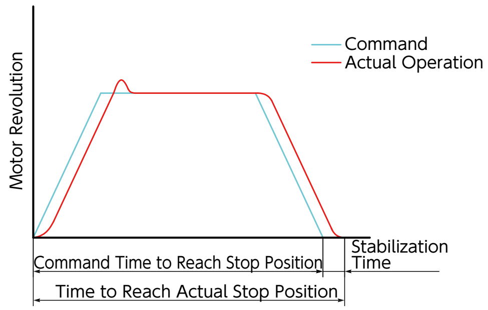
Technical Information

High-gain rubber types can improve productivity

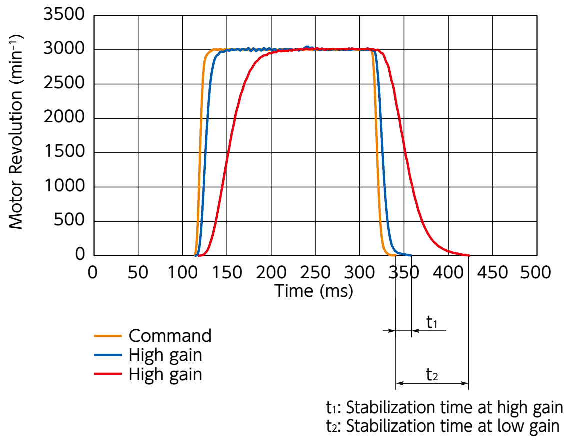
● Productivity and stabilization time

In a production facility, using servomotor's and actuator's, operating these components accurately, as directed by the program, can lead to the improvement of productivity.
Reality, in actual operation, execution of commands may be delayed. For example, when trying to stop the actuator at a predetermined position, the actuator stops somewhat later than the command.
We call this delay "stabilization time."
Since the operation does not shift to next process until the actuator completely stops, it is important to shorten the stabilization time to improve productivity.



● Gain and stabilization time of servomotor

Servomotor's gain is an indicator representing to what degree the motor operation can follow the command.
Although raising the gain can reduce the stabilization time, excessive gain increases are likely to cause hunting, thereby disable the control of the servomotor.
Raising the gain while suppressing hunting requires fine adjustment of respective parameters of the servomotor.
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 usually recommended to change to a more rigid coupling to increase the rigidity of the rotating system.
However, in reality, it is difficult 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 XGL2 XGS2 XGT XGL XGS

The high-gain rubber type can be used at higher gain than the disk type, enabling reduction of stabilization time.
In addition, the outstanding damping performance reduces the amount of troublesome parameter adjustments required, making it possible to make optimal actuator adjustments in a shorter time.

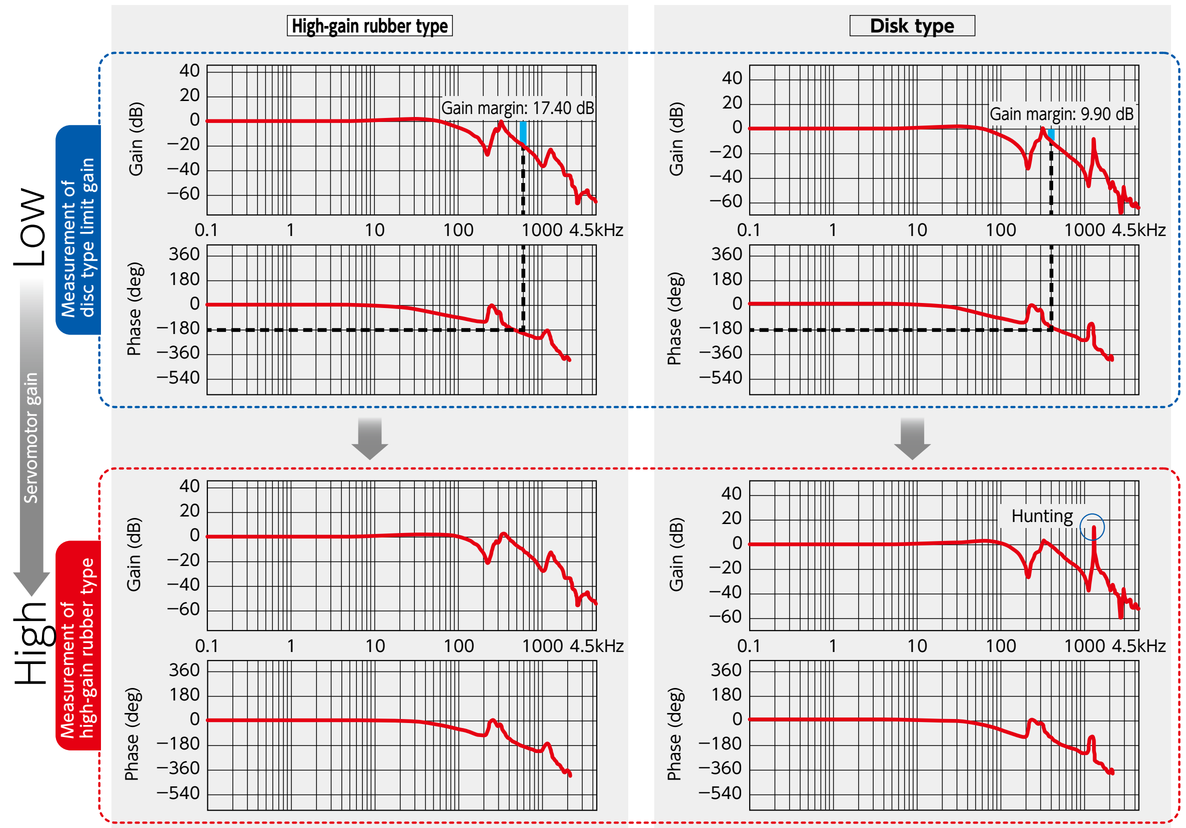
● Why does the high-gain rubber type allows higher gain setting than the disk type?

The main reasons can be understood from the bode plot.
Intersection point between 0 dB gain line the phase lag in the board wiring is −180 degrees is called the "gain margin".
As a general guideline, in servo systems, the gain margin should be 10 - 20 dB, and when the servomotor gain is increased, the gain margin decreases, with the risk of hunting occurs at 10 dB or lower.
A comparison at the disk type limit gain 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 are that both coupling damping ratio and dynamic rigidity are 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



High-gain rubber type:
- Larger gain margin compared to the disk type
- Allows higher servomotor gain settings.

Disk type:
- Smaller gain margin compared to the high-gainrubber type increases the risk of hunting.

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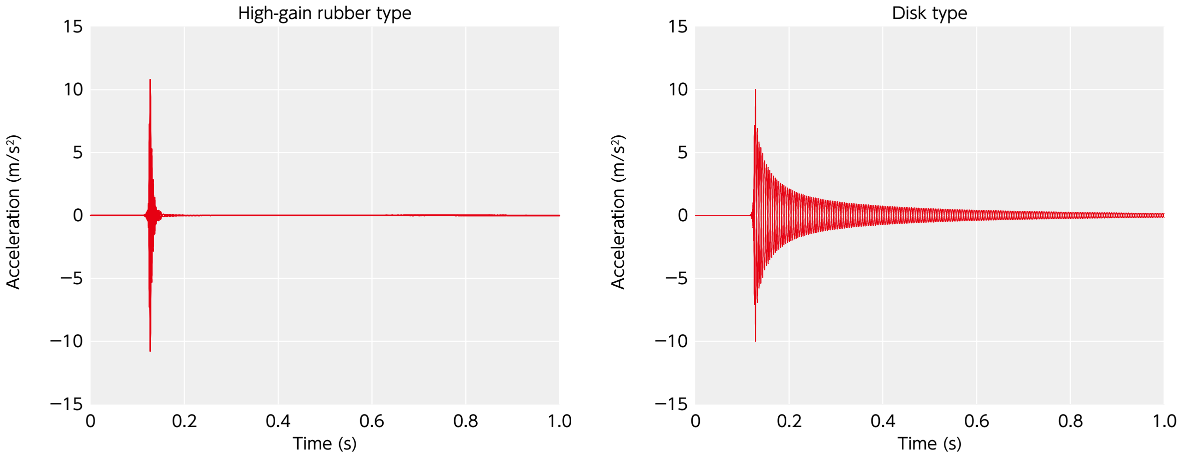
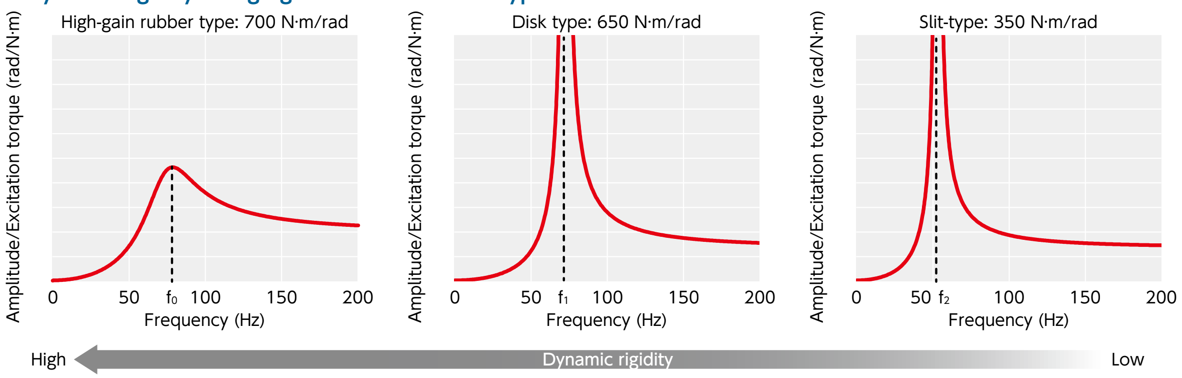
Technical Information

● Damping ratios of high-gain rubber and disk types



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

● Dynamic rigidity of high-gain rubber and disk types



The dynamic rigidity of the high-gain rubber type is equivalent to or higher than that of the disk type.
Dynamic rigidity (N·m/rad) = Excitation torque (N·m) / Amplitude (rad) at natural frequency (fn)

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

Verified test details based on using right : Test criteria

● Stabilization time
No differences between couplings as long as the gain is the same.
To reduce stabilization time, higher gains enabled by the use of the high-gain rubber types, especially the XG2 series, demonstrates clear advantage against the disk type.

● Positioning accuracy/Repeated positioning accuracy
No differences observed attributable to factors such as gain or coupling.

● Overshoot
Normally higher gain increases the degree of overshoot. At the same gaim, the XG2 series demonstrates the smallest overshoot.

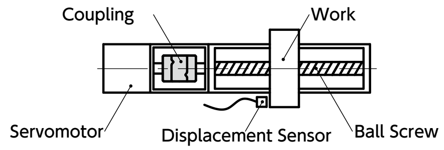
● The XG2 Series allows of higher servomotor gain settings than the existing XG series, enabling shorter stabilization time.

● Test Devices
Actuator : MCM08 Manufactured by NSK Ltd.
∗Ball screw lead: 10 mm
Servomotor : HF-KP13 Mitsubishi Electric

● Test Parameters
Motor revolution : 3000min⁻¹
Acceleration/Deceleration time : 50ms
Load on the work : 3.0kg
Load inertia moment ratio : 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*		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)	0.4	0.9	0.6	
27	Stabilization time (ms)	8	8	Occurrence of hunting	This is the upper gain limit for XG series. XG2 series have 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)	0.6	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 have no problems.
	Positioning accuracy (mm)	0.003			
	Repeated positioning accuracy (mm)	±0.001			
	Overshoot (μm)	1.7			

∗Values (1 - 32) are after adjustment of all gains including Position Control Gain and Speed Control Gain.
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 of the values 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 and the stopping position 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 the test conditions.

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Technical Information

● Changes in performance after cycles

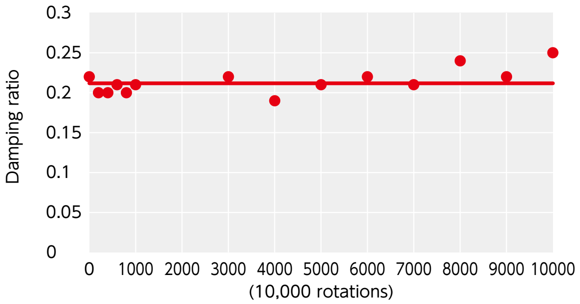
● Test Method ①

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

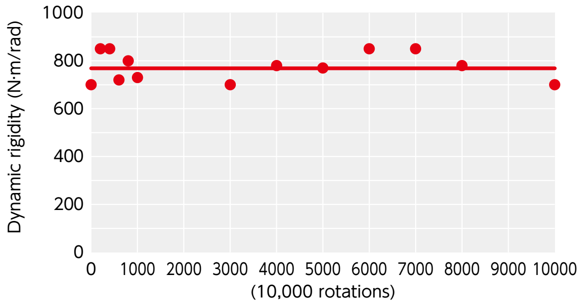
● Test Sample

XGT2 - 25C-12 - 12

● Changes in Damping Ratio depends on the number of cycles.



● Changes in Dynamic Rigidity depends on the number of cycles.



*No changes are observed in the damping ratio or dynamic rigidity after 100,000,000 rotations.

● Test Method ②

A motor and coupling are mounted on a single-shaft actuator, the work is set in reciprocating motion and the damping ratio and dynamic rigidity are measured.

● Test Devices

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

Servomotor : HF-KP13 Mitsubishi Electric

● Test Sample

XGT-25C-12 - 12

● Test Parameters

Motor revolution : 3000min^{-1}

Acceleration/Deceleration time : 10ms

Load on the work : 3.0kg

Load inertia moment ratio : 3.5

● Measurement of Damping Ratio and Dynamic Rigidity

	Before testing	After testing
Damping ratio	0.07	0.07
Dynamic rigidity (N·m/rad)	330	330

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

● Test Operation

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

Stroke: 100 mm, Total travel distance: 4400 km

● Test Method

The damping ratio and dynamic rigidity of the coupling are measured before and after the testing.

● Temperature-triggered changes in performance

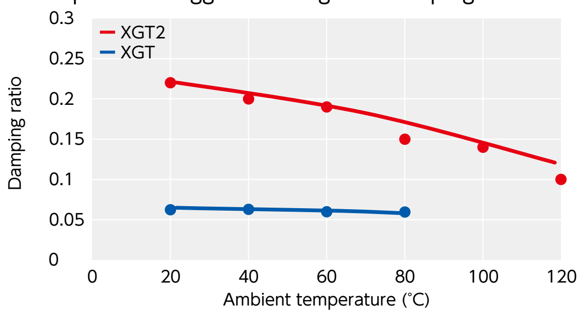
● Test Method

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

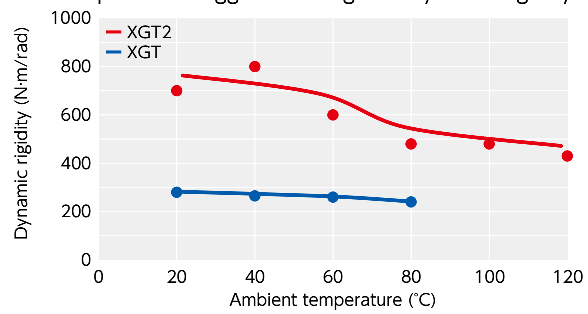
● Test Sample

XGT2 - 25C-12 - 12、XGT-25C-12 - 12

● Temperature-triggered changes in damping ratio

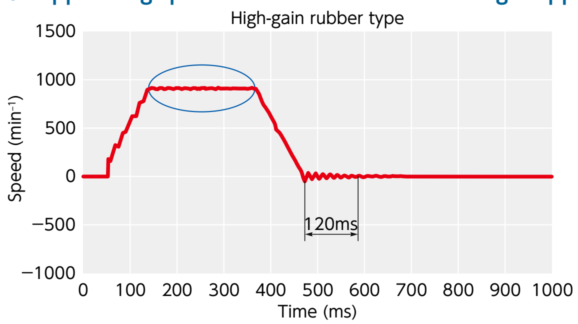


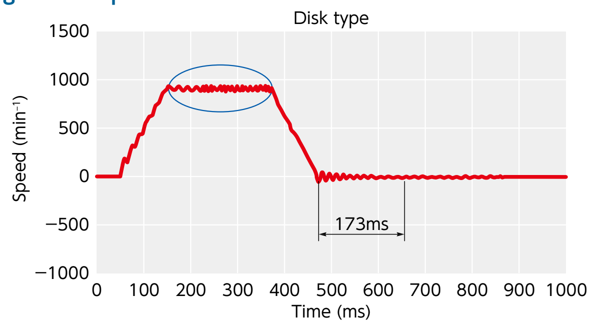
● Temperature-triggered changes in dynamic rigidity



*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.

● Suppressing speed unevenness Control during Stepping Motor Operation

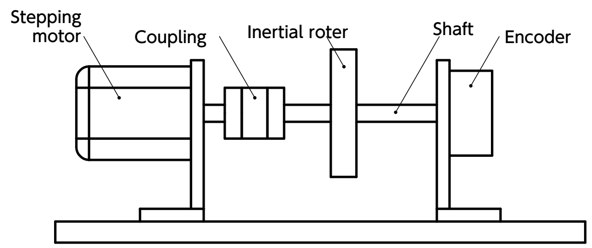




● Test Devices

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

Encoder : RD5000 Manufactured by Nikon Corporation



● Drive Parameters

Startup speed : 60min^{-1}

Drive speed : 900min^{-1}

Rotation angle : 1800°

Acceleration/Deceleration time : 0.1s

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

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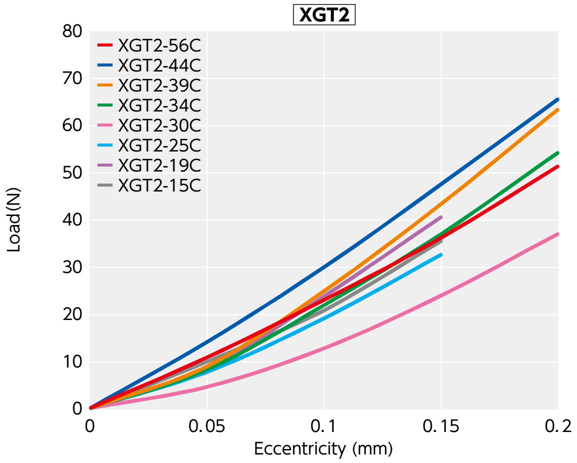
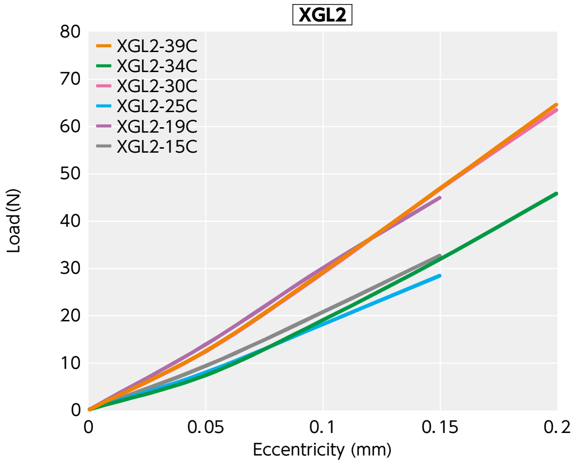
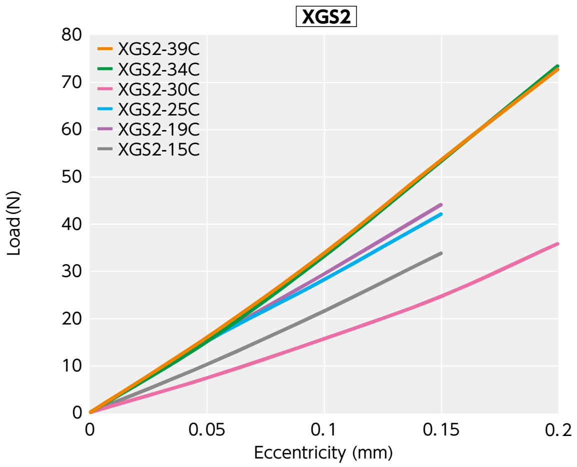
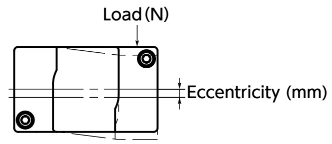
Technical Information

● Eccentric Reaction Force



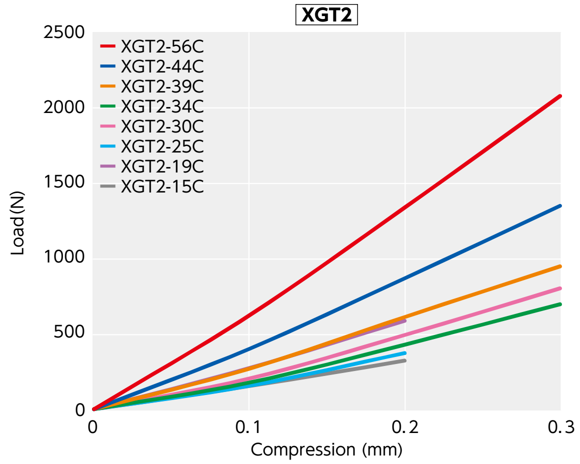


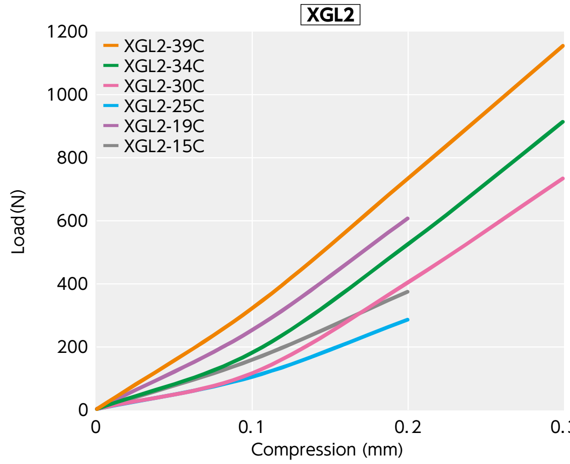


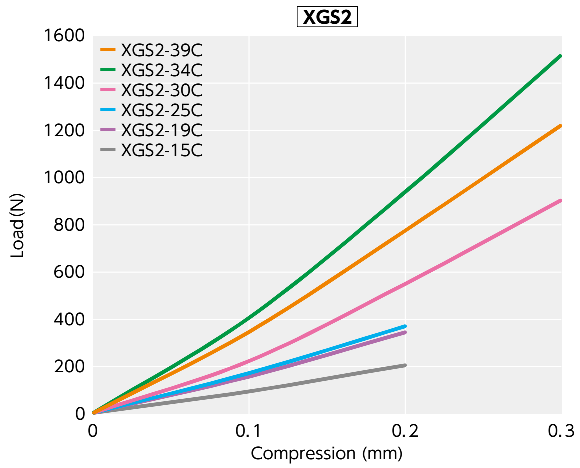


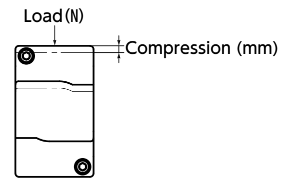
This is a force generated when making XGT2 XGL2 XGS2 in eccentric condition.
As the eccentric reaction force becomes smaller, the force acting on the shaft bearing also becomes smaller.

● Thrust Reaction Force









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

● Physical property and chemical resistance of vibration-resistance rubber (FKM)

	Effect
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	△

◎: Very Good ○: Available △: Fair pending on condition
×: Not available

● Slip Torque

Concerning the sizes shown in the following table, please note that the shaft's slip torque is smaller than the max. torque of XGT2-C XGL2-C XGS2-C .

Unit: N・m

Size	Bore Diameter (mm)																
	3	4	4.5	5	6	6.35	7	8	10	11	12	14	15	16	17	19	20
15C	1	1.3	1.6	1.8	1.9												
19C		2.3		3.1	3.1	3.3	4										
25C				4.7	5	5.6		6.8									
30C								7.5	11								
34C								8.3	10.5	10.7	12	13.4					
39C									13.3		15.2	17.1	20.8	18.9	25.7		
44C*											19.1	21.3	22.7	23.5	23.6	27.5	29.1
56C*													45			50	69.4

● These are test values based on the condition of shaft's dimensional allowance: h7, hardness: 34 - 40 HRC, and screw tightening torque of the values described in XGT2-C XGL2-C XGS2-C Dimension table.
*This is a size only for XGT2-C .

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