Introduction

The use of specially adapted thread grinding machines gives our rack a highly accurate helicoidal tooth profile which provides two distinct advantages - **very good pitch accuracy** and sufficient **tolerance of meshing conditions** (within 0.25°). This tooth form exhibits a high tolerance to misalignment when meshing with a straight-cut pinion and is ideal for harsh environments.

The way this tolerance is derived will be appreciated from the diagram below. Slight misalignment of the straight tooth pinion, in terms of deviation from a true right-angle between the axis and the rack in either plane, results merely in a change of position of the contact points across the face.

Mesh Geometry

// Points of contactStandard pressure angel is 20°25° pressure angle available on request



Features such as high reliability and repeatability ensure that rack and pinion systems are the first choice for linear and angular measurement applications. By butting lengths of rack together, extremely long axes can be measured to the highest accuracy.

For further information, please call us at **708/449-5700**.

RACK ACCURACY GRADES

Grade	5	4	4b	3	2	1
Max. pitch error between any two points per 300 mm of rack	0.005	0.008	0.008	0.015	0.025	0.050
Max end to end pitch error up to 300 mm of rack*	±0.004	±0.004	±0.008	±0.008	±0.013	±0.025
Adjacent tooth error	0.0025	0.0025	0.0025	0.005	0.010	0.013
Pitch Height Variation	+0 -0.013	+0 -0.013	+0 -0.013	+0 -0.013	+0 -0.018	+0 -0.025

*Applies pro rata to lengths > 300 mm Approximately equivalent to A.G.M.A. grades 9 to 14

All dimensions in mm



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Protected Rack Channel



Tests have shown that the bolted fixing of any measuring scale onto a mounting surface introduces distortion. This results in significant measuring errors, particularly for high resolution systems.

Rack Channel has been designed such that the neutral axes in bending intersect at the pitch line of the rack. Even if the channel is bent when installed, the calibrated accuracy will be unaffected. This results in significant savings for machinery builders, because mounting surfaces need not be perfectly flat (only 0.003 mm change in accuracy occurs when a 2 m channel is bent by 1 mm).



Thermal Matching -- Protected Rack Channel has a coefficient of thermal expansion equal to that of cast iron.

Reference Domes at the channel ends are within ± 0.012 mm of the nominal distance from the pitch line. When placed against a suitable abutment face, butted joint setting is greatly simplified.

Repeatability: ± 0.0015 mm bidirectional and ± 0.0005 mm unidirectional repeatability can be expected.



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Protected Rack Channel

All dimensions in mm unless otherwise noted



	Part Number Composition									
Style	Туре	Lengths	available	Pitch	Pressure angle	Grade	R	Т		
		millin	neters	10M						
		0400.	0600.	(1mm)		G5	26.83	20.0		
		0800.	1000.	20M	20 degree	or				
PRC	MC	1200.	1400.	(2mm)	standard	G4	26.51	20.0		
	(metric)	1600.	1800.	25M		or				
or		20	00	(2.5mm)		G3	26.28	20.0		
		inc	hes	101		G5				
URC		0016.	0024.	(1/10″)		or				
	IC	0032.	0048.		20 degree	G4	1.053″	1.00″		
	(imperial)	0056.	0064.	201	standard	or				
		0072.	0080.	(1/20″)		G3	1.037″	1.00″		

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	QUALITY	G5	G4	G3	G1
	Total Error Band	0.010	0.015	0.020	0.070
	for L up to 1000	0.010	0.015	0.030	0.070
	Total Error Band for L	0 0125	0.020	0.055	0 000
_	from 1001 to 2000	0.0125	0.020	0.055	0.070
	Max End to End pitch	0 0075	0.012	0 030	0.050
	error	0.0075	0.012	0.030	0.050

PITCH	1mm	2mm	2.5mm	1/20″	1/10″
Dimension R	26.83	26.51	26.28	1.0528″	1.0370″
Dimension W	20.0	20.0	20.0	1.0″	1.0″



*5 x INTERPOLATION OPTION ** HIGHER SPEEDS OPTIONAL

ACCURACY

± .00025" Non-cumulative cyclic error

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e-mail: schlenkent@aol.com

Angular Measuring Rack

All dimensions in mm



A unique feature of helicoidal rack is that it provides correct gear action even when mounted on a curved rather than straight surface.

Face gears can be constructed by clamping a number of racks around a cylindrical seating. These have a narrow face width and conform elastically to diameters of 570 mm or more.

Angular measuring rack occupies a minimum of axial space allowing rotary tables to be designed for greatest stability. All components are serviceable without dismantling the table.

ACCURACY

The rack circle is made up of either 12 or 24 racks which on assembly are positioned with their midpoints at exact angular locations (30° or 15°). Either a high resolution encoder or an optical polygon and autocollimator are suitable references. The major sources of error are the size tolerances of the seating diameter and its eccentricity:

a) The angular measuring error due to seating diameter tolerance is:

$$\delta \theta_{d} = \frac{\theta \delta D}{D}$$

where θ =Subtended angle (radians), δ D=Diametral error and D=Seating diameter. As each rack is individually positioned at its midpoint, this error can never accumulate over more than one rack. Hence the maximum point to point error is at :

$$\theta = \frac{2\pi}{N}$$

 $\delta \theta_{d}$

where N=Number of racks

Example: Seating diameter is

1000 mm ±0.02 mm. Number

peak error over one rack is 2.2

of racks is 12. The peak to

arc seconds (±1.1 arc sec-

onds, about the midpoint).

$$=\frac{2\pi\delta D}{ND}$$
 radians

 $\delta \theta_d = 1296000 \cdot \frac{\delta D}{ND}$ arc seconds

b) The angular measuring error due to seat eccentricity is:

$$\delta \theta_e = \frac{2e}{D} \sin \theta \text{ radians} \quad e = eccentricty \quad (TIR \div 2)$$



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Angular Measuring Rack

All dimensions in mm

However, because the rack midpoints are correctly positioned, the error does not accumulate from rack to rack:

The maximum error occurs on the two racks at 0° and 180° . The magnitude of this error is:



or 825000. $\underline{\mathbf{e}}$ sin $\underline{\pi}$ arc seconds

D N

Example: For 12 racks on diameter of 1000 mm and a TIR of 0.02 mm peak to peak error is 2.1 arc seconds (\pm 1/05 arc seconds, about mid point).

c) Total Accuracy

The nature of the above errors is such that there is always one rack for which the errors are additive. Hence the total peak to peak error in the example is 4.3 arc seconds and is confined to one rack. Total accuracy also includes secondary errors due to installation and pinion tolerances. Recommended tolerances for a total accuracy specification of \pm 10 arc seconds are presented in the table below--**preferred sizes**, **all 1 mm pitch**:

Seating diameter	Diameter tolerance	TIR	No. of racks	Rack length L	Rack face width F	Rack grade	Clamps per rack	Pinion tooth No.	Pinion carrier part No.	Angle per pinion revolution
570.958	±0.050	0.025	12	150	2.0	4	3	20	HPC1MX21-20AQ12	4°
685.549	±0.065	0.030	12	180	2.0	4	3	24	HPC1MX21-24AQ12	4°
800.141	±0.075	0.040	12	210	2.0	4	3	28	HPC1MX21-28AQ12	4°
914.232	±0.090	0.040	12	240	2.5	4	4	32	HPC1MX21-32AQ12	4°
1028.824	±0.100	0.050	12	270	2.5	4	4	36	HPC1MX21-36AQ12	4°
1200.711	±0.110	0.060	12	315	2.5	4	4	21	HPC1MX21-21AQ12	2°
1429.894	±0.130	0.070	12	375	2.5	4	4	25	HPC1MX21-25AQ12	2°
1601.782	±0.150	0.080	12	420	2.5	4	5	28	HPC1MX21-28AQ12	2°
1830.965	±0.170	0.090	12	480	2.5	4	5	32	HPC1MX21-32AQ12	2°
2002.852	±0.180	0.090	12	525	2.5	4	5	35	HPC1MX21-35AQ12	2°
2518.514	±0.400	0.220	24	330	2.5	3	4	22	HPC1MX21-22AQ12	1°
2976.881	±0.500	0.280	24	390	2.5	3	5	26	HPC1MX21-26AQ12	1°
3435.247	±0.600	0.320	24	450	2.5	3	5	30	HPC1MX21-30AQ12	1°
4008.204	±0.700	0.360	24	525	2.5	3	5	35	HPC1MX21-35AQ12	1°
4581.162	±0.800	0.400	24	600	2.5	3	5	40	HPC1MX21-40AQ12	1°

A wide range of other diameters can be accommodated. **Notes:**

- 1. The minimum seating diameter should not be less than 570.958 mm.
- 2. The maximum length of rack not to exceed 600 mm in length.
- 3. Hardened pinion carriers are recommended. Anti-backlash pinions cannot be used with angular measuring rack. Pinion carriers mounted onto flex-plates have found to be the best arrangement.
- 4. As a general rule, rack lengths below 255 mm should use 3 clamps per rack, 255 mm to 375 mm should use 4 clamps per rack, and rack lengths above 375 mm should use 5 or 6 clamps per rack.
- 5. Alternative pitches are available on request. Please contact our Technical Sales for further details.





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Angular Measuring Rack

All dimensions in mm



MOUNTING SURFACES

A cylindrical mounting seat is required to the diameter and tolerances stated. Where very high accuracy is required, we can compensate for small positive diametral errors by grinding the racks thinner by an appropriate amount.

Holes must not be drilled in the racks as this would prevent them from exactly conforming to the seat diameter. The clamp fixing holes should be positioned such that when the table is at its



datum (zero) position, the pinion will mesh at the midpoint of one of the racks.

ADJUSTMENT

Access must be provided for a wedge or drift to be used in the gap between racks to nudge them into position. Procedure:

i) Fully tighten clamps on datum rack only. All other racks should be held in position with only moderate pressure. ii) Set reference zero at datum position of table and zero the display. iii) Move to 30° or 15° on the display. iv) Read error from reference. v) Nudge rack until display reading agrees with reference. Tighten clamps. Repeat for all racks.





Standard Quality AQ12. Higher qualities available on request. Hardened pinion carriers are available. Maximum radial loading on pinion is 100N.

Part Number	Part Number		Number of Teeth					
		Circular				Preferred		
Anti-backlash	Plain	Pitch	N	lin	Мах	Size		
			A/B	Plain		Plain		
APC1MX20-	PC1MX21-	1mm	46	20	85	20		
APC2MX20-	PC2MX21-	2mm	25	10	40	10. 25		
APC25MX20-	PC25MX21-	2.5mm	20	10	32	10. 20		
APC31X20-	PC31X21-	1/10″	20	10	32	10. 20		
APC62X20-	PC62X21-	1/20″	37	20	65	20		

MATERIALS: Pinion and Bearings -Si Housing -Al

-Stainless Steel -Aluminum



H Adaptor plate, may be mounted left or right-handed Adaptor Plate Mounting holes øK Adaptor Plate Adaptor Plate Ad	
EP10 only	Adaptor plate, may be mounted left or right-handed Adaptor Plate Adaptor Plate Adaptor Plate Adaptor Plate

-12.7

<mark>€</mark> ₩4.749

-B^{63.5}

DIA

D 69.85

M6 THREAD 2 PLACES

50.8

DIMn.	FP21	FP10
А	76.2	111.1
В	38.10	69.85
С	19.0	20.6
D	82.4	101.6
Е	71.35	79.38
F	38.1	50.8
G	5.54	11.11
Н	17.5	24.6
Κ	5.5	7.1

For transducers up to 67 mm diameter, use FP21 For transducers larger than 67 mm diameter or pinion carriers user FP10

Adaptor Plates

Е

69.85

0

Æ

34.925

F

0

Flex-plate Assemblies

All dimensions in mm

These adaptor plates mount transducers onto a Flex-plate where a Pinion Carrier is not used.

Screws & Clamps supplied Material: Aluminum Alloy

SCHLENKER									
ENTERPRISES LTD P.O. Box 858	Transducer type	Adaptor Plate Part Number	ØA	ØB	С	D	E	F	Units
5143 Electric Ave. Hillside, IL 60162-858 U.S.A.	BEI Encoder H25E	B830-312-1	31.763 31.820	63.5	4.75	69.85	69.85	34.92	mm
Phone: 708/449-5700 800/992-2777 Fax: 708/449-5703 http: //www.schenkent.com	BEI Encoder H25G	B830-318	2.5005″ 2.5020″	2.687″	.375″	2 <mark>7</mark> 8	$2\frac{3}{4}$		inch
e-mail: schlenkent@aol.com	Blank for customer to finish	B830-315	17.50			69.85	69.85		mm

Eg. - a pinion shaft encoder

Flex-plates

All dimensions in mm



By sprig loading the pinion into mesh on both flanks of the teeth, complete backlash elimination is achieved. The flex-plate is shown in the diagram above. The pivot plate is free of play and rigid in the measuring direction, ensuring maximum repeatability. The spring force adjuster is set on installation to overcome the weight of the transducer and the effect of electrical cable stiffness. Net meshing force is between 300 and 600 grams. As with an anti-backlash pinion, there can be a temporary lag due to high accelerations. However, the adjustable stop screw limits pinion lift-out so that position is not lost.

For example: with a 300 gram mesh force, a 20 mm per revolution pinion and typical 60 mm diameter encoder, pinion lift-out does not occur at less than 1 g acceleration. Compared with anti-backlash pinions the flex-plate has several advantages:-

- It utilizes the full face of the rack.
- It does not introduce errors due to the rise and the fall of the pitch line.
- It has a greater range of movement.

Plain pinions on fixed mountings give acceptable levels of backlash for many low accuracy, low resolution (0.1 mm or greater) systems.

LIFE

Unless very hard pinions are used, the wear is predominantly on the pinion and rack life is indefinite. With lubricated meshes (on a machine tool stray cutting oil or lubricant is sufficient) no measurable wear occurs in a correctly installed system.



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Inch Ground Rack-- R8, R10

General Purpose

All dimensions in inches

Part Number		L	Pitch	Pitch P No Ho		Material
R8A	Grades		1/10	0.4480		
R8B	1 to 4	12	1/20	0.4639	6	Stainless Steel 416S21
R10A R10B	Grades 1 to 4	24	1/10 1/20	0.4480 0.4639	12	Hardened to 35-40 Rc

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