   | +88  | +44 | -    | -   | +122 | +78  | +194 | +150 | +220 | +150 | -               | -    | -   | +70  | 560 630                                   |
| +80  | +30 | -    | -   | +100 | +50 | -    | -   | +138 | +88  | +225 | +175 | +255 | +175 | -               | -    | -   | +80  | 630 710                                   |
| +80  | +30 | -    | -   | +100 | +50 | -    | -   | +138 | +88  | +225 | +175 | +255 | +175 | -               | -    | -   | +80  | 710 800                                   |
| +90  | +34 | -    | -   | +112 | +56 | -    | -   | +156 | +100 | +266 | +210 | +300 | +210 | -               | -    | -   | +90  | 800 900                                   |
| +90  | +34 | -    | -   | +112 | +56 | -    | -   | +156 | +100 | +266 | +210 | +300 | +210 | -               | -    | -   | +90  | 900 1000                                  |
| +106 | +40 | -    | -   | +132 | +66 | -    | -   | +186 | +120 | +316 | +250 | +355 | +250 | -               | -    | -   | +105 | 1000 1120                                 |
| +106 | +40 | -    | -   | +132 | +66 | -    | -   | +186 | +120 | +316 | +250 | +355 | +250 | -               | -    | -   | +105 | 1120 1250                                 |
| +126 | +48 | -    | -   | +156 | +78 | -    | -   | +218 | +140 | +378 | +300 | +425 | +300 | -               | -    | -   | +125 | 1250 1400                                 |
| +126 | +48 | -    | -   | +156 | +78 | -    | -   | +218 | +140 | +408 | +330 | +455 | +330 | -               | -    | -   | +125 | 1400 1600                                 |

# Appendix

## 2) Dimensional tolerance for housing bore

(Unit:  $\mu\text{m}$ )

| Diameter division<br>over (mm)<br>or less |      | E7   |      | E10  |      | E11  |      | E12  |      | F6   |      | F7   |      | F8   |      | G6   |     | G7   |     | H6   |     |
|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|------|-----|------|-----|
|   |      | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  | high | low | high | low | high | low |
| 3   | 6    | +32  | +20  | +68  | +20  | +95  | +20  | +140 | +20  | +18  | +10  | +22  | +10  | +28  | +10  | +12  | +4  | +16  | +4  | +8   | 0   |
| 6   | 10   | +40  | +25  | +83  | +25  | +115 | +25  | +175 | +25  | +22  | +13  | +28  | +13  | +35  | +13  | +14  | +5  | +20  | +5  | +9   | 0   |
| 10  | 18   | +50  | +32  | +102 | +32  | +142 | +32  | +212 | +32  | +27  | +16  | +34  | +16  | +43  | +16  | +17  | +6  | +24  | +6  | +11  | 0   |
| 18  | 30   | +61  | +40  | +124 | +40  | +170 | +40  | +250 | +40  | +33  | +20  | +41  | +20  | +53  | +20  | +20  | +7  | +28  | +7  | +13  | 0   |
| 30  | 40   | +75  | +50  | +150 | +50  | +210 | +50  | +300 | +50  | +41  | +25  | +50  | +25  | +64  | +25  | +25  | +9  | +34  | +9  | +16  | 0   |
| 40  | 50   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 50  | 65   | +90  | +60  | +180 | +60  | +250 | +60  | +360 | +60  | +49  | +30  | +60  | +30  | +76  | +30  | +29  | +10 | +40  | +10 | +19  | 0   |
| 65  | 80   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 80  | 100  | +107 | +72  | +212 | +72  | +292 | +72  | +422 | +72  | +58  | +36  | +71  | +36  | +90  | +36  | +34  | +12 | +47  | +12 | +22  | 0   |
| 100                                       | 120  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 120                                       | 140  | +125 | +85  | +245 | +85  | +335 | +85  | +485 | +85  | +68  | +43  | +83  | +43  | +106 | +43  | +39  | +14 | +54  | +14 | +25  | 0   |
| 140                                       | 160  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 160                                       | 180  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 180                                       | 200  | +146 | +100 | +285 | +100 | +390 | +100 | +560 | +100 | +79  | +50  | +96  | +50  | +122 | +50  | +44  | +15 | +61  | +15 | +29  | 0   |
| 200                                       | 225  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 225                                       | 250  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 250                                       | 280  | +162 | +110 | +320 | +110 | +430 | +110 | +630 | +110 | +88  | +56  | +108 | +56  | +137 | +56  | +49  | +17 | +69  | +17 | +32  | 0   |
| 280                                       | 315  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 315                                       | 355  | +182 | +125 | +355 | +125 | +485 | +125 | +695 | +125 | +98  | +62  | +119 | +62  | +151 | +62  | +54  | +18 | +75  | +18 | +36  | 0   |
| 355                                       | 400  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 400                                       | 450  | +198 | +135 | +385 | +135 | +535 | +135 | +765 | +135 | +108 | +68  | +131 | +68  | +165 | +68  | +60  | +20 | +83  | +20 | +40  | 0   |
| 450                                       | 500  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 500                                       | 560  | +215 | +145 | -    | -    | -    | -    | -    | -    | +120 | +76  | +146 | +76  | +186 | +76  | +66  | +22 | +92  | +22 | +44  | 0   |
| 560                                       | 630  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 630                                       | 710  | +240 | +160 | -    | -    | -    | -    | -    | -    | +130 | +80  | +160 | +80  | +205 | +80  | +74  | +24 | +104 | +24 | +50  | 0   |
| 710                                       | 800  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 800                                       | 900  | +260 | +170 | -    | -    | -    | -    | -    | -    | +142 | +86  | +176 | +86  | +226 | +86  | +82  | +26 | +116 | +26 | +56  | 0   |
| 900                                       | 1000 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 1000                                      | 1120 | +300 | +195 | -    | -    | -    | -    | -    | -    | +164 | +98  | +203 | +98  | +263 | +98  | +94  | +28 | +133 | +28 | +66  | 0   |
| 1120                                      | 1250 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 1250                                      | 1400 | +345 | +220 | -    | -    | -    | -    | -    | -    | +188 | +110 | +235 | +110 | +305 | +110 | +108 | +30 | +155 | +30 | +78  | 0   |
| 1400                                      | 1600 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |
| 1600                                      | 1800 | +390 | +240 | -    | -    | -    | -    | -    | -    | +212 | +120 | +270 | +120 | +350 | +120 | +124 | +32 | +182 | +32 | +92  | 0   |
| 1800                                      | 2000 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |      |     |      |     |

| Diameter division<br>over (mm)<br>or less |      | K6   |     | K7   |      | M6   |      | M7   |      | N6   |      | N7   |      | P6   |      | P7   |      | R6   |      | R7   |      |
|---|------|------|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|   |      | high | low | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  | high | low  |
| 3   | 6    | +2   | -6  | +3   | -9   | -1   | -9   | 0    | -12  | -5   | -13  | -4   | -16  | -9   | -17  | -8   | -20  | -12  | -20  | -11  | -23  |
| 6   | 10   | +2   | -7  | +5   | -10  | -3   | -12  | 0    | -15  | -7   | -16  | -4   | -19  | -12  | -21  | -9   | -24  | -16  | -25  | -13  | -28  |
| 10  | 18   | +2   | -9  | +6   | -12  | -4   | -15  | 0    | -18  | -9   | -20  | -5   | -23  | -15  | -26  | -11  | -29  | -20  | -31  | -16  | -34  |
| 18  | 30   | +2   | -11 | +6   | -15  | -4   | -17  | 0    | -21  | -11  | -24  | -7   | -28  | -18  | -31  | -14  | -35  | -24  | -37  | -20  | -41  |
| 30  | 40   | +3   | -13 | +7   | -18  | -4   | -20  | 0    | -25  | -12  | -28  | -8   | -33  | -21  | -37  | -17  | -42  | -29  | -45  | -25  | -50  |
| 40  | 50   |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 50  | 65   | +4   | -15 | +9   | -21  | -5   | -24  | 0    | -30  | -14  | -33  | -9   | -39  | -26  | -45  | -21  | -51  | -35  | -54  | -30  | -60  |
| 65  | 80   |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 80  | 100  | +4   | -18 | +10  | -25  | -6   | -28  | 0    | -35  | -16  | -38  | -10  | -45  | -30  | -52  | -24  | -59  | -44  | -66  | -38  | -73  |
| 100                                       | 120  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 120                                       | 140  | +4   | -21 | +12  | -28  | -8   | -33  | 0    | -40  | -20  | -45  | -12  | -52  | -36  | -61  | -28  | -68  | -56  | -81  | -48  | -88  |
| 140                                       | 160  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 160                                       | 180  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 180                                       | 200  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 200                                       | 225  | +5   | -24 | +13  | -33  | -8   | -37  | 0    | -46  | -22  | -51  | -14  | -60  | -41  | -70  | -33  | -79  | -71  | -100 | -63  | -109 |
| 225                                       | 250  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 250                                       | 280  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 280                                       | 315  | +5   | -27 | +16  | -36  | -9   | -41  | 0    | -52  | -25  | -57  | -14  | -66  | -47  | -79  | -36  | -88  | -85  | -117 | -74  | -126 |
| 315                                       | 355  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 355                                       | 400  | +7   | -29 | +17  | -40  | -10  | -46  | 0    | -57  | -26  | -62  | -16  | -73  | -51  | -87  | -41  | -98  | -97  | -133 | -87  | -144 |
| 400                                       | 450  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 450                                       | 500  | +8   | -32 | +18  | -45  | -10  | -50  | 0    | -63  | -27  | -67  | -17  | -80  | -55  | -95  | -45  | -108 | -113 | -153 | -103 | -166 |
| 500                                       | 560  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 560                                       | 630  | +0   | -44 | +0   | -70  | -26  | -70  | -26  | -96  | -44  | -88  | -44  | -114 | -78  | -122 | -78  | -148 | -    | -    | -    | -    |
| 630                                       | 710  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 710                                       | 800  | +0   | -50 | +0   | -80  | -30  | -80  | -30  | -110 | -50  | -100 | -50  | -130 | -88  | -138 | -88  | -168 | -    | -    | -    | -    |
| 800                                       | 900  |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 900                                       | 1000 | +0   | -56 | +0   | -90  | -34  | -90  | -34  | -124 | -56  | -112 | -56  | -146 | -100 | -156 | -100 | -190 | -    | -    | -    | -    |
| 1000                                      | 1120 |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1120                                      | 1250 | +0   | -66 | +0   | -105 | -40  | -106 | -40  | -145 | -66  | -132 | -66  | -171 | -120 | -186 | -120 | -225 | -    | -    | -    | -    |
| 1250                                      | 1400 |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1400                                      | 1600 | +0   | -78 | +0   | -125 | -48  | -126 | -48  | -173 | -78  | -156 | -78  | -203 | -140 | -218 | -140 | -265 | -    | -    | -    | -    |
| 1600                                      | 1800 |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1800                                      | 2000 | +0   | -92 | +0   | -150 | -58  | -150 | -58  | -208 | -92  | -184 | -92  | -242 | -170 | -262 | -170 | -320 | -    | -    | -    | -    |
| 1800                                      | 2000 |      |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

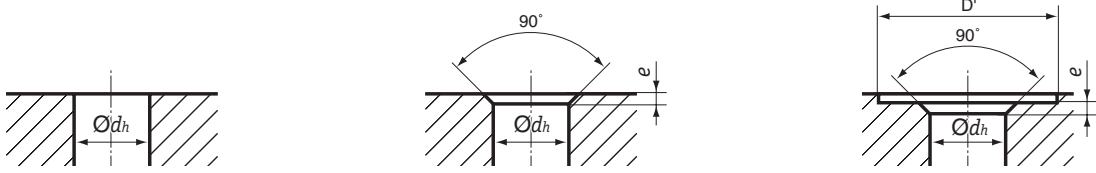
(Unit:  $\mu\text{m}$ )

| H7   |     | H8   |     | H9   |     | H10  |     | H11  |     | H13  |     | J6   |     | Js6   |       | J7   |     | Js7   |       | K5   |     | Diameter division<br>(mm)<br>over or less |      |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|-------|-------|------|-----|-------|-------|------|-----|---|------|
| high | low | high | low | high | low | high | low | high | low | high | low | high | low | high  | low   | high | low | high  | low   | high | low |   |      |
| +12  | 0   | +18  | 0   | +30  | 0   | +48  | 0   | +75  | 0   | +180 | 0   | +5   | -3  | +4    | -4    | +6   | -6  | +6    | -6    | +0   | -5  | 3   | 6    |
| +15  | 0   | +22  | 0   | +36  | 0   | +58  | 0   | +90  | 0   | +220 | 0   | +5   | -4  | +4.5  | -4.5  | +8   | -7  | +7.5  | -7.5  | +1   | -5  | 6   | 10   |
| +18  | 0   | +27  | 0   | +43  | 0   | +70  | 0   | +110 | 0   | +270 | 0   | +6   | -5  | +5.5  | -5.5  | +10  | -8  | +9    | -9    | +2   | -6  | 10  | 18   |
| +21  | 0   | +33  | 0   | +52  | 0   | +84  | 0   | +130 | 0   | +330 | 0   | +8   | -5  | +6.5  | -6.5  | +12  | -9  | +10.5 | -10.5 | +1   | -8  | 18  | 30   |
| +25  | 0   | +39  | 0   | +62  | 0   | +100 | 0   | +160 | 0   | +390 | 0   | +10  | -6  | +8    | -8    | +14  | -11 | +12.5 | -12.5 | +2   | -9  | 30  | 40   |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 40  | 50   |
| +30  | 0   | +46  | 0   | +74  | 0   | +120 | 0   | +190 | 0   | +460 | 0   | +13  | -6  | +9.5  | -9.5  | +18  | -12 | +15   | -15   | +3   | -10 | 50  | 65   |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 65  | 80   |
| +35  | 0   | +54  | 0   | +87  | 0   | +140 | 0   | +220 | 0   | +540 | 0   | +16  | -6  | +11   | -11   | +22  | -13 | +17.5 | -17.5 | +2   | -13 | 80  | 100  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 100                                       | 120  |
| +40  | 0   | +63  | 0   | +100 | 0   | +160 | 0   | +250 | 0   | +630 | 0   | +18  | -7  | +12.5 | -12.5 | +26  | -14 | +20   | -20   | +3   | -15 | 120                                       | 140  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 140                                       | 160  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 160                                       | 180  |
| +46  | 0   | +72  | 0   | +115 | 0   | +185 | 0   | +290 | 0   | +720 | 0   | +22  | -7  | +14.5 | -14.5 | +30  | -16 | +23   | -23   | +2   | -18 | 180                                       | 200  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 200                                       | 225  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 225                                       | 250  |
| +52  | 0   | +81  | 0   | +130 | 0   | +210 | 0   | +320 | 0   | +810 | 0   | +25  | -7  | +16   | -16   | +36  | -16 | +26   | -26   | +3   | -20 | 250                                       | 280  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 280                                       | 315  |
| +57  | 0   | +89  | 0   | +140 | 0   | +230 | 0   | +360 | 0   | +890 | 0   | +29  | -7  | +18   | -18   | +39  | -18 | +28.5 | -28.5 | +3   | -22 | 315                                       | 355  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 355                                       | 400  |
| +63  | 0   | +97  | 0   | +155 | 0   | +250 | 0   | +400 | 0   | +970 | 0   | +33  | -7  | +20   | -20   | +43  | -20 | +31.5 | -31.5 | +2   | -25 | 400                                       | 450  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 450                                       | 500  |
| +70  | 0   | +110 | 0   | +175 | 0   | +280 | 0   | +440 | 0   | -    | -   | -    | -   | +22   | -22   | -    | -   | +35   | -35   | -    | -   | 500                                       | 560  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 560                                       | 630  |
| +80  | 0   | +125 | 0   | +200 | 0   | +320 | 0   | +500 | 0   | -    | -   | -    | -   | +25   | -25   | -    | -   | +40   | -40   | -    | -   | 630                                       | 710  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 710                                       | 800  |
| +90  | 0   | +140 | 0   | +230 | 0   | +360 | 0   | +560 | 0   | -    | -   | -    | -   | +28   | -28   | -    | -   | +45   | -45   | -    | -   | 800                                       | 900  |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 900                                       | 1000 |
| +105 | 0   | +165 | 0   | +260 | 0   | +420 | 0   | +660 | 0   | -    | -   | -    | -   | +33   | -33   | -    | -   | +52.5 | -52.5 | -    | -   | 1000                                      | 1120 |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 1120                                      | 1250 |
| +125 | 0   | +195 | 0   | +310 | 0   | +500 | 0   | +780 | 0   | -    | -   | -    | -   | +39   | -39   | -    | -   | +62.5 | -62.5 | -    | -   | 1250                                      | 1400 |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 1400                                      | 1600 |
| +150 | 0   | +230 | 0   | +370 | 0   | +600 | 0   | +920 | 0   | -    | -   | -    | -   | +46   | -46   | -    | -   | +75   | -75   | -    | -   | 1600                                      | 1800 |
|      |     |      |     |      |     |      |     |      |     |      |     |      |     |       |       |      |     |       |       |      |     | 1800                                      | 2000 |



# Appendix

## 7. Diameter of clearance holes and counterbores for bolts and screws (JIS B 1001)



| Nominal diameter of screw thread | Bolt hole diameter $d_h$ <sup>(*)2</sup> |               |               |                         | Chamfering $e$ | Counterbore diameter $D'$ | Nominal diameter of screw thread | Bolt hole diameter $d_h$ <sup>(*)2</sup> |               |               |                         | Chamfering $e$ | Counterbore diameter $D'$ |
|----------------------------------|--|---------------|---------------|-------------------------|----------------|---------------------------|----------------------------------|--|---------------|---------------|-------------------------|----------------|---------------------------|
|                                  | Class 1 (H12)                            | Class 2 (H13) | Class 3 (H14) | Class 4 <sup>(*)1</sup> |                |                           |                                  | Class 1 (H12)                            | Class 2 (H13) | Class 3 (H14) | Class 4 <sup>(*)1</sup> |                |                           |
| 1                                | 1.1                                      | 1.2           | 1.3           | —                       | 0.2            | 3                         | 30                               | 31                                       | 33            | 35            | 36                      | 1.7            | 62                        |
| 1.2                              | 1.3                                      | 1.4           | 1.5           | —                       | 0.2            | 4                         | 33                               | 34                                       | 36            | 38            | 40                      | 1.7            | 66                        |
| 1.4                              | 1.5                                      | 1.6           | 1.8           | —                       | 0.2            | 4                         | 36                               | 37                                       | 39            | 42            | 43                      | 1.7            | 72                        |
| 1.6                              | 1.7                                      | 1.8           | 2             | —                       | 0.2            | 5                         | 39                               | 40                                       | 42            | 45            | 46                      | 1.7            | 76                        |
| 1.7                              | 1.8                                      | 2             | 2.1           | —                       | 0.2            | 5                         | 42                               | 43                                       | 45            | 48            | —                       | 1.8            | 82                        |
| 1.8                              | 2.0                                      | 2.1           | 2.2           | —                       | 0.2            | 5                         | 45                               | 46                                       | 48            | 52            | —                       | 1.8            | 87                        |
| 2                                | 2.2                                      | 2.4           | 2.6           | —                       | 0.3            | 7                         | 48                               | 50                                       | 52            | 56            | —                       | 2.3            | 93                        |
| 2.2                              | 2.4                                      | 2.6           | 2.8           | —                       | 0.3            | 8                         | 52                               | 54                                       | 56            | 62            | —                       | 2.3            | 100                       |
| 2.3                              | 2.5                                      | 2.7           | 2.9           | —                       | 0.3            | 8                         | 56                               | 58                                       | 62            | 66            | —                       | 3.5            | 110                       |
| 2.5                              | 2.7                                      | 2.9           | 3.1           | —                       | 0.3            | 8                         | 60                               | 62                                       | 66            | 70            | —                       | 3.5            | 115                       |
| 2.6                              | 2.8                                      | 3             | 3.2           | —                       | 0.3            | 8                         | 64                               | 66                                       | 70            | 74            | —                       | 3.5            | 122                       |
| 3                                | 3.2                                      | 3.4           | 3.6           | —                       | 0.3            | 9                         | 68                               | 70                                       | 74            | 78            | —                       | 3.5            | 127                       |
| 3.5                              | 3.7                                      | 3.9           | 4.2           | —                       | 0.3            | 10                        | 72                               | 74                                       | 78            | 82            | —                       | 3.5            | 133                       |
| 4                                | 4.3                                      | 4.5           | 4.8           | 5.5                     | 0.4            | 11                        | 76                               | 78                                       | 82            | 86            | —                       | 3.5            | 143                       |
| 4.5                              | 4.8                                      | 5             | 5.3           | 6                       | 0.4            | 13                        | 80                               | 82                                       | 86            | 91            | —                       | 3.5            | 148                       |
| 5                                | 5.3                                      | 5.5           | 5.8           | 6.5                     | 0.4            | 13                        | 85                               | 87                                       | 91            | 96            | —                       | —              | —                         |
| 6                                | 6.4                                      | 6.6           | 7             | 7.8                     | 0.4            | 15                        | 90                               | 93                                       | 96            | 101           | —                       | —              | —                         |
| 7                                | 7.4                                      | 7.6           | 8             | —                       | 0.4            | 18                        | 95                               | 98                                       | 101           | 107           | —                       | —              | —                         |
| 8                                | 8.4                                      | 9             | 10            | 10                      | 0.6            | 20                        | 100                              | 104                                      | 107           | 112           | —                       | —              | —                         |
| 10                               | 10.5                                     | 11            | 12            | 13                      | 0.6            | 24                        | 105                              | 109                                      | 112           | 117           | —                       | —              | —                         |
| 12                               | 13                                       | 13.5          | 14.5          | 15                      | 1.1            | 28                        | 110                              | 114                                      | 117           | 122           | —                       | —              | —                         |
| 14                               | 15                                       | 15.5          | 16.5          | 17                      | 1.1            | 32                        | 115                              | 119                                      | 122           | 127           | —                       | —              | —                         |
| 16                               | 17                                       | 17.5          | 18.5          | 20                      | 1.1            | 35                        | 120                              | 124                                      | 127           | 132           | —                       | —              | —                         |
| 18                               | 19                                       | 20            | 21            | 22                      | 1.1            | 39                        | 125                              | 129                                      | 132           | 137           | —                       | —              | —                         |
| 20                               | 21                                       | 22            | 24            | 25                      | 1.2            | 43                        | 130                              | 134                                      | 137           | 144           | —                       | —              | —                         |
| 22                               | 23                                       | 24            | 26            | 27                      | 1.2            | 46                        | 140                              | 144                                      | 147           | 155           | —                       | —              | —                         |
| 24                               | 25                                       | 26            | 28            | 29                      | 1.2            | 50                        | 150                              | 155                                      | 158           | 165           | —                       | —              | —                         |
| 27                               | 28                                       | 30            | 32            | 33                      | 1.7            | 55                        |                                  |  |               |               |                         |                |                           |

Note:

\*1 Class 4 shall be applied mainly to cast holes.

\*2 The values for the symbol of the dimensional tolerance is in accordance with JIS B 0401 (dimension tolerances and fits).

Reference:

1. The non-shaded area in this table that specifies nominal diameter of screw thread and bolt hole diameters is not specified in ISO 273.
2. The nominal diameter of screw head marked with is not specified in ISO 261.

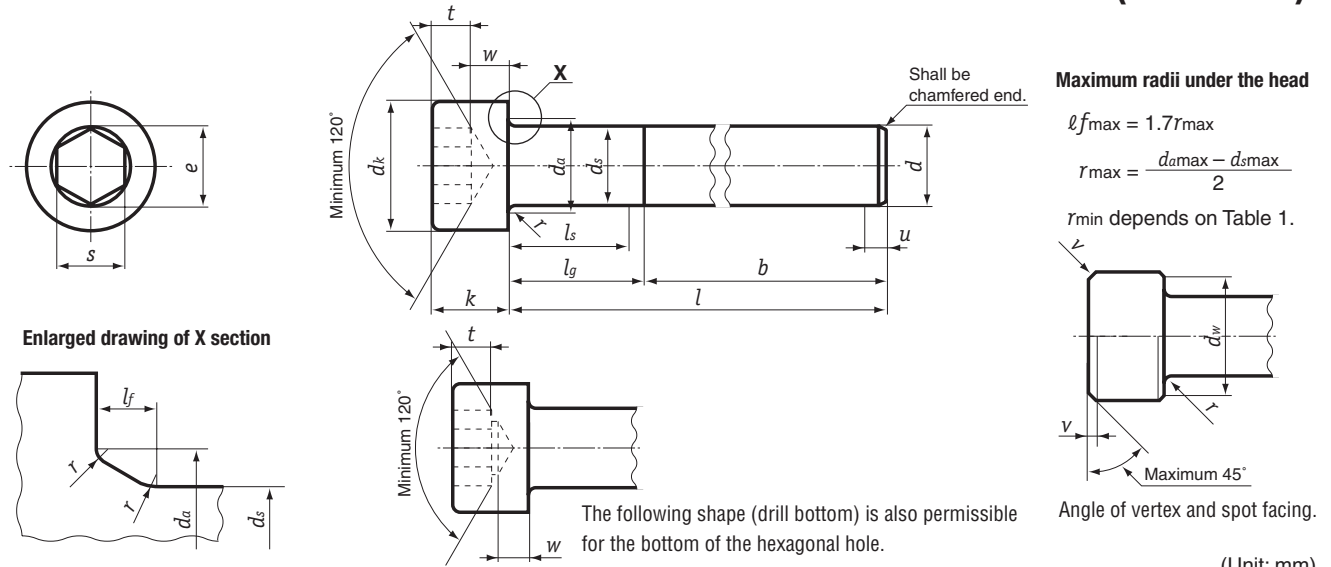
3. Hole chamfering shall be performed, as required, and its angle shall be 90 degrees as a rule.

4. Where counterbore diameters smaller or larger than the values specified in this table are required with respect to a certain screw-thread nominal diameter, their numerical values shall preferably be

selected from the series of counterbore diameters shown in this table as far as possible.

5. The counterbore surface shall be perpendicular to the centre line of the hole, and the counterbore depth shall generally be of such a degree that casting surface is removed.

## 8. Diameter of clearance holes and counterbores for bolts and screws (JIS B 1001)



(Unit: mm)

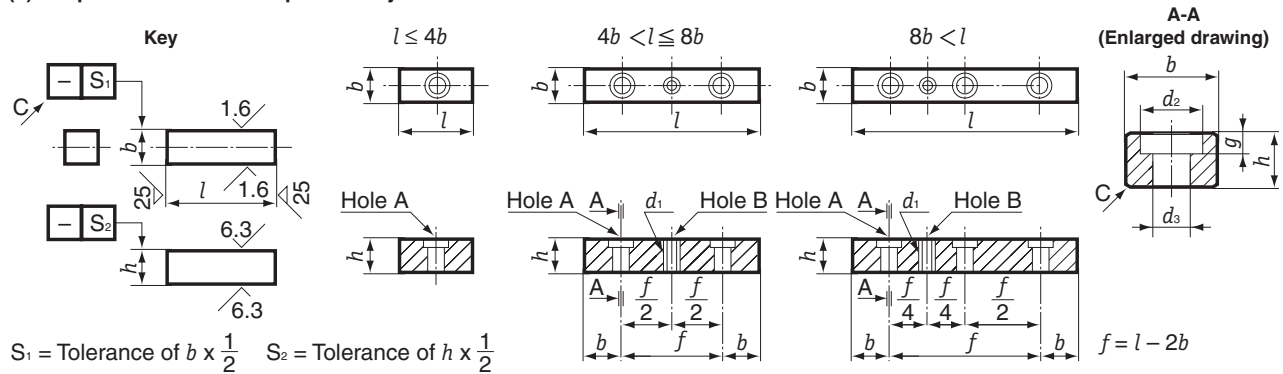
| Nominal designation of screw thread (d) |             | M3       | M4    | M5    | M6    | M8    | M10   | M12    | (M14)  | M16    | M20   | M24    | M30    |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|---|-------------|----------|-------|-------|-------|-------|-------|--------|--------|--------|-------|--------|--------|-----|-------|-----|-----|-----|-----|-----|------|------|-------|-----|------|------|-------|-----|-----|-----|-----|-----|--|--|--|--|--|--|
|   |             | <b>P</b> |       | 0.5   | 0.7   | 0.8   | 1     | 1.25   | 1.5    | 1.75   | 2     | 2      | 2.5    | 3   | 3.5   |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>b</b>                                | (Reference) | 18       | 20    | 22    | 24    | 28    | 32    | 36     | 40     | 44     | 52    | 60     | 72     |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>dk</b>                               | Max         | 5.68     | 7.22  | 8.72  | 10.22 | 13.27 | 16.27 | 18.27  | 21.33  | 24.33  | 30.33 | 36.39  | 45.39  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|   | Min         | 5.32     | 6.78  | 8.28  | 9.78  | 12.73 | 15.73 | 17.73  | 20.67  | 23.67  | 29.67 | 35.61  | 44.61  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>da</b>                               | Max         | 3.6      | 4.7   | 5.7   | 6.8   | 9.2   | 11.2  | 13.7   | 15.7   | 17.7   | 22.4  | 26.4   | 33.4   |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|   | Min         | 3.00     | 4.00  | 5.00  | 6.00  | 8.00  | 10.00 | 12.00  | 14.00  | 16.00  | 20.00 | 24.00  | 30.00  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>ds</b>                               | Max         | 2.86     | 3.82  | 4.82  | 5.82  | 7.78  | 9.78  | 11.73  | 13.73  | 15.73  | 19.67 | 23.67  | 29.67  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|   | Min         | 2.87     | 3.44  | 4.58  | 5.72  | 6.86  | 9.15  | 11.43  | 13.72  | 16     | 19.44 | 21.73  | 25.15  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>lf</b>                               | Max         | 0.51     | 0.6   | 0.6   | 0.68  | 1.02  | 1.02  | 1.45   | 1.45   | 1.45   | 2.04  | 2.04   | 2.89   |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>k</b>                                | Max         | 3.00     | 4.00  | 5.00  | 6.00  | 8.00  | 10.00 | 12.00  | 14.00  | 16.00  | 20.00 | 24.00  | 30.00  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|   | Min         | 2.86     | 3.82  | 4.82  | 5.7   | 7.64  | 9.64  | 11.57  | 13.57  | 15.57  | 19.48 | 23.48  | 29.48  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>r</b>                                | Min         | 0.1      | 0.2   | 0.2   | 0.25  | 0.4   | 0.4   | 0.6    | 0.6    | 0.6    | 0.8   | 0.8    | 1      |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>s</b>                                | Nominal     | 2.5      | 3     | 4     | 5     | 6     | 8     | 10     | 12     | 14     | 17    | 19     | 22     |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|   | Max         | 2.56     | 3.071 | 4.084 | 5.084 | 6.095 | 8.115 | 10.115 | 12.142 | 14.142 | 17.23 | 19.275 | 22.275 |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|   | Min         | 2.52     | 3.020 | 4.020 | 5.020 | 6.020 | 8.025 | 10.025 | 12.032 | 14.032 | 17.05 | 19.065 | 22.065 |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>t</b>                                | Min         | 1.3      | 2     | 2.5   | 3     | 4     | 5     | 6      | 7      | 8      | 10    | 12     | 15.5   |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>v</b>                                | Max         | 0.3      | 0.4   | 0.5   | 0.6   | 0.8   | 1     | 1.2    | 1.4    | 1.6    | 2     | 2.4    | 3      |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>dw</b>                               | Min         | 5.07     | 6.53  | 8.03  | 9.38  | 12.33 | 15.33 | 17.23  | 20.17  | 23.17  | 28.87 | 34.81  | 43.61  |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| <b>w</b>                                | Min         | 1.15     | 1.4   | 1.9   | 2.3   | 3.3   | 4     | 4.8    | 5.8    | 6.8    | 8.6   | 10.4   | 13.1   |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
|   |             | ls 及び lg |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| Length (l)                              |             | ls       |       | lg    |       | ls    |       | lg     |        | ls     |       | lg     |        | ls  |       | lg  |     | ls  |     | lg  |      | ls   |       | lg  |      | ls   |       | lg  |     | ls  |     | lg  |  |  |  |  |  |  |
| Nominal designation                     | Min         | Max      | Min   | Max   | Min   | Max   | Min   | Max    | Min    | Max    | Min   | Max    | Min    | Max | Min   | Max | Min | Max | Min | Max | Min  | Max  | Min   | Max | Min  | Max  | Min   | Max | Min | Max | Min | Max |  |  |  |  |  |  |
| 4                                       | 3.76        | 4.24     |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 5                                       | 4.76        | 5.24     |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 6                                       | 5.76        | 6.24     |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 8                                       | 7.71        | 8.29     |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 10                                      | 9.71        | 10.29    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 12                                      | 11.65       | 12.35    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 16                                      | 15.65       | 16.35    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 20                                      | 19.58       | 20.42    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 25                                      | 24.58       | 25.42    | 4.5   | 7     |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 30                                      | 29.58       | 30.42    | 9.5   | 12    | 6.5   | 10    | 4     | 8      |        |        |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 35                                      | 34.5        | 35.5     |       |       | 11.5  | 15    | 9     | 13     | 6      | 11     |       |        |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 40                                      | 39.5        | 40.5     |       |       | 16.5  | 20    | 14    | 18     | 11     | 16     | 5.75  | 12     |        |     |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 45                                      | 44.5        | 45.5     |       |       |       |       | 19    | 23     | 16     | 21     | 10.75 | 17     | 5.5    | 13  |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 50                                      | 49.5        | 50.5     |       |       |       |       | 24    | 28     | 21     | 26     | 15.75 | 22     | 10.5   | 18  |       |     |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 55                                      | 54.4        | 55.6     |       |       |       |       |       |        | 26     | 31     | 20.75 | 27     | 15.5   | 23  | 10.25 | 19  |     |     |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 60                                      | 59.4        | 60.6     |       |       |       |       |       |        | 31     | 36     | 25.75 | 32     | 20.5   | 28  | 15.25 | 24  | 10  | 20  |     |     |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 65                                      | 64.4        | 65.6     |       |       |       |       |       |        |        |        | 30.75 | 37     | 25.5   | 33  | 20.25 | 29  | 15  | 25  | 11  | 21  |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 70                                      | 69.4        | 70.6     |       |       |       |       |       |        |        |        | 35.75 | 42     | 30.5   | 38  | 25.25 | 34  | 20  | 30  | 16  | 26  |      |      |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 80                                      | 79.4        | 80.6     |       |       |       |       |       |        |        |        | 45.75 | 52     | 40.5   | 48  | 35.25 | 44  | 30  | 40  | 26  | 36  | 15.5 | 28   |       |     |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 90                                      | 89.3        | 90.7     |       |       |       |       |       |        |        |        |       |        | 50.5   | 58  | 45.25 | 54  | 40  | 50  | 36  | 46  | 25.5 | 38   | 15    | 30  |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 100                                     | 99.3        | 100.7    |       |       |       |       |       |        |        |        |       |        | 60.5   | 68  | 55.25 | 64  | 50  | 60  | 46  | 56  | 35.5 | 48   | 25    | 40  |      |      |       |     |     |     |     |     |  |  |  |  |  |  |
| 110                                     | 109.3       | 110.7    |       |       |       |       |       |        |        |        |       |        |        |     | 65.25 | 74  | 60  | 70  | 56  | 66  | 45.5 | 58   | 35    | 50  | 20.5 | 38   |       |     |     |     |     |     |  |  |  |  |  |  |
| 120                                     | 119.3       | 120.7    |       |       |       |       |       |        |        |        |       |        |        |     | 75.25 | 84  | 70  | 80  | 66  | 76  | 55.5 | 68   | 45    | 60  | 30.5 | 48   |       |     |     |     |     |     |  |  |  |  |  |  |
| 130                                     | 129.2       | 130.8    |       |       |       |       |       |        |        |        |       |        |        |     |       |     | 80  | 90  | 76  | 86  | 65.5 | 78   | 55    | 70  | 40.5 | 58   |       |     |     |     |     |     |  |  |  |  |  |  |
| 140                                     | 139.2       | 140.8    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     | 90  | 100 | 86  | 96   | 75.5 | 88    | 65  | 80   | 50.5 | 68    |     |     |     |     |     |  |  |  |  |  |  |
| 150                                     | 149.2       | 150.8    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     | 85.5 | 98   | 75    | 90  | 60.5 | 78   |       |     |     |     |     |     |  |  |  |  |  |  |
| 160                                     | 159.2       | 160.8    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     | 106  | 116  | 95.5  | 108 | 85   | 100  | 70.5  | 88  |     |     |     |     |  |  |  |  |  |  |
| 180                                     | 179.2       | 180.8    |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      | 115.5 | 128 | 105  | 120  | 90.5  | 108 |     |     |     |     |  |  |  |  |  |  |
| 200                                     | 199.075     | 200.925  |       |       |       |       |       |        |        |        |       |        |        |     |       |     |     |     |     |     |      |      | 135.5 | 148 | 125  | 140  | 110.5 | 128 |     |     |     |     |  |  |  |  |  |  |

# Appendix

## 9. Parallel keys and keyways (JIS B 1301)

(Unit: mm)

(a) Shape and dimension of parallel keys



| Nominal size of key<br>$b \times h$ | Key dimension      |                |                    |             | For screw hole |          |                              |       |       |     |   |   |
|-------------------------------------|--------------------|----------------|--------------------|-------------|----------------|----------|------------------------------|-------|-------|-----|---|---|
|                                     | $b$                |                | $h$                |             | $c^{*2}$       | $l^{*1}$ | Nominal designation<br>$d_1$ | $d_2$ | $d_3$ | $g$ |   |   |
|                                     | Standard dimension | Tolerance (h9) | Standard dimension | Tolerance   |                |          |                              |       |       |     |   |   |
| 2 x 2                               | 2                  | 0              | 2                  | 0           | 0.16 to 0.25   | h9       | -                            | -     | -     | -   |   |   |
| 3 x 3                               | 3                  | -0.025         | 3                  | -0.025      |                |          |                              |       |       |     |   |   |
| 4 x 4                               | 4                  | 0              | 4                  | 0           |                |          |                              |       |       |     |   |   |
| 5 x 5                               | 5                  | -0.030         | 5                  | -0.030      |                |          |                              |       |       |     |   |   |
| 6 x 6                               | 6                  | 0              | 6                  | 0           |                |          |                              |       |       |     |   |   |
| (7 x 7)                             | 7                  | 0              | 7                  | -0.036      | 0.25 to 0.40   | -        | -                            | -     | -     | -   |   |   |
| 8 x 7                               | 8                  | -0.036         | 7                  | 0           |                |          |                              |       |       |     |   |   |
| 10 x 8                              | 10                 | 0<br>-0.043    | 8                  | 0<br>-0.090 | 0.40 to 0.60   | h11      | -                            | -     | -     | -   | - |   |
| 12 x 8                              | 12                 |                | 8                  |             |                |          |                              |       |       |     |   |   |
| 14 x 9                              | 14                 |                | 9                  |             |                |          |                              |       |       |     |   |   |
| (15 x 10)                           | 15                 |                | 10                 |             |                |          |                              |       |       |     |   |   |
| 16 x 10                             | 16                 |                | 10                 |             |                |          |                              |       |       |     |   |   |
| 18 x 11                             | 18                 |                | 11                 |             |                |          |                              |       |       |     |   |   |
| 20 x 12                             | 20                 |                | 12                 |             |                |          |                              |       |       |     |   |   |
| 22 x 14                             | 22                 |                | 14                 |             |                |          |                              |       |       |     |   |   |
| (24 x 16)                           | 24                 |                | 16                 |             |                |          |                              |       |       |     |   |   |
| 25 x 14                             | 25                 |                | 14                 |             |                |          |                              |       |       |     |   |   |
| 28 x 16                             | 28                 | 16             |                    |             |                |          |                              |       |       |     |   |   |
| 32 x 18                             | 32                 | 0<br>-0.062    | 18                 | 0<br>-0.130 | 1.00 to 1.20   | h11      | -                            | -     | -     | -   | - |   |
| (35 x 22)                           | 35                 |                | 22                 |             |                |          |                              |       |       |     |   |   |
| 36 x 20                             | 36                 |                | 20                 |             |                |          |                              |       |       |     |   |   |
| (38 x 24)                           | 38                 |                | 24                 |             |                |          |                              |       |       |     |   |   |
| 40 x 22                             | 40                 |                | 22                 |             |                |          |                              |       |       |     |   |   |
| (42 x 26)                           | 42                 |                | 26                 |             |                |          |                              |       |       |     |   |   |
| 45 x 25                             | 45                 |                | 25                 |             |                |          |                              |       |       |     |   |   |
| 50 x 28                             | 50                 |                | 28                 |             |                |          |                              |       |       |     |   |   |
| 56 x 32                             | 56                 |                | 32                 |             |                |          |                              |       |       |     |   |   |
| 63 x 32                             | 63                 |                | 32                 |             |                |          |                              |       |       |     |   |   |
| 70 x 36                             | 70                 | -0.074         | 36                 | 0           | 1.60 to 2.00   | h11      | -                            | -     | -     | -   | - |   |
| 80 x 40                             | 80                 | 40             |                    |             |                |          |                              |       |       |     |   |   |
| 90 x 45                             | 90                 | 45             |                    |             |                |          |                              |       |       |     |   |   |
| 100 x 50                            | 100                | -0.087         | 50                 | -0.160      | 2.50 to 3.00   | h11      | -                            | -     | -     | -   | - | - |
|                                     |                    |                |                    |             |                |          |                              |       |       |     |   |   |

Note:

\*1 Select  $l$  from the following within the range of the table. The dimensional tolerance for  $l$  is basically h12 of JIS B0401.

6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 70, 80, 90, 100, 110, 125, 140, 160, 180, 200, 220, 250, 280, 320, 360, 400

\*2 Instead of 45° chamfering ( $c$ ), rounding ( $r$ ) is also acceptable.

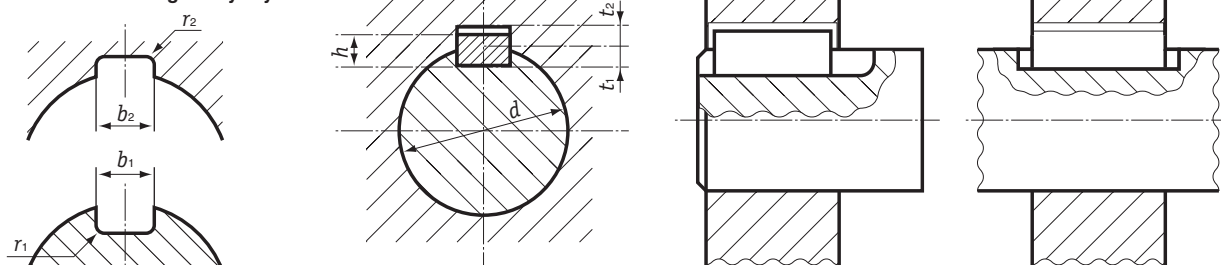
Reference:

Size codes in ( ) are not stipulated in the corresponding internal standards and should not be used in new designs.

(Unit: mm)

**(b) Shape and dimension of keyways for parallel keys**

Cross section drawing of keyway



| Nominal size of key $b \times h$ | Basic dimension of $b_1$ and $b_2$ | Sliding type   |                 | Regular type   |                 | Precision       | $r_1$ and $r_2$ | Basic dimension of $t_1$ | Basic dimension of $t_2$ | Tolerance of $t_1$ and $t_2$ | Reference Applicable shaft dia. <sup>(*)</sup> $d$ |
|----------------------------------|------------------------------------|----------------|-----------------|----------------|-----------------|-----------------|-----------------|--------------------------|--------------------------|------------------------------|--|
|                                  |                                    | $b_1$          | $b_2$           | $b_1$          | $b_2$           | $b_1$ and $b_2$ |                 |                          |                          |                              |  |
|                                  |                                    | Tolerance (H9) | Tolerance (D10) | Tolerance (N9) | Tolerance (Js9) | Tolerance (P9)  |                 |                          |                          |                              |  |
| 2 x 2                            | 2                                  | +0.025         | +0.060          | -0.004         | $\pm 0.0125$    | -0.006          | 0.08 to 0.16    | 1.2                      | 1.0                      | +0.1<br>0                    | 6 to 8   |
| 3 x 3                            | 3                                  | 0              | +0.020          | -0.029         | -0.031          | 1.8             |                 | 1.4                      | 8 to 10                  |                              |  |
| 4 x 4                            | 4                                  | +0.030         | +0.078          | 0              | $\pm 0.0150$    | -0.012          |                 | 2.5                      | 1.8                      |                              | 10 to 12   |
| 5 x 5                            | 5                                  | 0              | +0.030          | -0.030         | $\pm 0.0150$    | -0.042          | 0.16 to 0.25    | 3.0                      | 2.3                      | +0.2<br>0                    | 12 to 17   |
| 6 x 6                            | 6                                  |                |                 |                |                 | 3.5             |                 | 2.8                      | 17 to 22                 |                              |  |
| (7 x 7)                          | 7                                  | +0.036         | +0.098          | 0              | $\pm 0.0180$    | -0.015          |                 | 4.0                      | 3.3                      |                              | 20 to 25   |
| 8 x 7                            | 8                                  | 0              | +0.030          | -0.036         | $\pm 0.0180$    | -0.051          | 0.25 to 0.40    | 4.0                      | 3.3                      | +0.2<br>0                    | 22 to 30   |
| 10 x 8                           | 10                                 |                |                 |                |                 | 5.0             |                 | 3.3                      | 30 to 38                 |                              |  |
| 12 x 8                           | 12                                 |                |                 |                |                 | 5.0             |                 | 3.3                      | 38 to 44                 |                              |  |
| 14 x 9                           | 14                                 |                |                 |                |                 |                 |                 | 5.5                      | 3.8                      | 44 to 50                     |  |
| (15 x 10)                        | 15                                 | +0.043         | +0.120          | 0              | $\pm 0.0215$    | -0.018          | 0.40 to 0.60    | 5.0                      | 5.3                      | +0.2<br>0                    | 50 to 55   |
| 16 x 10                          | 16                                 | 0              | +0.050          | -0.043         | $\pm 0.0215$    | -0.061          |                 | 6.0                      | 4.3                      |                              | 58 to 65   |
| 18 x 11                          | 18                                 |                |                 |                |                 | 7.0             |                 | 4.4                      | 65 to 75                 |                              |  |
| 20 x 12                          | 20                                 |                |                 |                |                 |                 |                 | 7.5                      | 4.9                      | 75 to 85                     |  |
| 22 x 14                          | 22                                 |                |                 |                |                 |                 |                 | 9.0                      | 5.4                      | 80 to 90                     |  |
| (24 x 16)                        | 24                                 | +0.052         | +0.149          | 0              | $\pm 0.0260$    | -0.022          | 0.70 to 1.00    | 8.0                      | 8.4                      | +0.3<br>0                    | 85 to 95   |
| 25 x 14                          | 25                                 | 0              | +0.065          | -0.052         | $\pm 0.0260$    | -0.074          |                 | 9.0                      | 5.4                      |                              | 95 to 110  |
| 28 x 16                          | 28                                 |                |                 |                |                 | 10.0            |                 | 6.4                      | 110 to 130               |                              |  |
| 32 x 18                          | 32                                 |                |                 |                |                 |                 |                 | 11.0                     | 7.4                      | 125 to 140                   |  |
| (35 x 22)                        | 35                                 |                |                 |                |                 |                 |                 | 11.0                     | 11.4                     | 130 to 150                   |  |
| 36 x 20                          | 36                                 |                |                 |                |                 |                 |                 | 12.0                     | 8.4                      | 140 to 160                   |  |
| (38 x 24)                        | 38                                 | +0.062         | +0.180          | 0              | $\pm 0.0310$    | -0.026          | 1.20 to 1.60    | 12.0                     | 12.4                     | +0.3<br>0                    | 150 to 170   |
| 40 x 22                          | 40                                 | 0              | +0.080          | -0.062         | $\pm 0.0310$    | -0.088          |                 | 13.0                     | 9.4                      |                              | 160 to 180   |
| (42 x 26)                        | 42                                 |                |                 |                |                 |                 |                 | 13.0                     | 13.4                     |                              | 170 to 200   |
| 45 x 25                          | 45                                 |                |                 |                |                 |                 |                 | 15.0                     | 10.4                     | 200 to 230                   |  |
| 50 x 28                          | 50                                 |                |                 |                |                 |                 |                 | 17.0                     | 11.4                     | 230 to 260                   |  |
| 56 x 32                          | 56                                 |                |                 |                |                 |                 |                 | 20.0                     | 12.4                     | 260 to 290                   |  |
| 63 x 32                          | 63                                 | +0.074         | +0.220          | 0              | $\pm 0.0370$    | -0.032          | 2.00 to 2.50    | 20.0                     | 12.4                     | +0.3<br>0                    | 290 to 330   |
| 70 x 36                          | 70                                 | 0              | +0.100          | -0.074         | $\pm 0.0370$    | -0.106          |                 | 22.0                     | 14.4                     |                              | 330 to 380   |
| 80 x 40                          | 80                                 |                |                 |                |                 |                 |                 | 25.0                     | 15.4                     |                              | 380 to 440   |
| 90 x 45                          | 90                                 | +0.087         | +0.260          | 0              | $\pm 0.0435$    | -0.037          | 2.00 to 2.50    | 28.0                     | 17.4                     | +0.3<br>0                    | 440 to 500   |
| 100 x 50                         | 100                                | 0              | +0.120          | -0.087         | $\pm 0.0435$    | -0.124          |                 | 31.0                     | 19.5                     |                              |  |

## Note:

\*1 Applicable shaft diameters should be derived from the torque that corresponds to the key strength. Shown here, therefore, as reference for general usage. When the key size is appropriate for the transmission torque, a shaft larger than the applicable shaft diameter may be used. In that case, it is recommended to adjust  $t_1$  and  $t_2$  so that the key side uniformly contacts the shaft and hub. This does not apply to shafts smaller than the applicable shaft diameter.

## Reference:

Size codes in ( ) are not stipulated in the corresponding internal standards and should not be used in new designs.

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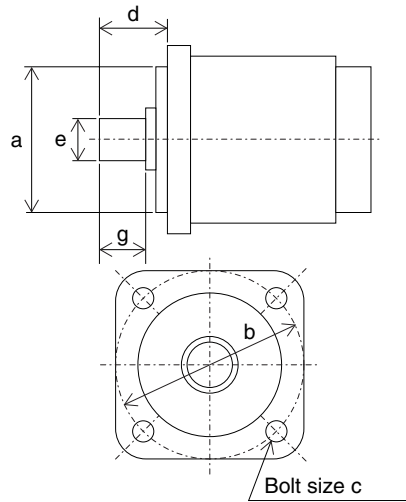
**Order Information Sheet** (Please complete the form below) and send it with your order. Date: \_\_\_\_\_

Company Name: \_\_\_\_\_ Dept. Name: \_\_\_\_\_  
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**System configuration and selected motor**

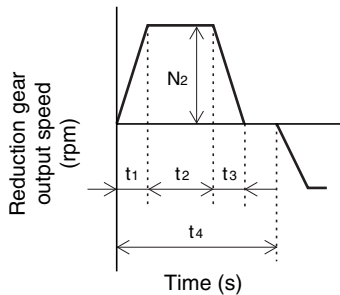
We would appreciate if you could provide your system configuration drawing that helps us to understand the speed, constant torque, and load inertia moment of the output shaft for the reduction gear.

**System configuration**



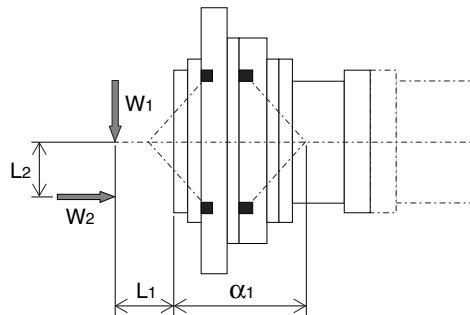
|                       |                                      |          |                                    |  |
|-----------------------|--------------------------------------|----------|------------------------------------|--|
| Motor model           |                                      | <b>a</b> | Motor mounting pilot diameter (mm) |  |
| <b>P</b>              | Motor rated output (KW)              | <b>b</b> | Motor mounting bolt P.C.D (mm)     |  |
| <b>T<sub>M0</sub></b> | Motor rated torque (N-m)             | <b>c</b> | Motor mounting bolt size (mm)      |  |
| <b>T<sub>M1</sub></b> | Motor momentary maximum torque (N-m) | <b>d</b> | Motor shaft length (mm)            |  |
| <b>N<sub>M0</sub></b> | Motor rated speed (rpm)              | <b>e</b> | Motor shaft diameter (mm)          |  |
|                       |                                      | <b>g</b> | Motor shaft effective length (mm)  |  |

**Operation pattern (output shaft for the reduction gear)**



Please inform us of whether a key is attached or not, and when it is attached, also inform us of its dimensions.

**External load (output shaft for the reduction gear)**



|                      |  |  |
|----------------------|--|--|
| <b>t<sub>1</sub></b> | Acceleration time (s)                      |  |
| <b>t<sub>2</sub></b> | Constant speed operation time (s)          |  |
| <b>t<sub>3</sub></b> | Deceleration time (s)                      |  |
| <b>t<sub>4</sub></b> | One operation cycle time (s)               |  |
| <b>Q<sub>1</sub></b> | Number of operation cycles per day (times) |  |
| <b>Q<sub>2</sub></b> | Number of operating days per year (days)   |  |
| <b>N<sub>2</sub></b> | Constant speed (rpm)                       |  |
| <b>T<sub>1</sub></b> | Max. torque for startup (N-m)              |  |
| <b>T<sub>2</sub></b> | Constant torque (N-m)                      |  |
| <b>T<sub>3</sub></b> | Max. torque for stop (N-m)                 |  |

|                      |   |  |
|----------------------|---|--|
| <b>W<sub>1</sub></b> | Radial load (N)                                       |  |
| <b>L<sub>1</sub></b> | Distance to the point of radial load application (mm) |  |
| <b>W<sub>2</sub></b> | Axial load (N)  |  |
| <b>L<sub>2</sub></b> | Distance to the point of axial load application (mm)  |  |

### **Cautions for use of GH series**

- If the end user of the product is a military interest or if the product is to be used in the manufacture of weapons, the product may be subject to export regulations prescribed in the Foreign Trade Control Act. Confirm these conditions before exporting the product and take the necessary steps.
- If failure or malfunction of the product may directly endanger human life or if it is used in units which may injure the human body (atomic facilities, space equipment, medical equipment, safety units, etc.), examination of individual situations is required. Contact our agent or nearest business office in such a case.
- Although this product has been manufactured under strict quality control, if it is to be used in equipment that could cause serious injury or damage to facilities as a result of failure of the product, all appropriate safety measures must be taken.
- When this product is used in a special environment (clean room, food handling facility, etc.), please contact our agent or nearest business office.
- Disassembling the product and analyzing the inside is prohibited under reverse engineering and other related regulations.

### **Guarantee**

- Nabtesco Corporation guarantees that the GH SERIES are free from defects in materials and workmanship.
- The term of guarantee shall be one year after delivery or 2,000 hours of operation after the installation on an actual machine, whichever is earlier, on condition that the product is operated under the rated operation conditions specified by us, under normal assembly and lubrication conditions.
- If any defect in materials or workmanship is detected during the above guarantee term, the product will be repaired or replaced at our expense, provided that the number of man-hours required for demounting and remounting the product from the machine, transportation expenses for re-delivery, warehousing and other incidental expenses shall be excluded from our obligation.
- No compensation will be provided for the lost opportunities or any other type of loss due to a shutdown of operation that was caused by a defect in the product.
- If compensation under the guarantee is discharged monetarily, the upper limit of the amount shall not exceed the selling price of the product which is the subject of the claim.



# Nabtesco

## Nabtesco Corporation

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• *Specifications are subject to change without notice.*

