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CW12

Sumitomo Heavy Industries, Ltd.

No. F2001E-2.1

Sumitomo Drive Technologies
Always on the Move

Motion Control Drives

CYCLO® F - Series

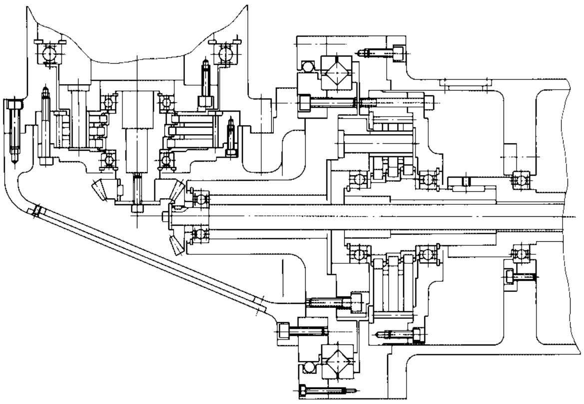
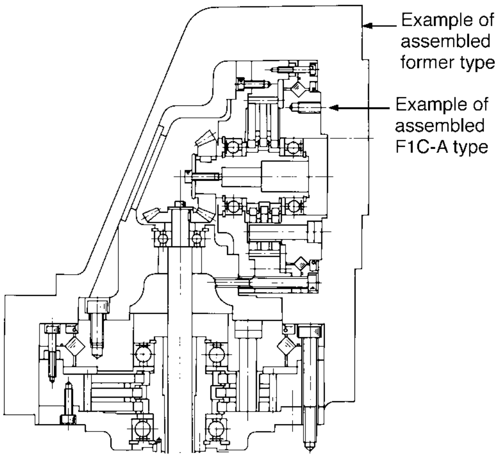
No. F2001E-2

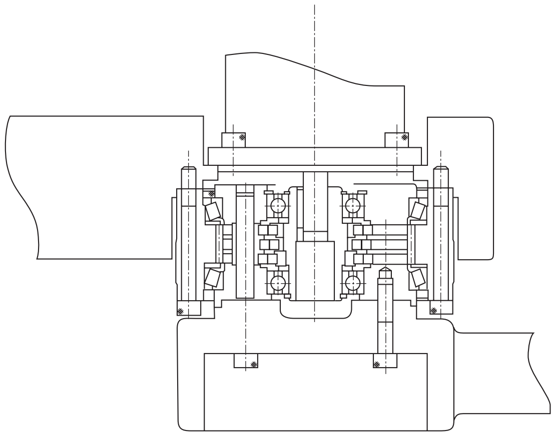
ADVANTAGES & EXAMPLE OF USE ACCORDING TO TYPE

Advantages common to

FC—A
F1C—A
F2C—A

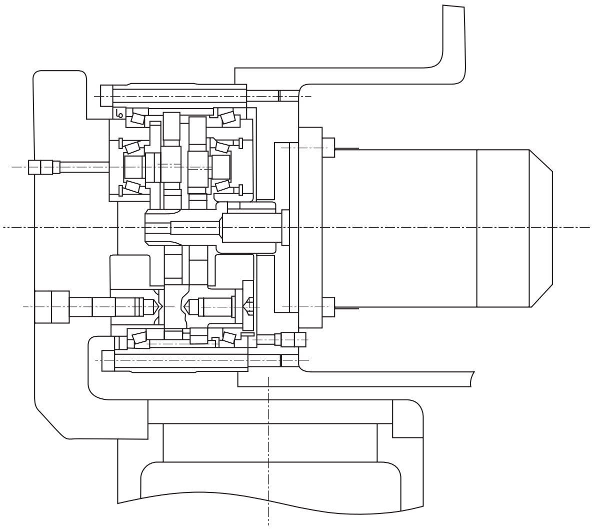
- **Low Backlash**
- **Compactness**
- **Low Vibration**
- **High Stiffness**
- **High Efficiency**
- **Long Lifetime**
- **Easy Assembly**
- **Easy Maintenance**

Type	Advantages	Main Example of Use
FC—A	**■Overhung Load Available for High-speed Shaft** High-speed shaft supported by two bearings provides overhung load capability.	●Wrist of Robot ●Positioner ●Traveling Carriage ●Drive for Winch ●Machine Tool 
F1C—A	**■Overhung Load Available for High-speed Shaft** In addition to advantages of FC-A Series, use of cross roller bearing realizes compactness. **■Overhung Load Available for High-speed Shaft** High-speed shaft supported by two bearings provides overhung load capability.	●Wrist of Robot ●Positioner ●Drive for Winch ●Machine Tool 

Type	Advantages	Main Example of Use
F2C—A	**■Overhung Load Available for High-speed Shaft** Because taper roller bearings is used as output side bearing, it has bigger capacity of radial load (moment) and more compact than F1C-A type. **■Overhung Load Available for High-speed Shaft** High-speed shaft supported by two bearings provides overhung load capability.	●Wrist of Robot ●Machine Tool ●Positioner 

Advantages common to FC—T F2C—T

Low Backlash	High Stiffness
Compactness	High Efficiency
Low Vibration	Long Lifetime
	High Shockload Capacity

Type	Advantages	Main Example of Use
	■High Precision in Trajectory Use of new two-teeth difference profile realizes lower vibration, higher efficiency and smaller hysteresis loss than A type. It is available to use for high precision in trajectory. **■Overhung Load Available for Output Flange (F2C-T)** Because taper roller bearings is used as output side bearing, it has big capacity of radial load (moment).	●Basic Axis of Robot (Arc welding robot) ●Wrist of Robot ●Machine Tool 

CONTENTS

FC—A Series
F1C—A Series
F2C—A Series

1. Nomenclature

F C S — A25 — 119

- 119: Reduction ratio
- A25: Frame size
- S:
  - Standard: –
  - Special specification: S
- C:
  - FC-A Series ：C
  - F1C-A Series ：1C（Output shaft with single cross roller bearing）
  - F2C-A Series ：2C（Output shaft with integrated taper roller bearings）
- F: Symbol of Fine CYCLO

2. Products

Table A-1

Mark ●：Model Lineup

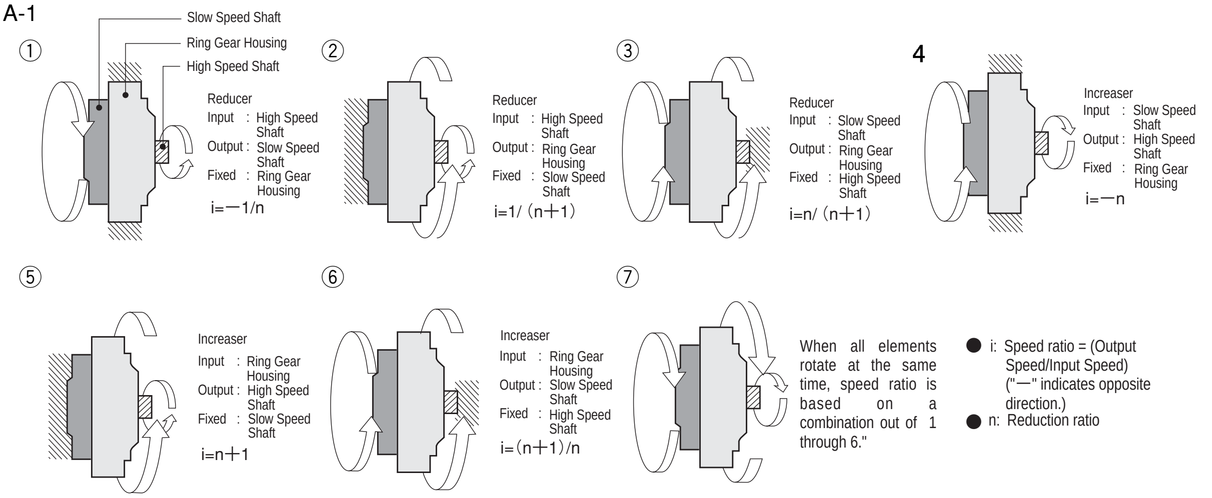
Frame size	Rated output torque		Reduction ratio	FC—A Serues	F1C—A Serues	F2C—A Serues
	N•m	kgf•m				
A15	142	14.5	59	●	●	●
			89	●	●	●
A25	334	34	29	●	●	●
			59	●	●	●
			89	●	●	●
			119	●	●	●
A35	638	65	29	●	●	●
			59	●	●	●
			89	●	●	●
			119	●	●	●
A45	1324	135	29	●		●
			59	●		●
			89	●		●
			119	●		●
A65	2453	250	29	●		
			59	●		
			89	●		
			119	●		
A75	3728	380	29	●		
			59	●		
			89	●		
			119	●		

（Note）

- Rated output torque is the value when input speed is 1750r/min.

3. Speed Ratio & Rotation Direction

Fig. A-1



When all elements rotate at the same time, speed ratio is based on a combination out of 1 through 6."

- ● i: Speed ratio = (Output Speed/Input Speed) ("−" indicates opposite direction.)
- ● n: Reduction ratio

4. Operating Principles

The reducer portion of the CYCLO gearmotor is fundamentaly different in principle and mechanism from the involute gearing mechanism of competitive gearmotors. The unique speed reducer portion is an ingenious combination of the following two mechanisms:

☆ A combination of a planet gear and a fixed internal sun gear. In the CYCLO gearmotor, the planet gear has cycloidal-shaped teeth and the sun gear has circular pin teeth.
The number of teeth in the planet gear is one or two less than the sun gear.

☆ A constant speed internal gearing mechanism.

Fig.A-2 Principle of internal Planetary Gearing

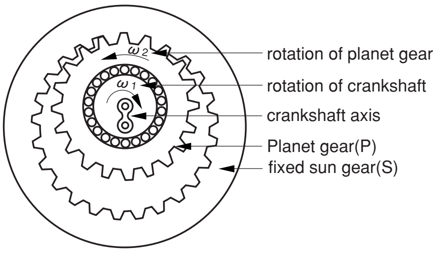


Fig.A-3 Epitrochoid Planet Gear-Circular(PIN) Tooth Sun Gear Combination

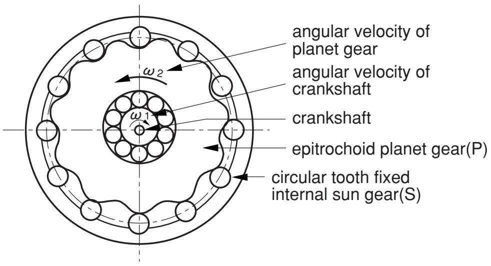


Fig.A-4 Constant Speed Internal Gearing

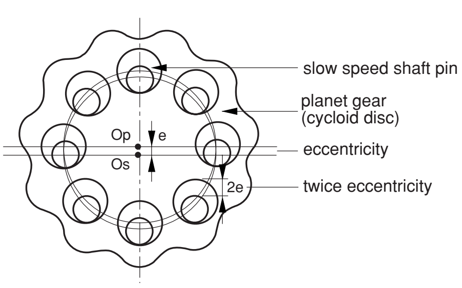
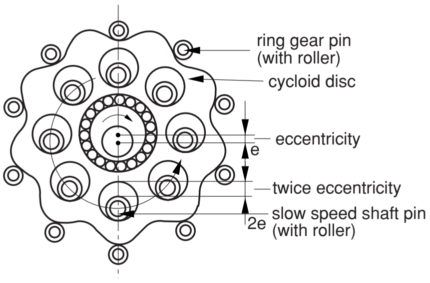


Fig.A-5 Combination of Planet-Sun Gears and Constant Speed Internal Gear



In equation 1, below, P identifies the number of the planet gear teeth, S that of the sun gear, ω2 the angular velocity of the planet gear around its own axis. The velocity ratio of ω2 to ω1 is shown as follows:

$$\frac{\omega 2}{\omega 1} = 1 - \frac{S}{P} = -\frac{S-P}{P} \cdots \text{Equation 1}$$

With S greater by one or two than P in this equation, the highest velocity ratio is obtainable.
That is, if S-P=1 is applied to Equation 1, the velocity ratio may be calculated from the following equation:

$$\frac{\omega 2}{\omega 1} = \frac{1}{P} \cdots \text{Equation 2}$$

Or if S-P=2 is applied to Equation 1, the velocity ratio may be calculated from the following equation:

$$\frac{\omega 2}{\omega 1} = \frac{2}{P} \cdots \text{Equation 3}$$

As the crankshaft rotates at the angular velocity ω1 around the axis of the sun gear, the planet gear rotates at the angular

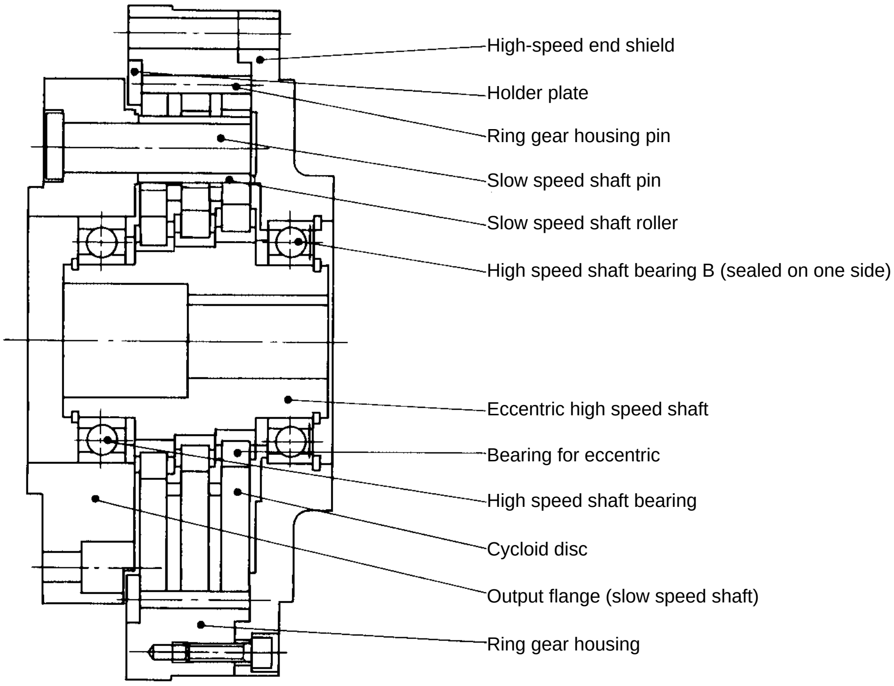
velocity $-\frac{1\omega 1}{P}$ or $-\frac{2\omega 1}{P}$

when P indicates the number of the teeth of the planet gear and the symbol indicates that the rotation of the planet gear is in a reverse direction to that of the crankshaft.
In the CYCLO gearmotor, illustrated in Fig. A-3, circular teeth(pins) are adapted for the sun gear and epitrochoid curved teeth for the planet gear, thereby avoiding tooth top interference. The rotation of the planet gear around its own axis is taken out through a constant speed internal gearing mechanism as shown in Fig. A-4.
In this mechanism shown in Fig. A-5, the pins of the slow speed shaft are evenly spaced on a circle that is concentric to the axis of the sun gear. The pins transmit the rotation of the planet gear by rolling internally on the circumference of the bores of each planet gear or cycloid disc. The diameter of the bores minus the diameter of the slow speed shaft pins is equal to twice the eccentricity value of the crank shaft (eccentric). This mechanism smoothly transmits only the rotation of the planet gear around its own axis to the slow speed shaft.

5. Construction & Advantages

(1) FC—A Series

Fig. A-6



●ADVANTAGES

1. LOW BACKLASH

Optimum load distribution provides stable repeatability.

2. COMPACTNESS

Three Cycloid discs provide more compactness.

3. OVERHUNG LOAD AVAILABLE FOR HIGH-SPEED SHAFT

High-speed shaft supported by two bearings provides overhung load capability without any additional parts.

4. LOW VIBRATION

Three Cycloid discs provide optimum load distribution. Stable load distribution provides low vibration.

5. HIGH STIFFNESS

Slow Speed shaft pins and optimum load distribution provide higher rigidity.

6. HIGH EFFICIENCY

Rolling contact of cycloid discs and optimum load distribution provide higher efficiency.

7. LONG LIFETIME

CYCLO is strong against shock load, with many simultaneous contact points made possible by its continuously curved gear-shape. In addition, many components of reducer part are made of high carbon and chromium bearing steels, which actualizes long lifetime.

8. EASY MAINTENANCE

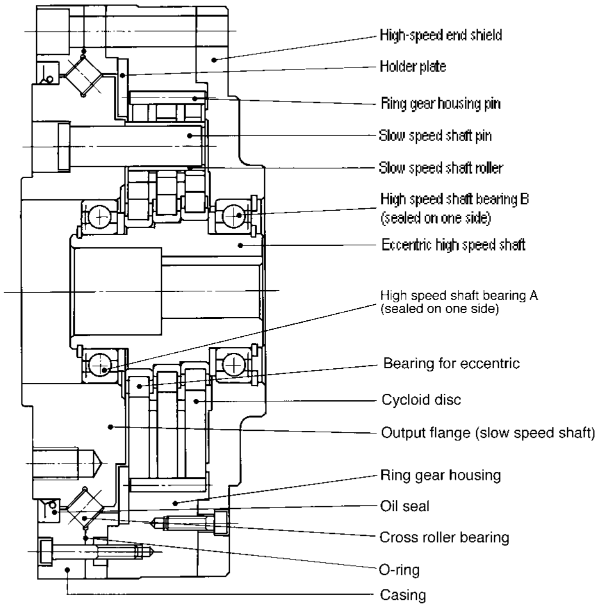
Output side flange and reduction section can be separated for easy maintenance.

9. EASY ASSEMBLY

Grease lubrication enables flexible mounting design.

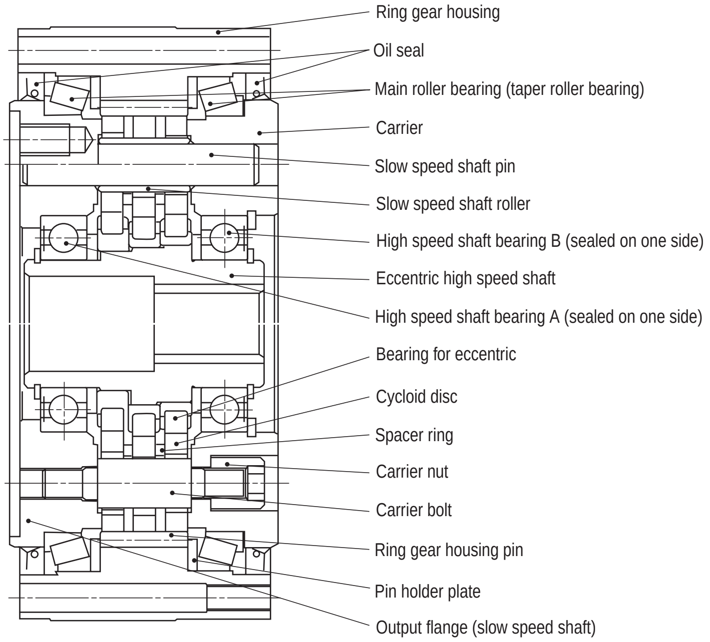
(2) F1C—A Series

Fig. A-7



(3) F2C—A Series

Fig. A-8



●ADVANTAGES

(1) F1C—A Series

In addition to advantages of FC-A Series, remarkable compactness is achieved in both directions of diameter and width because output shaft flange is shared with inner race of cross roller bearing.

(2) F2C—A Series

We have actualized significant increase in allowable moment by the use of great capacity taper roller bearing instead of cross roller along with more compact diameter and width.

Advantages of FC–A Series

1. Low backlash
2. Compactness
3. Overhung load available for high-speed shaft
4. Low vibration
5. High stiffness
6. High efficiency
7. Long lifetime
8. Easy maintenance
9. Easy assembly

+

Unique Advantage of F1C-A Series

Overall Cost Reduction

Overall cost reduction was actualized by reduction in assembly steps by shafts supported by bearing, and further, reduction of running cost by adopting maintenance free grease (Alvania RA).

Overhung Load Available for Slow Speed Shaft

Building in high rigidity compact cross roller bearing enabled support of radial load (moment shaft) by both input and output shaft of FC-A Series CYCLO DRIVE, which enabled input support in the prior version.

Unique Advantage of F1C-A Series

Overall Cost Reduction

F2C-A series has closed structure in addition with input and output shaft supported by bearing, which allows direct attachment to the customer's machine. This reduces overall cost, with shortened assembly time and by reducing running cost by becoming maintenance free.

Additional Increase in Compactness and Overhung Load Capacity

More compact size and larger output side radial load (moment) is allowed by taper roller bearing. It has more capacity and compact than F1C-A Series CYCLO DRIVE using cross roller.

6. Rating(FC−A, F1C−A, F2C−A Series)

Table A-2　Rating table (when used as reducer)

Model			Input speed (r/min)		4000			3000			2500			2000			1750		
			Frame size	Reduction ratio	Rated output torque (Upper／N•m) (Lower／kgf •m)	Output speed (r/min)	Allowable input power (kW)	Rated output torque (Upper／N•m) (Lower／kgf •m)	Output speed (r/min)	Allowable input power (kW)	Rated output torque (Upper／N•m) (Lower／kgf •m)	Output speed (r/min)	Allowable input power (kW)	Rated output torque (Upper／N•m) (Lower／kgf •m)	Output speed (r/min)	Allowable input power (kW)	Rated output torque (Upper／N•m) (Lower／kgf •m)	Output speed (r/min)	Allowable input power (kW)
FC—A Series	F1C—A Series	F2C—A Series	A15	59	111 11.3	67.8	0.98	121 12.3	50.8	0.80	128 13.0	42.4	0.71	136 13.9	33.9	0.60	142 14.5	29.7	0.55
				89	111 11.3	44.9	0.65	121 12.3	33.7	0.53	128 13.0	28.1	0.47	136 13.9	22.5	0.40	142 14.5	19.7	0.37
			A25	29				231 23.5	103	3.12	243 24.8	86.2	2.74	260 26.5	69.0	2.34	271 27.6	60.3	2.14
				59	260 26.5	67.8	2.30	284 28.9	50.8	1.88	299 30.5	42.4	1.66	321 32.7	33.9	1.42	334 34.0	29.7	1.29
				89	260 26.5	44.9	1.53	284 28.9	33.7	1.25	299 30.5	28.1	1.10	321 32.7	22.5	0.94	334 34.0	19.7	0.86
				119	260 26.5	33.6	1.14	284 28.9	25.2	0.93	299 30.5	21.0	0.82	321 32.7	16.8	0.70	334 34.0	14.7	0.64
			A35	29							429 43.7	86.2	4.83	458 46.7	69.0	4.13	477 48.6	60.3	3.76
				59				542 55.3	50.8	3.60	573 58.4	42.4	3.17	612 62.4	33.9	2.71	638 65.0	29.7	2.47
				89				542 55.3	33.7	2.39	573 58.4	28.1	2.10	612 62.4	22.5	1.80	638 65.0	19.7	1.64
				119				542 55.3	25.2	1.79	573 58.4	21.0	1.57	612 62.4	16.8	1.34	638 65.0	14.7	1.23
			A45	29										971 99.0	69.0	8.75	1010 103	60.3	7.97
				59							1187 121	42.4	6.57	1275 130	33.9	5.65	1324 135	29.7	5.13
				89							1187 121	28.1	4.36	1275 130	22.5	3.75	1324 135	19.7	3.40
				119							1187 121	21.0	3.26	1275 130	16.8	2.80	1324 135	14.7	2.55
			A65	29															
				59										2354 240	33.9	10.4	2453 250	29.7	9.51
				89										2354 240	22.5	6.91	2453 250	19.7	6.30
				119										2354 240	16.8	5.17	2453 250	14.7	4.71
			A75	29															
				59													3728 380	29.7	14.5
				89													3728 380	19.7	9.58
				119													3728 380	14.7	7.16

Table A-3　Maximum acceleration or deceleration torque

Model			Frame size	Maximum acceleration or deceleration torque		Peak torque for emergency stop			
						Allowable peak torque for emergency stop		Torque range requiring dowel pins (FC—A Serues only)	
				(N・m)	(kgf・m)	(N・m)	(kgf・m)	(N・m)	(kgf・m)
FC—A	F1C—A	F2C—A	A15	336	34.2	785	80	579	59
			A25	721	73.5	1933	197	1030	105
			A35	1393	142	3581	365	2345	239
			A45	2914	297	7210	735	4385	447
			A65	5131	523	13832	1410	8564	873
			A75	7613	776	24035	2450	9879	1007

1500			1000			750			600			Allowable maximum input speed (r/min)	Allowable mean input speed (r/min)		Equivalent on input shaft Upper/Moment of inertia ($\times 10^{-4}$kg·m^2) Lower/GD^2 ($\times 10^{-4}$kgf·m^2)		
Rated output torque (Upper／N·m) (Lower／kgf·m)	Output speed (r/min)	Allowable input power (kW)	Rated output torque (Upper／N·m) (Lower／kgf·m)	Output speed (r/min)	Allowable input power (kW)	Rated output torque (Upper／N·m) (Lower／kgf·m)	Output speed (r/min)	Allowable input power (kW)	Rated output torque (Upper／N·m) (Lower／kgf·m)	Output speed (r/min)	Allowable input power (kW)		50% ED	100% ED			
															FC—A	F1C—A	F2C—A
149 15.2	25.4	0.50	169 17.2	16.9	0.37	183 18.7	12.7	0.30	196 20.0	10.1	0.26	6150	5600	2800	0.31 1.25	0.32 1.26	0.46 185
149 15.2	16.9	0.33	169 17.2	11.2	0.25	183 18.7	8.43	0.20	196 20.0	6.74	0.17	6150	5600	2800	0.31 1.24	0.31 1.24	0.46 1.84
284 28.9	51.7	1.92	320 32.6	34.5	1.44	349 35.6	25.9	1.18	373 38.0	20.7	1.00	4350	3100	1550	1.38 5.50	1.40 5.58	1.42 5.68
349 35.6	25.4	1.16	394 40.2	16.9	0.87	430 43.8	12.7	0.71	460 46.9	10.1	0.61	5050	4200	2100	1.34 5.35	1.34 5.37	1.35 5.39
349 35.6	16.9	0.77	394 40.2	11.2	0.58	430 43.8	8.43	0.47	460 46.9	6.74	0.41	5050	4200	2100	1.33 5.32	1.33 5.33	1.34 5.36
349 35.6	12.6	0.58	394 40.2	8.40	0.43	430 43.8	6.30	0.35	460 46.9	5.04	0.30	5050	4200	2100	1.33 5.31	1.33 5.32	1.34 5.35
499 50.9	51.7	3.38	564 57.5	34.5	2.54	615 62.7	25.9	2.08	657 67.0	20.7	1.78	3500	2500	1250	4.45 17.8	4.50 18.0	4.58 18.3
668 68.1	25.4	2.22	754 76.9	16.9	1.67	822 83.8	12.7	1.37	879 89.6	10.1	1.17	3950	3300	1650	4.35 17.4	4.35 17.4	4.40 17.6
668 68.1	16.9	1.47	754 76.9	11.2	1.11	822 83.8	8.43	0.91	879 89.6	6.74	0.77	3950	3300	1650	4.33 17.3	4.33 17.3	4.35 17.4
668 68.1	12.6	1.10	754 76.9	8.40	0.83	822 83.8	6.30	0.68	879 89.6	5.04	0.58	3950	3300	1650	4.33 17.3	4.33 17.3	4.35 17.4
1059 108	51.7	7.16	1197 122	34.5	5.39	1305 133	25.9	4.41	1393 142	20.7	3.77	2700	1900	950	12.3 49.2		12.7 50.8
1383 141	25.4	4.60	1570 160	16.9	3.48	1707 174	12.7	2.84	1825 186	10.1	2.43	3150	2600	1300	12.0 48.0		12.1 48.5
1383 141	16.9	3.05	1570 160	11.2	2.30	1707 174	8.43	1.88	1825 186	6.74	1.61	3150	2600	1300	11.9 47.7		12.0 48.1
1383 141	12.6	2.28	1570 160	8.40	1.72	1707 174	6.30	1.41	1825 186	5.04	1.20	3150	2600	1300	11.9 47.7		12.0 48.1
1874 191	51.7	12.7	2109 215	34.5	9.50	2305 235	25.9	7.79	2462 251	20.7	6.66	2200	1500	750	46.8 187		
2570 262	25.4	8.54	2904 296	16.9	6.43	3159 322	12.7	5.25	3384 345	10.1	4.50	2350	2000	1000	45.8 183		
2570 262	16.9	5.66	2904 296	11.2	4.26	3159 322	8.43	3.48	3384 345	6.74	2.98	2350	2000	1000	45.5 182		
2570 262	12.6	4.23	2904 296	8.40	3.19	3159 322	6.30	2.60	3384 345	5.04	2.23	2350	2000	1000	45.5 182		
			3581 365	34.5	16.1	3904 398	25.9	13.2	4179 426	20.7	11.3	1950	1200	600	102 408		
3904 398	25.4	13.0	4405 449	16.9	9.76	4807 490	12.7	7.99	5140 524	10.1	6.83	2000	1750	850	100 401		
3904 398	16.9	8.60	4405 449	11.2	6.47	4807 490	8.43	5.29	5140 524	6.74	4.53	2000	1750	850	100 400		
3904 398	12.6	6.43	4405 449	8.40	4.84	4807 490	6.30	3.96	5140 524	5.04	3.39	2000	1750	850	100 399		

☐ : 50% ED range ▨ : 100% ED range

Notes:

1. Rated output torque
   Rated output torque implies allowable mean load torque at each output speed. Rated output torque for below 600r/min input is the same as 600r/min.
   Allowable input power is the value converted from rated output torque, when it is 100%. This value takes efficiency of CYCLO DRIVE in consideration.
2. Allowable maximum input speed and allowable mean input speed
   Reducer may be used within maximum input speed indicated in the Table, however, allowable mean input speed is limited by operation (%ED).
3. Allowable acceleration or deceleration peak torque
   Allowable peak torque at normal start and stop.
4. Allowable momentary maximum torque
   Allowable momentary maximum torque at emergency stop or heavy shock, when loading 1000 times in overall lifetime.
5. Moment of inertia, GD^2
   Value at input shaft. Divide them by g (Moment of inertia: 9.8m/sec^2) or 4g (GD^2: 4 x 9.8m/sec^2) to convert from them to inertia.

7. Engineering Data (FC-A, F1C-A, and F2C-A Series)

7-1. Stiffness and lost motion

Hysteresis curve shows the relationship between load and displacement of low speed shaft (deflected angle) when load is removed slowly from allowable torque to zero torque, with fixed input shaft.

There are two types of hysteresis curve at torsion; each close to 100% and 0% torque. Former is called stiffness and the latter is called lost motion.

Stiffness: Slope of the straight line connecting two points, when allowable torque is 50% and 100% on the hysteresis curve.

Lost Motion: Torsional deflected angle at ±3% of allowable output torque.

Fig. A-9 Hysteresis curve

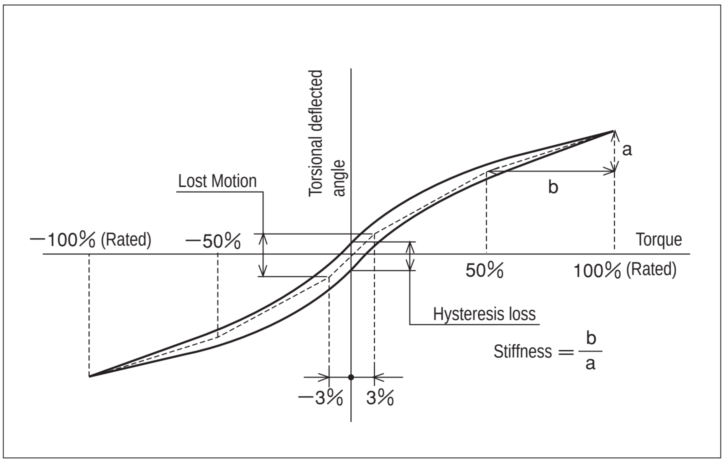


Table A-4 Engineering data

Frame size	Rated output torque 1750r／min Up／N•m Down／kgf•m	Lost Motion		Stiffness Up：N•m/arc min Down：kgf•m/arc min
		Measured torque (±) Up／N•m Down／kgf•m	Lost Motion arc min	
A15	142 14.5	4.32 0.44	1.0	27 2.8
A25	334 34	10.0 1.02		98 10
A35	638 65	19.1 1.95		208 21
A45	1324 135	39.7 4.05		441 45
A65	2453 250	73.6 7.50		765 78
A75	3728 380	112 11.4		1079 110

Note) Arc min indicates "minute" of the angle.
Stiffness is the average value (typical data).

(Example calculation of torsional deflected angle)

Calculation of torsion angle when torque is applied in one direction using A35 as example.

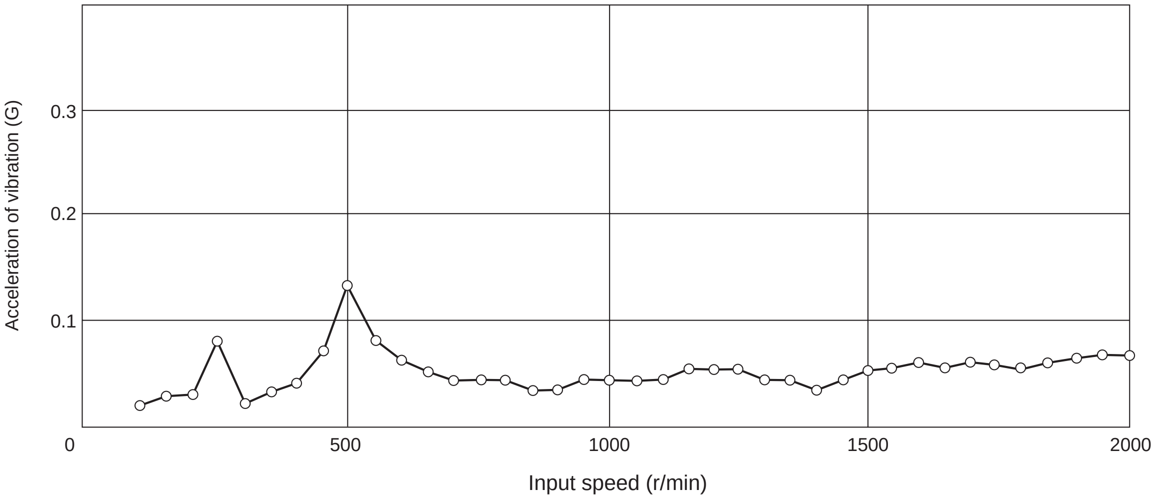
1) When load torque is 1.5kgf•m (When load torque is in the range of lost motion) $\theta_1 = \frac{1.5}{1.95} \times \frac{1}{2} = 0.38$ arc min

2) When load torque is 60kgf•m $\theta_1 = \frac{1}{2} + \frac{60-1.95}{21} = 3.3$ arc min

7-2. Vibration

Vibration indicates vibration of the disc (amplitude (mmp-p), acceleration (G)) when it is attached to output shaft and load of inertia is applied.

Fig. A-10 Value of Vibration at Flywheel (Constant Speed)



Measurement conditions

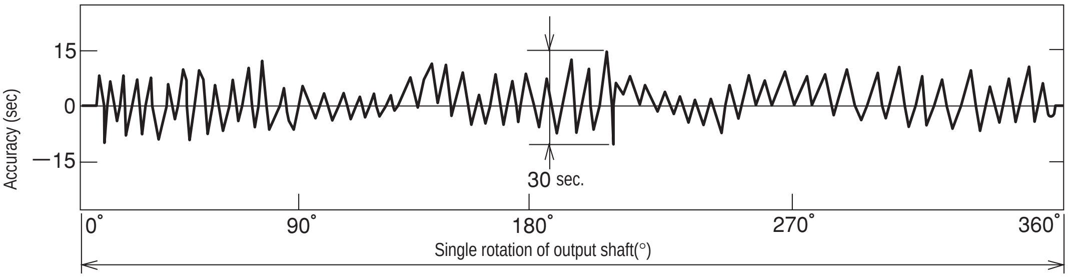
Type	FC-A35-59
Moment of inertia at output side	1100 kgf•cm•sec^2
Measured radius	550mm
Precision in Assembly Dimensions	Refer to 10-1-1.

7.3. Angle transmission accuracy

Angle transition accuracy"" indicates difference between theoretical output rotation angle and actual rotation angle when a rotation angle is applied to the input shaft.

$$\theta er(\text{Angle transmission accuracy}) = \frac{\theta in(\text{Rotation angle of input})}{i((\text{Reduction ratio})} - \theta out(\text{Actual rotation angle of input}$$

Fig. A-11　Angle transmission accuracy



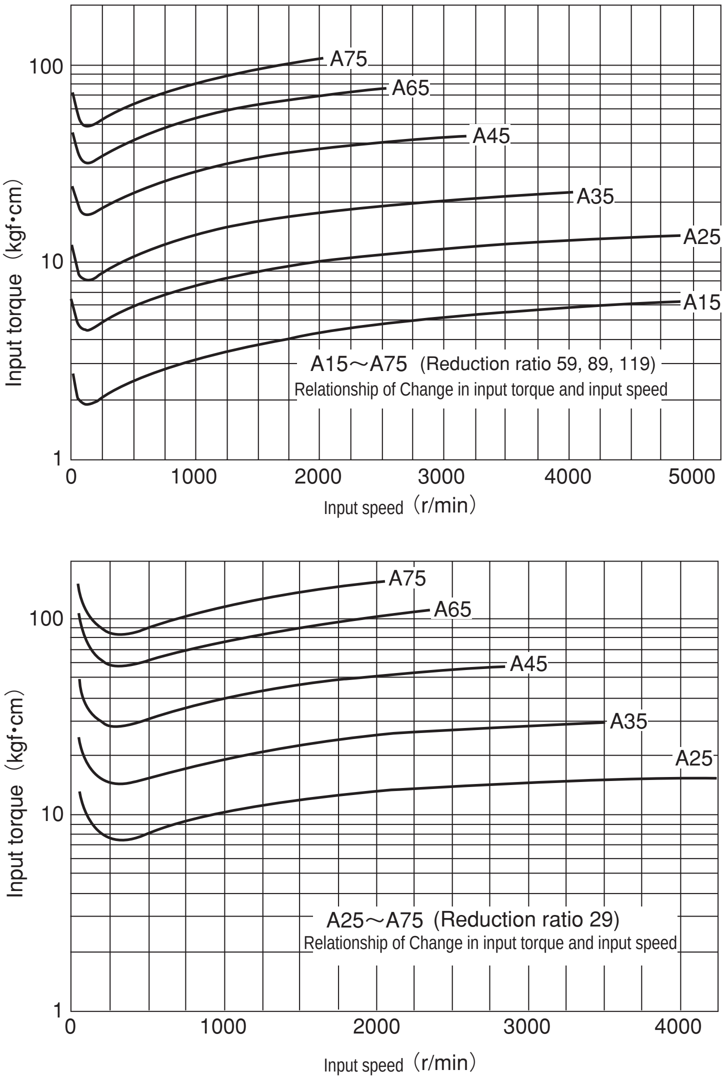
(Measurement condition)

Type	FC-A35-59
Load conditions	No load
Precision in assembly dimensions	Refer to 10.1.1

7-4. No Load Running Torque

No load running torque indicates torque on input shaft for rotating reducer under no-load condition.

Fig. A-12　Value of running torque under no load



Notes)　1. Fig. A-12 shows average data after reducers have been run.
2. Measurement Conditions

Ring gear housing temperature	Approx. 30°C
Accuracy in assembled dimensions	Refer to 10.1.1
Lubrication	Standard grease

7-5 No-Load Friction Torque on Output Shaft

Indicates torque necessary to start rotation from output side of reducer from stop without load.

Table A-5 Value of no-load friction torque on output shaft

Frame size	No-load friction torque on output shaft	
	N•m	kgf•m
A15	24	2.4
A25	49	5
A35	88	9
A45	167	17
A65	245	25
A75	392	40

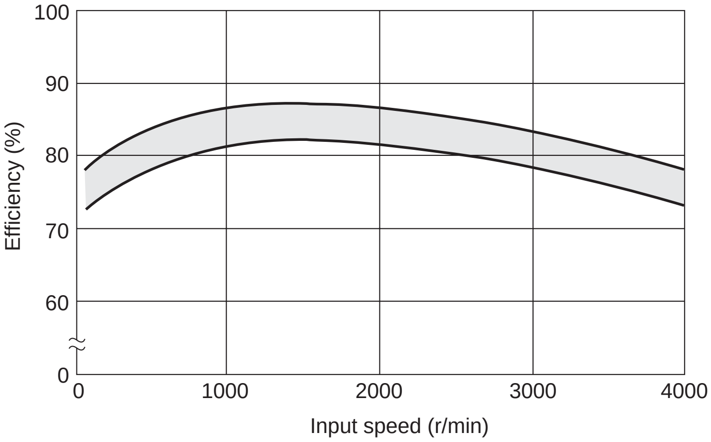
Notes: 1. Table A-5 shows average data after reducers have been run.

2. Measurement Conditions

Accuracy in assembled dimensions	Refer Item 10-1-1
Lubrication	Standard grease of FC-A Series

7-6 Efficiency

Fig. A-13 Efficiency Curve

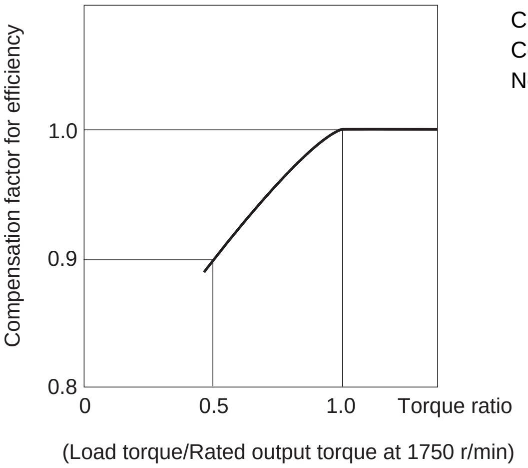


Efficiency varies by input speed, load torque, grease temperature, reduction ratio, etc.

Fig. A-13 indicates efficiency vs. input speed at allowable output torque with stable grease temperature.

Efficiency curve is indicated with flexible coverage for variations in models and reduction ratio.

Fig. A-14 Compensation Curve of Efficiency



Compensation efficiency=Efficiency（Fig.A-13) x Compensation factor for efficiency（Fig.A-14）

Note) 1. Efficiency varies when load torque differs with allowable torque. Check the compensation factor in the left diagram.

2. When torque ratio is over 1.0, compensation factor for efficiency is 1.0.

7-7. ALLOWABLE RADIAL LOAD & AXIAL LOAD OF HIGH SPEED SHAFT

When a gear or sheave is mounted on the high speed shaft, radial load and axial load should be equal to or less than allowable value. Check radial & axial load by following the next formula (①~③).

① Radial load Pr

$$Pr = \frac{T\ell}{R} \leqq \frac{Pro}{Lf \cdot Cf \cdot Fs_1} \text{ [N, kgf]} \qquad \text{(Formula A-1)}$$

② Axial load Pa

$$Pa \leqq \frac{Pao}{Cf \cdot Fs_1} \text{ [N, kgf]} \qquad \text{(Formula A-2)}$$

③ When radial and axial load co-exist

$$\left(\frac{Pr \cdot Lf}{Pro} + \frac{Pa}{Pao} \right) \cdot Cf \cdot Fs_1 \leqq 1 \qquad \text{(Formula A-3)}$$

Pr ：Actual radial load ［N, kgf］
Tℓ ：Equivalent torque on input shaft ［N•m, kgf•m］
R ：Pitch circle radius of sprocket, gear, or sheave ［m］
Pro ：Allowable radial load ［N, kgf］（Table A-6）
Pa ：Actual axial load ［N, kgf］
Pao ：Allowable axial load ［N, kgf］（Table A-7）
Lf ：（Table A-8）
Cf ：（Table A-9）
Fs_1 ：Shock factor（Table A-10）

Table A-6 Actual radial load Pro（Up：N／Down：kgf）

Frame size	Input speed r／min								
	4000	3000	2500	2000	1750	1500	1000	750	600
A15	226	245	255	275	294	304	353	383	412
	23	25	26	28	30	31	36	39	42
A25	334	363	392	422	441	461	530	579	628
	34	37	40	43	45	47	54	59	64
A35		491	520	559	589	618	706	775	834
		50	53	57	60	63	72	79	85
A45			608	657	687	716	824	903	981
			62	67	70	73	84	92	100
A65				883	932	981	1118	1236	1324
				90	95	100	114	126	135
A75					1177	1236	1413	1560	1668
					120	126	144	159	170

Table A-7 Actual axial load Pao（Up：N／Down：kgf）

Frame size	Input speed r／min								
	4000	3000	2500	2000	1750	1500	1000	750	600
A15	245	284	314	343	363	392	471	549	608
	25	29	32	35	37	40	48	56	62
A25	363	412	451	500	540	579	697	804	883
	37	42	46	51	55	59	71	82	90
A35		598	647	726	765	824	1001	1089	1089
		61	66	74	78	84	102	111	111
A45			1010	1118	1197	1285	1285	1285	1285
			103	114	122	131	131	131	131
A65				1442	1442	1442	1442	1442	1442
				147	147	147	147	147	147
A75					2119	2276	2766	3169	3208
					216	232	282	323	327

Table A-8 Load location on input shaft Lf

L（mm）	Frame size					
	A15	A25	A35	A45	A65	A75
10	0.90	0.86				
15	0.98	0.93	0.91			
20	1.25	1.00	0.96	0.89		
25	1.56	1.25	1.09	0.94		
30	1.88	1.50	1.30	0.99	0.89	0.89
35	2.19	1.75	1.52	1.13	0.93	0.92
40		2.00	1.74	1.29	0.97	0.96
45			1.96	1.45	1.02	0.99
50			2.17	1.61	1.14	1.09
60				1.94	1.36	1.30
70					1.59	1.52
80					1.82	1.74
Lf=When 1ofL（mm）	16	20	23	31	44	46

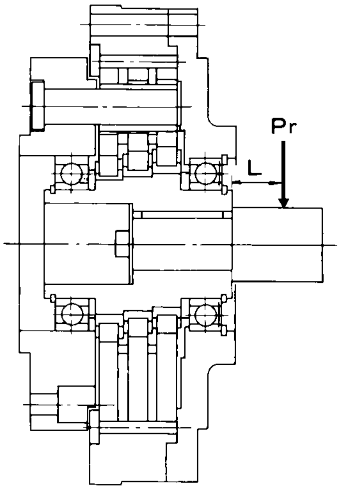


Fig. A-15 Load location on input shaft (Fig: FC-A Series)

Table A-9 Load location factor Cf

Connection method	Cf
General purpose chain	1
Machine gear or pinion	1.25
Timing belt	1.25
V-Belt	1.5

Table A-10 Shock factor Fs_1

Shock classification	Cf
Uniform load (no shock)	1
Moderate shocks	1～1.2
Heavy shocks	1.4～1.6

8. Main Bearings (F1C-A, F2C-A Series)

8-1. F1C-A Series

Check radial load on output shaft by the following formula.

$$Pr \leqq \frac{Pro}{Lf \cdot Cf \cdot Fs_1} \text{ [N, kgf]} \cdots\cdots\cdots\cdots\cdots \text{ (Formula A-4)}$$

Pr ：Actual radial load ［N, kgf］
Pro ：Allowable radial load ［N, kgf］（Table A-12）
Lf ：Load location factor （Table A-13）
Cf ：Load connection factor （Table A-14）
Fs_1 ：Shock factor （Table A-15）

Calculate equivalent radial load by following formula when radial and axial load coexists on slow speed shaft.

$$Pra = X \cdot Pr + Y \cdot Pa \cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{(Formula A-5)}$$

Pra ：Equivalent radial load ［N, kgf］
Pr ：Equivalent axial load ［N, kgf］
Pa ：Dynamic radial load factor ［N, kgf］
X ：Dynamic axial load factor （Table A-11）
Y ： （Table A-11）

Table A-11 Dynamic Radial Load Factor and Dynamic Axial Load Factor

	X	Y
$\frac{Pa}{Pr} \leqq 1.5$	1	0.45
$\frac{Pa}{Pr} > 1.5$	0.67	0.67

Table A-12 Allowable Radial Load Pro（Top: N／Bottom: kgf）

Frame size	Output speed r／min									
	～10	15	20	25	30	35	40	45	50	55
A15	7308	6484	5896	5474	5150	4895	4679	4493	4336	4199
	745	661	601	558	525	499	477	458	442	428
A25	7838	6828	6170	5709	5346	5062	4817	4621	4444	4287
	799	696	629	582	545	516	491	471	453	437
A35	17069	14941	13577	12596	11841	11232	10722	10301	9928	9604
	1740	1523	1384	1284	1207	1145	1093	1050	1012	979

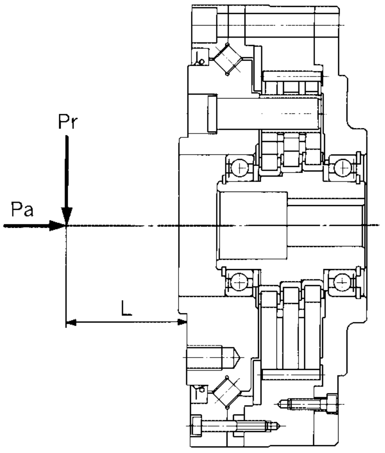


Fig. A-16 Load location on output shaft

Table A-13 Load Location Factor Lf

L（mm）	Frame size		
	A15	A25	A35
5	0.70	0.69	0.68
10	0.75	0.73	0.72
15	0.80	0.77	0.75
20	0.85	0.81	0.78
25	0.90	0.85	0.82
30	0.95	0.89	0.85
35	1.00	0.94	0.88
40	1.04	0.98	0.92
45	1.10	1.02	0.95
50	1.15	1.06	0.98
55	1.20	1.10	1.02
60	1.25	1.14	1.05
65		1.18	1.10
70			1.14
Lf=When 1 of L（mm）	35	43	52

Table A-14 Load Connection Factor Cf

Connection method	Cf
General purpose chain	1
Machine gear or pinion	1.25
Timing belt	1.25
V-Belt	1.5

Table A-15 Shock Factor Fs_1

Shock classification	Fs_1
Uniform load (no shock)	1
Moderate shocks	1～1.2
Heavy shocks	1.4～1.6

8-2. F2C-A Series

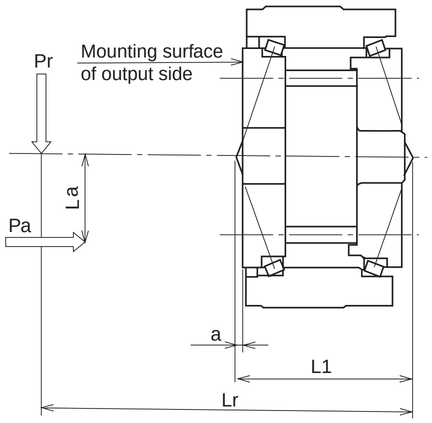


Fig. A-17 Span between each loading point

Note）Consult us if Lr>4XL1.

Pr：Actual radial load（N, kgf）
Pa：Actual axial load（N, kgf）

Table A-16 Span of Loading Points（mm）

Frame size	Span of Loading Points	
	L_1 (mm)	a (mm)
A15	72.6	6.5
A25	80.4	8.7
A35	108	14.5
A45	139.2	20.6

Table A-17 Moment stiffness

Frame size	Moment stiffness	
	（N•m／arcmin）	（kgf•m／arcmin）
A15	343	35
A25	589	60
A35	1177	120
A45	1570	160

1. Moment Stiffness

Indicates stiffness on inclination of output shaft with external moment.

External moment (M)

$M = Pr \cdot Lr + Pa \cdot La$ ·············· （Formula A-6）

2. Allowable Moment & Allowable Axial Load

Check external moment and external axial load with Formula A-7, Formula A-8 and Fig. A-18.

Equivalent moment (Me)

$Me = Cf \cdot Fs_1 \cdot Pr \cdot Lr + Cf \cdot Fs_1 \cdot Pa \cdot La$ ·· （Formula A-7）

Equivalent axial load (Pae)

$Pae = Cf \cdot Fs_1 \cdot Pa$ ·················· （Formula A-8）

Cf：Load Connection Factor［Table A-19］
Fs_1：Shock factor［Table A-20］

Table A-18 Allowable Moment & Allowable Axial Load

Frame size	Allowable moment		Allowable axial load	
	（N•m）	（kgf•m）	（N）	（kgf）
A15	608	62	2453	250
A25	1030	105	3924	400
A35	1619	165	5396	550
A45	2551	260	6867	700

Table A-19 Load Connection Factor Cf

Connection method	Cf
General purpose chain	1
Machine gear or pinion	1.25
Timing belt	1.25
V-belt	1.5

Table A-20 Shock factor Fs_1

Shock classification	Fs_1
Uniform load (no shock)	1
Moderate shocks	1～1.2
Heavy shocks	1.4～1.6

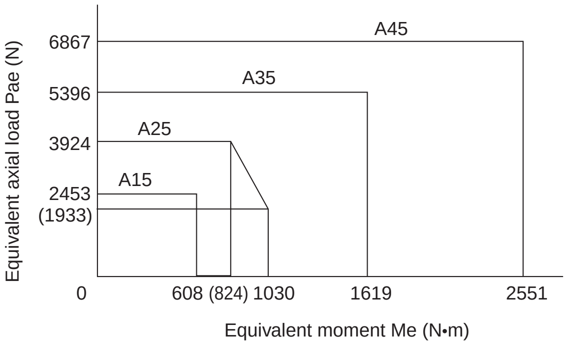
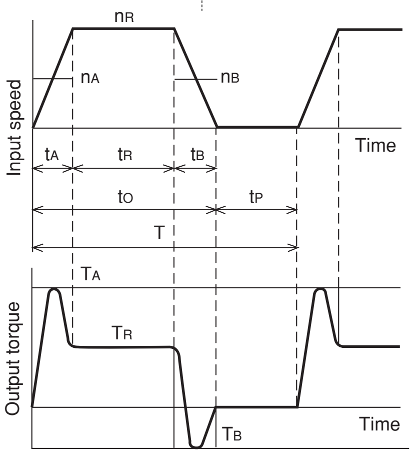


Fig. A-18 Diagram of Allowable Moment & Axial Load

9. Selection

9-1. Flow Cart and Formula of Selection

Fig. A-19 Load Cycle



n_A : Average input speed during acceleration under condition defined in Fig. A-19

$$n_A = \frac{n_R}{2}$$

n_R : Input speed with normal running

n_B : Average input speed during deceleration Fig. A-19

$$n_B = \frac{n_R}{2}$$

t_A : Acceleration time

t_R : Normal running time

t_B : Deceleration time

t_O : Total running time

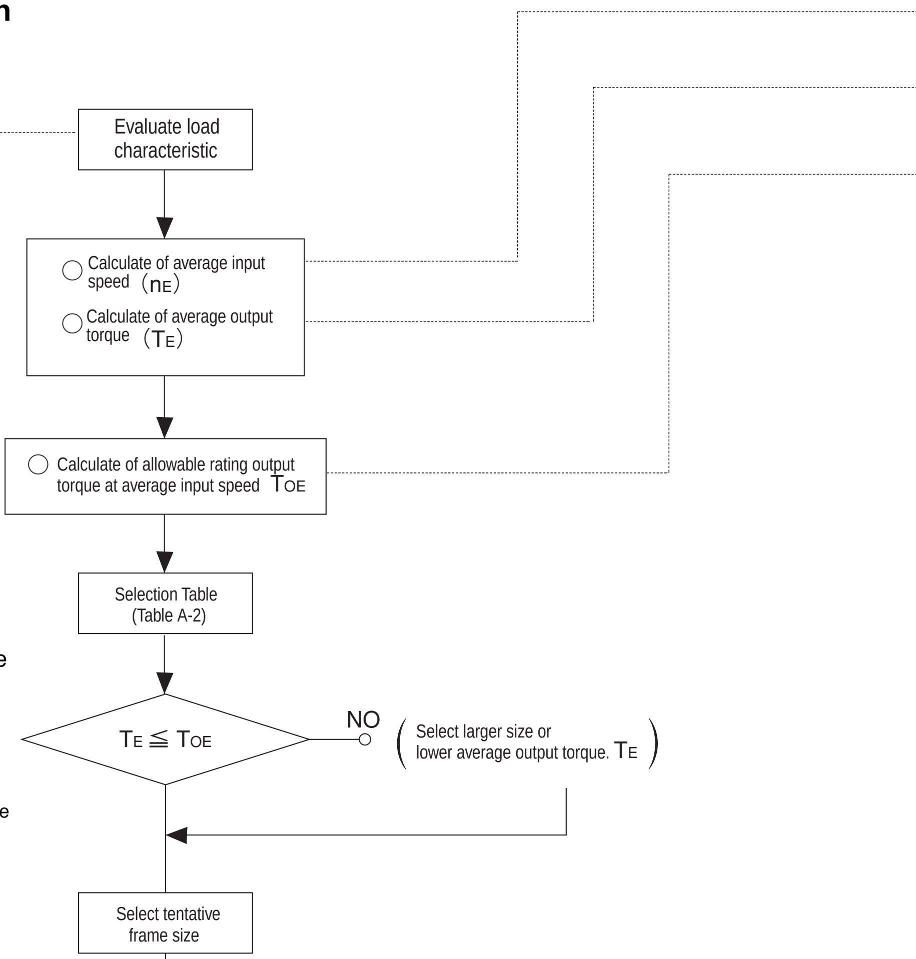
t_P : Standstill time

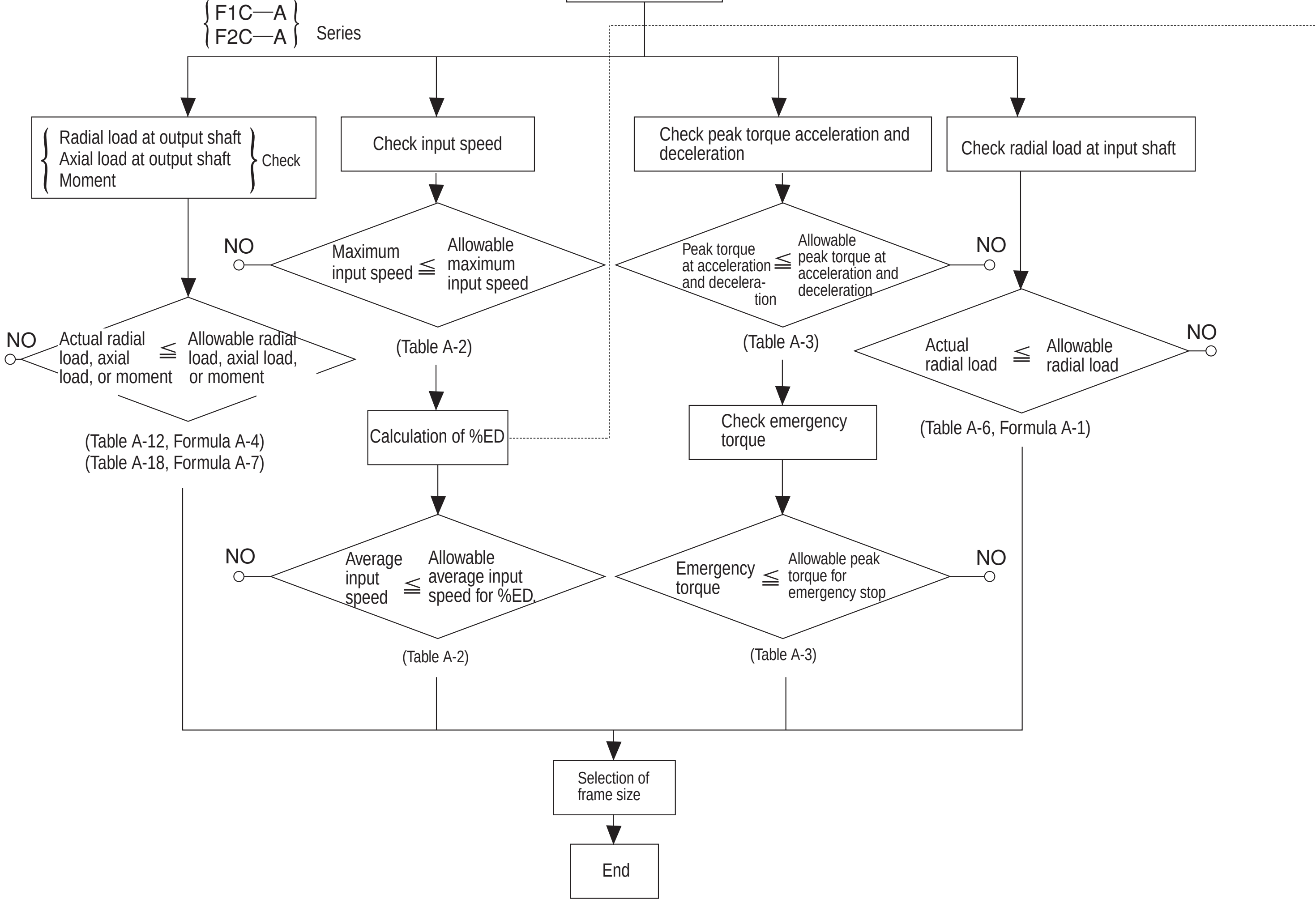
T : Time/Cycle

T_A : Acceleration peak torque

T_R : Torque during normal running

T_B : Peak torque at braking





Calculation in Load Condition of Fig.A-19

○ Average input speed $n_E = \dfrac{t_A \cdot n_A + t_R \cdot n_R + t_B \cdot n_B}{t_O}$ ……………………………（Formula A-9）

○ Average output torque $T_E = \left(\dfrac{t_A \cdot n_A \cdot T_A^{10/3} + t_R \cdot n_R \cdot T_R^{10/3} + t_B \cdot n_B \cdot T_B^{10/3}}{t_O \cdot n_E} \right)^{0.3} \times F_{S2}$ ‥ （Formula A-10）

○ Allowable rating output torque at average input speed $T_{OE} = \left(\dfrac{600}{n_E} \right)^{0.3} \times T_O$ …………………（Formula A-11）

To: Rated output torque at input speed 600r/min (Table A-2)

$n_E <$ When nE<600, ToE equals to To at input speed 600r/min.

○%ED $\%ED = \dfrac{t_O}{T} \times 100$ ………………………………… （Formula A-12）

Maximum of single cycle time is 10 minutes when calculating %ED. When single cycle time is over 10 minutes, calculate %ED as T=10 (minutes).

Table A-21 F_{S2} Load factor

Loading condition	F_{S2}
Uniform load	1
Moderate shock	1～1.2
Heavy shock	1.4～1.6

9-2. Example of Selection

Evaluate F1C-A25-119 for following specification.

(Specification)

T_A : Acceleration peak torque 600N•m

T_R : Normal running torque 250N•m

T_B : Peak torque at breaking 400N•m

Emergency torque: 1800N-m (1000 times during overall life time)

n_A : Average input speed during acceleration 1250r/min

n_R : Input speed with normal running 2500r/min

n_B : Average input speed during deceleration 1250r/min

t_A : Acceleration time 0.3sec

t_R : Normal running time 3.0sec

t_B : Deceleration time 0.3sec

t_P : Total running time 3.6sec

t_O : Standstill time 3.6sec

T : Single cycle time 7.2sec

Radial load at input shaft : Operated by timing belt with moderate shock 196N at point 25mm from end of shaft

Radial load at output shaft : Connection with gear, moderate shock 3433N at 55mm point from side of flange

It considered that reducer is used to operate wrist of robot with moderate shock.

(Calculate) Average input speed $n_E = \dfrac{0.3 \times 1250 + 3.0 \times 2500 + 0.3 \times 1250}{3.6} = 2292\,(\text{r/min})$

Average output torque $T_E = \left(\dfrac{0.3 \times 1250 \times 600^{10/3} + 3.0 \times 2500 \times 250^{10/3} + 0.3 \times 1250 \times 400^{10/3}}{3.6 \times 2292} \right)^{0.3} \times 1 = 306\,(\text{N} \cdot \text{m})$

○ Allowable output torque at average input speed $T_{OE} = \left(\dfrac{600}{2292} \right)^{0.3} \times 460 = 308\,(\text{N} \cdot \text{m}) \geqq 306\,(\text{N} \cdot \text{m})$ →F1C—A25—119

○Calculate of %ED $\%ED = \dfrac{3.6}{7.2} \times 100 = 50\%$

○Evaluate of maximum input speed 2500 (r/min) ＜5050 (r/min) （Table A-2）

○Evaluate of average input speed 2292 (r/min) at50％ED＜4200 (r/min) at50％ED （Table A-2）

○Evaluate of peak torque at acceleration and deceleration 600 (N•m) ＜721 (N•m) （Table A-3）

○Evaluate of emergency torque 1800(N-m) < 1933(N-m) (with dowel pins) （Table A-3）

○Allowable radial load at input shaft with coefficient in consideration

Pro=41kgf, Lf =1.25, Cf =1.25, Fs1=1.2 $\dfrac{Pro}{Lf \times Cf \times F_{S1}} = \dfrac{402}{1.25 \times 1.25 \times 1.2} = 214\,(\text{N}) > 196\,(\text{N})$ (Table A-6、Formula A-1)

○Allowable radial load at output shaft with coefficient in consideration

Pro= 629 Lf =1.1 Cf =1.25 Fs1=1.2 $\dfrac{Pro}{Lf \times Cf \times F_{S1}} = \dfrac{6170}{1.1 \times 1.25 \times 1.2} = 3739\,(\text{N}) > 3433\,(\text{N})$ — (Table A-12、Formula A-4)

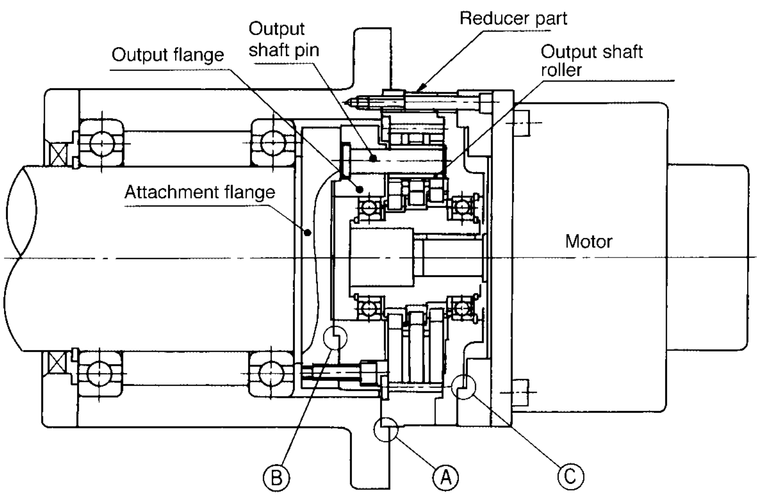
F1C-A25-119 is selected by evaluation above.

10. Notice for Designing

10-1. FC-A Series

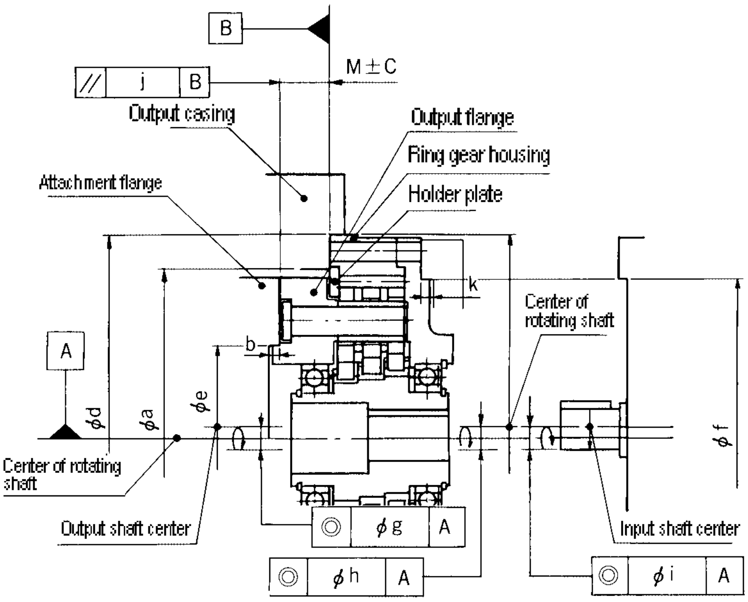
10-1-1 Precision in Assembly Dimensions

Fig. A-20 Method of Assembly



- ● Output side flange does not have bearing support on the reducer unit side. Always support by the bearing on the machine side as in the left diagram.
- ● Pilot for mounting CYCLO FC-A Series is as [A], [B], and [C] in Fig.A-20.
- ● Conform to necessary precision in assembly dimensions in "Table A-22" while designing and manufacturing, to maintain quality of products.

Fig. A-21 Precision in assembly dimensions



- ● Diameter should be less than φa to be secured by holder plate.
- ● Depth of attachment flange should be more than b.
- ● Attachment size between casing and attachment flange should be M±C to prevent output flange interfering with reducer part.
- ● Recommended precision of concentricity and parallelism for attachment parts should be the same as or less than Table A-22.
- ● Recommended attachment dimensions are d, e, and f in Table A-22.

Table A-22 (Unit：mm)

Frame size	a Max.	b Min.	k Min.	M±C	Attachment pilot			Concentricity for center of rotating shaft			Parallelism
					d	e	f	g	h	i	j
A15	90	5	4	15.5±0.3	φ115H7	φ 45H7	φ 85H7	φ0.030	φ0.030	φ0.030	0.025／87
A25	115	6	5	21±0.3	φ145H7	φ 60H7	φ110H7	φ0.030	φ0.030	φ0.030	0.035／112
A35	144	6	5	24±0.3	φ180H7	φ 80H7	φ135H7	φ0.030	φ0.030	φ0.030	0.040／137
A45	182	8	6	27±0.3	φ220H7	φ100H7	φ170H7	φ0.030	φ0.030	φ0.040	0.050／172
A65	226	8	6	33±0.3	φ270H7	φ130H7	φ210H7	φ0.030	φ0.030	φ0.040	0.065／212
A75	262	8	6	38±0.3	φ310H7	φ150H7	φ235H7	φ0.030	φ0.030	φ0.040	0.070／237

(3) DOWEL PIN HOLE REWORKING

Fig. A-22　Dowel Pins For Output Flange

Use two or three pre-drilled openings for dowel pins, on same pitch circle, for fastening dowel pins.

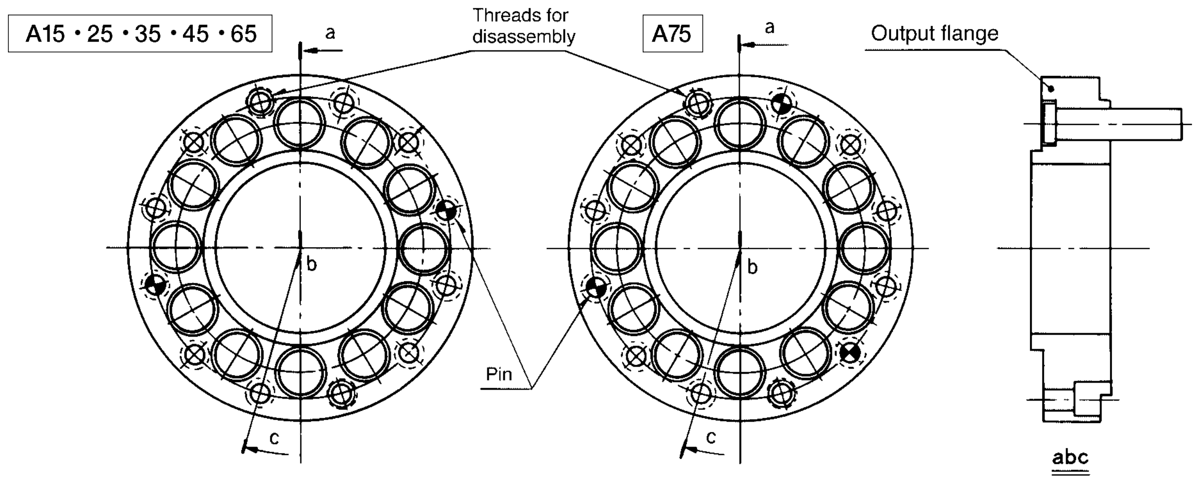
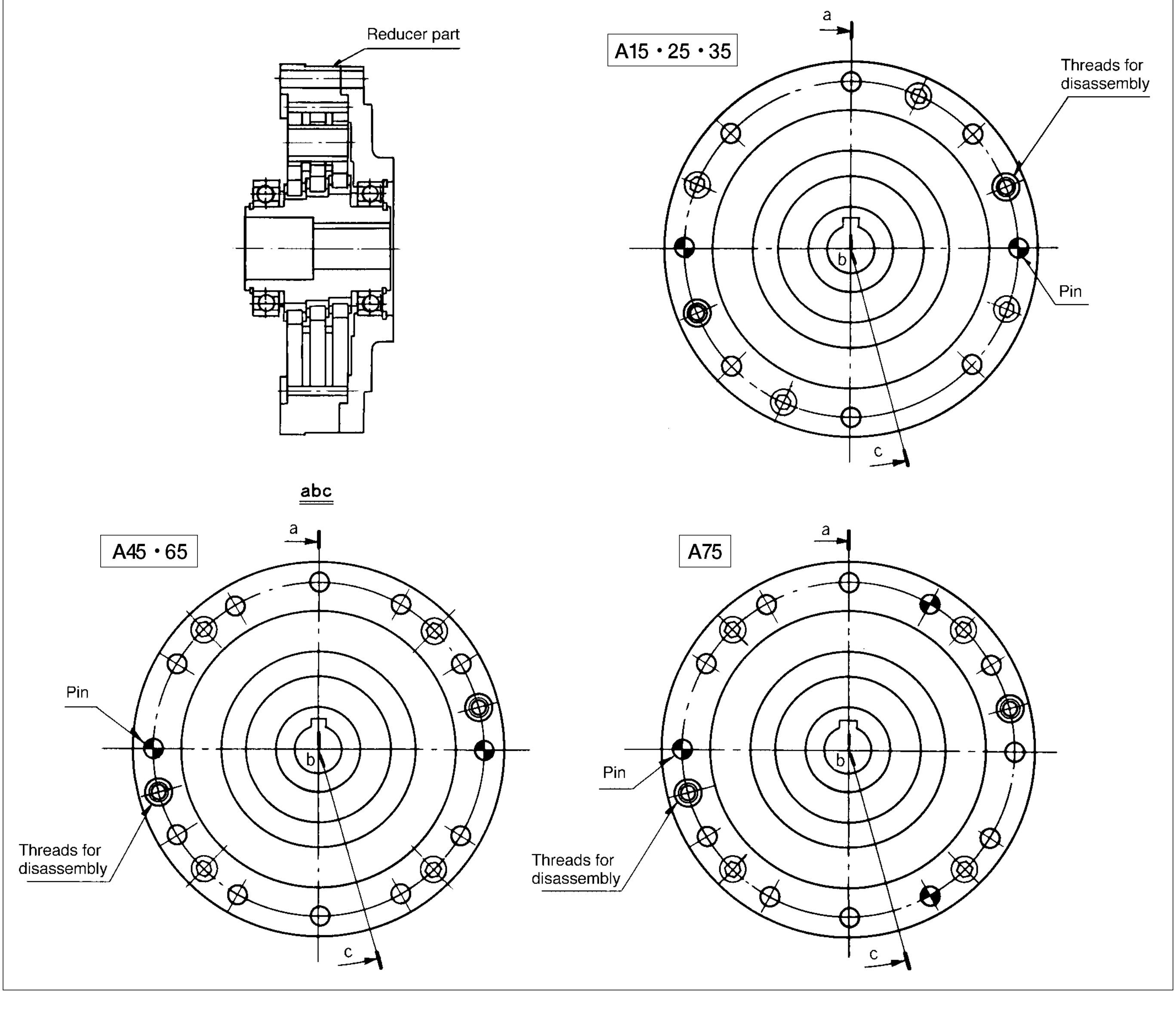


Fig. A-23　Dowel Pins For Ring Gear Housing

Use two or three pre-drilled openings for dowel pins, on same pitch circle, for fastening dowel pins.



10-1-2. Tightening Torque for Bolts and Allowable Transmitted Torque

(1) Allowable Transmitted Torque Limited by Bolts

Quantity, size, and tightening torque of bolt for output flange and ring gear housing are shown in Table A-23.

Allowable transmitted torque for the bolts are shown in Table A-24. (Rated output torque, allowable acceleration or deceleration, peak torque, and moderate shock torque can be transmitted.)

Use dowel pins in addition if the torque applied to reducer exceeds the allowable transmitted torque.

Table A-23

Frame size	Output flange bolts			Ring gear housing bolts		
	Number of bolts-size	Tightening torque		Number of bolts-size	Tightening torque	
		N•m	kgf•cm		N•m	kgf•cm
A15	12—M5	9.32	95	8—M5	9.32	95
A25	12—M6	15.7	160	8—M6	15.7	160
A35	12—M8	38.3	390	8—M8	38.3	390
A45	12—M10	76.5	780	12—M8	38.3	390
A65	12—M12	133	1360	12—M10	76.5	780
A75	12—M12	133	1360	12—M10	76.5	780

● Bolt: Use metric hexagon socket head cap screw based on JIS B1176, strength grade 12.9.
● Countermeasure for bolts loosening: Use adhesives (Loctite262, etc.) or spring washer (based on JIS B1252, class 2).

Table A-24

Frame size	Allowable transmitted torque limited by bolts	
	N•m	kgf•m
A15	579	59
A25	1030	105
A35	2345	239
A45	4385	447
A65	8564	873
A75	9879	1007

● Friction coefficient: 0.15

(2) Allowable transmitted torque with bolts and dowel pins

When output torque loaded reducer is over allowable transmitted torque in Table A-24, use dowel pins following Table A-25.

Allowable peak torque for emergency stop shown in Table A-3 can be transmitted with dowel pins also.

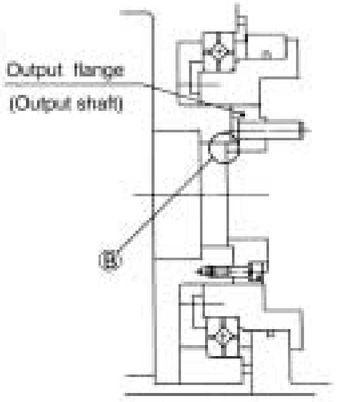
Table A-25

Frame size	Output flange bolts		Ring gear housing bolts	
	Number of bolts-size	Number of dowel pins material-size	Number of bolts-size	Number of dowel pins material-size
A15	10—M5	2—ϕ6	6 —M5	2—ϕ6
A25	10—M6	2—ϕ8	6 —M6	2—ϕ8
A35	10—M8	2—ϕ10	6 —M8	2—ϕ10
A45	10—M10	2—ϕ13	10—M8	2—ϕ10
A65	10—M12	2—ϕ16	10—M10	2—ϕ13
A75	9 —M12	3—ϕ16	9 —M10	3—ϕ16

● Dowel pins material：Should be equivalent to S45C (shearing stress of more than 294N/mm^2) or more.
● Condition for tightening bolts is as the data shown in Table A-23.

10-1-3. Assembly Procedure

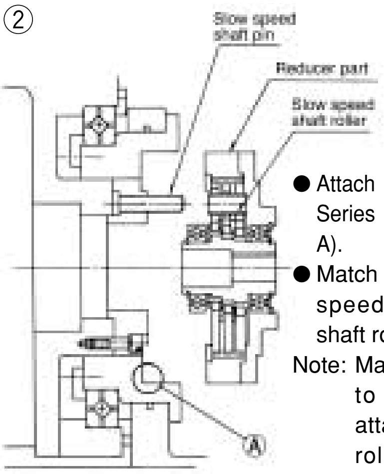
①



- ● Output flange of CYCLO F-Series is attached to the output shaft of the machine with bolts. (Pilot B)

Note: Grease supply at the time of assembly is not necessary. CYCLO DRIVE is filled with grease (Showa-Shell Alvania RA) before shipment to customer.

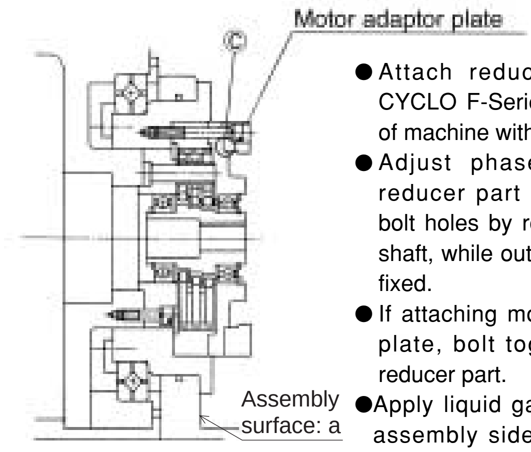
②



- ● Attach reducer parts of CYCLO F-Series to casing of machine (Pilot A).
- ● Match the phase between slow speed shaft pins and output shaft rollers at the beginning.

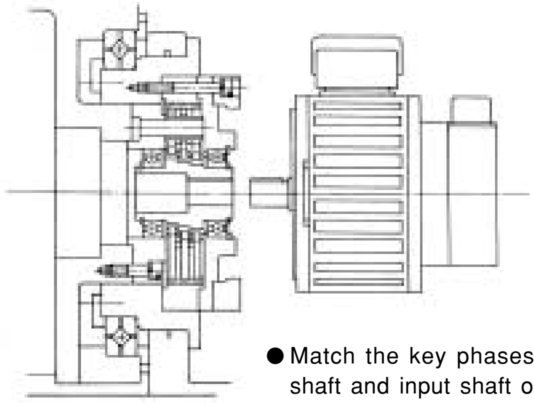
Note: Make sure to attach reducer to machine casing after attaching slow speed shaft rollers to reducer. If not, spacer rings (refer to drawing) may brake.

③



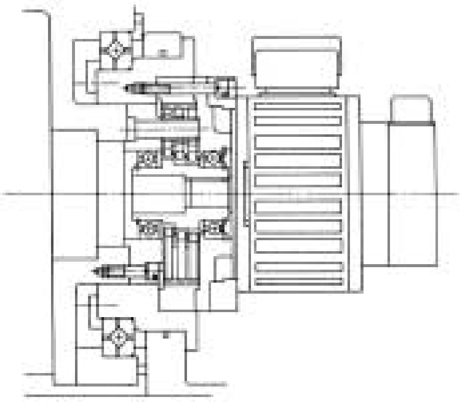
- ● Attach reducer part of CYCLO F-Series to casing of machine with bolts.
- ● Adjust phase between reducer part and casing bolt holes by rotating input shaft, while output flange is fixed.
- ● If attaching motor adapter plate, bolt together with reducer part.
- ●Apply liquid gasket to the assembly side "a" at this point.

④



- ● Match the key phases of motor shaft and input shaft of reducer. Then attach motor to CYCLO reducer with bolts. (Apply fretting prevention agent to motor shaft before assembly.)

⑤



Notes1) Make sure to apply specified tightening torque(refer to Table A-23) to bolts when attaching reducer.
Recommended liquid gasket: Liquid gasket Three Bond 1215 of Three Bond Co., Ltd.

10-1-4 Lubrication

- ● Grease supply at the time of assembly (see Table A-26) is not necessary. CYCLO DRIVE is filled with grease (Showa-Shell Alvania RA) before shipment to customer.
- ● Overhaul recommended when reducer runs for total 20000 hours or 3-5 years after purchase.
- ● Overhaul requires experience and technique. F-CYCLO must be sent to SHI-factory.

Table A-26 Quantity of grease (Unit：g)

Frame size	A15	A25	A35	A45	A65	A75
Grease	20	40	70	120	180	270

(Condition of use) Ambient temperature（—10～40℃）

10-2. F1C-A Series

10-2-1 Precision in assembly dimensions

Fig. A-24 Assembly Method

- Pilot for mounting input parts (motor, etc.) are as [C] in following figure.
- Use [B] for output shaft assembly and [A] for casing assembly as pilot for mounting.

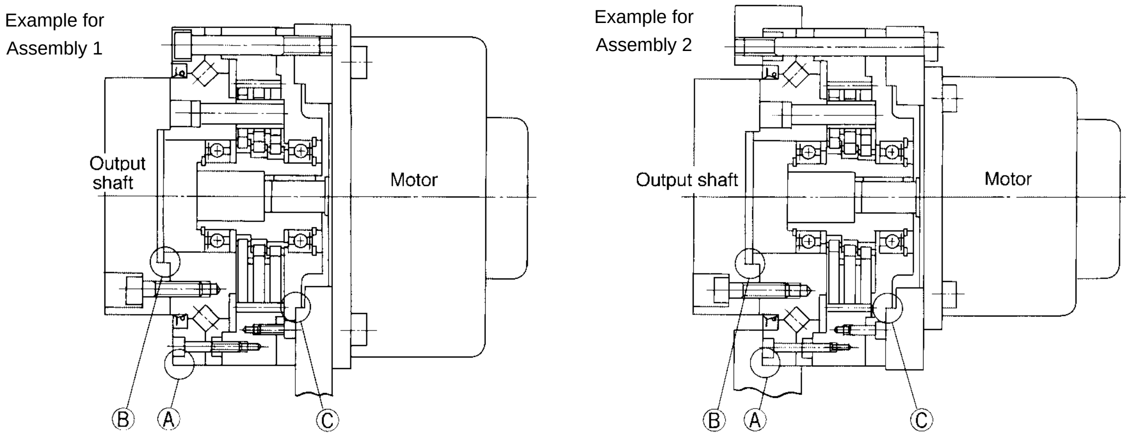
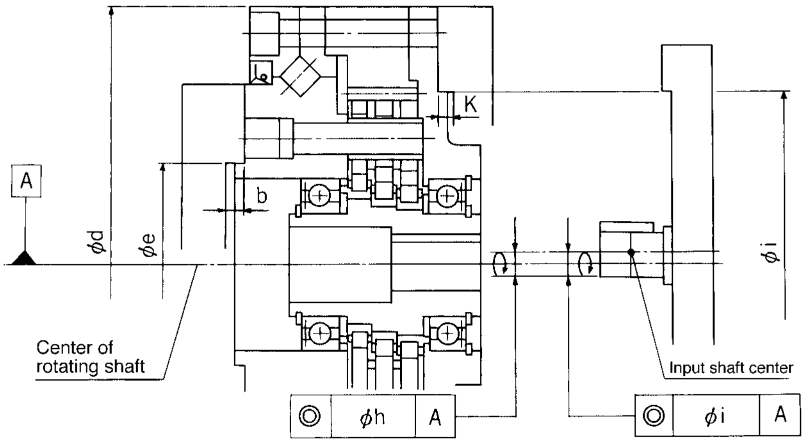


Fig. A-25 Precision in assembly dimensions



- Depth of attachment flange should be more than b.
- Recommended precision of concentricity for attachment parts should be the same as or less than Table A-27.
- Attachment pilots are d, e, f in Table A-27.

Table A-27

Frame size	b	k	Attachment pilot			Concentricity for center of rotating shaft	
	Min.	Min.	d	e	f	h	i
A15	5	4	φ140H7	φ45H7	φ 85H7	φ0.030	φ0.030
A25	6	5	φ170H7	φ60H7	φ110H7	φ0.030	φ0.030
A35	6	5	φ205H7	φ80H7	φ135H7	φ0.030	φ0.030

10-2-2. Tightening Torque and Allowable Transmitted Torque

(1) Allowable Transmitted Torque Limited by Bolts

Quantity, size, and tightening torque of bolt for the output flange and ring gear housing are shown in Table A-28. Allowable peak torque for emergency stop that can be transmitted is shown in Table A-29.

Table A-28

Frame size	Output flange bolts			Ring gear housing bolts		
	Number of bolts-size	Tightening torque		Number of bolts-size	Tightening torque	
		N•m	kgf•cm		N•m	kgf•cm
A15	12—M6	15.7	160	12—M6	15.7	160
A25	12—M8	38.3	390	12—M8	38.3	390
A35	12—M10	76.5	780	12—M10	76.5	780

- Bolt : Use metric hexagon socket head cap screw based on JIS B1176, strength grade 12.9.
- Countermeasure for bolts loosening: Use adhesives (Loctite262, etc.) or spring washer (based on JIS B1252, class 2).

Table A-29

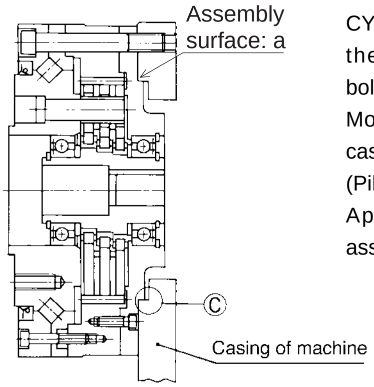
Frame size	Allowable transmitted torque by bolts	
	N•m	kgf•m
A15	932	95
A25	2090	213
A35	3885	396

- Friction coefficient: 0.15

10-2-3 Assembly Procedure

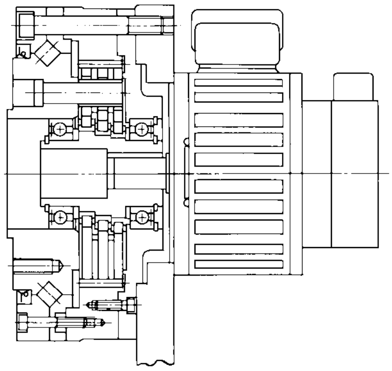
Example for Assembly 1

①



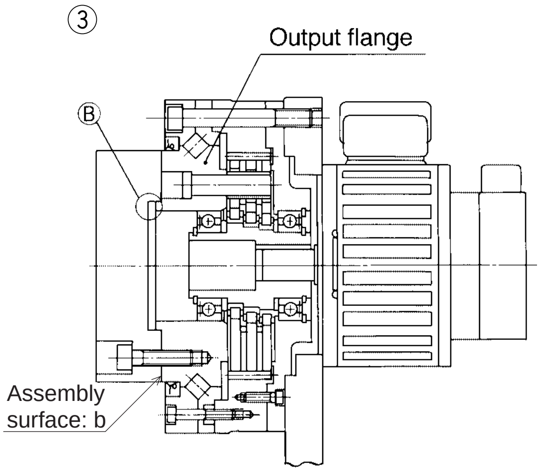
CYCLO F-Series is attached to the casing of machine with bolts.
Motor adaptor is a part of the casing in this example.
(Pilot: C)
Apply liquid gasket to the assembly side "a" at this point.

②



Match the phase of motor shaft and input shaft of reducer. Attach motor to reducer parts with bolts.
(Apply prevention agent for fretting to motor shaft before assembly.)

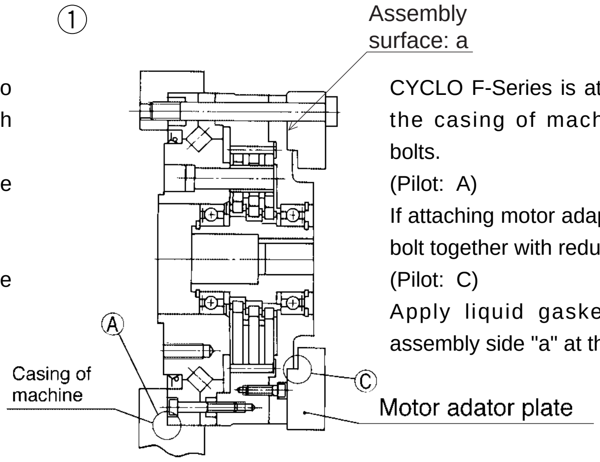
③



Attach output flange of CYCLO to output shaft of machine by bolts.
(Pilot: B)
Apply liquid gasket to the assembly side "b" at this point.

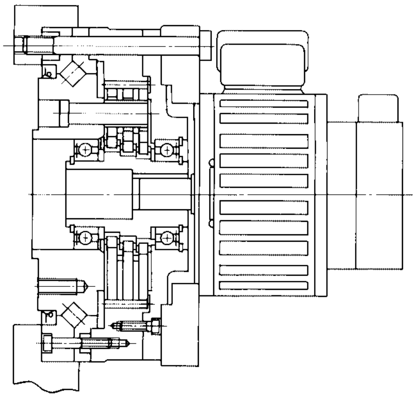
Example for Assembly 2

①



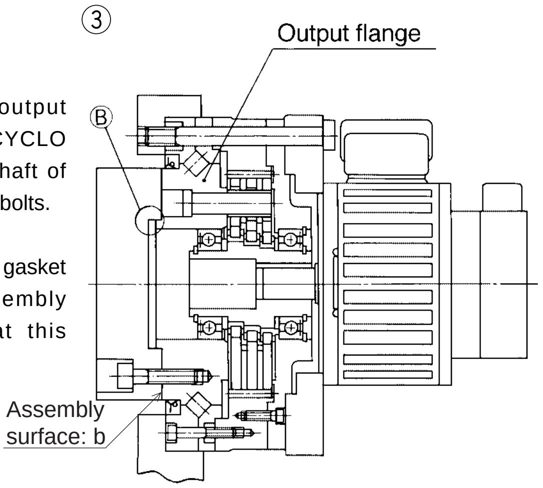
CYCLO F-Series is attached to the casing of machine with bolts.
(Pilot: A)
If attaching motor adapter plate, bolt together with reducer part.
(Pilot: C)
Apply liquid gasket to the assembly side "a" at this point.

②



Match the phase of motor shaft and input shaft of reducer. Attach motor to reducer parts with bolts.
(Apply prevention agent for fretting to motor shaft before assembly.)

③



Attach output flange of CYCLO to output shaft of machine by bolts.
(Pilot: B)
Apply liquid gasket to the assembly side "b" at this point

Notes1) Make sure to apply specified tightening torque(refer to Table A-28) to bolts when attaching reducer.
Notes2) Choose bolts shorter then the depth of tap indicated in output side flange in Outline Drawing (P37-P39), when attaching output shaft to output side flange (slow speed shaft)of CYCLO DRIVE.
Recommended liquid gasket: Liquid gasket Three Bond 1215 of Three Bond Co., Ltd.

10-2-4. Lubrication

- Grease supply at the time of assembly (see Table A-26) is not necessary. CYCLO DRIVE is filled with grease (Showa-Shell Alvania RA) before shipment to customer.
- Overhaul recommended when reducer runs for total 20000 hours or 3-5 years after purchase.
- Overhaul requires experience and technique. F-CYCLO must be sent to SHI-factory.

Table A-30 Quantity of grease （Unit：g）

Frame size	A15	A25	A35
Grease	20	40	70

(Condition of use) Ambient temperature（—10～40℃）

10-3 F2C-A Series

10-3-1 Precision in assembly dimensions

Fig. A-26 Assembly Method

- Pilot for mounting input parts (motor, etc.) are as [C] in following figure.
- Use [B] for output shaft assembly and [A] for casing assembly as pilot for mounting.

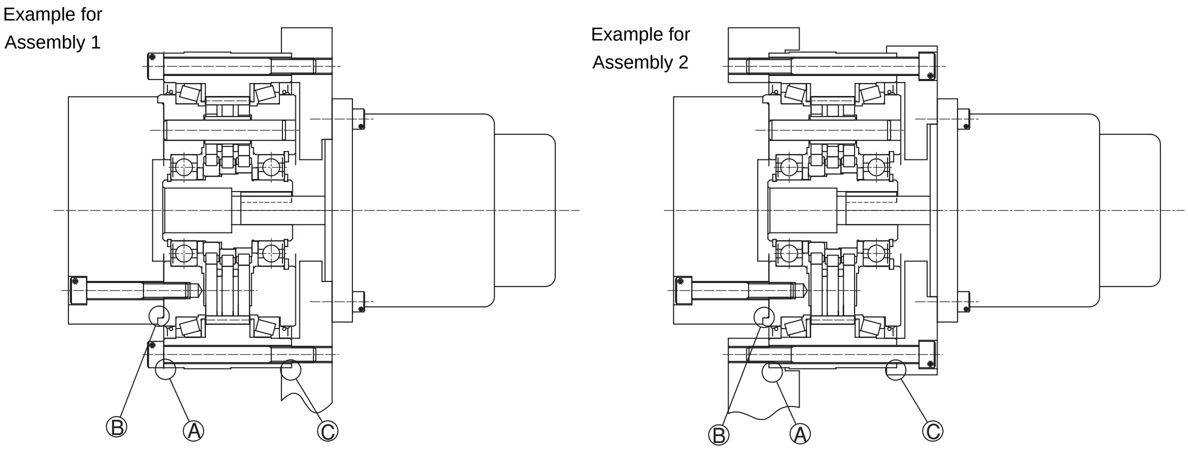
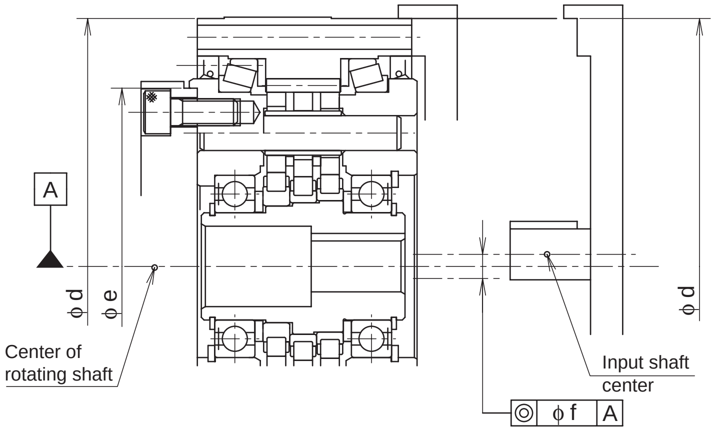


Fig. A-27 Precision in assembly dimensions



- Recommended precision of concentricity for attachment parts should be the same as or less than Table A-31.
- Attachment pilots are d, e, f in Table A-31.

Table A-31

Frame size	d	e	f
A15	125H7	84h7	0.03
A25	155H7	106h7	0.03
A35	185H7	133h7	0.03
A45	230H7	167h7	0.03

10-3-2. Tightening Torque and Allowable Transmitted Torque

(1) Allowable Transmitted Torque Limited by Bolts

Quantity, size, and tightening torque of bolt for the output flange and ring gear housing are shown in Table A-32. Allowable peak torque for emergency stop that can be transmitted is shown in Table A-33.

Table A-32

Frame size	Output flange bolts			Ring gear housing bolts		
	Number of bolts-size	Tightening torque		Number of bolts-size	Tightening torque	
		N•m	kgf•cm		N•m	kgf•cm
A15	12—M6	15.7	160	16—M6	12.8	130
A25	12—M8	38.3	390	12—M8	31.4	320
A35	12—M10	76.5	780	16—M8	31.4	320
A45	12—M14	206	2100	12—M12	107	1090

- Bolt : Use metric hexagon socket head cap screw based on JIS B1176, strength grade 12.9.
- Countermeasure for bolts loosening: Use adhesives (Loctite262, etc.) or spring washer (based on JIS B1252, class 2).

Table A-33

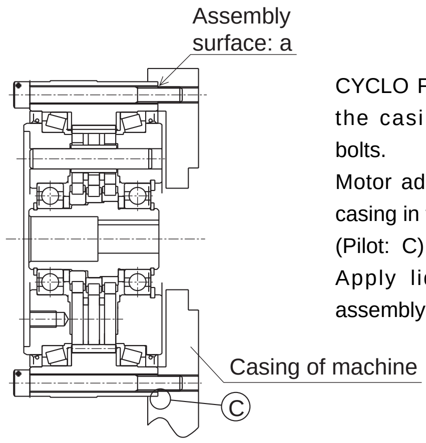
Frame size	Allowable transmitted torque by bolts	
	N•m	kgf•m
A15	736	75
A25	1678	171
A35	3384	345
A45	8525	869

- Friction coefficient: 0.15

10-3-3 Assembly Procedure

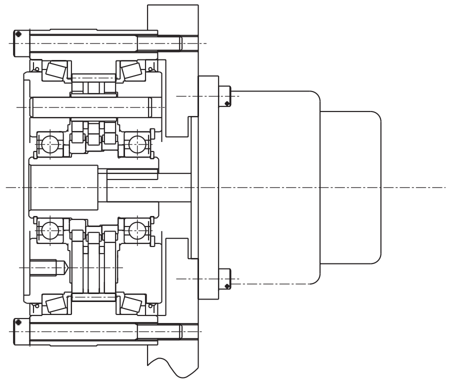
Example for Assembly 1

①



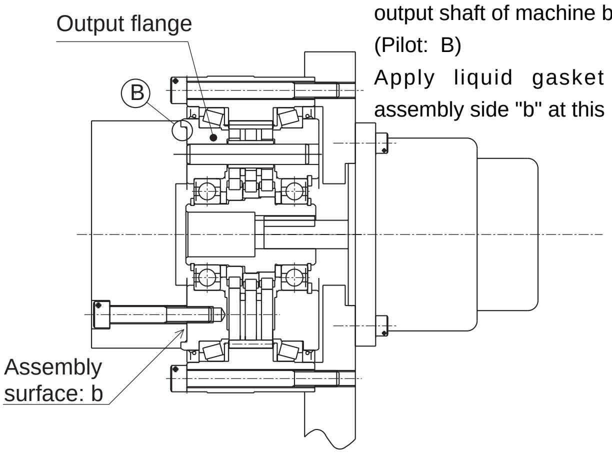
CYCLO F-Series is attached to the casing of machine with bolts.
Motor adaptor is a part of the casing in this example.
(Pilot: C)
Apply liquid gasket to the assembly side "a" at this point.

②



Match the phase of motor shaft and input shaft of reducer. Attach motor to reducer parts with bolts.
(Apply prevention agent for fretting to motor shaft before assembly.)

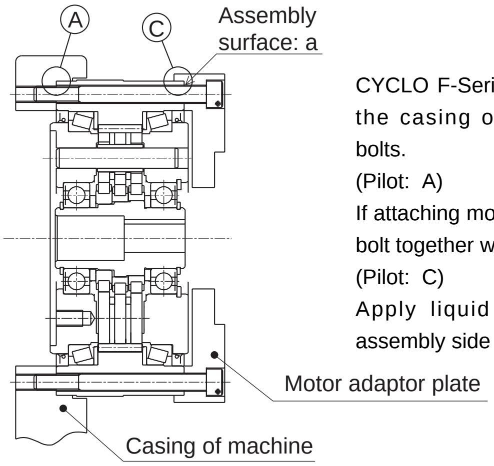
③



Attach output flange of CYCLO to output shaft of machine by bolts.
(Pilot: B)
Apply liquid gasket to the assembly side "b" at this point.

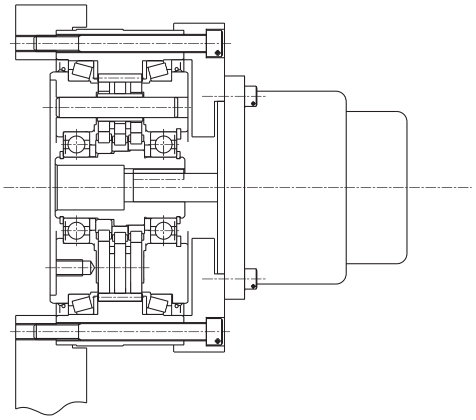
Example for Assembly 2

①



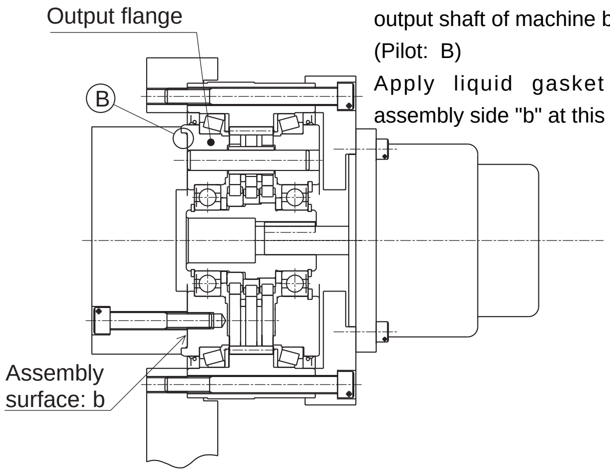
CYCLO F-Series is attached to the casing of machine with bolts.
(Pilot: A)
If attaching motor adapter plate, bolt together with reducer part.
(Pilot: C)
Apply liquid gasket to the assembly side "a" at this point.

②



Match the phase of motor shaft and input shaft of reducer. Attach motor to reducer parts with bolts.
(Apply prevention agent for fretting to motor shaft before assembly.)

③



Attach output flange of CYCLO to output shaft of machine by bolts.
(Pilot: B)
Apply liquid gasket to the assembly side "b" at this point.

Notes1) Make sure to apply specified tightening torque(refer to Table A-32) to bolts when attaching reducer.
Notes2) Choose bolts shorter then the depth of tap indicated in output side flange in Outline Drawing (P41-P44), when attaching output shaft to output side flange (slow speed shaft)of CYCLO DRIVE.
Recommended liquid gasket: Liquid gasket Three Bond 1215 of Three Bond Co., Ltd.

10-3-4. Lubrication

● Grease supply at the time of assembly (see Table A-26) is not necessary. CYCLO DRIVE is filled with grease (Showa-Shell Alvania RA) before shipment to customer.
● Overhaul recommended when reducer runs for total 20000 hours or 3-5 years after purchase.
● Overhaul requires experience and technique. F-CYCLO must be sent to SHI-factory.

Table A-34　Grease supply（F2C—A Series）（Unit：g）

Frame size	A15	A25	A35	A45
Grease	30	80	160	240

(Condition of use) Ambient temperature（—10～40℃）

Outline Drawing

FC—A Series
F1C—A Series
F2C—A Series

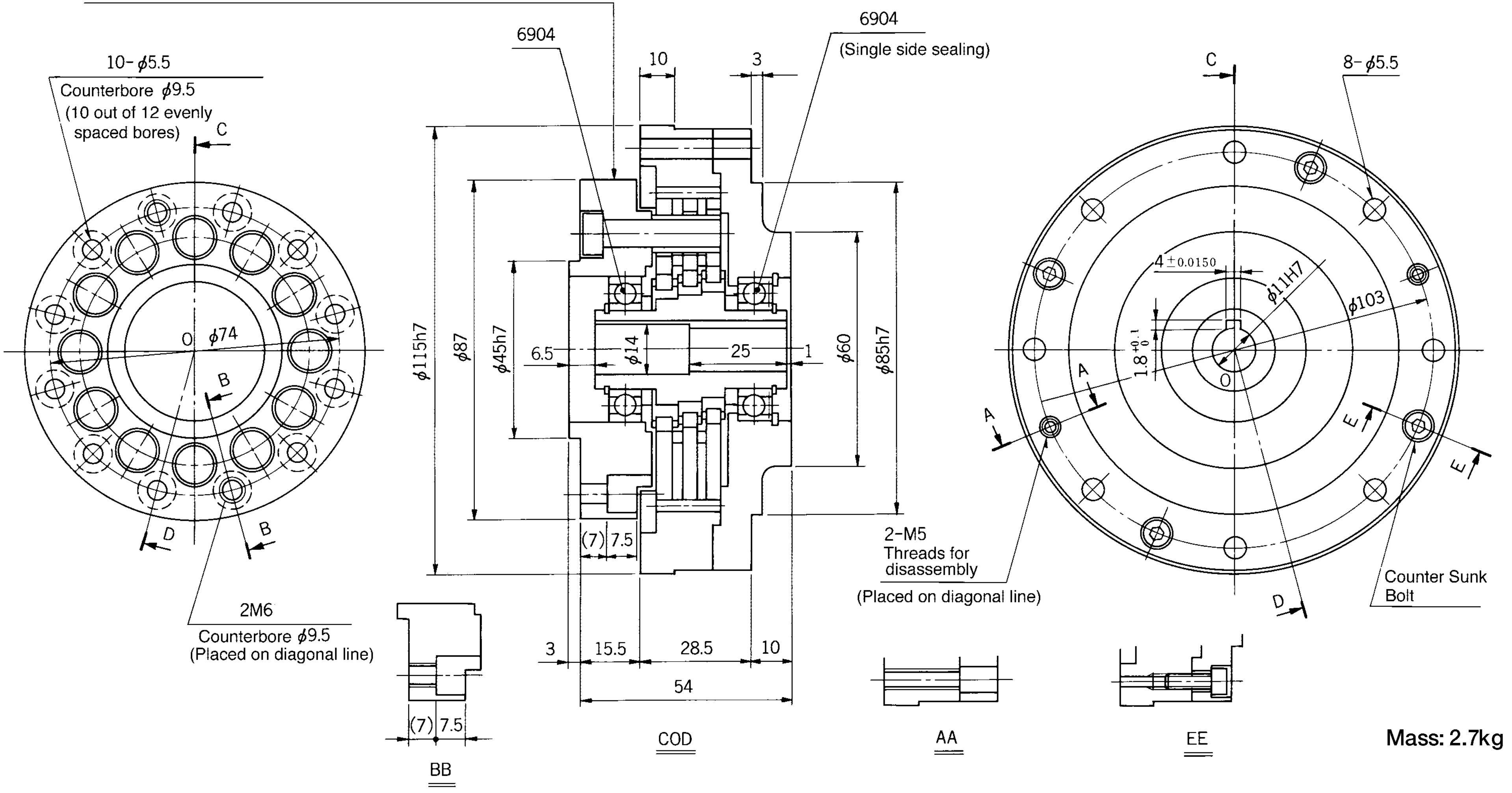
Index

FC—A Series

FC—A15 Outline Drawing

Output flange side requires bearing support on the machine side.
Refer to "10-1. FC-A Series" in section "10. Notice for Designing" on pages 19-20 for support method and installation precision.

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



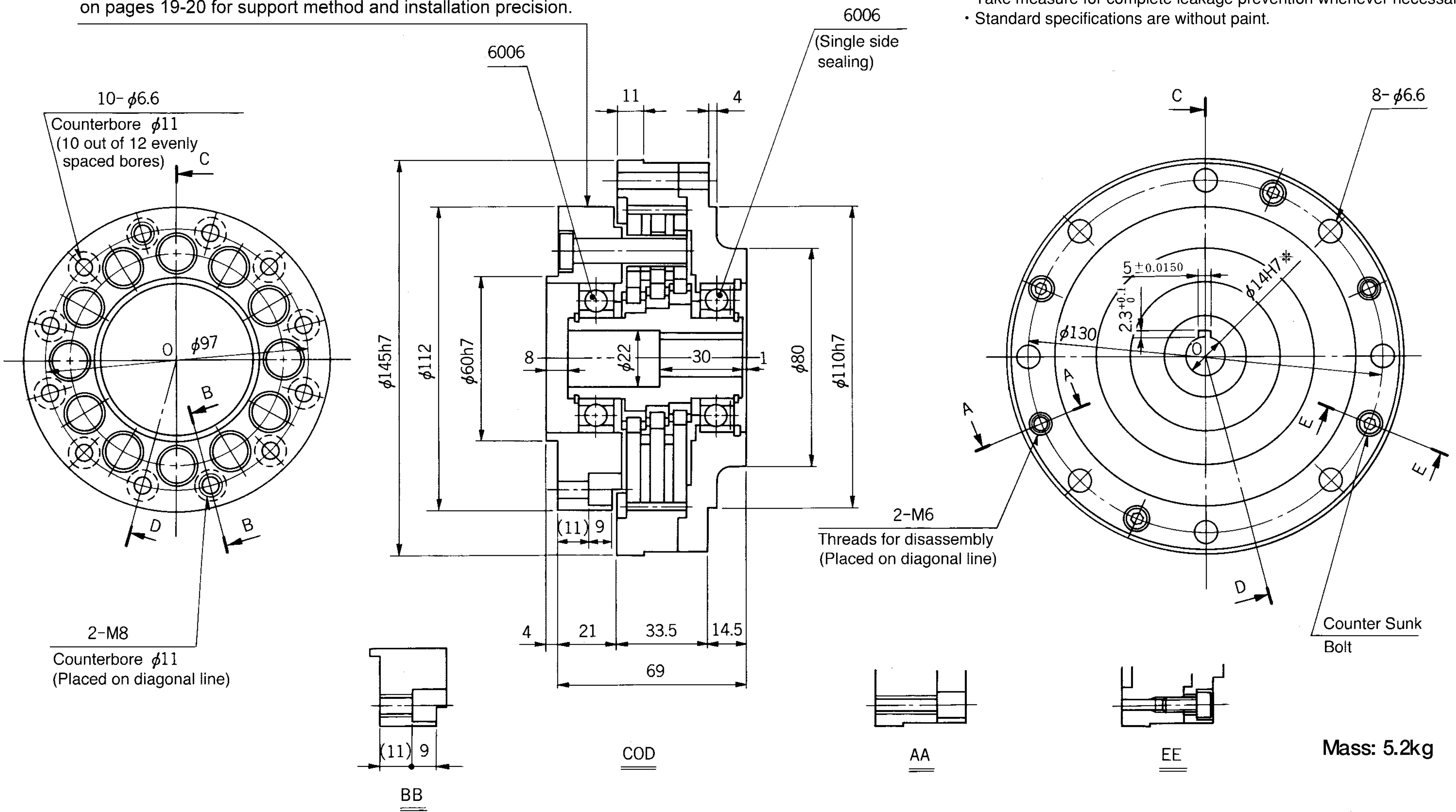
Mass: 2.7kg

※Maximum of diameter for high speed shaft bore is ϕ11mm.

FC—A25 Outline Drawing

Output flange side requires bearing support on the machine side.
Refer to "10-1. FC-A Series" in section "10. Notice for Designing" on pages 19-20 for support method and installation precision.

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



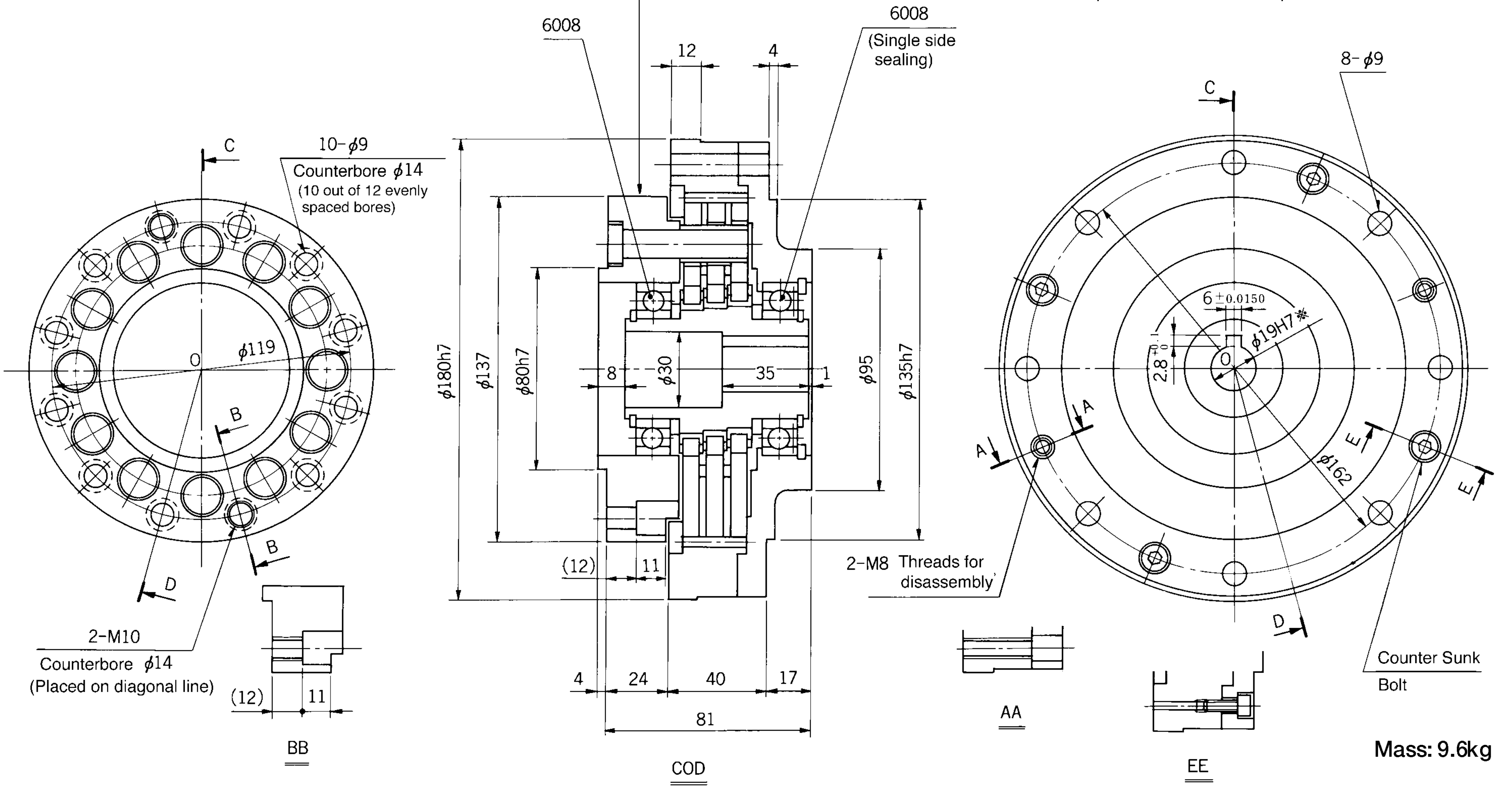
Mass: 5.2kg

※Maximum diameter of bore of high speed shaft can be up to ϕ19mm.

FC—A35 Outline Drawing

Output flange side requires bearing support on the machine side.
Refer to "10-1. FC-A Series" in section "10. Notice for Designing" on pages 19-20 for support method and installation precision.

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



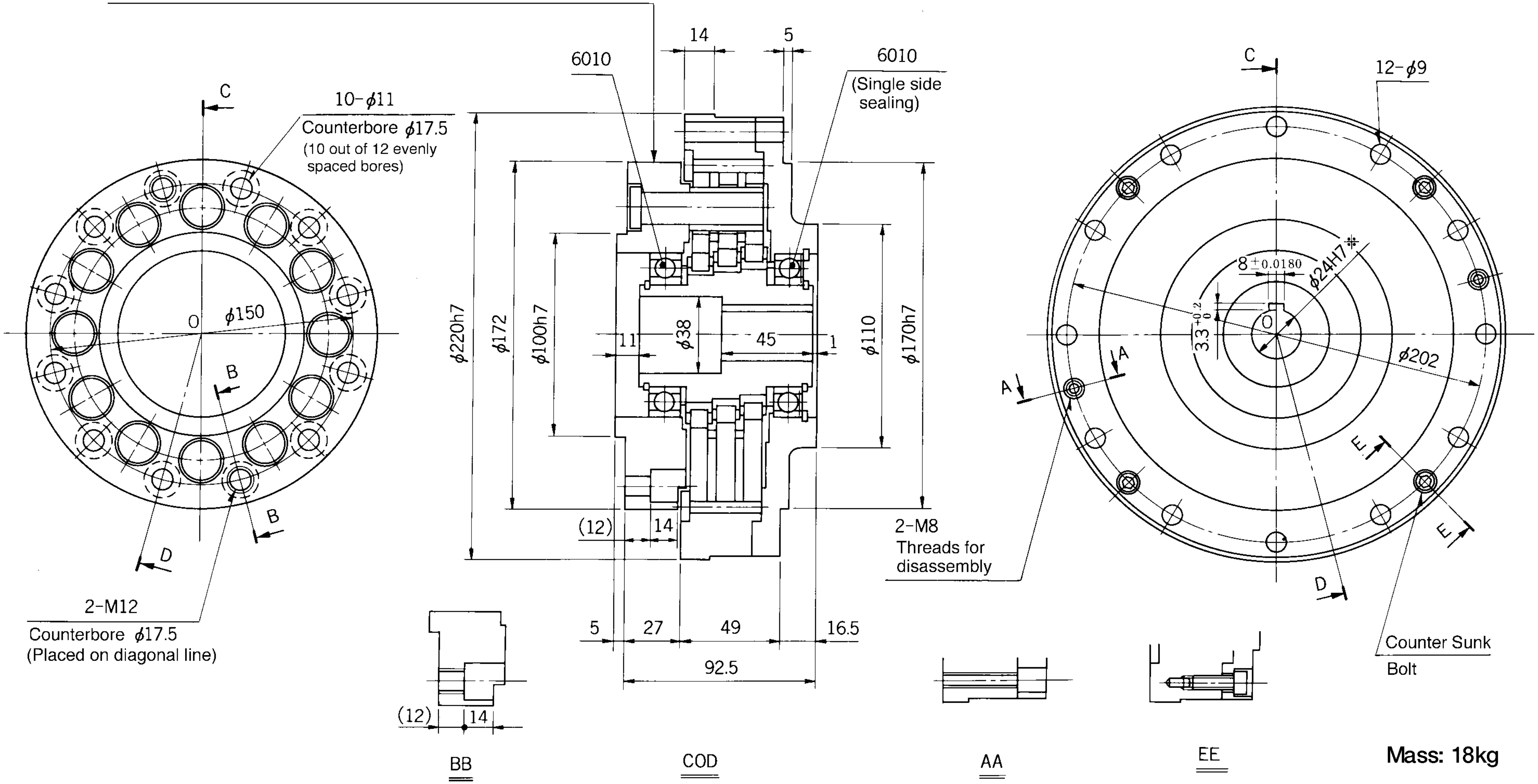
Mass: 9.6kg

※Maximum of diameter for high speed shaft bore is ϕ24mm.

FC—A45 Outline Drawing

Output flange side requires bearing support on the machine side.
Refer to "10-1. FC-A Series" in section "10. Notice for Designing" on pages 19-20 for support method and installation precision.

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



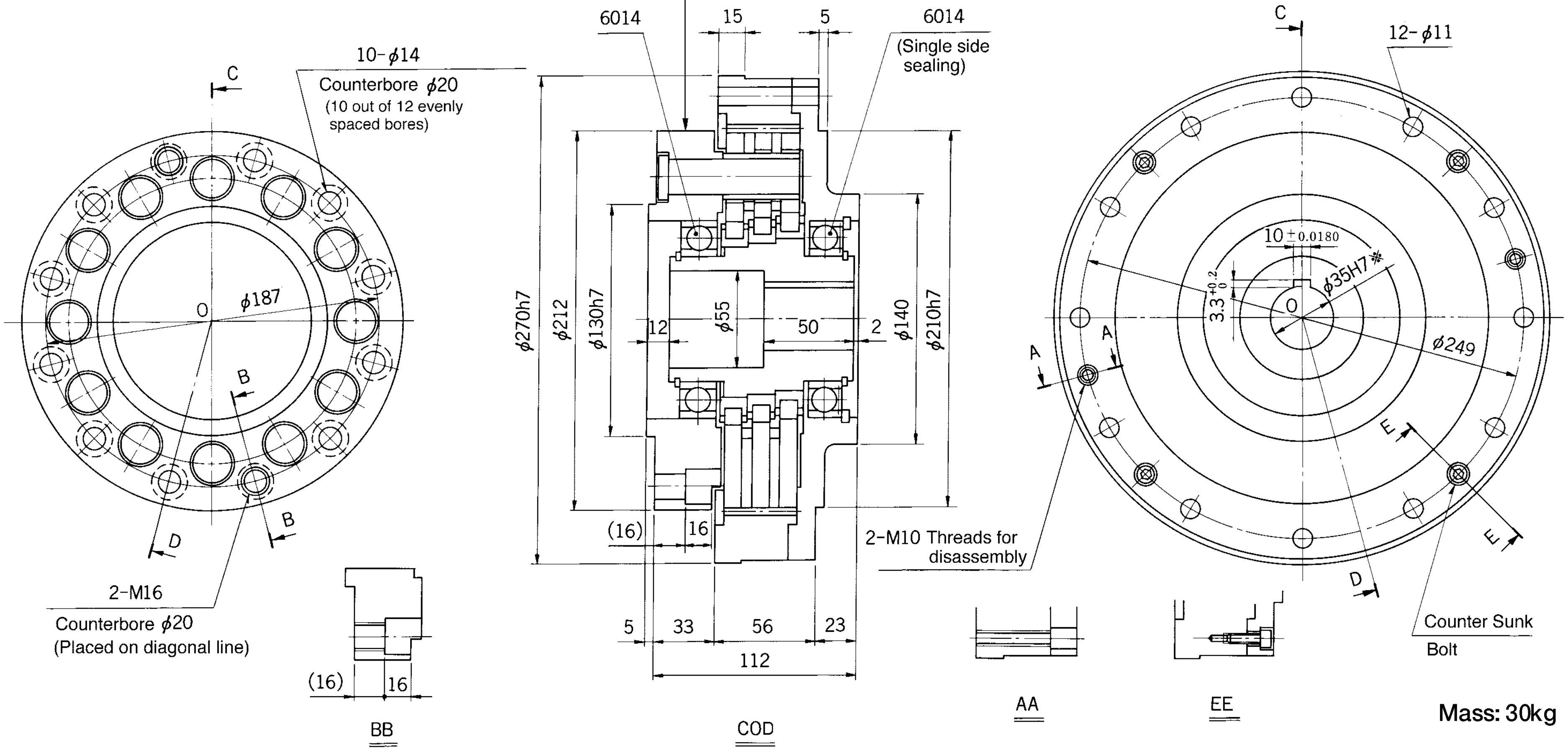
Mass: 18kg

※Maximum of diameter for high speed shaft bore is ϕ32mm.

FC—A65 Outline Drawing

Output flange side requires bearing support on the machine side.
Refer to "10-1. FC-A Series" in section "10. Notice for Designing" on pages 19-20 for support method and installation precision.

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



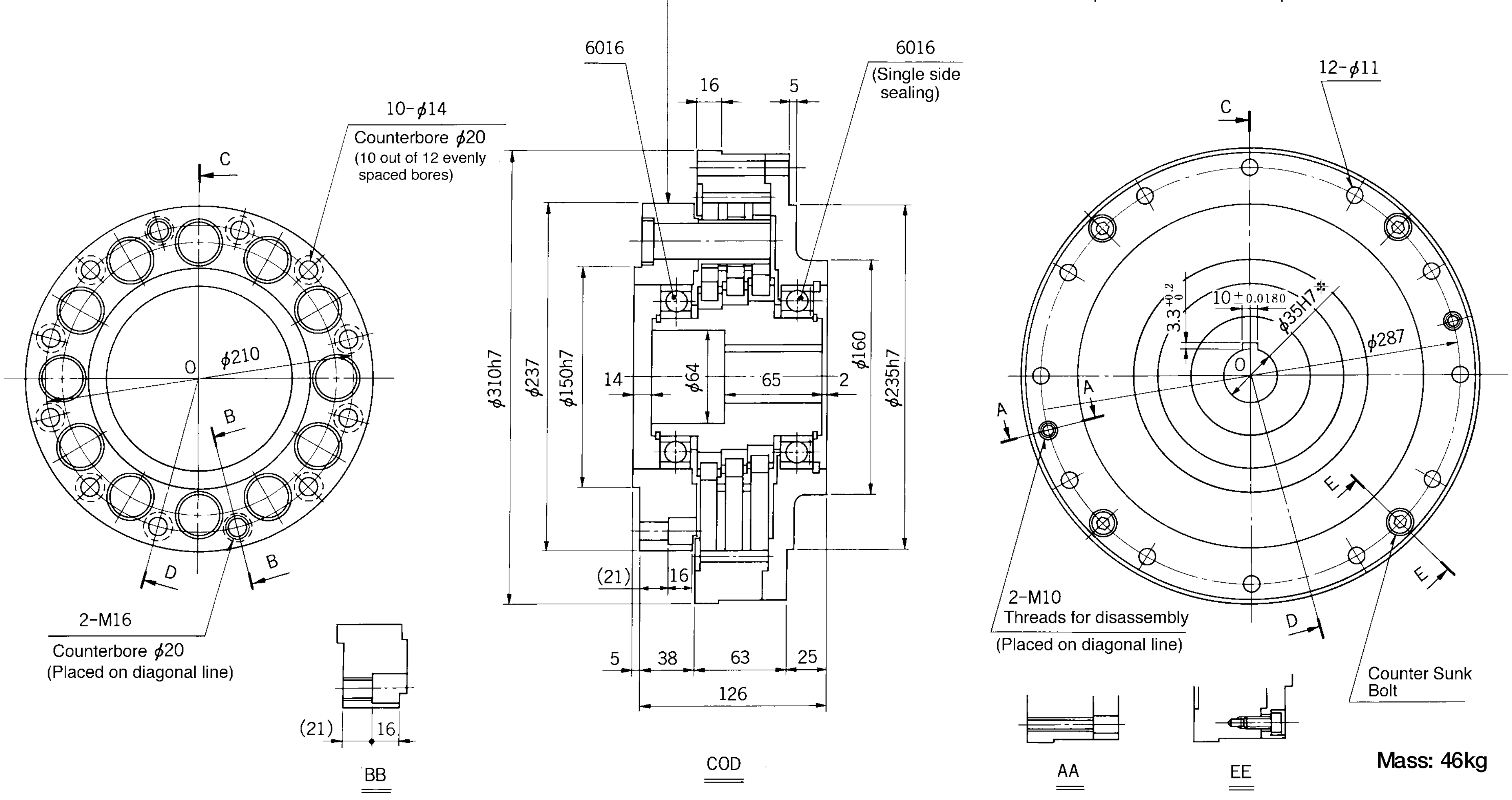
Mass: 30kg

※Maximum of diameter for high speed shaft bore is ϕ45mm.

FC—A75　Outline Drawing

Output flange side requires bearing support on the machine side.
Refer to "10-1. FC-A Series" in section "10. Notice for Designing" on pages 19-20 for support method and installation precision.

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



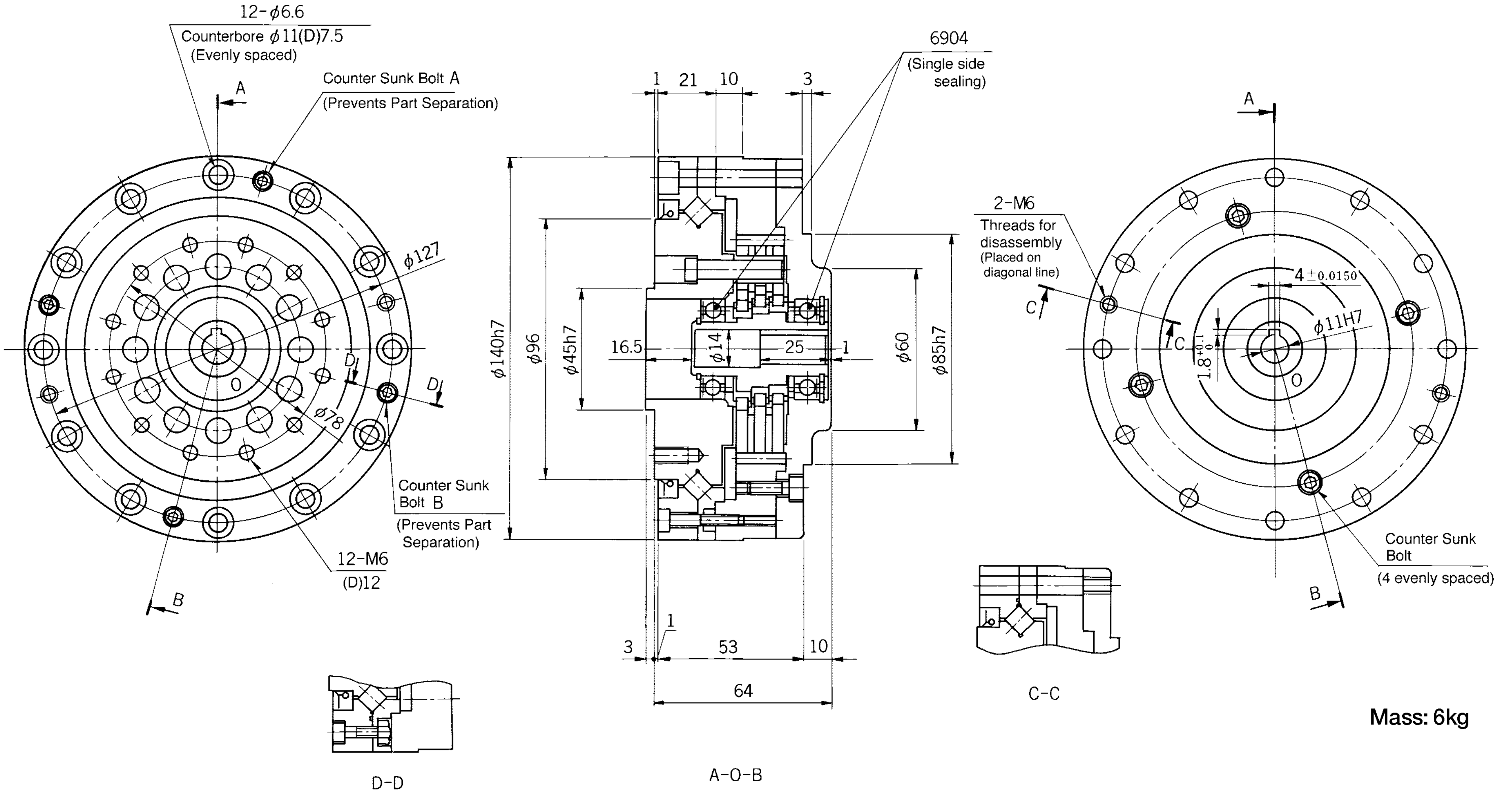
Mass: 46kg

※Maximum of diameter for high speed shaft bore is ϕ50mm.

F1C—A　Series

F1C—A15 Outline Drawing

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



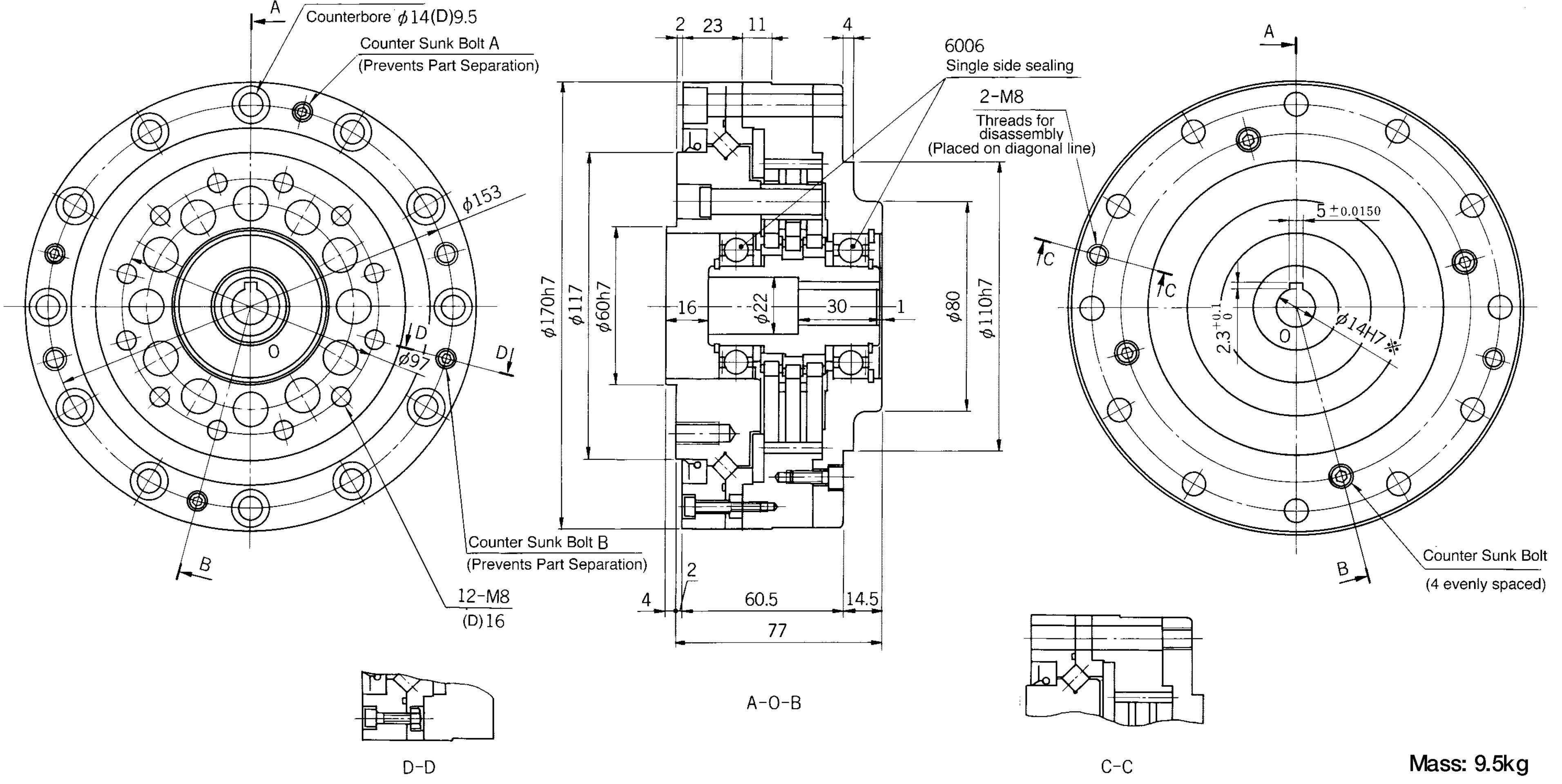
Mass: 6kg

※Maximum of diameter for high speed shaft bore is ϕ11mm.

Equivalent size to: Cross Roller Bearing 80×120×16

F1C—A25 Outline Drawing

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



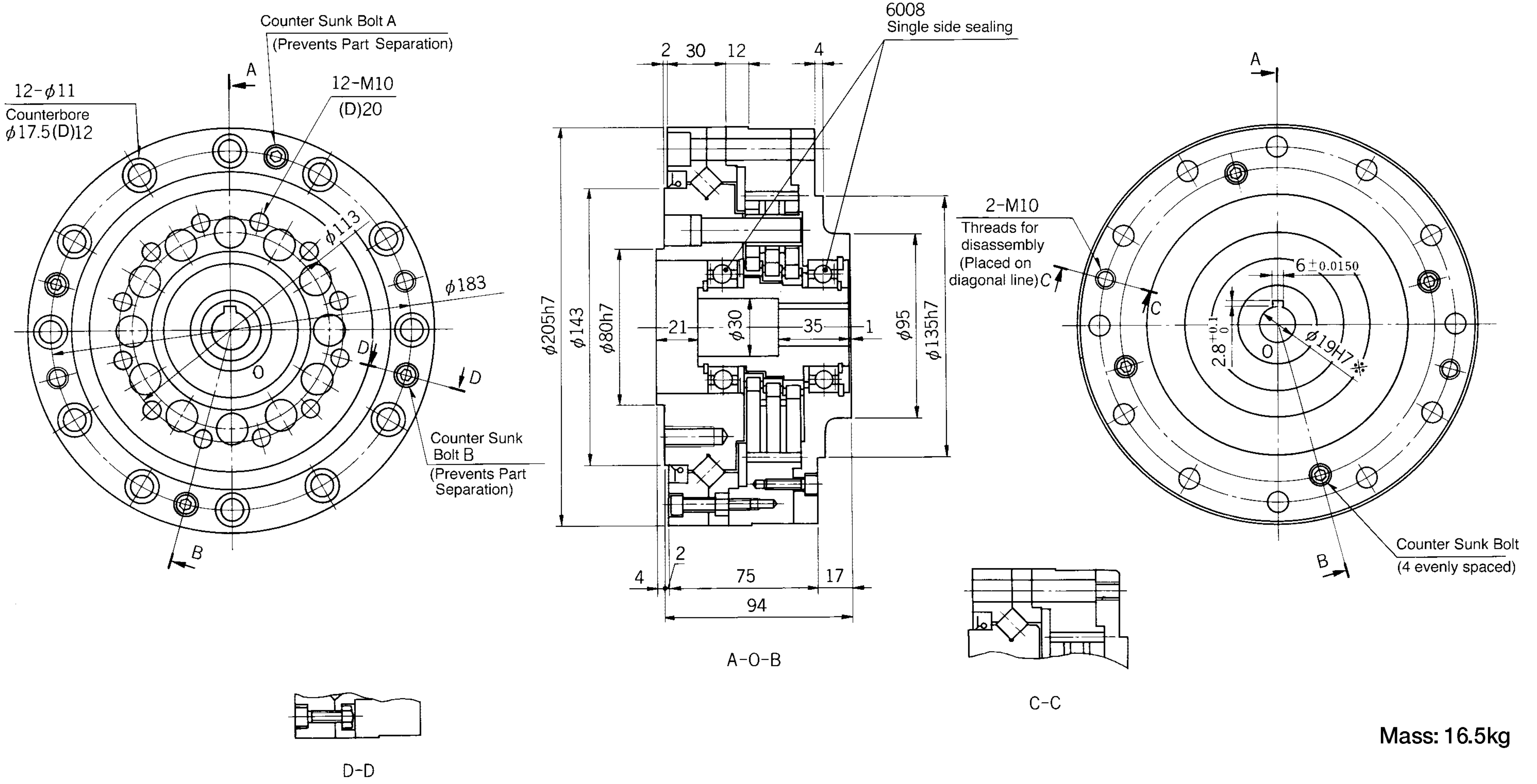
Mass: 9.5kg

※Maximum of diameter for high speed shaft bore is ϕ19mm.

Equivalent size to: Cross Roller Bearing 100×150×20

F1C—A35 Outline Drawing

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



Mass: 16.5kg

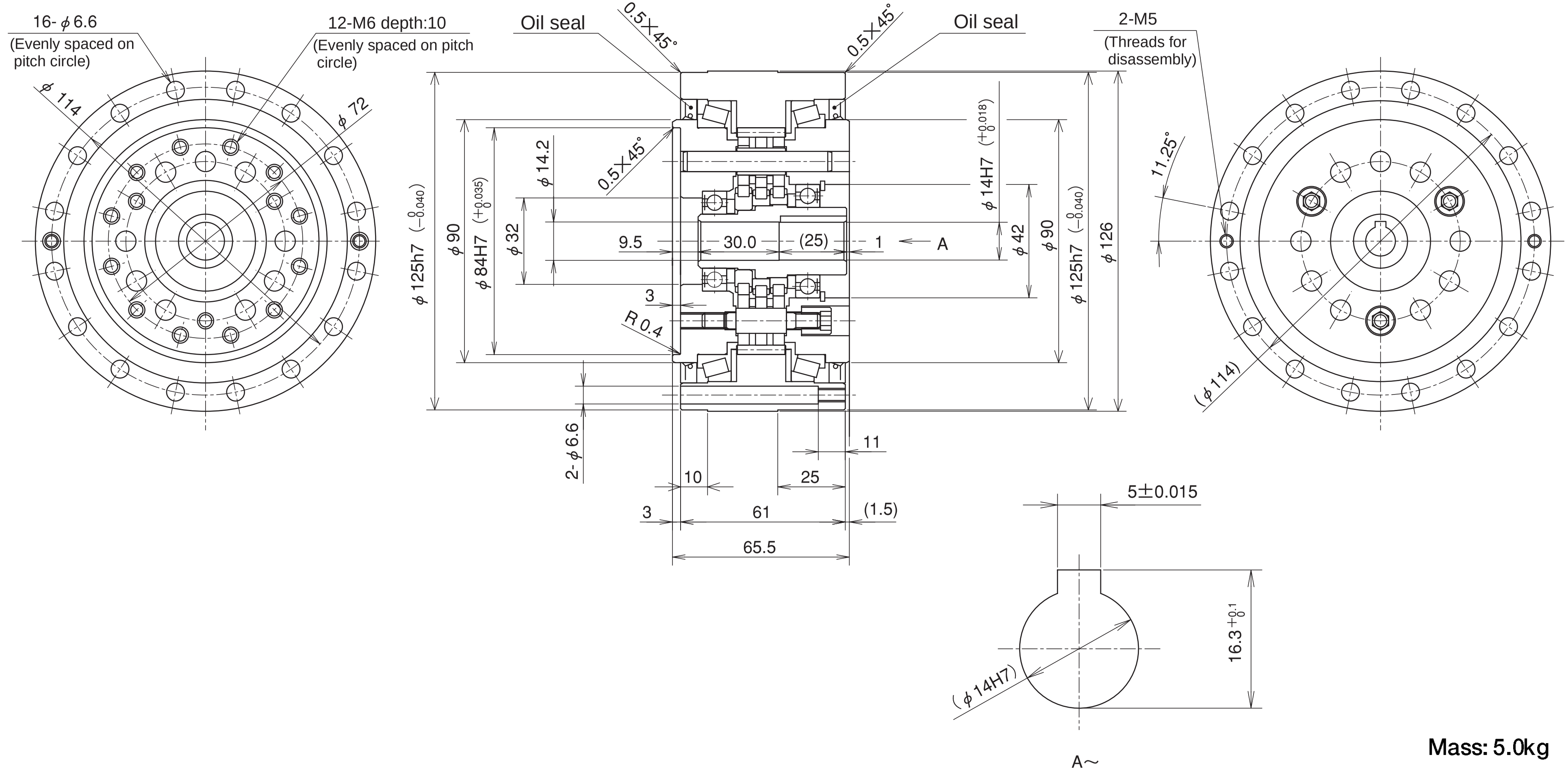
※Maximum of diameter for high speed shaft bore is ϕ24mm.

Equivalent size to: Cross Roller Bearing 120×180×25

F2C—A Series

F2C—A15 Outline Drawing

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.

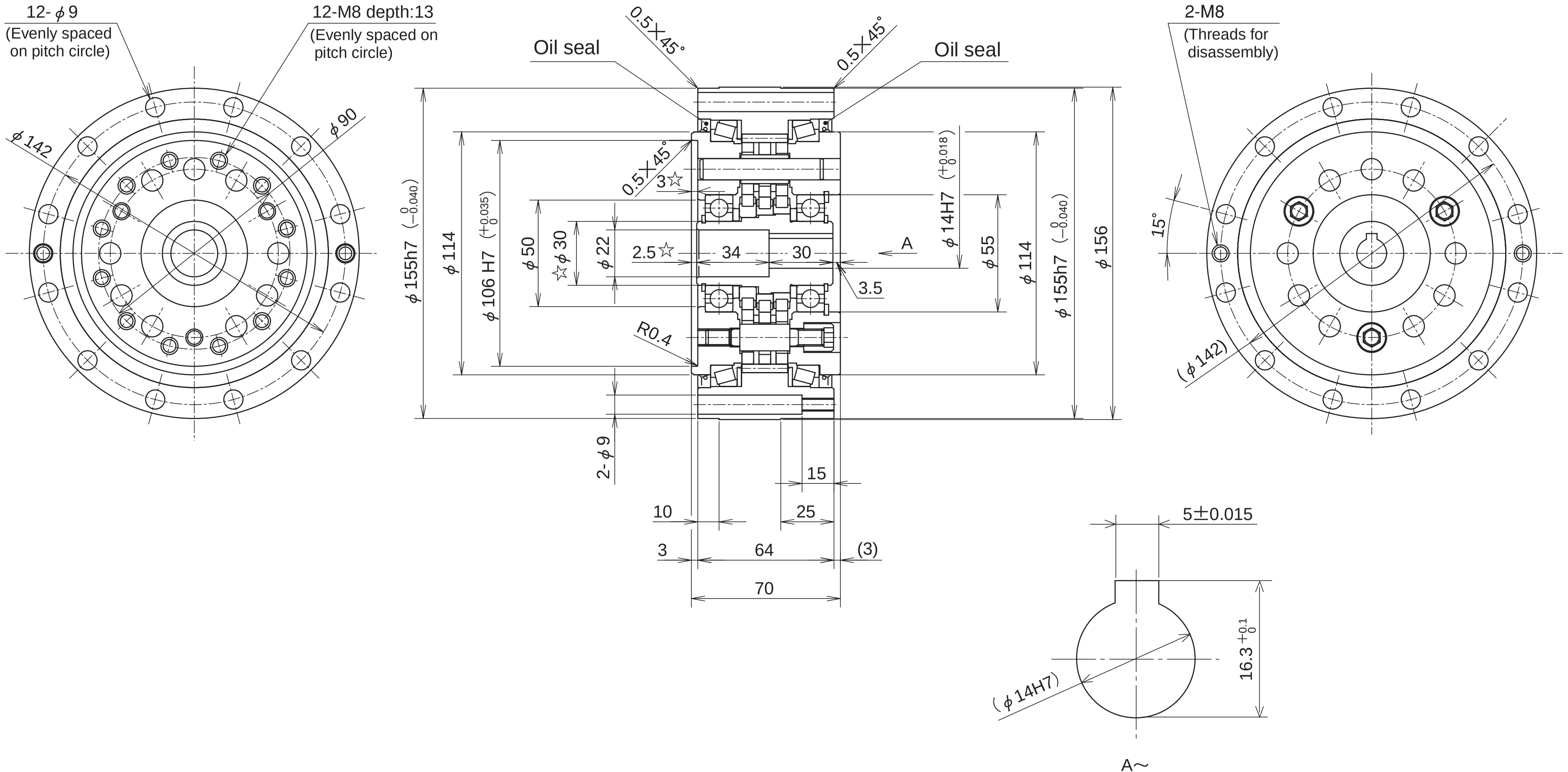


Mass: 5.0kg

※Maximum of diameter for high speed shaft bore is ϕ14mm.

F2C—A25　Outline Drawing

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



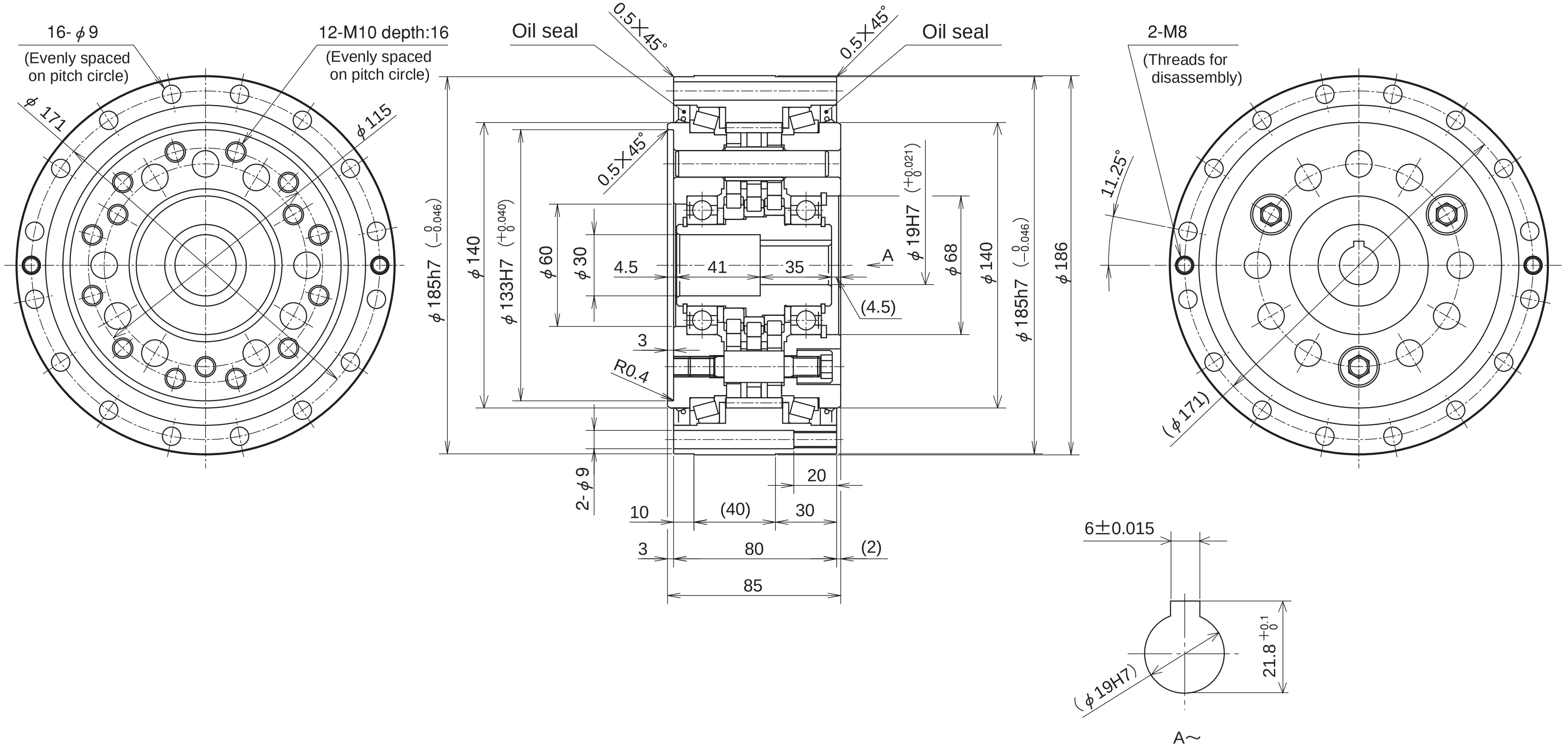
※1. Maximum diameter of bore of high speed shaft can be up to ϕ19mm.

※2. Be careful not to interface because part of ☆ projects from face of output flange.

Mass: 7.3kg

F2C—A35 Outline Drawing

- ・Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- ・Standard specifications are without paint.

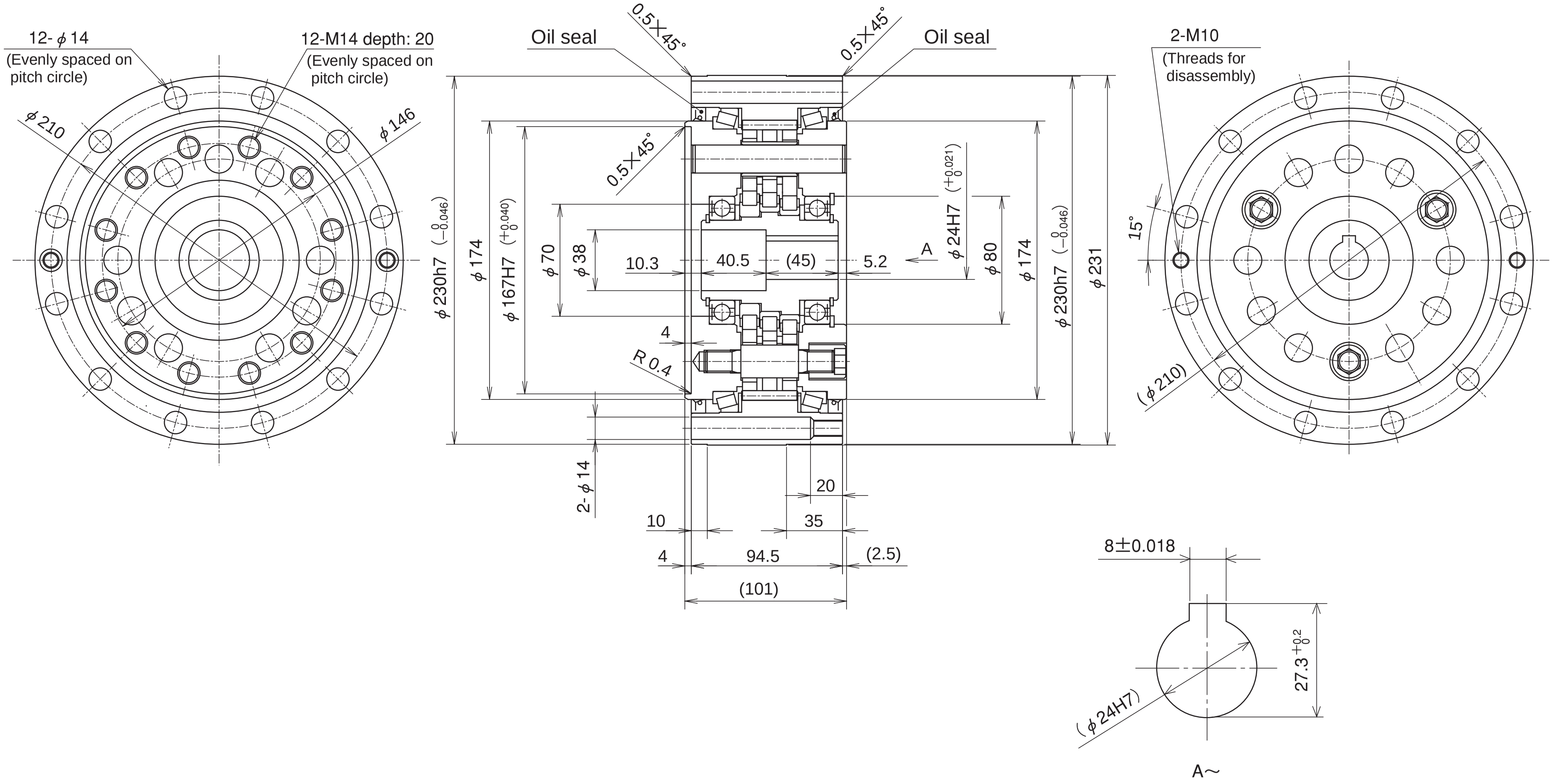


Mass:13.0kg

※Maximum of diameter for high speed shaft bore is ϕ24mm.

F2C—A45 Outline Drawing

- Single shielded bearing of the high speed shaft alone may not prevent grease leakage from the reducer completely.
  Take measure for complete leakage prevention whenever necessary.
- Standard specifications are without paint.



※Maximum of diameter for high speed shaft bore is ϕ32mm.

Mass:24.0kg

FC—T Series
F2C—T Series

FC—T
F2C—T Series

FEATURES

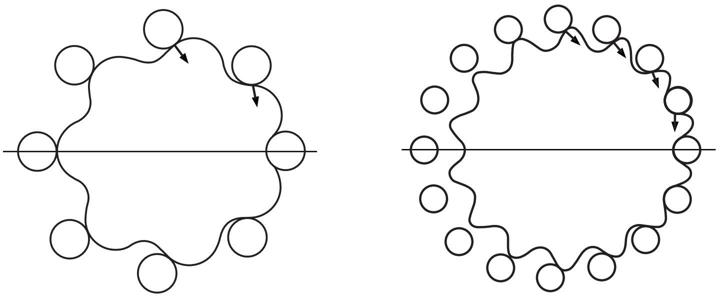
- ●High stiffness
- ●Compact
- ●Low backlash
- ●High efficiency (especially in low speed range)
- ●Low vibration
- ●Long lifetime
- ●Outer load support (reduced total cost, increased dependability)

Advantages of New Two-Tooth Difference Profile

There are following features in our original ""new two-tooth difference profile.

Many simultaneous contacts of gear teeth and pins

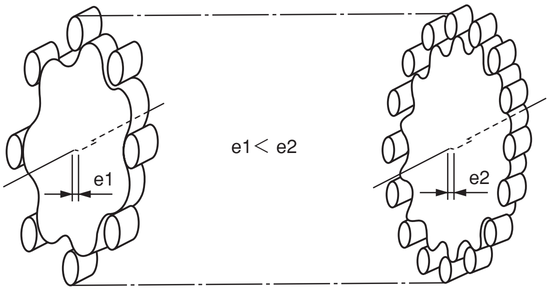
Small tooth surface pressure


One-tooth difference profile

New two-teeth difference profile

Large of eccentricity for eccentric planetary shaft

Small shaft load

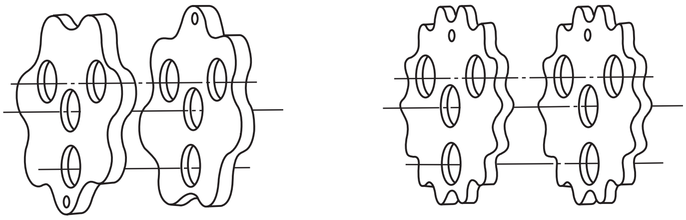

One-tooth difference profile

New two-teeth difference profile

Small slip between tooth and pin

Two Cycloid discs may be assembled in the same phase as they were processed.

Smaller effect of precision in processing


One-tooth difference profile

Necessary to rotate Cycloid discs 180° with each other for assembly.

New two-teeth difference profile

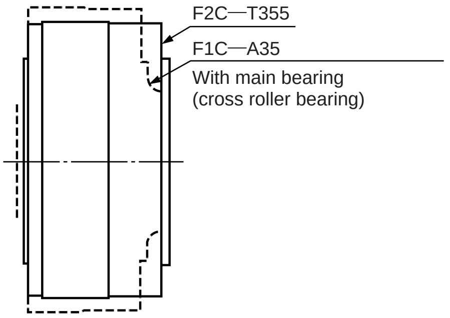
Two Cycloid discs may be assembled in the same phase as they were processed.

FC-T and F2C-T Series of CYCLO DRIVER® is especially outstanding in stiffness, level of vibration, and efficiency at low speed. This is enabled by our original new two-teeth difference profile type gear.
FC-T and F2C-T Series is excellent for purposes that require particular precision in trajectory, among uses such as industrial robot, machine tools, FA machineries.

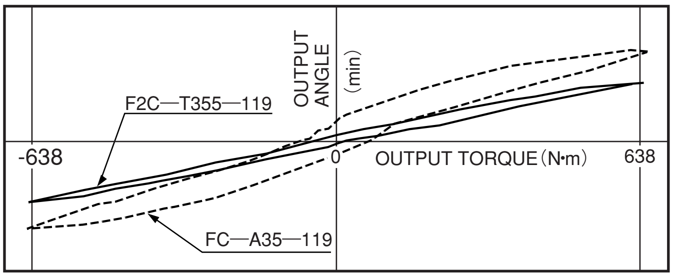
Compact and high stiffness

Long bearing lifetime

Comparison of Size



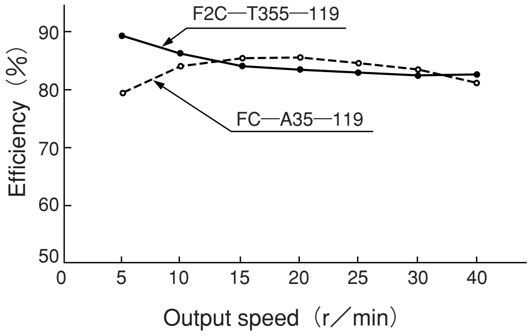
Example of Hysteresis Data



Small hysteresis loss

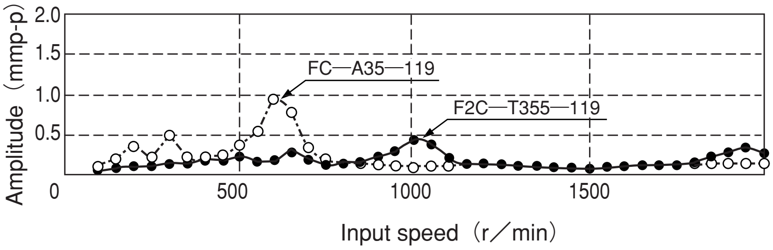
High efficiency at low speed

Example of Efficiency Data

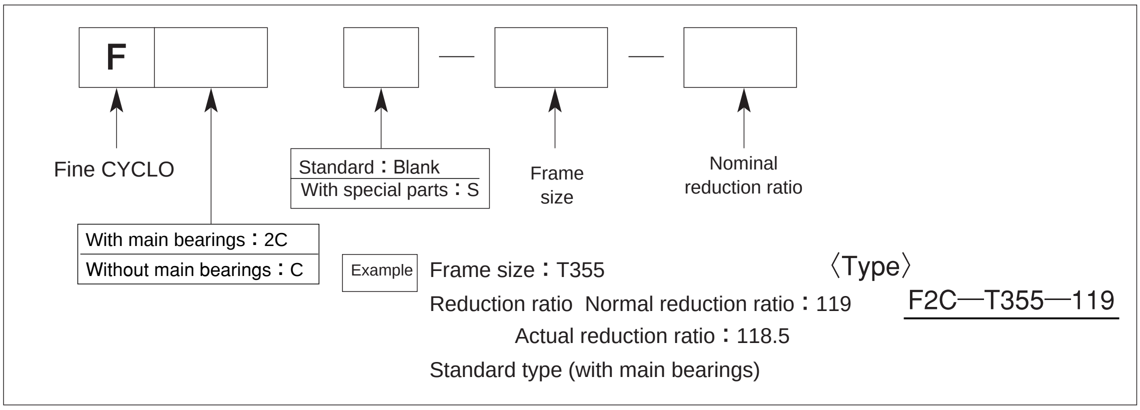


Low vibration

Example of Vibration Data



1. NOMENCLATURE



Frame size：T355

Reduction ratio Normal reduction ratio：119

Actual reduction ratio：118.5

Standard type (with main bearings)

〈Type〉

F2C—T355—119

2. Products

Table T-1

Frame size	Ratio		Normal reduction ratio			
	N•m	kgf•m	81	119※	141	171
T155	167	17	●	●	●	
T255	412	42	●	●	●	
T355	785	80	●	●	●	
T455	1275	130	●	●	●	●
T555	1962	200	●	●	●	●
T655	3139	320	●	●	●	●
T755	4415	450	●	●	●	●

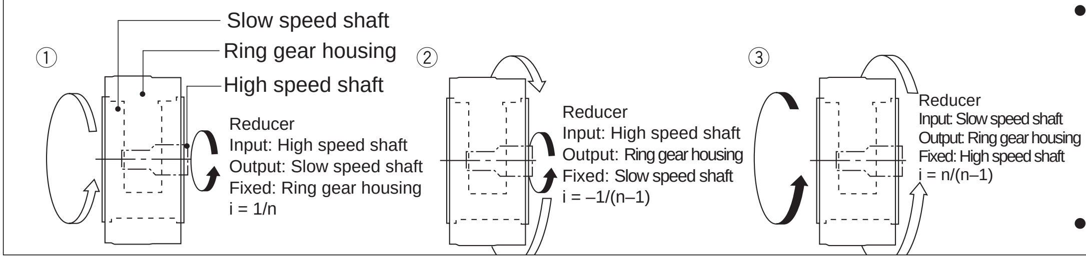
* Beware that actual reduction ratio is 118.5 when nominal reduction ratio is 119.

- Rated output torque is the value when output speed is 15r/min.
- Standard model of T-Series comes with main bearings (Nomenclature F2C-T).
- Consult us for types without main roller bearing (Nomenclature FC-T).

3. ROTATIONAL DIRECTION & SPEED RATIO

(When used as reducer)

Fig. T-1



- ● "i" indicates speed ratio of input and output for each case. "+" of speed ratio "i" indicates that output rotation is in the same direction of input rotation. "–" indicates that they are in the opposite direction.
- ● "n" means reduction ratio of reducer."

Note: Output rotational direction against input of T-series is not the same as FC-A, F1C-A and F2C-A series.

4. OPERATION PRINCIPLES OF T-SERIES

Operation Principles T series consists basically of ingenious combination of following three mechanisms.

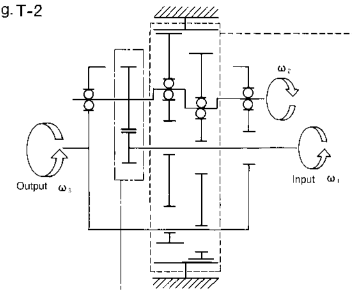
★Parallel involute gear system with involute tooth profile

★Internal epitrochoid planetary gearing with two-teeth difference tooth profile

★Constant speed internal gearing with circular tooth profile

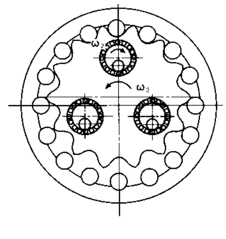
Arrows in the figure below indicate direction of rotation at each shaft. Direction of angular velocity $\omega_{1\sim3}$ is when direction of input rotation is considered positive. "-" indicates opposite direction of input.

Fig. T-2



Input angular velocity: ω_1
Output angular velocity: ω_3
Angular velocity of eccentric planetary shaft: ω_2

Fig. T-4



Epitrochoid planetary gearing with two-teeth difference profile and output rotation extraction mechanism operates through eccentric planetary shaft. These could be separated for understanding for each mechanism as in Fig.T-5, T-6.

Reduction Ratio of T-Series

From Formula T-1 and T-2

$$\omega_3 = -\frac{Zd - Zc}{Zc} \times \left\{ -\frac{Zb}{Za} (\omega_1 - \omega_3) + \omega_3 \right\} \cdots \text{(Formula T-3)}$$

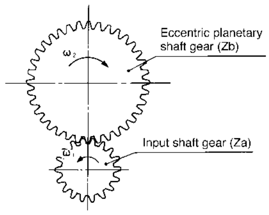
Where, $n = \omega_1 / \omega_3$: Overall speed ratio

$n_1 = Za / Zb$: Speed ratio when eccentric planetary shaft does not rotate around input shaft with parallel involute gearing

$n_2 = Zc / (Zd - Zc)$: Reduction ratio of internal planetary gearing

$$n = n_1 \times (n_2 + 1) + 1 \cdots \text{(Formula T-4)}$$

Fig. T-3 Parallel involute gearing

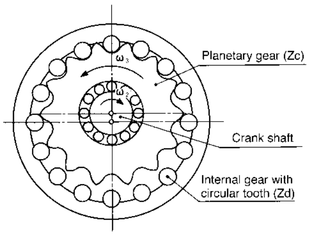


Eccentric planetary shaft rotates around input shaft at angular velocity ω_3.

When input shaft gear rotates at angular velocity ω_1, angular velocity ω_2 of eccentric planetary rotation is calculated by the following formula.

$$\omega_2 = -\frac{Zb}{Za} (\omega_1 - \omega_3) + \omega_3 \cdots \text{(Formula T-1)}$$

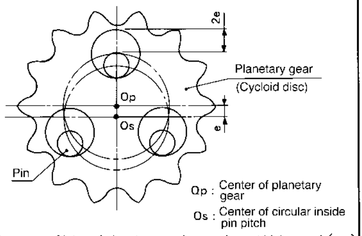
Fig. T-5 Internal planetary gearing



When ring gear housing is fixed and crank shaft is given angular velocity, ω_2, angular velocity of planet gear, ω_3, is calculated by following formula.

$$\omega_3 = -\frac{Zd - Zc}{Zc} \times \omega_2 \cdots \text{(Formula T-2)}$$

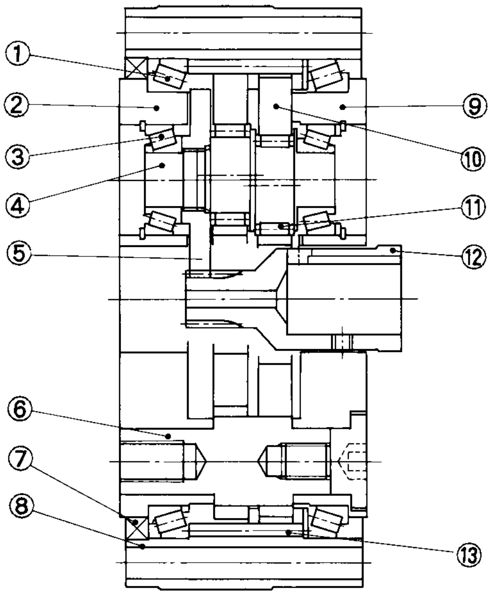
Fig. T-6 Constant Speed Internal Gearing



Planetary gear of internal planetary gearing revolves at high speed (ω_2) and rotates on its axis at low speed (ω_3) simultaneously.
Constant speed internal gearing is the system to extract only the rotation on its axis from two types of rotation. Slow speed shaft pin spaced evenly on concentric circle of the center of crank shaft is constant speed internal gear system.

5. CONSTRUCTION

Fig. T-7 Example of T-Series Construction（F2C—T）



①	Main roller bearing
②	Output flange
③	Bearing for eccentric planetary shaft
④	Eccentric planetary shaft
⑤	Eccentric planetary shaft gear
⑥	Carrier pin
⑦	Oil seal
⑧	Ring gear housing
⑨	Carrier
⑩	Cycloid disc
⑪	Bearing for eccentric
⑫	Input shaft gear (high speed shaft)
⑬	Ring gear housing pin

6. Rating

Table T-2　Rating Table (when used as reducer)

Output speed （r/min)			5			10			15			20			25		
Frame size	Nominal reduction ratio	Actual reduction ratio	Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power （kW)	Input speed (r/min)	Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power （kW)	Input speed (r/min)	Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power （kW)	Input speed (r/min)	Rated output torque (Upper/N•m) (Lower/kgf •m)	Input speed （kW)	Allowable input power (r/min)	Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power （kW)	Input speed (r/min)
T155	81	81	232 23.6	0.16	405	188 19.2	0.26	810	167 17.0	0.35	1215	153 15.6	0.43	1620	143 14.6	0.50	2025
	119	118.5			592.5			1185			1777.5			2370			2962.5
	141	141			705			1410			2115			2820			3525
T255	81	81	573 58.4	0.40	405	465 47.4	0.65	810	412 42.0	0.86	1215	378 38.5	1.05	1620	353 36.0	1.23	2025
	119	118.5			592.5			1185			1777.5			2370			2962.5
	141	141			705			1410			2115			2820			3525
T355	81	81	1089 111	0.76	405	886 90.3	1.24	810	785 80.0	1.64	1215	720 73.4	2.01	1620	673 68.6	2.35	2025
	119	118.5			592.5			1185			1777.5			2370			2962.5
	141	141			705			1410			2115			2820			3525
T455	81	81	1776 181	1.24	405	1442 147	2.01	810	1275 130	2.67	1215	1167 119	3.26	1620	1099 112	3.81	2025
	119	118.5			592.5			1185			1777.5			2370			2962.5
	141	141			705			1410			2115			2820			3525
	171	171			855			1710			2565			3420			4275
T555	81	81	2727 278	1.90	405	2217 226	3.09	810	1962 200	4.10	1215	1795 183	5.02	1620	1687 172	5.87	2025
	119	118.5			592.5			1185			1777.5			2370			2962.5
	141	141			705			1410			2115			2820			3525
	171	171			855			1710			2565			3420			4275
T655	81	81	4365 445	3.04	405	3541 361	4.94	810	3139 320	6.56	1215	2884 294	8.03	1620	2698 275	9.39	2025
	119	118.5			592.5			1185			1777.5			2370			2962.5
	141	141			705			1410			2115			2820			3525
	171	171			855			1710			2565			3420			4275
T755	81	81	6141 626	4.28	405	4983 508	6.95	810	4415 450	9.23	1215	4052 413	11.3	1620	3787 386	13.2	2025
	119	118.5			592.5			1185			1777.5			2370			2962.5
	141	141			705			1410			2115			2820			3525
	171	171			855			1710			2565			3420			4275

Note:
1. Rated output torque"
   Rated output torque implies allowable mean load torque at each output speed. Rated output torque for below 5r/min input is the same as 5r/min.
   Allowable input power is the value converted from rated output torque, when it is 100%. This value takes efficiency of CYCLO DRIVE in consideration.
2. Allowable acceleration or deceleration peak torque
   Allowable peak torque at normal start and stop.
3. Allowable momentary maximum torque
   Allowable momentary maximum torque at emergency stop or heavy shock, when loading 1000 times in overall lifetime.

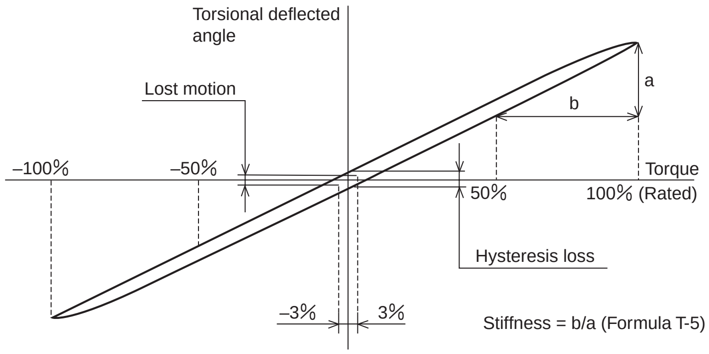
30			40			50			60			Maximum acceleration or deceleration torque (Upper/N•m) (Lower/kgf •m)	Allowable peak torque for emergency stop (Upper/N•m) (Lower/kgf •m)	Allowable maximum output speed (r/min)	On input shaft Upper/Moment of inertia (×10^{-4}kg•m^2) Lower/GD^2 (×10^{-4}kgf•m^2)		Mass kg
Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power (kW)	Input speed (r/min)	Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power (kW)	Input speed (r/min)	Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power (kW)	Input speed (r/min)	Rated output torque (Upper/N•m) (Lower/kgf •m)	Allowable input power (kW)	Input speed (r/min)				※1	※2	
135 13.8	0.57	2430	125 12.7	0.69	3240	116 11.8	0.81	4050	110 11.2	0.92	4860	412 42	824 84	60	0.138 0.550	0.062 0.247	4.8
		3555			4740			5925			7110				0.103 0.411	0.041 0.165	
		4230			5640			7050			8460				0.092 0.366	0.034 0.134	
335 34.1	1.40	2430	307 31.3	1.71	3240	287 29.3	2.00	4050				1030 105	2060 210	50	0.373 1.49	0.184 0.734	8.4
		3555			4740			5925							0.263 1.05	0.114 0.454	
		4230			5640			7050							0.230 0.918	0.090 0.360	
638 65.0	2.67	2430	585 59.6	3.26	3240							1962 200	3924 400	40	1.05 4.20	0.52 2.06	14
		3555			4740										0.733 2.93	0.320 1.28	
		4230			5640										0.638 2.55	0.255 1.02	
1040 106	4.33	2430										3188 325	6377 650	30	2.55 10.2	1.31 5.23	24
		3555													1.92 7.66	0.798 3.19	
		4230													1.72 6.86	0.630 2.52	
		5130													1.54 6.17	0.480 1.92	
1589 162	6.66	2430										4905 500	9810 1000	30	4.98 19.9	2.68 10.7	34
		3555													3.65 14.6	1.64 6.56	
		4230													3.23 12.9	1.30 5.19	
		5130													2.88 11.5	0.990 3.96	
												7848 800	15696 1600	25 ※3	9.65 38.6	5.10 20.4	48
															7.13 28.5	3.13 12.5	
															6.35 25.4	2.47 9.88	
															5.68 22.7	1.88 7.53	
												11036 1125	22073 2250	25 ※3	16.7 66.8	8.93 35.7	71
															12.2 48.9	5.48 21.9	
															10.8 43.2	4.33 17.3	
															9.60 38.4	3.30 13.2	

4. Moment of inertia, GD^2
   Value at input shaft. Divide them by g (Moment of inertia: 9.8m/sec^2) or 4g (GD^2: 4 x 9.8m/sec^2) to convert from them to inertia.
   ※1：Containing standard input shaft gear
   ※2：In regard with only width of input shaft gear
5. ※3：Allowable maximum output speed of T655-119 and T755-119 is 25.2r/min (allowable maximum input speed is 3000r/min).

7. Engineering Data

7-1 Stiffness and lost motion

- Hysteresis curve : Relationship between load and displacement of slow speed shaft (rotational angle) when load is removed slowly from allowable torque to zero torque, while high speed shaft is fixed.
- Lost motion : Torsional deflected angle at ±3% of allowable output torque.
- Stiffness : Slope of the straight line connecting two points, when allowable torque is 50% and 100% on the hysteresis curve.



Stiffness = b/a (Formula T-5)

Fig. T-8 Hysteresis curve

7-2. Vibration

- Vibration:Value at the flywheel (amplitude (mmp-p), acceleration (G)) when load of inertia (flywheel) is applied while being attached to output shaft.

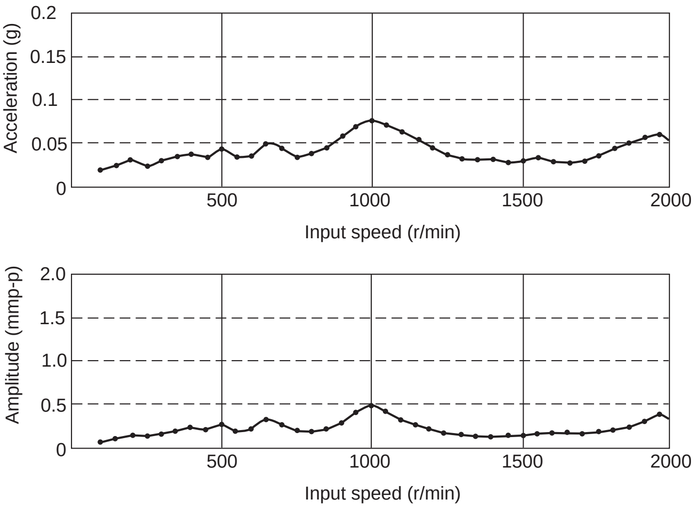


Fig. T-9 Value of vibration

Table T-4 Measurement conditions

Frame size - Reduction ratio	T355—119 （Actual reduction ratio: 118.5）
Inertia at output side	1100 kgf·cm·sec^2
Measured radius	550mm

Table T-3 Engineering Data

Frame size	Rated output torque 15 r／min Top／N•m Bottom／kgf•m	Lost motion		Stiffness Top：N•m/arc min Bottom：kgf・m/arc min
		Measured torque (±) Top／N•m Bottom／kgf•m	Lost motion arc min	
T155	167 17	5.00 0.51	0.75	42 4.25
T255	412 42	12.4 1.26	0.5	118 12
T355	785 80	23.5 2.4		206 21
T455	1275 130	38.3 3.9		343 35
T555	1962 200	58.9 6.0		589 60
T655	3139 320	94.2 9.6		981 100
T755	4415 450	132 13.5		1275 130

Note) arc min means minute of the angle.
Stiffness is the average data (typical data).

（Example calculation of torsional deflected angle）

Torsion angle is calculated when torque is applied in one direction using T355 as example.

1）When load torque is 15-Nm

（When load torque is 15Nm (When load torque is in the range of lost motion)）

$$\theta = \frac{15}{23.5} \times \frac{0.5}{2} = 0.16 \text{ arcmin}$$

2）When load torque is 600Nm

$$\theta = \frac{0.5}{2} + \frac{600-23.5}{206} = 3.0 \text{ arcmin}$$

7-3. Angle transition accuracy

Angle transition accuracy: Difference between theoretical and actual rotation angle when a rotation angle is applied to the input shaft.

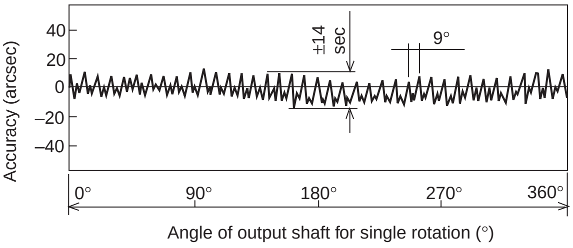


Fig. T-10 Angle transmission accuracy

Table T-5 Measurement conditions

Frame size - Reduction ratio	T355—119（Actual reduction ratio 118.5）
Load conditions	No load

7-4. Efficiency

- Efficiency is changed by output speed, load torque, grease temperature and frame size.
- Fig. T-11 and T-12 indicates average efficiency vs. output speed at allowable output torque with stable grease temperature after reducers have been run.
- When loading torque is not same as allowable torque, compensate efficiency by compensation curve for efficiency shown in Fig.A-14.

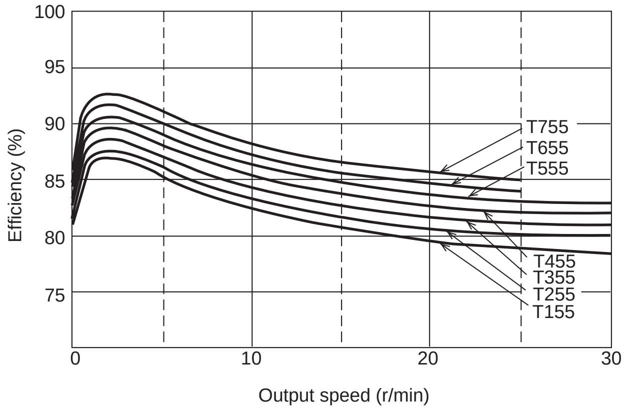


Fig. T-11　Efficiency Curve

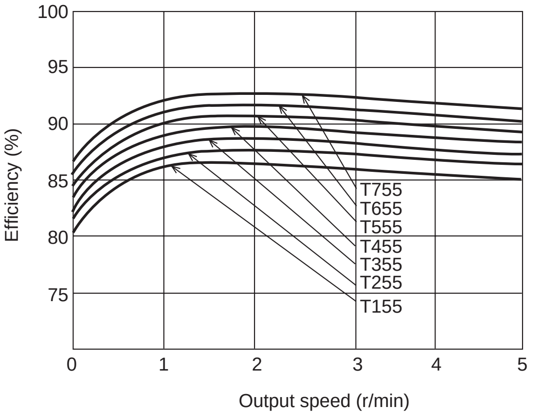


Fig. T-12　Efficiency Curve at Low Speed and Static

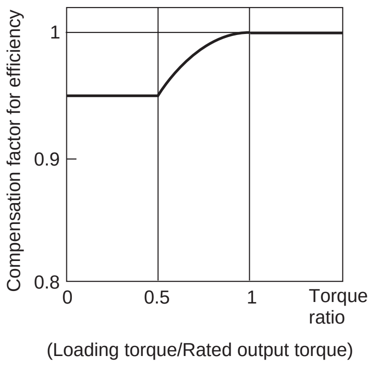


Fig. T-13　Compensation Curve for Efficiency

Note)1.　Efficiency varies when load torque differs with allowable torque. Check the compensation factor in the Fig.T-13

Note)2.　When torque ratio is over 1.0, compensation factor for efficiency is 1.0.

(Efficiency Calculation Example)

Efficiency is calculated for T355-119 in the following condition.

Table T-6

Load torque	Half of allowable torque
Output speed	25 r／min
Temperature	Constant

- Compensation factor when torque ratio is 0.5 is roughly 0.95 from efficiency curve Fig.T-13.
- Efficiency is 81% from Fig.T-11, when output speed is 25r/min.

Compensation factor= 81×0.95 = 77.0（%）

7-5. No Load Running Torque

Torque on input shaft necessary to rotate input shaft of reducer under no-load condition.

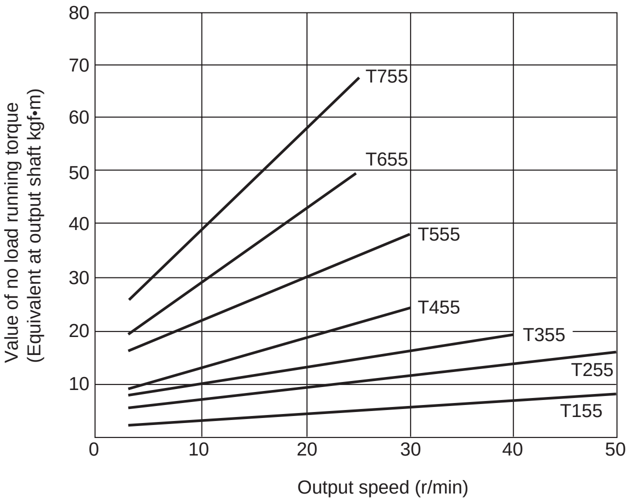


Fig. T-14　Value of no load running torque

Note 1）Calculate input torque using the following formula by substituting no load running output torque in Fig.T-14.

- Equivalent value at output shaft（kgf・cm）

$$= \frac{\text{Equivalent value at output shaft}}{N} \times 100 \text{（N : Reduction ratio）・・（FormulaT-6）}$$

Note 2）Fig.T-14 shows average data after running reducers.

Table T-7　Measurement condition

Ring gear housing temperature	30℃
Lubrication	Optimol Longtime PD0

7-6. No-load friction torque on output shaft

Torque on output shaft necessary to start rotation of output shaft of reducer

Table T-8　Value of No-load friction torque on output shaft

Frame size	No-load friction torque on output shaft	
	N•m	kgf•m
T155	20	2
T255	49	5
T355	88	9
T455	108	11
T555	137	14
T655	167	17
T755	196	20

Note）Table T-8 indicates average data after reducers have been run.

Table T-9　Measurement Condition

Lubrication	Optimol Longtime PD0

8. Main Bearings

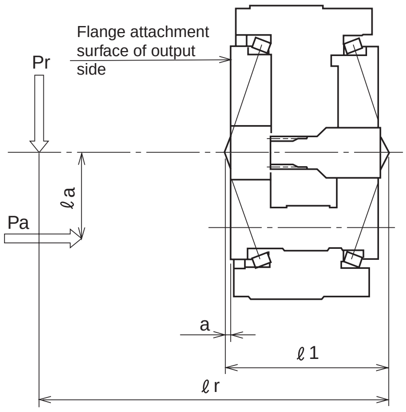


Fig. T-15　Span of loading points

Note）Consult us if:　$\ell r > 4 \times \ell_1$

1. Moment Stiffness

Stiffness for inclination of output shaft receiving external moment

External moment (M)

$M = Pr \cdot \ell r + Pa \cdot \ell a$ ····（Formula T-7）

2. Allowable Moment & Allowable Axial Load

Check external moment and external axial load referring to FormulaT-8, Formula T-9, and Fig.T-16.

Equivalent moment (Me)

$Me = Cf \cdot Fs_1 \cdot Pr \cdot \ell r + Cf \cdot Fs_1 \cdot Pa \cdot \ell a$ ····（Formula T-8）

Equivalent axial load (Pae)

$Pae = Cf \cdot Fs_1 \cdot Pa$ ····（Formula T-9）

Cf ：Load connection factor［Table T-13］

Fs_1：Shock factor［Table T-14］

Pr：Actual radial load （N, kgf）

Pa：Actual axial load（N, kgf）

Table T-10　Span of Loading Points（mm）

Frame size	Span of Loading Points	
	ℓ_1（mm）	a（mm）
T155	80.9	5.2
T255	92.4	5.7
T355	120.0	12.0
T455	147.2	22.6
T555	169.8	28.9
T655	205.8	39.4
T755	227.8	43.9

Table T-11　Moment Stiffness

Frame size	Moment Stiffness	
	（N•m／arcmin）	（kgf•m／arcmin）
T155	392	40
T255	834	85
T355	1373	140
T455	1864	190
T555	2943	300
T655	4415	450
T755	6377	650

Table T-12　Allowable Moment & Allowable Axial Load

Frame size	Allowable Moment		Allowable	
	（N•m）	（kgf•m）	（N）	（kgf）
T155	883	90	3924	400
T255	1177	120	3924	400
T355	1815	185	5396	550
T455	2747	280	6867	700
T555	4169	425	8339	850
T655	6377	650	10791	1100
T755	9565	975	13734	1400

Table T-13

Load connection factor　Cf

Connection method	Cf
General purpose chain	1
Machine gear or pinion	1.25
Timing belt	1.25
V-Belt	1.5

Table T-14　Shock factor　Fs_1

Load Classification	Fs_1
Uniform load (no shock)	1
Moderate shocks	1～1.2
Heavy shocks	1.4～1.6

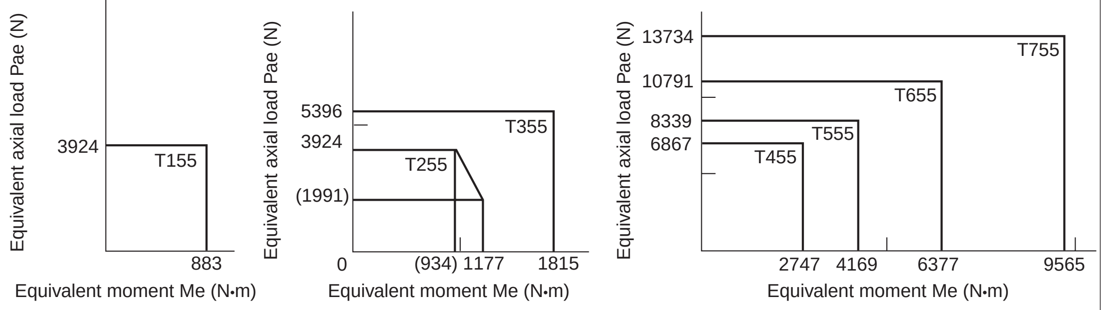


Table T-16　Diagram of Allowable Moment & Axial Load

9. Selection

9-1. Flow Chart and Selection Formula

Fig. T-17

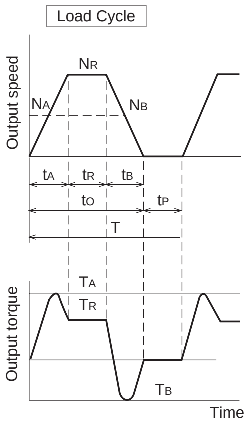
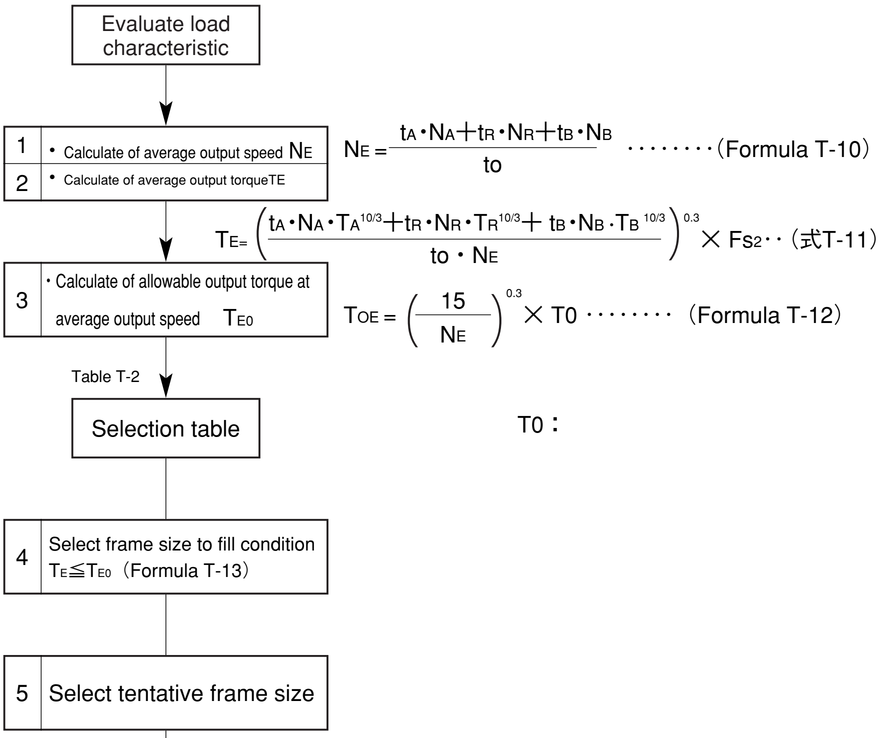


Table T-15

Symbol	Name		
N_A	Average output speed during acceleration	t_O	Total running time
N_R	Input speed during normal running	t_P	Standstill time
N_B	Average input speed for deceleration	T	Time/cycle
t_A	Acceleration time	T_A	Acceleration peak torque
t_R	Normal running time	T_R	Peak torque during normal running
t_B	Deceleration time	T_B	Peak torque when braking
—	———	T_S	Emergency torque

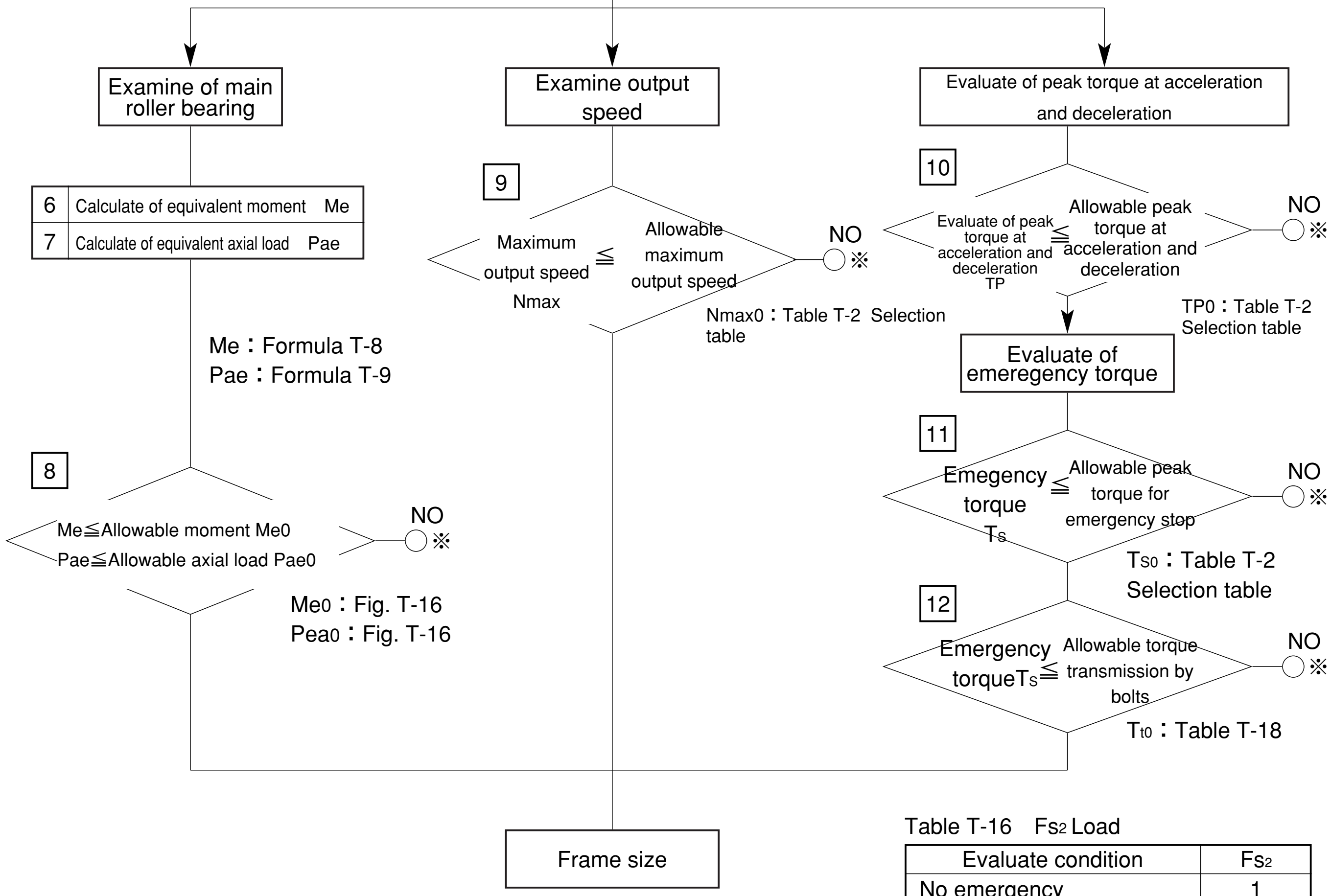


$$N_E = \frac{t_A \cdot N_A + t_R \cdot N_R + t_B \cdot N_B}{t_O}$$ ········(Formula T-10)

$$T_E = \left(\frac{t_A \cdot N_A \cdot T_A^{10/3} + t_R \cdot N_R \cdot T_R^{10/3} + t_B \cdot N_B \cdot T_B^{10/3}}{t_O \cdot N_E}\right)^{0.3} \times F_{S2}$$ ··（式T-11）

$$T_{OE} = \left(\frac{15}{N_E}\right)^{0.3} \times T0$$ ········（Formula T-12）

T0：



Me：Formula T-8
Pae：Formula T-9

Me0：Fig. T-16
Pea0：Fig. T-16

Nmax0：Table T-2 Selection table

TP0：Table T-2 Selection table

Ts0：Table T-2 Selection table

Tt0：Table T-18

Table T-16 Fs2 Load

Evaluate condition	Fs2
No emergency	1
Emergency	1～1.2
Strong emergency	1.4～1.6

Note）Return to "5" at "※".

9-2. Selection Example

Evaluate F2C-T255-119 for following specification.

(Specification)

T_A	：Acceleration peak torque	600N・m	t_A	：Acceleration time	0.3sec
T_R	：Normal running torque	250N・m	t_r	：Normal running time	3.0sec
T_B	：Deceleration peak torque	400N・m	t_B	：Deceleration time	0.3sec
T_S	：Emergency Torque:	1600N-m (1000times	t_P	：Standstill time	3.6sec
		during all life time)	t_O	：Total running time	3.6sec
n_A	：Average output speed during acceleration	10.5 r／min	T	：Time/Cycle	7.2sec
n_R	：Average output speed during normal running	21.1 r／min			
n_B	：Average output speed during deceleration	10.5 r／min			
P_r	：Radial load	1000N	P_a	：Axial load	200N
l_r	：Location of radial load	350mm	l_a	：Location of axial load	50mm

It is considered that reducer is used with moderate shock.

(Calculate) Average output speed

$$n_E = \frac{0.3 \times 10.5 + 3.0 \times 21.1 + 0.3 \times 10.5}{3.6} = 19.3\,(r／min)$$

Average output torque

$$T_E = \left(\frac{0.3 \times 10.5 \times 600^{10/3} + 3 \times 21.1 \times 250^{10/3} + 0.3 \times 10.5 \times 400^{10/3}}{3.6 \times 19.3}\right)^{0.3} \times 1.0 = 306\,(N \cdot m)$$

○ Allowable output torque at average output speed

$$T_{OE} = \left(\frac{15}{19.3}\right)^{0.3} \times 412 = 382\,(N \cdot m) \geqq 306\,(N \cdot m)\ (=T_E)$$ →F2C—T255—119を仮枠番選定する。

○Evaluate equivalent moment

$M_e = 1000 \times 350 \times 10^{-3} + 200 \times 50 \times 10^{-3} = 360\,(N \cdot m) \leqq 1177\,(N \cdot m)\ (=M_{e0})$

○Evaluate equivalent axial load

$P_a = 200\,(N) \leqq 3924\,(N)\ (=P_{a0})$

○Evaluate maximum output speed

$n_{max} = 21.1\,(r／min) \leqq 50\,(r／min)$

○Evaluate average output speed

$T_p = 600\,(N \cdot m) \leqq 1030\,(N \cdot m)$

○Evaluate emergency torque

$T_s = 1600\,(N \cdot m) \leqq 2060\,(N \cdot m)$

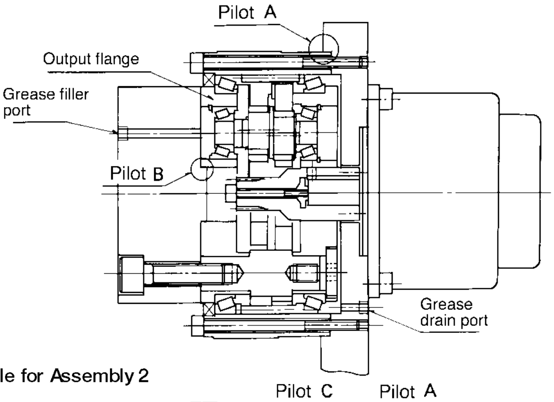
F2C-T255-119 may be selected from above evaluation process.

10. Notice for Designing

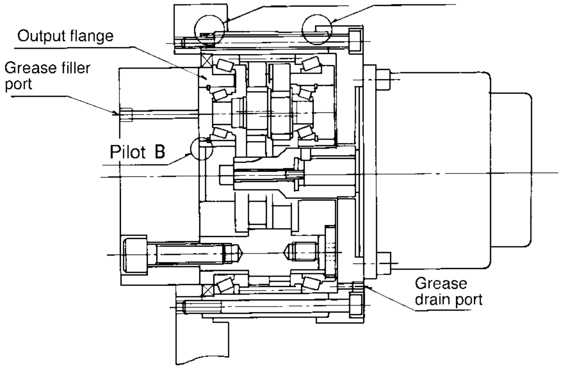
10-1. Method of Assembly and Precision in Assembly Dimensions

Fig. T-18 Method of Assembly

Example for Assembly 1

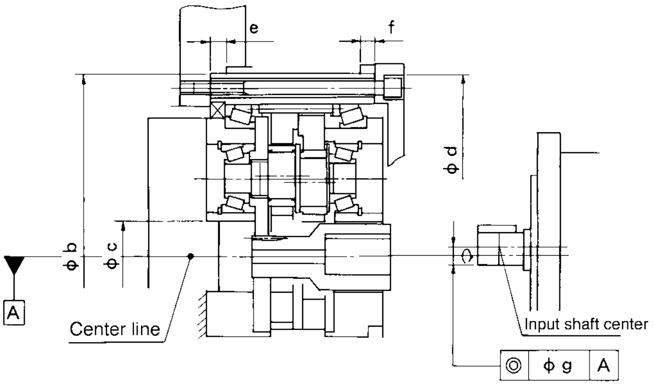


Example for Assembly 2



- ●Output side flange does not have bearing supported on the reduction mechanism side.
  Always support output side flange by bearing on your machine side as in the left figure.
- ●Use pilot B for reducer output shaft assembly and pilot C for casing assembly.
- ●Apply liquid gasket to assembly surface to prevent moisture or dust entering.

Fig. T-19 Precision in assembly dimensions



- ・Attachment pilots are "b," "c," and "d" in Table T-17.
- ・Depth of attachment flange should be the same or less than "e," "f," in Table T-17.
- ・Concentricity for shaft center is shown in Table T-17.

Table T-17

Frame size	Pilot for attachment			Depth of Pilot		Concentricity for shaft center g
	b	c	d	e	f	
T155	ϕ125 H7／h7	ϕ23.5 H7／h7	ϕ125 H7／h7	8	8	ϕ0.03
T255	ϕ155 H7／h7	ϕ28 H7／h7	ϕ155 H7／h7	8	8	
T355	ϕ185 H7／h7	ϕ35 H7／h7	ϕ185 H7／h7	8	8	
T455	ϕ230 H7／h7	ϕ42 H7／h7	ϕ230 H7／h7	10	10	
T555	ϕ260 H7／h7	ϕ47 H7／h7	ϕ260 H7／h7	10	10	ϕ0.05
T655	ϕ295 H7／h7	ϕ58 H7／h7	ϕ295 H7／h7	10	10	
T755	ϕ330 H7／h7	ϕ62 H7／h7	ϕ330 H7／h7	15	15	

10-2. Tightening Torque and Allowable Transmitted Torque for Bolts

The quantity, size, tightening torque and allowable transmitted torque of bolt for the output flange and ring gear housing are shown in Table T-18.

Table T-18

Frame size	Output Flange Bolts								Ring gear housing bolts					
	Number of bolts-size	PCD of bolts	Tightening torque		Allowable transmitted torque by bolts (Every pitch)		Allowable transmitted torque by bolts (Total)		Number of bolts-size	PCD of bolts	Tightening torque		Allowable transmitted torque by bolts (Total)	
		mm	N•m	kgf•cm	N•m	kgf•m	N•m	kgf•m		mm	N•m	kgf•cm	N•m	kgf•m
T155	6-M8	72	31.4	320	669	68	1231	126	16-M6	114	12.8	130	1552	158
	∗3-M8	66	31.4	320	307	31								
	6-M6	45	12.8	130	255	26								
T255	6-M12	84	107	1090	1795	183	2639	269	12-M8	142	31.4	320	2639	269
	∗3-M8	82	31.4	320	383	39								
	6-M8	50	31.4	320	461	47								
T355	6-M14	104	172	1750	3041	310	5484	559	16-M8	171	31.4	320	4238	432
	∗3-M12	102	107	1090	1089	111								
	6-M12	63	107	1090	1354	138								
T455	6-M16	135	265	2700	5386	549	8751	892	12-M12	210	107	1090	8996	917
	∗3-M12	129	107	1090	1373	140								
	6-M12	93	107	1090	1991	203								
T555	6-M18	165	363	3700	8044	820	13538	1380	16-M12	240	107	1090	13734	1400
	∗3-M14	150	172	1750	2158	220								
	6-M14	115	172	1750	3335	340								
T655	6-M22	180	706	7200	13832	1410	21778	2220	16-M14	272	172	1750	21190	2160
	∗3-M16	170	265	2700	3335	340								
	6-M16	115	265	2700	4611	470								
T755	6-M24	200	903	9200	17952	1830	28940	2950	16-M16	305	265	2700	32471	3310
	∗3-M18	190	363	3700	4611	470								
	6-M18	130	363	3700	6377	650								

●Bolt : Use metric hexagon socket head cap screw based on JIS B1176, strength grade 10.9"

●Countermeasure for bolts loosening: Use adhesives (Loctite262, etc.) or spring washer (based on JIS B1252, class 2).

●Tighten the bolts with "∗" in outline drawing when tightening output flange. If not, reducer may disassemble.

●Friction Coefficient: 0.15

10-3. Lubrication

- T-Series are shipped with grease drained at the time of shipment. Customer must prepare and fill appropriate amount of (Table .T-20) recommended grease (Table.T-19).
- Use quantity indicated in Table T-20 as a guide, check the actual grease level when filling grease.
- Match the position of filler and drain port at output side with one of eccentric planetary shaft bearing. (See ""A"" in Fig.T-20 and Table T-20)"
- When supplying with grease for the first time, fill from lower drain port to ensure grease circulation.
- Change grease every 20,000 hours or every 3～5 years.
  Overhaul recommended when reducer runs for total 20000 hours or 3-5 years after purchase.

Table T-19 Recommended Grease for FC-T and F2C-T Series

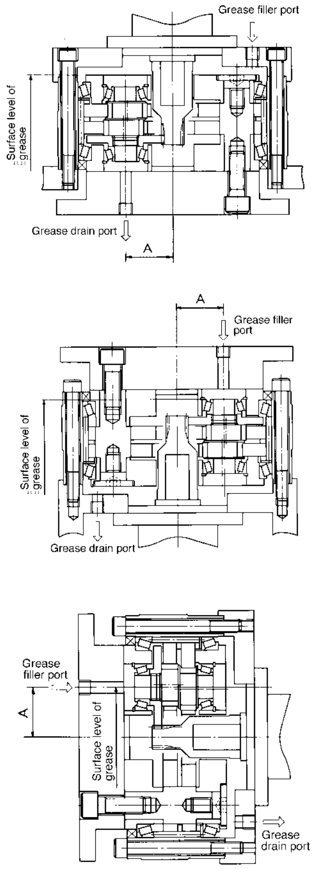
Name of recommended grease	Supplier
Shell Alvania EP Grease R0	Showa Shell Sekiyu K.K.
Multemp FZ No.00	Kyodo Yushi Co., Ltd.

Ambient Temperature: -10℃～40℃

Table T-20 Quantity of Grease (space capacity of reducer)

Frame size	Grease (g)		Position of grease filler port A(mm)
	Vertical	Horizontal	
T155	80	60	25
T255	120	100	31
T355	230	180	39
T455	300	240	47
T555	400	320	55
T655	700	560	63
T755	800	640	72

Fig. T-20


Vertical ①

Vertical ②

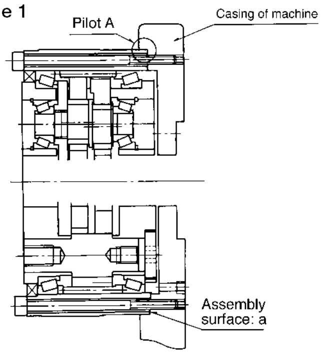
Horizontal

10-4. Assembly Example 1

Fig. T-21

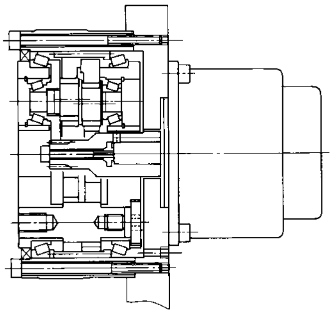
Assembly example 1

①



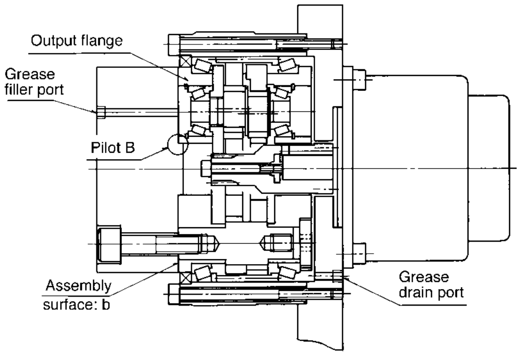
Attach CYCLO F-Series to the casing with bolts.
Apply liquid gasket to the assembly side "a" at this point.
In this example, motor adaptor is a part of casing.

②



Fix input gear shaft of CYCLO DRIVE to motor shaft with key and bolts.
Phase input gear shaft and eccentric planetary shaft gear. Then fix motor to CYCLO reducer part with bolts.
(Apply fretting prevention agent to motor shaft before assembly.)

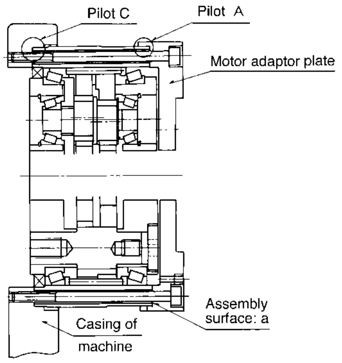
③



Output shaft of machine is attached to output flange of CYCLO by bolts.
Apply liquid gasket to the assembly side "b" at this point.
Fill in specified amount of grease through drain port and close both drain port and filler port on output shaft.

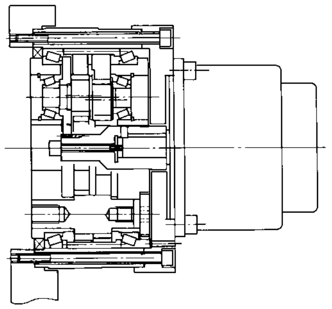
Assembly example 2

①



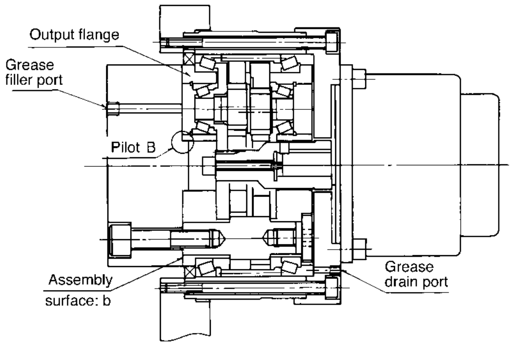
Attach CYCLO F-Series to the casing with bolts.
Apply liquid gasket to the assembly side "a", "c" at this point.
In this example, motor adaptor is a part of casing.

②



Fix input gear shaft of CYCLO DRIVE to motor shaft with key and bolts.
Phase input gear shaft and eccentric planetary shaft gear. Then fix motor to CYCLO reducer part with bolts.
(Apply fretting prevention agent to motor shaft before assembly.)

③



Output shaft of machine is attached to output flange of CYCLO by bolts.
Apply liquid gasket to the assembly side "b" at this point.
Fill in specified amount of grease through drain port and close both drain port and filler port on output shaft.

Note1) Make sure to apply specified tightening torque (refer to Table T-18) to bolts when attaching reducer.
Note 2) Choose bolts shorter than the depth of tap indicated in output side flange in Outline Drawing (P62˜68), when attaching output shaft to output side flange (slow speed shaft) of CYCLO DRIVE."

Recommended liquid gasket:
Liquid gasket Three Bond 1215 of Three Bond Co., Ltd.

Outline Drawing

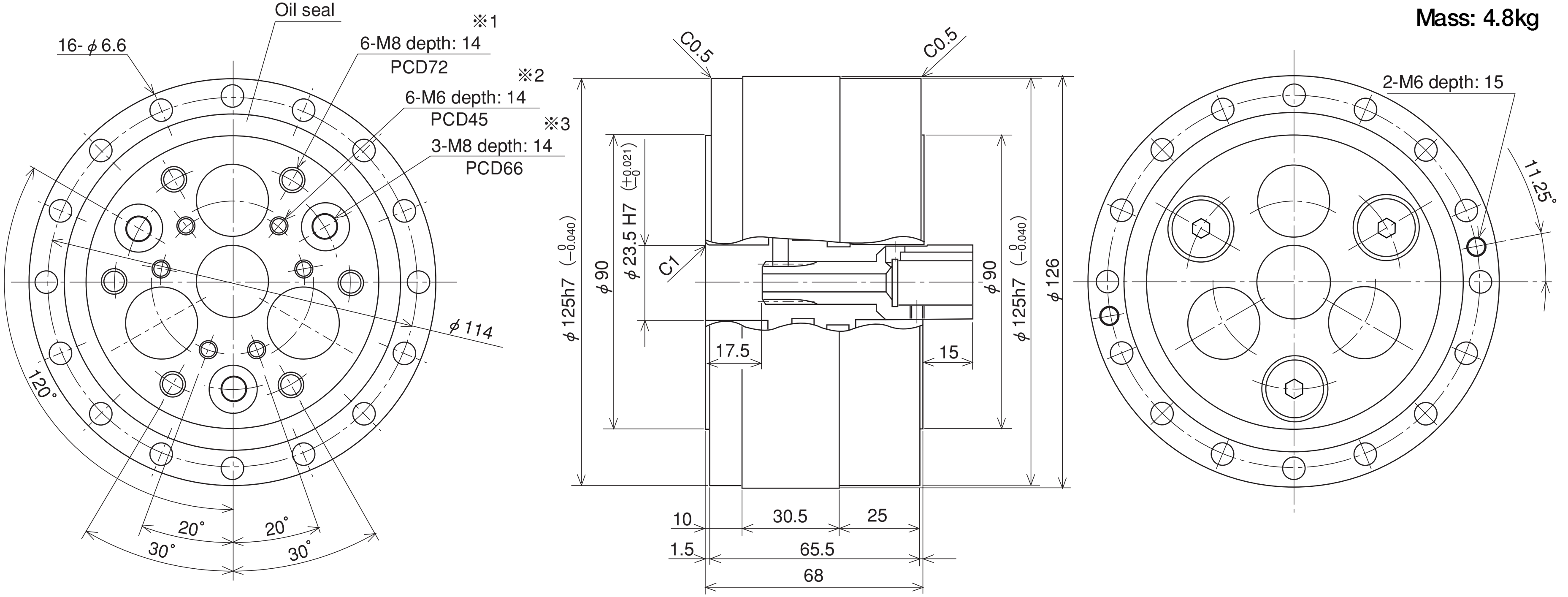
FC—T Series
F2C—T Series

Contents

※Outline and assembly dimensions of FC-T series are the same as F2C-T Series.

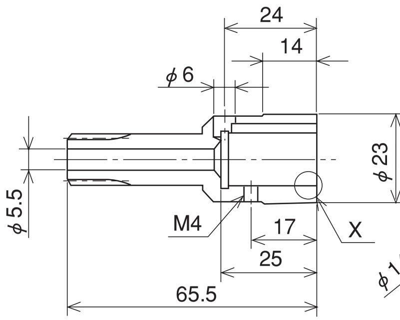
T155 Outline drawing

Mass: 4.8kg



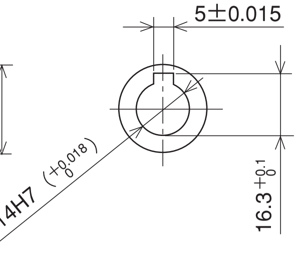
Notes:

1. Make sure to tighten the bolts "※3" in the drawing with specified tightening torque (refer to page 59). (If not, reducer may disassemble.)
2. Apply liquid gasket to the attachment surface with the reducer to avoid grease leak.
3. Bolts and washers for assembly, liquid gasket and grease are prepared by the customer. (See P. 59)
4. The dimensions in these drawings are subject to change without prior notice.
5. Standard specifications are without paint.

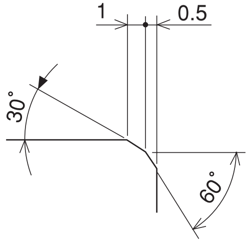


Details of Input Gear Shaft

- Maximum diameter for hollow bore of input gear shaft is f16 mm.



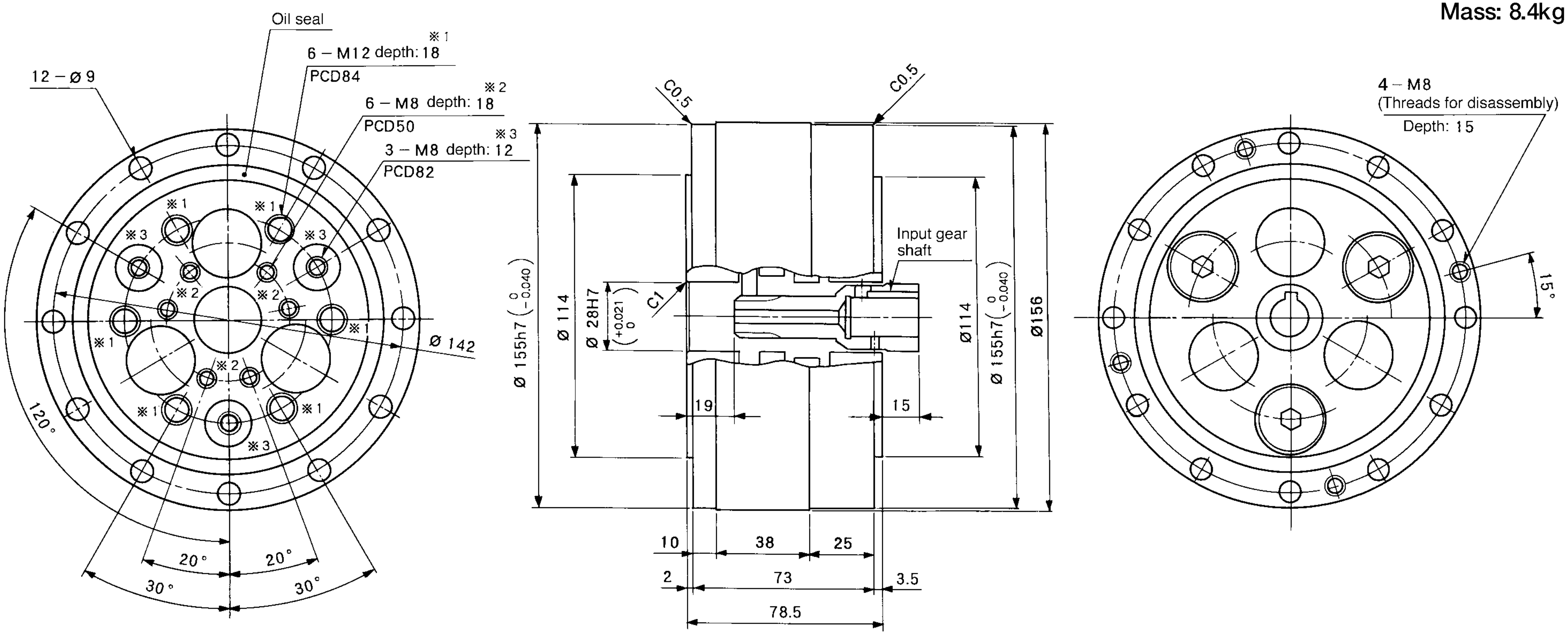
Details of Input Gear Shaft

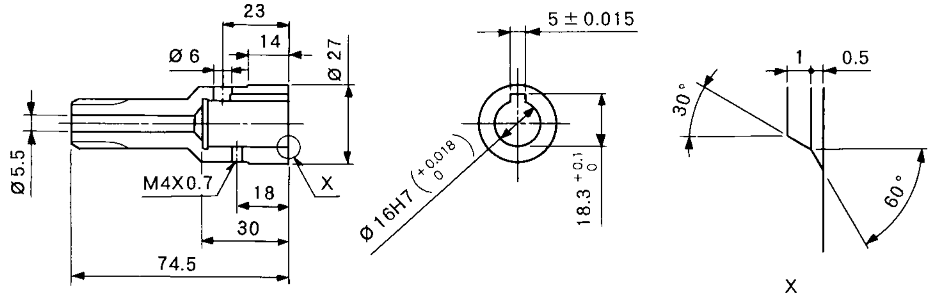


Details of X

T255 Outline drawing

Mass: 8.4kg





Details of Input Gear Shaft

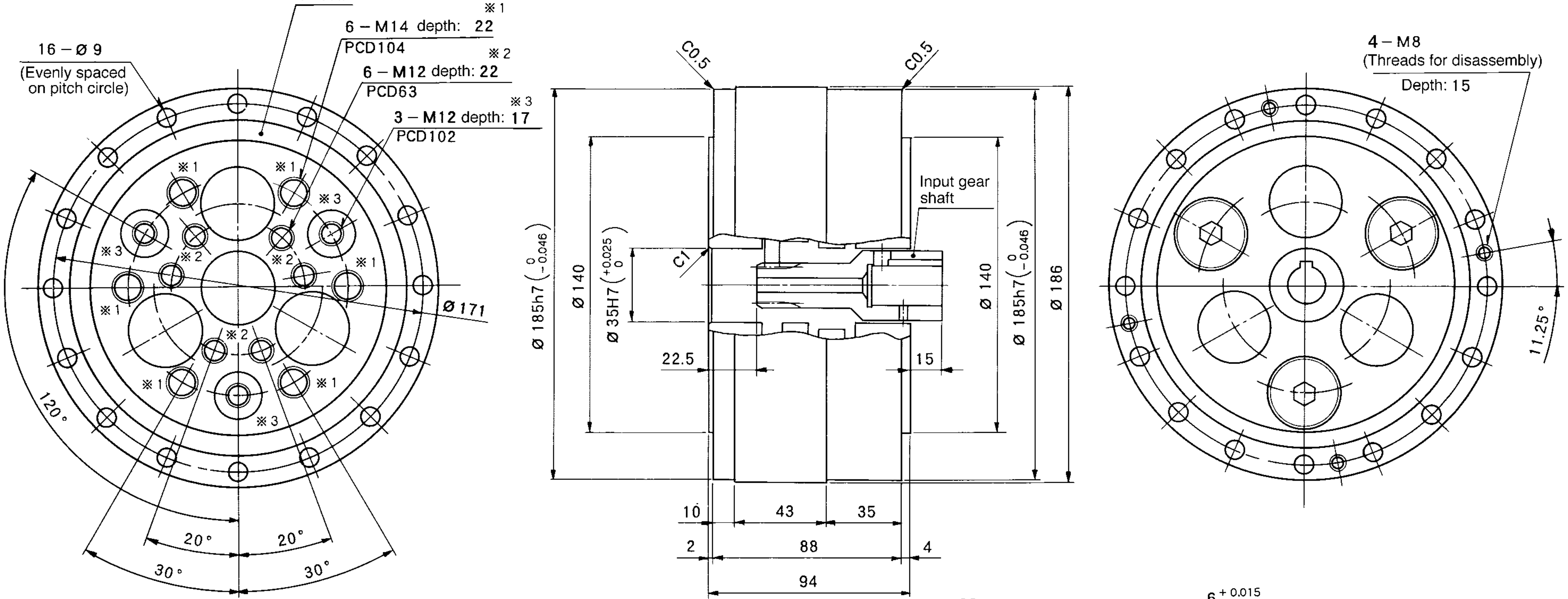
- Maximum diameter for hollow bore of input gear shaft is ϕ16 mm.

Notes:

1. Make sure to tighten the bolts "※3" in the drawing with specified tightening torque (refer to page 59). (If not, reducer may disassemble.)
2. Apply liquid gasket to the attachment surface with the reducer to avoid grease leak.
3. Bolts and washers for assembly, liquid gasket and grease are prepared by the customer. (See P. 59)
4. The dimensions in these drawings are subject to change without prior notice.
5. Standard specifications are without paint.

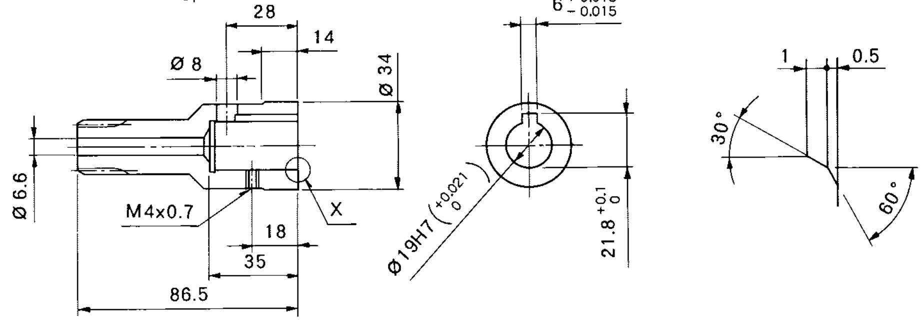
T355 Outline drawing

Mass: 14kg



Notes:

1. Make sure to tighten the bolts "※3" in the drawing with specified tightening torque (refer to page 59). (If not, reducer may disassemble.)
2. Apply liquid gasket to the attachment surface with the reducer to avoid grease leak.
3. Bolts and washers for assembly, liquid gasket and grease are prepared by the customer. (See P. 59)
4. The dimensions in these drawings are subject to change without prior notice.
5. Standard specifications are without paint.

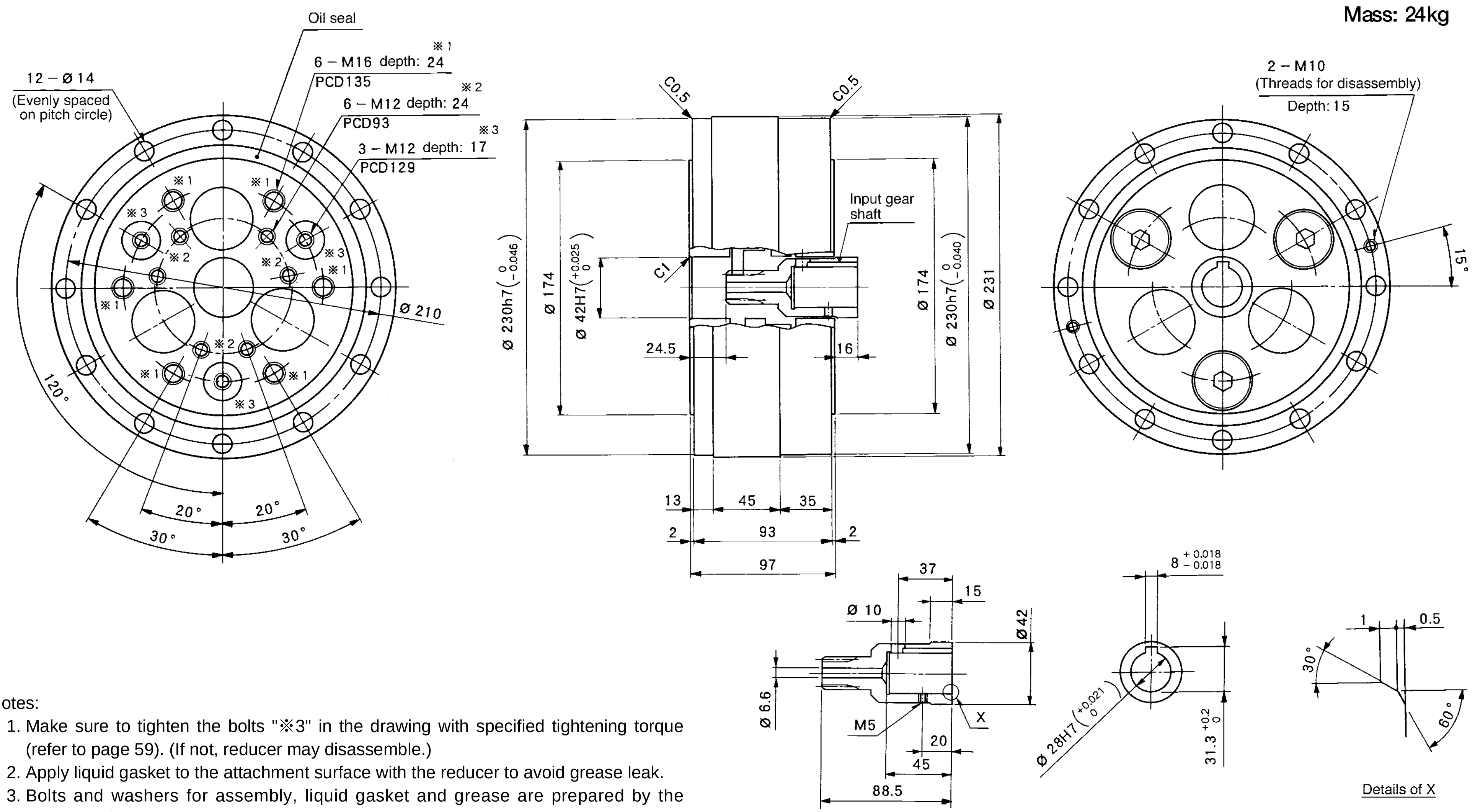


Details of Input Gear Shaft

- Maximum diameter for hollow bore of input gear shaft is ϕ22mm.

T455 Outline drawing

Mass: 24kg



Notes:

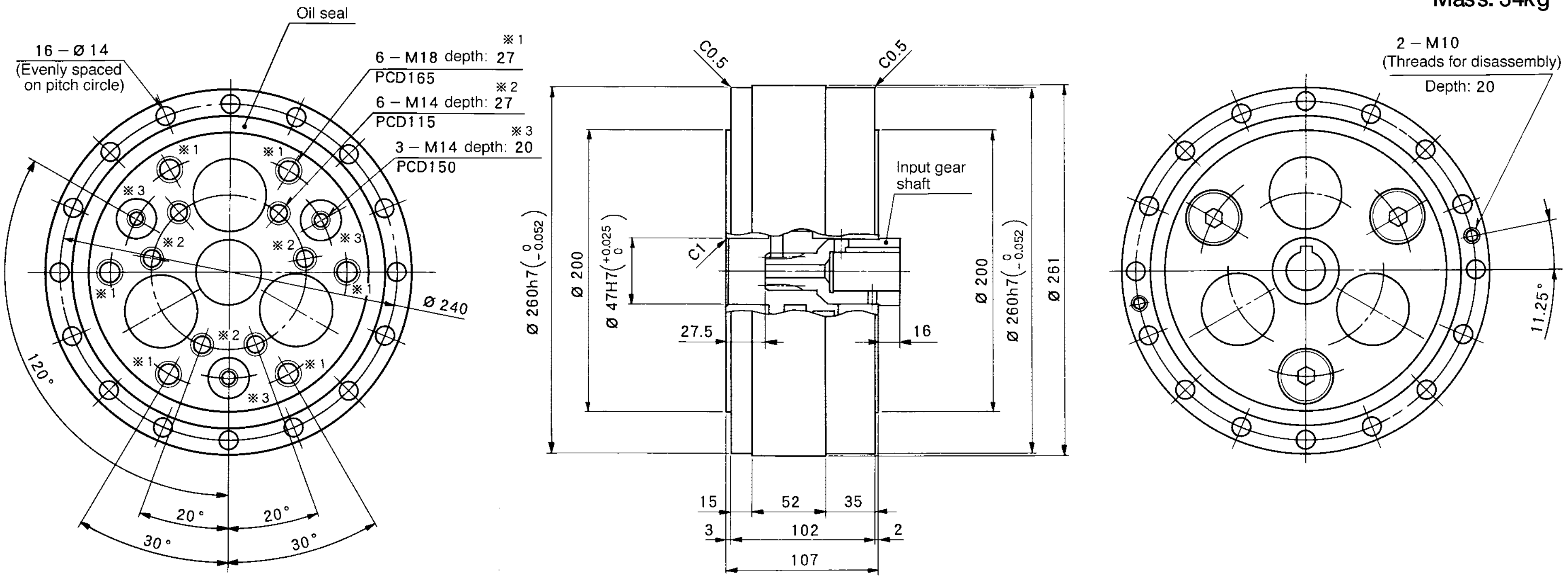
1. Make sure to tighten the bolts "※3" in the drawing with specified tightening torque (refer to page 59). (If not, reducer may disassemble.)
2. Apply liquid gasket to the attachment surface with the reducer to avoid grease leak.
3. Bolts and washers for assembly, liquid gasket and grease are prepared by the customer. (See P. 59)
4. The dimensions in these drawings are subject to change without prior notice.
5. Standard specifications are without paint.

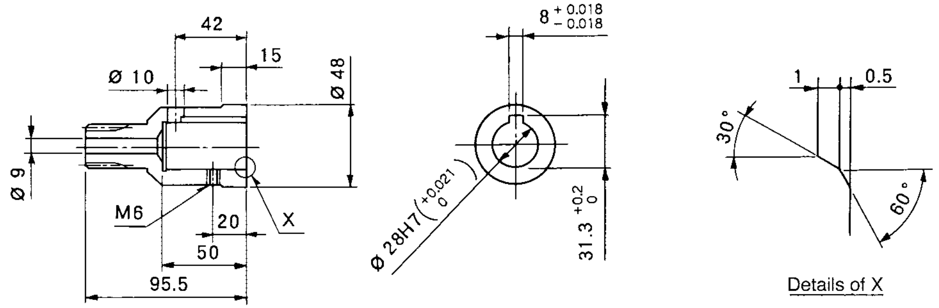
Details of Input Gear Shaft

- Maximum diameter for hollow bore of input gear shaft is ϕ28 mm.

T555 Outline drawing

Mass: 34kg





Notes:

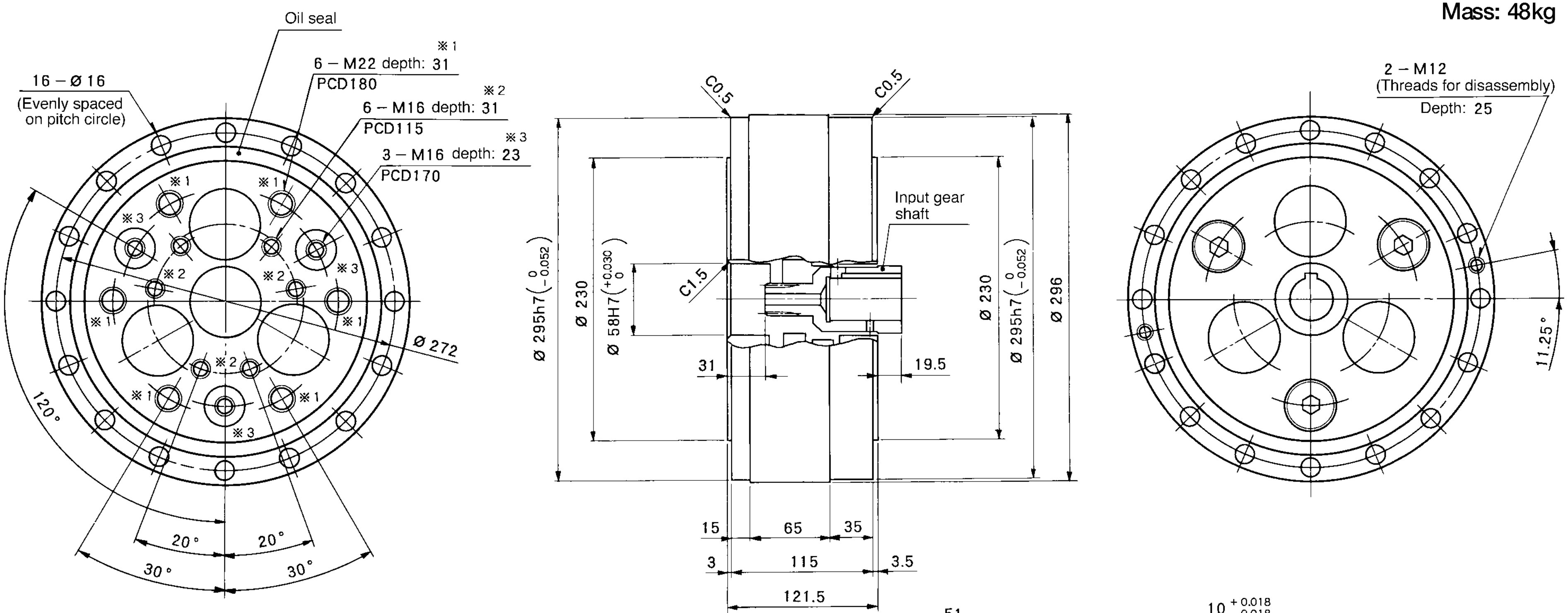
1. Make sure to tighten the bolts "※3" in the drawing with specified tightening torque (refer to page 59). (If not, reducer may disassemble.)
2. Apply liquid gasket to the attachment surface with the reducer to avoid grease leak.
3. Bolts and washers for assembly, liquid gasket and grease are prepared by the customer. (See P. 59)
4. The dimensions in these drawings are subject to change without prior notice.
5. Standard specifications are without paint.

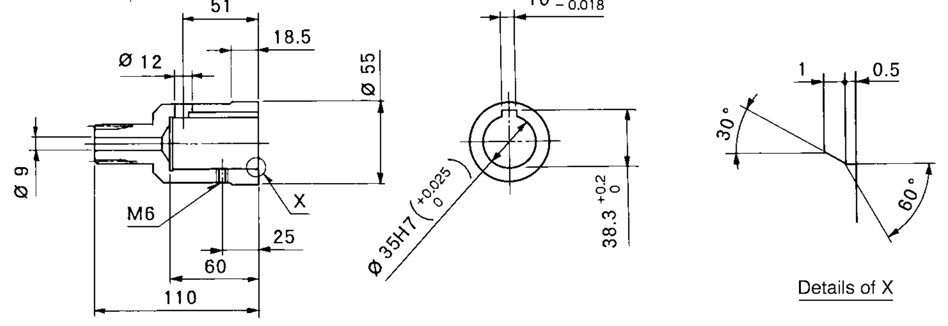
Details of Input Gear Shaft

- Maximum diameter for hollow bore of input gear shaft is ϕ30 mm.

T655 Outline drawing

Mass: 48kg





Notes:

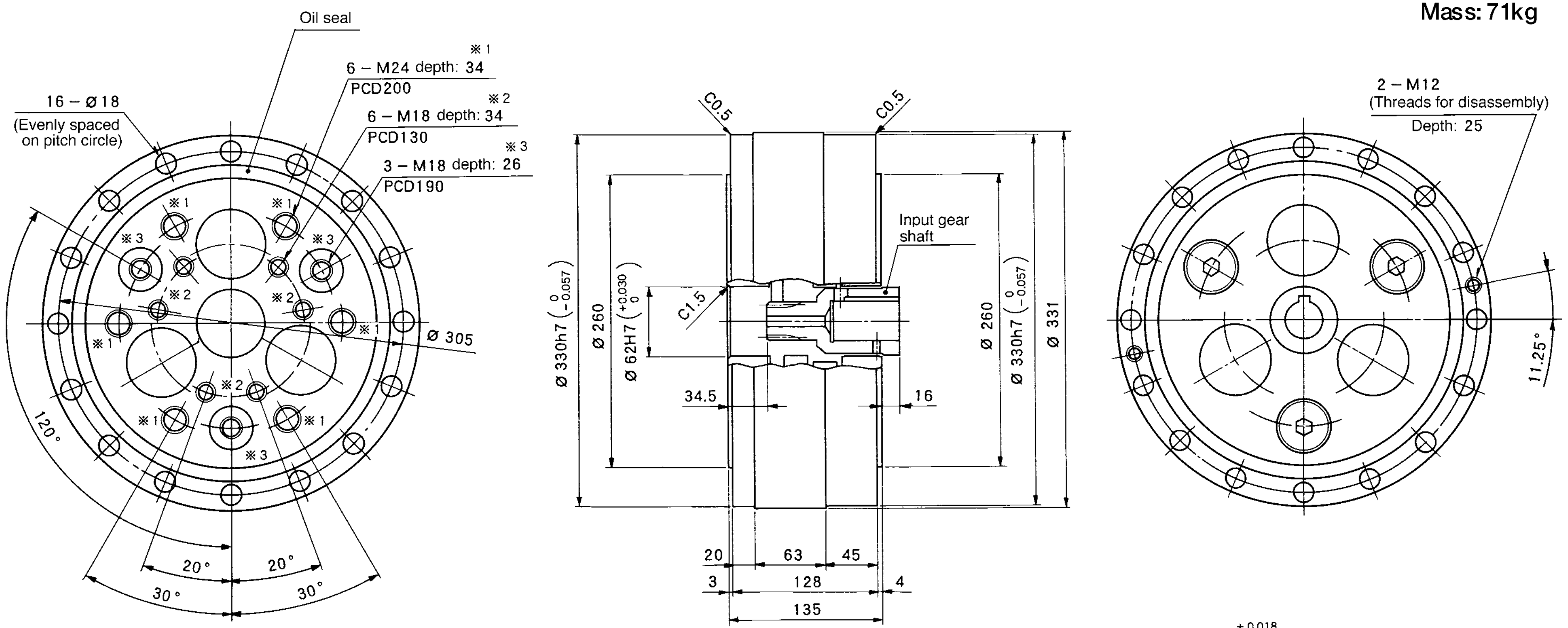
1. Make sure to tighten the bolts "※3" in the drawing with specified tightening torque (refer to page 59). (If not, reducer may disassemble.)
2. Apply liquid gasket to the attachment surface with the reducer to avoid grease leak.
3. Bolts and washers for assembly, liquid gasket and grease are prepared by the customer. (See P. 59)
4. The dimensions in these drawings are subject to change without prior notice.
5. Standard specifications are without paint.

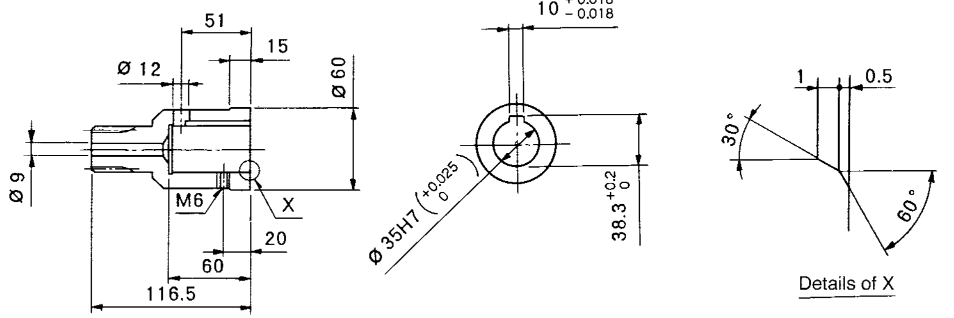
Details of Input Gear Shaft

- Maximum diameter for hollow bore of input gear shaft is ϕ35 mm.

T—755 Outline drawing

Mass: 71kg





Notes:

1. Make sure to tighten the bolts "※3" in the drawing with specified tightening torque (refer to page 59). (If not, reducer may disassemble.)
2. Apply liquid gasket to the attachment surface with the reducer to avoid grease leak.
3. Bolts and washers for assembly, liquid gasket and grease are prepared by the customer. (See P. 59)
4. The dimensions in these drawings are subject to change without prior notice.
5. Standard specifications are without paint.

Details of Input Gear Shaft

- Maximum diameter for hollow bore of input gear shaft is ϕ40 mm.

Warranty

The scope of our warranty for our products is limited to the range of our manufacture.

Warranty (period and contents)

Warranty Period	The warranty period for the Products shall be 18 months after the commencement of delivery or 18 months after the shipment of the Products from the seller's works or 12 months from the Products coming into operation, whether comes first.
Warranty Condition	In the event that any problem or damage to the Product arises during the “Warranty Period” from defects in the Product whenever the Product is properly installed and combined with the Buyer’s equipment or machines, maintained as specified in the maintenance manual, and properly operated under the conditions described in the catalog or as otherwise agree upon in writing between the Seller and the Buyer or its customers ; the Seller will provide, at its sole discretion, appropriate repair or replacement of the Product without charge at a designted facility, except as stipulated in the “Warranty Exclusions” as described below. However, if the Product is installed or integrated into the Buyer’s equipment or machines, the Seller shall not reimburse the cost of : removal or re-installation of the Product or other incidental costs related thereto, any lost opportunity, any profit loss or other incidental or consequential losses or damages incurred by the Buyer or its customers.
Warranty Exclusions	Notwithstanding the above warranty, the warranty as set forth herein shall not apply to any problem or damage to the Product that is caused by : 1. installation, connection, combination or integration of the Product in or to the other equipment or machine that is rendered by any person or entity other than the Seller ; 2. insufficient maintenance or improper operation by the Buyer or its customers, such that the Product is not maintained in accordance with the maintenance manual provided or designated by the Seller ; 3. improper use or operation of the Product by the Buyer or its customers that is not informed to the Seller, including, without limitation, the Buyer’s or its customers’ operation of the Product not in conformity with the specifications, or use of lubricating oil in the Product that is not recommended by the Seller ; 4. any problem or damage on any equipment or machine to which the Product is installed, connected or combined or on any specifications particular to the Buyer or its customers ; 5. any changes, modifications, improvements or alterations to the Product or those functions that are rendered on the Product by any person or entity other than the Seller ; 6. any parts in the Product that are supplied or designated by the Buyer or its customers ; 7. earthquake, fire, flood, sea-breeze, gas, thunder, acts of God or any other reasons beyond the control of the Seller ; 8. normal wear and tear, or deterioration of the Product’s parts, such as bearings, oil-seals ; 9. any other troubles, problems or damage to the Product that are not attributable to the Seller.