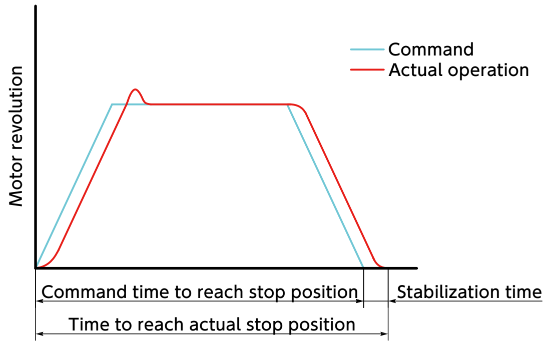
Technical Information

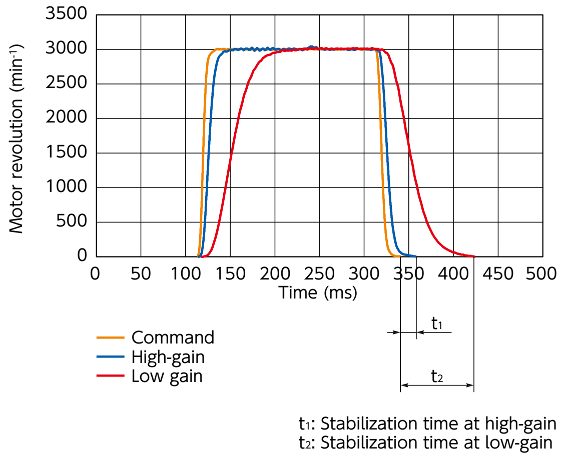
● Productivity and stabilization time

In a production facility which uses servomotors, single-axis actuators and ball screws, the key to improved productivity is operating these components accurately, as directed by a program. However, occasionally the command execution may be delayed.
For example, when trying to stop the actuator at a predetermined position, sometimes it will stop later than the command, which we refer to as a delay in stabilization time. Since the operation does not shift to the next process until the actuator completely stops, it is important to shorten stabilization time and thereby improve productivity.



● Gain and stabilization time of servomotor

This shows how the servomotor gain movement follows the command.
Increasing the gain helps to reduce stabilization time, but increasing it too far causes hunting, making servomotor control impossible.
Increasing the gain while suppressing hunting requires fine adjustment of the servomotor parameters.
However, when a servomotor is combined with a coupling with a metal disk type in the elastic segment, raising the gain tends to cause hunting, making it difficult to resolve the problem by fine adjustments to parameters.
When hunting occurs, it is generally recommended to change to a coupling with higher rigidity to increase the rigidity of the rotating system.
However, in reality, it is not possible to increase the rigidity of the entire rotating system including the ball screw simply by changing the coupling; so changing to a highly rigid coupling such as a disk-type may not be effective.



● High-gain Rubber Type

XGT2-C XGL2-C XGS2-C XGT XGL XGS

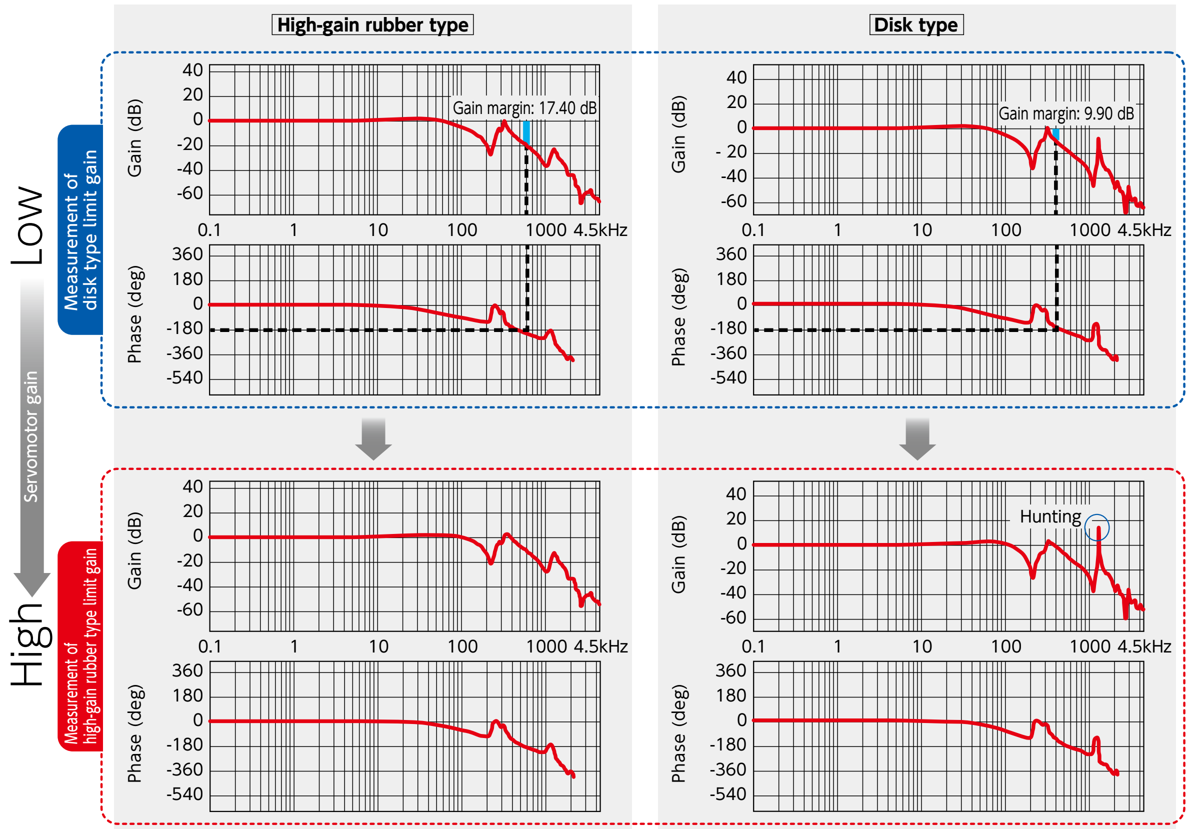
The high-gain rubber type can be used at even higher gain than high-rigidity couplings such as the disk type, enabling reduction of stabilization time.
The vibration absorption function reduces the amount of parameter adjustment work, and lowers the time required to find optimal parameters.

● Why can gain be increased even further with high-gain rubber types than with disk types?

The Bode plot makes it clear why the high-gain rubber type can increase servomotor gain beyond the capacity of the disk type.
The width of the gain relative to 0 dB when the phase delay on the Bode plot is –180° is called the gain margin and the phase width relative to the frequency intersecting at 180° is called the phase margin.
General guidelines for servo systems call for setting the gain margin between 10 and 20 dB and the phase margin between 40° and 60°, but as the servomotor gain is increased, the gain margin decreases. When the gain margin falls below 10 dB, hunting tends to occur.
A comparison with the disk type limit gain (upper limit of the gain in which coupling can be used without hunting) shows not only that the high-gain rubber type features a larger gain margin, but also that the gain margin is over 10 dB. This is why the high-gain rubber type allows greater servomotor gain than the disk type.
To increase the gain margin, both the coupling damping performance and its dynamic rigidity must be high. ➡ P. xxxx

Gain margin at the disk type limit gain
High-gain rubber type : 17.40 dB
Disk type : 9.90 dB

● Bode Plot



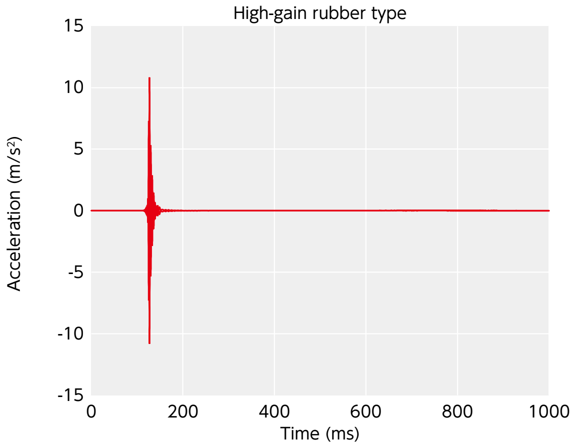
● Larger gain margin compared to the disk type
● Allows higher servomotor gain settings

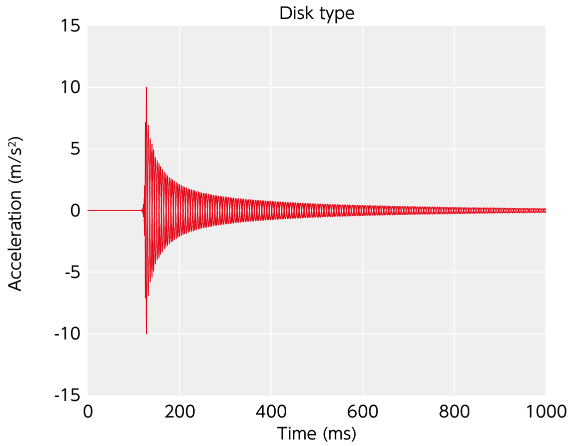
● Smaller gain margin compared to the high-gain rubber type increases the risk of hunting

Technical Information

● Damping performance comparison of high-gain rubber and disk types

Damping ratio of high-gain rubber type that shows damping characteristics is far higher than that of the disk type, enabling rapid absorption of vibration.





● Comparison of High-gain Rubber Type (XG2 Series/XG Series) and Disk Type Couplings

In tests using servo motors and actuators, the following are confirmed.

● Stabilization Time

Increasing the gain shortens the stabilization time, and the gain can be set especially high in the XG2 and XG series.

There were no differences in stabilization time between couplings as long as the gain was the same.

To reduce stabilization time, higher gain settings enabled by the use of the high-gain rubber types, especially the XG2 series, demonstrate clear advantage against the disk type.

● Positioning Accuracy/Repeated Positioning Accuracy

No differences attributable to factors such as gain or coupling were observed.

● Overshoot

Increasing the gain increases the overshoot, and the same gain resulted in no difference in the overshoot.

● Conclusion

The XG2 Series allows higher gain settings, enabling shorter stabilization time. The positioning accuracy, repetition positioning accuracy and overshoot did not differ due to coupling.

As a result, it was confirmed that the XG2 series is effective for shortening the cycle time of devices and equipment.

● Test Devices

Actuator : MCM08 Manufactured by NSK Co., Ltd.
∗ Ball screw lead 10 mm

Servomotor : HF-KP13 Manufactured by Mitsubishi Electric Corporation

● Test Conditions

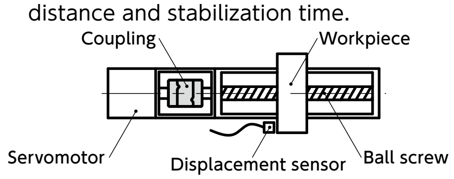
Motor revolution : 3000 min^{-1}
Acceleration/deceleration time : 50 ms
Workpiece load : 3.0 kg
Ratio of moment of inertia of load : 3.5

● Test Operation

Normal rotation (1 rev) → Stop (500 ms) → Reverse rotation (1 rev)

● Test Method

Measure the work movement with a displacement sensor and also measure the work piece's travel distance and stabilization time.



● Measurement of Stabilization Time, Positioning Accuracy and Overshoot

Gain∗1		XG2 Series	XG Series	Disk Type	Consideration
25	Stabilization Time (ms)	12	12	12	This is the upper gain limit for the disk type. XG series and XG2 series have no problems.
	Positioning Accuracy (mm)	0.002	0.002	0.002	
	Repeated Positioning Accuracy (mm)	±0.001	±0.002	±0.002	
	Overshoot (μm)	0.6	0.6	0.6	
27	Stabilization Time (ms)	8	8	Occurrence of Hunting	This is the upper gain limit for the XG series. XG2 series has no problems. The disk type is not usable due to hunting.
	Positioning Accuracy (mm)	0.002	0.003		
	Repeated Positioning Accuracy (mm)	±0.002	±0.002		
	Overshoot (μm)	1	1		
32	Stabilization Time (ms)	3	Occurrence of Hunting	Occurrence of Hunting	The disk type and XG series are not usable due to hunting. XG2 series has no problems.
	Positioning Accuracy (mm)	0.003			
	Repeated Positioning Accuracy (mm)	±0.001			
	Overshoot (μm)	1.7			

∗1 : Values with all gains, such as position control gain and speed control gain, adjusted (Min: 1 - Max: 32)

Positioning Accuracy

: Positioning operation is performed and the absolute value of the difference between the target point and the actual stop position is determined. Max. value is found by performing this measurement from the home position at all positions within the max. stroke range.

Repeated Positioning Accuracy

: Positioning is repeated 7 times from the same direction of movement to a randomly-selected point, the stopping positions are measured, and the difference between the max. and minimum values of the stopping position is determined. This method of measurement is applied at positions at the middle and both ends of the max. stroke range, then the max. value becomes the measured value, halved and prefixed with ±.

● The values in the table vary depending on testing conditions.

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Technical Information

● Changes in performance after cycles

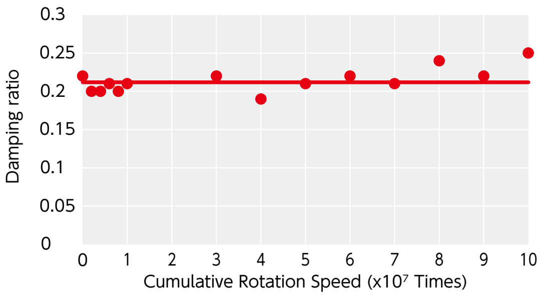
● Test Method ①

Rated torque load is applied to a coupling which rotates in a single direction, and the damping ratio and dynamic rigidity are measured.

● Couplings

XGT2-25C-12-12

● Changes in Damping Ratio Depending on Number of Cycles (Cumulative Rotation Speed)



*No changes are observed in the damping ratio or dynamic rigidity after cumulative rotation speed of 10^8 times.

● Test Method ②

A motor and coupling are mounted on a single-axis actuator, the workpiece is set in reciprocating motion and the damping ratio is measured.

● Couplings

XGT-25C-8-8

● Test Operation

Forward rotation (10 rev) → Reverse rotation (10 rev) This operation is repeated.

Stroke 100 mm, total travel distance 4400 km

● Measurement of Damping Ratio and Dynamic Rigidity

	Before Testing	After Testing
Damping Ratio	0.07	0.07

*No changes are observed in the damping ratio even after a total travel distance of 4400 km.

● Test Devices

Actuator : BG46 Manufactured by Nippon Bearing Co., Ltd.
 * Ball screw lead 10 mm

Servomotor : HF-KP13 Manufactured by Mitsubishi Electric Corporation

● Test Conditions

Motor revolution : 3000 min^{-1}
Acceleration/deceleration time : 10 ms
Workpiece load : 3.0 kg
Ratio of moment of inertia of load : 3.5

● Test Method

The damping ratio of the coupling is measured before and after the testing.

● Temperature-triggered changes in performance

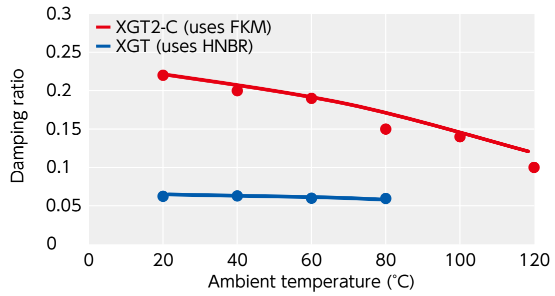
● Test Method

A coupling is left at the prescribed ambient temperature for 4 hours and damping ratio and dynamic rigidity measured.

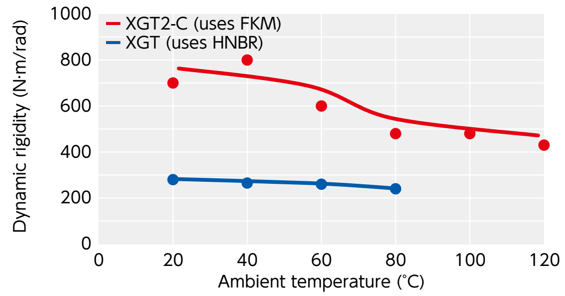
● Couplings

XGT2-25C-12-12 XGT-25C-12-12

● Temperature-triggered Changes in Damping Ratio

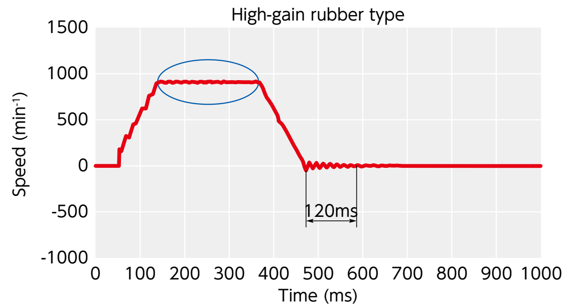


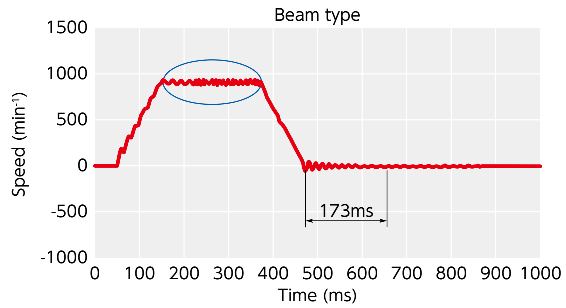
● Temperature-triggered Changes in Dynamic Rigidity



*Although the damping ratio and dynamic rigidity decrease as the temperature rises, XGT2 exceeds the damping ratio and dynamic rigidity of XGT across the entire temperature range.
* XGT2-68C uses HNBR high-gain rubber.

● Suppressing speed unevenness Control during Stepping Motor Operation

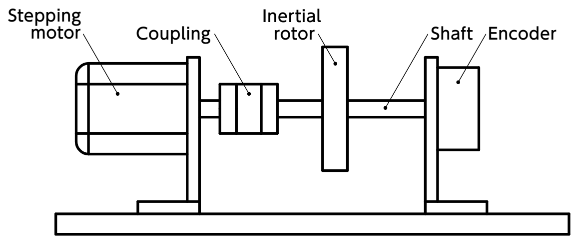




● Test Devices

Motor : α step AR66AK-1 Manufactured by Oriental Motor Co., Ltd.
 Set voltage――24 VDC
 Resolution――1000 p/r
 Moment of inertia――1250×10^{-7}kg・cm^2

Encoder : RD5000 Manufactured by Nikon Corporation



● Drive Parameters

Startup speed : 60 min^{-1}
Drive speed : 900 min^{-1}
Rotation angle : 1800°
Acceleration/deceleration time : 100 ms

*The high-gain rubber type is effective to suppress speed unevenness during fixed-speed rotation.

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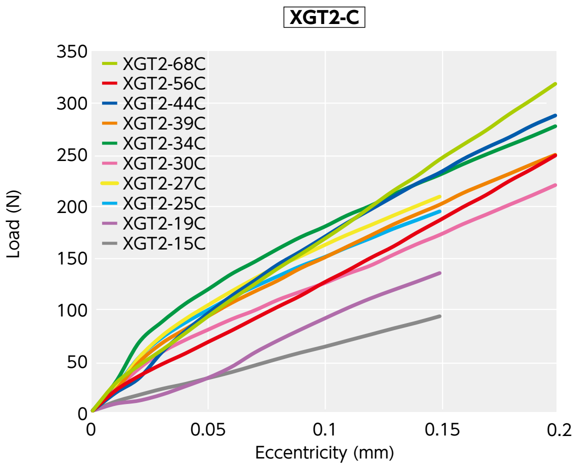
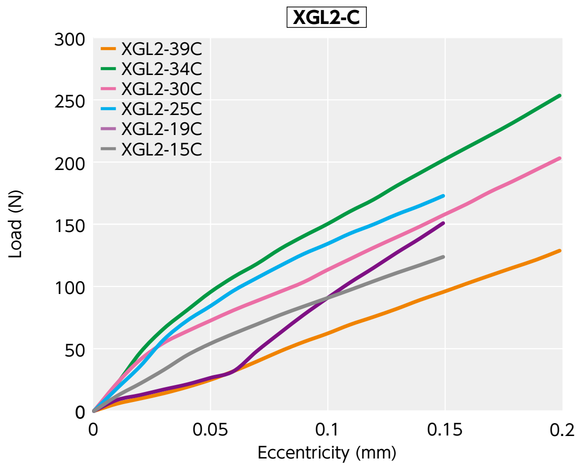
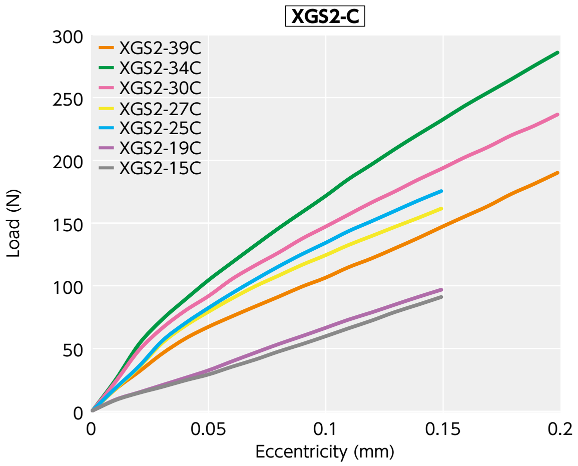
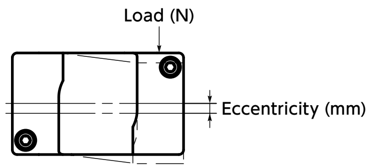
● Eccentric Reaction Force



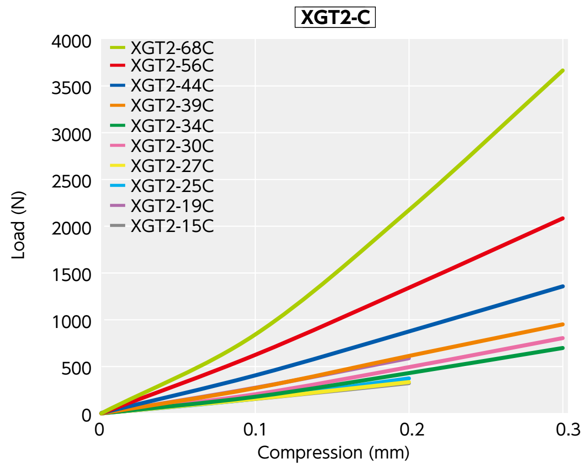


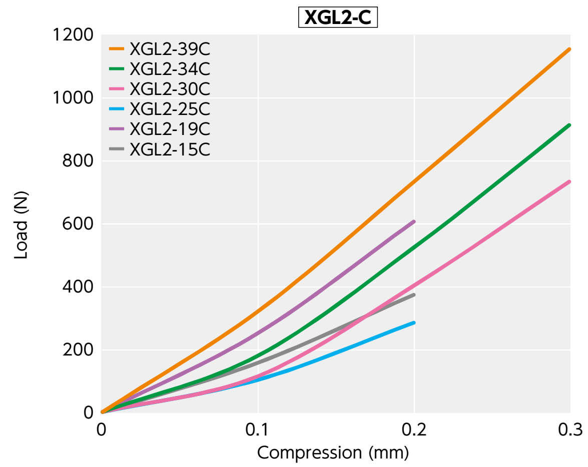


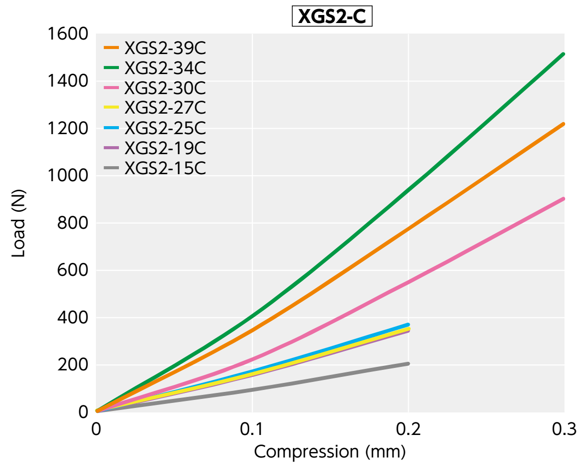
This is the force generated when placing XGT2-C XGL2-C XGS2-C in an eccentric condition.
As the eccentric reaction force becomes smaller, the force acting on the shaft bearing also becomes smaller.



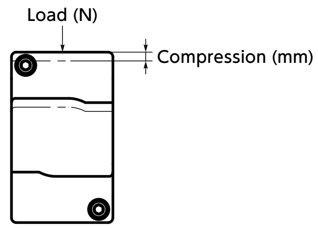
● Thrust Reaction Force







This is the force generated when compressing XGT2-C XGL2-C XGS2-C in the axial direction.
As the thrust reaction force becomes smaller, the force acting on the motor also becomes smaller.



● Physical properties and chemical resistance of high-gain type rubber

	Effect	
	FKM	HNBR
Aging Resistance	◎	◎
Weather Resistance	◎	◎
Ozone Resistance	◎	◎
Gasoline / Gas Oil	◎	○ - ◎
Benzene / Toluene	◎	△ - ○
Alcohol	◎	◎
Ether	× - △	× - △
Ketone (MEK)	×	×
Ethyl Acetate	×	× - △
Water	◎	◎
Organic Acid	×	◎
High Concentration Inorganic Acid	◎	○
Low Concentration Inorganic Acid	◎	◎
Strong Alkali	×	◎
Weak Alkali	△	◎

◎: Excellent ○: Available △: Available depending on conditions ×: Not available

● Slip Torque

As in the table below, the clamping types XGT2-C, XGL2-C, and XGS2-C have different slip torque according to the bore diameter. Take care during selection.

Unit : N・m

Outside Diameter	Bore Diameter (mm)																
	3	4	4.5	5	6	6.35	7	8	10	11	12	14	15	16	17	19	20
15	1	1.3	1.5	1.7	1.9												
19		2.2		2.7	3.1	3.3	3.8										
25				4.3	5	5.5		6.8									
27				3.8	5			6.8									
30								7.5	10	12							
34								8.3	10	10	12	13					
39									13		15	17	18	18	23	25	
44											16	19	20	21	23	25	27
56													45			50	61

- These are test values based on the conditions of shaft dimensional allowance: h7, hardness: 34 - 40 HRC, and screw tightening torque of the values described in XGT2-C XGL2-C XGS2-C dimension tables. They are not guaranteed values.
- Slip torque changes with usage conditions. Carry out tests under conditions similar to actual conditions in advance.