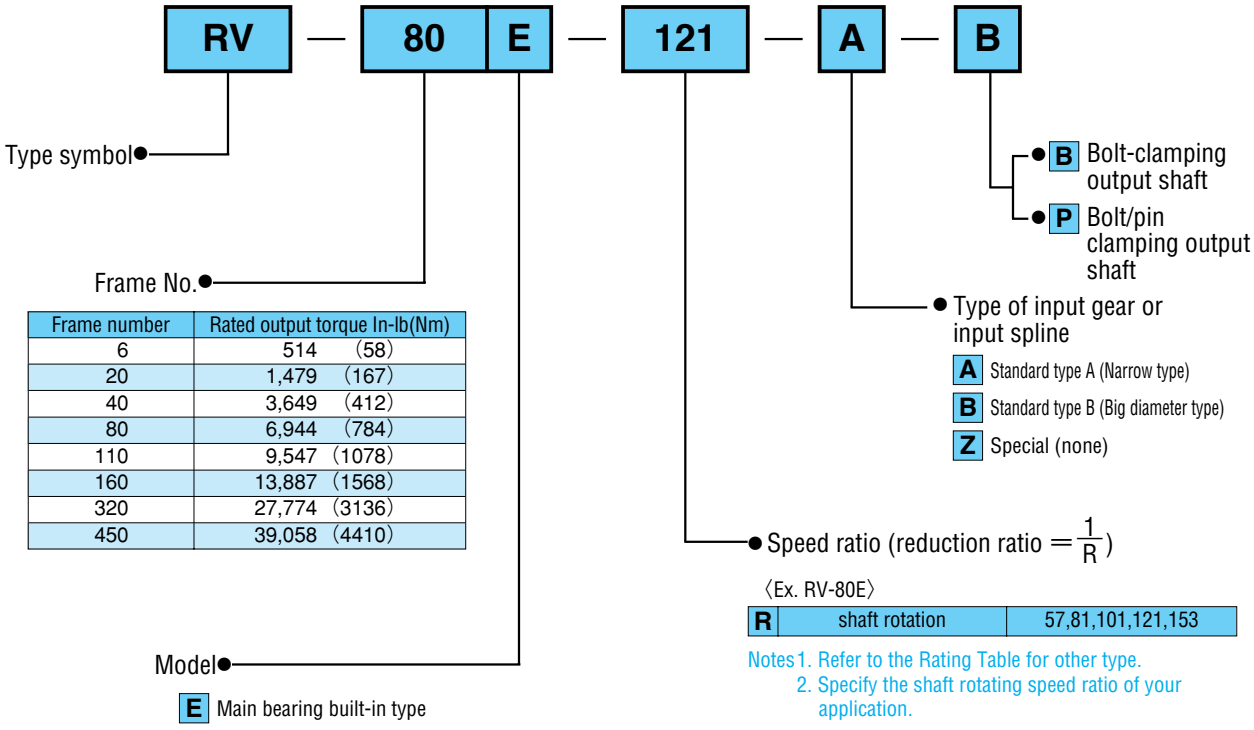
1 ORDERING INFORMATION

■RV-E series

●Product identification for ordering purpose.



Frame number	Rated output torque In-lb(Nm)
6	514 (58)
20	1,479 (167)
40	3,649 (412)
80	6,944 (784)
110	9,547 (1078)
160	13,887 (1568)
320	27,774 (3136)
450	39,058 (4410)

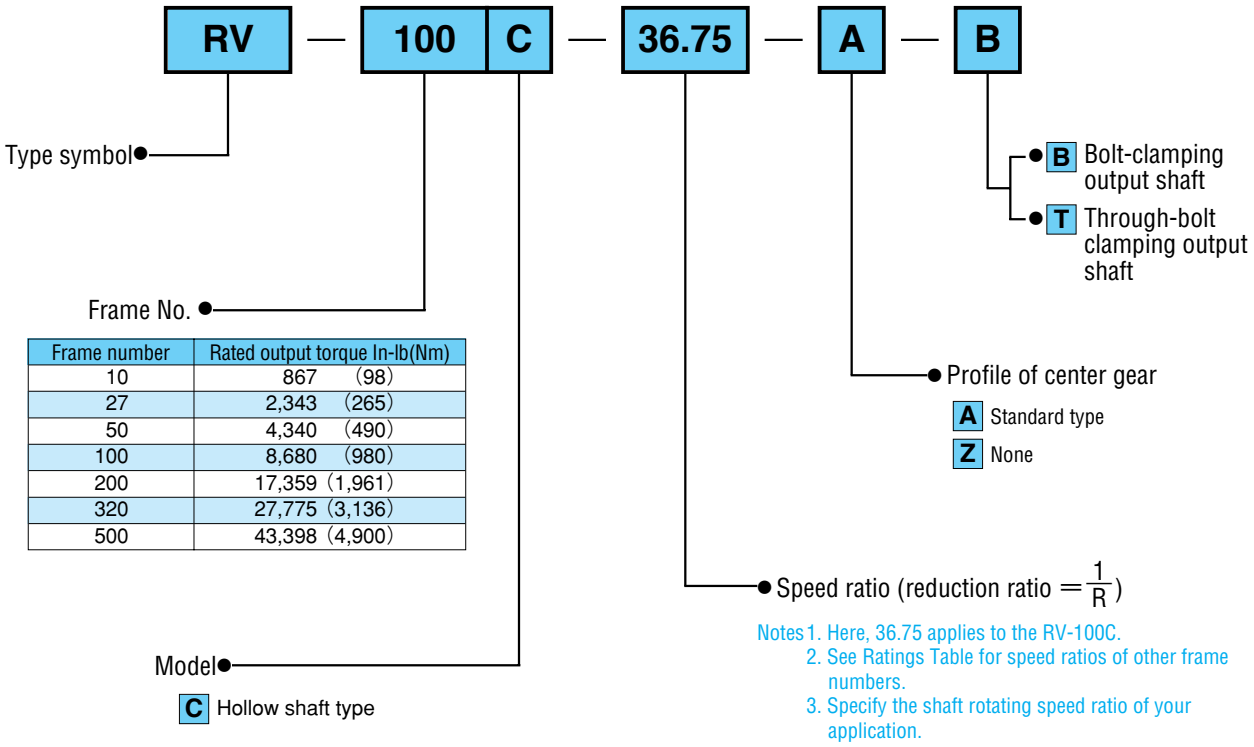
〈Ex. RV-80E〉

R	shaft rotation	57,81,101,121,153

Notes 1. Refer to the Rating Table for other type.
2. Specify the shaft rotating speed ratio of your application.

■RV-C series

●Product identification for ordering purpose.

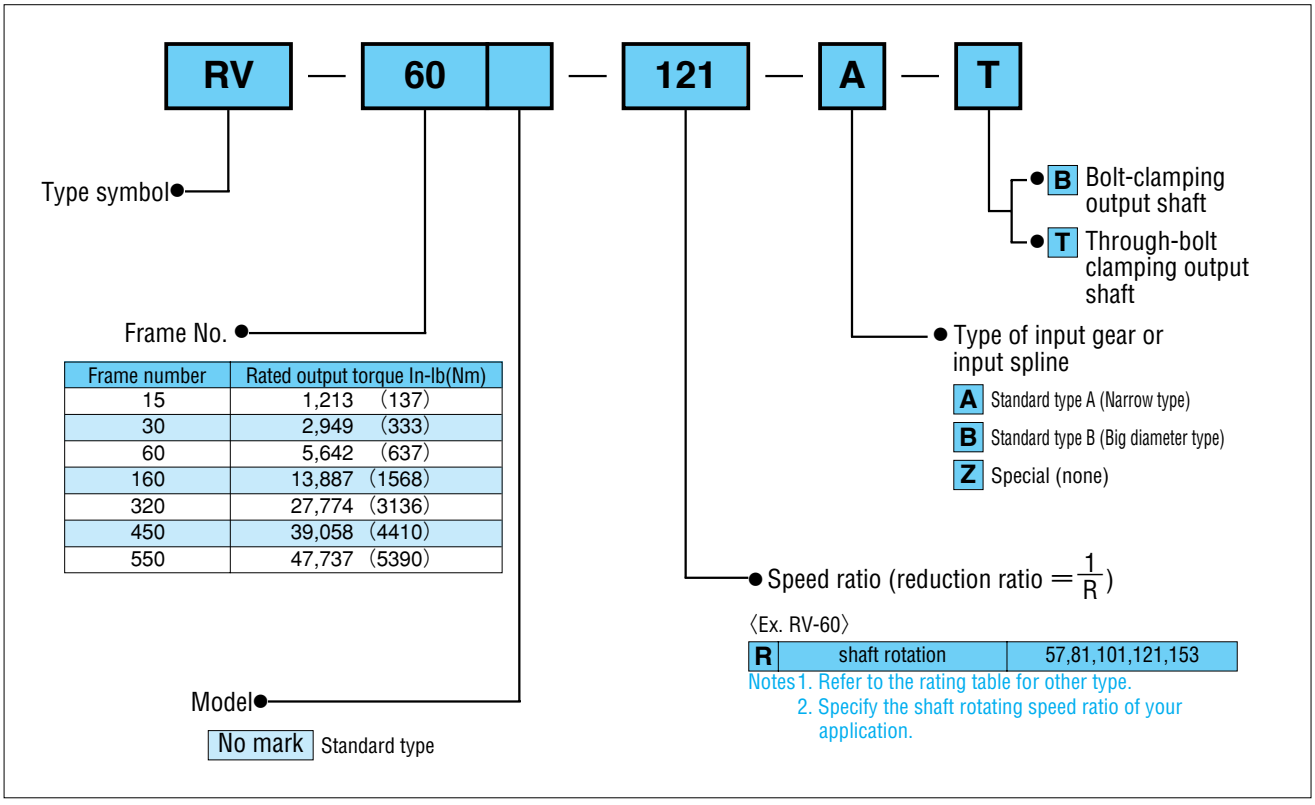


Frame number	Rated output torque In-lb(Nm)
10	867 (98)
27	2,343 (265)
50	4,340 (490)
100	8,680 (980)
200	17,359 (1,961)
320	27,775 (3,136)
500	43,398 (4,900)

Notes 1. Here, 36.75 applies to the RV-100C.
2. See Ratings Table for speed ratios of other frame numbers.
3. Specify the shaft rotating speed ratio of your application.

■RV series

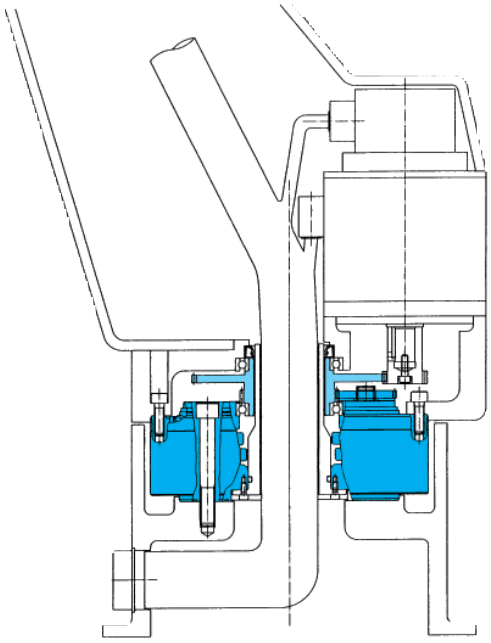
●Product identification for ordering purpose.



Frame number	Rated output torque In-lb(Nm)
15	1,213 (137)
30	2,949 (333)
60	5,642 (637)
160	13,887 (1568)
320	27,774 (3136)
450	39,058 (4410)
550	47,737 (5390)

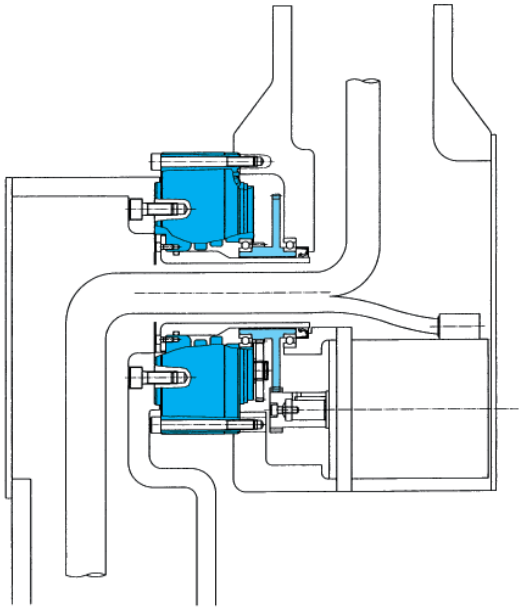
Robot Swing Axis
RV-C series

- Allows space-saving design
- Main bearing is not required on robot side.

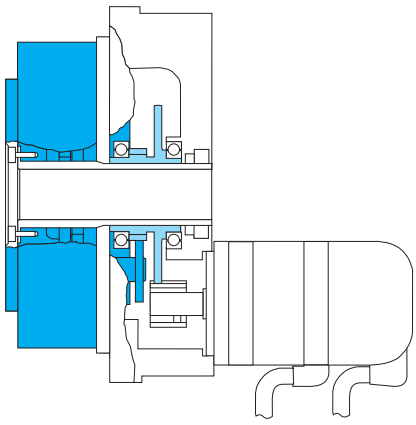


Robot arm
RV-C series

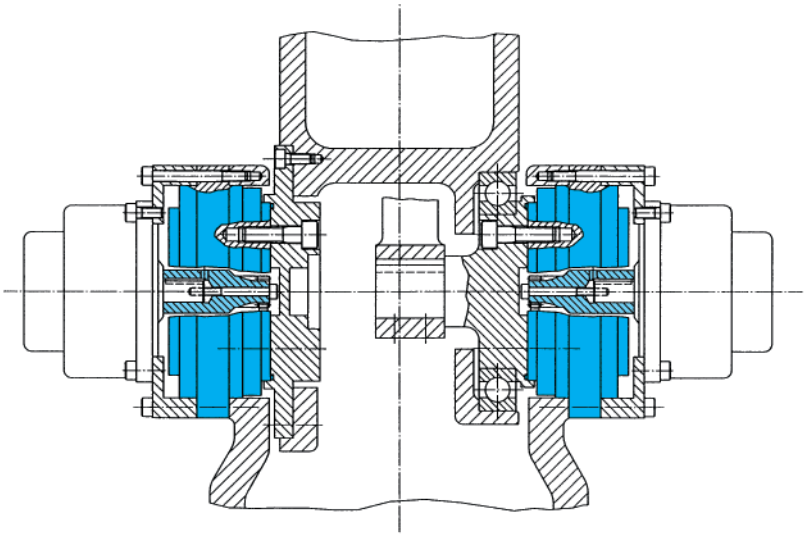
- Greater internal resistance to adverse enovironments-allows safe throughput of cables.
- Wider operating angle.



Indexing Table
RV-C series

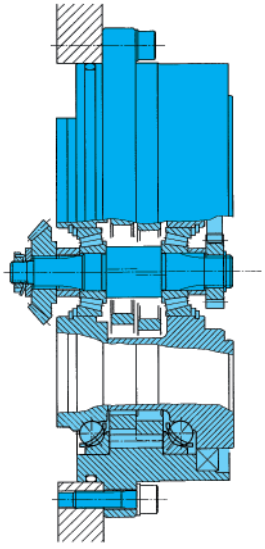


Robot arm
RV-E series

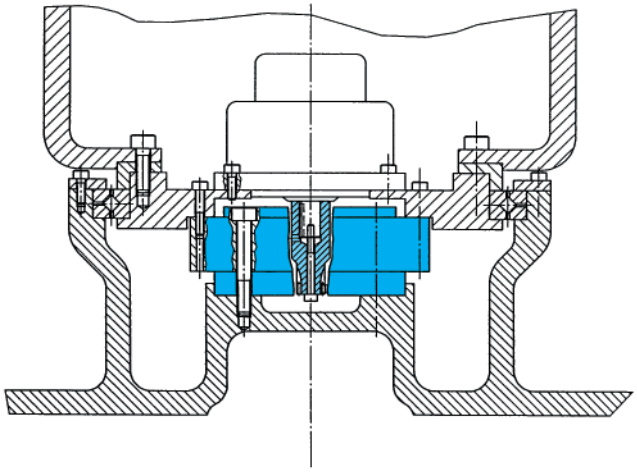


Robot Wrist Axis
RV-E series

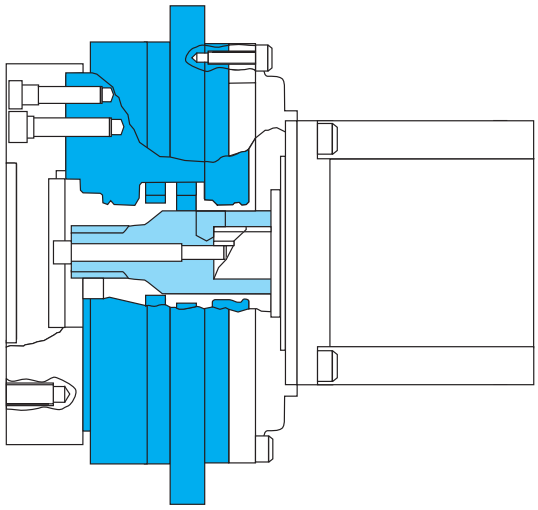
As shown in the figure(right), the input gear can also be supported within the reduction gear mechanism.
Please contact TS Corporation for more details.



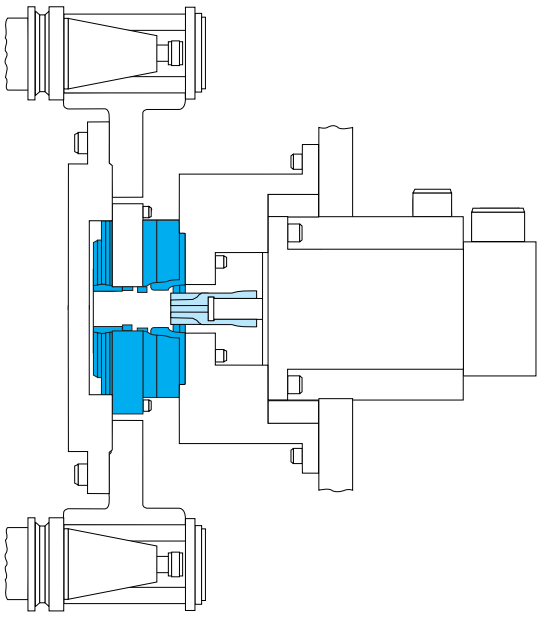
Robot Swing Axis
RV series



Positioner
RV-E series



ATC Magazine
RV-E series



RV-C

series

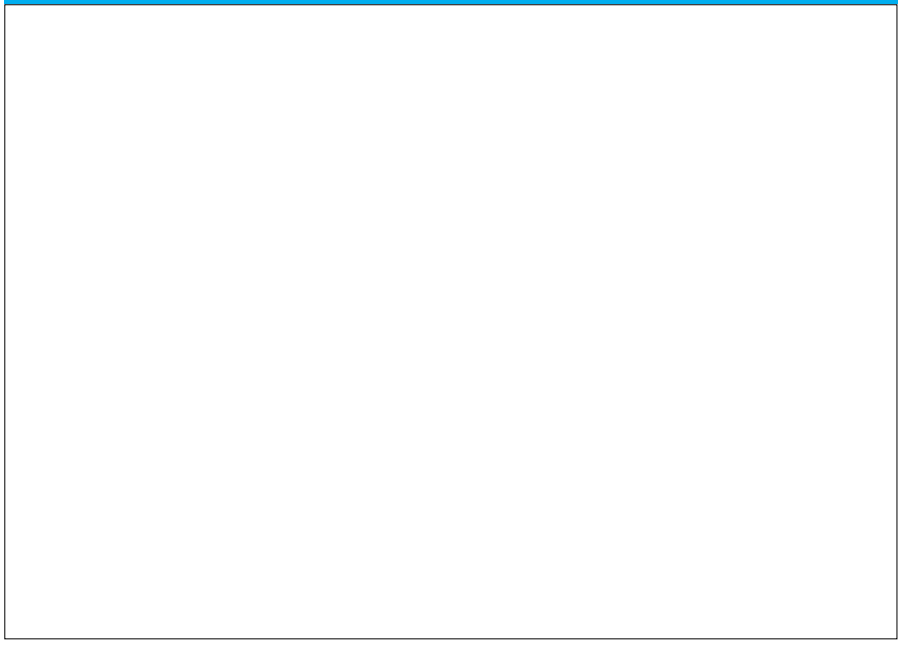
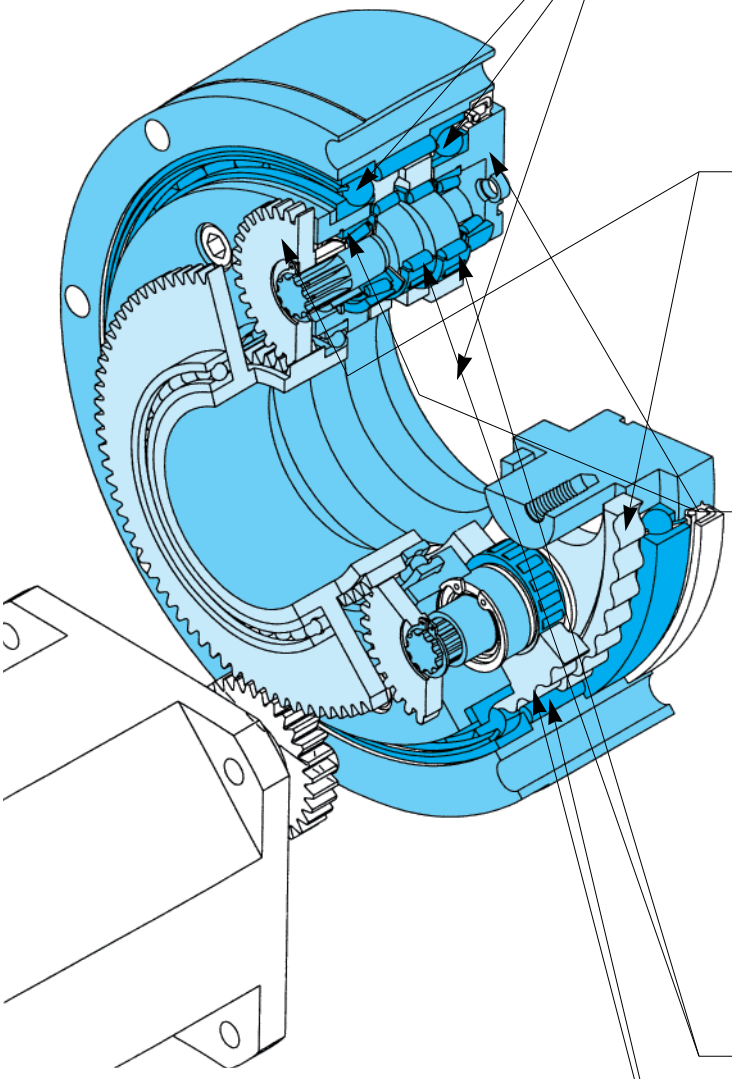


Fig.1



Hollow shaft structure

- Cables and other lines can pass through the reduction gear
- Allows space saving design

INTEGRATED ANGULAR BALL BEARINGS

Benefits:
- Increases reliabilty
- Reduces overall cost

Attributed to:
- Built-in angular ball bearing construction improves ability to support external loads, increases moment rigidity and maximum allowable moment.
- Reduces the number of components required.
- Simplifies installation and maintenance.

2 STAGE REDUCTION

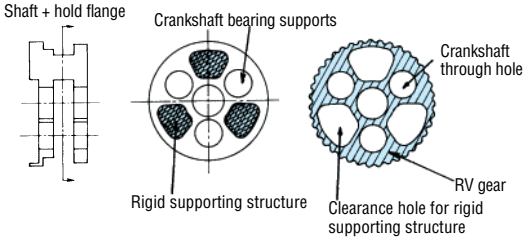
Benefits:
- Reduces vibration
- Reduces inertia (GD^2)

Attributed to:
- Low speed rotation of the RV gear reduces vibration.
- Reduced size of the motor coupling part (input gear) lowers intertia.

ALL MAIN ELEMENTS ARE SUPPORTED FROM BOTH SIDES

Benefits:
- Higher torsional stiffness
- Less vibration
- High shock load capability (5 times rated torque)

Detail:
- Crankshafts are supported on both sides of the reduction gear as shown below.



ROLLING CONTACT ELEMENTS

Benefits:
- Excellent starting efficiency
- Low wear and longer life
- Low backlash (Less than 1 arc. min.)

Attributed to:
- Use of roller bearings throughout.

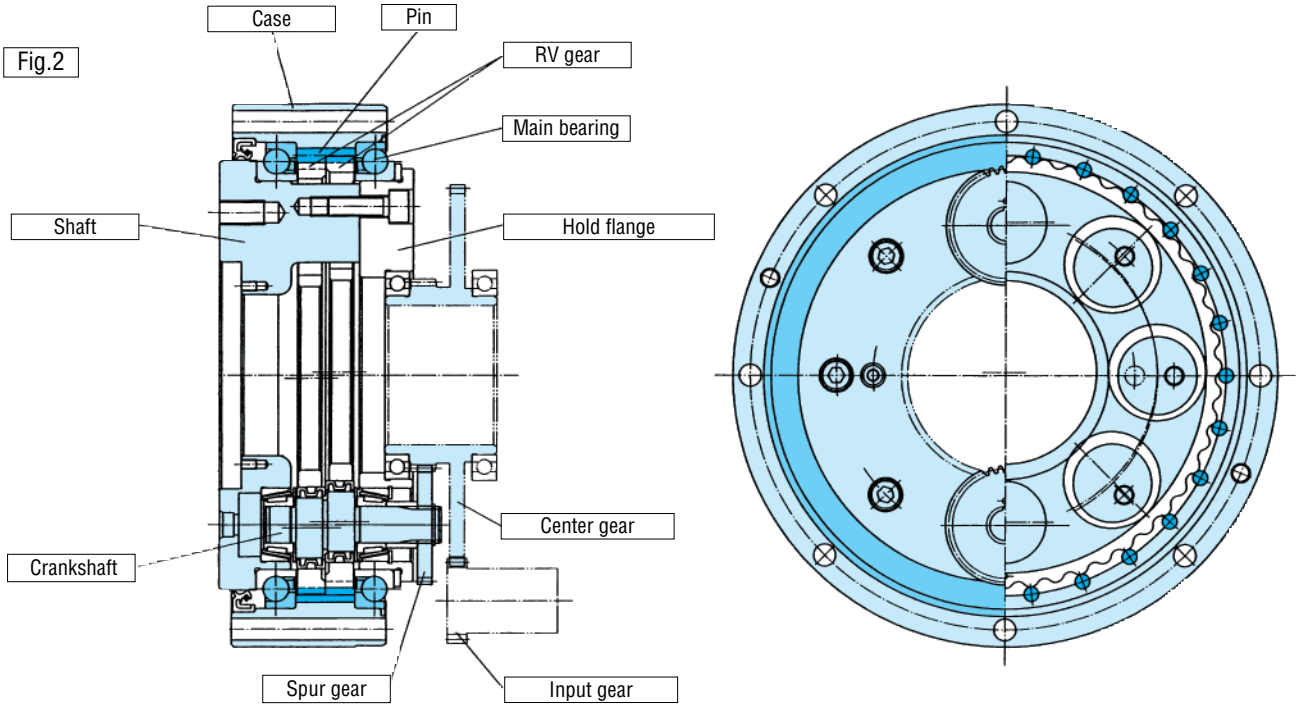
PIN & GEAR STRUCTURE

Benefits:
- Very low backlash (Less than 1 arc. min.)
- Higher shock load capability (5 times rated torque)

Attributed to:
- Synchromeshing of many precision ground gear teeth and pins.

■Construction

Fig.2



■Principle of speed reduction

The RV-C is a 2-stage reduction gear.

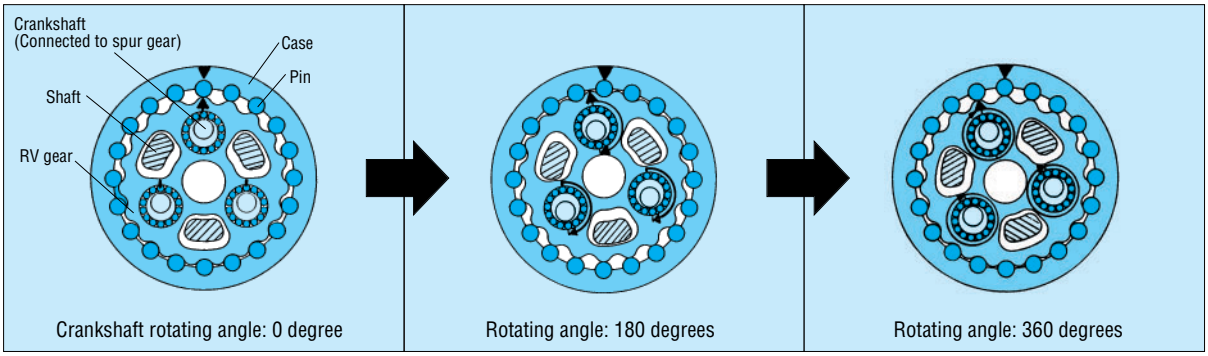
1st stage ···Spur gear reduction

- An input gear engages with and rotates a center gear which then engages and rotates spur gears that are coupled to crankshafts. Several overall gear ratios can be provided by selecting various first stage ratios.

2nd stage ···Epicyclic gear reduction

- Crankshafts driven by the spur gears cause an eccentric motion of two epicyclic gears called RV gears that are offset 180 degrees from one another to provide a balanced load.
- The eccentric motion of the RV gears causes engagement of the cycloidal shaped gear teeth with cylindrically shaped pins located around the inside edge of the case.
- In the course of one revolution of the crankshafts the teeth of the RV gear move the distance of one pin in the opposite direction of the rotating cranks. The motion of the RV gear is such that the teeth remain in close contact with the pins and many teeth share the load simultaneously.
- The output can be either the shaft or the case. If the case is fixed, the shaft is the output. If the shaft is fixed, the case is the output.

Fig.3

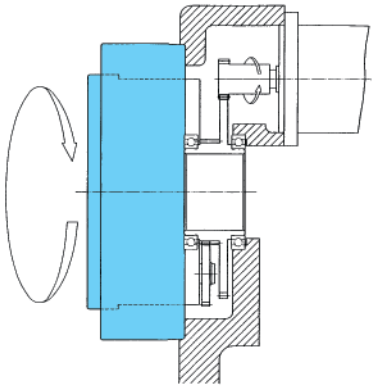


③ ROTARY DIRECTION and SPEED RATIO

The rotary direction and speed ratio of the RV-C reduction gear are shown below.

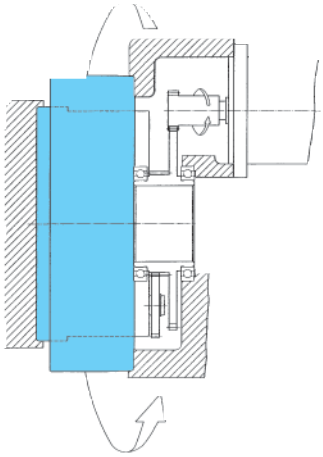
Fig.4

①Case is fixed, shaft output



$i = -\frac{1}{R}$

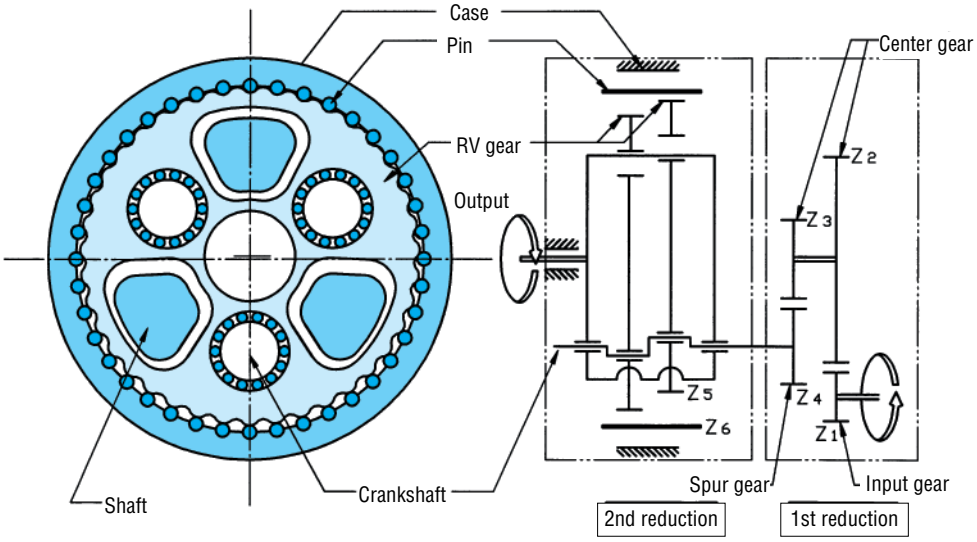
②Shaft fixed, case output



$i = \frac{1}{R}$

Mechanism block drawing

Fig.5



■Speed Ratio

The overall ratio can be determined from the following equation:

With the shaft as output; $R = R_1 \times \frac{Z_2}{Z_1}$

$$i = \frac{-1}{R}$$

$$(R_1 = 1 + \frac{Z_4}{Z_3} \cdot Z_6)$$

R : Overall speed ratio
R_1: Speed ratio of a discrete reduction gear
Z_1 : Number of teeth on input gear
Z_2 : Number of teeth on large center gear
Z_3 : Number of teeth on small center gear
Z_4 : Number of teeth on spur gear
Z_5 : Number of teeth on RV gear
Z_6 : Number of pins
i : Reduction ratio

4 RATING TABLE

Table 1

Output speed (r/min)		5		10		15		20		25		30		40		50	
Model	Speed ratio of a discrete reduction gear (R_1)	Output torque	Input capacity	Output torque	Input capacity	Output torque	Input capacity	Output torque	Input capacity	Output torque	Input capacity	Output torque	Input capacity	Output torque	Input capacity	Output torque	Input capacity
		In-lb (Nm)	kW	In-lb (Nm)	kW	In-lb (Nm)	kW	In-lb (Nm)	kW	In-lb (Nm)	kW	In-lb (Nm)	kW	In-lb (Nm)	kW	In-lb (Nm)	kW
RV-10C	27	1,204 (136)	0.09	983 (111)	0.16	868 (98)	0.21	797 (90)	0.25	744 (84)	0.29	709 (80)	0.34	647 (73)	0.41	602 (68)	0.47
RV-27C	36.57 (1,390/38)	3,259 (368)	0.26	2,648 (299)	0.42	2,347 (265)	0.55	2,152 (243)	0.68	2,010 (227)	0.79	1,904 (215)	0.90	1,745 (197)	1.10	1,630 (184)	1.29
RV-50C	32.54 (1,985/61)	6,031 (681)	0.48	4,907 (554)	0.77	4,340 (490)	1.03	3,985 (450)	1.26	3,720 (420)	1.47	3,525 (398)	1.67	3,242 (366)	2.04	3,020 (341)	2.38
RV-100C	36.75	12,063 (1362)	0.95	9,804 (1107)	1.55	8,679 (980)	2.05	7,962 (899)	2.51	7,448 (841)	2.94	7,050 (796)	3.33	6,465 (730)	4.08		
RV-200C	34.86 (1,499/43)	24,125 (2,724)	1.90	19,617 (2,215)	3.09	17,368 (1,961)	4.11	15,968 (1,803)	5.04	14,932 (1,686)	5.88	14,144 (1,597)	6.69				
RV-320C	35.61 (2,778/78)	38,624 (4,361)	3.04	31,335 (3,538)	4.94	27,774 (3,136)	6.57	25,516 (2,881)	8.05	23,824 (2,690)	9.41						
RV-500C	37.34	60,322 (6,811)	4.75	49,039 (5,537)	7.73	43,397 (4,900)	10.26	39,837 (4,498)	12.56								

Notes: 1. The overall speed ration is calculated with the formula in page 56.
2. Set maximum input shaft speed to a value equal to or lower than the value of maximum allowable output speed multiplied by the overall speed ratio for each type.
3. The input capacity (KW) in the above table is determined by the efficiency of these reduction gears.
4. The output torque (In-lb) is so determined that the service life may be maintained constant for any output revolutions. ($N \cdot T^{\frac{10}{3}} = \text{Constant}$)
5. The rated torque is a torque at an output speed of 15 r/min, which is used as a basis for service life calculations. (Refer to the rated service life, page 61.)

60		Moment rigidity Typical Value	Allowable moment	Momentary max. allowable moment (Shockload)	Allowable max. output speed (Continuous)	Allowable acceleration/ deceleration torque	Momentary max. allowable torque (E-stop)	Lost motion	Torsional rigidity (Stiffness) Typical Value	I(= $\frac{GD^2}{4}$) (Inertia of reduction gear unit	I(= $\frac{GD^2}{4}$) (Inertia of center gear	Weight
Output torque	Input capacity	In-lb/ arc.min. (Nm/arc.min.)	In-lb (Nm)	In-lb (Nm)	r/min	In-lb (Nm)	In-lb (Nm)	MAX. arc.min.	In-lb/ arc.min. (Nm/arc.min.)	kg-m²	kg-m²	lb (kg)
576 (65)	0.54	3,726 (421)	6,076 (686)	12,151 (1,372)	80	2,170 (245)	4,340 (490)	1	416 (47)	1.34×10^{-5}	0.678×10^{-3}	10.1 (4.6)
1,541 (174)	1.46	9,452 (1,068)	8,679 (980)	17,359 (1,960)	60	5,863 (662)	11,717 (1,323)	1	1,302 (147)	0.628×10^{-4}	0.563×10^{-3}	18.7 (8.5)
		17,346 (1,960)	15,623 (1,764)	31,246 (3,528)	50	10,849 (1,225)	Bolt joint 21,699 (2,450) / Through-bolt joint 17,359 (1,960)	1	2,258 (255)	1.82×10^{-4}	0.363×10^{-2}	33.1 (15)
		24,895 (2,813)	21,699 (2,450)	43,397 (4,900)	40	21,699 (2,450)	Bolt joint 43,397 (4,900) / Through-bolt joint 30,378 (3,430)	1	4,517 (510)	0.47×10^{-3}	0.953×10^{-2}	43.0 (19.5)
		86,730 (9,800)	78,115 (8,820)	156,230 (17,640)	30	43,397 (4,900)	Bolt joint 86,795 (9,800) / Through-bolt joint 65,096 (7,350)	1	8,679 (980)	0.995×10^{-3}	1.94×10^{-2}	125.7 (57)
		112,830 (12,740)	182,269 (20,580)	347,179 (39,200)	25	69,436 (7,840)	138,872 (15,680)	1	17,359 (1,960)	0.68×10^{-2}	0.405×10^{-1}	176.4 (80)
		216,990 (24,500)	303,781 (34,300)	694,358 (78,400)	20	108,493 (12,250)	216,987 (24,500)	1	30,378 (3,430)	0.98×10^{-2}		352.7 (160)

6. The $\frac{GD^2}{4}$ value is a value for a discrete reduction gear, and the $\frac{GD^2}{4}$ for center and input gears is not included. Therefore, refer to the following equation regarding the $\frac{GD^2}{4}$ converted to motor shaft.

$$\frac{\frac{GD^2}{4}\text{ of reduction gear unit} + \frac{GD^2}{4}\text{ of center gear}}{(\text{Number of teeth on large center gear} / \text{Number of teeth on input gear})^2} + \frac{GD^2}{4}\text{ of input gear}$$

7. If a higher speed than the above allowable maximum output speed is required, contact TS Corporation for further information.
8. The output revolution is for forward-reverse changeover applications and not applicable for continuous rotation in a single direction. Contact TS Corporation when using the reduction gear for continuous single-direction rotation.

5-1 Selection flow chart

Determine load characteristic

Check the load torque applied to the speed reduction gear. An example is shown at right.

●Calculate average load torque (Tm)
●Calculate average output speed (Nm)

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

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

Fig.6
Duty cycle diagram

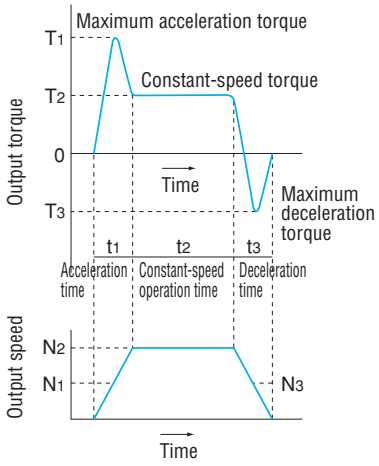


Table 2 Considerations for selection

		For starting (Max)	For constant speed	For stopping (Max)	For impact due to emergency stop
Load torque	In-lb	T_1	T_2	T_3	T_{em}
Speed	r/min	N_1	N_2	N_3	N_{em}
Time	sec	t_1	t_2	t_3	t_{em}

Output speed
From the rating table (page 57)
N_m
Output torque
T_m

Temporary selection of frame number

Increase the frame number or reduce the load.

Service life calculation (L_h)

$$L_h = K \times \frac{N_o}{N_m} \times \left(\frac{T_o}{T_m}\right)^{\frac{10}{3}}$$ (Refer to page 61)

NO ○ L_h=Specified value

Determine the input speed

$\frac{\text{Input speed}}{\text{Reduction gear ratio}} \leqq$ Maximum output speed

NO

Determine the acceleration/deceleration torque (T_1,T_3)

T_1 and $T_3 \leqq$ Allowable acceleration/deceleration torque

NO

Determine the external shock torque (T_{em}) due to emergency stop.

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

NO

Determine the number of allowable operation cycles (Cem)

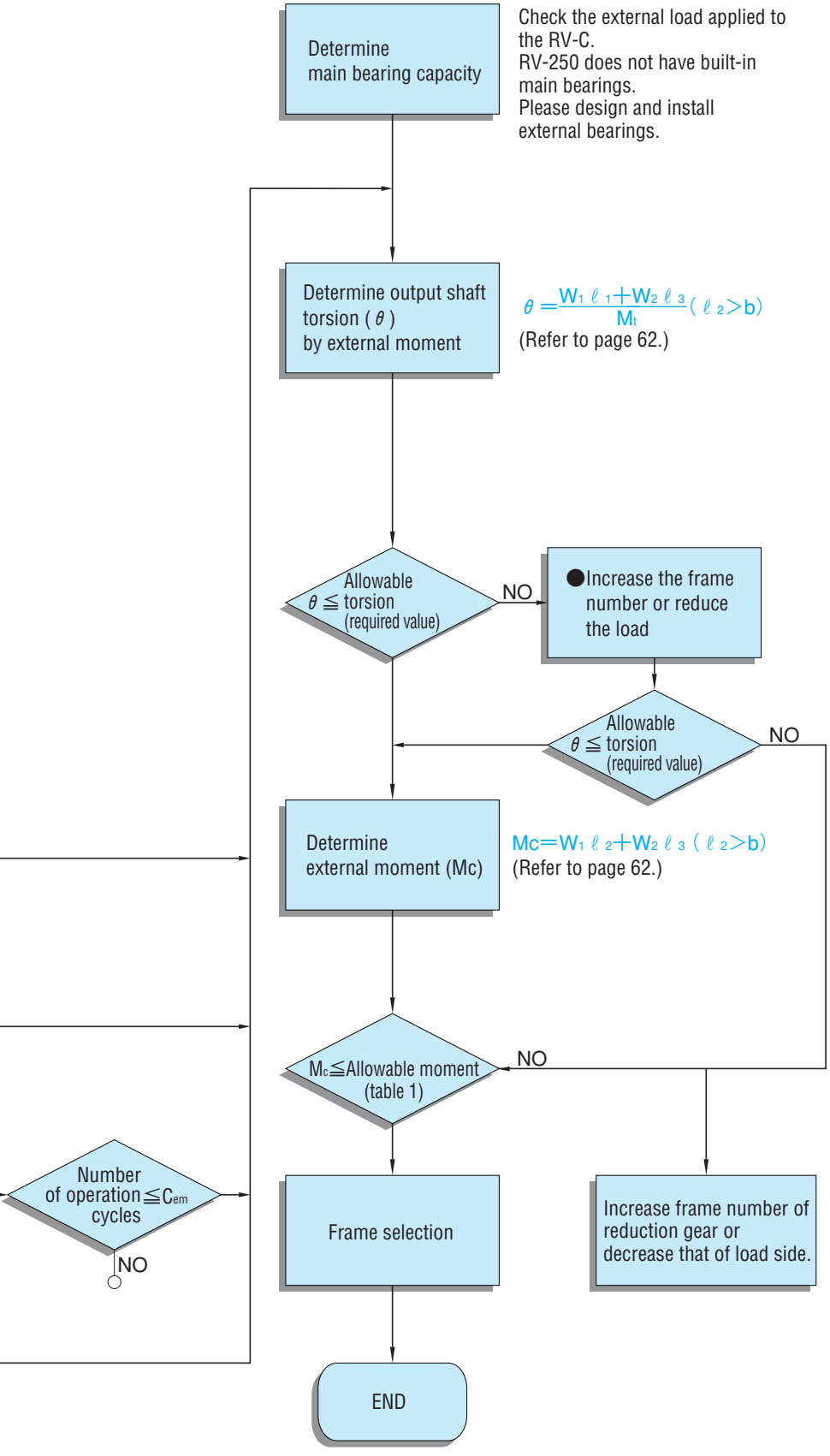
$$C_{em} = \frac{775 \times \left(\frac{5 \times T_o}{T_{em}}\right)^{\frac{10}{3}}}{40 \times \frac{N_{em}}{60} \times t_{em}}$$

Determine the external shock torque (Tout) when motor shaft speed is zero

Tout: Estimated value

Tout $\leqq$ Momentary maximum allowable torque

NO



Selection example

Selection conditions

T_1=5,310In-lb T_2=1,328In-lb
T_3=2,655In-lb T_{em}=15,045In-lb
t_1=0.2sec. t_2=0.5sec.
t_3=0.2sec. t_{em}=0.05sec.
N_1=N_3=10r/min N_2=20r/min
N_{em}=20r/min

Determine load characteristic

●Determine average load torque

$$T_m = \sqrt[\frac{10}{3}]{\frac{0.2\times10\times5{,}310^{\frac{10}{3}}+0.5\times20\times1{,}328^{\frac{10}{3}}+0.2\times10\times2{,}655^{\frac{10}{3}}}{0.2\times10+0.5\times20+0.2\times10}}$$

=3,088In-lb

●Determine average output speed

$$N_m=\frac{0.2\times10+0.5\times20+0.2\times10}{0.2+0.5+0.2}=15.6\text{r/min}$$

Provisional selection of RV-50C.

●Calculation to determine whether reduction gear service life meets required specification value.

$$L=6{,}000\times\frac{15}{15.6}\times\left(\frac{4{,}340}{3{,}088}\right)^{\frac{10}{3}}=17{,}940\text{Hr}$$

●Determine output speed

Maximum output speed 20r/min＜50r/min

Maximum allowable output speed of RV-50C

●Determine torque during starting and stopping

T_1=5,310In-lb＜10,849In-lb

Allowable acc./dec. torque for RV-50C

T_3=2,655In-lb＜10,849In-lb

Allowable acc./dec. torque for RV-50C

●Determine emergency stop and external shock torque

T_{em}=15,045In-lb＜21,699In-lb

Momentary max. allowable torque for RV-50C

$$C_{em}=\frac{775\times\left(\frac{5\times4{,}340}{15{,}045}\right)^{\frac{10}{3}}}{40\times\frac{20}{60}\times0.05}=3{,}941\text{ times}$$

Determine main bearing capacity

●External load condition

W_1=550lbs ℓ_1=19.7in.
W_2=220lbs ℓ_3=7.9in.

Determine moment rigidity

●Determine whether output shaft deflection angle meets required specification value.

$$\theta=\frac{550\times19.7+220\times7.9}{17{,}346}=0.72\text{(arc.min.)}$$

●Determine external moment

$$\ell_2=19.7+\frac{7.37}{2}=23.39\text{in.}$$

M_c=550×23.39+220×7.9
=14,603In-lb＜15,623In-lb

Allowable moment of RV-50C

Since all required specification are satisfied, select RV-50C.

RV-C series

5-2 Strength and service life

■5-2-1 Allowable torque during acceleration or deceleration

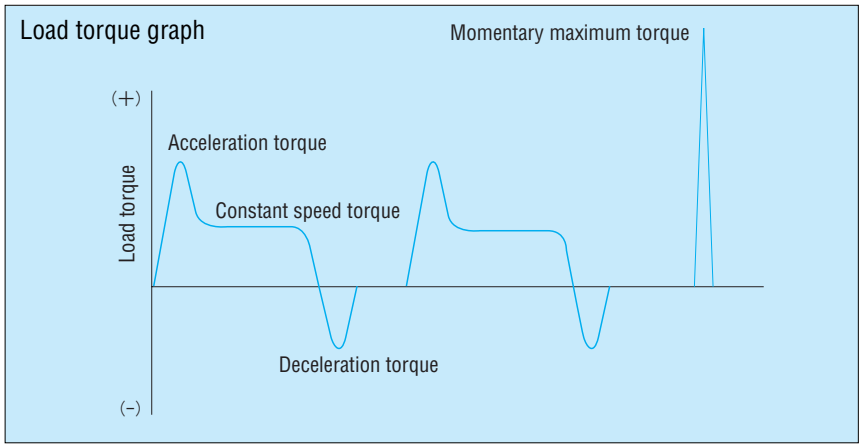
When the Machine starts (or stops), a larger torque than the steady-state torque is applied to the reduction gear because of the inertial loads. The values in the rating table (see page 57) show the allowable value of the peak torque when the reduction gear starts or stops.
The allowable acceleration/deceleration torque is 250% of the rated torque.

■5-2-2 Momentary maximum allowable torque

A large torque during an emergency stop or external shock may be applied to the reduction gear. The maximum allowable torque is shown in the ratings table(see page 57).
Momentary maximum allowable torque is 500% of the rated torque.

Note)When shock torque is applied, be sure to use at or below the limit cycle (refer to selection flowchart on page 59).

Fig.7



■5-2-3 Rated service life

The service life of the RV-C reduction gear is based on the life of the roller bearings of the crankshafts. The service life is set as shown in Table 3 for all models and ratios at rated torque and at rated output speed.

Table 3

L_h	Service life (Hrs)	
L_{10}	K	6,000

When in actual service installed in the equipment, calculate the service life using the following formula because the load condition depends on the types of reduction gear.

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

L_h : Service life to be obtained (Hr)
N_m : Average output speed (r/min) (calculation on page 59)
T_m : Average output torque (In-lb) (calculation on page 59)
N_o : Rated output speed (r/min) (table 4)
T_o : Rated output torque (In-lb) (table 4)

Table 4

Type	Rated torque In-lb(Nm)	Rated output speed (N_o)
RV-10C	868 (98)	15r/min
RV-27C	2,347 (265)	
RV-50C	4,340 (490)	
RV-100C	8,679 (980)	
RV-200C	17,368 (1,961)	
RV-320C	27,774 (3,136)	
RV-500C	43,397 (4,900)	

5-3 Capacity of main bearing

Angular contact ball bearings are incorporated in the RV-C Series reduction gears so that external loads may be supported. However, the RV-250C is not equipped with the built-in main bearings and users are requested to design external bearings.

■5-3-1 Moment rigidity

When an external load is applied to the output shaft, its deflection angle is proportional to the external moment (where $\ell_2 > b$).
The moment rigidity is expressed as an external moment value, which is required to deflect the output shaft 1 arc. min. (See Table 7.)

$$\theta = \frac{W_1 \ell_1 + W_2 \ell_3}{M_t}$$

θ : Deflected angle of output shaft (arc. min.)
M_t : Moment rigidity (In-lb/arc.min.) (table 5)
W_1、W_2 : Weight (lbs)
ℓ_1、ℓ_3 : Arm length (in.)
$\ell_1 = \ell + \frac{b}{2} - a$
ℓ : The distance between the output shaft mounting surface and the loading point (in.)

Fig.8 External loading diagram

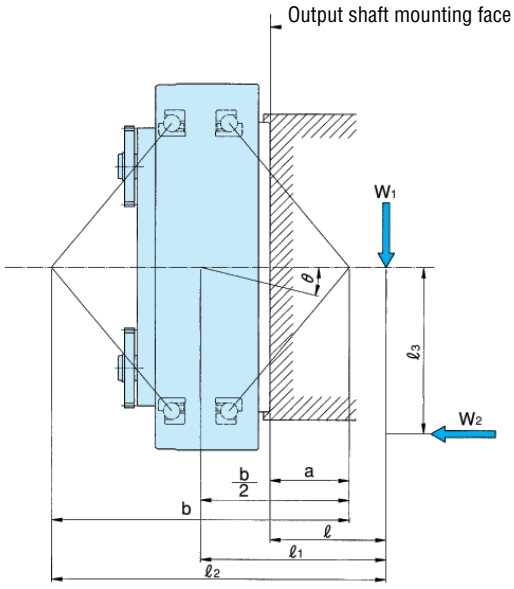


Table 5

Model	Moment rigidity (Mt) In-lb/arc.min. Typical Value	Size (in.) a	Size (in.) b
RV-10C	3,729	1.10	4.69
RV-27C	9,459	1.50	5.92
RV-50C	17,359	1.98	7.37
RV-100C	24,914	2.31	8.17
RV-200C	86,795	2.99	11.04
RV-320C	112,833	4.5	14.19
RV-500C	216,987	4.92	16.28

■5-3-2 Allowable moment

Table 6 shows the external moment values(moments during starting and stopping, etc.) that can be supported by the RV-C Series.
Refer to figure 9 indicating the range of allowable moment for simultaneous application of external moment and external thrust.

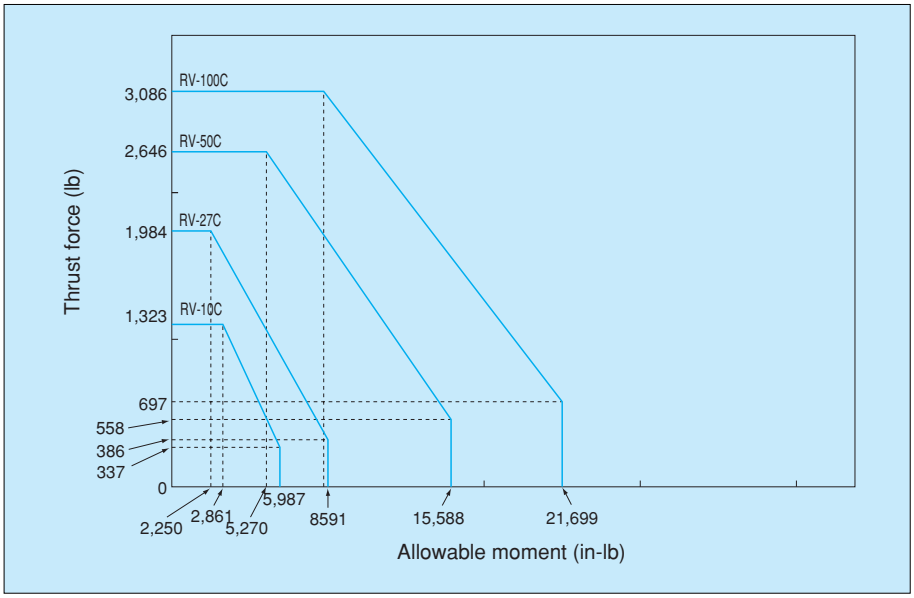
$M_C \leqq$ Allowable moment value
$M_C = W_1 \ell_2 + W_2 \ell_3 \quad (\ell_2 > b)$

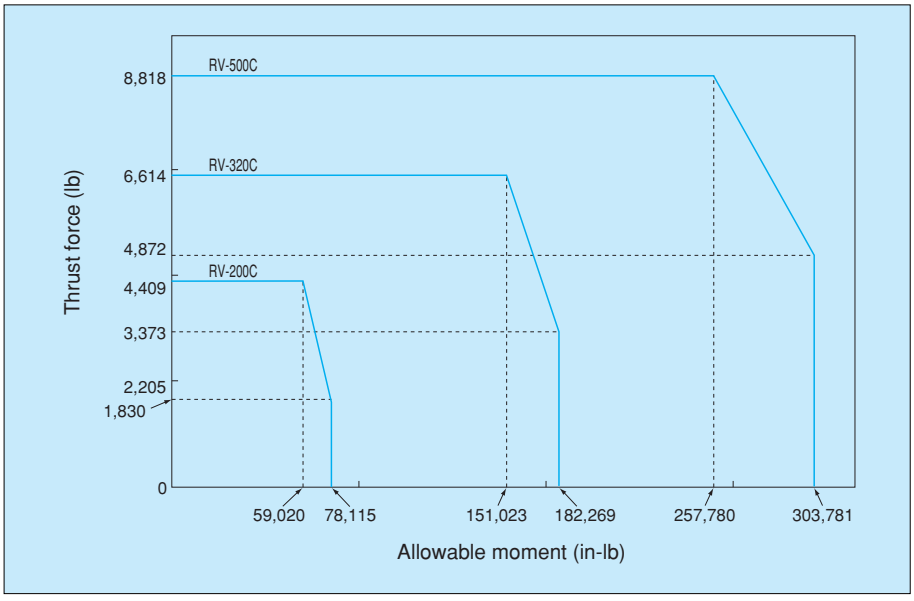
M_C : External moment (In-lb)
W_1、W_2 : Load (lb)
ℓ_2、ℓ_3 : Distance to load point(in.)
$\ell_2 = \ell + b - a$
ℓ : Distance from output shaft mounting face to load point (in.)

Table 6

Model	Allowable moment In-lb(Nm)	Allowable thrust lbs(N)
RV-10C	6,076 (686)	1,323 (5,880)
RV-27C	8,679 (980)	1,984 (8,820)
RV-50C	15,623 (1,764)	2,646 (11,760)
RV-100C	21,699 (2,450)	3,086 (13,720)
RV-200C	78,115 (8,820)	4,409 (19,600)
RV-320C	182,269 (20,580)	6,614 (29,400)
RV-500C	303,781 (34,300)	8,818 (39,200)

Fig.9 Allowable moment diagram





■5-3-3 Momentary maximum allowable moment

A large torque and moment due to emergency stop or external impact may be applied to the reduction gear.

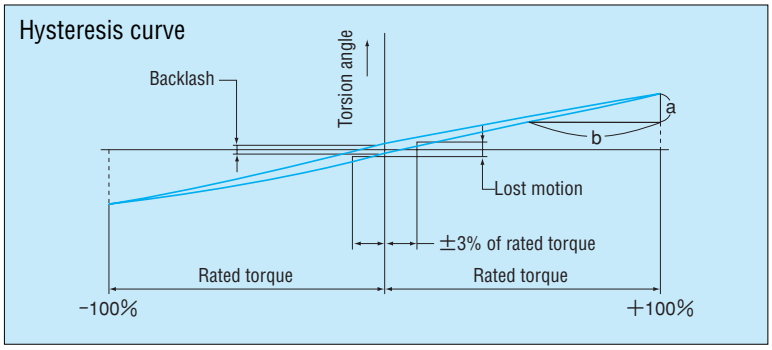
The rating table (page 57) shows the momentary maximum allowable moment values.

The momentary maximum allowable moment is twice the allowable moment.

6-1 Rigidity (Torsional rigidity and lost motion) and backlash

When a torque is applied to the output shaft while the input shaft (center gear) is fixed, torsion is generated according to the torque value and a hysteresis curve result is shown in Fig. 10.

Fig.10



The rigidity of the reduction gear is expressed by the torsional rigidity and the lost motion in this curve. RV reduction gears are especially superior in their stiffness characteristics.

●Torsional rigidity $= \frac{b}{a}$

●Lost motion
The torsion angle at the mid point of the hysteresis curve width at ±3% of rated torque.

●Backlash
The torsion angles when the torque indicated by the hysteresis curve is zero.

■6-1-1 Calculation of torsion (an example)

Take an example of the RV-100C and find a torsion where a torque is applied in one direction.

1) If a torque of 88.5 In-lb is applied, the resulting torsion ST_1, is found as shown below.
●Note that the torque is in the lost motion range.
$ST_1 = \frac{88.6}{260.4} \times \frac{1(\text{arc.min.})}{2} = 0.17\text{arc.min.}$

2) If a torque of 5,314 In-lb is applied, the resulting torsion ST_2 is found as shown below.
●Note that the torque is in the rated torque range.
$ST_2 = \frac{1}{2} + \frac{5{,}314 - 260.4}{4{,}517} = 1.62\text{arc.min.}$

Note: The above torsion value is that of the reduction gear assembly.

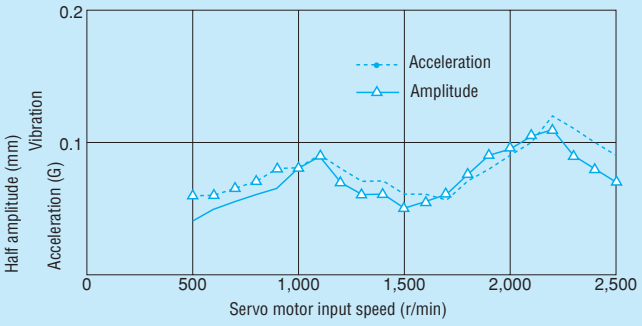
Table 7

Model	Torsional rigidity In-lb/arc.min.	Lost motion		Backlash arc.min.
		Lost motion arc.min.	Measured torque in-lb	
RV-10C	416	MAX1	± 26.0	MAX1
RV-27C	1,302		± 70.3	
RV-50C	2,258		± 130.2	
RV-100C	4,517		± 260.4	
RV-200C	8,679		± 520.8	
RV-320C	17,359		± 833.4	
RV-500C	30,378		± 1301.9	

6-2 Vibration

The vibration is a torsional vibration in the circumferential direction when driven by a servomotor with an inertia load applied.
The vibration is one of the most important characteristics, especially when precise contouring control is required. For example, the industrial robot requires exact and smooth contour control for its longer arm. An actual measured example of the vibration characteristics is shown in Fig. 11.

Fig.11



Test conditions
1. Model: RV-100C
2. Reduction ratio: 1/161
3. Assembly accuracy:
   Recommended accuracy (page 69)
4. Load: Moment of inertia 107.8Nm・sec^2
5. Measured radius: 550 mm

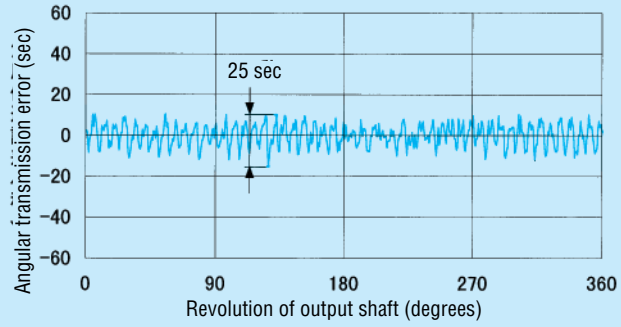
6-3 Angular transmission accuracy

Angular transmission accuracy refers to a difference between the theoretical output revolution angle and the actual revolution angle (θ out) when any revolution angle (θ in) is the input, and is expressed as an angular transmission error (θ er). The angular transmission error is found in the following equation.

$$\theta \text{ er} = \frac{\theta \text{ in}}{R} - \theta \text{ out (where R = reduction ratio)}$$

The measured example is shown below.

Fig.12



Test conditions
1. Model: RV-100C
2. Assembly accuracy:
   Recommended accuracy (see page 69)
3. Load conditions: no-load
4. Detector: USR324 + UC101
   (manufactured by Nippon Kogaku K.K.)
   Resolution: 1 sec

6-4 No-load running torque

The no-load running torque means a torque required on the input shaft (center gear) side in order to rotate the RV-C reduction gear under no load. Fig. 13 shows the no-load running torque on the output shaft side, which is converted from the no-load running torque according to the following equation.

●No-load running torque converted to motor shaft (In-lb)

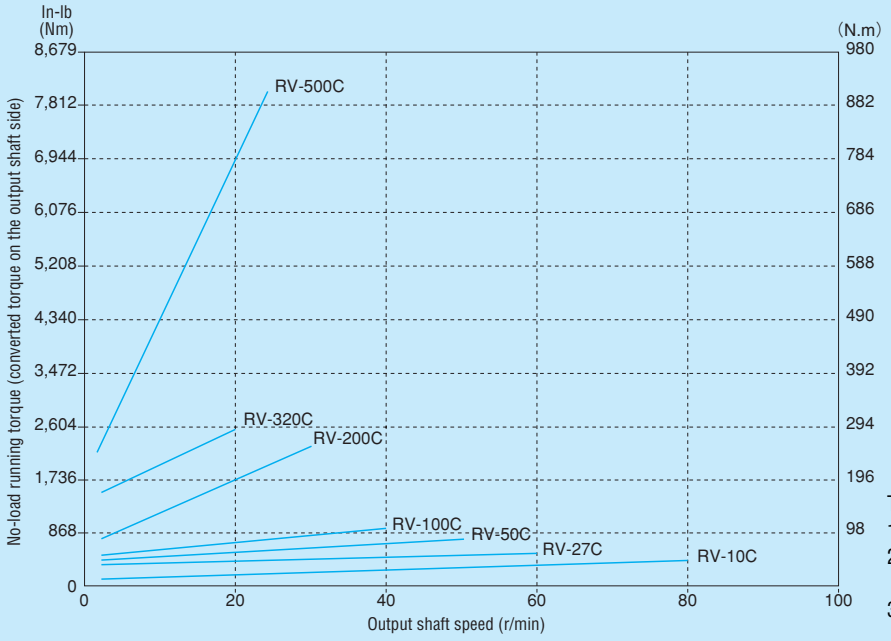
$$T_M = T_L \times \frac{Z_1}{Z_2} + \text{frictional resistance of center gear}$$

Z_1 : Number of teeth on input gear
Z_2 : Number of teeth on large center gear

$$T_L = \frac{\text{Converted torque on the output shaft side (In-lb)}}{R} \quad \text{(where R=speed ratio of RV reduction gear)}$$

Note: The diagram below shows average values obtained after a RV-C reduction gear has been run in. The agitation resistance of center gear is not included in the values.

Fig.13



Test conditions
1. Ambient temperature: 30℃
2. Assembly accuracy: recommended accuracy (see page 69)
3. Lubricant: grease (Molywhite RE00)

6-5 Backdriving torque

The backdriving torque refers to a torque required for starting the output shaft, with the RV-C reduction gear left under no-load. If the input shaft (input gear) is released while a torque equal to or more than the backdriving torque is kept applied to the output shaft, the input shaft (center gear) starts running at an augmented speed. Special care should be given to the backdriving torque to start the RV-C reduction gear.

Table 8

Model	Backdriving torque In-lb(Nm)
RV-10C	89 (10)
RV-27C	461 (52)
RV-50C	841 (95)
RV-100C	1,063 (120)
RV-200C	1,328 (150)
RV-320C	1,948 (220)
RV-500C	2,657 (300)

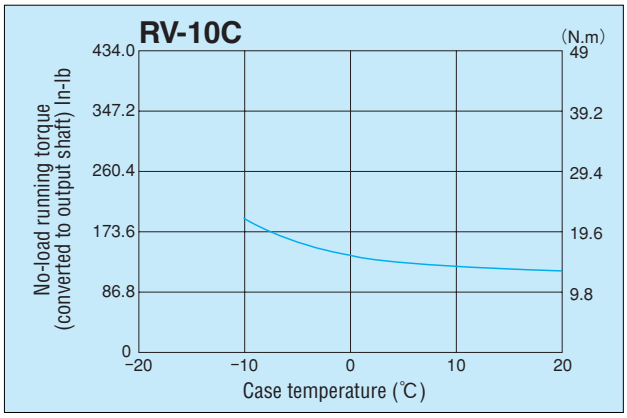
Test conditions
Assembly accuracy: recommended accuracy (see page 69)
Lubricant: grease (Molywhite RE00)

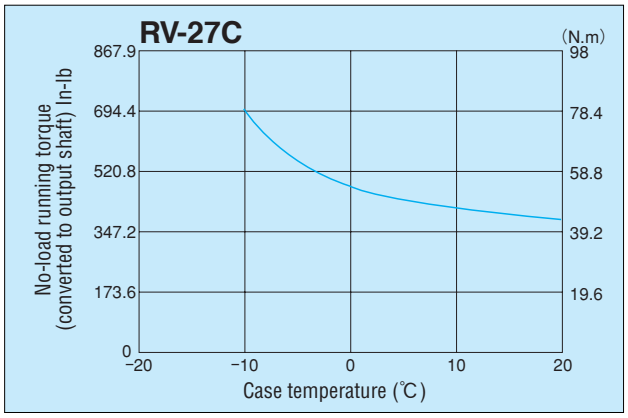
6-6 Low-temperature Characteristics (No-load running torque under low temperature)

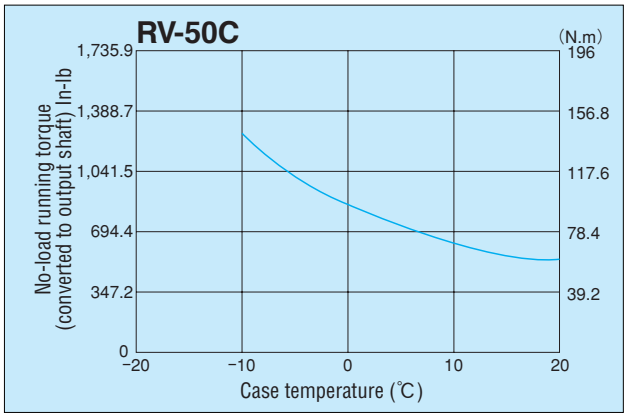
Test conditions
1. Assembly accuracy: recommended accuracy (page 69)
2. Lubricant: grease (Molywhite RE00)
3. Input speed: 15 r/min
4. Loss at center gear is not included.

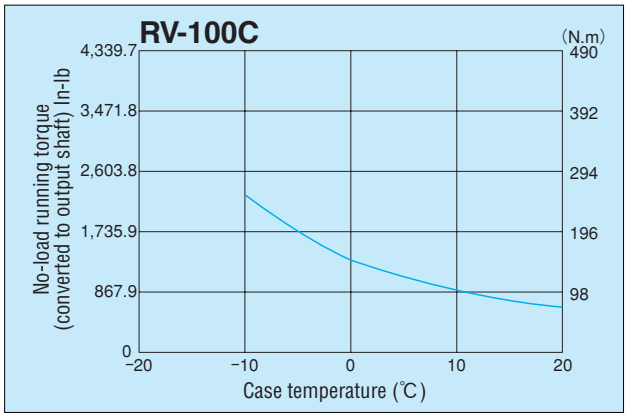
When the RV-C reduction gear is used under a low temperature, viscosity of lubricant increases and causes a larger no-load running torque.
The no-load running torque under low temperature is shown below.

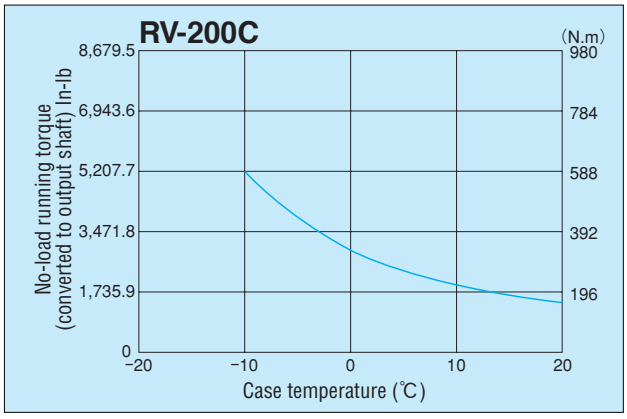
Fig.14

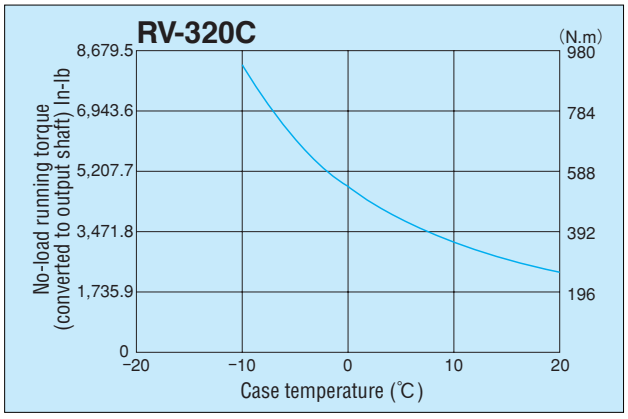










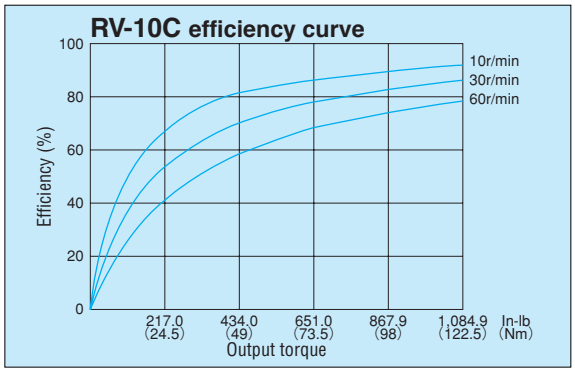


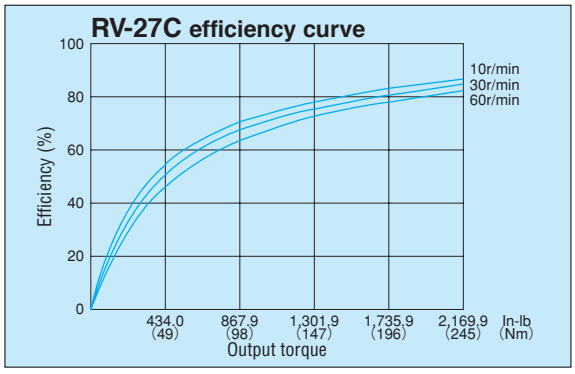
※Please inform TS Corporation if you have a plan to use the RV-500C in cold temperature environment.

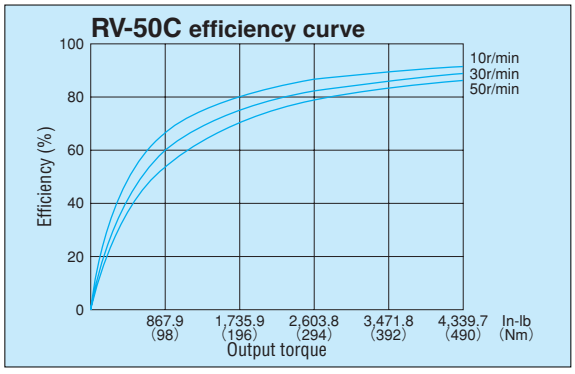
6-7 Efficiency charts

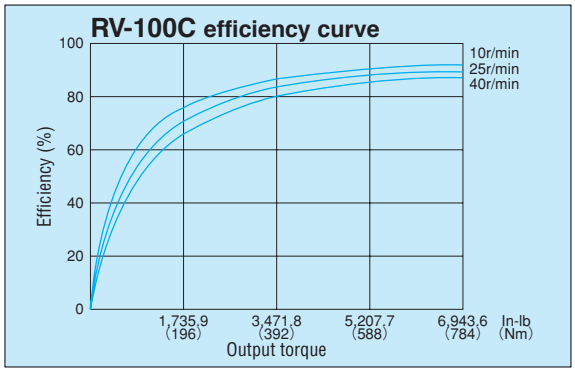
Test conditions
1. Case temperature: 30℃
2. Assembly accuracy: recommended accuracy (page 69)
3. Lubricant: grease (Molywhite RE00)
4. Loss at center gear is not included.

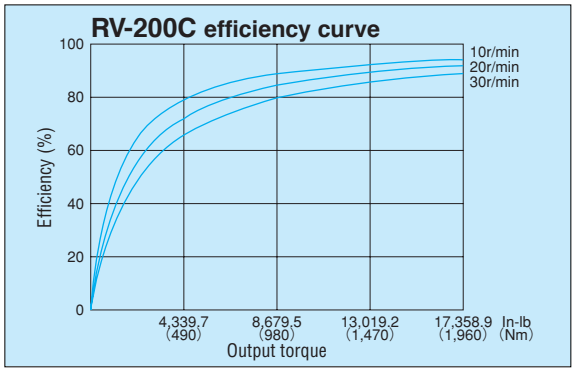
Fig.15

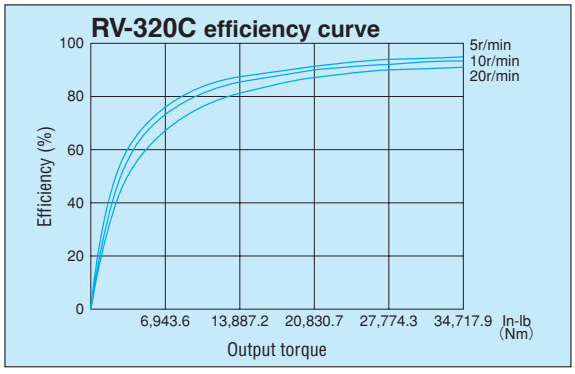


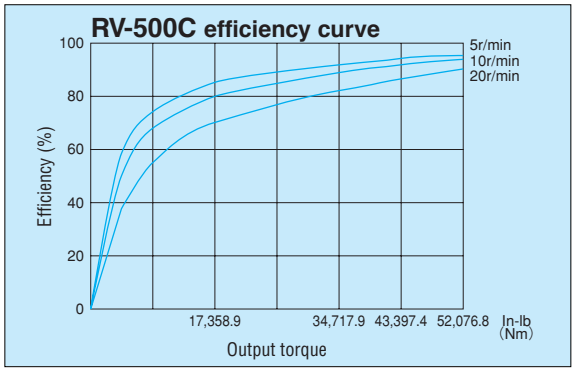












7 INSTALLATION AND ASSEMBLY

To get maximum performance from RV-C reduction gears, it is important to pay attention to the assembly accuracy, installation, lubrication and sealing. Angular ball bearings are used as the main bearings with RV-C Series reduction gears. When designing the layout, make sure the bearing retainer will not touch the motor mounting flange. Refer to the outline drawings on the pages after page 78.

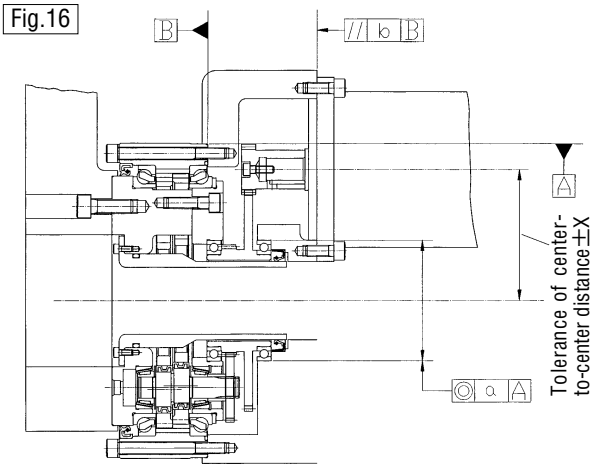
Note: Two types of RV-C are available: bolt clamping output shaft type (refer to pages 77 to 83 for outline drawings, and through bolt clamping output shaft type (refer to pages 84 to 89 for outline drawings excluding RV-500C). Please be sure to specify when ordering.

7-1 Assembly accuracy

Design the assembly side of the RV-C reduction gear within tolerances shown in Table 9. Poor assembly accuracy causes vibration and particularly noise or backlash.

■7-1-1 Assembly accuracy

Fig.16



R indicates distance from center of reduction gear to center of motor.

Table 9

(Unit:mm)

Model	Tolerance of center-to-center distance X	Concentricity tolerance a	Tolerance of parallelism b
RV-10C	±0.03	MAX0.03	MAX0.03
RV-27C			
RV-50C			
RV-100C			
RV-200C			
RV-320C			
RV-500C			

7-2 Installation procedure

●The typical installation examples for RV-C reduction gears are shown below. Be sure to seal the designated type of grease to the designated level. (See page 75)
Slow speed tube and the output surface of the RV-C reduction gear need to be sealed.
●Be sure that seals are used between mating parts on the input side. Refer to the O-ring seal installation illustrated.
●If the use of an O-ring seal is impossible because of the design, use Gasket sealant. See table 10 at right.

Table 10 Recommended Gasket sealant

Manufacturer	Name
Loctite	5699 Grey High Performance RTV Silicone Gasket Maker
Permatex	Moto Seal 2 Ultimate Gasket Maker White

Notes 1. Do not use for copper material or copper alloy material.
2. If it is used under special conditions such as concentrated alkali, pressurized steam, etc., please contact TS Corporation.

■7-2-1 Assembly example of center tube

The center tube is used to protect the cable which runs through the hollow section and to seal grease filled in the reduction gear. The assembly example of center tube is shown in Fig.18 for reference.

Fig.18

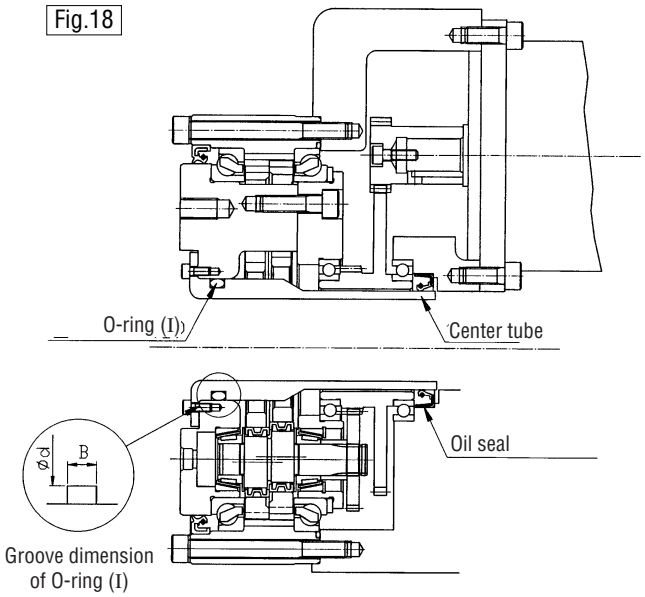


Table 11 Dimensions of O-ring (I) seal (for reference)

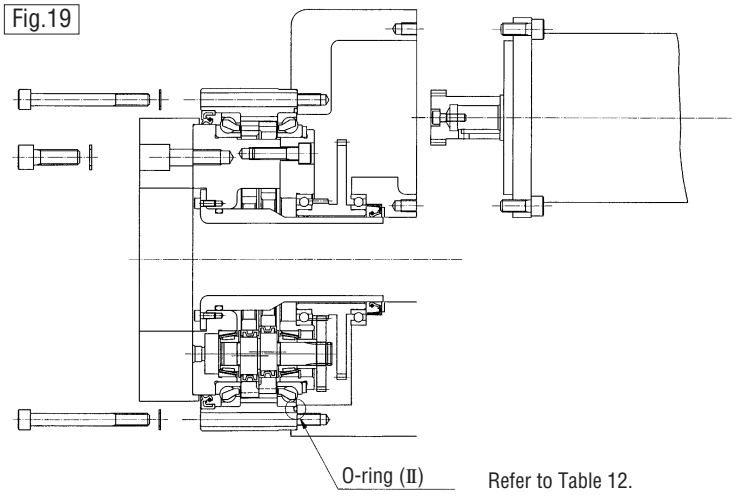
(Unit:mm)

			RV-10C	RV-27C	RV-50C	RV-100C	RV-200C	RV-320C	RV-500C
Dimensions	O-ring	ID number	CO 0625	CO 0634	CO 0643	CO 0546A	G95 (Metric)	G135 (Metric)	G145 (Metric)
		Wire dia.	ϕ 2.4 $\pm$0.07	←	ϕ 3.5 $\pm$0.1	ϕ 2.0 $\pm$0.1	ϕ 3.1 $\pm$0.1	←	←
		I. D.	ϕ 29.7	ϕ 42.2	ϕ 59.6	ϕ 69.5	ϕ 94.4	ϕ 134.4	ϕ 144.4
	Groove size	I. D.: d	ϕ 30.2 $^{0}_{-0.08}$	ϕ 43.2 $^{0}_{-0.08}$	ϕ 60.3 $^{0}_{-0.10}$	ϕ 70.0 $^{0}_{-0.05}$	ϕ 95.0 $^{0}_{-0.10}$	ϕ 135.0 $^{0}_{-0.08}$	ϕ 145.0 $^{0}_{-0.10}$
		Width: B	3.2 $^{+0.25}_{0}$	←	4.7 $^{+0.25}_{0}$	2.7 $^{+0.25}_{0}$	4.1 $^{+0.25}_{0}$	←	←

■7-2-2 Assembly example with the output shaft bolt clamping type

If center tube, oil seal and O-ring (I) are used together, the seal on the mounting surface of output shaft side is not required.

Fig.19



Refer to Table 12.

Table 12 O-ring (II)

	Applicable O-ring seal
RV-10C	AS568-048
RV-27C	AS568-163
RV-50C	AS568-169
RV-100C	AS568-173
RV-200C	AS568-277
RV-320C	AS568-281
RV-500C	G460 (Metric)

The O-ring (II) can be applied to both bolt clamping and through-bolt clamping output shaft types.

■7-2-3 Assembly example of through-bolt clamping output shaft type (RV-27C, 50C, 100C and 200C)

The O-ring groove is provided at the end face of output shaft of the reduction gear.
Use O-rings as shown below.

Fig.20

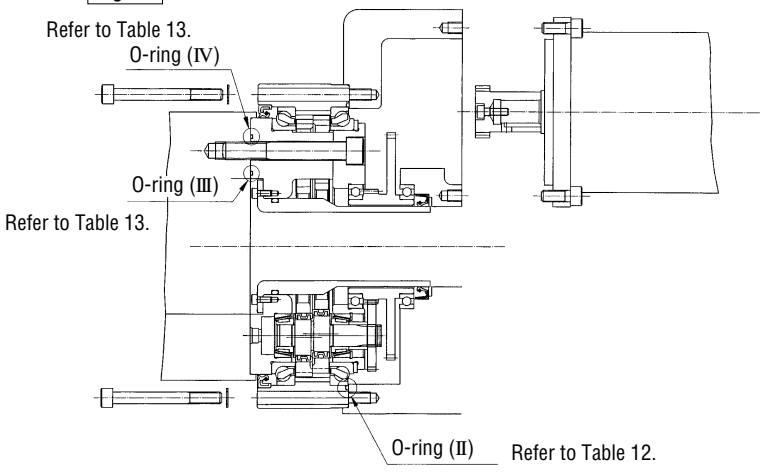


Table 13

	Applicable O-ring (Ⅲ)	Applicable O-ring (Ⅳ)
RV-27C	S75 (Metric)	S120 (Metric)
RV-50C	S100 (Metric)	S150 (Metric)
RV-100C	G115 (Metric)	AS568-165
RV-200C	S150 (Metric)	AS568-271

■7-2-4 Assembly example of through-bolt clamping output shaft type (RV-10C and 320C)

Provide the O-ring groove on the counterpart component. Dimensions of O-rings are shown below for reference.

Fig.21

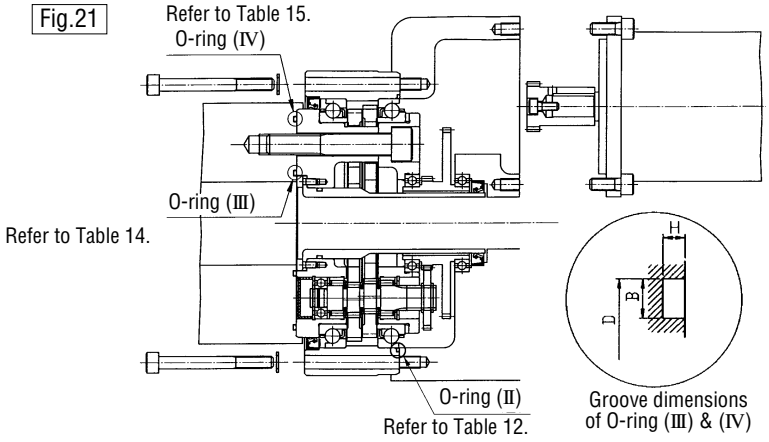


Table 14 O-ring(Ⅲ)seal dimensions (for reference) (Unit:mm)

			RV-10C	RV-320C
Dimensions	O-ring	ID number	AS568-032	G210 (Metric)
		Wire dia.	ϕ 1.78 $\pm$0.07	ϕ 5.7 $\pm$0.13
		I. D.	ϕ 47.35 $\pm$0.38	ϕ209.3
	Groove size	O. D.: d	ϕ 51.0 $^{+0.05}_{0}$	ϕ220.0 $^{+0.1}_{0}$
		Depth: H	1.27 $\pm$0.05	5.5 $\pm$0.05
		Width: B	2.39 $^{+0.25}_{0}$	7.5 $^{+0.25}_{0}$

Table 15 O-ring(Ⅳ)seal dimensions (for reference) (Unit:mm)

			RV-10C	RV-320C
Dimensions	O-ring	ID number	S100 (Metric)	G290 (Metric)
		Wire dia.	ϕ 2.0 $\pm$0.1	ϕ 5.7 $\pm$0.13
		I. D.	ϕ 99.5 $\pm$0.4	ϕ289.3
	Groove size	O. D.: d	ϕ103.0 $^{+0.05}_{0}$	ϕ300.0 $^{+0.1}_{0}$
		Depth: H	1.5 $^{0}_{-0.1}$	5.5 $\pm$0.05
		Width: B	2.7 $^{+0.25}_{0}$	7.5 $^{+0.25}_{0}$

Notes: "G", "S" Part numbers are Japanese Industrial Standard (JIS B 2401) Metric O-Rings
"CO" Part numbers are NOK's.

7-3 Center gear and input gear

■7-3-1 Accuracy of center gear and input gear

Poor installation accuracy of center gear and input gear may cause noise and backlash, so design center gear and input gear to the following tolerances.

Table 16 Accuracy of center gear and input gear (Unit:mm)

Tolerance of fitting X	Tolerance of concentricity a	Tooth grade of small center gear	Tooth grade of large center gear	Tooth grade of input gear
h6	MAX0.03	JIS 5 class	JIS 4 class	JIS 5 class

Fig.25

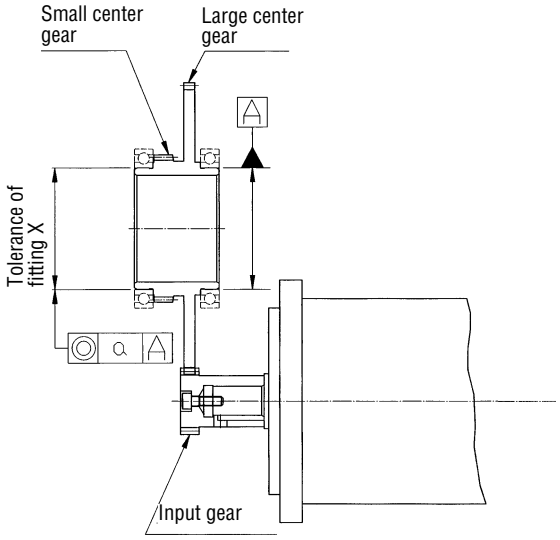


Table 17 (Unit:mm)

	Backlash between input gear and large center gear
RV-10C	0.035～0.090
RV-27C	0.040～0.110
RV-50C	0.050～0.130
RV-100C	0.060～0.140
RV-200C	0.075～0.180
RV-320C	
RV-500C	

Table 18 Specifications of small center gear tooth

	Module	Number of teeth	Addendum modification coefficient
RV-10C	1.0	48	−0.04
RV-27C	1.0	57	+0.2
RV-50C	1.25	61	0
RV-100C	1.75	48	+0.3
RV-200C	2.5	43	0
RV-320C	2	78	0
RV-500C	2	83	0

■7-3-2 Standard center gear

The standard center gears for RV-C reduction gear are available from TS Corporation.
If the standard center gear is needed, please specify when ordering. Specifications of standard large center gears are shown below. Refer to the external dimension for installation.

Table 19 Specifications of standard large center gear

	Module	Number of teeth	Addendum modification coefficient
RV-10C	2	57	0
RV-27C	1.25	78	0
RV-50C	2	78	0
RV-100C	1.75	112	0
RV-200C	2	110	0
RV-320C	2	125	0

7-4 Bolt tightening torque and allowable transmission torque

Use hexagonal socket bolts to assemble the RV-C reduction gear and tighten to the torque as specified below. When the pin/bolt mounting output shaft type is used, also use the taper pin. The serrated lock washer is recommended to prevent the bolt from loosening and protect the bolt seat face from flaws.

Table 20 Bolt tightening torque and tightening force

Hexagonal socket bolt nominal size x pitch (mm)	Tightening torque In-lb(Nm)	Tightening force (R) N	Bolt specification
M5 ×0.8	80 ±4 (9.01 ±0.49)	9,310	●Hexagonal socket bolt JIS B 1176 ●Strength class JIS B 1051 12.9 ●Thread JIS B 0205 6g or class 2
M6 ×1.0	138 ±7 (15.6 ±0.78)	13,180	
M8 ×1.25	329 ±16 (37.2 ±1.86)	23,960	
M10×1.5	651 ±30 (73.5 ±3.43)	38,080	
M12×1.75	1,137 ±56 (128.4 ±6.37)	55,100	
M14×2.0	1,814 ±90 (204.8 ±10.2)	75,860	
M16×2.0	2,821 ±141 (318.5 ±15.9)	103,410	
M18×2.5	3,906 ±196 (441 ±22.1)	126,720	

Notes 1. The valves listed are for steel or cast iron material.
2. If softer material such as aluminum is used, limit the tightening torque. Also pay attention to the system torque requirements.

Calculation of allowable transmission torque of bolts

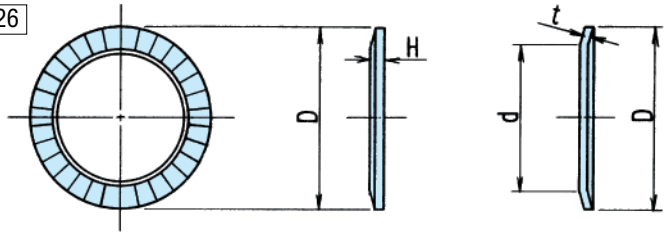
$$T_1 = F \times \frac{D_1}{2} \times \mu \times n_1$$

T_1 : bolt allowable transmission torque (Nm)
F : bolt tightening force (N)
D_1 : bolt P.C.D. (m)
μ : friction factor
μ = 0.15: where lubricants remained
μ = 0.2: where left dried with no lubricant
n_1 : number of bolts

Serrated lock washer external teeth for hexagonal socket bolt

Material: steel
Hardness: HRC40～48

Fig.26



(Unit:mm)

Table 21

Nominal size	O.D. and I.D. of washer d Basic size	O.D. and I.D. of washer D	t	H
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
18	18.9	27	2.6	3.15

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

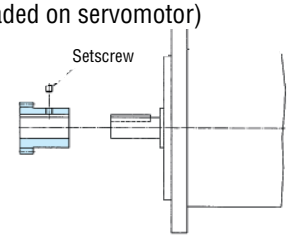
7-5 Installation of input gear

The profile of servomotor shaft and examples of input gear installation are shown below as a reference for designing. User must provide set screw, hexagonal socket bolt or hexagonal nut.

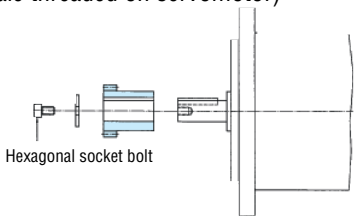
Straight shaft

(No female threaded on servomotor)

Fig.27

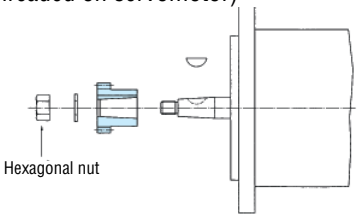


(With female threaded on servomotor)



Taper shaft

(With male threaded on servomotor)



Note: A radial load due to the counterforce of torque is applied by the center gear on the RV-C reduction gear. Therefore, examine the strength of the motor shaft and the service life of bearings which support the motor shaft.

7-6 Lubrication

To maximize the performance of the RV-C reduction gear, the use of Molywhite RE00 manufactured by TS Corporation is recommended. Do not mix with other lubricants.

Table 22 Working temperature range (ambient temperature)

Working temperature range (ambient temperature)	−10℃～40℃

Note: Please contact TS Corporation if grease or gear oil is to be used beyond the specified temperature range.

1) Grease level in RV-C reduction gear

The RV-C reduction gear when it is shipped from the plant is not greased. Therefore, ensure that the necessary amount of recommended grease is charged when installing the RV-C reduction gear.

Note: The quantity required for the RV-C reduction gear is shown below. The volume of grease listed below does not include the volume required to fill the shaded areas in figure 28. These areas must also be charged with grease. When there exists a cavity, such as when a slow-speed tube is being used, exclude the volume of such cavity. However, too much filling may causes damage for an oil seal with increase of internal pressure. Please leave about 10% of the room inside.

Table 23 Horizontal installation

Type	Quantity	
	cc	(g)
RV-10C	147	(128)
RV-27C	266	(231)
RV-50C	498	(433)
RV-100C	756	(658)
RV-200C	1,831	(1,593)
RV-320C	2,880	(2,506)
RV-500C	5,934	(5,163)

Vertical installation

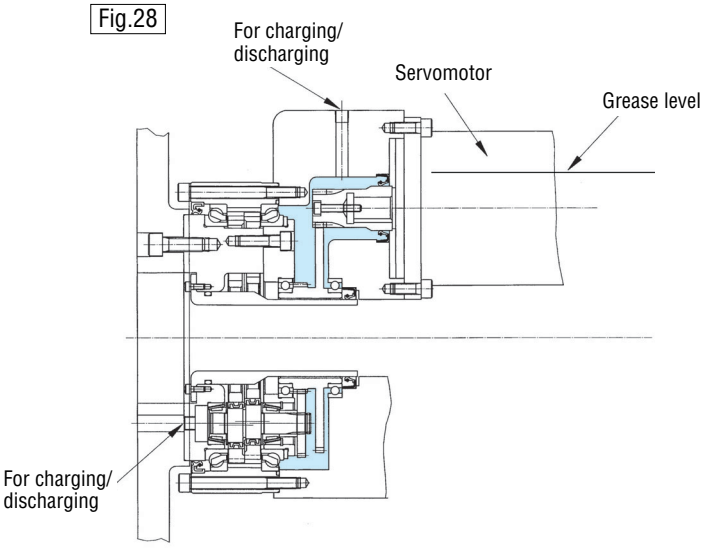
Type	Quantity	
	cc	(g)
RV-10C	167	(145)
RV-27C	305	(265)
RV-50C	571	(497)
RV-100C	857	(746)
RV-200C	2,076	(1,806)
RV-320C	3,191	(2,776)
RV-500C	6,900	(6,003)

2) Grease lubrication points

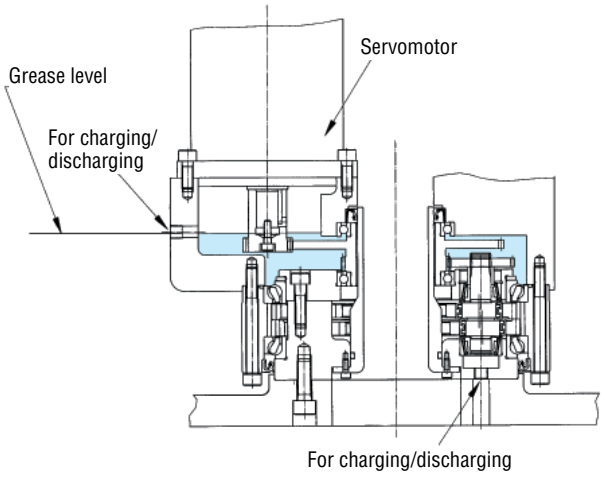
The RV-C reduction gear is provided with charging/discharging taps (or through holes) on the reduction gear unit (for details refer to the external dimension drawings). As an option these taps (or holes) can be covered with rubber caps (except RV-27C and RV-320C). This must be specified when ordering.

Horizontal installation

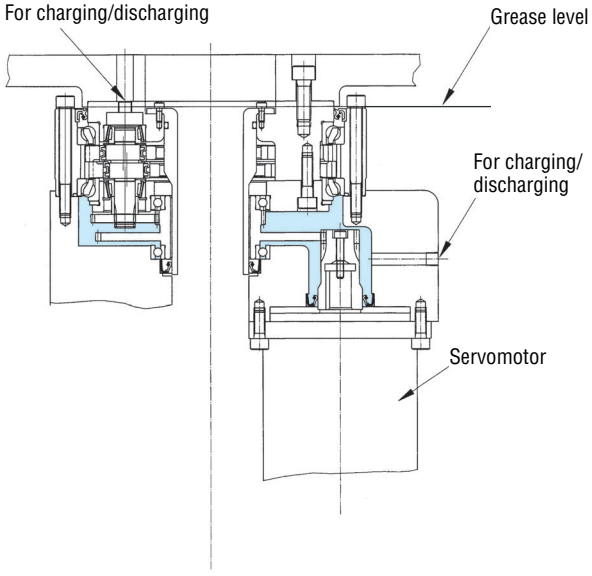
Fig.28



Vertical installation(1)



Vertical installation(2)



3) Interval between grease change

Change grease at a standard interval of 20,000 hours after initially supplying the RV-C reduction gear with grease in the specified quantity (see Fig.28) in order to protect the RV-C reduction gear from deteriorated grease.

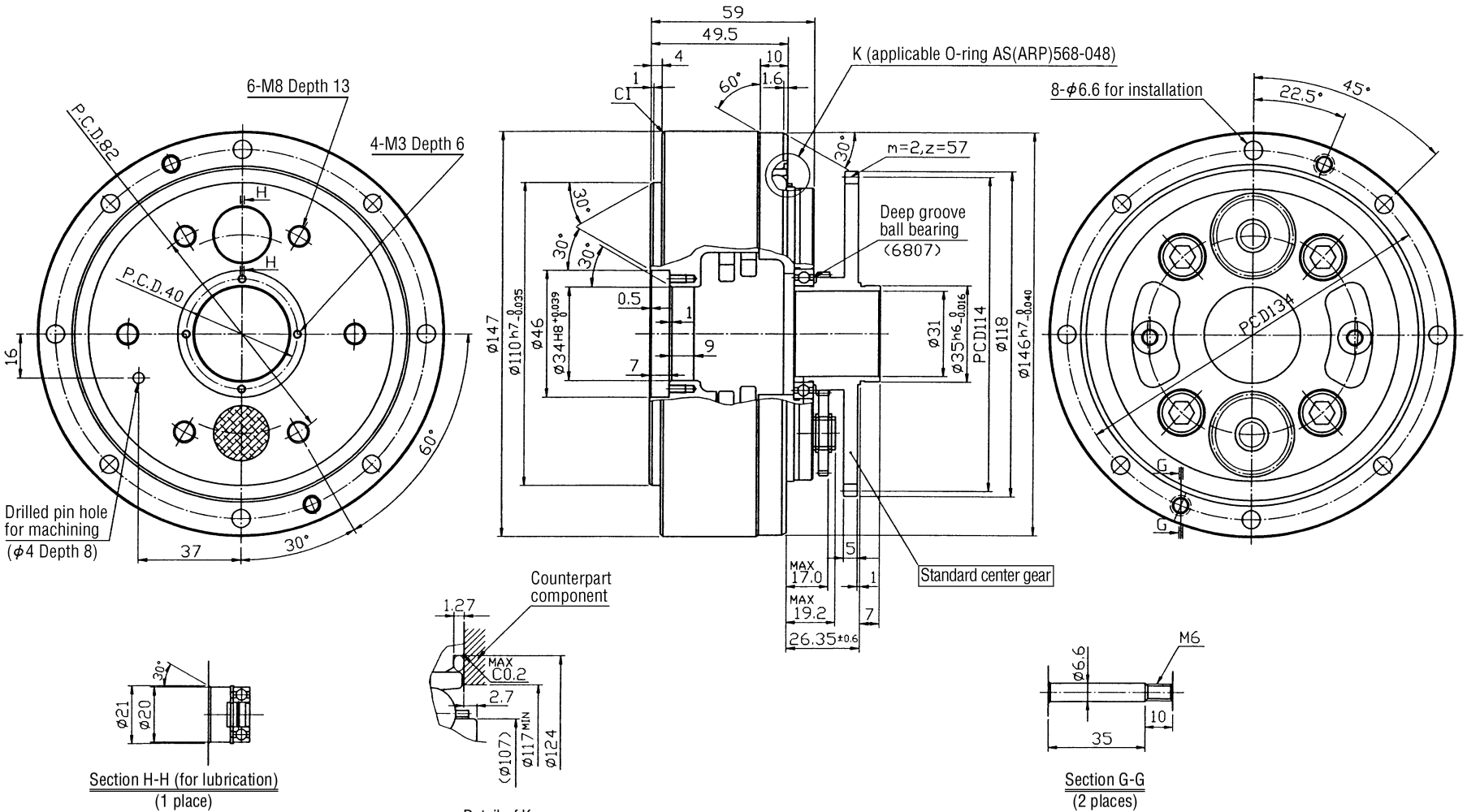
If grease is contaminated for any reason or used at an ambient temperature of 40˚C or more, check the grease for contamination or deterioration, to determine the proper maintenance interval.

7-7 Warranty

TS Corporation guaranties that the reduction gears of the model RV are free from defects of 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 earlier,on condition that the product is operated under the rated operation conditions specified by us,in normal assembly and lubrication condition.
If any defect in materials or workmanship is detected during the above guaranteeterm,the product will be repaired or substituted at our expense,provided that the No.of man-hour required for demounting and remounting the product from the machine,transportation expense for re-delivery,warehousing and other incidental expenses shall be excluded from our obligation.
No expenses for damages of the machine due to shutdown of operation attributable to defect of the product are guaranteed.
If the guarantee is accomplished with money,the upper limit of the amount shall not exceed the selling price of that claimed product.

8-1 RV-10C External dimensions of bolt clamping output shaft type

Type code RV-10C-27-A-B (Speed ratio)



Section H-H (for lubrication)
(1 place)

Detail of K

Section G-G
(2 places)

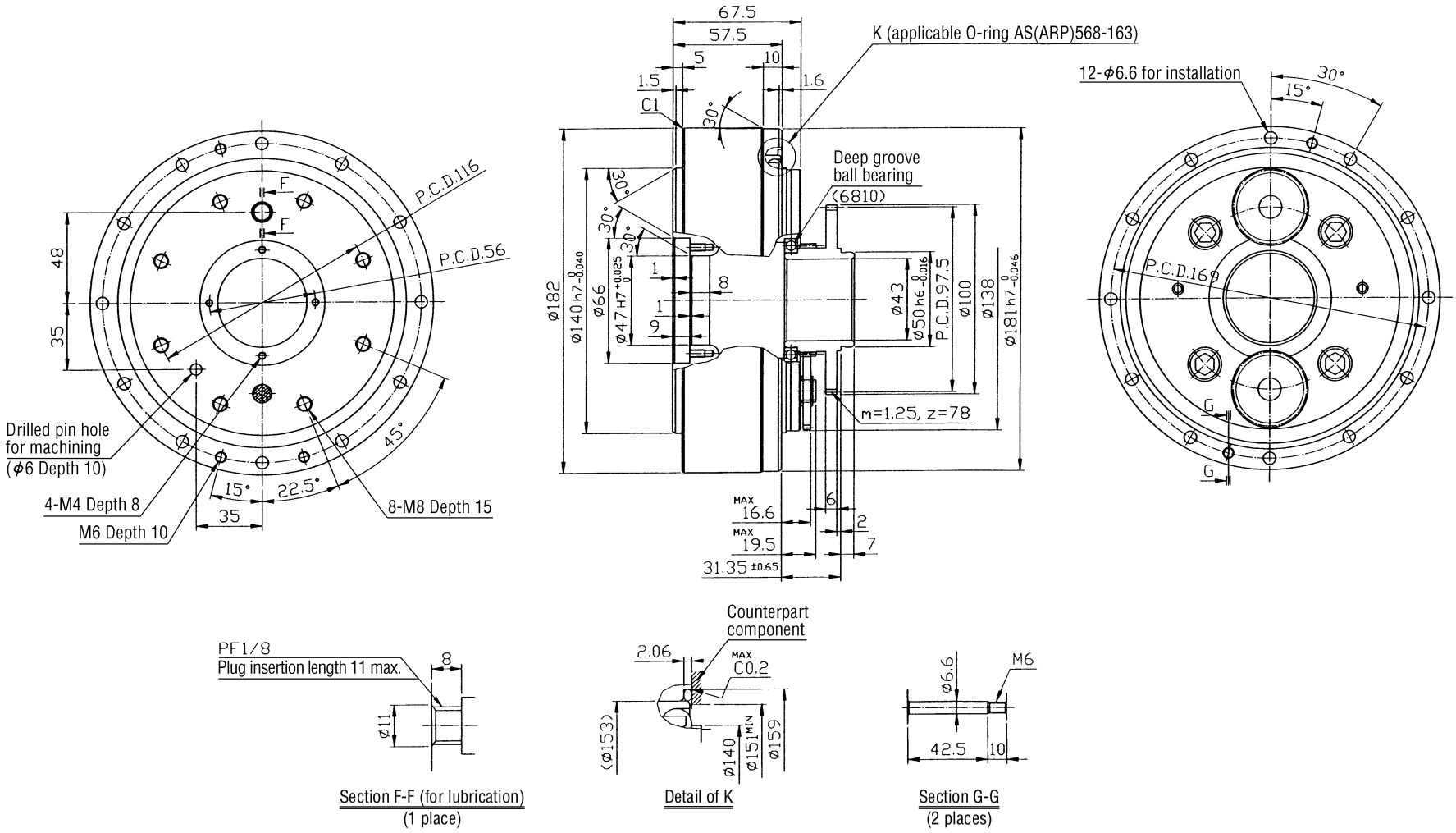
Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	8-M6	1,058.4Nm
Shaft side	6-M8	882Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-2 RV-27C External dimensions of bolt clamping output shaft type

Type code RV-27C-Speed ratio [36, 57]-[A]-B



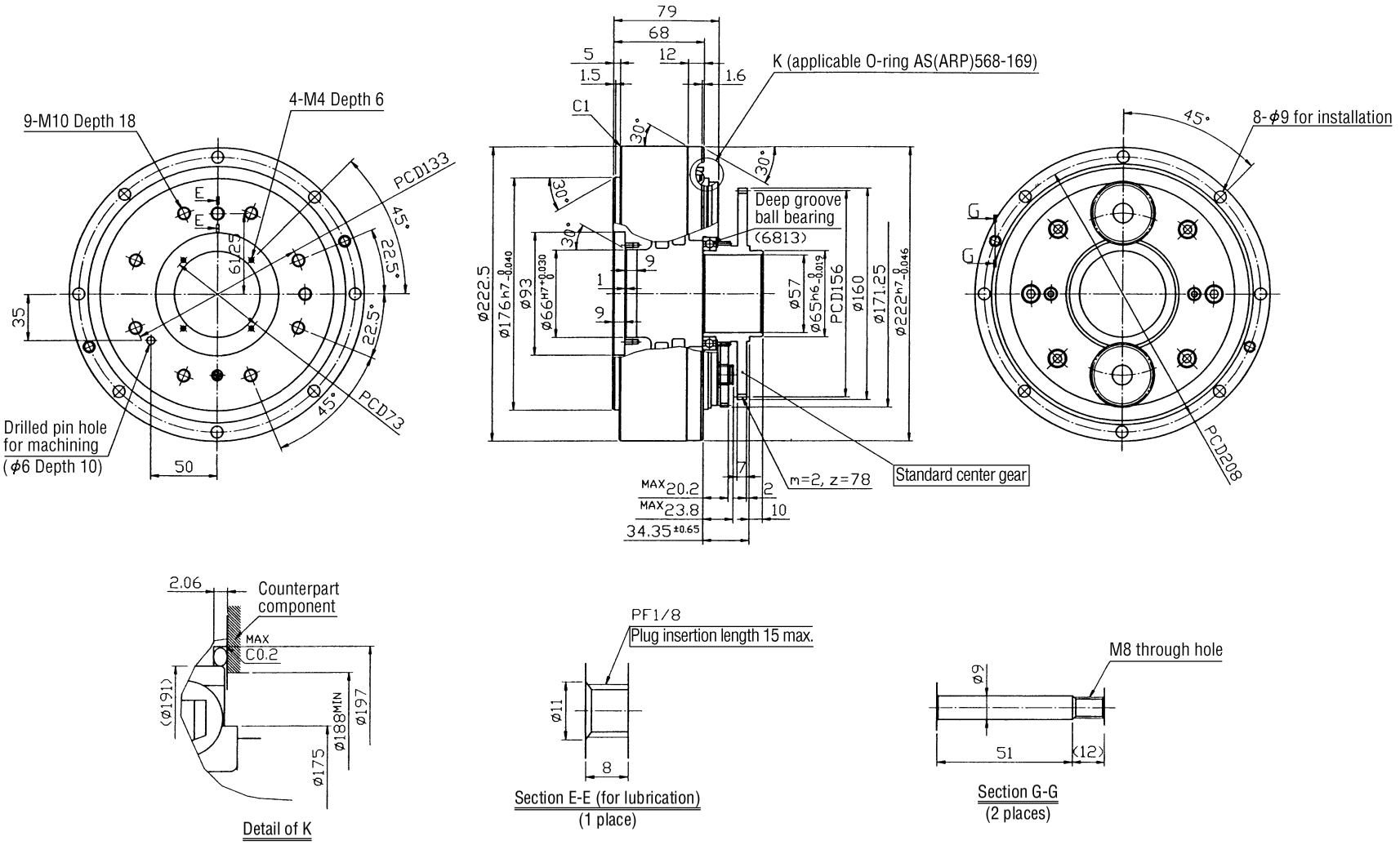
Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	12-M6	1,999.2Nm
Shaft side	8-M8	1,666Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-3 RV-50C External dimensions of bolt clamping output shaft type

Type code RV-50C-[Speed ratio 32, 54]-[A]-B



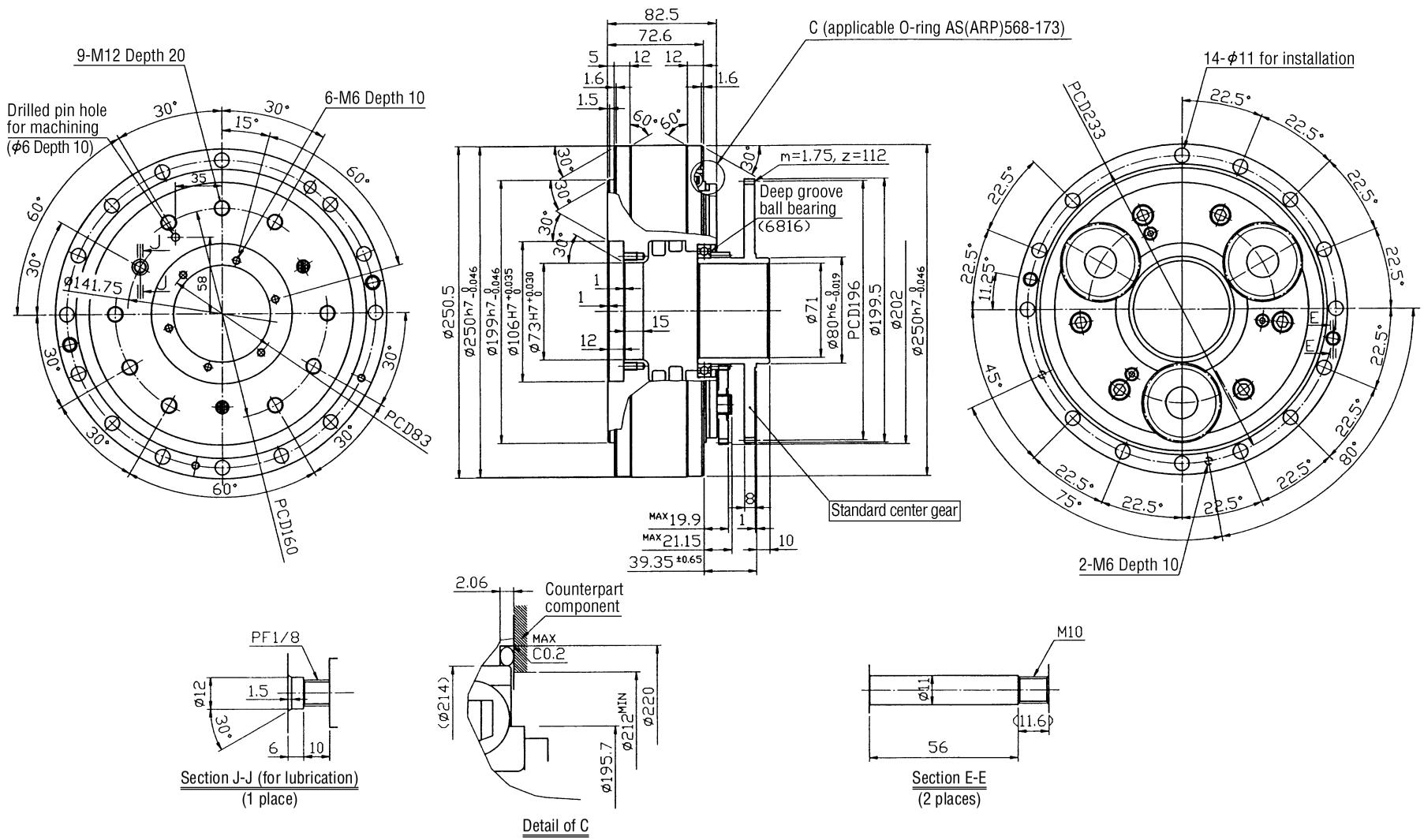
Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	8-M8	2,989Nm
Shaft side	9-M10	3,410.4Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-4 RV-100C External dimensions of bolt clamping output shaft type

Type code RV-100C-[Speed ratio 36, 75]-[A]-B



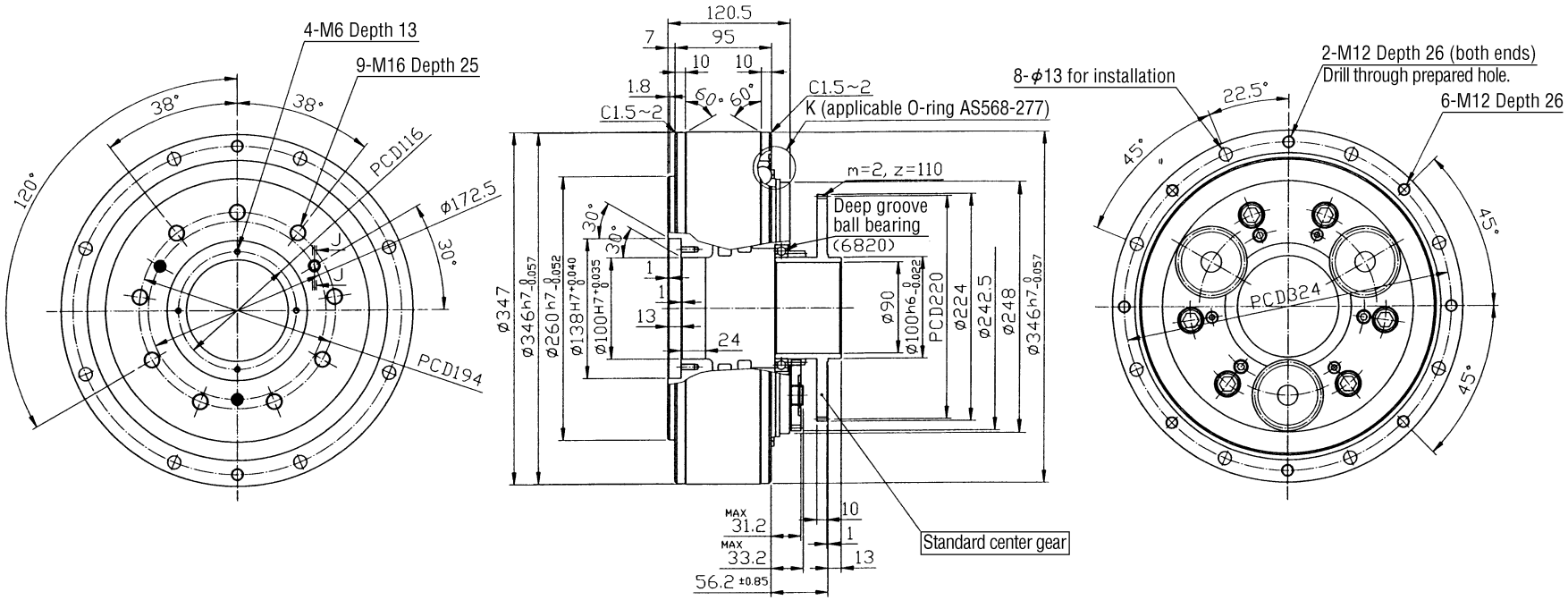
Allowable transmission torque

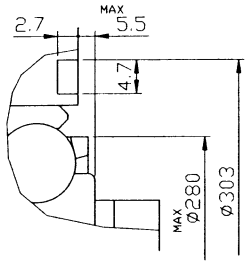
	Number of bolts & size	Allowable transmission torque
Case side	14-M10	9,310Nm
Shaft side	9-M12	5,948.6Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

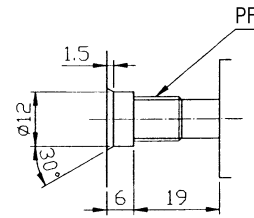
8-5 RV-200C External dimensions of bolt clamping output shaft type

Type code RV-200C-Speed ratio [34, 86]-[A]-B





Detail of K



Section J-J (for lubrication)
(1 place)

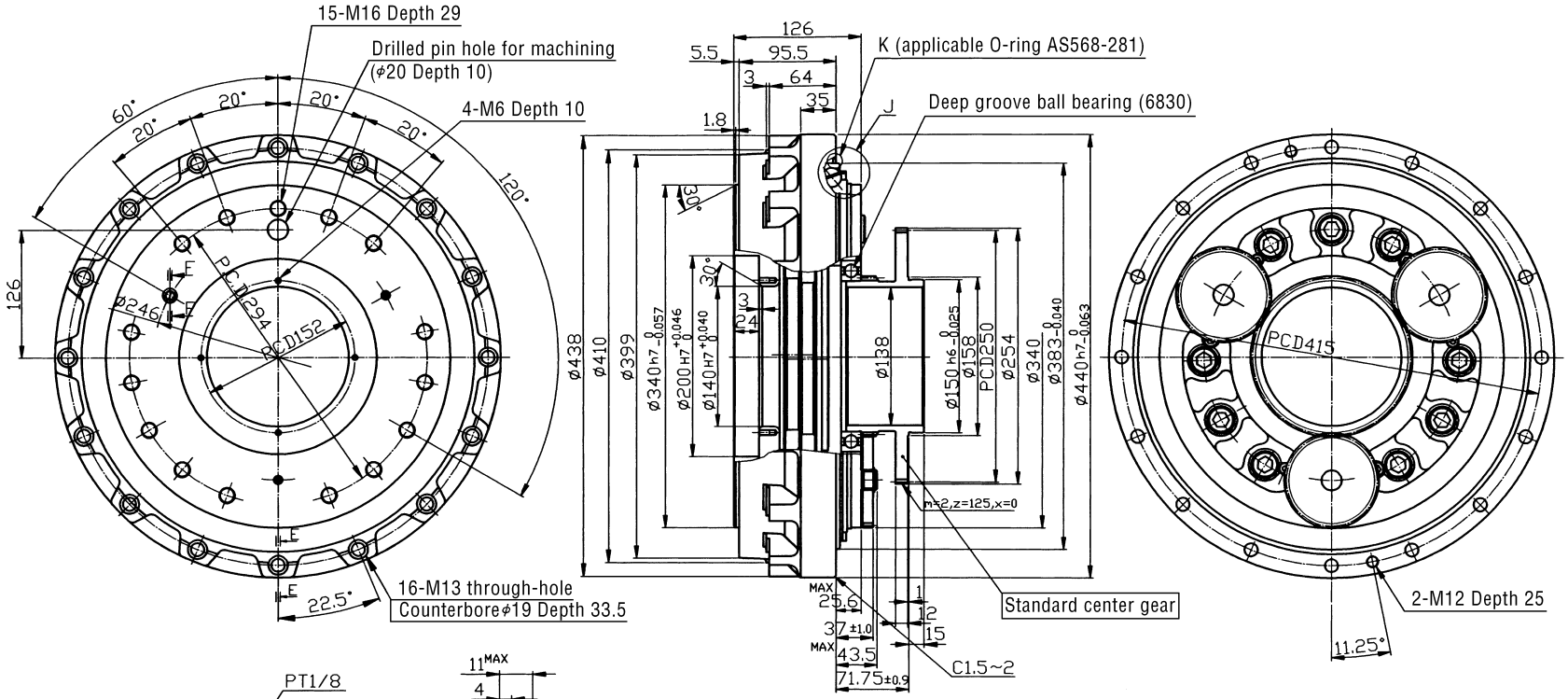
Allowable transmission torque

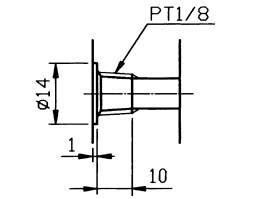
	Number of bolts & size	Allowable transmission torque
Case side	8-M12	10,701.6Nm
Shaft side	9-M16	13,543Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

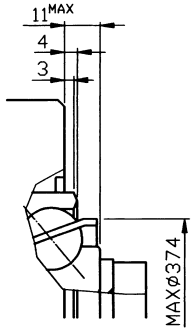
8-6 RV-320C External dimensions of bolt clamping output shaft type

Type code RV-320C-[Speed ratio 35, 61]-[A]-B

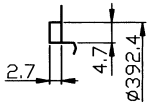




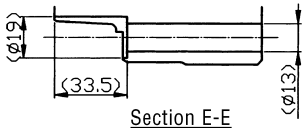
Section F-F (for lubrication)
(1 place)



Detail of J



Detail of K



Section E-E
(16 place)

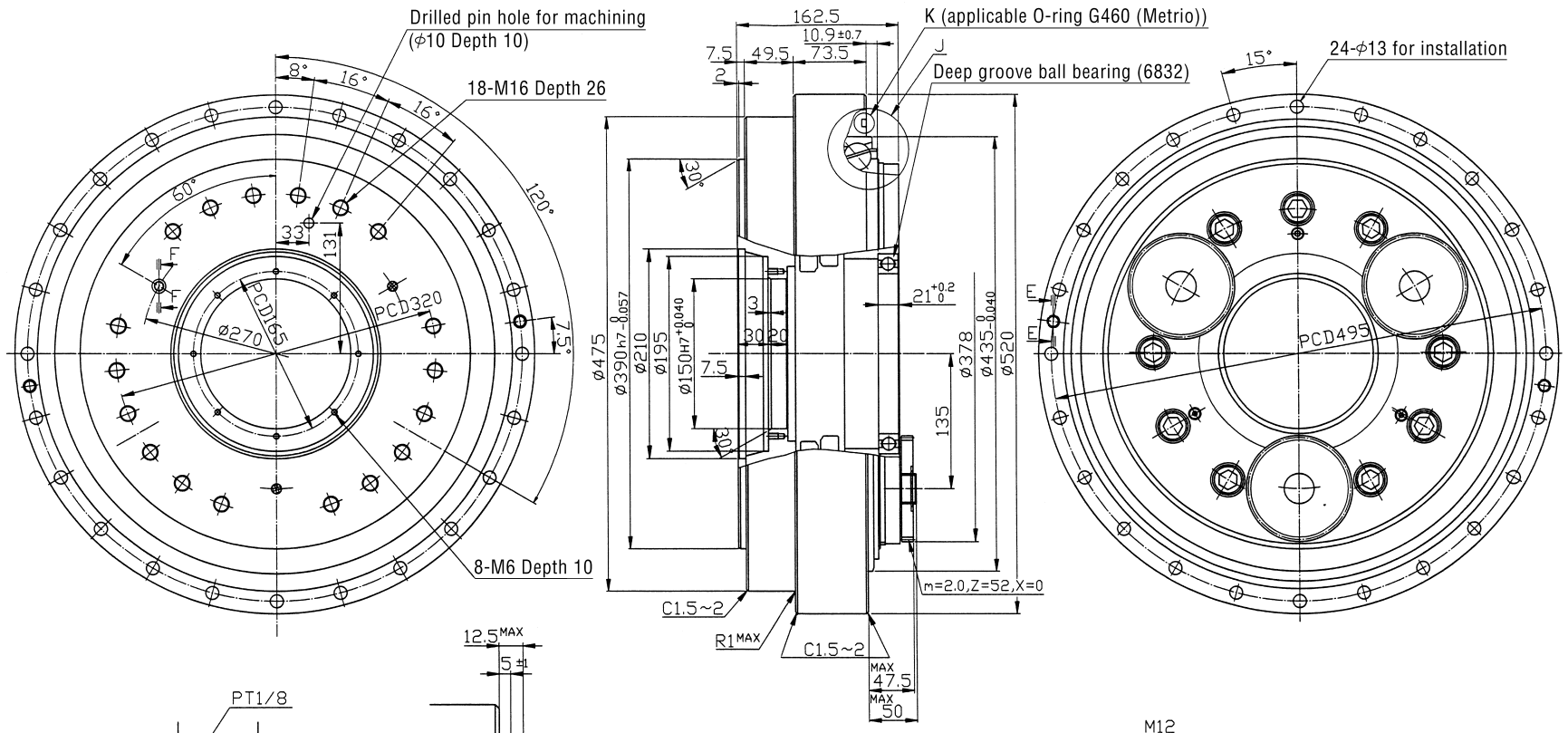
Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	16-M12	27,440Nm
Shaft side	15-M16	34,202Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-7 RV-500C External dimensions of bolt clamping output shaft type

Type code RV-500C-Speed ratio [37. 34]-[Z]-B



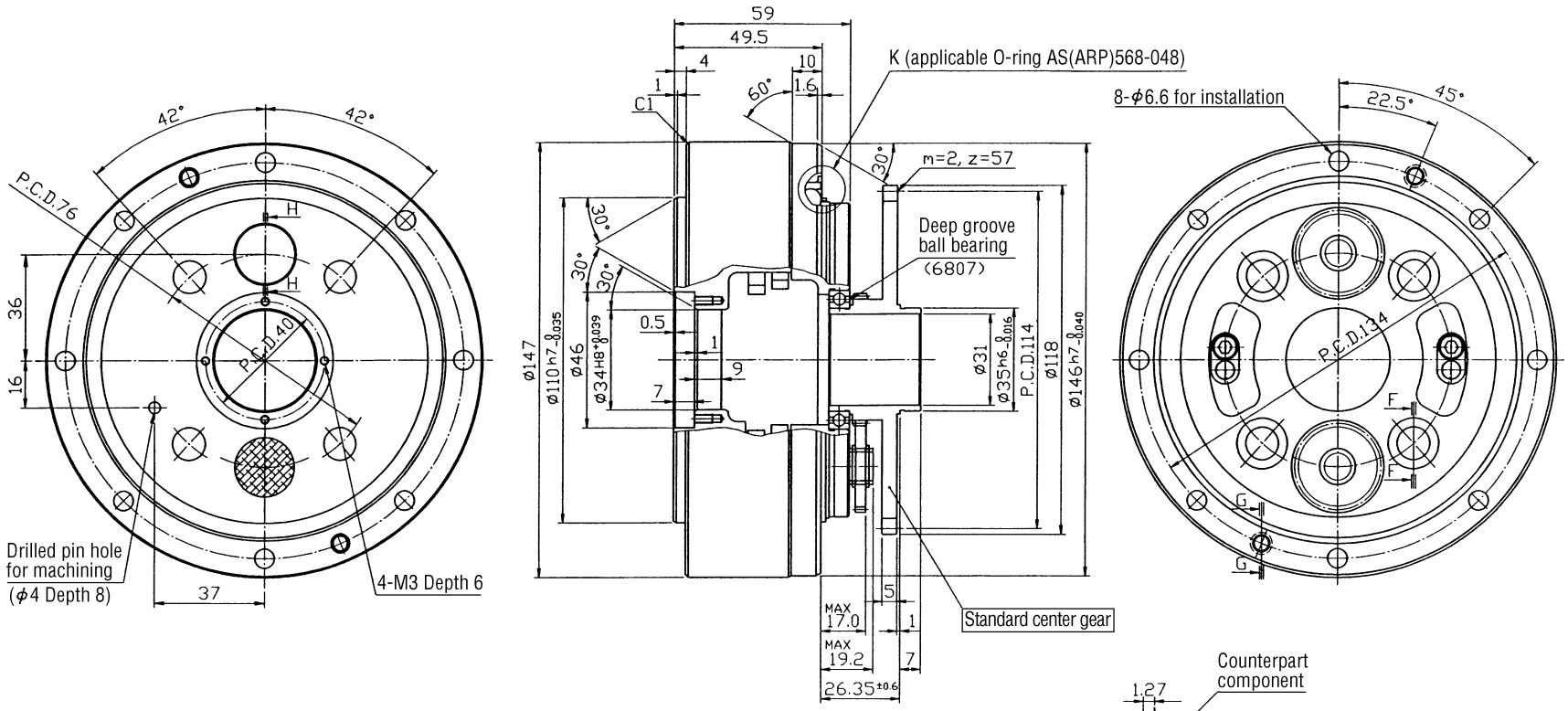
Allowable transmission torque

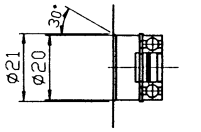
	Number of bolts & size	Allowable transmission torque
Case side	24-M12	49,088.2Nm
Shaft side	18-M16	44,668.4Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

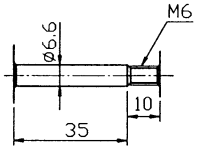
8-8 RV-10C External dimensions of through-bolt clamping output shaft type

Type code RV-10C-27-A-T (Speed ratio)

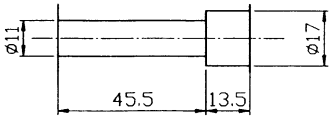




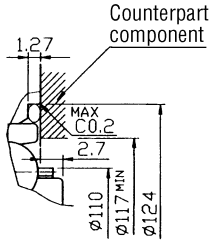
Section H-H (for lubrication)
(1 place)



Section G-G
(2 place)



Section F-F
(4 place)



Detail of K

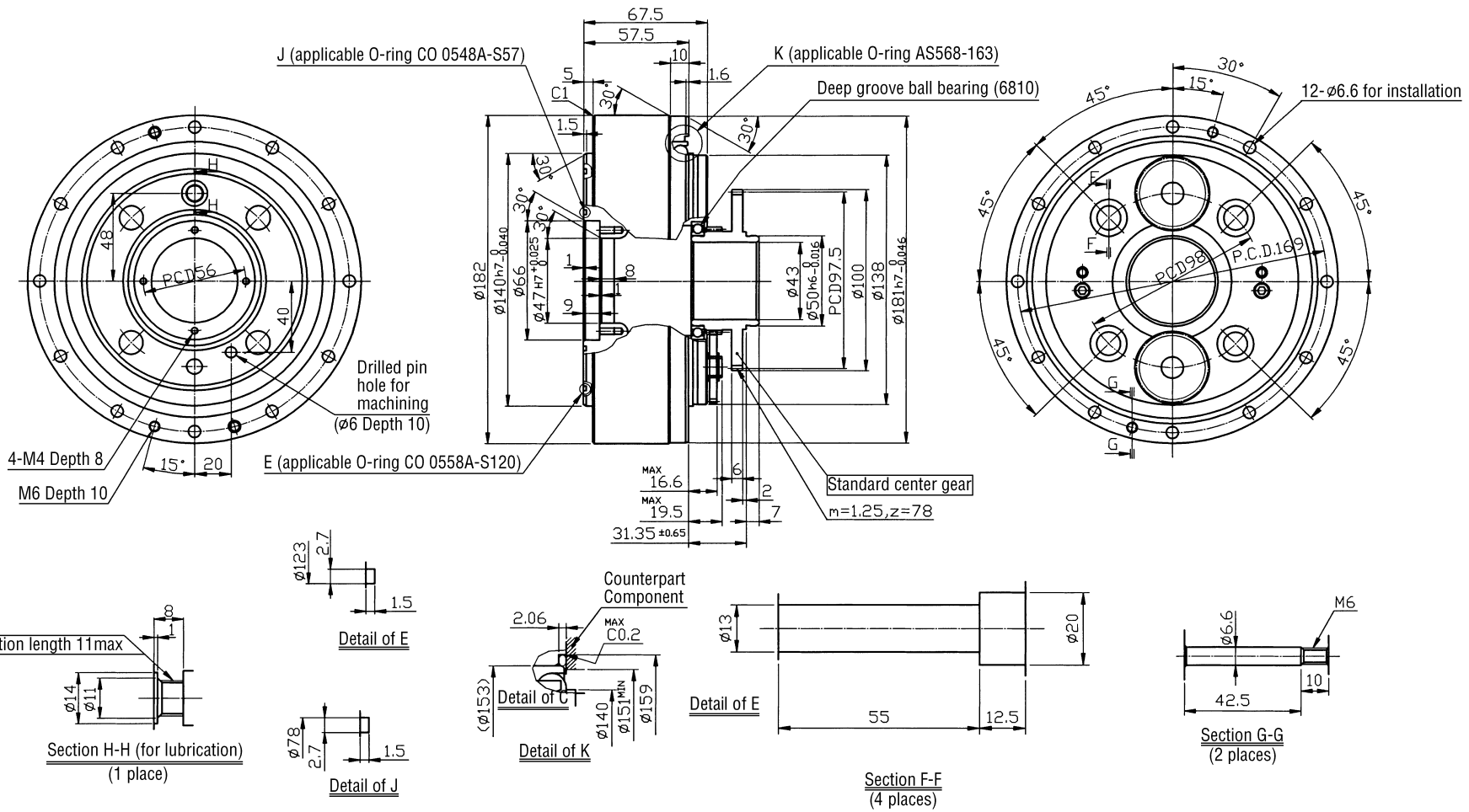
Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	8-M6	1,058.4Nm
Shaft side	4-M10	862.4Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-9 RV-27C External dimensions of through-bolt clamping output shaft type

Type code RV-27C-Speed ratio [36, 57]-[A]-T



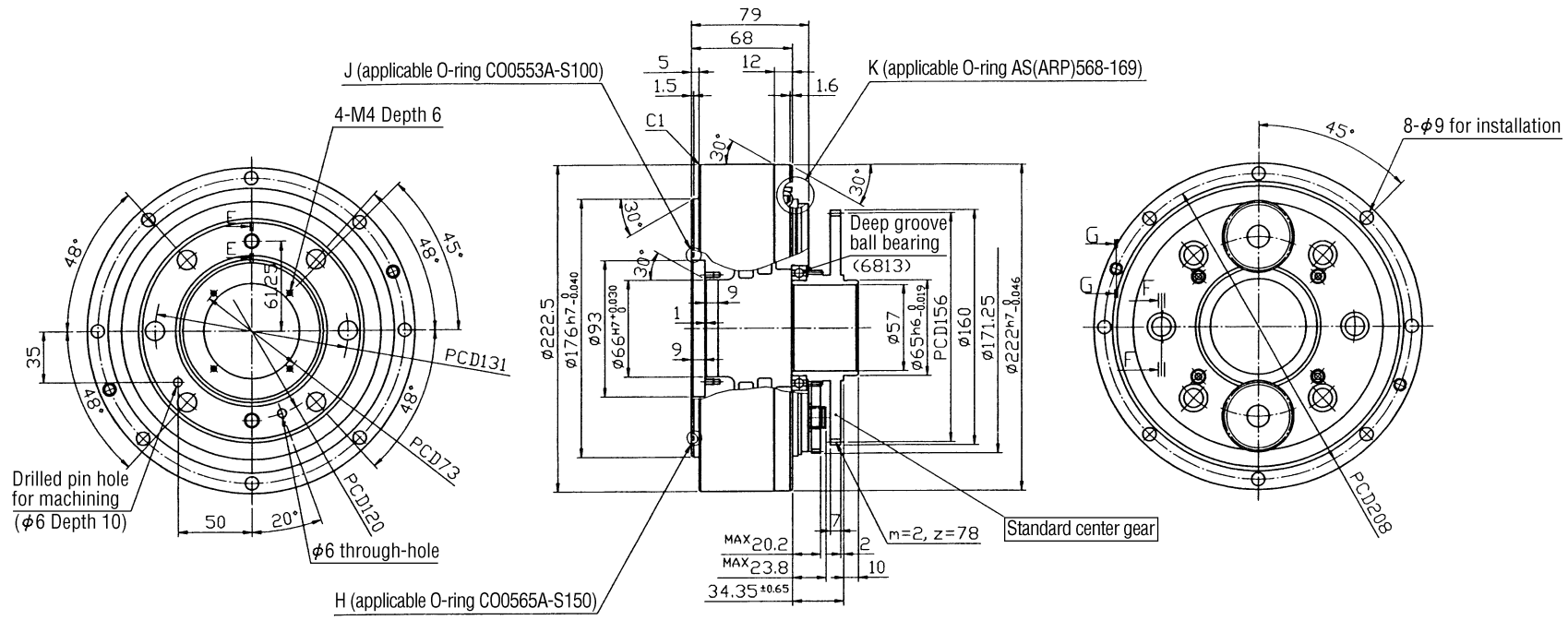
Allowable transmission torque

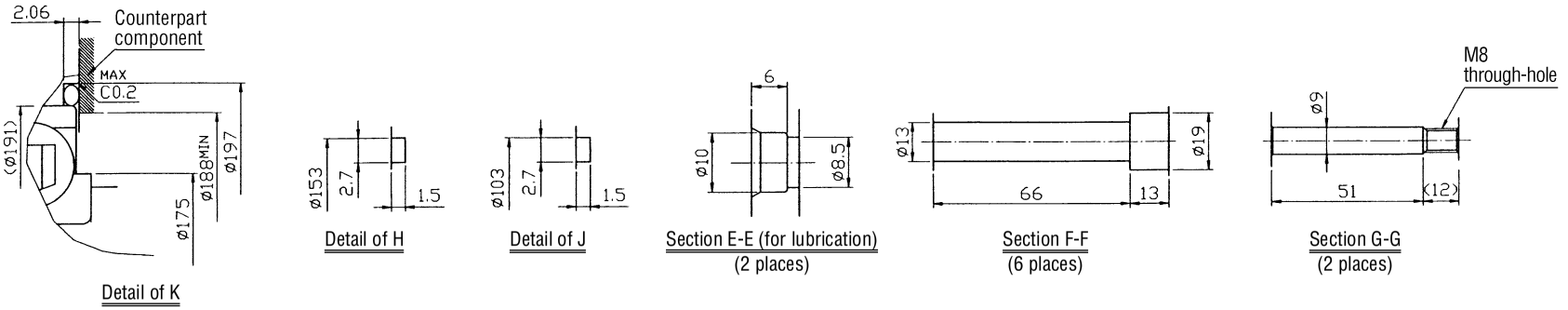
	Number of bolts & size	Allowable transmission torque
Case side	12-M6	1,999.2Nm
Shaft side	4-M12	1,617Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-10 RV-50C External dimensions of through-bolt clamping output shaft type

Type code RV-50C-[Speed ratio 32, 54]-[A]-T



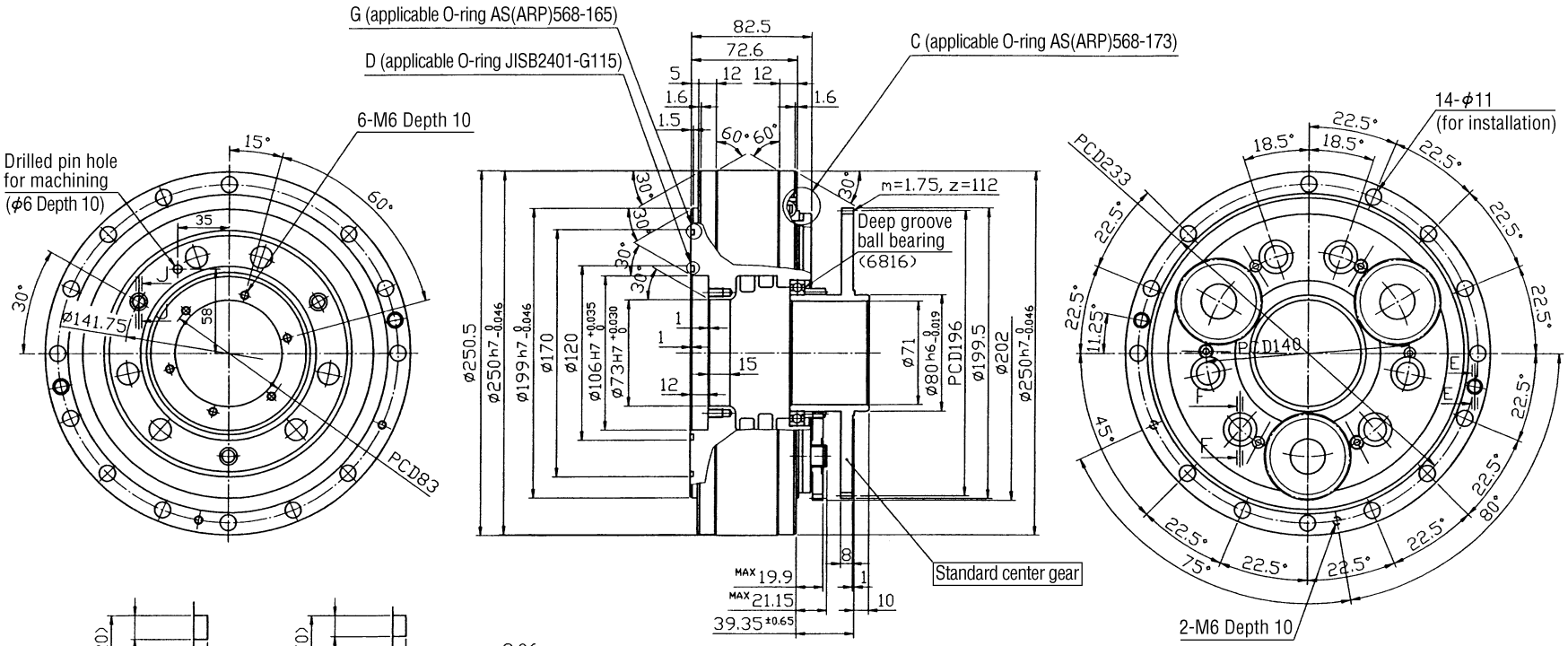


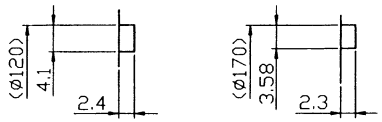
Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	8-M8	2,989Nm
Shaft side	6-M12	3,243.8Nm

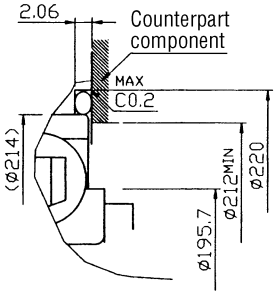
Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-11 RV-100C External dimensions of through-bolt clamping output shaft type Type code RV-100C-[Speed ratio 36, 75]-[A]-T

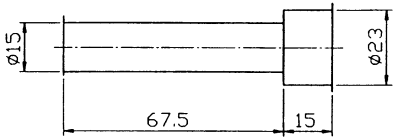




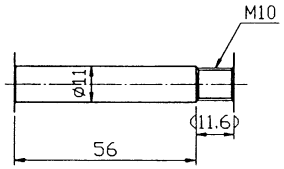
Detail of D　　Detail of G



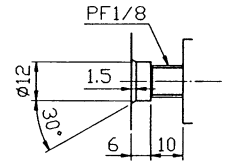
Detail of C



Section F-F
(6 places)



Section E-E
(2 places)



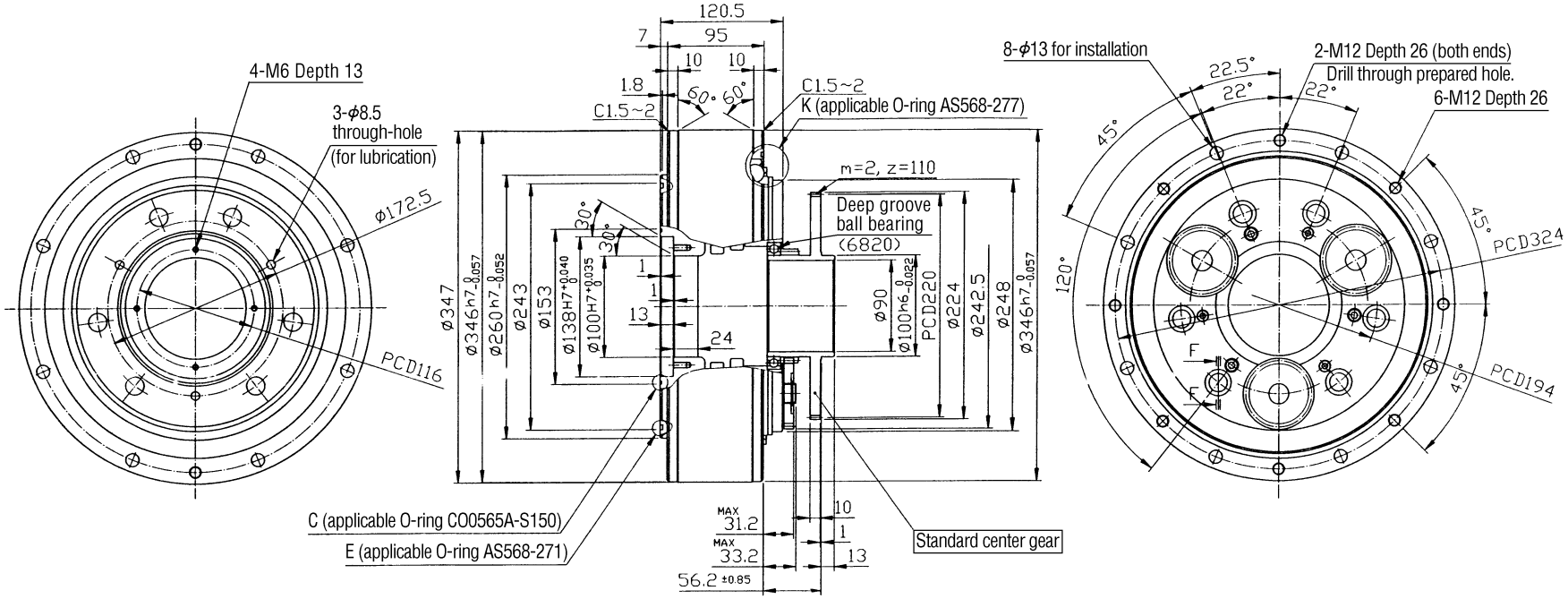
Section J-J (for lubrication)
(1 places)

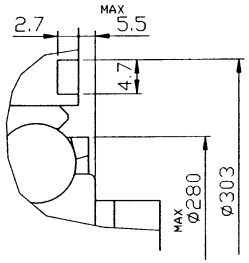
Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

Allowable transmission torque

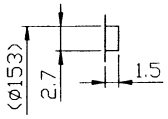
	Number of bolts & size	Allowable transmission torque
Case side	14-M10	9,310Nm
Shaft side	6-M14	4,772.6Nm

8-12 RV-200C External dimensions of through-bolt clamping output shaft type Type code RV-200C-[Speed ratio 34, 86]-[A]-T

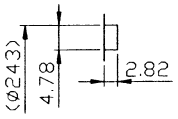




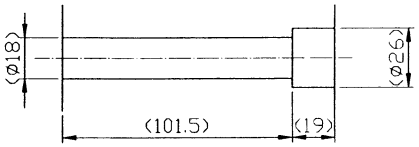
Detail of K



Detail of C



Detail of E



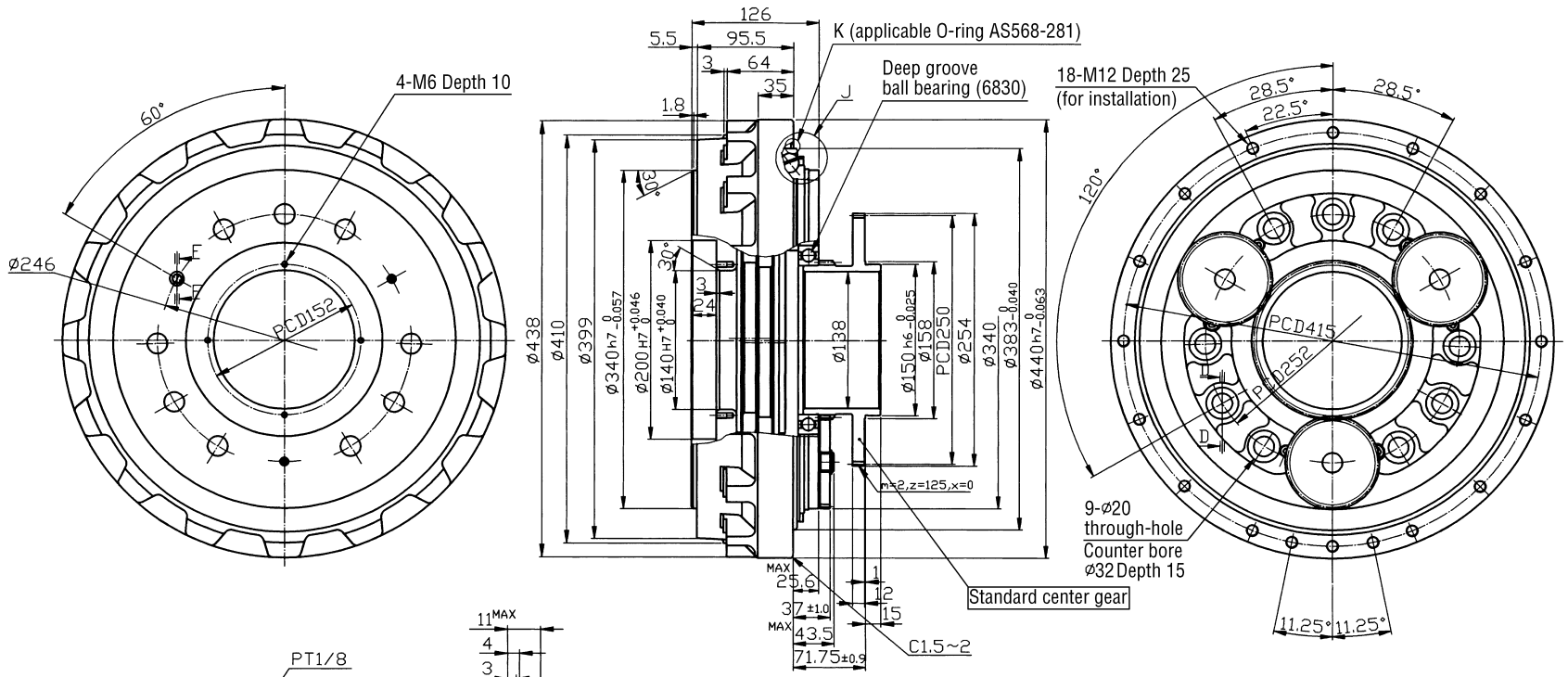
Section F-F
(2 places)

Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	8-M12	10,701.6Nm
Shaft side	6-M16	9,025.8Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.

8-13 RV-320C External dimensions of through-bolt clamping output shaft type Type code RV-320C-[Speed ratio 35, 61]-[A]-T



Allowable transmission torque

	Number of bolts & size	Allowable transmission torque
Case side	18-M12	30,870Nm
Shaft side	9-M18	21,560Nm

Notes 1. Use commercial goods to supply items such as O-rings, mounting bolts and seal washers.
2. Specifications and dimensions are subject to change without notice.