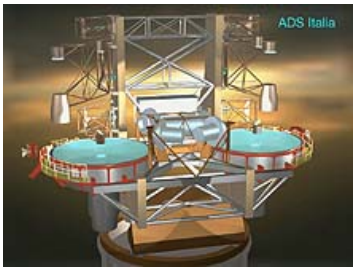

LBT PROJECT
2x8,4m TELESCOPE

Doc.No. : 671x002
Issue : a
Date : 11 Oct 2006

LBT PROJECT

2 X 8,4m OPTICAL TELESCOPE

Instrument Rotator and Cable Chain

Bent Gregorian Bearing Information

	Signature	Date
Prepared	Robert Meeks	10-Nov-06
Reviewed		
Approved		

1. Revision History

Issue	Date	Changes	Responsible
a	10-Nov-06	First Draft	Robert Meeks

2. Table Of Contents

3. About this document

3.1. Purpose

The purpose of this document is consolidate various manufacturer measurements and information related bearing information in a single place. Most of the information in this document was communicated to various LBT engineers by email or fax..

3.2. Reference Documents

None.

Robert Meeks

From: Shawn Callahan [scallahan@as.arizona.edu]
Sent: Monday, October 02, 2006 3:13 PM
To: rmeeks@as.arizona.edu
Cc: scallahan@as.arizona.edu
Subject: FW: RAdial, axial, and moment stiffness for 14690001

More info

-----Original Message-----
From: Schaub, Brian [mailto:Bschaub@kaydon.com]
Sent: Thursday, November 10, 2005 9:44 AM
To: scallahan@as.arizona.edu
Subject: RAdial, axial, and moment stiffness for 14690001

Shawn,

The estimated stiffness for P/N 1468001 is:

Radial Stiffness:	3.38x 109 N/m	1.93 x 107 lbs/in
Axial Stiffness:	4.29 x 109 N/m	2.45 x 107 lbs/in
Moment Stiffness:	1.27 x 109 Nm/radians	1.12 x 1010 in-lbs/radians

If you have any more questions, feel free to contact me.

Best regards,

Brian Schaub
Sr. Product Engineer
Kaydon Custom Bearings
2860 McCracken St
Muskegon, MI 49443
Phone: (231)755-3747 Extension 209
Fax: (231)759-4102
E-mail: bschaub@kaydon.com

670a021

14680001 FINAL INSPECTION

PART S/N S-001-0C0 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903008

14680-002 S/N 5741502003

COPY

CHARACTERISTICS	PRINT REQUIREMENT	ACTUAL
OUTER PILOT DIA. -X-	70.857" TO 70.866"	70.860
OUTER -X- DIAMETER SURFACE FINISH	125 MAX.	14
OUTER PILOT DEPTH	2.835 MIN.	2.9265
OUTER PILOT RUNOUT -X- TO -Y-	.0012" MAX.	.001
-A- FACE RUNOUT TO -C-	.002" MAX.	.0015
-A- FACE SURFACE FINISH	125 MAX.	46
OUTER RACE BEARING O.A.	3.504" TO 3.582"	3.557
(24) OUTER HOLES THRU	.705" TO .715"	P-487
(24) OUTER C'BORE HOLES	1.019" TO 1.054"	1.041
(24) OUTER C'BORE DEPTH	.679" TO .739"	.681 - .711
(8) OUTER JACKING HOLES	.431" TO .438"	Approved Pins
(8) JACKING HOLES DEPTH FACE	2.923" TO 2.983"	2.9
(8) JACKING HOLES THREADED THRU FACE	M10 X 1.5-6H	O-6
SECTION E-E		
(2) LUBE HOLES THREADS 022	M10 X 1-6H	O-355
(2) LUBE HOLES THREAD DEPTH	.500 MIN.	.765
(2) LUBE HOLES PLUGGED	SEE NOTE # 12	Approved
OUTER "G" STAMP	SEE NOTE# 7	Approved
INNER PILOT DIAMETER -Z-	61.417" TO 61.426"	61.4195
-Z- PILOT DEPTH	1.750 MIN.	3.506
INNER PILOT SURFACE FINISH	125 MAX.	79
INNER PILOT RUNOUT -Z- TO -Y-	.0012" MAX.	.0002
FACE -B- RUNOUT TO -C-	.002 MAX.	.001
FACE -B- SURFACE FINISH	125 MAX.	20
INNER RACE BEARING O.A.	3.504" TO 3.582"	3.506
(24) INNER HOLES THREADED	M16 X 2-6H	O-582
(24) INNER HOLES THREAD DEPTH	1.181 MIN.	1.675
INNER "G" STAMP & S/N MARKINGS	SEE NOTE# 7	Approved

ASEMBLE AND INSPECTED BY 403 DATE 3-28-00

ENG 406

670a021

14680001 FINAL INSPECTION

PART S/N 5-001-0C0 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B

COPY

REV. B

14680-003 S/N 5758903008 SHEET 2 OF 3

14680-002 S/N 5741502003

CHARACTERISTICS	PRINT REQUIREMENT		ACTUAL	
BEARING O.A.	3.533" TO 3.543"		3.534	
(8) INNER JACKING HOLES	.431" TO .438"		Approved. Pins	
(8) INNER JACKING HOLES DEPTH	2.923" TO 2.983"		2.966	
(8) JACKING HOLES THUR	M10 X 1.5-6H		0-6	
PRELOAD	.001" TO .003" PRELOAD		.001	
.750" GRADE 25 BALLS NO.	HEAT NO.		"A" 9902	"B" Re 1383
GREASE MOBILITH 220	SEE NOTE # 5		Approved	
SEALS DETAIL F	SEE NOTES # 11 & 13		Approved	
BEARING WEIGHT	880 LBS.		900 LBS.	
STARTING TORQUE PER NOTE 2				
STARTING TORQUE / INNER LOADED	CW	CCW	CW	CCW
0°	21 FT LBS	18 FT LBS	21	18
90°	21 FT LBS	21 FT LBS	21	21
180°	21 FT LBS	21 FT LBS	21	21
270°	21 FT LBS	18 FT. LBS	21	18
STARTING TORQUE / OUTER LOADED				
0°	24 FT LBS	21 FT LBS	24	21
90°	24 FT LBS.	21 FT LBS	24	21
180°	24 FT LBS.	24 FT LBS	24	24
270°	24 FT LBS.	21 FT. LBS	24	21
AVG. OF (8) READINGS	22.5 FT LBS	20.6 FT LBS	22.5 FT LBS	20.6 FT LBS
NOT TO EXCEED 285 FT. LBS.	22.5 FT LBS	20.6 FT LBS	22.5 FT LBS.	20.6 FT LBS
TORQUE VARIATION NOT TO EXCEED 57 FT. LBS.	9 FT. LBS	18 FT. LBS.	9 FT LBS	18 FT. LBS.
AXIAL DEFLECTION PER NOTE 1				
INNER RACE AXIAL DEFLECTION				
NO SINGLE READING TO EXCEED .0006				
0°	.00035		.00035	
90°	.0004		.0004	

ASEMBLED AND INSPECTED BY 403 DATE 3-28-00

ENG 406

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14680001 FINAL INSPECTION

PART S/N 8-01-000 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903008 COPY SHEET 3 OF 3

14680-002 S/N 5741502003

180°	.00035	.00035
270°	.0006	.0006
AVG.	.000425	.000425
OUTER RACE AXIAL DELECTION		
NO SINGLE READING TO EXCEED .0006		
0°	.0001	.0001
90°	.00005	.00005
180°	.00015	.00015
270°	.0001	.0001
AVG.	.0001	.0001
CONTACT ANGLE	40° +/- 7°	
PATH "A"	42°	42°
PATH "B"	35.5°	35.5°
BALL SIZE PATH "A"	25/32 +.00/991	
PATH "B"	25/32 +.000039	

ASSEMBLED AND INSPECTED BY 403 ENG 406 DATE 3-28-00

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14680001 FINAL INSPECTION

PART S/N S-002-0C0 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903007 SHEET 1 OF 3

14680-002 S/N 5741502008

COPY

CHARACTERISTICS	PRINT REQUIREMENT	ACTUAL
OUTER PILOT DIA. -X-	70.857" TO 70.866"	70.857
OUTER -X- DIAMETER SURFACE FINISH	125 MAX.	13
OUTER PILOT DEPTH	2.835 MIN.	2.900
OUTER PILOT RUNOUT -X- TO -Y-	.0012" MAX.	.0005
-A- FACE RUNOUT TO -C-	.002" MAX.	.0013
-A- FACE SURFACE FINISH	125 MAX.	36
OUTER RACE BEARING O.A.	3.504" TO 3.582"	3.525
(24) OUTER HOLES THRU	.705" TO .715"	.487
(24) OUTER C'BORE HOLES	1.019" TO 1.054"	1.025
(24) OUTER C'BORE DEPTH	.679" TO .739"	.717 - .721
(8) OUTER JACKING HOLES	.431" TO .438"	Approved
(8) JACKING HOLES DEPTH FACE	2.923" TO 2.983"	2.980
(8) JACKING HOLES THREADED THRU FACE	M10 X 1.5-6H	O - ~~355~~ 6
SECTION E-E		
(2) LUBE HOLES THREADS 022	M10 X 1-6H	O - 355
(2) LUBE HOLES THREAD DEPTH	.500 MIN.	.870
(2) LUBE HOLES PLUGGED	SEE NOTE # 12	Approved
OUTER "G" STAMP	SEE NOTE# 7	Approved
INNER PILOT DIAMETER -Z-	61.417" TO 61.426"	61.421
-Z- PILOT DEPTH	1.750 MIN.	3.534
INNER PILOT SURFACE FINISH	125 MAX.	35
INNER PILOT RUNOUT -Z- TO -Y-	.0012" MAX.	.0002
FACE -B- RUNOUT TO -C-	.002 MAX.	.0013
FACE -B- SURFACE FINISH	125 MAX.	19
INNER RACE BEARING O.A.	3.504" TO 3.582"	3.537
(24) INNER HOLES THREADED	M16 X 2-6H	O-582
(24) INNER HOLES THREAD DEPTH	1.181 MIN.	1.680
INNER "G" STAMP & S/N MARKINGS	SEE NOTE# 7	Approved

ASEMBLED AND INSPECTED BY 403 ENG 406 DATE 3-29-00

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14680001 FINAL INSPECTION

PART S/N 5-002-000 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B COPY REV. B

14680-003 S/N 5758903 0007 SHEET 2 OF 3

14680-002 S/N 5741502 0008

CHARACTERISTICS	PRINT REQUIREMENT	ACTUAL
BEARING O.A.	3.533" TO 3.543"	3.537
(8) INNER JACKING HOLES	.431" TO .438"	Pins
(8) INNER JACKING HOLES DEPTH	2.923" TO 2.983"	2.982
(8) JACKING HOLES THUR	M10 X 1.5-6H	~~G-355~~ 0-6
PRELOAD	.001" TO .003" PRELOAD	
.750" GRADE 25 BALLS NO.	HEAT NO.	"A" 9902F "B" CR32A
GREASE MOBILITH 220	SEE NOTE # 5	Approved
SEALS DETAIL F	SEE NOTES # 11 & 13	Approved
BEARING WEIGHT	880 LBS.	900 Lbs.
STARTING TORQUE PER NOTE 2		
STARTING TORQUE / INNER LOADED	CW CCW	CW CCW
0°	18 18	18 FT Lbs.
90°	18 18	18 FT Lbs.
180°	18 18	18 FT Lbs.
270°	18 18	18 FT Lbs.
STARTING TORQUE / OUTER LOADED		
Inner Sumos 0°	8 x 3 = 24 Ft/lbs	12 x 3 = 36 Ft/lbs
90°	8 x 3 = 24 Ft/lbs	10 x 3 = 30 Ft/lbs
180°	10 x 3 = 30 Ft/lbs	8 x 3 = 24 Ft/lbs
270°	10 x 3 = 30 Ft/lbs	12 x 3 = 36 Ft/lbs
AVG. OF (8) READINGS		~~24.8~~ Ft/lbs
NOT TO EXCEED 285 FT. LBS.		24.8 FT. LBS.
TORQUE VARIATION NOT TO EXCEED 57 FT. LBS.		18 FT. LBS.
AXIAL DEFLECTION PER NOTE 1		
INNER RACE AXIAL DEFLECTION		
NO SINGLE READING TO EXCEED .0006		
0°		.0003
90°		.00035

ASEMBLED AND INSPECTED BY 403 ENG 406 DATE 3-29-00

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14680001 FINAL INSPECTION

PART S/N S-002-000 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903007 COPY SHEET 3 OF 3

14680-002 S/N 5741502008

180°		.0005
270°		.0004
AVG.		.0004
OUTER RACE AXIAL DELECTION		
NO SINGLE READING TO EXCEED .0006		
0°	.0001	.0001
90°	.0000	.0000
180°	.0000	.0000
270°	.0000	.0000
AVG.	.000025	.000025
CONTACT ANGLE	40° +/- 7°	BALL
PATH A	37.5°	25/32 +.0019
PATH B	36.5°	25/32 -.0006

ASEMBLED AND INSPECTED BY 403 ENG 406 DATE 3-~~28~~-00

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14680001 FINAL INSPECTION

PART S/N S-003-000 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903002 SHEET 1 OF 3

14680-002 S/N 5741502-006

COPY

CHARACTERISTICS	PRINT REQUIREMENT	ACTUAL
OUTER PILOT DIA. -X-	70.857" TO 70.866"	70.860
OUTER -X- DIAMETER SURFACE FINISH	125 MAX.	14
OUTER PILOT DEPTH	2.835 MIN.	2.948
OUTER PILOT RUNOUT -X- TO -Y-	.0012" MAX.	.0003
-A- FACE RUNOUT TO -C-	.002" MAX.	.0017
-A- FACE SURFACE FINISH	125 MAX.	35
OUTER RACE BEARING O.A.	3.504" TO 3.582"	3.538
(24) OUTER HOLES THRU	.705" TO .715"	P-487
(24) OUTER C'BORE HOLES	1.019" TO 1.054"	1.035
(24) OUTER C'BORE DEPTH	.679" TO .739"	.708
(8) OUTER JACKING HOLES	.431" TO .438"	Approved P.W.S
(8) JACKING HOLES DEPTH FACE	2.923" TO 2.983"	2.946
(8) JACKING HOLES THREADED THRU FACE	M10 X 1.5-6H	0-6
SECTION E-E		
(2) LUBE HOLES THREADS 022	M10 X 1-6H	0-355
(2) LUBE HOLES THREAD DEPTH	.500 MIN.	.750
(2) LUBE HOLES PLUGGED	SEE NOTE # 12	
OUTER "G" STAMP	SEE NOTE# 7	APPROVED
INNER PILOT DIAMETER -Z-	61.417" TO 61.426"	61.423
-Z- PILOT DEPTH	1.750 MIN.	3.535
INNER PILOT SURFACE FINISH	125 MAX.	8
INNER PILOT RUNOUT -Z- TO -Y-	.0012" MAX.	.0004
FACE -B- RUNOUT TO -C-	.002 MAX.	.0011
FACE -B- SURFACE FINISH	125 MAX.	32
INNER RACE BEARING O.A.	3.504" TO 3.582"	3.535
(24) INNER HOLES THREADED	M16 X 2-6H	0-582
(24) INNER HOLES THREAD DEPTH	1.181 MIN.	1.495
INNER "G" STAMP & S/N MARKINGS	SEE NOTE# 7	APPROVED

ASEMBLED AND INSPECTED BY 403 DATE 3-30-00

ENG 406

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14680001 FINAL INSPECTION

PART S/N S-003-0C0 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903002 COPY SHEET 2 OF 3

14680-002 S/N 5741502006

CHARACTERISTICS	PRINT REQUIREMENT	ACTUAL
BEARING O.A.	3.533" TO 3.543"	3.538
(8) INNER JACKING HOLES	.431" TO .438"	Approved Pins
(8) INNER JACKING HOLES DEPTH	2.923" TO 2.983"	2.946
(8) JACKING HOLES THUR	M10 X 1.5-6H	0-6
PRELOAD	.001" TO .003" PRELOAD	
.750" GRADE 25 BALLS NO.	HEAT NO.	054423
GREASE MOBILITH 220	SEE NOTE # 5	
SEALS DETAIL F	SEE NOTES # 11 & 13	
BEARING WEIGHT	880 LBS.	900 LBS.
STARTING TORQUE PER NOTE 2		
STARTING TORQUE / INNER LOADED		
0°		60 FT. LBS.
90°		60 FT. LBS.
180°		60 FT. LBS.
270°		66 FT. LBS.
STARTING TORQUE / OUTER LOADED		
0°		60 FT. LBS.
90°		60 FT. LBS.
180°		60 FT. LBS.
270°		54 FT. LBS.
AVG. OF (8) READINGS		60 FT. LBS.
NOT TO EXCEED 285 FT. LBS.		
TORQUE VARIATION NOT TO EXCEED 57 FT. LBS.		36 FT. LBS.
AXIAL DEFLECTION PER NOTE 1		
INNER RACE AXIAL DEFLECTION		
NO SINGLE READING TO EXCEED .0006		
0°		.0002
90°		.0005

403

ASEMBLED AND INSPECTED BY _____ DATE 3-30-00

ENG 406

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14680001 FINAL INSPECTION

PART S/N S-003-000 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903002 SHEET 3 OF 3

14680-002 S/N 5741502006

COPY

180°		.0002
270°		.0002
AVG.		.000275
OUTER RACE AXIAL DELECTION		
NO SINGLE READING TO EXCEED .0006		
0°		.0002
90°		.0002
180°		.0001
270°		.00015
AVG.		.0001625
CONTACT ANGLE	40° +/- 7°	PATH "A" PATH "B"
		35.5° 37.5°
	BALL SIZE	25/32+.0004 25/32+.0004

ASEMBLED AND INSPECTED BY 403 DATE 3-30-00

ENG 406

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14680001 FINAL INSPECTION

PART S/N S-004-0C0 CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5758903005 SHEET 1 OF 3

14680-002 S/N 5741502004

CHARACTERISTICS	PRINT REQUIREMENT	ACTUAL
OUTER PILOT DIA. -X-	70.857" TO 70.866"	70.861
OUTER -X- DIAMETER SURFACE FINISH	125 MAX.	.16
OUTER PILOT DEPTH	2.835 MIN.	2.940
OUTER PILOT RUNOUT -X- TO -Y-	.0012" MAX.	.0004
-A- FACE RUNOUT TO -C-	.002" MAX.	.0009
-A- FACE SURFACE FINISH	125 MAX.	24
OUTER RACE BEARING O.A.	3.504" TO 3.582"	3.533
(24) OUTER HOLES THRU	.705" TO .715"	P-487
(24) OUTER C'BORE HOLES	1.019" TO 1.054"	1.0375
(24) OUTER C'BORE DEPTH	.679" TO .739"	.708
(8) OUTER JACKING HOLES	.431" TO .438"	Approved Pins
(8) JACKING HOLES DEPTH FACE	2.923" TO 2.983"	2.9
(8) JACKING HOLES THREADED THRU FACE	M10 X 1.5-6H	0-6
SECTION E-E		
(2) LUBE HOLES THREADS 022	M10 X 1-6H	0-355
(2) LUBE HOLES THREAD DEPTH	.500 MIN.	.920
(2) LUBE HOLES PLUGGED	SEE NOTE # 12	Approved
OUTER "G" STAMP	SEE NOTE# 7	Approved
INNER PILOT DIAMETER -Z-	61.417" TO 61.426"	61.423
-Z- PILOT DEPTH	1.750 MIN.	3.525
INNER PILOT SURFACE FINISH	125 MAX.	18
INNER PILOT RUNOUT -Z- TO -Y-	.0012" MAX.	.0002
FACE -B- RUNOUT TO -C-	.002 MAX.	.0017
FACE -B- SURFACE FINISH	125 MAX.	64
INNER RACE BEARING O.A.	3.504" TO 3.582"	3.525
(24) INNER HOLES THREADED	M16 X 2-6H	0-582
(24) INNER HOLES THREAD DEPTH	1.181 MIN.	1.490
INNER "G" STAMP & S/N MARKINGS	SEE NOTE# 7	Approved

403

ASEMBLED AND INSPECTED BY _____ DATE 3-31-00

ENG 406

670a021

14680001 FINAL INSPECTION

PART S/N S-004-0CD CUSTOMER LTBC QCF-45-1500

CUSTOMER # 670A021 B REV. B

14680-003 S/N 5258903005 SHEET 2 OF 3

14680-002 S/N 5741502004

CHARACTERISTICS	PRINT REQUIREMENT	ACTUAL
BEARING O.A.	3.533" TO 3.543"	3.534
(8) INNER JACKING HOLES	.431" TO .438"	Approved Pins
(8) INNER JACKING HOLES DEPTH	2.923" TO 2.983"	2.965
(8) JACKING HOLES THUR	M10 X 1.5-6H	0-6
PRELOAD	.001" TO .003" PRELOAD	.0015
.750" GRADE 25 BALLS NO.	HEAT NO.	PATH A 054423 PATH B 9902F
GREASE MOBILITH 220	SEE NOTE # 5	Approved
SEALS DETAIL F	SEE NOTES # 11 & 13	Approved
BEARING WEIGHT	880 LBS.	900 LBS.
STARTING TORQUE PER NOTE 2		
STARTING TORQUE / INNER LOADED		CW CCW
0°		24 Ft.Lbs. 24 Ft.Lbs.
90°		21 Ft.Lbs. 18 Ft.Lbs.
180°		21 Ft.Lbs. 21 Ft.Lbs.
270°		18 Ft.Lbs. 21 Ft.Lbs.
STARTING TORQUE / OUTER LOADED		
0°		18 Ft.Lbs. 24 Ft.Lbs.
90°		21 Ft.Lbs. 21 Ft.Lbs.
180°		21 Ft.Lbs. 21 Ft.Lbs.
270°		21 Ft.Lbs. 21 Ft.Lbs.
AVG. OF (8) READINGS		20.6 Ft.Lbs. 20.4 Ft.Lbs.
NOT TO EXCEED 285 FT. LBS.		
TORQUE VARIATION NOT TO EXCEED 57 FT. LBS.		18 Ft. Lbs.
AXIAL DEFLECTION PER NOTE 1		
INNER RACE AXIAL DEFLECTION		
NO SINGLE READING TO EXCEED .0006		
0°		.00045
90°		.00055

ASEMBLED AND INSPECTED BY 403 DATE 3-31-00

ENG 406

670A021
14680001 FINAL INSPECTION

PART S/N S-004-000 CUSTOMER LTBC

CUSTOMER # 670A021 B

14680-003 S/N 5758903 005

14680-002 S/N 5741502 004

QCF-45-1500
REV. B
SHEET 3 OF 3

180°		.0002
270°		.0004
AVG.		.0004
OUTER RACE AXIAL DELECTION		
NO SINGLE READING TO EXCEED .0006		
0°		.0002
90°		.0002
180°		.0005
270°		.0000
AVG.		.000225
CONTACT ANGLE	40° +/- 7°	PATH "A" PATH "B"
		42° 39.5°
	BALL SIZE	25/32+.0004 25/32+.0001

ASEMBLED AND INSPECTED BY 403 ENG 406 DATE 3-31-00

Installation and Care of Kaydon Turntable Bearings

Part I—Design Considerations (For Guidance of the Equipment Designer)

Mounting structure

Most designs are necessarily a compromise from the ideal to the practical. The design of mountings for large multiload bearings is no exception. Several conditions, however, must be satisfied by the mounting structures above and below the bearing, in order to give good bearing life and performance. These conditions are stiffness, flatness, hole location accuracy, protection, access for maintenance, and attachment method.

Stiffness

The ideal bearing mounting would be absolutely rigid, but mobile equipment is by its very nature flexible and thus elastic deflections will occur. However, distortions can be held to tolerable levels if the shape of the main structural members above and below the bearing are generally in the form of a cylinder whose outer diameter is equal to or slightly larger than the bearing ring to which they are attached. An example is the flanged drums commonly used on crawler trucks.

Figure 40 has been prepared to show the maximum allowable deflections ball bearings can withstand and still function properly. Deflection must be gradual. Avoid short, stiff sections in the mounting as these can adversely affect the loading pattern of the rolling elements by causing extremely high loads between a few elements and the raceways. They also have a similarly adverse effect on bolt loads. In addition, excessive turning torque may result, causing high gear tooth loads.

Figure 40—Allowable mounting deflection (circumferential)

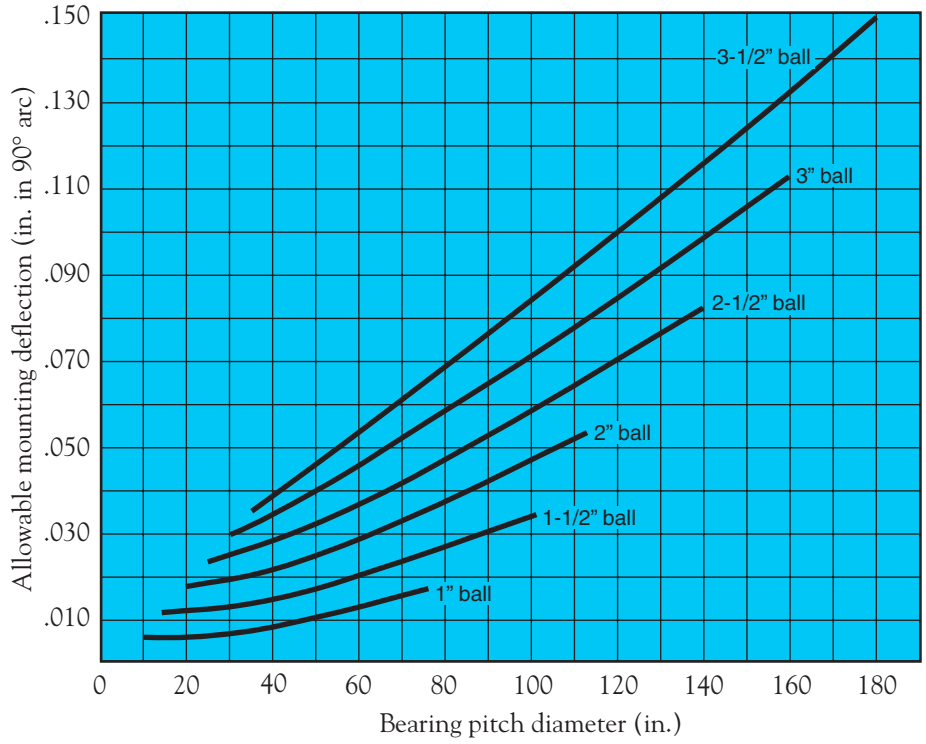
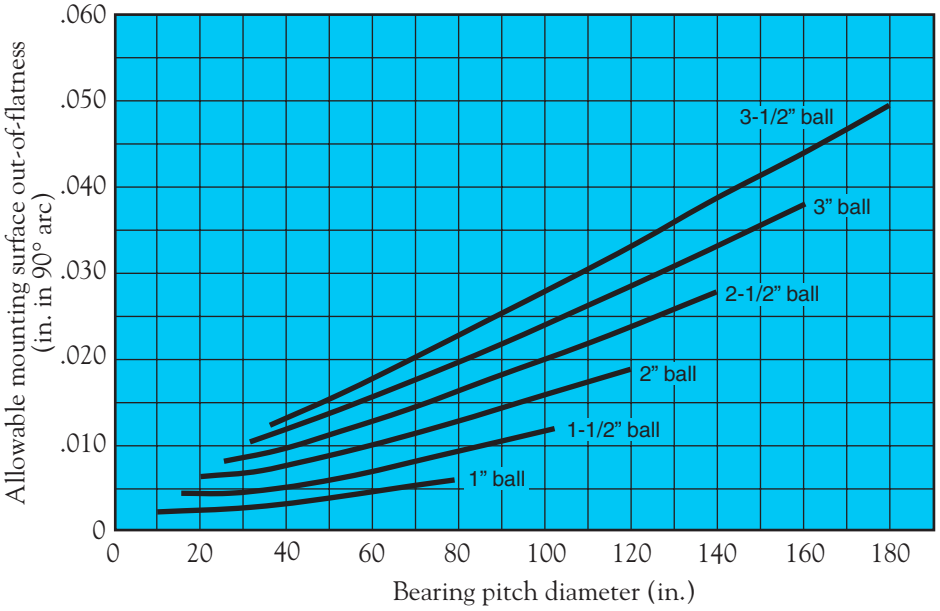


Figure 41—Allowable mounting out-of-flatness (circumferential)



NOTE: These charts refer to ball bearings. For roller bearings, consult Kaydon for allowable stiffness and flatness.

Flatness

Bearing mounting surfaces must be machined flat after all welding and stress relief treatment on the structures is complete. If subsequent welding is necessary, it must be done in such a manner that no distortion is experienced by the machined mounting surface. The allowable degree of out-of-flatness is shown in Figure 41. Out-of-flatness like distortion, must be gradual.

Questions are often asked about shimming or grouting of mounting surfaces to compensate for excessive out-of-flatness. While shimming is acceptable if done properly, most equipment builders find it so difficult to control in production that it is more troublesome and costly than machining. Plastic grout has such a low modulus of elasticity that under cyclic loading mounting bolt fatigue failure can result. Thus, KAYDON STRONGLY RECOMMENDS AGAINST THE USE OF GROUTING WHEREVER CYCLIC THRUST AND MOMENT LOADS ARE EXPECTED.

Another consideration is the allowable deviation from a true plane in a radial direction ("dish"), which is more difficult to control in machining mounting surfaces. Table 16 shows allowable values for out-of-flatness as machined and for deflection under load.

Table 16

Allowable out-of-flatness and deflection—radial ("dish")		
Ball dia. inches	Out-of-flatness inches per radial inch of mounting surface	Deflection inches per radial inch of mounting surface
1	.0010	.0030
1-1/2	.0015	.0045
2	.0020	.0060
2-1/2	.0025	.0075
3	.0030	.0090
3-1/2	.0035	.0105

Hole location accuracy, pilots

Mounting holes and dowel holes, if any, must be within the true location tolerances required to prevent distortion of the bearing due to interference. See the applicable drawing for the bearing tolerances. Use of bearings as templates for transfer of hole location is permissible if care is taken not to distort thin section bearings. But bearings should never be used as drill jigs.

Pilots, if used, must be round and accurately sized so that they do not distort the bearing. Mounting hole location tolerance must include any eccentricity of the hole pattern with pilot diameters.

Protection

In general, Kaydon bearings are designed to withstand all normal operating environments. However, if the upper structure does not provide complete cover for the upper bearing, a seal or shield should be added. Also, an external gear that would be exposed to very dirty conditions should be shrouded.

Shields and shrouds should be designed with cover doors, plugs, or other means of access to the bearing for the purposes discussed below.

Access for maintenance

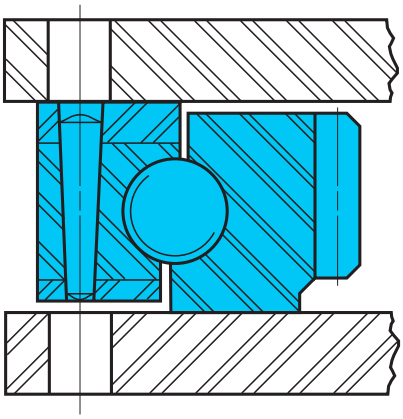
Like all mechanical components on a machine, the bearing must be accessible so that it can be properly maintained. The following must be considered.

*__Mounting bolts__ require periodic checking and retightening. Access to every mounting bolt must be readily available, or this maintenance item will be neglected and may result in mounting bolt failure.

__Lubrication of Gear and Raceway__ is required and therefore convenient access to the gear and bearing grease fittings must be provided. Convenience is stressed because of the human element involved. It is best to add remote lines to the bearing so that it may be rotated as grease is introduced to the raceways.

__The Taper Pin Retainer__ for the ball loading hole plug must be removed on rare occasions *by qualified personnel* to inspect raceways or to replace rolling elements or spacers. A hole, approximately 11/4 inches in diameter must be located in both upper and lower mounting structures directly above and below the "Taper Pin Retainer," so that it may be removed. (See Figure 42.)

Figure 42—Access holes for loading hole plug



*Attachment

The method of attachment of Kaydon bearings to the support structure significantly affects their design. The type, size, and quantity of fasteners must be determined if bolts will be used. If welding is to be done, a decision must be made as to which race will be so attached and whether a "band" will be welded to the inner or outer diameter or a "ring" will be welded to one of the faces.

*Bolts

The preferred bolting arrangement is a full circle of equally spaced fasteners in through holes in both bearing races. This benefits both the bearing and the bolts. The bearing races are reinforced by the bolt pretension. The greater bolt length makes for more accurate and uniform pretension.

*For three important reasons responsibility for the quantity, size, and thread engagement of fasteners must be accepted by the equipment designer.

a. There is no universally accepted method of analyzing the forces imposed on the fasteners in a joint subjected to moment loading.

b. The stiffness and uniformity of the structures to which the bearing is attached have an extremely high degree of influence on the load in the fasteners. Only the equipment designer can control this.

c. The quality of the fasteners, the method of pretensioning, the hardness of the surfaces under the heads and the thread lubricant are other important factors over which the equipment manufacturer has control.

*This should be done with the advice and assistance of the supplier of the bolts because the quality of bolts varies widely as do the recommendations for methods of pretensioning and maintenance of pretension. Attention to such details as a head/body fillet radius, thread form, as well as the more obvious freedom from cracks and other possibly fatal flaws are very important to the safety of the equipment. The importance of adequate and uniform pretensioning is evident from the proliferation of and advances in devices offered for this purpose—ranging from turn of the nut indicator to preload indicating washers to torque wrenches with integral "yield" sensors to computerized torque wrenches to hydraulic bolt stretchers.

*At the least, Kaydon recommends the use of high strength bolts with coarse threads and hexagon heads, and heavy series nuts of equivalent strength. Also, recommended is the use of thread lubricant and hardened steel flat, Belleville, or calibrated preload indicating washers. Use of lockwashers is *NOT* recommended when bolts are tensioned by torquing, because of the danger of undertensioning due to high friction torque.

For the protection of the equipment builder, specifications should require that the bolts carry not only the standard SAE grade code but also a positive means of identifying the manufacturer.

Bolt Loading

To aid the designer, a method is presented here to calculate the *approximate* load on the heaviest loaded bolt. This method is based upon past experience and yields results that have proved satisfactory for most applications. It is analogous to the method Kaydon uses to determine the load in the heaviest loaded rolling element within a bearing.

However, for the reasons stated Kaydon makes no warranty, expressed or implied, regarding the adequacy of the bolts. The only certain way to determine the actual load is by *testing*, which is *strongly recommended*.

Bolt Load

$$Rb = \frac{M \times Ff}{D \times N} \pm \frac{Ft}{N}$$

Factor of Safety

$$*Fs = \frac{\text{Bolt Proof Load Rating}}{Rb}$$

M = Moment load in pounds-inches
Ff = Flexibility factor. Use 3 for bearings and support structures of average stiffness
Ft = Axial load in lbs.
D = Bolt circle dia. in inches
N = total number of equally spaced bolts
Rb = Total load on heaviest loaded bolt in lbs.
*Fs = *Factor of safety of bolts. Recommended minimum value 3*

Bolt Proof Load
Coarse Thread Series
S.A.E. Grade #8 and ASTM A 490

Bolt Dia. Ins.	Proof Load Lbs.	Bolt Dia. Ins.	Proof Load Lbs.
1/2	17,000	1	72,700
5/8	27,100	1-1/8	91,600
3/4	40,100	1-1/4	116,300
7/8	55,400	1-1/2	168,600

*Welding

Of late, the attachment of bearings by welding has been limited on new applications to unusual situations. These are best handled by working directly with the Kaydon Engineering Department to establish both the optimum design and the best welding procedures.

Gears

Kaydon offers integral gears as either straight or helical spur, and either internal or external. Use of a 20° pressure angle is favored because of availability of standard cutters, but 14-1/2°, 25°, and special pressure angles can be furnished.

Selection

The machine designer will usually determine the tooth size and form, working within the constraints of his application and basing his selection on his own

*See warranty, page 33.

methods of calculation and past experience. However, the commonly accepted Lewis equation may be used to determine the size of the gear.

$$L = \frac{SFY}{P}$$

L = Tangential Tooth Load

S = Allowable Bending Stress

Y = Tooth Form Factor (Table 17)

P = Diametral Pitch

F = Face Width

Allowable bending stress (S)

Core Hardness		Allowable Bending Stress P.S.I.
241-285	BHN (23-30Rc)	34,000
262-302	BHN (27-32Rc)	37,000
277-321	BHN (29-34Rc)	40,000

The stresses given above are for maximum or "Stall Torque" conditions. When shock factors are included in the loading, higher stresses may be used.

The "Stub" tooth form is often used in large gears. Economics is the main reason this tooth form is selected. It requires less material in the ring forging and less gear cutting time. The "Full Depth" tooth form provides a greater contact ratio, and consequently smoother operation but lower bending strength.

Surface hardening

Induction hardened gear teeth, with minimum surface hardness of 55 Rc should be considered when high tooth surface pressures constantly occur. An excavator or logger which sees a high rate of acceleration and a rapid deceleration during a swing cycle would be typical of this condition.

A full root radius with root hardening is recommended when gear teeth are induction hardened. The tooth pattern and depth of hardness are critical.

Table 17

Tooth form factor (Y)						
No. of teeth	20° full depth involute system	20°stub tooth system	Fellows stub tooth system 4/5	5/7	6/8	Internal gears 20°full depth system
12	.245	.311	.301	.349	.320	
13	.261	.324	.317	.361	.336	
14	.276	.339	.330	.374	.352	
15	.289	.348	.339	.386	.361	
16	.295	.361	.349	.396	.374	
17	.302	.367	.358	.405	.383	
18	.308	.377	.367	.411	.389	
19	.314	.386	.374	.412	.399	
20	.320	.393	.380	.424	.405	
21	.327	.399	.386	.430	.411	
22	.330	.405	.393	.437	.412	
24	.336	.415	.402	.446	.427	
26	.346	.424	.408	.455	.437	
28	.352	.430	.418	.462	.443	.691
30	.358	.437	.424	.468	.449	.678
34	.371	.446	.437	.480	.461	.660
38	.383	.456	.440	.484	.468	.644
43	.396	.462	.452	.446	.480	.628
50	.408	.474	.462	.506	.490	.613
60	.421	.484	.471	.515	.499	.597
75	.434	.496	.484	.525	.509	.581
100	.446	.506	.496	.537	.521	.565
150	.459	.518	.509	.547	.534	.550
300	.471	.534	.525	.563	.550	.534
Use in Lewis Formula for P_____			4	5	6	

Therefore, a high degree of quality control must be exercised to assure that the proper pattern is maintained, and that cracks are non-existent. Some typical depths of hardness are as follows:

Table 18

Case depth-induction hardened gears		
Diametral pitch	Flank depth	Root depth
4.00	.040	.030
3.50	.050	.035
3.00	.060	.040
2.50	.075	.050
2.00	.100	.070
1.75	.125	.080
1.50	.150	.100

Backlash

Proper backlash must be provided in any pair of gears. This is especially true of bearing gears, where large diameters and large center distances require greater manufacturing tolerances. Therefore, the allowance for backlash must be sufficient to allow for these greater tolerances. Typical backlash allowances are shown in Table 19.

Table 19

Gear Pitch Dia.	Minimum Backlash (in.)	Maximum Backlash (in.) Diametral Pitch				
		1.5	1.75	2	2.5	3,4,5
20	.014	.029	.027	.025	.023	.022
30	.015	.030	.028	.026	.024	.023
40	.016	.031	.029	.027	.025	.024
60	.018	.033	.031	.029	.027	.026
80	.020	.035	.033	.031	.029	.028
100	.022	.037	.035	.033	.031	.030
120	.024	.039	.037	.035	.033	.032

Other factors bear on the machine designer's decision whether or not to provide backlash by adjustment of center distance between gear and pinion. But the cost advantages of adjustment should be kept in mind. Gear size tolerance can be greater and life can be extended by take-up for wear.

Storage before installation

There is no need for special care or lubrication of Kaydon Turntable Bearings before being put into service. They are packed with general purpose grease at the factory and are sealed to exclude ordinary foreign matter. However, they should be kept in the shipping container in a horizontal position until time for installation. Outdoor storage is not recommended and if installation is not made within a year, new grease should be introduced.

External surfaces of turntable bearings, including the gear, are coated with a preservative oil to give them nominal protection during storage.

Installation

Installation of the bearing/gear assembly should be done in a clean, dry, well-lighted area. Mounting surfaces and pilots of the housings should be unpainted and wiped clean of chips, dirt, and lint, since even "soft" material when entrapped will act as high spots. When this has been done, examine for and remove weld spatter, nicks and burrs and wipe clean again. The bearing may now be unwrapped and lifted or hoisted into position. Use eye bolts in mounting holes or nonmetallic slings to avoid damage to bearing mounting faces and pilots, and to gear teeth.

Inherent in the hardening process of most turntable bearings is a small gap at one point in the raceway. The loading hole (see Page 26) is drilled through this gap. The location in the mating race is steel stamped "G" on the seal face. Hardening gaps and load hole plugs in races with through holes should be positioned at minimum load points if possible. LOAD HOLE PLUGS IN RACES WITH TAPPED HOLES OR WELD RINGS MUST BE SO POSITIONED. With the rotating race, this may be done by placing the loading hole 90° from the maximum load zone due to moment loading. With the stationary race the position will depend upon the location of the lightest load relative to the lower structure of the machine.

*SAE Grade 8 or better bolts should be used to ensure adequate bolt strength

For good internal load distribution and smooth, low torque operation, the bear-ing should be as round as possible when the bolts are tightened. If one of the races is doweled or piloted, it should be mounted first whenever possible. On unpiloted, gear bearings the gear/pinion backlash should be checked and adjusted to the desired amount. The minimum backlash point of the gear is identified by yellow paint in the tooth space. We recommend the following procedure to assure trouble-free operation:

- Leave all mounting bolts loose until both mating parts are attached to the bearing.
- While applying a moderate centered thrust load to the bearing, measure the torque to rotate the bearing.
- Then tighten all bolts to the level prescribed by the bolt manufacturer. **THIS IS VERY IMPORTANT. Improperly tightened bolts can fail due to fatigue; such failure can cause damage to equipment and endanger human life.**
- Again measure the torque required to rotate the bearing.
- If greater than the first measurement this indicates that the bearing is being distorted. Determine and correct the cause.

Gears on fixed centers may now be checked for backlash, and pinions on adjustable centers set for proper backlash.

When all backlash checks are completed, the gear should be given a coating of grease suitable for the operating conditions, and rotated to assure coverage of all contacting surfaces with the pinions.

Complete installation of all rotating components of significant weight, and check bearing for freedom of rotation. Excessive torque level or variation is indicative of some unsatisfactory installation condition.

Relubricate the bearing prior to shipment of the machine.

***NOTE:** For installation procedure for weld ring bearings contact your Kaydon Representative or Kaydon factory.

Maintenance

While Kaydon turntable bearings require almost no attention, what little they are given will pay big dividends

*See warranty, page 33.

in long life, high performance, and trouble-free service.

Relubrication of the bearing is recommended every 100 operating hours for relatively slow rotating or oscillating applications such as backhoes, excavators, and cranes. In more rapidly moving or continuously rotating machinery such as trenchers, borers, and distributors the bearing should be lubricated every day, or every 8 hours if on round-the-clock service.

Idle equipment should not be neglected. Grease dries out and "breathing" due to temperature changes, can cause condensation within the bearing. Whether used or not, the bearing should have grease introduced every 6 months. It is always a good idea to rotate the bearing a few turns to coat all surfaces with fresh grease.

There is a tendency to take much better care of the bearing than of the gear. This may be due to the rather crude gears used in the past. The meshing action and usual position of the gear tends to purge the lubricant; thus, the gear should be regreased frequently with a small amount of lubricant. The gear is deserving of good care and will return the favor in long, smooth quiet service. It is recommended that grease be introduced at the point of mesh of pinion and gear every 8 hours of slow or intermittent operation, and more often for rapidly or continuously rotating applications.

The cyclic nature of the loading on the mounting bolts gives rise to the possibility of their working loose or to inelastic deformation of the threads and other stressed surfaces. Bolts should be checked periodically and retightened to the proper level.

***THIS IS A VERY IMPORTANT SAFETY PRECAUTION.**

Part II—Installation (For Guidance of the Equipment Builder)

Refer to Part I to determine that the designer has properly applied the bearing and made provision for proper installation. But keep in mind that the best design in the world can fail to live up to its potential if the execution of the design by the builder is faulty.

Before installation

Recognize the vital role of the bearing/gear and the fastening means (bolts or welds).

Prepare detailed and clear instructions to the tradesmen. If bolts are to be used as the means of attachment, conduct necessary tests to prove the method of pretensioning. Check to see that the bolts carry not only the standard SAE grade code but also a positive means of identifying the manufacturer. The code for SAE Grade 8 is 6 radial lines on the top of the hex head.

If the bearing is to be attached by welding, conduct the necessary tests to prove that the specified joint will be developed by the intended method.

Provide a clean, dry, well-lighted area for performance of the installation work.

Keep the bearing wrapped in its original wrapping until all preparations have been made for its installation.

When handling individual bearings use eye bolts in mounting holes. If the bearing must be turned over or slings are used for other reasons, use nylon web slings or equivalent to avoid damaging the bearing mounting surfaces, the gear, or the seals. Do not use chains or metallic mesh slings in contact with the bearing!

During installation

Wipe equipment mounting surfaces and pilots clean of chips, dirt, and lint. Even "soft" material when entrapped will act as high spots.

Examine for and remove weld spatters, nicks, and burrs. If surfaces have been painted, remove completely. Unpackage the bearing; wipe free of all foreign matter; visually inspect for damage in shipping.

Recheck bolt tightness. The reason for any loss of pretensioning must be determined and eliminated.

If equipment is not delivered immediately, introduce fresh grease into the bearing until grease can be seen exuding from seals. Move bearing in rotation several times to ensure a complete fill. Repeat every 6 months on idle equipment.

Remove any minor burrs from mounting surfaces caused in shipping or handling. Use a hand file, taking care to remove only as much material as necessary to insure full contact of bearing surface with equipment mounting surface. **DO NOT DISASSEMBLE BEARING** without express approval of and instruction from Kaydon. Removal of loading hole plug voids our warranty.

Wipe bearing and equipment mounting and pilot surfaces clean once more.

Lift bearing into position for installation. Rotate races to align loading hole plug (in ungeared race) and stamped "G" (on gear race) in accordance with your designer instructions.

Install bearing in manner and sequence prescribed by your designer paying particular attention to the gear mesh, to free entry of bolts into bolt holes, to the bolt pretensioning, and to changes in bearing torque. Determine reason for and eliminate any problems with any of these items before proceeding. Do not distort

*See warranty, page 33.

the bearing to permit bolts to enter holes that do not line up. Welding instructions for attachment of weld-ring bearings must incorporate every detail including, but not limited to welding rod, protective material and/or atmosphere, all machine settings, tacking procedure, preheating, heating while welding, post-heating, number of passes and inspection procedures.

When all backlash checks are complete, the gear should be given a coating of grease suitable for the operating conditions and rotated to assure coverage of all contacting surfaces with the pinions.

Complete installation of all rotating components of significant weight, and check bearing for freedom of rotation. Excessive torque level or variation is indicative of some unsatisfactory installation condition.

*After installation

When equipment has been completely assembled, and before testing, check bolt tightness. The reason for loss of pretensioning beyond a reasonable amount for seating of mounting surfaces and threads must be determined and eliminated. Conduct required tests.

*Recheck bolt tightness. The reason for any loss of pretensioning must be determined and eliminated.

Relubricate the bearing prior to delivery of the machine. Introduce fresh grease into the bearing until grease can be seen exuding from the seals. Move bearing in rotation several times to insure a complete fill. Repeat every 6 months on idle equipment.

*Kaydon recommends that the Owner's Manual prepared by the equipment builder be submitted to the Kaydon Engineering Department for review and approval of the sections relating to the bearings and gears supplied by Kaydon.

Part III - Use & Care (For Guidance of Equipment Owner and/or User)

While Kaydon Turntable Bearings require almost no attention, what little they are given will pay big dividends in long life, high performance, and trouble-free service.

Before Use

If you cannot be sure that the bearing/gear has been lubricated within the past six months or after 100 hours of operation, introduce fresh grease in accordance with equipment manufacturer's instruction manual (owner's manual).

*During Use

- Relubricate bearing and gear in accordance with Owner's Manual.
- Inspect seals, making certain that they are in proper position in grooves and intact.
- Retighten mounting bolts in accordance with Owner's Manual. **THIS IS A VERY IMPORTANT PRECAUTION.**
- Be alert to changes in torque, unusual sounds, vibrations.

*See warranty, page 33.

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