(1) High reliability

PMI has accumulated many years experience in production managing. It covers the whole production sequence, from receiving the order, designing, material preparation, machining, heat treating, grinding, assembling, inspection, packaging and delivery. The systemized managing ensures high reliability of ***PMI*** Ballscrews.

(2) High accuracy

PMI Ballscrews are machined, ground, assembled and Q.C. inspected under the constant temperature control (20°C) to ensure high precision of Ballscrews. Fig.1.1 accuracy inspection certificate.

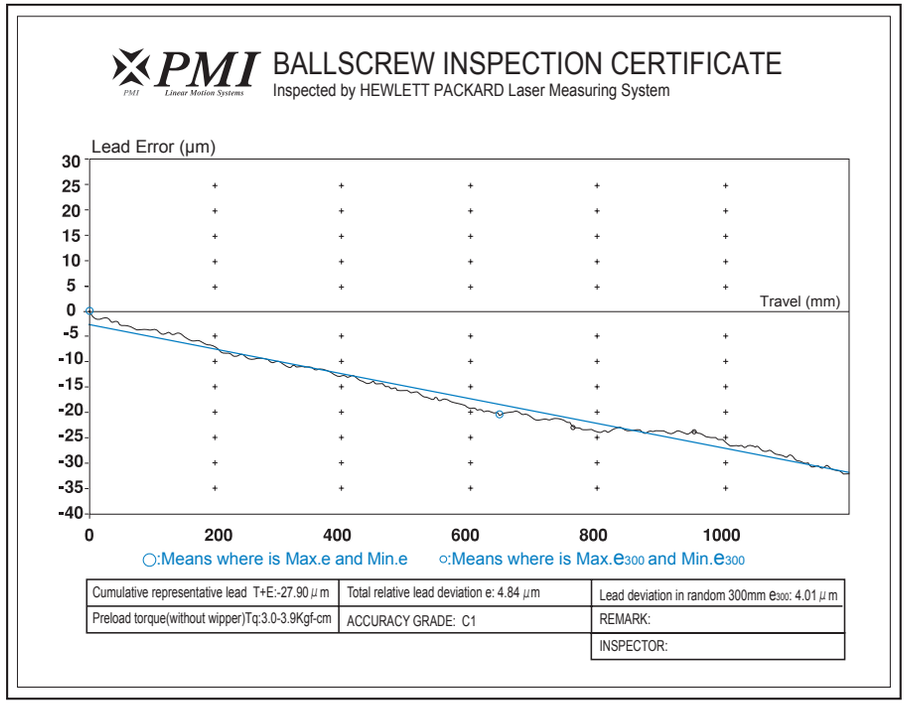

Fig.1.1 Accuracy inspection certificate.

(3) Long durability

PMI Ballscrews are Alloy steels, which are well quenching and tempering treated for good rigidity, along with suitable surface hardening to ensure long durability.

(4) High working efficiency

Balls are rotating inside the Ballscrew nut to offer high working efficiency. Comparing with the traditional ACME screws, which work by friction sliding between the nut and screw, the Ballscrews needs only 1/3 of driving torque. It is easy to transmit linear motion into rotation motion.

(5) No backlash and with high rigidity

The Gothic profile is applied by ***PMI*** Ballscrews. It offers best contact between balls and the grooves. If suitable preload is exerted on Ballscrew hence to eliminate clearance between the ball nut and screw and to reduce elastic deformation, the ballscrew shall get much better rigidity and accuracy.

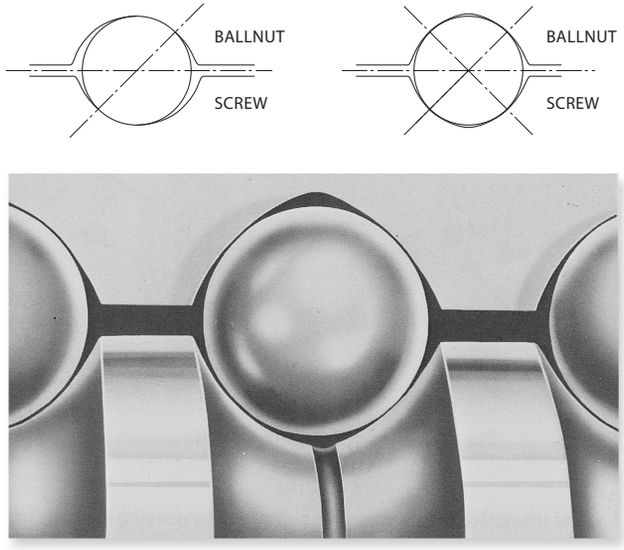

Fig.1.2 Gothic arch thread

2 Lead Accuracy and Torque

2.1 Lead Accuracy

PMI's precision ground Ballscrews are controlled in accordance with JIS B 1192.
The permissible values and each part of definitions are shown below.

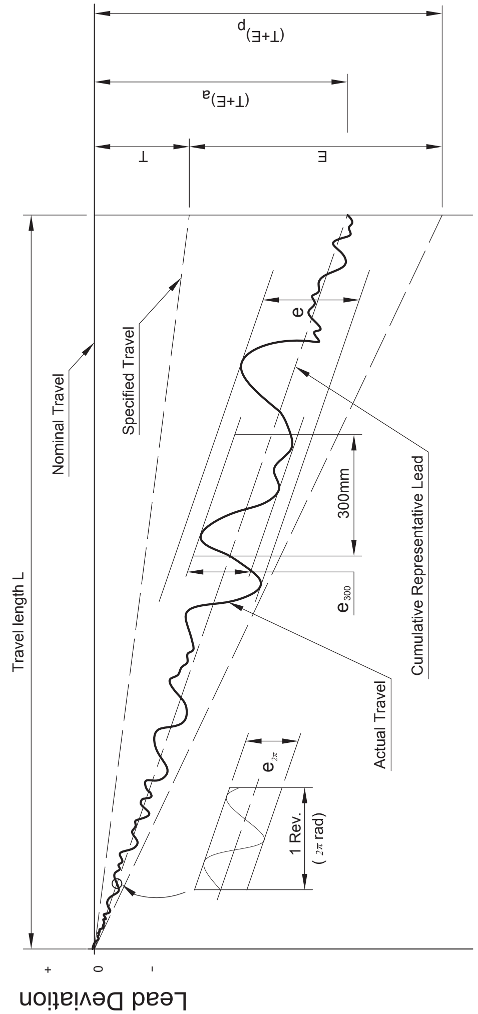

Fig.2.1 Technical Terms Concerning the Lead

Table2.1 Terms

T+E	Cumulative representative lead. A straight line representing the tendency of the cumulative actual lead. This is obtained by least square method and measured by laser system.
P	Permissible value.
a	Actual value.
T	Specified travel. This value is determined by customer and maker as it depends on different application requirements.
E	Accumulated reference lead deviation. This is allowable deviation of specified travel. It is decided by both of the accuracy grade and effective thread length.
e	Total relative lead variation Maximum width of variation over the travel length.
e_{300}	Lead deviation in random 300 mm.
$e_{2\pi}$	Lead deviation in random 1 revolution 2π rad.

Table 2.2 Accumulated reference lead deviation (±E) and total relative variation (e)

Unit: μm

Effective thread length (mm)														
GRADE			C0		C1		C2		C3		C4		C5	
OVER	UP TO		E	e	E	e	E	e	E	e	E	e	E	e
-	315		4	3.5	6	5	8	7	12	8	12	12	23	18
315	400		5	3.5	7	5	9	7	13	10	14	12	25	20
400	500		6	4	8	5	10	7	15	10	16	12	27	20
500	630		6	4	9	6	11	8	16	12	18	14	30	23
630	800		7	5	10	7	13	9	18	13	20	14	35	25
800	1000		8	6	11	8	15	10	21	15	22	16	40	27
1000	1250		9	6	13	9	18	11	24	16	25	18	46	30
1250	1600		11	7	15	10	21	13	29	18	29	20	54	35
1600	2000		-	-	18	11	25	15	35	21	35	22	65	40
2000	2500		-	-	22	13	30	18	41	24	41	25	77	46
2500	3150		-	-	26	15	36	21	50	29	50	29	93	54
3150	4000		-	-	32	18	44	25	60	35	62	35	115	65
4000	5000		-	-	-	-	52	30	72	41	76	41	140	77
5000	6300		-	-	-	-	65	36	90	50	95	50	170	93
6300	8000		-	-	-	-	-	-	110	62	120	62	210	115
8000	10000		-	-	-	-	-	-	137	75	157	75	260	140

Table 2.3 Accuracy grade

Variation in random 300mm (e_{300}) and wobble ($e_{2\pi}$)

e_{300} Unit: μm

GRADE	C0	C1	C2	C3	C4	C5	C6	C7	C10
JIS	3.5	5	-	8	-	18	-	50	210
ISO	3.5	6	-	12	-	23	-	52	210
DIN	-	6	-	12	-	23	-	52	210
PMI	3.5	5	7	8	12	18	25	50	210

$e_{2\pi}$ Unit: μm

GRADE	C0	C1	C2	C3	C4	C5
JIS	3	4	-	6	-	8
ISO	3	4	-	6	-	8
DIN	-	4	-	6	-	8
PMI	3	4	4	6	8	8

Table 2.4 Accuracy grades of ball screw and their application

Application		Name of axis	Accuracy grade								
			C0	C1	C2	C3	C4	C5	C6	C7	C10
NC Machine tools	Lathe	X	●	●	●	●	●	●			
		Z				●	●	●			
	Machining center	X,Y		●	●	●	●	●			
		Z			●	●	●	●			
	Drilling machine	X,Y				●	●	●			
		Z						●	●	●	
	Milling machine Boring machine	X,Y		●	●	●	●	●			
		Z			●	●	●	●			
	Jig boring machine	X,Y	●	●							
		Z	●	●							
	Grinder	X,Y	●	●	●						
		Z		●	●	●					
	Electric discharge machine	X,Y		●	●	●					
		Z			●	●	●	●			
	Wire cutting Electric discharge machine	X,Y		●	●	●					
		Z		●	●	●	●				
	Punch press	X,Y				●	●	●			
	Laser cutting machine	X,Y				●	●	●			
		Z				●	●	●			
	Woodworking machine							●	●	●	●
General industrial machines Machines for specific use						●	●	●	●	●	●

Application		Name of axis	Accuracy grade								
			C0	C1	C2	C3	C4	C5	C6	C7	C10
Industrial robots	Cartesian type	Assembly			●	●	●	●	●	●	
		other purposes						●	●	●	●
	Articulate type	Assembly				●	●	●	●	●	
		other purposes						●	●	●	
	SCARA type					●	●	●	●	●	
Semiconductor/ associated industrial	Lithographic machine		●	●							
	Chemical processing equipment					●	●	●	●	●	●
	Wire bonder			●	●						
	Prober		●	●	●						
	Printed circuit board drilling machine			●	●	●	●	●			
	Electric component mounted device				●	●	●	●			
Three-dimensional coordinate measuring machine			●	●	●						
Office machine								●	●	●	●
Image processing machine			●	●							
Plastic injection molding machine										●	●
Steel mills equipment										●	●
Nuclear power	Fuel rod control					●	●	●	●	●	
	Mechanical snubber									●	●
Aircraft						●	●	●			

2.2 Preloading Torque

The preloading torque of the Ballscrew is controlled in accordance with JIS B 1192.

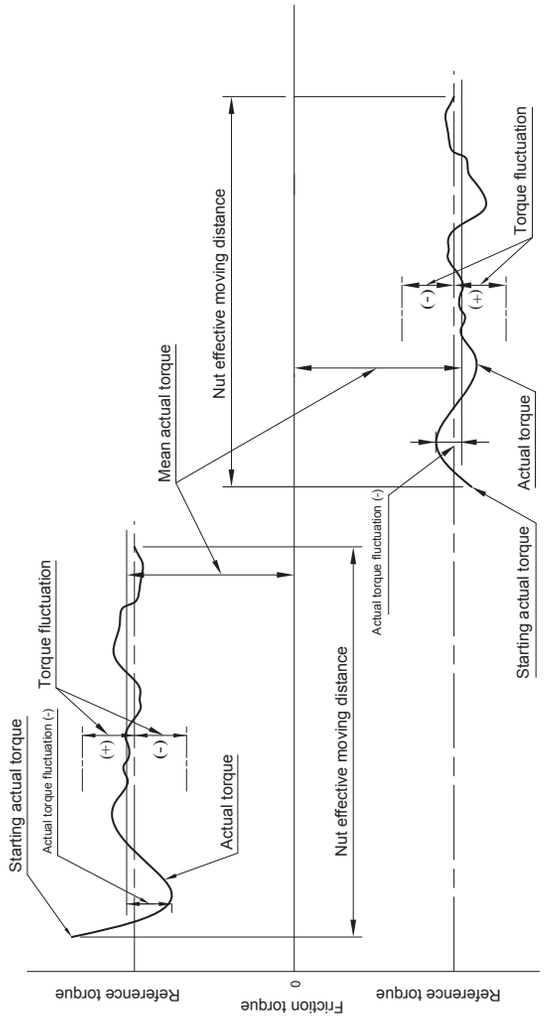

Fig.2.2 Technical terms concerning preload

Preload	The goal in preload is to clear axial play and increase rigidity of Ballscrew. Reference to 5.1.3
Preload torque	Torque needed to continuously turn a Ballscrew with preload with no other load applied to it.
Reference torque	Preload torque set as a goal.
Torque fluctuation	Fluctuation from a goal value of the preload torque. Defined as positive or negative in respect to the reference torque.
Rating of torque fluctuation	Rating on reference torque and torque fluctuation.
Actual torque	Preloaded dynamic torque measured by using an actual value of Ballscrew.
Mean actual torque	In the effective thread length, the net reciprocate to measure the maximum actual torque and minimum actual torque are doing count mean.
Actual torque fluctuation	In the effective thread length, the net reciprocate to measure the maximum fluctuant value.
Rating of Actual torque fluctuation	Rating on mean actual torque and actual torque fluctuation.

Table2.5 Allowable range of preload torque

Reference torque ($kgf.cm$)		Effective Thread Length (mm)										
		up to and incl. 4000								over 4000 up to and incl. 10000.		
		Slenderness ratio: up to and incl. 40				Slenderness ratio: over 40 up to and incl. 60						
		Accuracy grade				Accuracy grade				Accuracy grade		
OVER	OR LESS	C0	C1	C3	C5	C0	C1	C3	C5	C1	C3	C5
2	4	±30%	±35%	±40%	±50%	±40%	±40%	±50%	±60%	-	-	-
4	6	±25%	±30%	±35%	±40%	±35%	±35%	±40%	±45%	-	-	-
6	10	±20%	±25%	±30%	±35%	±30%	±30%	±35%	±40%	-	±40%	±45%
10	25	±15%	±20%	±25%	±30%	±25%	±25%	±30%	±35%	-	±35%	±40%
25	63	±10%	±15%	±20%	±25%	±20%	±20%	±25%	±30%	-	±30%	±35%
63	100	-	±15%	±15%	±20%	-	-	±20%	±25%	-	±25%	±30%

Reference torque

$$T_P = 0.05(\tan\beta)^{-0.5} \times \frac{Fao \times l}{2\pi} \quad \cdots\cdots (2.1)$$

Here

T_P Reference torque ($kgf \cdot cm$)　　l Lead(cm)

Fao Preload (kgf)　　β Lead angle

2.3 Tolerances on Various Areas of *PMI* Ballscrew

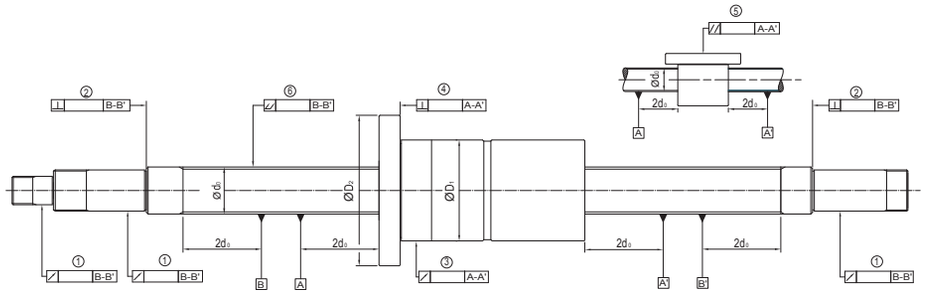

Fig.2.3

Those on above are samples of accuracy of tolerance on various areas of *PMI* Ballscrew.

⊥ : **Perpendicularity**　↗ : **Radial runout**　// : **Parallel**　A : **Reference**

Accuracy on various areas of *PMI* Ballscrew has to measure items:

1. Radial run-out of the circumference of the screw shaft supported portion in respect to the B-B' line.
2. Perpendicularity of the screw shaft supported portion end face to the B-B' line.
3. Radial run-out of the nut circumference in respect to the A-A' line.
4. Perpendicularity of the flange mounting surface to the A-A' line.
5. Parallelism between the nut circumference to the A-A' line.
6. Overall radial run-out to the A-A' line.

Note: 1.The mounting surface of the Ballscrew is finished to the accuracy specified in JIS B 1192:1997
2.Standard tolerance of accuracy measuring from Jan. 1st 2012 on.

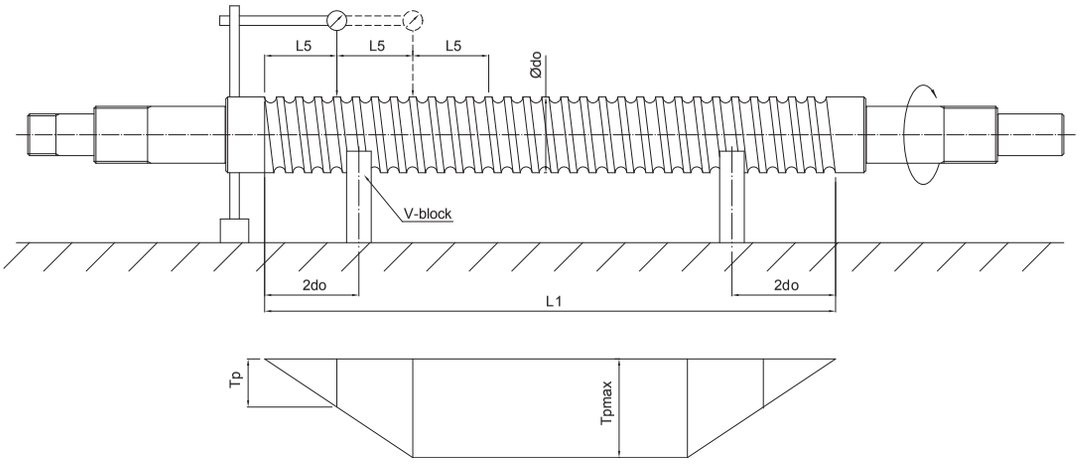

Table2.6 Total runout in radial direction of outside diameter of screw shaft threaded part in respect to measuring basic length
(measuring basic length is accoring to DIN 69051 and JIS B1192)

Unit: μm

Normial diameter $do(mm)$		Measuring basic length L_r	PMI s' Grade Tpmax								
above	up to and incl.	-	C0	C1	C2	C3	C4	C5	C6	C7	C10
6	12	80	20	20	20	23	25	28	32	40	80
12	25	160									
25	50	315									
50	100	630									
100	200	1250									
Slenderness ratio $L_r/do(mm)$			PMI s' Grade $(L1 \geq 4L5)$								
above		up to and incl	C0	C1	C2	C3	C4	C5	C6	C7	C10
-		40	40	40	40	45	50	60	64	80	160
40		60	60	60	60	70	75	85	96	120	240
60		80	100	100	100	115	125	140	160	200	400
80		100	160	160	160	180	200	220	256	320	640

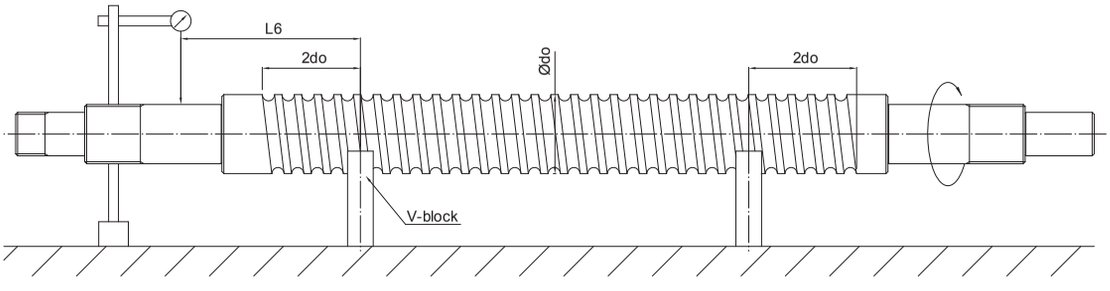

Table2.7 Circumferential runout in radial direction of outside diameter of mounting part of parts in respect to threaded part axial line of screw shaft
(measuring basic length is accoring to DIN 69051 and JIS B1192)

Unit: μm

Normial diameter $do(mm)$		Measuring basic length L_r	PMI s' Grade(L6<Lr)								
above	up to and incl.	-	C0	C1	C2	C3	C4	C5	C6	C7	C10
6	20	80	6	8	10	11	12	16	20	40	63
20	50	125	8	10	12	14	16	20	25	50	80
50	125	200	10	12	16	18	20	26	32	63	100
125	200	315	-	-	-	20	25	32	40	80	125

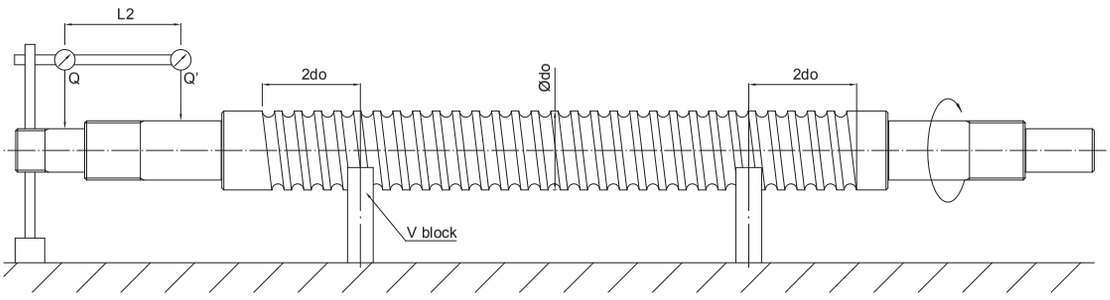

Table2.8 Perpendicularity on supporting-part end face in respect to the threaded part axial line of screw shaf (measuring basic length is accoring to DIN 69051 and JIS B1192)(Difference of maximum value whinin Q and Q')

Unit: μm

Normial diameter *do(mm)*		Measuring basic length L_r	*PMI* s' Grade($L_2 \leq L_r$)								
above	up to and incl.	-	C0	C1	C2	C3	C4	C5	C6	C7	C10
6	20	80	4	5	5	6	6	7	8	12	16
20	50	125	5	6	6	7	8	9	10	16	20
50	125	200	6	7	8	9	10	11	12	20	25
125	200	315	-	-	-	10	12	14	16	25	32

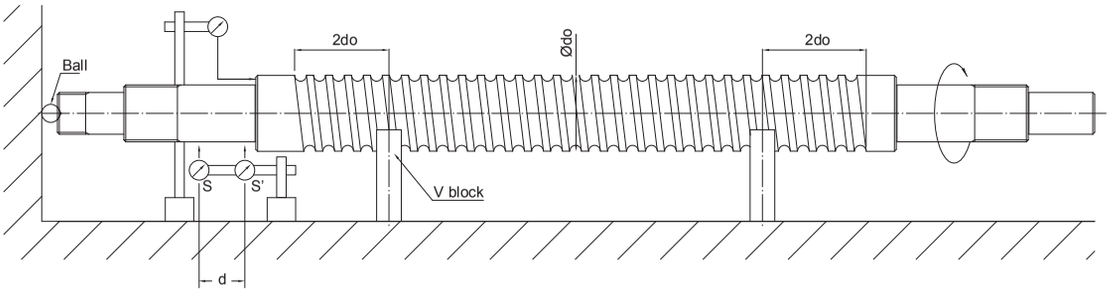

Table2.9 Perpendicularity on supporting-part end face in respect to the threaded part axial line of screw shaf (measuring basic length is accoring to DIN 69051 and JIS B1192)(the value of deflection supports two ends' deflection of difference between S and S')

Unit: μm

Normial diameter *do(mm)*		*PMI* s' Grade								
above	up to and incl.	C0	C1	C2	C3	C4	C5	C6	C7	C10
6	63	3	3	3	4	4	5	5	6	10
63	125	3	4	4	5	5	6	6	8	12
125	200	-	-	-	6	6	8	8	10	16

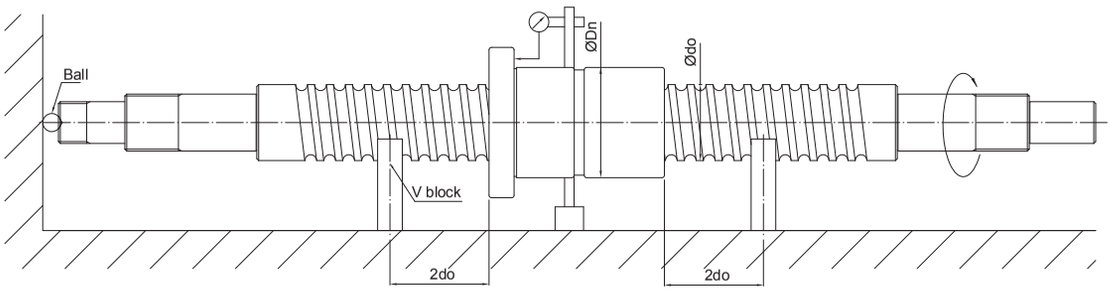

Table2.10 Perpendicularty on mounting face of flang of nut
(measuring basic length is accoring to DIN 69051 and JIS B1192)

Unit: μm

Outside diameter of nut D_n		*PMI*s' Grade								
above	up to and incl.	C0	C1	C2	C3	C4	C5	C6	C7	C10
-	20	5	6	7	8	9	10	12	14	-
20	32	5	6	7	8	9	10	12	14	-
32	50	6	7	8	8	10	11	15	18	-
50	80	7	8	9	10	12	13	16	18	-
80	125	7	9	10	12	14	15	18	20	-
125	160	8	10	11	13	15	17	19	20	-
160	200	-	11	12	14	16	18	22	25	-
200	250	-	12	14	15	18	20	25	30	-

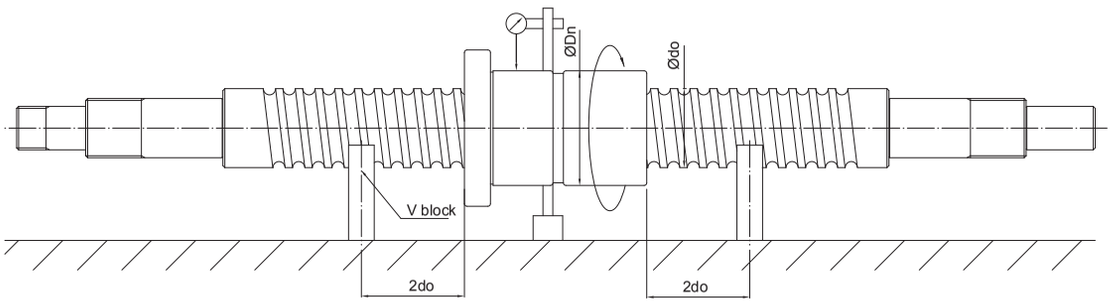

Table2.11Circumferential runout in radial direction on outer peripheral face of face of nut
(measuring basic length is accoring to DIN 69051 and JIS B1192)

Unit: μm

Outside diameter of nut Dn		*PMI*s' Grade								
above	up to and incl.	C0	C1	C2	C3	C4	C5	C6	C7	C10
-	20	5	6	7	9	10	12	16	20	-
20	32	6	7	8	10	11	12	16	20	-
32	50	7	8	10	12	14	15	20	25	-
50	80	8	10	12	15	17	19	25	30	-
80	125	9	12	16	20	21	22	25	40	-
125	160	10	13	17	22	25	28	32	40	-
160	200	-	16	20	22	25	28	32	40	-
200	250	-	17	20	22	25	28	32	40	-

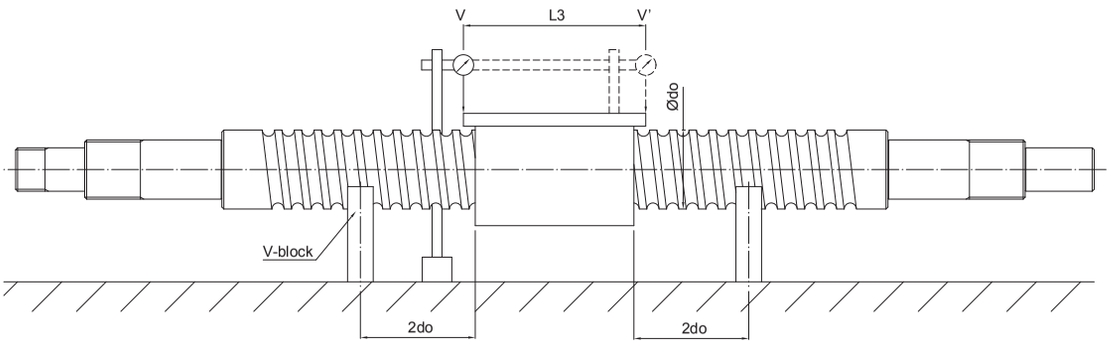

Table2.12 Parallelism on outer peripheral face of nut
(V-V')(measuring basic length is accoring to DIN 69051 and JIS B1192)

Unit: μm

Measuring basic length L_3		*PMI*s' Grade								
above	up to and incl	C0	C1	C2	C3	C4	C5	C6	C7	C10
-	50	5	6	7	8	9	10	14	17	-
50	100	6	7	8	10	11	12	15	17	-
100	200	-	10	11	13	15	17	24	30	-