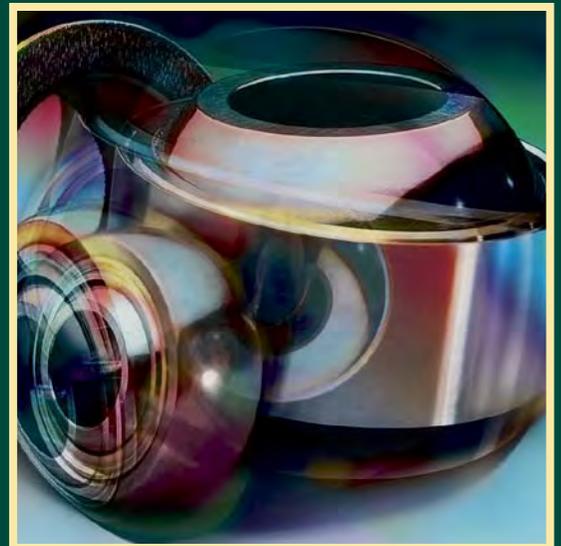




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**spherical bearings**  
**loader slot bearings**  
**rod end bearings**  
**sleeve bearings**

**ASTRO DIVISION**  
**PRODUCTS AND**  
**ENGINEERING**



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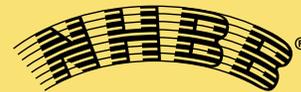
## ***Welcome to the Astro Division of NHBB***

The Astro Division of NHBB has firmly established its leadership position in the rod end and spherical-bearing business by providing engineering solutions for complex application problems.

Product quality is NHBB's first priority. The employees of the Astro Division are dedicated to manufacturing products that meet the exacting specifications of today's demanding market environment. Initiatives such as AS9100 Rev. C, ISO 9001:2008 and D6-82479 are the foundation for our organization's commitment to quality.

While the Astro Division is well positioned to provide a standard product line at a competitive price, the Division also has extraordinary strength in custom design and production. This catalog is designed to help you find both the custom and standard products you may need for your applications.

Please contact Astro's sales or engineering groups for assistance with your specific requirements.



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# SECTION 1

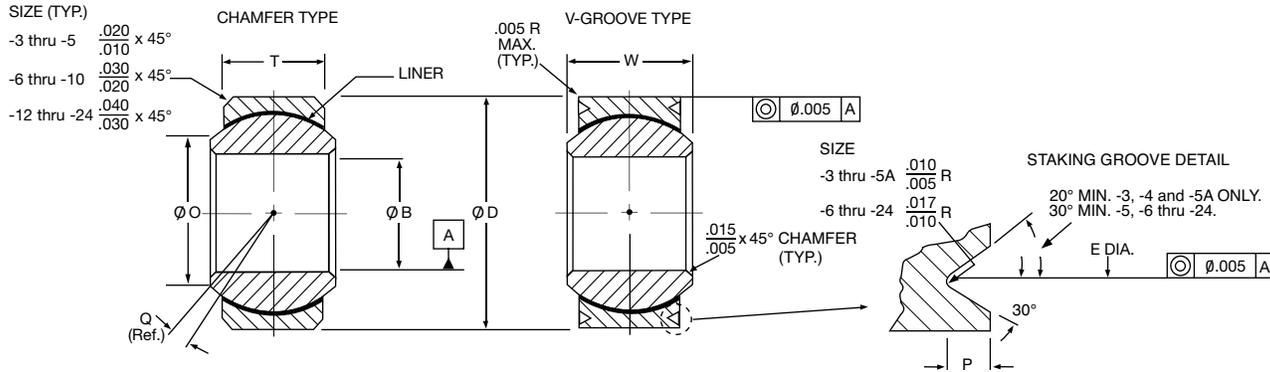
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# SPHERICAL BEARINGS – Self-Lubricating

## AS81820 Narrow



Part Number	MS Dash No.	(B) Bore Diameter	(D) Outside Diameter	(W) Ball Width	(T) Race Width	(O) Shoulder Diameter	Ball Diameter	(E) Pitch Diameter	(P) Groove Depth	(Q°) Misalignment	Limit Static Radial Load	Limit Static Axial Load	Dynamic Osc. Radial Load	Weight
V-Grooved*		Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Degree	lbs.	lbs.	lbs.	lbs.
<b>MS14101</b>		+0.000	+0.000	+0.000	±.005	Min.	Ref.	+0.000	+0.000	Ref.				Ref.
<b>MS14104</b>		-0.005	-0.005	-0.002				-0.008	-0.010					
ADB3V(L)	-3	.1900	.5625	.281	.218	.293	.406	.500	.025	10°	3975	150	1500	.020
ADB4V(L)	-4	.2500	.6562	.343	.250	.364	.500	.594	.025	10°	6040	430	3320	.020
ADB5V(L)	-5	.3125	.7500	.375	.281	.419	.562	.650	.035	10°	8750	700	5460	.030
ADB5VA(L)	-5A	.3125	.7500	.375	.281	.419	.562	.660	.035	10°	8750	700	5460	.030
ADB6V(L)	-6	.3750	.8125	.406	.312	.475	.656	.712	.035	9°	10540	1100	6600	.040
ADB7V(L)	-7	.4375	.9062	.437	.343	.530	.718	.806	.035	8°	13200	1400	8050	.050
ADB8V(L)	-8	.5000	1.0000	.500	.390	.600	.813	.876	.055	8°	17900	2100	10400	.070
ADB9V(L)	-9	.5625	1.0937	.562	.437	.670	.875	.970	.055	8°	23200	3680	13000	.090
ADB10V(L)	-10	.6250	1.1875	.625	.500	.739	.968	1.063	.055	8°	30500	4720	16450	.120
ADB12V(L)	-12	.7500	1.4375	.750	.593	.920	1.187	1.313	.055	8°	46400	6750	23600	.210
ADB14V(L)	-14	.8750	1.5625	.875	.703	.980	1.312	1.438	.055	8°	62200	9350	30250	.270
ADB16V(L)	-16	1.0000	1.7500	1.000	.797	1.118	1.500	1.626	.055	8°	82200	12160	38000	.390
ADB18V(L)	-	1.1250	2.1250	1.125	.900	1.334	1.750	2.003	.055	8°	105880	13500	42350	.720
ADB20V(L)	-	1.2500	2.3125	1.250	1.000	1.473	1.937	2.190	.055	8°	131230	16930	52490	.930
ADB22V(L)	-	1.3750	2.5625	1.375	1.100	1.654	2.156	2.440	.055	8°	161700	20750	64680	1.280
ADB24V(L)	-	1.5000	2.8125	1.500	1.200	1.794	2.344	2.690	.055	8°	191973	24950	77110	1.670

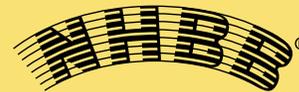
\*For chamfered version, delete 'V' from part number.

### Notes:

- Bearing sizes 3 through 16 listed in the tables are approved for procurement to AS81820 and Aerospace Standards AS14101 through AS14104.
- Bearing sizes 18 through 24 listed are not included in current Aerospace Standards, but are offered as NHBB catalog items only.
- Temperature: Operating temperature range per AS81820 is -65° to 325°F. Broader temperature capabilities are achievable.

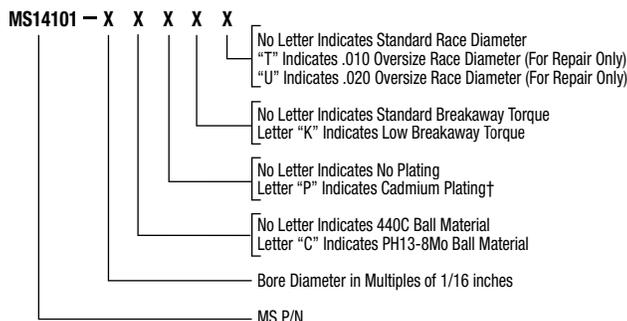
### Materials

Part No.	Ball	Race	Liner
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required
Catalog No. + 13-8	CRES PH13-8Mo AMS 5629 Rc43-47	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required

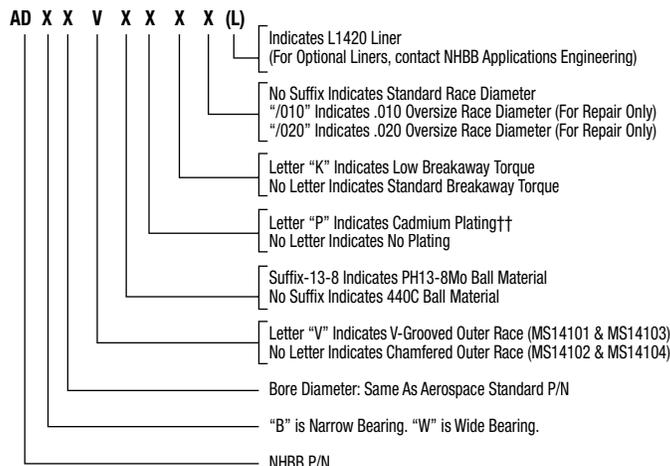


# AS81820 Wide

## Aerospace Standard P/N



## NHBB P/N



P/N Series	NHBB P/N	Description
MS14101	ADB V	Narrow Grooved
MS14102	ADW	Wide Chamfered
MS14103	ADW V	Wide Grooved
MS14104	ADB	Narrow Chamfered

† Cadmium plate MS14102 & MS14104 O.D. and O.D. chamfers per AMS-QQ-P-416, Type II, Class 2. Dimensions apply after plating.

†† Cadmium plate MS14101 & MS14103 O.D. and on the flats between the outside diameter and the grooves per AMS-QQ-P-416, Type II, Class 2. Dimensions apply after plating.

Part Number	MS Dash No.	(B) Bore Diameter	(D) Outside Diameter	(W) Ball Width	(T) Race Width	(O) Shoulder Diameter	Ball Diameter	(E) Pitch Diameter	(P) Groove Depth	(Q°) Misalignment	Limit Static Radial Load	Limit Static Axial Load	Dynamic Osc. Radial Load	Weight
V-Grooved*		Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Degree	lbs.	lbs.	lbs.	lbs.
<b>MS14102</b>		+ .0000	+ .0000	+ .000		Min.	Ref.	+ .000	+ .000	Ref.				Ref.
<b>MS14103</b>		- .0005	- .0005	- .002	± .005			- .008	- .010					
ADW3V(L)	-3	.1900	.6250	.437	.327	.300	.531	.563	.025	15°	2500	1770	4900	.031
ADW4V(L)	-4	.2500	.6250	.437	.327	.300	.531	.563	.025	15°	5500	1770	4900	.031
ADW5V(L)	-5	.3125	.6875	.437	.317	.360	.593	.625	.025	14°	9400	1640	6050	.035
ADW6V(L)	-6	.3750	.8125	.500	.406	.466	.687	.712	.035	8°	13700	2630	8310	.060
ADW7V(L)	-7	.4375	.9375	.562	.442	.537	.781	.837	.035	10°	20700	3650	11750	.080
ADW7V52(L)	-7A	.4375	.9062	.562	.442	.537	.781	.806	.035	10°	19700	3650	11750	.080
ADW8V(L)	-8	.5000	1.0000	.625	.505	.607	.875	.900	.035	9°	21400	4970	14950	.100
ADW9V(L)	-9	.5625	1.1250	.687	.536	.721	1.000	1.025	.035	10°	26600	5370	18100	.135
ADW10V(L)	-10	.6250	1.1875	.750	.567	.747	1.062	1.087	.035	12°	29000	6130	20250	.160
ADW12V(L)	-12	.7500	1.3750	.875	.630	.845	1.250	1.251	.055	13°	37000	7730	26200	.240
ADW14V(L)	-14	.8750	1.6250	.875	.755	.995	1.375	1.501	.055	6°	65200	10800	33600	.350
ADW16V(L)	-16	1.0000	2.1250	1.375	1.005	1.269	1.875	2.001	.055	12°	104000	19300	56250	.970
ADW18V(L)	-	1.1250	2.2500	1.437	1.067	1.338	1.968	2.128	.055	14°	142570	19640	57000	1.000
ADW20V(L)	-	1.2500	2.3750	1.500	1.130	1.460	2.093	2.253	.055	13°	159200	21970	63680	1.120
ADW20-5V(L)	-	1.2500	2.0000	1.093	.942	1.406	1.781	1.878	.055	6°	112360	14890	44940	.564
ADW22V(L)	-	1.3750	2.5625	1.687	1.223	1.535	2.281	2.440	.055	15°	190000	25970	76000	1.390
ADW24V(L)	-	1.5000	2.6875	1.687	1.223	1.693	2.390	2.567	.055	14°	199000	25970	79640	1.480

\*For chamfered version, delete 'V' from part number.

### No Load Breakaway Torque

Bore Sizes	Standard (in - lbs.)	"K" Type
3 & 4	0.25 to 5.0	0 to 0.5
5 to 12	0.25 to 8.0	0 to 1.0
14 & 16	0.25 to 12.0	0 to 2.0
18 & 20	0.25 to 18.0	0 to 2.0
22 & 24	0.25 to 24.0	0 to 2.0

### Radial and Axial Play

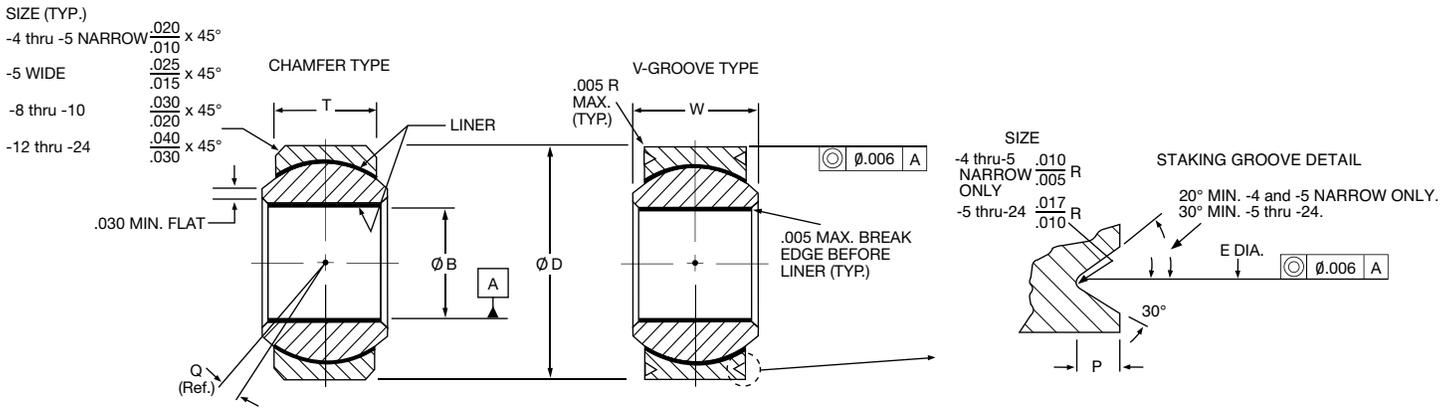
P/N Series MS14101 & MS14104		
Bore Size	Max. Radial Play	Max. Axial Play
3K Thru 12K	0.0007 Inch	0.0028 Inch
14K Thru 16K	0.0010 Inch	0.0040 Inch

P/N Series MS14102 & MS14103		
Bore Size	Max. Radial Play	Max. Axial Play
3K Thru 12K	0.0007 Inch	0.0021 Inch
14K Thru 16K	0.0010 Inch	0.0030 Inch

# SPHERICAL BEARINGS – Self-Lubricating

## AS81820 Lined Bore Series – Narrow



Part Number	MS Dash No.	(B) Bore Diameter	(D) Outside Diameter	(W) Ball Width	(T) Race Width	Ball Diameter	(E) Pitch Diameter	(P) Groove Depth	(Q) Mis-alignment	Limit Static Radial Load	Limit Static Axial Load	Dynamic Osc. Radial Load	Weight
V-Grooved*		Inch	Inch	Inch	Inch	Inch	Inch	Inch	Degree	lbs.	lbs.	lbs.	lbs.
M81820/1		+ .0000	+ .0000	+ .000	± .005	Ref.	+ .000	+ .000	Ref.				Ref.
M81820/4		- .0010	- .0005	- .002			- .008	- .010					
ADBL4V(L)	-4	.2510	.6562	.343	.250	.500	.594	.025	10°	5550	430	2650	.020
ADBL5V(L)	-5	.3135	.7500	.375	.281	.562	.660	.035	10°	7700	700	3700	.030
ADBL6V(L)	-6	.3760	.8125	.406	.312	.656	.712	.035	9°	10200	1100	4900	.040
ADBL7V(L)	-7	.4385	.9062	.437	.343	.718	.806	.035	8°	12950	1400	6700	.050
ADBL8V(L)	-8	.5010	1.0000	.500	.390	.813	.876	.055	8°	17250	2100	8250	.070
ADBL9V(L)	-9	.5635	1.0937	.562	.437	.875	.970	.055	8°	22150	3680	10600	.090
ADBL10V(L)	-10	.6260	1.1875	.625	.500	.968	1.063	.055	8°	27700	4720	13250	.120
ADBL12V(L)	-12	.7510	1.4375	.750	.593	1.187	1.313	.055	8°	40600	6750	19400	.210
ADBL14V(L)	-14	.8760	1.5625	.875	.703	1.312	1.438	.055	8°	55950	9350	26750	.270
ADBL16V(L)	-16	1.0010	1.7500	1.000	.797	1.500	1.626	.055	9°	73800	12160	35250	.390
ADBL18V(L)	-	1.1260	2.1250	1.125	.900	1.750	2.001	.055	8°	94080	13500	37870	.720
ADBL20V(L)	-	1.2510	2.3125	1.250	1.000	1.937	2.188	.055	8°	116250	16930	46920	.930
ADBL22V(L)	-	1.3760	2.5625	1.375	1.100	2.156	2.438	.055	8°	140770	20750	56950	1.280
ADBL24V(L)	-	1.5010	2.8125	1.500	1.200	2.344	2.688	.055	8°	167630	24950	67950	1.670

\*For chamfered version, delete 'V' from part number.

### Notes:

- All dimensions, materials and configurations of sizes 4 through 16 conform to requirements of Aerospace Standards. Consult QPL for NHBB approvals to P/N series AS81820/1 through AS81820/4.
- Bearing sizes 18 thru 24 are not included in current Aerospace Standards but are offered as NHBB catalog items only.
- Temperature: Operating temperature range per AS81820 is -65° to 325°F. Broader temperature capabilities are achievable.

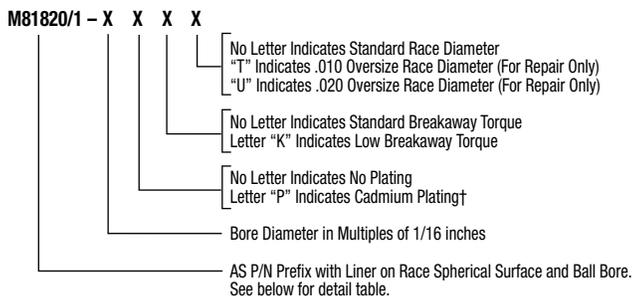
### Materials

Part No.	Ball	Race	Liner
Catalog No.	CRES PH13-8Mo AMS 5629 Cond. H-1000 (Rc43 min.)	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. & Ball Bore No Lub. Required

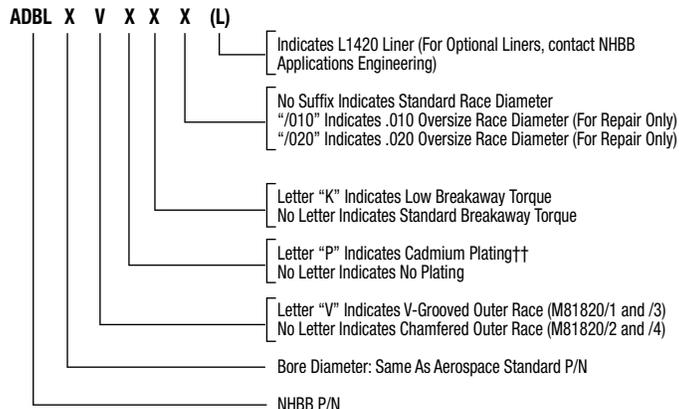


# AS81820 Lined Bore Series – Wide

## Aerospace Standard P/N



## NHBB P/N



† Cadmium plate M81820/1 & M81820/3 O.D. and on the flats between the outside diameter and the grooves per AMS-QQ-P-416, Type II, Class 2. Dimensions apply after plating.  
 †† Cadmium plate M81820/2 & M81820/4 O.D. and O.D. chamfers per AMS-QQ-P-416, Type II, Class 2. Dimensions apply after plating.

Aerospace Standard P/N	NHBB P/N	Description
M81820/1	ADBL V	Narrow Grooved
M81820/2	ADWL	Wide Chamfered
M81820/3	ADWL V	Wide Grooved
M81820/4	ADBL	Narrow Chamfered

Part Number	MS Dash No.	(B) Bore Diameter	(D) Outside Diameter	(W) Ball Width	(T) Race Width	Ball Diameter	(E) Pitch Diameter	(P) Groove Depth	(Q°) Mis-alignment	Limit Static Radial Load	Limit Static Axial Load	Dynamic Osc. Radial Load	Weight
<b>M81820/2</b>		Inch +.0000	Inch +.0000	Inch +.000	Inch	Inch Ref.	Inch +.000	Inch +.000	Degree Ref.	lbs. 9250	lbs. 1640	lbs. 4450	lbs. .035
<b>M81820/3</b>		-.0010	-.0005	-.002	±.005		-.008	-.010					
ADWL5V(L)	-5	.3135	.6875	.437	.317	.593	.625	.025	14°	9250	1640	4450	.035
ADWL6V(L)	-6	.3760	.8125	.500	.406	.687	.712	.035	8°	13000	2630	6200	.060
ADWL7V(L)	-7	.4385	.9375	.562	.442	.781	.837	.035	10°	17300	3650	8250	.080
ADWL7V52(L)	-7A	.4385	.9062	.562	.442	.781	.806	.035	10°	17250	3650	8250	.080
ADWL8V(L)	-8	.5010	1.0000	.625	.505	.875	.900	.035	9°	21400	4970	10600	.100
ADWL9V(L)	-9	.5635	1.1250	.687	.536	1.000	1.025	.035	10°	26600	5370	13200	.135
ADWL10V(L)	-10	.6260	1.1875	.750	.567	1.062	1.087	.035	12°	29000	6130	16150	.160
ADWL12V(L)	-12	.7510	1.3750	.875	.630	1.250	1.251	.055	13°	37000	7730	24800	.240
ADWL14V(L)	-14	.8760	1.6250	.875	.755	1.375	1.501	.055	6°	56000	10800	26750	.350
ADWL16V(L)	-16	1.0010	2.1250	1.375	1.005	1.875	2.001	.055	12°	103300	19300	49300	.970
ADWL18V(L)	-	1.1260	2.2500	1.437	1.067	1.968	2.126	.055	14°	120410	19640	48760	1.000
ADWL20V(L)	-	1.2510	2.3750	1.500	1.130	2.093	2.251	.055	13°	139690	21970	56620	1.120
ADWL20-5V(L)	-	1.2510	2.0000	1.093	.942	1.781	1.876	.055	6°	101540	14890	40840	.564
ADWL22V(L)	-	1.3760	2.5625	1.687	1.223	2.281	2.438	.055	15°	172940	25970	70250	1.390
ADWL24V(L)	-	1.5010	2.6875	1.687	1.223	2.390	2.563	.055	14°	188670	25970	76640	1.480

\*For chamfered version, delete "V" from part number.

## No Load Breakaway Torque

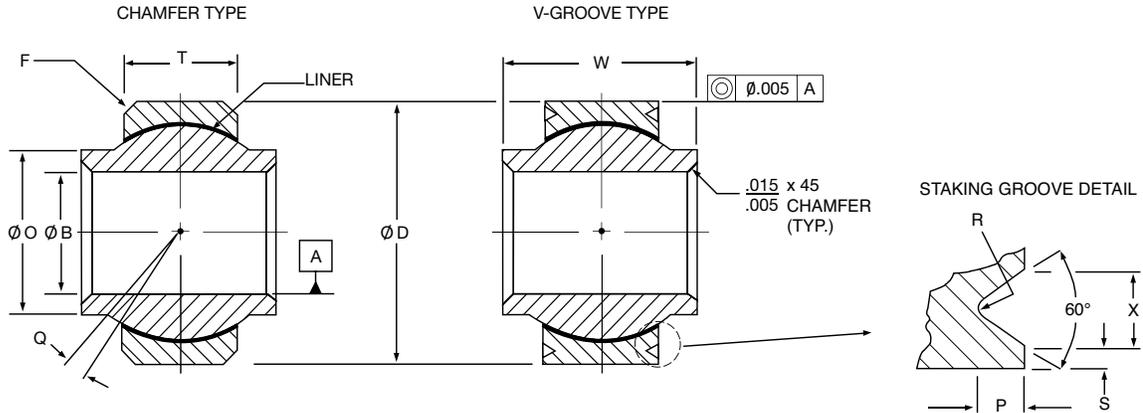
Bore Sizes	Standard (in - lbs.)	"K" Type
4 (Narrow only)	1.0 to 5.0	0 to 0.5
5 to 12	1.0 to 15.0	0 to 1.0
14 to 24	1.0 to 25.0	0 to 2.0

## Radial and Axial Play

P/N Series M81820/1 & M81820/4		
Bore Size	Max. Radial Play	Max. Axial Play
3K Thru 12K	0.0007 Inch	0.0028 Inch
14K Thru 16K	0.0010 Inch	0.0040 Inch
P/N Series M81820/2 & M81820/3		
Bore Size	Max. Radial Play	Max. Axial Play
3K Thru 12K	0.0007 Inch	0.0021 Inch
14K Thru 16K	0.0010 Inch	0.0030 Inch

# SPHERICAL BEARINGS – Self-Lubricating

## High Misalignment



Part Number V-Grooved*	(B)	(D)	(W)	(T)	(O)	Ball Diameter	(F)	(Q)	(P)	(R)	(S)	(X)	No Load Rotational Breakaway Torque	Limit Static Radial Load	Dynamic Osc. Radial Load	Weight	
	Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter		Race Chamfered x 45°	Mis-alignment		Staking Groove Data							
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.	Inch	Inch	Inch	Inch	Inch - lbs.	lbs.	lbs.	lbs.	
	+0.000 -0.005	+0.000 -0.005	+0.00 -0.005	+0.010 -0.000	Ref.	Ref.	+0.000 -0.010		+0.000 -0.015	+0.000 -0.010	+0.000 -0.010	+0.000 -0.010					Ref.
ADBY3V(L)	.1900	.5625	.500	.205	.319	.437	.020	15°	.030	.015	.020	.045	0.25-5.0	6440	3780	.018	
ADBY4V(L)	.2500	.7400	.593	.250	.390	.593	.020	24°	.030	.015	.020	.045	0.25-5.0	10790	5390	.036	
ADBY5V(L)	.3125	.6875	.625	.250	.418	.593	.020	20°	.030	.015	.020	.045	1.0-15.0	10790	5390	.029	
ADBY6V(L)	.3750	.9060	.813	.340	.512	.781	.030	23°	.030	.015	.020	.045	1.0-15.0	19170	9580	.068	
ADBY7V(L)	.4375	1.0000	.875	.340	.618	.875	.030	22°	.030	.015	.020	.045	1.0-15.0	21720	10860	.095	
ADBY8V(L)	.5000	1.1250	.937	.396	.730	1.000	.030	20°	.030	.015	.020	.045	1.0-15.0	28810	14400	.159	
ADBY10V(L)	.6250	1.3750	1.200	.562	.856	1.250	.030	20°	.040	.020	.030	.055	1.0-15.0	50260	25130	.245	
ADBY12V(L)	.7500	1.5625	1.280	.615	.970	1.375	.040	18°	.060	.020	.030	.080	1.0-15.0	60500	30250	.315	
ADBY14V(L)	.8750	1.7500	1.400	.620	1.140	1.531	.040	18°	.060	.020	.030	.080	1.0-24.0	68640	34320	.430	
ADBY16V(L)	1.0000	2.1250	1.875	.830	1.278	1.875	.040	21°	.060	.020	.030	.080	1.0-24.0	111280	55640	.831	
ADBY18V(L)	1.1250**	2.3125**	1.875	.937	1.400	2.062	.040	20°	.060	.020	.030	.080	1.0-24.0	138100	68970	1.096	
ADBY20V(L)	1.2500**	2.5000**	1.875	1.000	1.523	2.250	.040	21°	.060	.020	.030	.080	1.0-24.0	160660	80330	1.318	
ADBY22V(L)	1.3750**	2.7500**	2.125	1.093	1.670	2.500	.040	22°	.060	.020	.030	.080	1.0-24.0	195310	97550	1.800	
ADBY24V(L)	1.5000**	3.0000**	2.250	1.170	1.800	2.672	.040	21°	.060	.020	.030	.080	1.0-24.0	223470	111740	2.223	

\* For chamfered version, delete 'V' from part number.  
 \*\* Bore and O.D. tolerances: +.0000, -.0008.

### Notes:

- Temperature: Operating temperature range -65° to 325°F. Broader temperature capabilities are achievable.
- Options: Bearings with PH13-8Mo balls will be designated by "13-8" suffix (Example: ADBY16-13-8(L)). For outside race diameter with plate per AMS-QQ-P-416, Type II, Class 2, add suffix "P" (Example: ADBY16VP(L)).
- Qualification: Liner approved to AS81820.

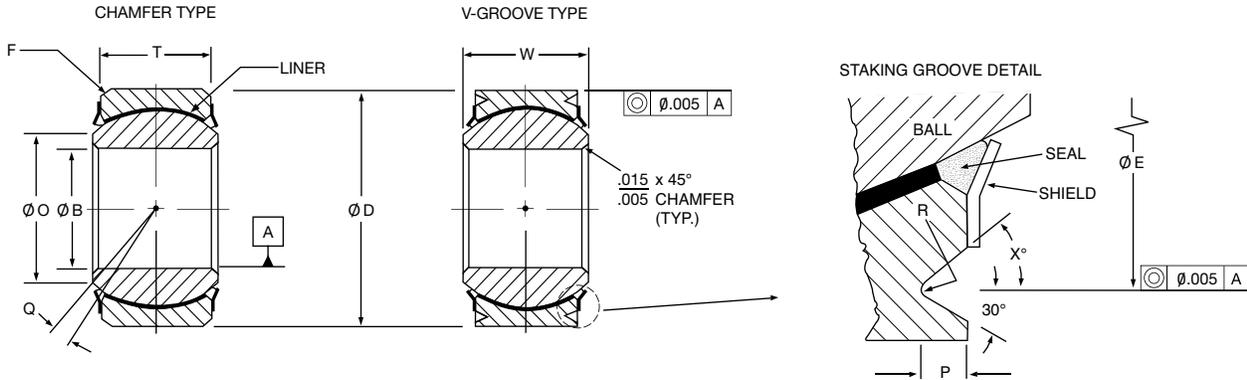
### Materials

Part No.	Ball	Race	Liner
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required
Catalog No. + 13-8	CRES PH13-8Mo AMS 5629 Rc43-47	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required



# SPHERICAL BEARINGS – Self-Lubricating

## Sealed Narrow



Part Number V-Grooved*	(B)	(D)	(W)	(T)	(Ø)	(F)	(Q)	(E)	(P)	(R)	(X)	No Load Rotational Breakaway Torque	Limit Static Radial Load	Limit Static Axial Load	Dynamic Osc. Radial Load	Weight	
	Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter	Ball Diameter	Race Chamfered x45°	Mis- alignment	Pitch Diam.	Staking Groove Data							Inch - lbs.
	Inch +.0000 -.0005	Inch +.0000 -.0005	Inch +.000 -.002	Inch ±.005	Inch Min.	Inch Ref.	Inch +.000 -.010	Min.	Inch +.000 -.010	Inch +.000 -.015	Inch						
ADB3VN(L)	.1900	.5625	.281	.218	.293	.406	.020	5°	.502	.030	.005-.010	20° min.	0.25-8.0	3975	150	1500	.020
ADB4VN(L)	.2500	.6562	.343	.250	.364	.500	.020	5°	.596	.030	.005-.010	20° min.	0.25-8.0	6040	430	3320	.020
ADB5VN(L)	.3125	.7500	.375	.281	.419	.562	.020	5°	.652	.040	.005-.010	30°	1.0-20.0	8750	700	5460	.030
ADB5VAN(L)	.3125	.7500	.375	.281	.419	.562	—	5°	.662	.040	.005-.010	20°	1.0-20.0	8750	700	5460	.030
ADB6VN(L)	.3750	.8125	.406	.312	.475	.656	.030	4.5°	.714	.040	.010-.020	30°	1.0-20.0	10540	1100	6600	.040
ADB7VN(L)	.4375	.9062	.437	.343	.530	.718	.030	4°	.808	.040	.010-.020	30°	1.0-20.0	13200	1400	8050	.050
ADB8VN(L)	.5000	1.0000	.500	.390	.600	.813	.030	4°	.878	.060	.010-.020	30°	1.0-20.0	17900	2100	10400	.070
ADB9VN(L)	.5625	1.0937	.562	.437	.670	.875	.030	4°	.972	.060	.010-.020	30°	1.0-20.0	23200	3680	13000	.090
ADB10VN(L)	.6250	1.1875	.625	.500	.739	.968	.030	4°	1.065	.060	.010-.020	30°	1.0-20.0	30500	4720	16450	.120
ADB12VN(L)	.7500	1.4375	.750	.593	.920	1.187	.040	4°	1.315	.060	.010-.020	30°	1.0-20.0	46400	6750	23600	.210
ADB14VN(L)	.8750	1.5625	.875	.703	.980	1.312	.040	4°	1.440	.060	.010-.020	30°	1.0-30.0	62200	9350	30250	.270
ADB16VN(L)	1.0000	1.7500	1.000	.797	1.118	1.500	.040	4.5°	1.628	.060	.010-.020	30°	1.0-30.0	82200	12160	38000	.390
ADB18VN(L)	1.1250	2.1250	1.125	.900	1.334	1.750	.040	4°	2.003	.060	.010-.020	30°	1.0-30.0	105880	13500	42350	.720
ADB20VN(L)	1.2500	2.3125	1.250	1.000	1.473	1.937	.040	4°	2.190	.060	.010-.020	30°	1.0-30.0	131230	16930	52490	.930
ADB22VN(L)	1.3750	2.5625	1.375	1.100	1.654	2.156	.040	4°	2.440	.060	.010-.020	30°	1.0-30.0	161700	20750	64680	1.280
ADB24VN(L)	1.5000	2.8125	1.500	1.200	1.794	2.344	.040	4°	2.690	.060	.010-.020	30°	1.0-30.0	192780	24950	77110	1.670

\*For chamfered version, delete 'V' from part number.

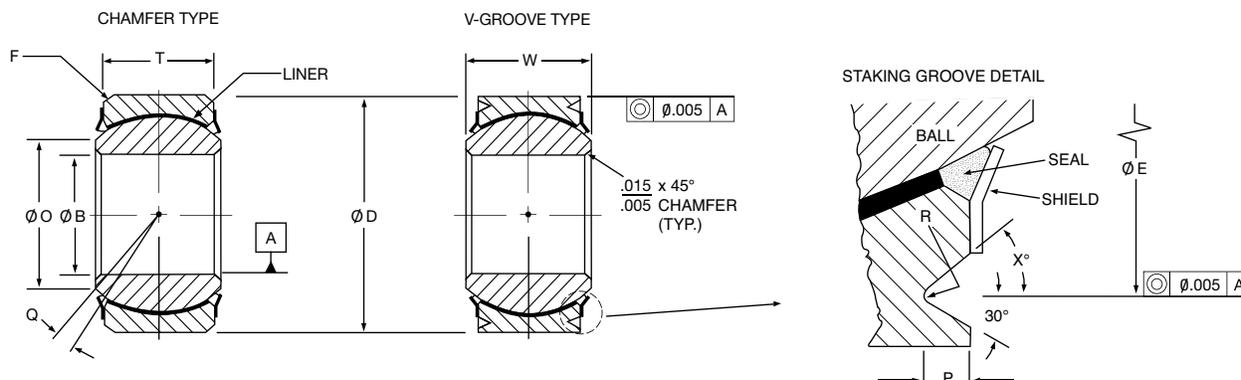
### Notes:

- For more information on sealed bearings, see page 70.
- Temperature: Operating temperature range -65° to 325°F. Broader temperature capabilities are achievable.
- Options: Bearings with PH13-8Mo balls will be designated by "13-8" suffix (Example: ADB16VN13-8(L)). For outside race diameter with cadmium plate per AMS-QQ-P-416, Type II, Class 2, add suffix "P" (Example: ADW16VNP(L)).
- Qualification: Liner approved to AS81820.

### Materials

Part No.	Ball	Race	Liner
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required
Catalog No. + 13-8	CRES PH13-8Mo AMS 5629 Rc43-47	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required

# Sealed Wide



Part Number V-Grooved*	(B)	(D)	(W)	(T)	(O)	Ball Diameter	(F)	(Q)	(E)	(P)	(R)	(X)	No Load Rotational Breakaway Torque	Limit Static Radial Load	Limit Static Axial Load	Dynamic Osc. Radial Load	Weight
	Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter		Race Chamfered x 45°	Mis-alignment	Pitch Diam.	Staking Groove Data							
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Min.	Inch	Inch	Inch		Inch - lbs.	lbs.	lbs.	lbs.	lbs.
	+0.000	+0.000	+0.000	±.005	Min.	Ref.	+0.000		+0.000	+0.000							
	-0.005	-0.005	-0.002				-0.010		-0.010	-0.015							
ADW3VN(L)	.1900	.6250	.437	.327	.300	.531	.025	7.5°	.565	.030	.005-.015	20° min.	0.25-8.0	2500	1770	4900	.031
ADW4VN(L)	.2500	.6250	.437	.327	.300	.531	.025	7.5°	.565	.030	.005-.015	20° min.	0.25-8.0	5500	1770	4900	.031
ADW5VN(L)	.3125	.6875	.437	.317	.360	.593	.025	7°	.627	.030	.005-.015	30°	1.0-20.0	9400	1640	6050	.035
ADW6VN(L)	.3750	.8125	.500	.406	.466	.687	.030	4°	.714	.040	.010-.020	30°	1.0-20.0	13700	2630	8310	.060
ADW7VN(L)	.4375	.9375	.562	.442	.537	.781	.030	5°	.839	.040	.010-.020	30°	1.0-20.0	20700	3650	11750	.080
ADW7V52N(L)	.4375	.9062	.562	.442	.537	.781	—	5°	.808	.040	.010-.020	30°	1.0-20.0	19700	3650	11750	.080
ADW8VN(L)	.5000	1.0000	.625	.505	.607	.875	.030	4.5°	.902	.040	.010-.020	30°	1.0-20.0	21400	4970	14950	.100
ADW9VN(L)	.5625	1.1250	.687	.536	.721	1.000	.030	5°	1.027	.040	.010-.020	30°	1.0-20.0	26600	5370	18100	.135
ADW10VN(L)	.6250	1.1875	.750	.567	.747	1.062	.030	6°	1.089	.040	.010-.020	30°	1.0-20.0	29000	6130	20250	.160
ADW12VN(L)	.7500	1.3750	.875	.630	.845	1.250	.040	7.5°	1.253	.060	.010-.020	30°	1.0-20.0	37000	7730	26200	.240
ADW14VN(L)	.8750	1.6250	.875	.755	.995	1.375	.040	3°	1.503	.060	.010-.020	30°	1.0-30.0	65200	10800	33600	.350
ADW16VN(L)	1.0000	2.1250	1.375	1.005	1.269	1.875	.040	6°	2.003	.060	.010-.020	30°	1.0-30.0	104000	19300	56250	.970
ADW18VN(L)	1.1250	2.2500	1.437	1.067	1.338	1.968	.040	7°	2.128	.060	.010-.020	30°	1.0-30.0	142570	19640	57000	1.000
ADW20VN(L)	1.2500	2.3750	1.500	1.130	1.460	2.093	.040	6.5°	2.253	.060	.010-.020	30°	1.0-30.0	159200	21970	63680	1.120
ADW20-5VN(L)	1.2500	2.0000	1.093	.942	1.406	1.781	.040	3°	1.878	.060	.010-.020	30°	1.0-30.0	112360	14890	44940	.564
ADW22VN(L)	1.3750	2.5625	1.687	1.223	1.535	2.281	.040	7.5°	2.440	.060	.010-.020	30°	1.0-30.0	190000	25970	76000	1.390
ADW24VN(L)	1.5000	2.6875	1.687	1.223	1.693	2.390	.040	7°	2.567	.060	.010-.020	30°	1.0-30.0	199000	25970	79640	1.480

\*For chamfered version, delete 'V' from part number.

## Notes:

- For more information on sealed bearings, see page 70.
- Temperature: Operating temperature range -65° to 325°F. Broader temperature capabilities are achievable.
- Options: Bearings with PH13-8Mo balls will be designated by "13-8" suffix (Example: ADB16VN13-8(L)). For outside race diameter with cadmium plate per AMS-QQ-P-416, Type II, Class 2, add suffix "P" (Example: ADW16VNP(L)).
- Qualification: Liner approved to AS81820.

## Materials

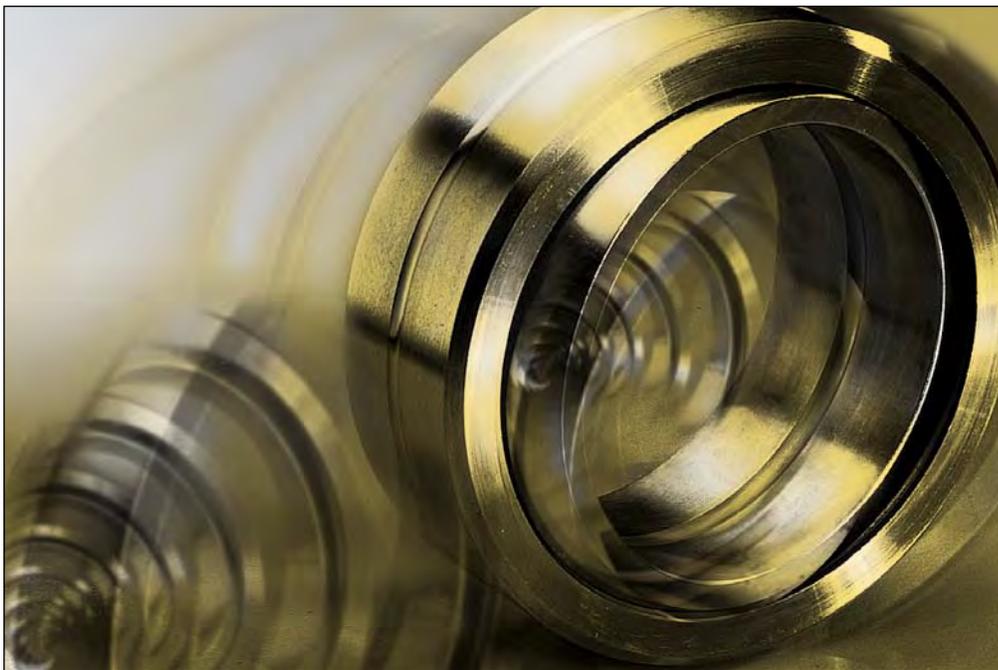
Part No.	Ball	Race	Liner
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required
Catalog No. + 13-8	CRES PH13-8Mo AMS 5629 Rc43-47	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required



## SECTION 2

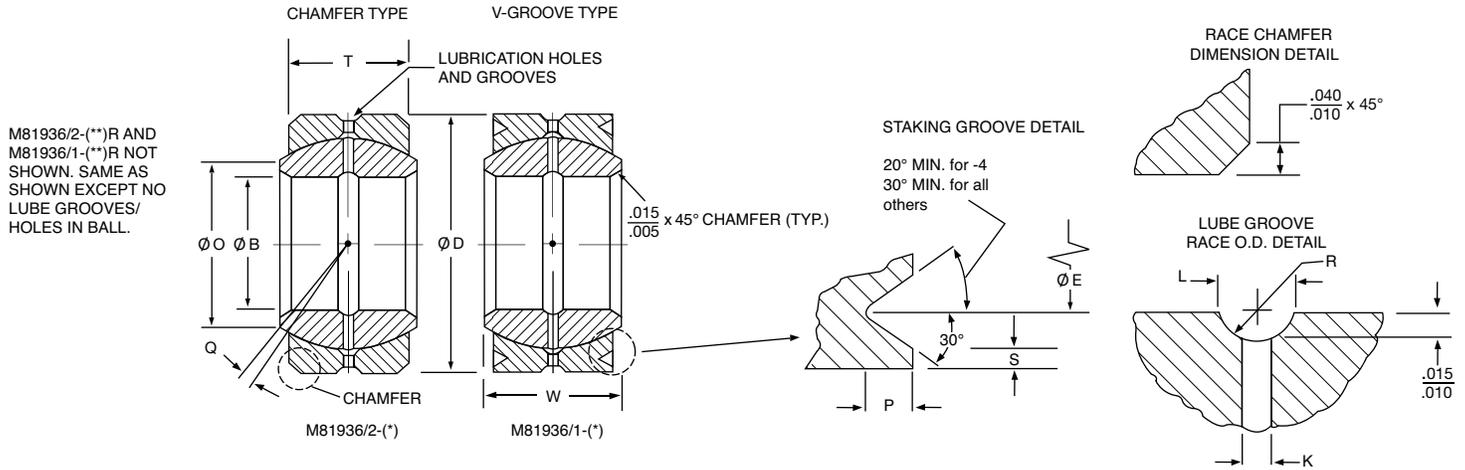
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# SPHERICAL BEARINGS – Metal-to-Metal

## AS81936 Beryllium Copper Ball



M81936/2-(\*\*)R AND M81936/1-(\*\*)R NOT SHOWN. SAME AS SHOWN EXCEPT NO LUBE GROOVES/HOLES IN BALL.

Part Number V-Grooved*	Part Number V-Grooved*	(B) Bore Diameter	(D) Outside Diameter	(W) Ball Width	(T) Race Width	(O) Shoulder Diameter	(Ø) Ball Diameter	(K) Lube Hole Diameter	(L) Groove Width ID & OD of Race & ID of Ball	(R) Groove Radius ID & OD of Race & ID of Ball
		Inch +.0000 -.0005	Inch +.0000 -.0005	Inch +.000 -.002	Inch +.000 -.005	Inch Min.	Inch Ref.	Inch	Inch	Inch
<b>M81936/1-(**)R</b>	<b>M81936/1-(**)R</b>									
AGB4V	AGB4VA	.2500	.6562	.343	.250	.357	.501	.032-.062	.042-.078	.030-.062
AGB5V	AGB5VA	.3125	.7500	.375	.281	.413	.563	.042-.062	.042-.078	.030-.062
AGB6V	AGB6VA	.3750	.8125	.406	.312	.509	.657	.042-.062	.042-.078	.030-.062
AGB7V	AGB7VA	.4375	.9062	.437	.343	.563	.719	.052-.062	.065-.094	.060-.094
AGB8V	AGB8VA	.5000	1.0000	.500	.390	.634	.814	.052-.062	.065-.094	.060-.094
AGB9V	AGB9VA	.5625	1.0937	.562	.437	.664	.876	.052-.062	.065-.094	.060-.094
AGB10V	AGB10VA	.6250	1.1875	.625	.500	.732	.969	.062-.078	.073-.109	.070-.125
AGB12V	AGB12VA	.7500	1.4375	.750	.593	.913	1.188	.062-.078	.073-.109	.070-.125
AGB13V	AGB13VA	.8125	1.5625	.812	.650	.984	1.282	.062-.078	.073-.109	.070-.125
AGB14V	AGB14VA	.8750	1.6562	.875	.703	1.054	1.376	.062-.078	.073-.109	.070-.125
AGB16V	AGB16VA	1.0000	1.8750	1.000	.797	1.193	1.563	.078-.093	.082-.109	.090-.125
AGB18V	AGB18VA	1.1250	2.1250	1.125	.900	1.334	1.751	.078-.093	.082-.109	.090-.125
AGB20V	AGB20VA	1.2500	2.3125	1.250	1.000	1.473	1.938	.078-.093	.082-.109	.090-.125
AGB22V	AGB22VA	1.3750	2.5625	1.375	1.100	1.654	2.157	.078-.093	.082-.109	.090-.125
AGB24V	AGB24VA	1.5000	2.8125	1.500	1.200	1.794	2.345	.078-.093	.082-.109	.090-.125

\* For chamfered version, delete 'V' from part number (M81936/2 -(\*)).

\*\* Add bore codes in multiples of 1/16.

### Notes:

- Radial Clearance: Free turning to 0.001.
- Axial Clearance: Free turning to 0.005.
- Concentricity: Outside diameter (D) and pitch diameter (E) to bore diameter (B) within .005 FIM.
- Bearings prepacked with MIL-PRF-81322.
- Temperature: Operating temperature range -65° to 350°F.
- Groove dimensions on ID of race and grease holes through race are before bearing assembly, but swaging shall not restrict grease flow.

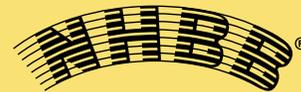
### Materials

Ball	Race
BeCu, ASTM B196†	CRES 17-4PH, AMS 5643
Condition TH04††	Cond. H-1150
Rc37 min.	(Rc28-36)

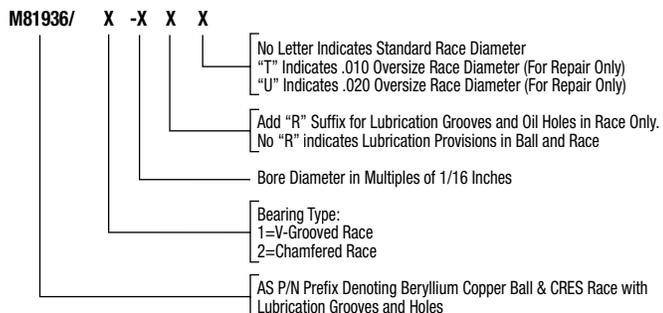
†Formerly QQ-C-530 ††Formerly HT

### Lubrication

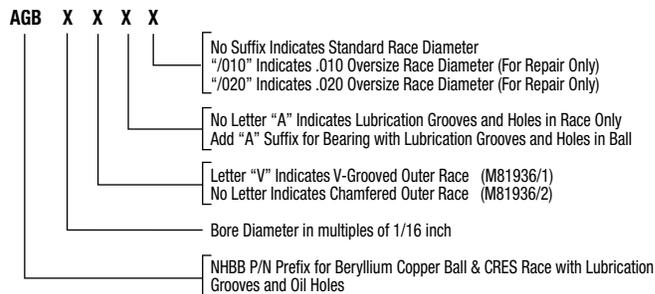
AGB & AGB-V	Lubrication grooves in race and 3 equally spaced holes through race only.
AGB-A & AGB-VA	Lubrication grooves in race and bore of ball and 3 equally spaced holes through race and ball.



### Aerospace Standard P/N



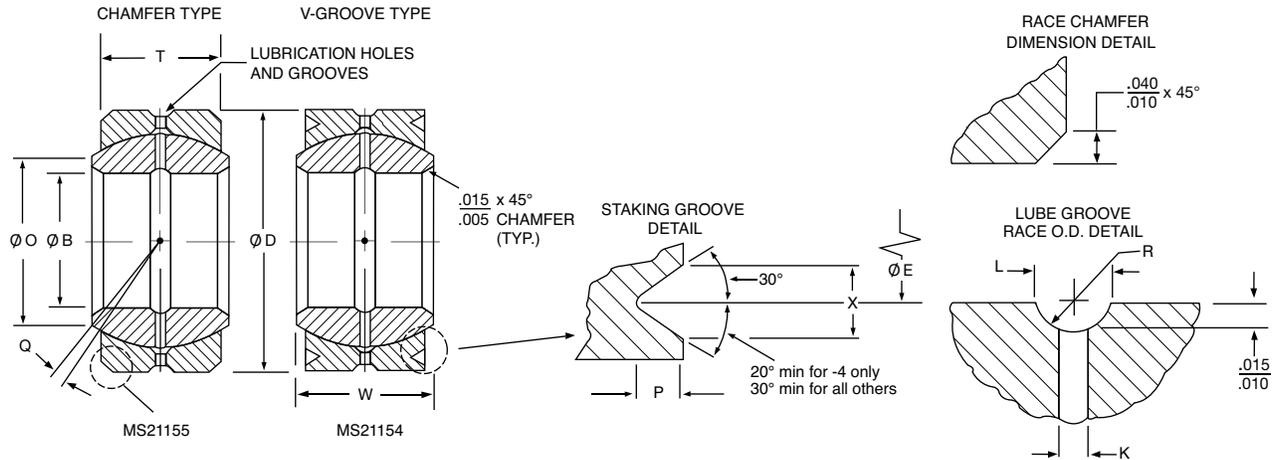
### NHBB P/N



	(E)	(S)	(P)	Limit Static Radial Load	Limit Static Axial Load	Weight
	Pitch Diameter	Staking Groove Data				
	Inch	Inch	Inch	lbs.	lbs.	lbs.
	+.000	+.000	+.000			Ref.
	-.010	-.010	-.015			
	.596	.020	.030	6330	1930	.02
	.652	.030	.040	8460	2450	.03
	.714	.030	.040	11400	3090	.04
	.808	.030	.040	14800	3740	.05
	.878	.030	.060	20400	4860	.07
	.972	.030	.060	26700	6100	.09
	1.065	.030	.060	33100	8080	.11
	1.315	.030	.060	50000	11440	.21
	1.440	.030	.060	59000	13800	.24
	1.534	.030	.060	70300	16160	.27
	1.753	.030	.060	77700	20850	.39
	2.003	.030	.060	121500	26740	.72
	2.190	.030	.060	152000	33065	.93
	2.440	.030	.060	186000	40120	1.28
	2.690	.030	.060	224000	47820	1.67

# SPHERICAL BEARINGS – Metal-to-Metal

## AS8976 – Narrow



Part Number V-Grooved* Steel Race	Part Number V-Grooved* Bronze Race	(B)	(D)	(W)	(T)	(O)	Ball Diameter		(K)	(L)	(Q)	
		Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter	Bronze Race	Steel Race	Lube Hole Diameter	Groove Width ID & OD of Race & ID of Ball	Misalignment	
		Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Min.
		+ .0000	+ .0000	+ .000	+ .005	Min.	Max.	Max.	+ .010	+ .005		
<b>MS21154S(**)</b>	<b>MS21154B(**)</b>	- .0005	- .0005	- .002	- .005				- .010	- .005		
ABG3VA(L)	ABG3VA-501(L)	.1900	.5625	.281	.218	.293	.438	.407	.047	.062	10°	
ABG4VA(L)	ABG4VA-501(L)	.2500	.6562	.343	.250	.364	.501	.501	.047	.062	10°	
ABG5VA(L)	ABG5VA-501(L)	.3125	.7500	.375	.281	.419	.594	.563	.062	.078	10°	
ABG6VA(L)	ABG6VA-501(L)	.3750	.8125	.406	.312	.475	.657	.657	.062	.078	9°	
ABG7VA(L)	ABG7VA-501(L)	.4375	.9062	.437	.343	.530	.719	.719	.062	.078	8°	
ABG8VA(L)	ABG8VA-501(L)	.5000	1.0000	.500	.390	.600	.814	.814	.062	.078	8°	
ABG9VA(L)	ABG9VA-501(L)	.5625	1.0937	.562	.437	.670	.907	.907	.062	.078	8°	
ABG10VA(L)	ABG10VA-501(L)	.6250	1.1875	.625	.500	.739	1.001	.907	.078	.093	8°	
ABG12VA(L)	ABG12VA-501(L)	.7500	1.4375	.755	.593	.920	1.251	1.188	.078	.093	8°	
ABG14VA(L)	ABG14VA-501(L)	.8750	1.5625	.875	.703	.980	1.376	1.313	.078	.093	8°	
ABG16VA(L)	ABG16VA-501(L)	1.0000	1.7500	1.000	.797	1.118	1.563	1.501	.078	.093	9°	

\* For chamfered version MS21155, delete 'V' from part number.

\*\* Add bore codes in multiples of 1/16.

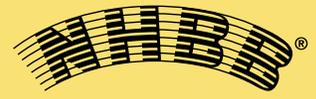
### Notes:

- Radial Clearance: 0.0005 to 0.0020.
- Axial Clearance: 0.010 Maximum.
- Dimensions: All dimensions apply after plating.
- Concentricity: Outside diameter (D) to bore diameter (B) within .005 FIM.
- Temperature: Operating temperature range -65° to 250°F.
- Lubrication: MIL-PRF-21164.
- Groove dimensions on ID of race and grease holes through race are before bearing assembly, but swaging shall not restrict grease flow.

### Materials

Part No.	Ball	Race
ABG-A	ABG-VA	4340 STL/AMS6415 4130 STL, or 8630 STL Rc56 Min. Chrome Plated†
ABG-A-501	ABG-VA-501	Aluminum Bronze (AMS 4635 and ASTM B 50/B150M), Cadmium Plated

† Plating: When specified in materials block, ball spherical diameter and ends are hard chrome plated per AMS-QQ-C-320, CL. 2 (.0002 to .0005 inch thickness). All external surfaces of race are cadmium plated per AMS-QQ-P-416.



### Aerospace Standard P/N

**MS21154 S 03**

- └─ Bore Diameter in Multiples of 1/16 Inch (2 Digits)
- └─ Letter "S" Indicates Alloy Steel (4340, 4130 or 8630) Race Material
- └─ Letter "B" Indicates Aluminum Bronze (AMS 4635) Race Material
- └─ AS P/N Prefix Denoting Narrow, Metal on Metal Spherical Bearing with Lube Grooves and Lube Holes in Race and Ball (MS21154=V-Grooved, MS21155=Chamfered)

### NHBB P/N

**ABG 3 V A X X (L)**

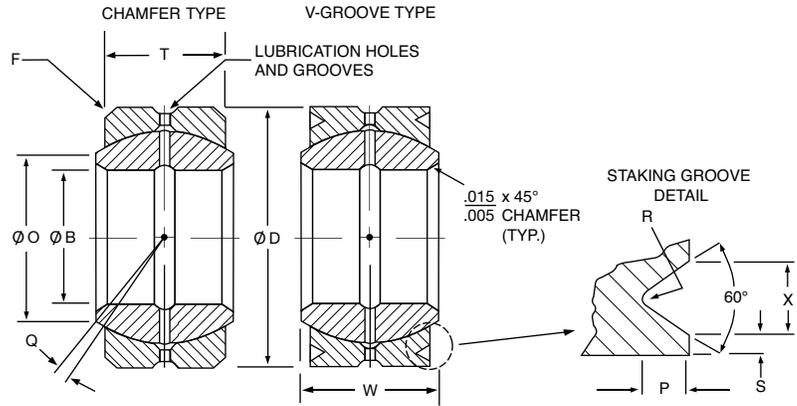
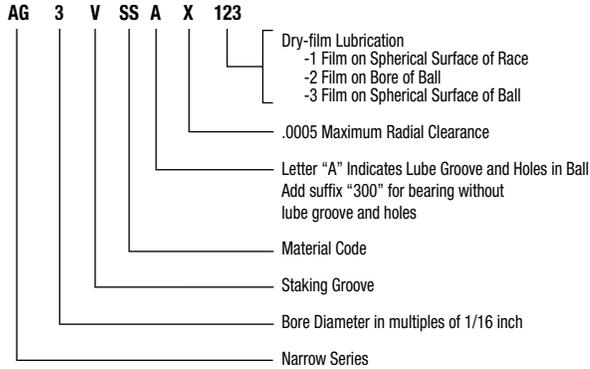
- └─ NHBB Manufacturing Code
- └─ Letters "CR" Indicate Optional 440C Ball Material
- └─ "-501" Indicates Aluminum Bronze (AMS 4635) Race Material
- └─ Blank Indicates Alloy Steel (4340, 4130 or 8630) Race Material
- └─ Letter "A" Indicates Lube Groove and Lube Holes in Ball
- └─ Letter "V" Indicates V-Grooved Outer Race (MS21154)
- └─ No Letter "V" Indicates Chamfered Outer Race (MS21155)
- └─ Bore Diameter in multiples of 1/16 inch
- └─ NHBB P/N Prefix for Narrow, Metal-to-Metal Spherical Bearing

	(R) Groove Radius ID & OD of Race & ID of Ball	(E) Pitch Diameter	(P)		(X)				Weight
			Staking Groove Data		Limit Static Load				
					Bronze Race		Steel Race		
Inch Ref.	Inch +.000 -.010	Inch +.000 -.015	Inch +.000 -.010	Radial lbs.	Axial lbs.	Radial lbs.	Axial lbs.	lbs. Ref.	
	.045	.502	.030	.045	2800	850	4600	2100	.02
	.045	.596	.030	.045	4300	1100	7080	2800	.02
	.065	.662	.040	.055	5200	1400	8500	3550	.03
	.065	.714	.040	.055	6750	1760	11050	4400	.04
	.065	.808	.040	.055	8500	2150	13900	5400	.05
	.065	.878	.060	.080	11500	2800	18850	7050	.07
	.065	.972	.060	.080	15600	3550	25500	8900	.09
	.088	1.065	.060	.080	19500	4650	31950	11700	.11
	.088	1.315	.060	.080	28500	6575	46750	16500	.21
	.088	1.440	.060	.080	38300	9300	62750	23300	.27
	.088	1.628	.060	.080	51000	12000	83350	30000	.39

# SPHERICAL BEARINGS – Metal-to-Metal

## Narrow

### NHBB P/N



Part Number V-Grooved*	(B)	(D)	(W)	(T)	(O)	Ball Diameter	(F)	(Q)	(P)	(R)	(S)	(X)	Limit Static Radial Load		Weight
	Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter		Race Chamfered x 45°	Mis- alignment		Staking Groove Data			Bronze Race	Steel Race	
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.	Inch	Inch	Inch	Inch	lbs.	lbs.	lbs.
	+ .0000	+ .0000	+ .000	+ .005	Ref.	Ref.	+ .000		+ .000	+ .000	+ .000	+ .000			Ref.
	- .0005	- .0005	- .005	- .005			- .010		- .015	- .010	- .010	- .010			
AG3V	.1900	.5625	.281	.218	.293	.406	.020	11°	.030	.015	.020	.045	2350	4060**	.02
AG4V	.2500	.6562	.343	.250	.364	.500	.022	13°	.030	.015	.020	.045	3700	6660	.02
AG5V	.3125	.7500	.375	.281	.419	.562	.032	11.5°	.040	.020	.030	.055	4580	8240	.03
AG6V	.3750	.8125	.406	.312	.517	.656	.032	9.5°	.040	.020	.030	.055	6360	11450	.04
AG7V	.4375	.9062	.437	.343	.572	.718	.032	9°	.040	.020	.030	.055	8080	14540	.05
AG8V	.5000	1.0000	.500	.390	.642	.813	.032	9°	.060	.020	.030	.080	11060	19900	.07
AG9V	.5625	1.0937	.562	.437	.671	.875	.032	10°	.060	.020	.030	.080	13960	25120	.09
AG10V	.6250	1.1875	.625	.500	.739	.968	.032	9°	.060	.020	.030	.080	17760	31970	.11
AG12V	.7500	1.4375	.750	.593	.920	1.187	.040	9°	.060	.020	.030	.080	27300	49140	.21
AG14V	.8750	1.5625	.875	.703	.980	1.312	.040	9°	.060	.020	.030	.080	36080	64940	.27
AG16V	1.0000	1.7500	1.000	.797	1.118	1.500	.040	9.5°	.060	.020	.030	.080	48300	86940	.39
AG18V	1.1250	2.1250	1.125	.900	1.334	1.750	.040	8°	.060	.020	.030	.080	63000	113400	.72
AG20V	1.2500	2.3125	1.250	1.000	1.473	1.937	.040	8°	.060	.020	.030	.080	79420	142950	.93
AG22V	1.3750	2.5625	1.375	1.100	1.654	2.156	.040	8°	.060	.020	.030	.080	99180	178520	1.28
AG24V	1.5000	2.8125	1.500	1.200	1.794	2.344	.040	8°	.060	.020	.030	.080	119540	215180	1.67

\* For chamfered version, delete 'V' from part number.

\*\* Based on pin limitation.

### Notes:

- Radial Clearance: Free running to .002 max.
- Dimensions: All dimensions apply after plating.
- Groove dimensions on ID of race and grease holes through race are before bearing assembly, but swaging shall not restrict grease flow.

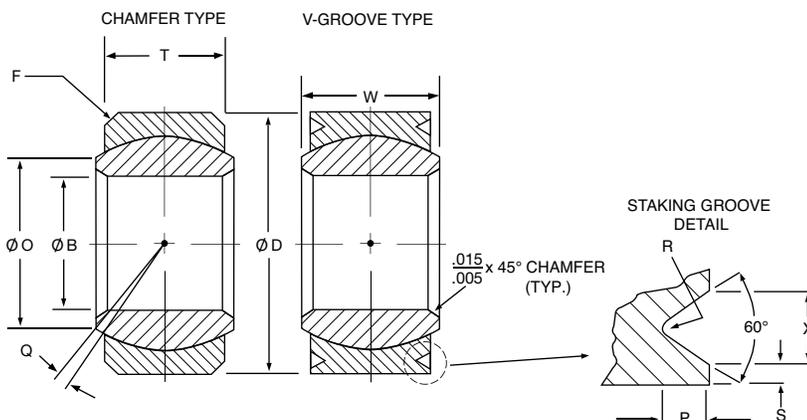
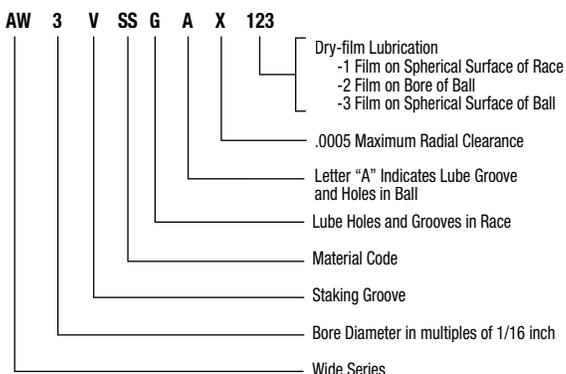
### Materials

Part No.	Ball	Race
Catalog No.	52100 Alloy Steel Chrome Plated†	Aluminum Bronze (AMS 4635 and ASTM B 50/B150M) Cadmium Plated†
Catalog No. + S	"	4130 Alloy Steel Cadmium Plated†
Catalog No. + SS	"	CRES 17-4PH
Catalog No. + CR	CRES 440C	"
Catalog No. + CRP	CRES 440C, Chrome Plated†	"

† Plating: When specified in materials block, ball spherical diameter and ends are hard chrome plated per AMS-QQ-C-320, CL. 2 (.0002 to .0005 inch thickness). All external surfaces of race are cadmium plated per AMS-QQ-P-416.

# Wide

## NHBB P/N

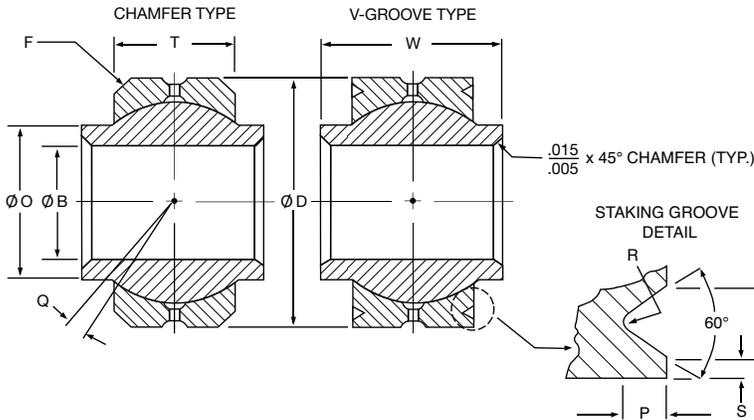


Part Number V-Grooved*	(B)	(D)	(W)	(T)	(O)	Ball Diameter	(F)	(Q)	(P)	(R)	(S)	(X)	Limit Static Radial Load(†)		Weight
	Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter		Race Chamfered x 45°	Mis- alignment	Staking Groove Data			Bronze Race	Steel Race		
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.	Inch	Inch	Inch	Inch	lbs.	lbs.	lbs.
	+ .0000 - .0005	+ .0000 - .0005	+ .000 - .005	+ .010 - .000	Ref.	Ref.	+ .000 - .015		+ .000 - .015	+ .000 - .010	+ .000 - .010	+ .000 - .010			Ref.
AW3-5V	.1900	.6250	.437	.322	.301	.531	.025	18°	.030	.015	.020	.045	4060**	4060**	.030
AW3V	.1900	.5000	.359	.281	.249	.437	.025	15°	.030	.015	.020	.045	4060**	4060**	.015
AW4V	.2500	.6250	.437	.322	.301	.531	.025	18°	.030	.015	.020	.045	7040**	7040**	.030
AW5V	.3125	.6875	.437	.312	.401	.593	.025	15.5°	.030	.015	.020	.045	8360	11010**	.033
AW6V	.3750	.8125	.500	.401	.471	.687	.025	11°	.040	.020	.030	.055	12740	15860**	.053
AW7V	.4375	.9375	.562	.437	.542	.781	.025	12°	.040	.020	.030	.055	15890	21600**	.079
AW8V	.5000	1.0000	.625	.500	.612	.875	.035	10.5°	.040	.020	.030	.055	20560	28220**	.097
AW9V	.5625	1.1250	.687	.531	.726	1.000	.035	11°	.040	.020	.030	.055	23550	35720**	.133
AW10V	.6250	1.1875	.750	.562	.752	1.062	.035	13°	.040	.020	.030	.055	26660	44110**	.140
AW12V	.7500	1.3750	.875	.625	.892	1.250	.035	14°	.060	.020	.030	.080	35310	63520	.232
AW14V	.8750	1.6250	.875	.750	1.061	1.375	.035	6.5°	.060	.020	.030	.080	47440	85390	.346
AW15-101V	.9375	1.3750	.450	.350	1.100	1.188	.025	5°	.060	.020	.030	.080	19010	34210	.090
AW16V	1.0000	2.1250	1.375	1.000	1.275	1.875	.035	15°	.060	.020	.030	.080	88120	112980**	.970
AW18V	1.1250	2.2500	1.437	1.067	1.338	1.968	.035	14°	.060	.020	.030	.080	98600	143010**	1.000
AW20V	1.2500	2.3750	1.500	1.125	1.460	2.093	.035	13°	.060	.020	.030	.080	111450	176570**	1.110
AW20-5V	1.2500	2.0000	1.093	.937	1.406	1.781	.035	6°	.060	.020	.030	.080	78100	140570	.564
AW22V	1.3750***	2.5625	1.687	1.218	1.535	2.281	.045	15°	.060	.020	.030	.080	129790	213670**	1.390
AW24V	1.5000***	2.6875	1.687	1.218	1.693	2.390	.045	14°	.060	.020	.030	.080	135990	244780	1.480
AW26V	1.6250***	2.8750	1.750	1.281	1.828	2.531	.045	13°	.060	.020	.030	.080	121580	273570	1.750
AW28V	1.7500***	3.0000***	1.812	1.312	1.964	2.672	.045	13°	.060	.020	.030	.080	131670	296270	1.910
AW30V	1.8750***	3.1250***	1.875	1.343	2.096	2.812	.045	13°	.060	.020	.030	.080	142060	319640	2.120
AW32V	2.0000***	3.2500***	1.937	1.375	2.208	2.937	.045	13°	.060	.020	.030	.080	152140	342310	2.220
AW36V	2.2500***	3.6250***	2.000	1.406	2.442	3.156	.045	12.5°	.060	.020	.030	.080	167390	376640	2.780
AW40V	2.5000***	3.9375***	2.062	1.437	2.750	3.437	.045	12°	.060	.020	.030	.080	186560	419760	3.280
AW44V	2.7500***	4.1250***	2.187	1.500	2.968	3.687	.045	12°	.060	.020	.030	.080	209420	471200	3.550
AW48V	3.0000***	4.3750***	2.312	1.562	3.187	3.937	.045	12.5°	.060	.020	.030	.080	233380	525120	4.000

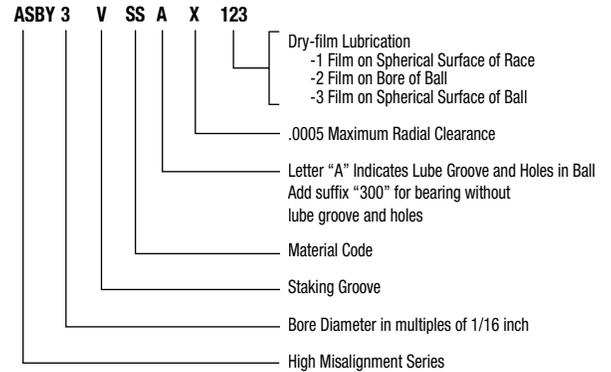
\* For chamfered version, delete 'V' from part number.  
 \*\* Based on pin limitation.  
 \*\*\* Tolerance: +.0000-.0008.  
 † Loads based on parts with no lubrication grooves.

# SPHERICAL BEARINGS – Metal-to-Metal

## High Misalignment



### NHBB P/N



Part Number V-Grooved*	(B)	(D)	(W)	(T)	(Ø)	Ball Diameter	(F)	(Q)	(P)	(R)	(S)	(X)	Limit Static Radial Load		Weight
	Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter		Race Chamfered x 45°	Mis- alignment		Staking Groove Data			Bronze Race	Steel Race	
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.	Inch	Inch	Inch	Inch	lbs.	lbs.	lbs.
	+ .0000 - .0005	+ .0000 - .0005	+ .000 - .005	+ .010 - .000	Ref.	Ref.	+ .000 - .010		+ .000 - .015	+ .000 - .010	+ .000 - .010	+ .000 - .010			Ref.
ASBY3V	.1900	.5625	.500	.205	.319	.437	.020	15°	.030	.015	.020	.045	2470	4060**	.018
ASBY4V	.2500	.7400	.593	.250	.390	.593	.022	24°	.030	.015	.020	.045	4680	7040**	.036
ASBY5V	.3125	.6875	.625	.250	.418	.593	.022	20°	.030	.015	.020	.045	4680	8430	.029
ASBY6V	.3750	.9060	.813	.340	.512	.781	.032	23°	.030	.015	.020	.045	9060	15860**	.068
ASBY7V	.4375	1.0000	.875	.340	.618	.875	.032	22°	.030	.015	.020	.045	10150	18270	.095
ASBY8V	.5000	1.1250	.937	.396	.730	1.000	.032	20°	.040	.020	.030	.055	14400	25920	.159
ASBY10V	.6250	1.3750	1.200	.562	.856	1.250	.032	20°	.040	.020	.030	.055	27440	49390	.245
ASBY12V	.7500	1.5625	1.280	.615	.970	1.375	.044	18°	.040	.020	.030	.055	33820	60880	.315
ASBY14V	.8750	1.7500	1.400	.620	1.140	1.531	.044	18°	.060	.020	.030	.080	36510	65720	.430
ASBY16V	1.0000	2.1250	1.875	.830	1.278	1.875	.044	21°	.060	.020	.030	.080	64410	115930	.831
ASBY18V	1.1250***	2.3125***	1.875	.937	1.400	2.062	.044	20°	.060	.020	.030	.080	78560	141410	1.096
ASBY20V	1.2500***	2.5000***	1.875	1.000	1.523	2.250	.044	21°	.060	.020	.030	.080	92810	167060	1.318
ASBY22V	1.3750***	2.7500***	2.125	1.093	1.670	2.500	.044	22°	.060	.020	.030	.080	91800	206550	1.800
ASBY24V	1.5000***	3.0000***	2.250	1.170	1.800	2.672	.044	21°	.060	.020	.030	.080	106340	239280	2.223

\* For chamfered version, delete 'V' from part number.

\*\* Based on pin limitation.

\*\*\* Bore and O.D. tolerance: +.0000-.0008.

### Notes:

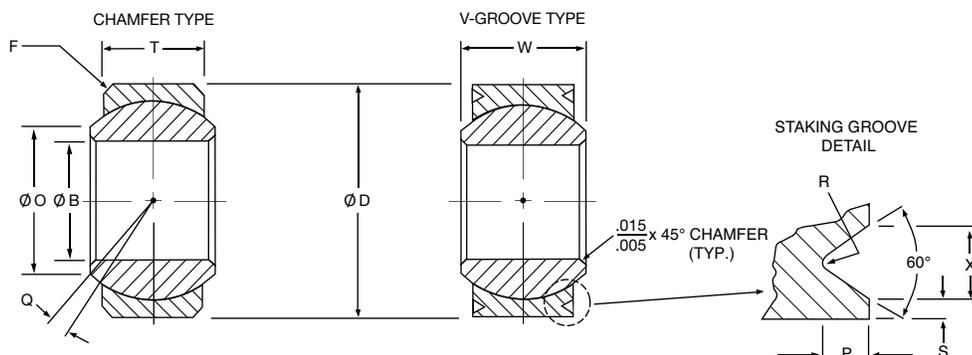
- Radial Clearance: Free running to .002 max.
- Dimensions: All dimensions apply after plating.
- Groove dimensions on ID of race and grease holes through race are before bearing assembly, but swaging shall not restrict grease flow.

### Materials

Part No.	Ball	Race
Catalog No.	52100 Alloy Steel, Chrome Plated†	Aluminum Bronze (AMS 4635 and ASTM B 50/B150M) Cadmium Plated†
Catalog No. + S	"	4130 Alloy Steel, Cadmium Plated†
Catalog No. + SS	"	CRES 17-4PH
Catalog No. + CR	CRES 440C	"
Catalog No. + CRP	CRES 440C, Chrome Plated†	"

†Plating: When specified in materials block, ball spherical diameter and ends are hard chrome plated per AMS-QQ-C-320, CL. 2 (.0002 to .0005 inch thickness). All external surfaces of race are cadmium plated per AMS-QQ-P-416.

# High Temperature



Part Number V-Grooved*	Part Number V-Grooved*	(B)	(D)	(W)	(T)	(O)	Ball Diameter	(F)	(Q)	(P)	(R)	(S)	(X)	Limit Static Radial Load		Weight
		Bore Diameter	Outside Diameter	Ball Width	Race Width	Shoulder Diameter		Race Chamfered x 45°	Mis- alignment					Staking Groove Data		
		Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.	Inch	Inch	Inch	Inch	lbs.	lbs.	lbs.
AHT3V	AHET3V	.1900	.5625	.281	.218	.293	.406	.020	11°	.030	.015	.020	.045	4060**	4060**	.02
AHT4V	AHET4V	.2500	.6562	.343	.250	.364	.500	.022	13°	.030	.015	.020	.045	7040**	6390	.02
AHT5V	AHET5V	.3125	.7500	.375	.281	.419	.562	.032	11.5°	.040	.020	.030	.055	10080	8210	.03
AHT6V	AHET6V	.3750	.8125	.406	.312	.517	.656	.032	9.5°	.040	.020	.030	.055	13250	10790	.04
AHT7V	AHET7V	.4375	.9062	.437	.343	.572	.718	.032	9°	.040	.020	.030	.055	16120	13140	.05
AHT8V	AHET8V	.5000	1.0000	.500	.390	.642	.813	.032	9°	.060	.020	.030	.080	21040	17140	.07
AHT9V	AHET9V	.5625	1.0937	.562	.437	.671	.875	.032	10°	.060	.020	.030	.080	23730	19330	.09
AHT10V	AHET10V	.6250	1.1875	.625	.500	.739	.968	.032	9°	.060	.020	.030	.080	30700	25010	.11
AHT12V	AHET12V	.7500	1.4375	.750	.593	.920	1.187	.040	9°	.060	.020	.030	.080	45690	37230	.21
AHT14V	AHET14V	.8750	1.5625	.875	.703	.980	1.312	.040	9°	.060	.020	.030	.080	61020	49720	.27
AHT16V	AHET16V	1.0000	1.7500	1.000	.797	1.118	1.500	.040	9.5°	.060	.020	.030	.080	80040	65220	.39

\* For chamfered version, delete 'V' from part number.  
 \*\* Based on pin limitation.

## Notes:

- Load ratings are based on short-term exposure. Not intended for continuous use at temperature shown.
- Radial clearance: Free running to .002 max.

## Materials

Series	Ball	Race	Temp.
AHT	INCONEL® alloy 718, thin dense chrome plated	CRES A-286, solution treated and aged, spherical surface silver plated	Brief exposure to 1000°F
AHET	STELLITE® alloy #3, thin dense chrome plated	"	Brief exposure to 1200°F

INCONEL® is a registered trademark of Inco Alloys International, Inc.  
 STELLITE® is a registered trademark of Kennametal, Inc.



# SECTION 3

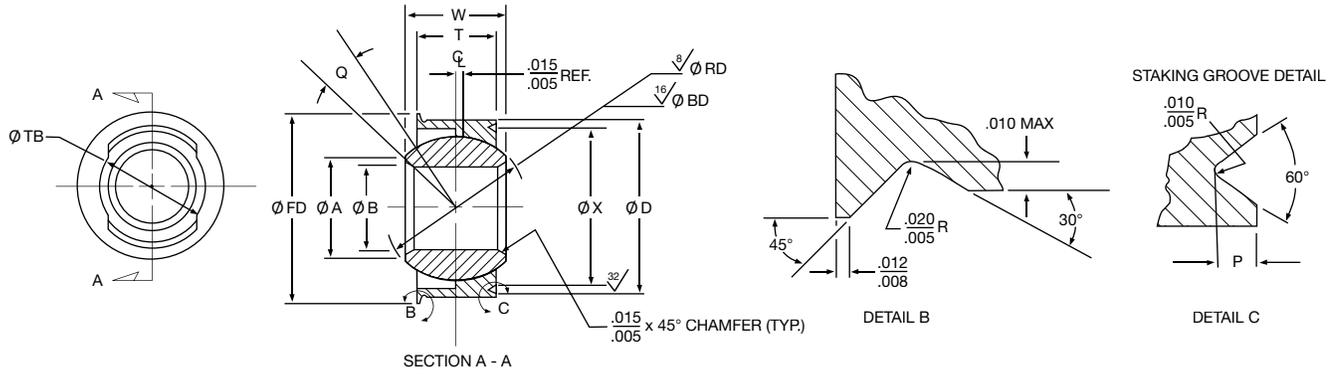
## LOADER SLOT BEARINGS

Plain .....	.24
Sealed .....	.25
Rod End – 2-Piece Male Thread .....	.26



# LOADER SLOT BEARINGS

## Plain



Part Number	(B) Bore Diameter	(D) Outside Diameter	(W) Ball Width	(T) Race Width	(BD) Ball Spherical Diameter	(RD) Race Spherical Diameter	(A) Ball Flat Diameter	(TB) Thru Bore	(Q) Mis-alignment	(FD) Flange Diameter	(P) V-Groove Depth	(X) V-Groove Centerline	Radial Static Limit Load <sup>∠</sup>	Axial Static Limit Load <sup>∠</sup>	Weight
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.	Inch	Inch	Inch	lbs.	lbs.	lbs.
	+ .0000 - .0005	+ .0000 - .0005	+ .000 - .002	+ .003 - .003	+ .0000 - .0005	+ .0005 - .0000	Ref.	+ .003 - .003		+ .002 - .002	+ .004 - .004	+ .003 - .003		Ref.	Ref.
AMB3	.1900	.5625	.281	.218	.4060	.4070	.293	.360	10°	.582	.026	.494	2820	995	.02
AMB4	.2500	.6562	.343	.250	.5000	.5010	.364	.449	12°	.676	.026	.588	4880	1160	.02
AMB5	.3125	.7500	.375	.281	.5625	.5635	.419	.503	11°	.770	.026	.682	8920	1320	.03
AMB6	.3750	.8125	.406	.312	.6250	.6260	.475	.563	10°	.852	.036	.714	14260	1630	.04
AMB7	.4375	.9062	.437	.343	.7180	.7190	.572	.651	9°	.946	.036	.808	20800	1810	.05
AMB8	.5000	1.0000	.500	.390	.8125	.8135	.640	.733	9°	1.040	.036	.902	23800	2000	.07
AMB9	.5625	1.0937	.562	.437	.8750	.8760	.671	.785	9°	1.174	.056	.970	26890	2550	.09
AMB10	.6250	1.1875	.625	.500	.9680	.9690	.739	.875	9°	1.267	.056	1.064	29070	2770	.11
AMB12	.7500	1.4375	.750	.593	1.1870	1.1880	.920	1.056	9°	1.517	.056	1.314	35210	3350	.21
AMB14	.8750	1.5625	.875	.703	1.3120	1.3130	.978	1.138	9°	1.642	.056	1.439	40500	3640	.27
AMB16	1.0000	1.7500	1.000	.797	1.5000	1.5010	1.118	1.300	9°	1.830	.056	1.627	46580	4080	.39

∠ Static limit loads calculated are approximate values, based on the following:  
 Radial - .0018 inch pin deflection.  
 Axial - bearing push-out (of housing).

### Notes:

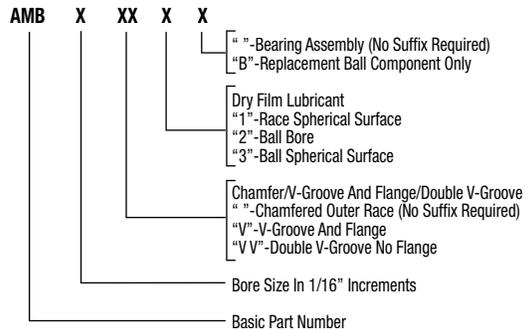
- Nitride or Malcomize spherical race ID.
- Balls rotate freely under finger pressure @ 72°F.
- Balls are fully interchangeable. No selective assembly allowed.
- Operating temperature range -65°F to 350°F.

### Materials (AMB)

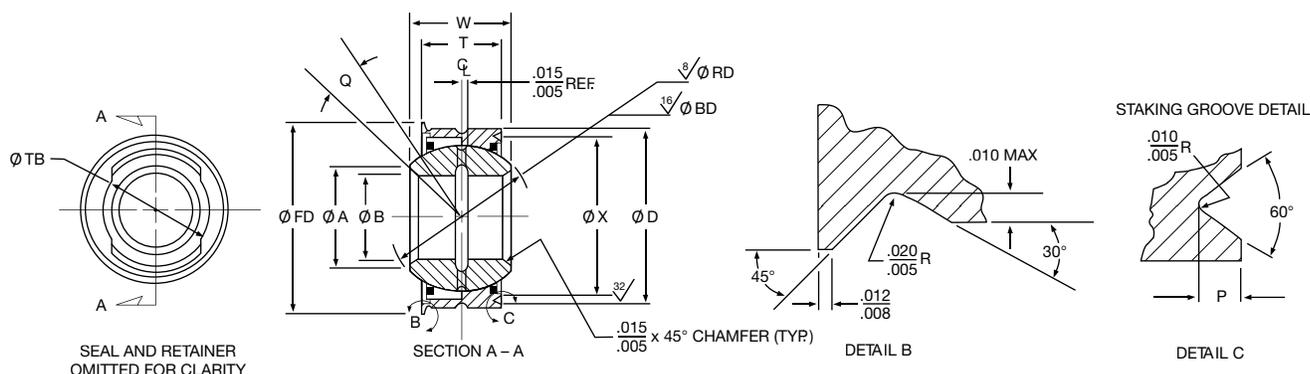
Part No.	Ball	Race
Catalog No.	STELLITE® alloy #6 AMS 5387 Rc37 min.	17-4PH AMS 5643 Rc34-40

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### NHBB Part Numbering



# Sealed



Part Number	(B) Bore Diameter	(D) Outside Diameter	(W) Ball Width	(T) Race Width	(BD) Ball Spherical Diameter	(RD) Race Spherical Diameter	(A) Ball Flat Diameter	(TB) Thru Bore	(Q) Mis-alignment	(FD) Flange Diameter	(P) V-Groove Depth	(X) V-Groove Centerline	Radial Static Limit Load <sup>∠</sup>	Axial Static Limit Load <sup>∠</sup>	Weight
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.	Inch	Inch	Inch	lbs.	lbs.	lbs.
	+0.000 -0.0005	+0.000 -0.0005	+0.000 -0.002	+0.002 -0.002	+0.0000 -0.0003	+0.0005 -0.0000	+0.003 -0.003			+0.002 -0.002	+0.004 -0.004	+0.003 -0.003			Ref.
AMBG4	.2500	.7500	.375	.280	.5625	.5635	.419	.515	11°	.770	.026	.682	3650	1320	.04
AMBG5	.3125	.8125	.375	.300	.6250	.6260	.500	.574	7.5°	.852	.036	.714	8370	1630	.04
AMBG6	.3750	.8750	.406	.312	.6865	.6875	.554	.635	8°	.915	.036	.777	14200	1750	.05
AMBG7	.4375	.9375	.437	.360	.7500	.7510	.610	.698	6.5°	.977	.036	.839	19900	1880	.06
AMBG8	.5000	1.0000	.500	.410	.8125	.8135	.640	.740	7°	1.040	.036	.902	22750	2000	.08
AMBG9	.5625	1.1250	.562	.460	.9060	.9070	.710	.814	7.5°	1.205	.056	1.002	25690	2620	.11
AMBG10	.6250	1.2500	.625	.510	1.0000	1.0010	.780	.900	7.5°	1.330	.056	1.127	26530	2910	.15
AMBG12	.7500	1.5000	.750	.624	1.1875	1.1885	.920	1.075	7°	1.580	.056	1.377	33640	3500	.25
AMBG14	.8750	1.7500	.875	.730	1.3750	1.3760	1.060	1.238	7°	1.830	.056	1.627	39140	4080	.40
AMBG16	1.0000	1.8750	1.000	.812	1.5625	1.5635	1.200	1.410	8°	1.955	.056	1.752	45790	4370	.49
AMBG18	1.1250	2.1250	1.125	.936	1.7500*	1.7510	1.340	1.556	7.5°	2.205	.056	2.002	50420	7960	.73
AMBG20	1.2500	2.3125	1.250	1.030	1.9375*	1.9385	1.480	1.720	8°	2.392	.056	2.189	56870	8670	.94
AMBG22	1.3750	2.5625	1.375	1.124	2.1250*	2.1260	1.620	1.885	7.5°	2.642	.056	2.439	62560	9610	1.27
	+0.010 -0.000	+0.000 -0.0008	+0.000 -0.003		+0.0000 -0.0005	+0.0006 -0.0000									
AMBG24	1.5000	2.8125	1.500	1.250	2.3125*	2.3135	1.760	2.030	7.5°	2.892	.056	2.689	67280	10540	1.70
AMBG26	1.6250	3.0000	1.625	1.350	2.5000*	2.5010	1.900	2.190	7.5°	3.080	.056	2.877	73060	11250	2.07
AMBG28	1.7500	3.1875	1.750	1.450	2.6875	2.6885	2.040	2.350	8°	3.267	.056	3.064	78840	11950	2.49
AMBG30	1.8750	3.3750	1.875	1.560	2.8750	2.8760	2.180	2.505	7.5°	3.455	.056	3.252	84150	12650	2.96
AMBG32	2.0000	3.6250	2.000	1.680	3.1250	3.1260	2.401	2.725	7°	3.705	.056	3.502	88980	13590	3.72

\* Ball spherical diameter tolerance +.0000/-0.0004.

∠ Static limit loads are calculated approximate values, based on the following: Radial - .0018 inch pin deflection. Axial - bearing push-out (of housing).

## Notes:

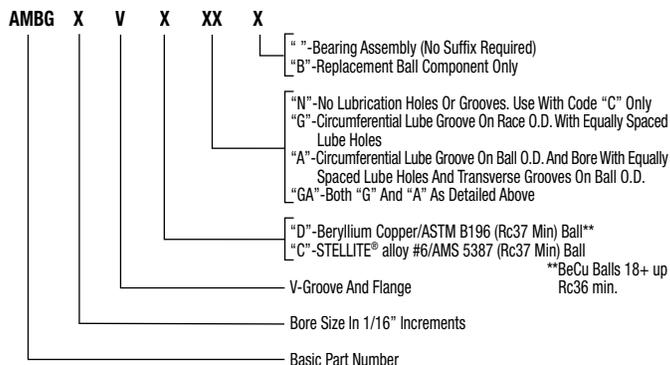
- Nitride or Malcomize spherical race ID.
- Balls rotate freely under finger pressure @ 72°F.
- Balls are fully interchangeable. No selective assembly allowed.
- Operating temperature range -65°F to 350°F.

## Materials (AMBG)

Part Number	Ball	Race	Seal	Retainer	Pellet/Patch
Catalog No. + D	BeCu ASTM B196 Rc36 min.	17-4PH AMS 5643 Rc34-40	PTFE	17-4PH AMS 5643 Rc40-44	Nylon
Catalog No. + C	STELLITE® alloy #6 AMS 5387 Rc37 min.	"	"	"	"

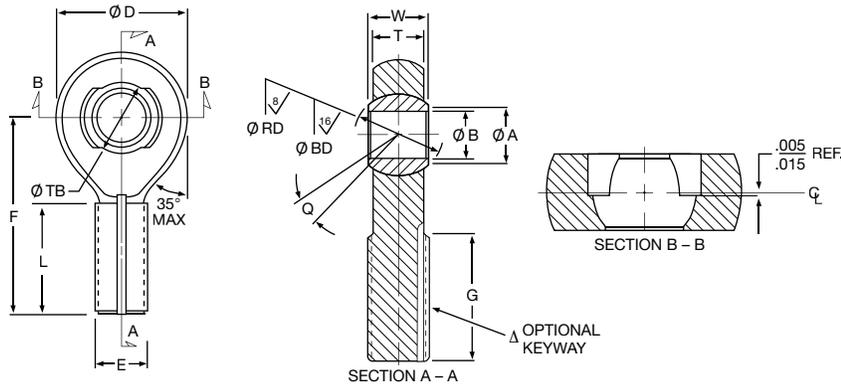
STELLITE® is a registered trademark of Kennametal, Inc.

## NHBB Part Numbering



# LOADER SLOT BEARINGS

## Rod End – 2-Piece Male Thread

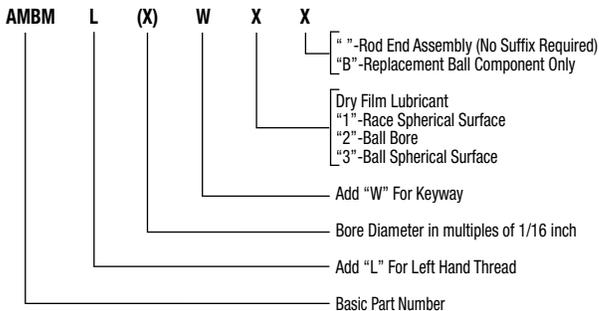


△ For keyway details, refer to engineering section, pages 68-69.

Part Number	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(BD) Ball Spherical Diameter	(RD) Rod End Spherical Diameter	(A) Ball Flat Diameter	(Q) Mis-alignment	(TB) Thru Bore	(F) Ball C/L To End	(E) Thread Size	(L) Thread Length	(G) Keyway Flat	Limit Static Radial Load	Ultimate Static Radial Load	Weight
	Inch +.0000 -.0005	Inch +.010 -.010	Inch +.000 -.002	Inch +.010 -.010	Inch +.0000 -.0005	Inch +.0005 -.0000	Inch Ref.	Ref.	Inch +.003 -.003	Inch +.010 -.010	UNJF-3A	Inch +.031 -.031	Inch +.020 -.020	lbs.	lbs.	lbs. Ref.
AMBM3	.1900	.680	.281	.228	.4060	.4070	.293	10°	.360	1.315	1/4-28	.775	.896	2820	4950	.04
AMBM4	.2500	.827	.343	.260	.5000	.5010	.364	10°	.449	1.443	1/4-28	.775	.896	3380	7200	.05
AMBM5	.3125	.984	.375	.291	.5625	.5635	.419	10°	.503	1.948	5/16-24	1.187	1.308	5440 *	11250	.08
AMBM6	.3750	1.131	.406	.322	.6250	.6260	.475	9°	.563	2.030	3/8-24	1.187	1.308	8380 *	15750	.12
AMBM7	.4375	1.294	.437	.353	.7180	.7190	.530	8°	.651	2.250	7/16-20	1.281	1.402	11320 *	19350	.17
AMBM8	.5000	1.459	.500	.400	.8125	.8135	.600	8°	.733	2.544	1/2-20	1.468	1.589	15420 *	25200	.25
AMBM10	.6250	1.763	.625	.510	.9680	.9690	.739	8°	.857	2.832	5/8-18	1.562	1.683	24910 *	40500	.46
AMBM12	.7500	2.140	.750	.603	1.1870	1.1880	.920	8°	1.056	3.193	3/4-16	1.687	1.808	35210	58500	.77
AMBM14	.8750	2.372	.875	.713	1.3120	1.3130	.980	8°	1.138	3.677	7/8-14	2.000	2.121	40500	78300	1.14
AMBM16	1.0000	2.681	1.000	.807	1.5000	1.5010	1.118	9°	1.300	3.968	1-12	2.100	2.221	46580	101250	1.65

\*Shank limited.

### NHBB Part Numbering



### Notes:

- Nitride or Malcomize spherical body ID.
- Balls rotate freely under finger pressure @ 72°F.
- Balls are fully interchangeable. No selective assembly allowed.
- After limit load, slight crazing of the Nitride/Malcomized surface treatment may occur.

### Materials

Part No.	Ball	Body
Catalog No.	STELLITE® alloy #6, AMS 5387, Rc37 min.	17-4PH AMS 5643 or AMS 5355, Rc34-40

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# SECTION 4

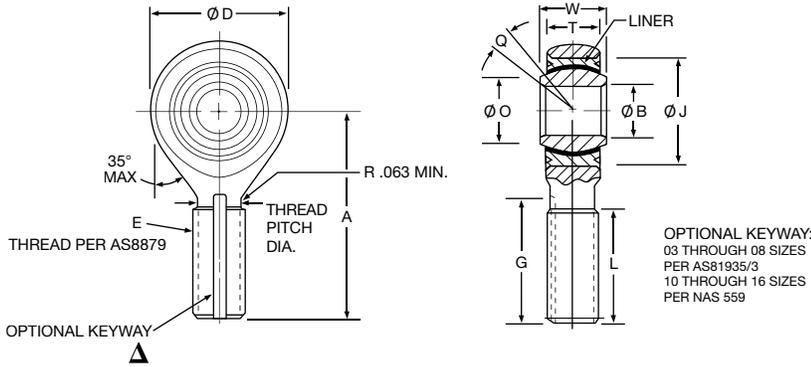
## ROD END BEARINGS – Self-Lubricating

AS81935/4 Narrow – Male Thread . . . . .	30
AS81935/1 Wide – Male Thread. . . . .	31
AS81935/5 Narrow – Female Thread . . . . .	32
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3-Piece Heavy Duty – Male & Female Threads . . . . .	34
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# ROD END BEARINGS – Self-Lubricating

## AS81935/4 Narrow – Male Thread



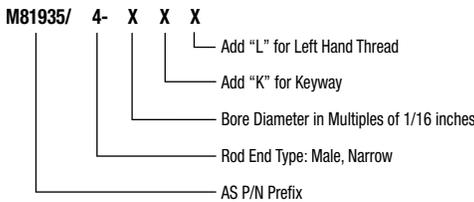
### Notes:

- Bearings listed in the tables are approved for procurement to AS81935.
- Temperature: Operating temperature range per AS81935; -65° to 325°F . Broader temperature capabilities are achievable. Contact NHBB Applications Engineering.

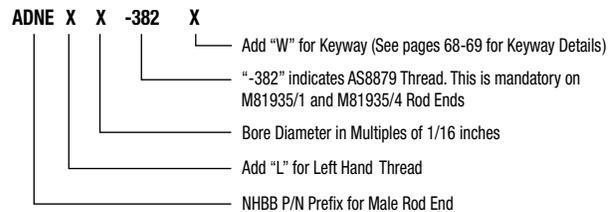
△ For keyway details, refer to the engineering section, pages 68-69.

Part Number	MS Dash No.	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(A) Ball C/L to End	(E) Thread Size	(L) Complete Thread	(J) Housing I.D.	(G) Keyway Flat	(Q) Mis-alignment
		Inch +.0000 -.0005	Inch +.010 -.010	Inch +.000 -.002	Inch +.005 -.005	Inch Min.	Inch Ref.	Inch +.010 -.010		Inch +.031 -.031	Inch Max.	Inch +.000 -.020	Ref.
<b>M81935/4</b>									UNJF-3A				
ADNE3-382	-03	.1900	.680	.281	.228	.293	.406	1.315	1/4-28	.775	.5625	.896	10°
ADNE4-382	-04	.2500	.827	.343	.260	.364	.500	1.443	1/4-28	.775	.6562	.896	10°
ADNE5-382	-05	.3125	.984	.375	.291	.419	.562	1.948	5/16-24	1.187	.7500	1.308	10°
ADNE6-382	-06	.3750	1.131	.406	.322	.475	.656	2.030	3/8-24	1.187	.8125	1.308	9°
ADNE7-382	-07	.4375	1.294	.437	.353	.530	.718	2.250	7/16-20	1.281	.9062	1.402	8°
ADNE8-382	-08	.5000	1.459	.500	.400	.600	.813	2.544	1/2-20	1.468	1.0000	1.589	8°
ADNE10-382	-10	.6250	1.763	.625	.510	.739	.968	2.832	5/8-18	1.562	1.1875	1.683	8°
ADNE12-382	-12	.7500	2.140	.750	.603	.920	1.187	3.193	3/4-16	1.687	1.4375	1.808	8°
ADNE14-382	-14	.8750	2.372	.875	.713	.980	1.312	3.677	7/8-14	2.000	1.5625	2.121	8°
ADNE16-382	-16	1.0000	2.681	1.000	.807	1.118	1.500	3.968	1-12	2.100	1.7500	2.221	9°

### Aerospace Standard P/N - Narrow



### NHBB P/N - Narrow



### Materials

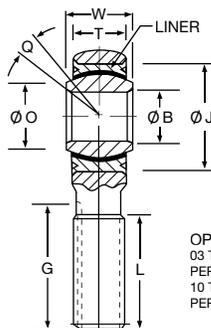
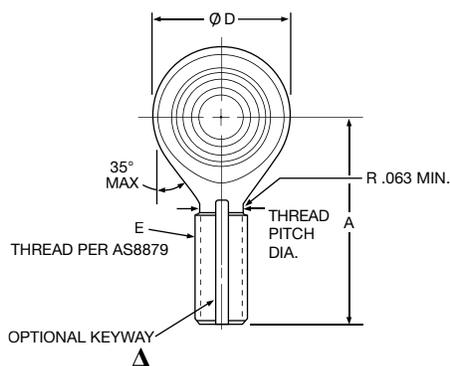
Part No.	Ball	Race	Liner	Body
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	4340 Alloy Steel AMS6415 Rc39-42 H.T. Cadmium Plated††
Catalog No. + CR†	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	CRES 17-4PH AMS 5643 Rc39-44 Passivated

†† Body cadmium plated per AMS-QQ-P-416, Type II, CL. 2 on all surfaces including body bore.  
† Stainless Steel Series is not available to Aerospace Standard, but may be ordered to NHBB Part Number as indicated. Example: ADNE4CRJ or ADNE4-382CR

### Performance Properties - Narrow

MS Dash No.	No Load Rotational Breakaway Torque	Ultimate Static Radial Load	Axial Static Proof Load	Fatigue Load	Approx. Weight	
						In-lbs.
M81935/4						
ADNE3-382	-03	0.5-6.0	3000	150	1100	.038
ADNE4-382	-04	0.5-6.0	5300	430	1500	.045
ADNE5-382	-05	1.0-15.0	8600	700	2400	.081
ADNE6-382	-06	1.0-15.0	13000	1100	3600	.120
ADNE7-382	-07	1.0-15.0	17800	1400	5000	.172
ADNE8-382	-08	1.0-15.0	24200	2040	6800	.254
ADNE10-382	-10	1.0-15.0	38500	2430	10800	.455
ADNE12-382	-12	1.0-15.0	56600	2940	16000	.774
ADNE14-382	-14	1.0-24.0	77400	3190	21900	1.141
ADNE16-382	-16	1.0-24.0	101400	3570	28600	1.646

# AS81935/1 Wide - Male Thread



OPTIONAL KEYWAY:  
03 THROUGH 08 SIZES  
PER AS81935/3  
10 THROUGH 16 SIZES  
PER NAS 559

### Notes:

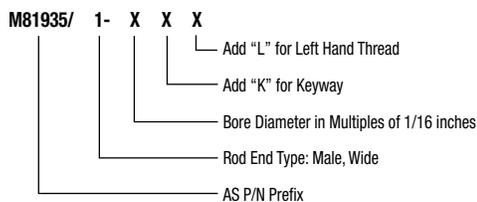
- Bearings listed in the tables are approved for procurement to AS81935.
- Temperature: Operating temperature range per AS81935; -65° to 325°F . Broader temperature capabilities are achievable. Contact NHBB Applications Engineering.

△ For keyway details, refer to the engineering section, pages 68-69.

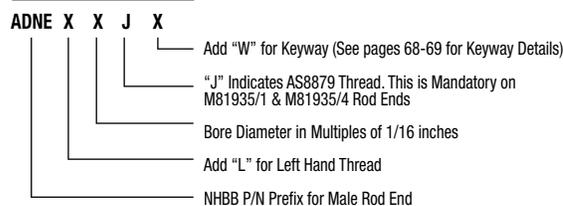
Part Number	MS Dash No.	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(A) Ball C/L to End	(E) Thread Size	(L) Complete Thread	(J) Housing I.D.	(G) Keyway Flat	(Q) Mis-alignment
		Inch	Inch	Inch	Inch	Inch	Inch	Inch		Inch	Inch	Inch	Ref.
<b>M81935/1*</b>		+ .0000 - .0005	+ .010 - .010	+ .000 - .002	+ .005 - .005	Min.	Ref.	- .010	UNJF-3A	- .031	Max.	- .020	
ADNE3J	-03	.1900	.806	.437	.337	.300	.531	1.562	5/16-24	.968	.6250	.980	15°
ADNE4J	-04	.2500	.806	.437	.337	.300	.531	1.562	5/16-24	.968	.6250	.980	15°
ADNE5J	-05	.3125	.900	.437	.327	.360	.593	1.875	5/16-24	1.187	.6875	1.270	14°
ADNE6J	-06	.3750	1.025	.500	.416	.470	.687	1.938	3/8-24	1.187	.8125	1.235	8°
ADNE7J	-07	.4375	1.150	.562	.452	.540	.781	2.125	7/16-20	1.281	.9062	1.402	10°
ADNE8J	-08	.5000	1.337	.625	.515	.610	.875	2.438	1/2-20	1.468	1.0000	1.589	9°
ADNE10J	-10	.6250	1.525	.750	.577	.750	1.062	2.625	5/8-18	1.562	1.1875	1.683	12°
ADNE12J	-12	.7500	1.775	.875	.640	.850	1.250	2.875	3/4-16	1.687	1.3750	1.808	13°
ADNE14J	-14	.8750	2.025	.875	.765	1.000	1.375	3.375	7/8-14	2.000	1.6250	2.121	6°
ADNE16J	-16	1.0000	2.775	1.375	1.015	1.270	1.875	4.125	1 1/4-12	2.343	2.1250	2.464	12°

\*For rod ends with threads per MIL-S-7742 Rev. D (UNF-3A), omit "J" from part number.

### Aerospace Standard P/N - Wide



### NHBB P/N - Wide



### Materials

Part No.	Ball	Race	Liner	Body
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	4340 Alloy Steel AMS6415 Rc39-42 H.T. Cadmium Plated††
Catalog No. + CR†	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	CRES 17-4PH AMS 5643 Rc39-44 Passivated

†† Body cadmium plated per AMS-QQ-P-416, Type II, CL. 2 on all surfaces including body bore.

† Stainless Steel Series is not available to Aerospace Standard, but may be ordered to NHBB Part Number as indicated. Example: ADNE4CRJ or ADNE4-382CR

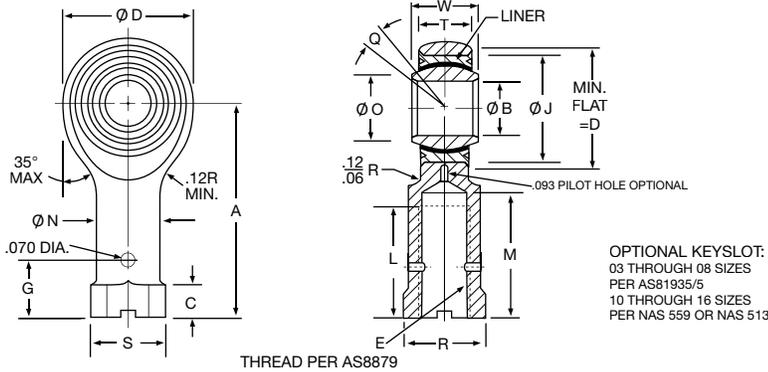
### Performance Properties - Wide

MS Dash No.	No Load Rotational Breakaway Torque	Ultimate Static Radial Load	Axial Static Proof Load	Fatigue Load	Approx. Weight	
						In-lbs.
MS						
M81935/1*						
ADNE3J	-03	0.5-6.0	2360	1000	1470	.072
ADNE4J	-04	0.5-6.0	4860	1000	2380	.072
ADNE5J	-05	1.0-15.0	7180	1100	2770	.087
ADNE6J	-06	1.0-15.0	8550	1660	3570	.136
ADNE7J	-07	1.0-15.0	12000	1850	4800	.183
ADNE8J	-08	1.0-15.0	19500	2040	7680	.278
ADNE10J	-10	1.0-15.0	21900	2430	9180	.424
ADNE12J	-12	1.0-15.0	29300	2810	11600	.639
ADNE14J	-14	1.0-24.0	34500	3320	13100	.963
ADNE16J	-16	1.0-24.0	80300	4340	30400	2.546

\*For rod ends with threads per MIL-S-7742 Rev. D (UNF-3A), omit "J" from part number.

# ROD END BEARINGS – Self-Lubricating

## AS81935/5 Narrow – Female Thread



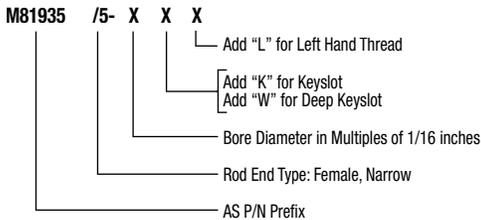
### Notes:

- Bearings listed in the tables are approved for procurement to AS81935.
- Temperature: Operating temperature range per AS81935; -65° to 325°F. Broader temperature capabilities are achievable.

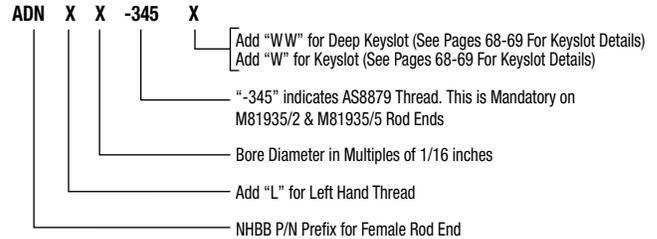
△ For keyslot details, refer to the engineering section, pages 68-69.

Part Number	MS Dash No.	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	(A) Ball Diameter	(E) Ball C/L to End	Thread Size	(L) Complete Thread	(N) Shank Diameter	(M) Drill Depth	(C) Flange Thickness	(R) Wrench Flat	(S) Corners or Diam.	(G) Drill C/L to End	(J) Housing I.D.	(Q) Mis-alignment
<b>M81935/5</b>		Inch +.0000 -.0005	Inch +.010 -.010	Inch +.000 -.002	Inch +.005 -.005	Inch Min.	Inch Ref.	Inch +.010 -.010	UNJF-3B	Inch Min.	Inch +.010 -.010	Inch Max.	Inch +.010 -.062	Inch +.002 -.010	Inch Ref.	Inch +.020 -.020	Inch Max.	Ref.
ADN3-345	-03	.1900	.680	.281	.228	.293	.406	1.210	1/4-28	.625	.329	.750	.188	.375	.430	.312	.5625	10°
ADN4-345	-04	.2500	.827	.343	.260	.364	.500	1.338	1/4-28	.625	.329	.750	.188	.375	.430	.312	.6562	10°
ADN5-345	-05	.3125	.984	.375	.291	.419	.562	1.566	5/16-24	.750	.413	.875	.188	.437	.500	.375	.7500	10°
ADN6-345	-06	.3750	1.131	.406	.322	.475	.656	1.908	3/8-24	1.000	.501	1.125	.250	.625	.720	.437	.8125	9°
ADN7-345	-07	.4375	1.294	.437	.353	.530	.718	2.125	7/16-20	1.125	.584	1.250	.250	.625	.720	.500	.9062	8°
ADN8-345	-08	.5000	1.459	.500	.400	.600	.813	2.356	1/2-20	1.250	.672	1.375	.375	.875	1.020	.562	1.0000	8°
ADN10-345	-10	.6250	1.763	.625	.510	.739	.968	2.707	5/8-18	1.375	.845	1.500	.375	.875	1.020	.687	1.1875	8°
ADN12-345	-12	.7500	2.140	.750	.603	.920	1.187	3.193	3/4-16	1.625	1.017	1.750	.500	1.125	1.300	.812	1.4375	8°
ADN14-345	-14	.8750	2.372	.875	.713	.980	1.312	3.677	7/8-14	1.875	1.187	2.062	.500	1.250	1.375	.937	1.5625	8°
ADN16-345	-16	1.0000	2.681	1.000	.807	1.118	1.500	4.101	1-12	2.125	1.356	2.312	.500	1.375	1.590	1.062	1.7500	9°

### Aerospace Standard P/N - Narrow



### NHBB P/N - Narrow



### Materials

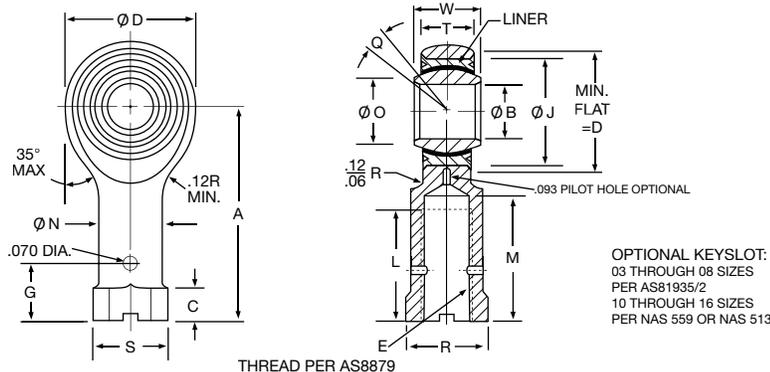
Part No.	Ball	Race	Liner	Body
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	4340 Alloy Steel, AMS6415 Rc39-42 Cadmium Plated††
Catalog No. + CR†	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	CRES 17-4PH AMS 5643 Rc39-44 Passivated

†† Body Cadmium plated per AMS-QQ-P-416, Type II, CL. 2 on all surfaces including body bore.  
† Stainless Steel Series is not available to Aerospace Standard, but may be ordered to NHBB Part Number as indicated. Example: ADN4CRJ or ADN4-345CR

### Performance Properties – Narrow

MS Dash No.	No Load Rotational Breakaway Torque	Ultimate Static Radial Load	Axial Static Proof Load	Fatigue Load	Approx. Weight	
						In-lbs.
ADN3-345	-03	0.5-6.0	3000	150	1100	.044
ADN4-345	-04	0.5-6.0	5500	430	1300	.052
ADN5-345	-05	1.0-15.0	8900	700	2000	.087
ADN6-345	-06	1.0-15.0	13400	1100	3100	.137
ADN7-345	-07	1.0-15.0	18200	1400	4200	.193
ADN8-345	-08	1.0-15.0	24600	2040	5700	.279
ADN10-345	-10	1.0-15.0	39500	2430	9200	.504
ADN12-345	-12	1.0-15.0	57200	2940	13500	.860
ADN14-345	-14	1.0-24.0	77800	3100	18400	1.266
ADN16-345	-16	1.0-24.0	101100	3570	24000	1.814

# AS81935/2 Wide – Female Thread



### Notes:

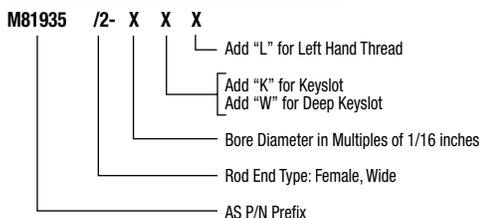
- Bearings listed in the tables are approved for procurement to AS81935.
- Temperature: Operating temperature range per AS81935; -65° to 325°F. Broader temperature capabilities are achievable.

Δ For keyslot details, refer to the engineering section, pages 68-69.

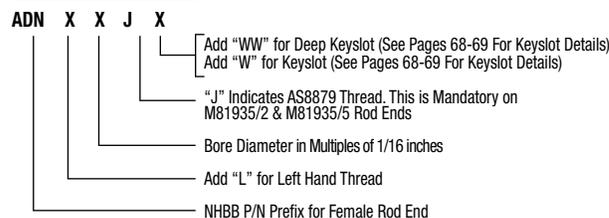
Part Number	MS Dash No.	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(A) Ball C/L to End	(E) Thread Size	(L) Complete Thread	(N) Shank Diameter	(M) Drill Depth	(C) Flange Thickness	(R) Wrench Flat	(S) Corners or Diam.	(G) Drill C/L to End	(J) Housing I.D.	(Q) Mis-alignment
		Inch	Inch	Inch	Inch	Inch	Inch	Inch		Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Ref.
<b>M81935/2*</b>		+ .0000 - .0005	+ .010 - .010	+ .000 - .002	+ .005 - .005	Min.	Ref.	+ .010 - .010	UNJF-3B	Min.	+ .010 - .010	Max.	+ .010 - .062	+ .002 - .010	Ref.	+ .020 - .020	Max.	
ADN3J	-03	.1900	.806	.437	.337	.300	.531	1.375	5/16-24	.750	.422	.875	.188	.437	.500	.375	.6250	15°
ADN4J	-04	.2500	.806	.437	.337	.300	.531	1.469	5/16-24	.750	.422	.875	.188	.437	.500	.375	.6250	15°
ADN5J	-05	.3125	.900	.437	.327	.360	.593	1.625	3/8-24	.875	.485	1.000	.250	.500	.580	.437	.6875	14°
ADN6J	-06	.3750	1.025	.500	.416	.470	.687	1.812	3/8-24	1.000	.547	1.125	.250	.562	.660	.437	.8125	8°
ADN7J	-07	.4375	1.150	.562	.452	.540	.781	2.000	7/16-20	1.125	.610	1.250	.250	.625	.720	.500	.9062	10°
ADN8J	-08	.5000	1.337	.625	.515	.610	.875	2.250	1/2-20	1.250	.735	1.375	.250	.750	.880	.562	1.0000	9°
ADN10J	-10	.6250	1.525	.750	.577	.750	1.062	2.500	5/8-18	1.375	.860	1.500	.375	.875	1.020	.687	1.1875	12°
ADN12J	-12	.7500	1.775	.875	.640	.850	1.250	2.875	3/4-16	1.625	.985	1.750	.375	1.000	1.160	.812	1.3750	13°
ADN14J	-14	.8750	2.025	.875	.765	1.000	1.375	3.375	7/8-14	1.875	1.110	2.062	.500	1.125	1.300	.937	1.6250	6°
ADN16J	-16	1.0000	2.775	1.375	1.015	1.270	1.875	4.125	1 1/4-12	2.125	1.688	2.312	.563	1.750	2.020	1.312	2.1250	12°

\* For rod ends with threads per MIL-S-7742 Rev. D (UNF-3B), omit "J" from part number.

### Aerospace Standard P/N - Wide



### NHBB P/N - Wide



### Materials

Part No.	Ball	Race	Liner	Body
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	4340 Alloy Steel, AMS6415 Rc39-42 Cadmium Plated††
Catalog No. + CR†	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE/Fabric Bonded to Race I.D. No Lub. Required	CRES 17-4PH AMS 5643 Rc39-44 Passivated

†† Body Cadmium plated per AMS-QQ-P-416, Type II, CL. 2 on all surfaces including body bore.

† Stainless Steel Series is not available to Aerospace Standard, but may be ordered to NHBB Part Number as indicated. Example: ADN4CRJ or ADN4-345CR

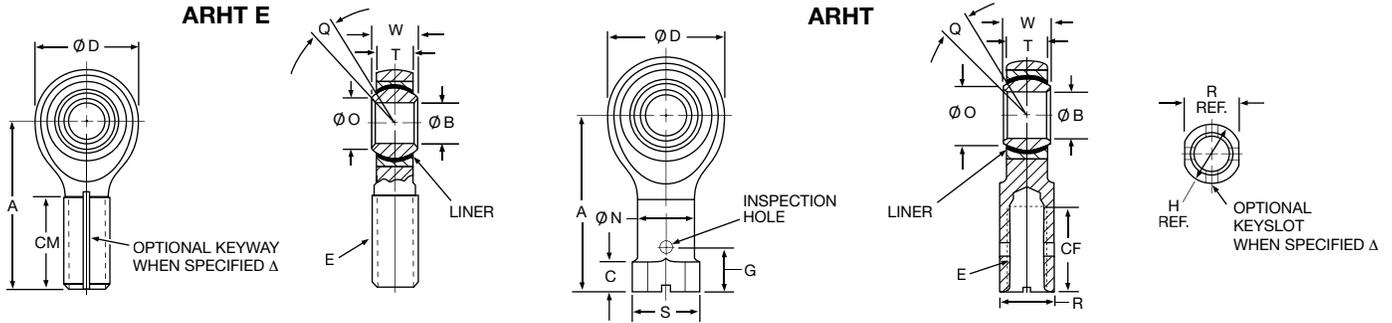
### Performance Properties – Wide

MS Dash No.	No Load Rotational Breakaway Torque	Ultimate Static Radial Load	Axial Static Proof Load	Fatigue Load	Approx. Weight	
						In-lbs.
ADN3J	-03	0.5-6.0	2360	1000	1470	.080
ADN4J	-04	0.5-6.0	4860	1000	2380	.084
ADN5J	-05	1.0-15.0	7180	1100	3020	.102
ADN6J	-06	1.0-15.0	8550	1660	3570	.161
ADN7J	-07	1.0-15.0	12000	1850	4800	.212
ADN8J	-08	1.0-15.0	19500	2040	8260	.325
ADN10J	-10	1.0-15.0	21900	2430	9180	.481
ADN12J	-12	1.0-15.0	29300	2810	11600	.673
ADN14J	-14	1.0-24.0	34500	3320	13100	.959
ADN16J	-16	1.0-24.0	80300	4340	30400	2.717

\* For rod ends with threads per MIL-S-7742 Rev. D (UNF-3B), omit "J" from part number

# ROD END BEARINGS – Self-Lubricating

## 3-Piece Heavy Duty – Male & Female Threads



Δ For keyway and keyslot details, refer to the engineering section, pages 68-69.

Part Number	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Ball Diameter	(A) Flat Diameter	(E) Ball C/L to End	(Q) Thread Size	(M) Mis-alignment	(C) Thread Length	(CF) Thread Depth	(G) Drill C/L to end	(N) Shank Diameter	(S) Flange Diameter	(C) Flange Thickness	(R) Wrench Flat	No Load Rotational Breakaway Torque	Limit Static Radial Load	Axial Static Proof Load	Weight
	Inch +.0000 -.0005	Inch +.010 -.010	Inch +.000 -.002	Inch +.005 -.005	Inch Ref.	Inch Ref.	Inch +.010 -.010	UNF - 3A* UNF - 3B*	Ref.	Inch +.031 -.031	Min.	Inch Ref.	Inch +.010 -.010	Inch Ref.	Inch +.010 -.062	Inch +.002 -.010	Inch - lbs.	lbs.	lbs.	lbs. Ref.
ARHT4E ARHT4	.2500	.806	.375	.337	.531	.375	1.562	5/16 - 24	5°	.968	.750	.375	.485	.562	.188	.500	0.5- 6.0	6060	1000	.067 .084
ARHT5E ARHT5	.3125	.900	.437	.327	.593	.401	1.875	3/8 - 24	14°	1.187	.875	.437	.547	.625	.250	.562	1.0-10.0	7290	1100	.095 .102
ARHT6E ARHT6	.3750	1.025	.500	.416	.687	.471	1.938	7/16 - 20	9°	1.187	1.000	.500	.610	.687	.250	.625	1.0-10.0	8870	1660	.140 .160
ARHT7E ARHT7	.4375	1.150	.562	.452	.781	.542	2.125	1/2 - 20	10°	1.281	1.125	.562	.735	.875	.250	.750	1.0-10.0	9560	1850	.210 .230
ARHT8E ARHT8	.5000	1.337	.625	.515	.875	.612	2.438	5/8 - 18	9°	1.468	1.250	.687	.860	1.000	.250	.875	1.0-10.0	18560	2040	.330 .340
ARHT10E ARHT10	.6250	1.525	.750	.577	1.062	.752	2.625	3/4 - 16	12°	1.562	1.375	.812	.985	1.125	.375	1.000	1.0-10.0	20610	2430	.480 .490
ARHT12E ARHT12	.7500	1.775	.875	.640	1.250	.892	2.875	7/8 - 14	13°	1.687	1.625	.937	1.110	1.250	.375	1.125	1.0-10.0	27640	2810	.730 .740

\* UNF-3A = Male Thread. UNF-3B = Female Thread per MIL-S-7742, Rev. D.

### Notes:

- † Plating: When specified in materials block, body cadmium plated all surfaces per AMS-QQ-P-416.
- Dimensions: Dimensions apply after plating.
- Temperature: Operating temperature range -65° to 350°F (ADY only).
- Qualifications: Liner is approved to MIL-B-8942 Rev. A (ARHT series only).
- Options:
  1. For left hand threads, add "L" to prefix. (Examples: ARHTL4E or ARHTL4)
  2. For Keyway or keyslot options add suffix "W" to part number.
  3. For "J" form threads per AS8879, add suffix "J" to part number. (Examples: ARHT10EJW or ARHT10JW)

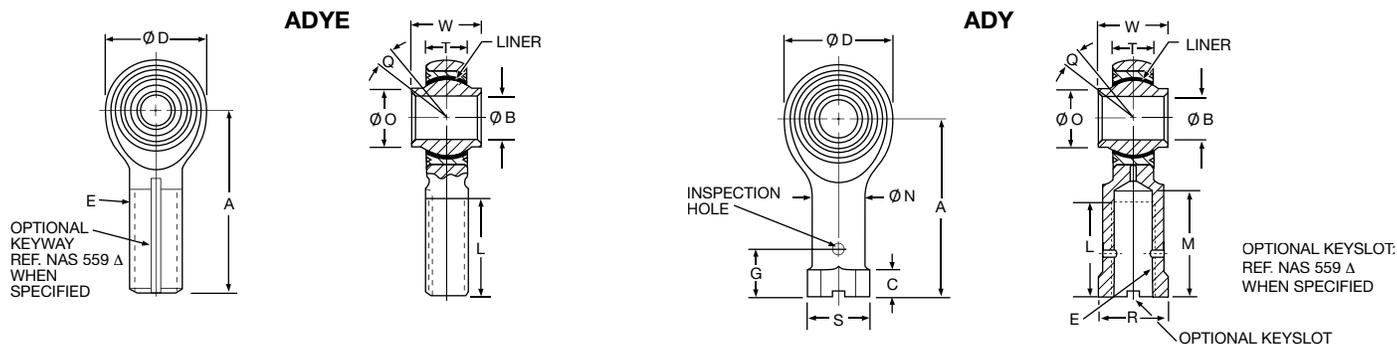
### Materials (ARHT)

Designation	Ball	Race	Liner	Body
Basic†	CRES 440C	Stainless	PTFE	C.M. Steel
Part No.	AMS 5630 Rc55-62	Steel, H.T.††	Fabric Bonded to Race I.D.	H.T., Cadmium Plated
No. + CR	CRES 440C AMS 5630 Rc55-62	Stainless Steel, H.T.††	PTFE Fabric Bonded to Race I.D.	CRES 17-4PH AMS 5643 H.T.

† Stainless Steel Series may be ordered to NHBB Part Number as indicated.

†† Part No. designation as shown furnished with CRES 410 race material. To specify CRES 17-4PH race material, add suffix "H" to designation. Examples: ARHT8ECRH or ARHT8CRH.

### 3-Piece High Misalignment – Male & Female Threads



ΔFor keyway and keyslot details, refer to the engineering section, page 68-69.

Part Number	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(A) Ball C/L to End	(E) Thread Size	(Q) Mis-alignment	(L) Thread Length	(N) Shank Diameter	(R) Wrench Flat	(S) Flange Diameter	(C) Flange Thickness	(G) Drill C/L to End	No Load Rotational Breakaway Torque	Limit Static Radial Load	Weight
	Inch +0.0000 -0.0005	Inch Max.	Inch +0.000 -0.005	Inch +0.005 -0.005	Inch Ref.	Inch Ref.	Inch +0.06 -0.06	UNF - 3A* UNF - 3B*	Ref.	Inch +0.06 -0.06	Inch +0.010 -0.010	Inch Ref.	Inch Ref.	Inch +0.010 -0.062	Inch +0.002 -0.010	Inch - lbs.	lbs.	lbs. Ref.
ADYE3(L) ADY3(L)	.1900	.781	.560	.337	.301	.531	1.562 1.625	5/16 - 24	16°	1.000 .750	.500	.515	.562	.250	.375	0.5-6.0	2425	.07 .08
ADYE3-101(L) ADY3-101(L)	.1900	.750	.500	.220	.319	.437	1.500 1.375	5/16 - 24	15°	1.000 .750	.437	.452	.500	.250	.375	0.5-6.0	4060**	.07 .06
ADYE4(L) ADY4(L)	.2500	1.000	.593	.265	.390	.593	1.938 1.625	3/8 - 24	23°	1.250 .937	.562	.577	.625	.250	.437	1.0-15.0	7040**	.11 .11
ADYE5(L) ADY5(L)	.3125	1.125	.813	.355	.512	.781	2.125 1.812	7/16 - 20	23°	1.375 1.062	.625	.640	.688	.250	.500	1.0-15.0	8260	.16 .18
ADYE6(L) ADY6(L)	.3750	1.125	.813	.355	.512	.781	2.125 1.812	7/16 - 20	23°	1.375 1.062	.625	.640	.688	.250	.500	1.0-15.0	8260	.15 .17
ADYE7(L) ADY7(L)	.4375	1.312	.875	.355	.618	.875	2.437 2.125	1/2 - 20	22°	1.500 1.125	.750	.765	.812	.250	.562	1.0-15.0	12420	.25 .26
ADYE8(L) ADY8(L)	.5000	1.500	.937	.411	.730	1.000	2.625 2.625	5/8 - 18	20°	1.625 1.500	.875	.890	.938	.375	.687	1.0-15.0	17430	.39 .40
ADYE10(L) ADY10(L)	.6250	1.750	1.200	.577	.856	1.250	2.875 2.875	3/4 - 16	20°	1.750 1.750	1.000	1.015	1.125	.375	.812	1.0-15.0	23620	.62 .63
ADYE12(L) ADY12(L)	.7500	2.000	1.280	.630	.970	1.375	3.375 3.375	7/8 - 14	18°	1.875 1.875	1.125	1.140	1.250	.500	.937	1.0-24.0	30550	.90 .87
ADYE14(L) ADY14(L)	.8750	2.200	1.400	.635	1.140	1.531	3.750 3.750	7/8 - 14	18°	2.000 2.000	1.125	1.140	1.250	.500	.937	1.0-24.0	31970	1.08 1.01
ADYE16(L) ADY16(L)	1.0000	2.750	1.875	.845	1.278	1.875	4.125 4.125	1 1/4 - 12	21°	2.125 2.125	1.688	1.703	1.813	.562	1.312	1.0-24.0	59510	2.20 2.31
ADYE20(L) ADY20(L)	1.2500	3.125	1.875	1.015	1.523	2.250	5.000 5.000	1 1/4 - 12	21°	2.875 3.125	1.688	1.703	1.813	.562	1.312	1.0-24.0	70060	3.10 3.15

\* UNF-3A = Male Thread. UNF-3B = Female Thread per MIL-S-7742, Rev. D.

\*\* Load based on pin limitation.

#### Notes:

- †Plating: When specified in materials block, body cadmium plated all surfaces per AMS-QQ-P-416.
- Dimensions: Dimensions apply after plating.
- Temperature: Operating temperature range -65° to 350°F (ADY only).
- Qualifications: Liner is approved to AS81820 (ADY series only).
- Options:
  1. For left hand threads, add "L" to prefix. (Examples: ADYEL4(L) or ADYL4(L))
  2. For Keyway or keyslot options add suffix "W" to part number.
  3. For "J" form threads per AS8879, add suffix "J" to part number. (Examples: ADYE4JW(L) or ADY4JW(L))

#### Materials (ADYE & ADY)

Part No.	Ball	Race	Liner	Body
Catalog No.	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE Fabric Bonded to Race I.D. No Lub.Required	4130 Alloy Steel H.T., and Cadmium Plated†
Catalog No. + SS	CRES 440C AMS 5630 Rc55-62	CRES 17-4PH AMS 5643 Rc28-37	PTFE Fabric Bonded to Race I.D. No Lub.Required	CRES 17-4PH AMS 5643 H.T., and Passivated

† Stainless Steel Series may be ordered to NHBB Part Number as indicated.



# SECTION 5

## ROD END BEARINGS – Metal-to-Metal

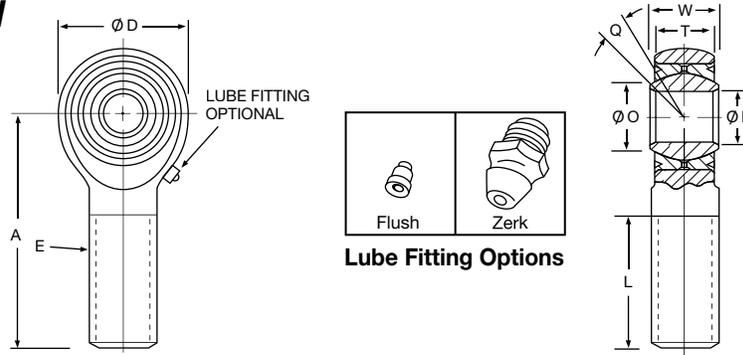
Metal-to-Metal

- 3-Piece Male Thread . . . . .38
- 3-Piece Female Thread . . . . .39
- 3-Piece Heavy Duty – Male & Female Threads . . . . .40
- 3-Piece Standard – Male & Female Threads . . . . .41
- 3-Piece High Misalignment – Male Thread . . . . .42
- 3-Piece High Misalignment – Female Thread . . . . .43



# ROD END BEARINGS – Metal-to-Metal

## 3-Piece Male Thread



Part Number	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(Q) Misalign-ment	(A) Ball C/L to End	(E) Thread Size	(L) Thread Length	Ultimate Static Radial Load*	Weight
	Inch +.0000 -.0005	Inch Max.	Inch +.000 -.005	Inch +.005 -.005	Inch Ref.	Inch Ref.	Ref.	Inch +.06 -.06	UNF - 3A	Inch +.06 -.06	lbs.	lbs. Ref.
AB3E101	.1900	.875	.500	.337	.318	.593	23°	1.812	3/8 - 24	1.062	6840	.09
AB3E	.1900	.781	.437	.337	.301	.531	16°	1.562	5/16 - 24	1.000	5170	.07
AB4E101	.2500	.875	.500	.327	.318	.593	23°	1.812	3/8 - 24	1.062	6840	.09
AB4E	.2500	.781	.437	.337	.301	.531	16°	1.562	5/16 - 24	1.000	5170	.07
ARB4E	.2500	.750	.375	.281	.376	.531	13°	1.562	5/16 - 24	1.000	4550	.06
AB5E	.3125	.875	.437	.327	.402	.593	14°	1.875	5/16 - 24	1.062	6840	.08
ARB5E	.3125	.875	.437	.344	.402	.593	12°	1.875	3/8 - 24	1.250	6940	.09
AB6E101	.3750	1.312	.812	.577	.468	.937	22°	2.531	7/16 - 20	1.500	15150	.28
AB6E	.3750	1.000	.500	.406	.472	.687	10.5°	1.938	3/8 - 24	1.250	9540	.12
ARB6E	.3750	1.000	.500	.406	.472	.687	10.5°	1.938	7/16 - 20	1.250	9540	.13
AB7E	.4375	1.125	.562	.442	.544	.781	11.5°	2.125	7/16 - 20	1.375	10430	.17
ARB7E	.4375	1.125	.562	.437	.544	.781	12°	2.125	1/2 - 20	1.375	10350	.19
AB8E	.5000	1.312	.625	.515	.614	.875	9.5°	2.438	1/2 - 20	1.500	18620	.28
ARB8E	.5000	1.312	.625	.500	.614	.875	10.5°	2.438	5/8 - 18	1.500	18210	.30
AB10E	.6250	1.500	.750	.567	.752	1.062	12.5°	2.625	5/8 - 18	1.625	20030	.41
ARB10E	.6250	1.500	.750	.562	.752	1.062	13°	2.625	3/4 - 16	1.625	19890	.47
AB12E	.7500	1.750	.875	.640	.894	1.250	13.5°	2.875	3/4 - 16	1.750	28200	.63
ARB12E	.7500	1.750	.875	.687	.894	1.250	11°	2.875	7/8 - 14	1.750	29740	.70
AB14E	.8750	2.000	.875	.750	1.060	1.375	7°	3.375	7/8 - 14	1.875	42390	.90
ARB14E	.8750	2.000	.875	.765	1.062	1.375	6°	3.375	1 - 12	1.875	43040	1.07
AB16E	1.0000	2.750	1.375	1.000	1.275	1.875	15°	4.125	1 1/4 - 12	2.125	77500	2.50
ARB16E	1.0000	2.750	1.375	1.015	1.275	1.875	14.5°	4.124	1 1/4 - 12	2.125	78410	2.50
AB20E	1.2500	2.875	1.500	1.140	1.460	2.093	12°	5.000	1 1/2 - 12	3.125	66620	3.10
ARB20E	1.2500	2.875	1.500	1.250	1.460	2.093	7.5°	5.000	1 1/2 - 12	3.125	86380	3.80

\* Load ratings are for rod ends without lubricators.

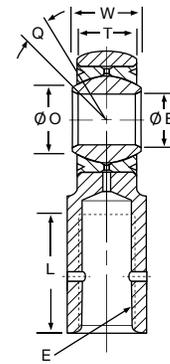
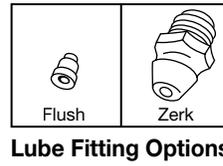
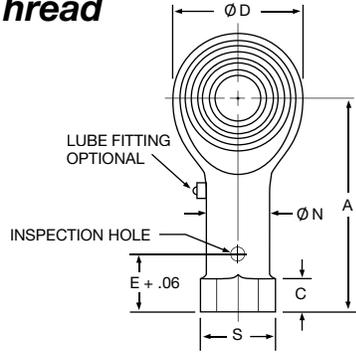
### Notes:

- Radial Clearance: .002 max.
- † Plating: When specified in materials block, ball spherical diameter and ends are hard chrome plated per AMS-QQ-C-320, CL. 2 (.0002 to .0005 thickness). All external surfaces of race and/or body are cadmium plated per AMS-QQ-P-416.
- Dimensions: All dimensions apply after plating.
- Options: Radial clearance, lubrication holes and groove in ball, lubrication fittings, dry film lubrication, keyways, left hand or AS8879 threads see page 39.

### Materials

Part No.	Ball	Race	Body
Catalog No. †	52100 Alloy Steel, H.T., Chrome Plated Rc59-63	Aluminum Bronze (AMS 4635 and ASTM B 50/B150M) Cadmium Plated	4130 Alloy Steel, H.T., Cadmium Plated
Catalog No. + S†	"	4130 Alloy Steel, H.T., Cadmium Plated	"
Catalog No. + SS†	"	CRES 17-4PH AMS5643	CRES 17-4PH AMS5643
Catalog No. + CR	CRES 440C AMS5630	"	"
Catalog No. + CR†	CRES 440C, AMS5630 Chrome Plated	"	"

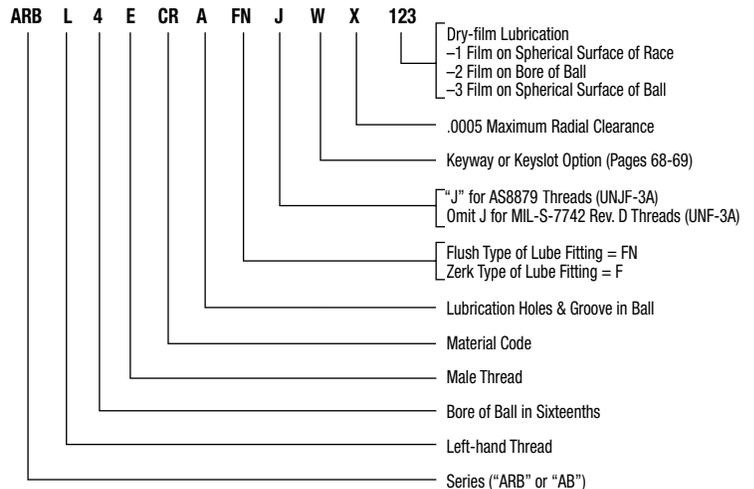
### 3-Piece Female Thread



Part Number	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(A) Ball C/L to End	(E) Thread Size	(Q) Misalignment	(L) Thread Depth	(N) Shank Diameter	(S) Flange Diameter	(C) Flange Thickness	Ultimate Static Radial Load*	Weight
	Inch +.0000 -.0005	Inch Max.	Inch +.000 -.005	Inch +.005 -.005	Inch Ref.	Inch Ref.	Inch +.06 -.06			Inch +.00 -.09	Inch +.010 -.010	Inch Ref.	Inch Ref.	lbs.	lbs. Ref.
AB3	.1900	.781	.437	.337	.301	.531	1.375	5/16 - 24	16°	.750	.437	.500	.180	5170	.06
AB3-101	.1900	.781	.437	.337	.301	.531	1.000	1/4 - 28	16°	.375	.375	.440	.180	5170	.06
AB3-102	.1900	.781	.437	.337	.301	.531	1.375	1/4 - 28	16°	.750	.375	.440	.180	5170	.07
AB3-103	.1900	.875	.500	.337	.318	.593	1.625	5/16 - 24	23°	.750	.500	.560	.180	6840	.11
AB4	.2500	.781	.437	.337	.301	.531	1.375	1/4 - 28	16°	.750	.375	.440	.180	5170	.07
AB4-101	.2500	.781	.437	.337	.301	.531	1.469	5/16 - 24	16°	.750	.437	.500	.180	5170	.08
AB4-102	.2500	.875	.500	.327	.318	.593	1.625	5/16 - 24	24°	.750	.500	.560	.180	6680	.10
AB4-103	.2500	.750	.375	.296	.376	.531	1.312	1/4 - 28	11°	.750	.375	.440	.180	4750	.06
ARB4	.2500	.750	.375	.281	.376	.531	1.312	1/4 - 28	13°	.750	.375	.437	.180	4550	.06
AB5	.3125	.875	.437	.327	.402	.593	1.375	5/16 - 24	14°	.750	.437	.500	.180	6680	.08
ARB5	.3125	.875	.437	.344	.402	.593	1.375	5/16 - 24	12°	.750	.437	.500	.180	6940	.07
AB6	.3750	1.000	.500	.406	.472	.687	1.625	3/8 - 24	10.5°	.937	.562	.620	.180	9540	.12
ARB6	.3750	1.000	.500	.406	.472	.687	1.625	3/8 - 24	10.5°	.937	.562	.625	.180	9540	.12
AB7	.4375	1.125	.562	.442	.544	.781	1.812	7/16 - 20	11.5°	1.062	.625	.680	.180	10430	.18
ARB7	.4375	1.125	.562	.437	.544	.781	1.812	7/16 - 20	12°	1.062	.625	.750	.180	10350	.18
AB8	.5000	1.312	.625	.515	.614	.875	2.125	1/2 - 20	9.5°	1.125	.750	.870	.180	18620	.28
ARB8	.5000	1.312	.625	.500	.614	.875	2.125	1/2 - 20	10.5°	1.187	.750	.875	.180	18210	.28
AB10	.6250	1.500	.750	.567	.752	1.062	2.625	5/8 - 18	12.5°	1.500	.875	.930	.250	20030	.42
ARB10	.6250	1.500	.750	.562	.752	1.062	2.500	5/8 - 18	13°	1.500	.875	.937	.250	19890	.42
AB12	.7500	1.750	.875	.640	.894	1.250	2.875	3/4 - 16	13.5°	1.750	1.000	1.060	.250	28200	.63
ARB12	.7500	1.750	.875	.687	.894	1.250	2.875	3/4 - 16	11°	1.750	1.000	1.062	.250	29740	.63
ARB14	.8750	2.000	.875	.765	1.062	1.375	3.375	7/8 - 14	6°	1.875	1.125	1.187	.312	43040	.90
ARB16	1.0000	2.750	1.375	1.015	1.275	1.875	4.125	1 - 12	14.5°	2.125	1.250	1.312	.375	78410	2.00
ARB20	1.2500	2.875	1.500	1.250	1.460	2.093	5.000	1 1/4 - 12	7.5°	3.125	1.688	1.750	.375	86380	3.10

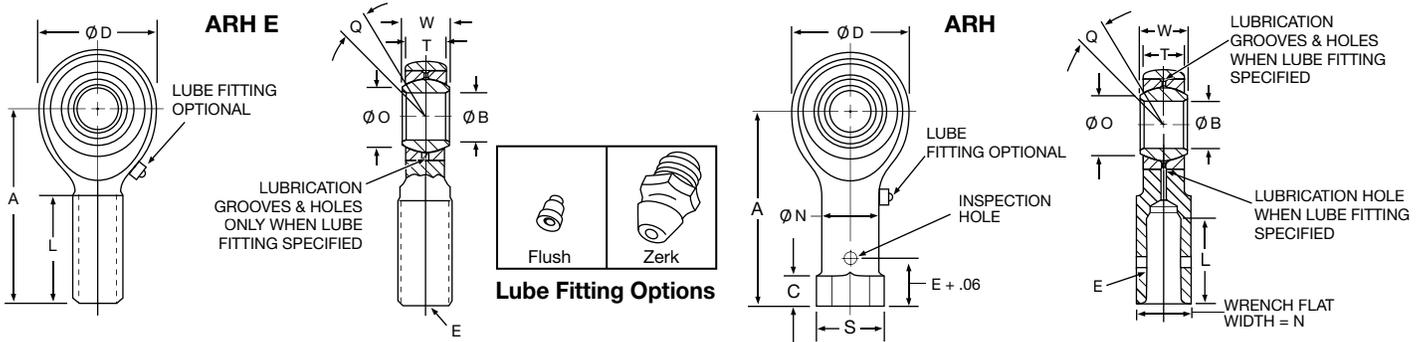
\* Load ratings are for rod ends without lubrication fittings.

#### NHBB P/N



# ROD END BEARINGS – Metal-to-Metal

## 3-Piece Heavy Duty – Male & Female Threads



Part Number	(B)	(D)	(W)	(T)	(O)	Ball Diameter	(A)	(E)	(L)	(Q)	(N)	(S)	(C)	Static Radial Limit Load**		Weight
	Bore Diameter	Head Diameter	Ball Width	Body Width	Shoulder Diameter		Ball C/L to End	Thread Size	Thread Length	Misalignment	Shank Diameter	Flange Diameter	Flange Thickness	Steel Race	Bronze Race	
	Inch +.0005 -.0005	Inch +.010 -.010	Inch +.000 -.005	Inch +.005 -.005	Inch Ref.	Inch Ref.	Inch +.010 -.010	UNF - 3A* UNF - 3B*	Inch +.031 -.031		Inch Ref.	Inch Ref.	Inch +.010 -.062	lbs.	lbs.	lbs.
ARH4E	.2500	.806	.375	.337	.375	.531	1.562	5/16 - 24	.968	5°				6060	6060	.067
ARH4							1.469		.750		.485	.562	.188			.084
ARH5E	.3125	.900	.437	.327	.401	.593	1.875	3/8 - 24	1.187	14°				7290	7290	.095
ARH5							1.625		.875		.547	.625	.250			.102
ARH6E	.3750	1.025	.500	.416	.471	.687	1.938	7/16 - 20	1.187	9°				8860	8860	.140
ARH6							1.812		1.000		.610	.687	.250			.160
ARH7E	.4375	1.150	.562	.452	.542	.781	2.125	1/2 - 20	1.281	10°				9560	9560	.210
ARH7							2.000		1.125		.735	.875	.250			.230
ARH8E	.5000	1.337	.625	.515	.612	.875	2.438	5/8 - 18	1.468	9°				18560	18560	.330
ARH8							2.225		1.250		.860	1.000	.250			.340
ARH10E	.6250	1.525	.750	.577	.752	1.062	2.625	3/4 - 16	1.562	12°				20610	20610	.480
ARH10							2.500		1.375		.985	1.125	.375			.490
ARH12E	.7500	1.775	.875	.644	.892	1.250	2.875	7/8 - 14	1.687	13°				27640	27640	.730
ARH12							2.875		1.625		1.110	1.250	.375			.740

\* UNF-3A = Male Thread, UNF-3B = Female Thread, per MIL-S-7742 Rev. D.

\*\* Load ratings are based on male rod ends without lubrication fitting. For rod end load ratings with lubrication fittings please contact NHBB engineering department.

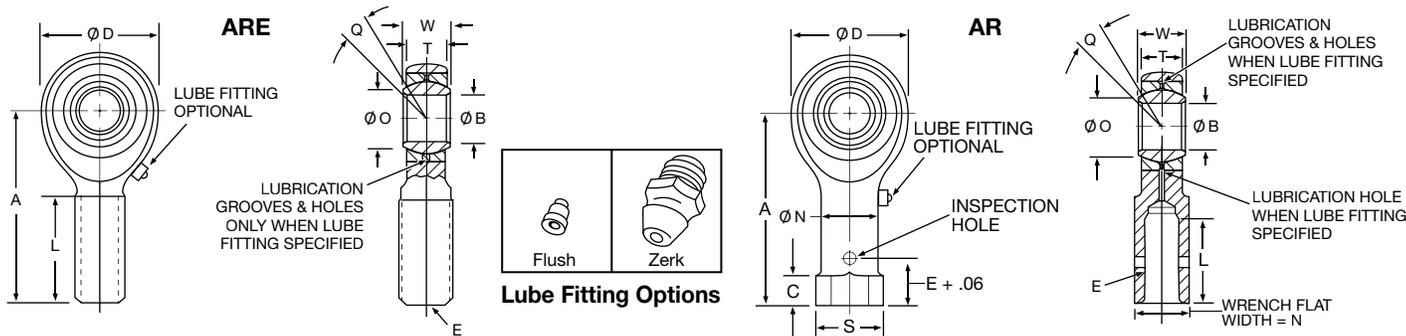
### Notes:

- Radial Clearance: .002 max.
- † Plating: When specified in materials block, ball spherical diameter and ends are hard chrome plated per AMS-QQ-C-320, CL. 2 (.0002 to .0005 thickness). All external surfaces of race and/or body are cadmium plated per AMS-QQ-P-416.
- Unless otherwise noted, part number designation as shown furnished with CRES 410 race material. To specify CRES 17-4PH, add suffix "H" to designation. Example: ARH8ECRPLH or ARH8CRPLH.
- Dimensions: All dimensions apply after plating.
- Options: Radial clearance, lubrication holes and groove in ball, lubrication fittings, dry film lubrication, keyways, left hand or AS8879 threads see page 41.

### Materials

Designation	Ball	Race	Body
Basic Part No.†	52100 Alloy Steel, H.T. & Chrome Plated	4130 Alloy Steel, H.T. & Cad. Plated	C.M. Steel, H.T. & Cad. Plated
Part No. + SS†	52100 Alloy Steel, H.T. & Chrome Plated	Stainless Steel† H.T.	C.M. Steel, H.T. & Cad. Plated
Part No. + CR†	CRES 440C H.T.	Stainless Steel† H.T.	CRES 17-4PH H.T.
Part No. + CRPL†	CRES 440C H.T. & Chrome Plated	Stainless Steel† H.T.	CRES 17-4PH H.T.
Part No. + 501†	52100 Alloy Steel H.T. & Chrome Plated	Aluminum Bronze (AMS 4635 and ASTM B 50/B150M) Cad. Plated	C.M. Steel, H.T. & Cad. Plated

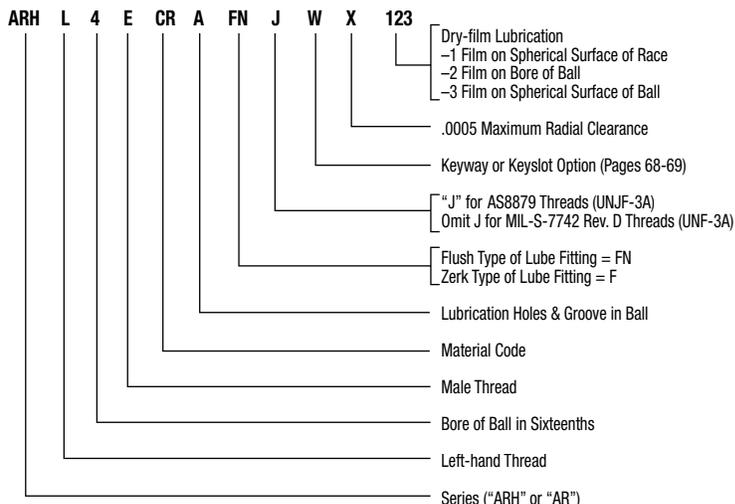
### 3-Piece Standard – Male & Female Threads



Part Number	(B)	(D)	(W)	(T)	(O)	Ball Diameter	(A)	(E)	(L)	(Q)	(N)	(S)	(C)	Static Radial Limit Load**		Weight
	Bore Diameter	Head Diameter	Ball Width	Body Width	Shoulder Diameter		Ball C/L to End	Thread Size	Thread Length	Misalignment	Shank Diameter	Flange Diameter	Flange Thickness	Steel Race	Bronze Race	
	Inch +.0015 -.0005	Inch +.010 -.010	Inch +.000 -.005	Inch +.005 -.005	Inch Ref.	Inch Ref.	Inch +.010 -.010	UNF - 3A* UNF - 3B*	Inch +.031 -.031		Inch +.010 -.010	Inch +.010 -.010	Inch +.010 -.062	lbs.	lbs.	lbs.
AR3E	.1900	.806	.437	.337	.301	.531	1.562	5/16 - 24	.968	16°				4060	4060	.07
AR3							1.375		.750		.422	.500	.188			.08
AR4E	.2500	.806	.437	.337	.301	.531	1.562	5/16 - 24	.968	16°				6060	6060	.07
AR4							1.469		.750		.422	.500	.188			.08
AR5E	.3125	.900	.437	.327	.401	.593	1.875	5/16 - 24	1.187	14°				7290	7290	.08
AR5							1.625		.875		.485	.580	.250			.10
AR6E	.3750	1.025	.500	.416	.471	.687	1.938	3/8 - 24	1.187	9°				8860	8860	.13
AR6							1.812		1.000		.547	.660	.250			.16
AR7E	.4375	1.150	.562	.452	.542	.781	2.125	7/16 - 20	1.281	11°				9560	9560	.18
AR7							2.000		1.125		.610	.720	.250			.21
AR8E	.5000	1.337	.625	.515	.612	.875	2.438	1/2 - 20	1.468	9°				18560	18560	.27
AR8							2.250		1.250		.735	.880	.250			.32
AR10E	.6250	1.525	.750	.577	.752	1.062	2.625	5/8 - 18	1.562	12°				20610	20610	.42
AR10							2.500		1.375		.860	1.020	.375			.48
AR12E	.7500	1.775	.875	.640	.892	1.250	2.875	3/4 - 16	1.687	14°				27640	27640	.63
AR12							2.875		1.625		.985	1.160	.375			.87
AR14E	.8750	2.025	.875	.765	1.061	1.375	3.375	7/8 - 14	2.000	6°				32140	32140	.96
AR14							3.375		1.875		1.110	1.300	.500			.95
AR16E	1.0000	2.775	1.375	1.015	1.275	1.875	4.125	1 1/4 - 12	2.343	14°				72270	72270	2.67
AR16							4.125		2.125		1.688	2.020	.563			2.68

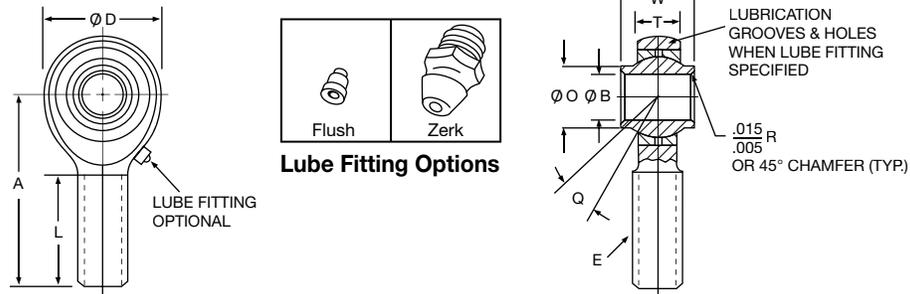
\* UNF-3A = Male Thread, UNF-3B = Female Thread, per MIL-S-7742 Rev. D.  
 \*\* Load ratings are based on male rod ends without lubrication fitting.  
 For rod end load ratings with lubrication fittings please contact NHBB engineering department.  
 † Load based on pin limitation.

#### NHBB P/N



# ROD END BEARINGS – Metal-to-Metal

## 3-Piece High Misalignment – Male Thread



Part Number	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(A) Ball C/L to End	(E) Thread Size	(L) Thread Length	(Q) Misalignment	Limit Static Radial Load**	Weight
	Inch +.0000 -.0005	Inch Max.	Inch +.000 -.005	Inch +.005 -.005	Inch Ref. -.005	Inch Ref.	Inch +.06 -.06	UNF - 3A*	Inch +.06 -.06	Ref.	lbs.	lbs. Ref.
ARY3	.1900	.781	.560	.337	.301	.531	1.562	5/16 - 24	1.000	16°	4060 ◇	.07
ARY3-101	.1900	.750	.500	.220	.319	.437	1.500	5/16 - 24	1.000	15°	4060 ◇	.07
ARY4	.2500	1.000	.593	.265	.390	.593	1.938	3/8 - 24	1.250	23°	7040 ◇	.11
ARY5	.3125	1.125	.813	.355	.512	.781	2.125	7/16 - 20	1.375	23°	8260	.16
ARY5-101	.3125	.875	.625	.265	.418	.593	1.875	5/16 - 24	1.062	16°	5290	.09
ARY 6	.3750	1.125	.813	.355	.512	.781	2.125	7/16 - 20	1.375	23°	8260	.15
ARY7	.4375	1.312	.875	.355	.618	.875	2.437	1/2 - 20	1.500	22°	12420	.25
ARY8	.5000	1.500	.937	.411	.730	1.000	2.625	5/8 - 18	1.625	20°	17430	.39
ARY10	.6250	1.750	1.200	.577	.856	1.250	2.875	3/4 - 16	1.750	20°	23620	.62
ARY12	.7500	2.000	1.280	.630	.970	1.375	3.375	7/8 - 14	1.875	18°	30550	.90
ARY14	.8750	2.200	1.400	.635	1.140	1.531	3.750	7/8 - 14	2.000	18.5°	31970	1.08
ARY16	1.0000	2.750	1.875	.845	1.278	1.875	4.125	1 1/4 - 12	2.125	21°	59510	2.20
ARY20	1.2500	3.125	1.875	1.015	1.523	2.250	5.000	1 1/4 - 12	2.875	21°	70060	3.10

\* UNF-3A = Male Thread, per MIL-S-7742 Rev. D.

\*\* Load ratings are for rod ends without lubrication fittings.

◇ Based on pin limitation.

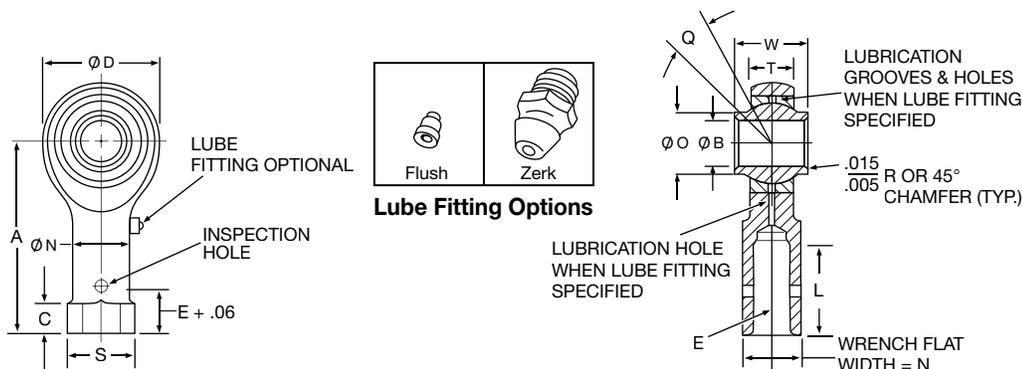
### Notes:

- Radial Clearance: .002 max.
- † Plating: When specified in materials block, ball spherical diameter and ends are hard chrome plated per AMS-QQ-C-320, CL. 2 (.0002 to .0005 thickness). All external surfaces of race and/or body are cadmium plated per AMS-QQ-P-416.
- Dimensions: All dimensions apply after plating.
- Options: Radial clearance, lubrication holes and groove in ball, lubrication fittings, dry film lubrication, keyways, left hand or AS8879 threads see page 43.

### Materials

Part No.	Ball	Race	Body
Catalog No. †	52100 Alloy Steel, H.T., Chrome Plated Rc59-63	Aluminum Bronze, (AMS 4635 and ASTM B 50/B150M) Cadmium Plated	4130 Alloy Steel, H.T., Cadmium Plated
Catalog No. + S†	"	4130 Alloy Steel, H.T., Cadmium Plated	"
Catalog No. + SS†	"	CRES 17-4PH AMS5643	CRES 17-4PH AMS5643
Catalog No. + CR†	CRES 440C AMS5630	"	"
Catalog No. + CRP†	CRES 440C, AMS5630 Chrome Plated.	"	"

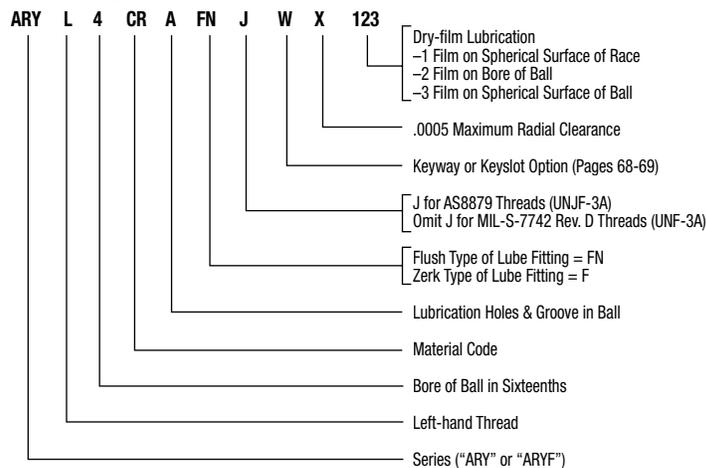
### 3-Piece High Misalignment – Female Thread



Part Number	(B) Bore Diameter	(D) Head Diameter	(W) Ball Width	(T) Body Width	(O) Shoulder Diameter	Ball Diameter	(A) Ball C/L to End	(E) Thread Size	(L) Thread Length	(Q) Misalignment	(N) Shank Diameter	(S) Flange Diameter	(C) Flange Thickness	Limit Static Radial Load**	Weight
	Inch +.0000 -.0005	Inch Max.	Inch +.000 -.005	Inch +.005 -.005	Inch Ref.	Inch Ref.	Inch +.06 -.06	UNF - 3B*	Inch +.06 -.06	Ref.	Inch +.010 -.010	Inch Ref.	Inch Ref.	lbs. Ref.	lbs. Ref.
ARYF3	.1900	.781	.560	.337	.301	.531	1.625	5/16 - 24	.750	16°	.500	.562	.250	4060 ◇	.08
ARYF3-101	.1900	.750	.500	.220	.319	.437	1.375	5/16 - 24	.750	15°	.437	.500	.250	4060 ◇	.06
ARYF4	.2500	1.000	.593	.265	.390	.593	1.625	3/8 - 24	.937	23°	.562	.625	.250	7040 ◇	.11
ARYF5	.3125	1.125	.813	.355	.512	.781	1.812	7/16 - 20	1.062	23°	.625	.688	.250	8260	.18
ARYF5-101	.3125	.875	.625	.265	.418	.593	1.375	5/16 - 24	.750	16°	.437	.500	.250	5290	.10
ARYF6	.3750	1.125	.813	.355	.512	.781	1.812	7/16 - 20	1.062	23°	.625	.688	.250	8260	.17
ARYF7	.4375	1.312	.875	.355	.618	.875	2.125	1/2 - 20	1.125	22°	.750	.812	.250	12420	.26
ARYF8	.5000	1.500	.937	.411	.730	1.000	2.625	5/8 - 18	1.500	20°	.875	.938	.375	17430	.40
ARYF10	.6250	1.750	1.200	.577	.856	1.250	2.875	3/4 - 16	1.750	20°	1.000	1.125	.375	23620	.63
ARYF12	.7500	2.000	1.280	.630	.970	1.375	3.375	7/8 - 14	1.875	18°	1.125	1.250	.500	30550	.87
ARYF14	.8750	2.200	1.400	.635	1.140	1.531	3.750	7/8 - 14	2.000	18.5°	1.125	1.250	.500	31970	1.01
ARYF16	1.0000	2.750	1.875	.845	1.278	1.875	4.125	1 1/4 - 12	2.125	21°	1.688	1.813	.562	59510	2.31
ARYF20	1.2500	3.125	1.875	1.015	1.523	2.250	5.000	1 1/4 - 12	3.125	21°	1.688	1.813	.562	70060	3.15

\* UNF-3B = Female Thread per MIL-S-7742 Rev. D.  
 \*\* Load ratings are for rod ends without lubrication fittings.  
 ◇ Based on pin limitation.

#### NHBB P/N





# SECTION 6

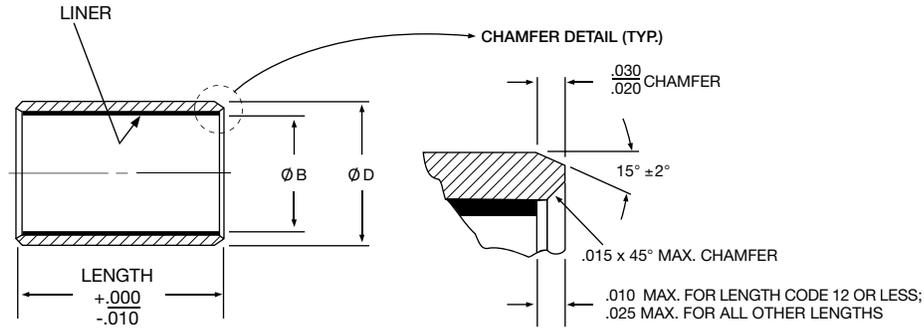
## SLEEVE BEARINGS – Self-Lubricating

AS81934/1 Plain .....	.46
AS81934/2 Flanged .....	.48



# SLEEVE BEARINGS – Self-Lubricating

## AS81934/1 Plain



Part Number	(B) Bore Diameter	(D) Outside Diameter			Weight lbs./In (Ref)		
		Alum. Tol. +.0005/-0.0005	CRES Tol. +.0000/-0.0005	Standard	1st Oversize	2nd Oversize	Alum. L = 1.000
	Inch					lb/in	lb/in
<b>M81934/1</b>	+0.0000 -0.0010						
AD04	.2512	.3760	.3860	.3960	.006	.016	
AD05	.3140	.4386	.4486	.4586	.007	.019	
AD06	.3765	.5012	.5112	.5212	.008	.022	
AD07	.4390	.5638	.5738	.5838	.009	.025	
AD08	.5015	.6265	.6365	.6465	.011	.028	
AD09	.5640	.6892	.6992	.7092	.012	.031	
AD10	.6265	.8142	.8242	.8342	.021	.056	
AD11	.6890	.8767	.8867	.8967	.022	.060	
AD12	.7515	.9393	.9493	.9593	.024	.065	
AD14	.8765	1.0645	1.0745	1.0845	.028	.075	
AD16	1.0015	1.1898	1.1998	1.2098	.031	.084	
AD18	1.1265	1.3148	1.3248	1.3348	.035	.094	
AD20	1.2515	1.4398	1.4498	1.4598	.038	.103	
AD22	1.3765	1.5648	1.5748	1.5848	.041	.113	
AD24	1.5015	1.7523	1.7623	1.7723	.062	.171	
AD26	1.6265	1.8773	1.8873	1.8973	.067	.183	
AD28	1.7515	2.0023	2.0123	2.0223	.071	.196	
AD32	2.0015	2.2523	2.2623	2.2723	.081	.222	

### Notes:

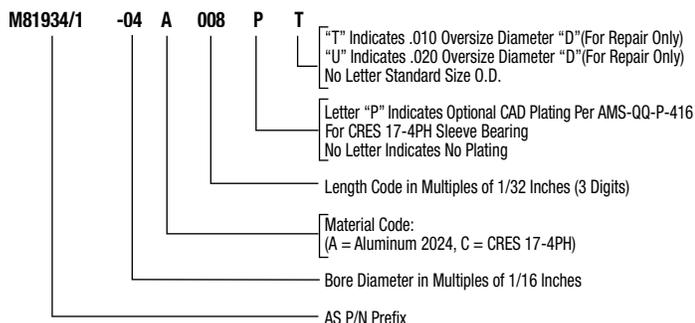
- Static Limit Load:  
Alum., 50,000 psi X B(L - .10) = lbs.  
CRES, 78,500 psi X B(L - .10) = lbs.
- Dynamic Capacity: 37,500 X B(L - .10) = lbs.
- Temperature: Operating temperature range -65° to 325°F.
- Concentricity tolerance between B and D diameters shall not exceed .003 FIM.
- Bearings listed in table are approved for procurement to AS81934 .

### Materials

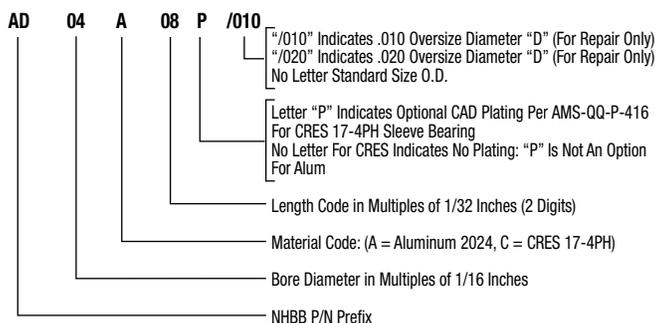
Material Code	Sleeve	Liner
A	Aluminum Alloy 2024-T851 or 2024-T8511 per AMS-QQ-A-225/6 or AMS-QQ-A-200/3.Finish Anodized per AMS-A-8625, Type I or II or Alodine per AMS-C-5541	PTFE/Fabric Bonded to Bore, No Lub. Required
C	CRES 17-4PH H.T. to Condition H-1150 per AMS-H-6875	



### Aerospace Standard P/N



### NHBB P/N



### Length (Tolerance +.000, -.010)

Bore Code	5/32	3/16	7/32	1/4	9/32	5/16	11/32	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 3/4	3
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12				08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52									
14				08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52									
16				08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60							
18					10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60								
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22								12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68					
24								12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	
26										16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96
28										16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96
32										16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96

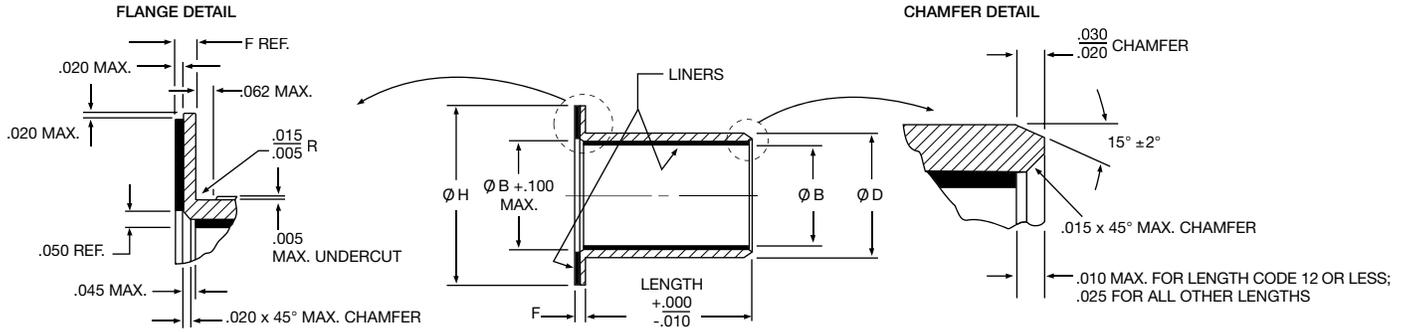
### Shaft and Housing Information

For optimum performance with lined sleeve bearings, considerable care must be exercised in the design of housings and shafts. For extreme applications involving dissimilar materials, elevated temperatures, or extreme loads, contact NHBB Applications Engineering for application recommendations. The adjacent table applies to normal conditions.

	Shaft	Housing
Diameter	B - .001 to - .002	D - .0006 to - .0011
Taper and Roundness	Not to exceed .0005	Not to exceed .0005
Finish	8 max. Polished or honed after grind	
Hardness	Rc50 min.	

# SLEEVE BEARINGS – Self-Lubricating

## AS81934/2 Flanged



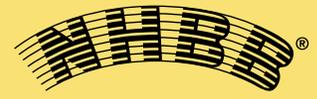
Part Number	(B) Bore Diameter	(D) Outside Diameter			(H) Flange Diameter	(F) Flange Thickness	Approx. Sleeve Weight		Flange Weight			
		Alum. Tol. +.0005/- .0005	CRES Tol. +.0000/- .0005	Standard			1st Oversize	2nd Oversize	LB. In. (Ref.) L = 1.000	CRES	Alum.	CRES
	Inch				Inch	Inch	Inch	Inch	lb/in	lb/in		
<b>M81934/2</b>	+ .0000 - .0010				+ .000 - .020	+ .000 - .005	- .005 - .005					
ADLF04	.2515	.3760	.3860	.3960	.750	.0625	.006	.016	.002	.006		
ADLF05	.3140	.4386	.4486	.4586	.812	.0625	.007	.019	.003	.007		
ADLF06	.3765	.5012	.5112	.5212	.875	.0625	.008	.022	.003	.007		
ADLF07	.4390	.5638	.5738	.5838	.937	.0625	.009	.025	.003	.008		
ADLF08	.5015	.6265	.6365	.6465	1.000	.0625	.011	.028	.003	.009		
ADLF09	.5640	.6892	.6992	.7092	1.125	.0625	.012	.031	.004	.011		
ADLF10	.6265	.8142	.8242	.8342	1.250	.0625	.021	.056	.005	.014		
ADLF11	.6890	.8767	.8867	.8967	1.375	.0625	.022	.060	.006	.016		
ADLF12	.7515	.9393	.9493	.9593	1.500	.0625	.024	.065	.007	.020		
ADLF14	.8765	1.0645	1.0745	1.0845	1.625	.0625	.028	.075	.008	.022		
ADLF16	1.0015	1.1898	1.1998	1.2098	1.750	.0625	.031	.084	.009	.024		
ADLF18	1.1265	1.3148	1.3248	1.3348	1.875	.0937	.035	.094	.015	.041		
ADLF20	1.2515	1.4398	1.4498	1.4598	2.000	.0937	.038	.103	.016	.045		
ADLF22	1.3765	1.5648	1.5748	1.5848	2.125	.0937	.041	.113	.017	.048		
ADLF24	1.5015	1.7523	1.7623	1.7723	2.250	.0937	.062	.171	.018	.051		
ADLF26	1.6265	1.8773	1.8873	1.8973	2.375	.0937	.067	.183	.020	.055		
ADLF28	1.7515	2.0023	2.0123	2.0223	2.500	.0937	.071	.196	.021	.058		
ADLF32	2.0015	2.2523	2.2623	2.2723	2.750	.0937	.081	.222	.023	.065		

### Notes:

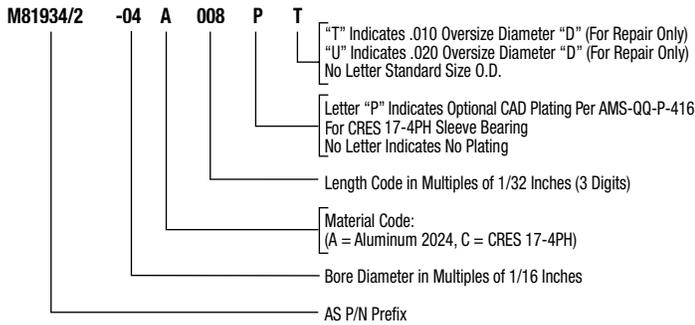
- Static Limit Load:  
Alum., 50,000 psi X B(L + F - .13) = lbs.  
CRES, 78,500 psi X B(L + F - .13) = lbs.
- Dynamic Capacity: 37,500 X B(L + F - .13) = lbs.
- Temperature: Operating temperature range -65° to 325°F.
- Concentricity tolerance between B and D diameters shall not exceed .003 FIM.
- Bearings listed in table are approved for procurement to AS81934.

### Materials

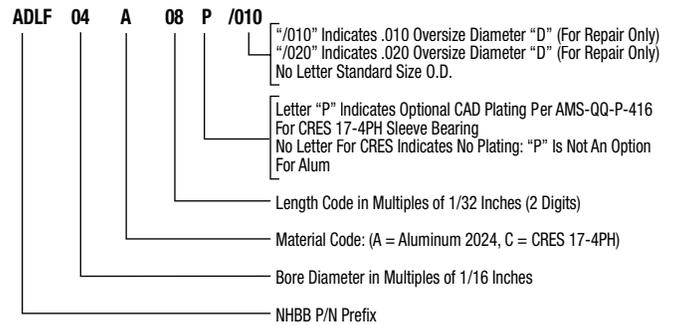
Material Code	Sleeve	Liner
A	Aluminum Alloy 2024-T851 or 2024-T8511 per AMS-QQ-A-225/6 or AMS-QQ-A-200/3. Finish Anodized per AMS-A-8625, Type I or II or Alodine per AMS-C-5541	PTFE/Fabric Bonded to Bore and Flange Face. No Lub. Required.
C	CRES 17-4PH H.T. to Condition H-1150 per AMS-H-6875	"



### Aerospace Standard P/N



### NHBB P/N



### Length (Tolerance +.000, -.010)

Bore Code	5/32	3/16	7/32	1/4	9/32	5/16	11/32	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 3/4	3
04	05	06	07	08	09	10	11	12	14																					
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24								12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	
26									16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96	
28									16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96	
32									16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96	

### Shaft and Housing Information

For optimum performance with lined sleeve bearings, considerable care must be exercised in the design of housings and shafts. For extreme applications involving dissimilar materials, elevated temperatures, or extreme loads, contact NHBB Applications Engineering for application recommendations. The adjacent table applies to normal conditions.

	Shaft	Housing
Diameter	B - .001 to - .002	D - .0006 to - .0011
Taper and Roundness	Not to exceed .0005	Not to exceed .0005
Finish	8 max. Polished or honed after grind	
Hardness	Rc50 min.	



# SECTION 7

## ENGINEERING

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## Product Applications

NHBB manufactures many different styles of spherical, rod end, and sleeve bearings. NHBB products are used extensively in the aerospace industry in rotary wing aircraft, fixed wing aircraft, and jet engine applications.

1, 2 and 3 illustrate the various areas in which NHBB bearings continue to find wide acceptance.

**1** Rotary wing aircraft applications for spherical, rod end, and sleeve bearings.

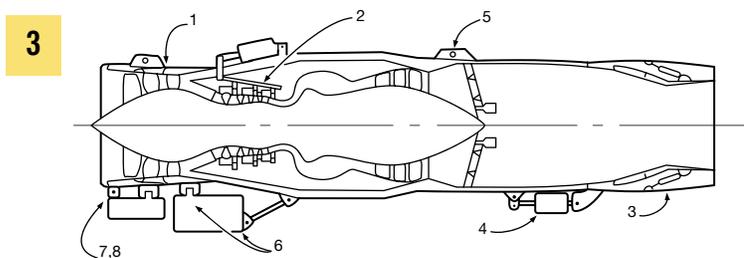
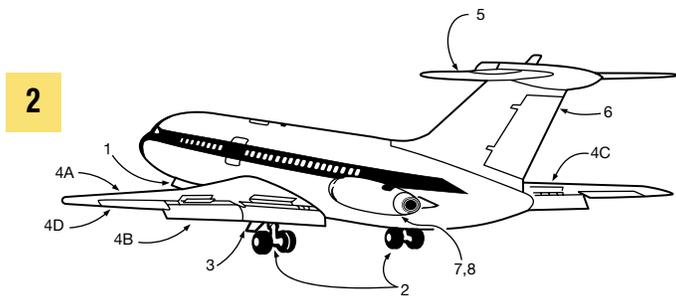
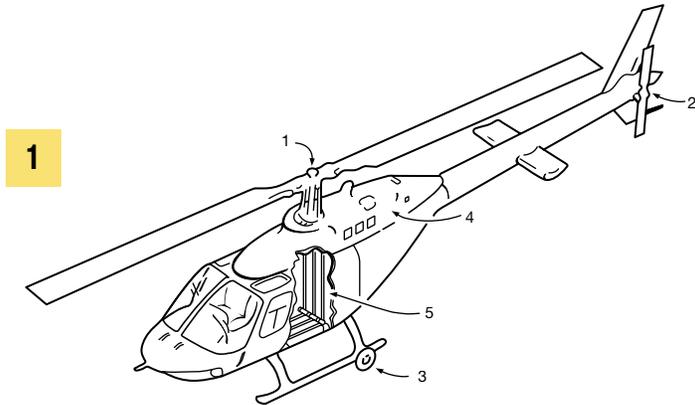
- (1) Main rotor pitch change links, damper bearings, and swashplate bearings;
- (2) tail rotor pitch change links and bearings;
- (3) landing gear actuator and support bearings;
- (4) engine mount bearings;
- (5) controls for main and tail rotor.

**2** Fixed wing aircraft applications for spherical, rod end, track roller, and sleeve bearings.

- (1) Nose landing gear actuator, steering and support bearings;
- (2) main landing gear actuator and support bearings;
- (3) door and canopy actuator and support bearings;
- (4A) leading edge slat actuator and support bearings;
- (4B) trailing edge flap actuator and support bearings;
- (4C) spoiler actuator and support bearings;
- (4D) aileron actuator and support bearings;
- (5) horizontal stabilizer actuator and support bearings;
- (6) vertical stabilizer actuator and support bearings;
- (7) thrust reverser actuator bearings;
- (8) pylon and engine mount bearings.

**3** Jet engine applications for spherical, rod end, track roller, and sleeve bearings.

- (1) Fan, variable geometry actuator bearings;
- (2) compressor, variable geometry actuator bearings;
- (3) variable nozzle, actuator bearings;
- (4) thrust reverser and blocker door actuator and support bearings;
- (5) engine mounts;
- (6) gearbox mounts;
- (7) oil tank mounts;
- (8) oil cooler mounts.



## Bearing Types and Details of Construction

NHBB, Astro Division produces a variety of sliding surface bearings. The construction and material selection of each varies depending on factors such as load, temperature, hardness, and dimensional limitations. NHBB engineers are also pleased to discuss the design and manufacture of special bearing designs.

For a discussion of the available liner and lubrication systems, see pages 59-60 and 66-67, respectively.

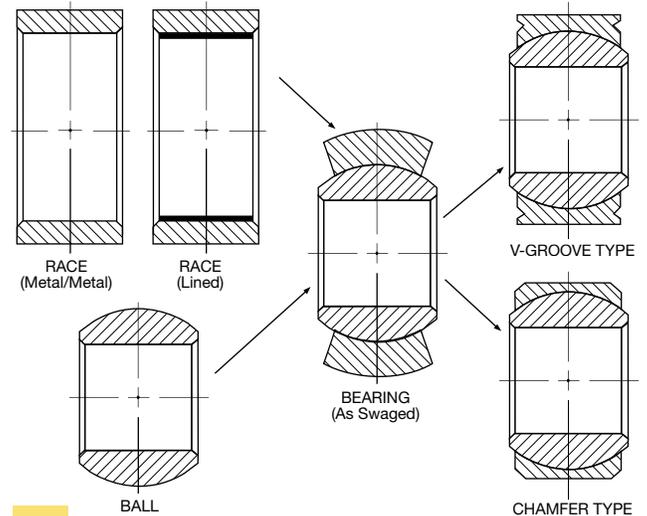
### SWAGED BEARINGS

The primary product of NHBB, Astro Division is the swaged spherical bearing. This bearing is manufactured by swaging a ductile race around a hardened ball. The race is machined and the assembly loosened (released) to obtain proper clearance or torque, or both, and then ground to finished size.

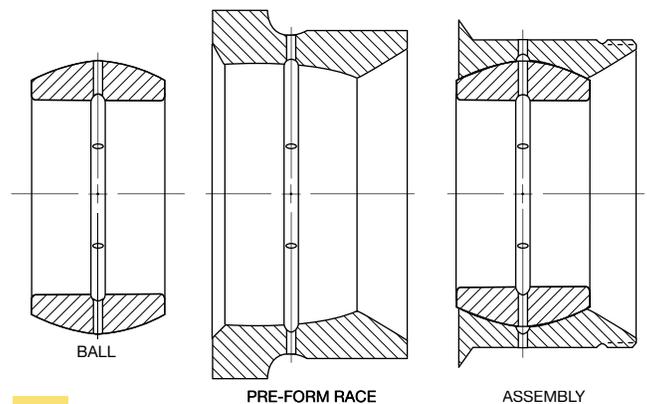
Swaged sphericals normally feature 80% to 100% contact between the race I.D. and the ball O.D. The large contact area between ball and race allows the all-metal bearing to take very high static loads and beryllium copper and PTFE lined bearings to take high static and dynamic loads.

**4** Shows the assembly procedures for a swaged spherical bearing.

An alternative swaging method used when the bearing geometry precludes or renders impractical the double swaging method is shown in **5**. The pre-form design is used when the bearing outer race is not symmetrical about the spherical centerline due to a flange or a wide overhang on one side, or a combination of both. In such case, the problem side of the race is pre-formed by machining and grinding, and the opposite side only is swaged.



**4**



**5**

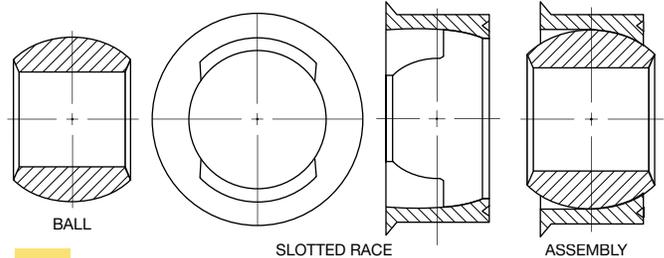
## Bearing Types and Details of Construction

### LOADER SLOT BEARINGS

A loader slot bearing, is a non-swaged bearing type (see **6**). The spherical race ID is fully machined, case hardened, and lapped. The race has entry slots machined 180° apart into one face of the race to facilitate assembly of the ball.

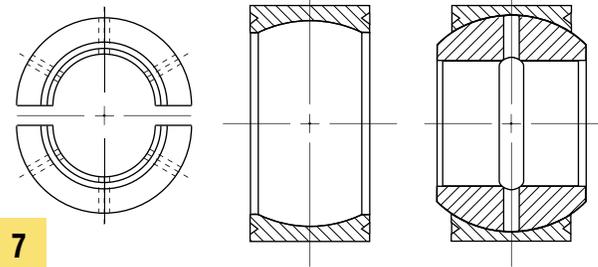
Attributes of this design are:

- Non-swageable race materials can be used.
- Race spherical ID's can be chemically or physically enhanced to improve wear resistance (ie: nitriding or plating).
- Ball replaceability; generally, the ball wears at a more rapid rate than the hardened race spherical ID. The loader slot design allows for the ball to be replaced without removing the bearing assembly from the housing. The net effect is reduced down time and maintenance cost due to on-wing repair.
- Race spherical ID can be lapped to a very close tolerance to provide excellent ball-to-race conformity.
- When required, the race can be designed with the sphere/slot entry intersection off-center. This design provides for a slight entry slot/ball interference (sometimes referred to as pop-in). This prevents the ball from falling out of the slot during shipping or handling.
- Entry slots should be oriented 90° with respect to the load. This bearing is generally recommended for applications with vibratory or static loads where there is small relative motion between the ball and race. This bearing is not recommended for applications where there is moderate to high relative motion between the ball and race under load. Under these conditions for long durations, these bearings exhibit high friction and excessive wear.



**6**

*Loader Slot Bearing*



**7**

*Two-Piece, Split Ball Spherical Bearing*

### SPLIT BALL SPHERICAL BEARINGS

Split ball spherical bearings (see **7**) are designed to offer similar advantages to grease lubricated load slot bearings. Unlike the load slot bearing, there is no loss of bearing area due to the entry slot. Split ball designs are intended for applications only where pin rotation will occur. There is no clamping on the ball faces.

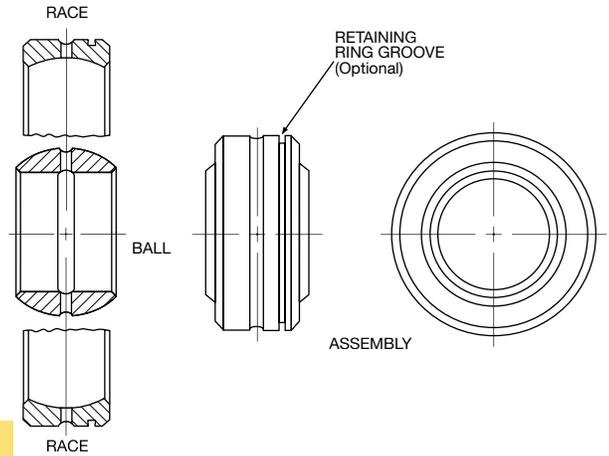
The split ball is machined and ground in matched sets with a “zero” gap at the separation plane. The ball is typically a copper alloy. Like the load slot bearing, the race is fully machined, wear surface hardened, then finished with a lap operation. Because the race is the harder member, wear is intended to occur on the ball. The split ball feature allows the ball to be replaced “on the aircraft” in certain applications.

## FRACTURED RACE BEARINGS

Fractured race bearings (see **8**) are an alternative to loader slot bearings. In this design the race is ground all over (including the race I.D.), notched, and transversely fractured in half.

This bearing has full ball-to-race contact, which reduces stress and results in reduced wear, particularly in high vibration applications. This type of bearing must utilize a very hard race to facilitate the fracturing process.

The advantage of fractured race bearings is that no bearing area is sacrificed. PTFE liners are not usually used in these bearings.



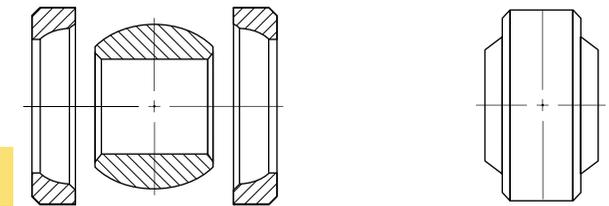
**8**

*Fractured Race Bearing*

## SPLIT RACE BEARINGS

Split race bearings (see **9**) have a race that is circumferentially or transversely split. The resulting two half races are placed around the ball and retained by a housing.

Split race designs are used principally on larger bearings when installation in the application is difficult. These bearings can be made of any material and can incorporate a PTFE liner.

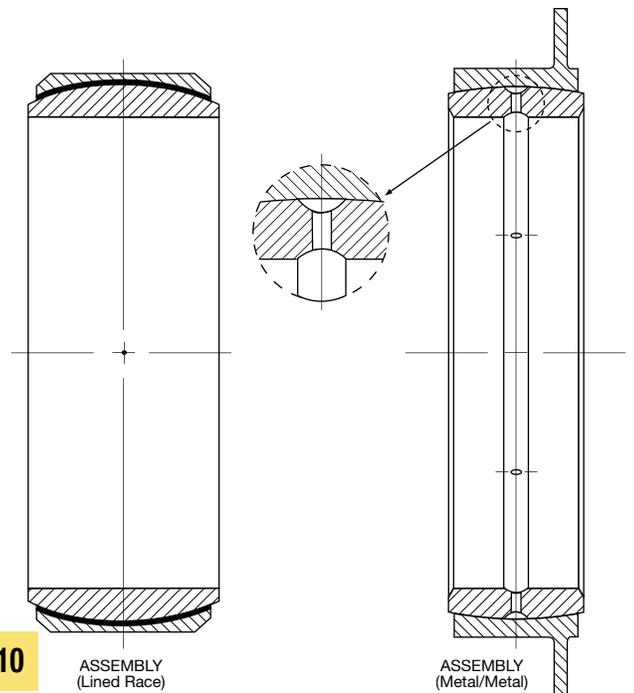


**9**

*Split Race Bearing*

## SNAP-ASSEMBLED BEARINGS

Snap-Assembled bearings, sometimes referred to as “snap-in”, are generally designed with a relatively large diameter, thin cross section, and narrow ball geometries (see **10**). NHBB uses a race width to ball diameter ratio of .20 as a design consideration for this bearing configuration. Snap-assembly is accomplished by deflecting the race, ball, or both within their elastic limits to allow entry of the ball into the race. This type of design is generally used only when all other methods are impractical or impossible due to problem geometry or processing restraints.



**10**

*Snap-Assembled Bearings*

## Bearing Types and Details of Construction

NHBB manufactures two- and three-piece rod ends. Two-piece rod ends consist of a rod end body and a ball. The three-piece rod end consists of a two-piece spherical bearing cartridge pressed and staked into a machined rod end body.

### TWO-PIECE COINED ROD END

The coined two-piece rod end (see 11) is used when maximum strength in a given envelope is required. The coined two-piece rod end has better ball-to-race conformity than a “mohawk rod end”, particularly in the area just above the shank. PTFE liner installation is not possible for this type of rod end.

### TWO-PIECE MOHAWK ROD END

The Mohawk two-piece rod end (see 12) is used for lightly loaded applications. However, head strength is sacrificed. PTFE liners are often used in this type of construction.

### THREE-PIECE ROD END

The three-piece rod end (see 13 & 14) is the standard and preferred construction at NHBB. It offers the best formed ball-to-race conformity and moderate strength. During manufacture, a swaged spherical bearing cartridge is installed in a rod end body and usually retained by staking. The most popular means of retention utilizes the V-groove (see 13). The V-groove is machined into the bearing cartridge race face. The lip formed by this groove is flared over a chamfer in the housing. This method provides moderate thrust capacity and allows a worn bearing to be removed without damaging the housing. Three-piece rod ends may be PTFE lined.

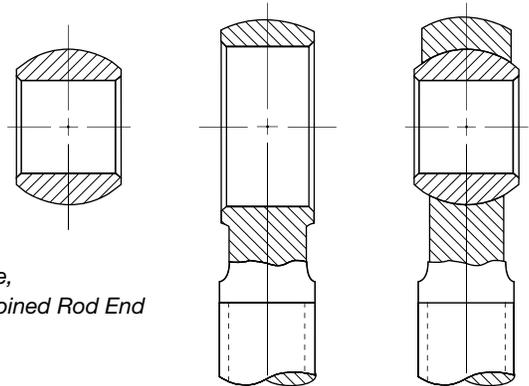
A three-piece housing staked rod end configuration (see 14) is generally used only when other factors such as non-ductile race material, insufficient race face area to facilitate a V-groove, or economy of production are factors.

### LOADER SLOT AND SPLIT BALL ROD ENDS

Loader slot rod ends and split ball rod ends provide alternative two-piece precision ground ball and body construction with the same design benefits of the comparable spherical design. Maximum body strength and bearing projected area is offered by the split ball design because of the omission of the loader slot.

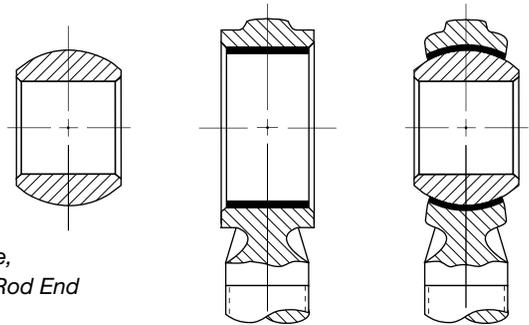
11

Two-Piece,  
Swage-Coined Rod End



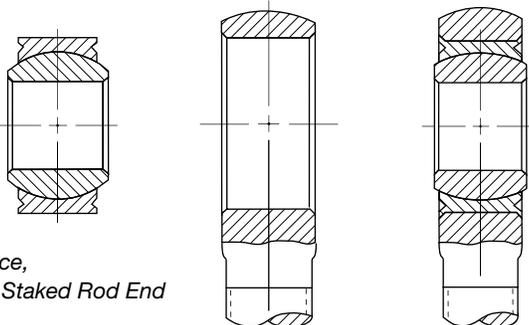
12

Two-Piece,  
Mohawk Rod End



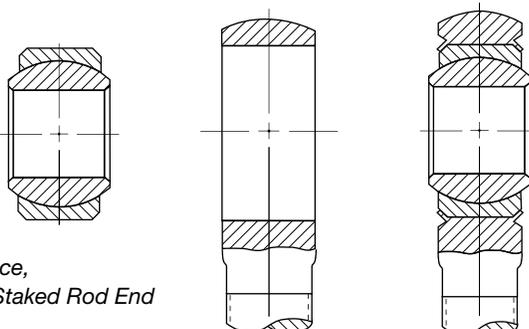
13

Three-Piece,  
V-Groove Staked Rod End



14

Three-Piece,  
Housing Staked Rod End

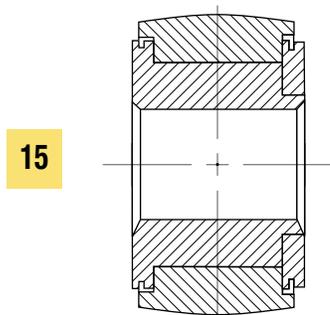


## TRACK ROLLERS

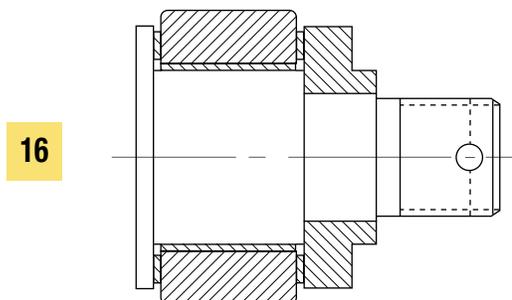
NHBB manufactures track rollers (see **15** and **16**) as an alternative to needle roller bearings. The PTFE composite track roller can be designed to existing needle roller envelope dimensions. The track roller is made up of an outer member (roller) which slides over an inner member (bushing or stud) and these two members sandwich a low friction, low wearing PTFE composite material. The inner and outer members are retained in the axial direction by thrust washers that are either press fit, staked or welded onto the inner member to support axial loading.

Design features of NHBB's track rollers are high load carrying capability, resistance to many corrosive chemicals and environmental contaminants, and the ability to absorb heavy vibratory loads. Sliding surface track rollers offer improved bearing performance over needle rollers with respect to these design features.

While this product may be utilized in many rolling applications, it is not recommended for high rotational speeds or where low needle roller type frictional characteristics are required. For additional information, please contact NHBB Applications Engineering Department.



**15**

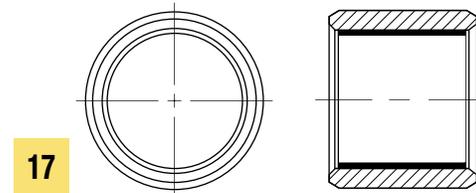


**16**

## SLEEVE BEARINGS (SELF-LUBRICATING) MILITARY SERIES

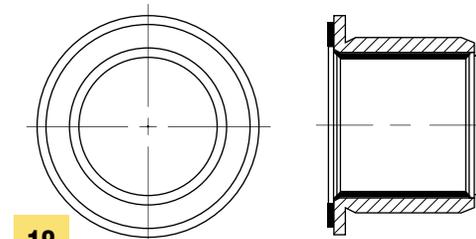
**17** Shows the NHBB AD series which are approved for procurement to M81934/1 P/N series.

**18** Shows the NHBB ADLF series which are approved for procurement to M81934/2 P/N series.



**17**

*Plain, PTFE Lined*



**18**

*Flanged, PTFE Lined*

## Bearing Materials

### BALL, RACE, AND ROD END BODY MATERIALS

In addition to the more common metals, NHBB's engineers and machinists work regularly with exotic materials. A partial list of commonly used ball, race, rod end body, and sleeve materials

is given in table 2. For materials not listed, please contact NHBB for available information.

**TABLE 2: Common Bearing Alloys And Applications**

Application	Corrosion Resistant Steel	Nickel Based	Cobalt Based	Titanium Based	Copper Based	Aluminum Based	Low Alloy Steels
BALL	303 440C PH13-8Mo 15-5PH 17-4PH A-286 BG42® Greek Ascology	Inconel® 718 Inconel® X-750 Rene 41 Waspaloy	Stellite® 3 Stellite® 6 Stellite® 6B L-605 MP35N®	6Al 4V	Al Bronze Al-Ni Bronze Beryllium Copper	2024 6061 7075	4140 4340 52100 M-2 M-42 M-50 Maraging 250 Maraging 300 D-2
RACE	303, 304 410, 416, 422 431, 440C PH13-8Mo 15-5PH 17-4PH A-286 AM-355 Greek Ascology Nitronic® 60 BG42®	Inconel® 718 Inconel® X-750 Monel® 400 Monel® K500 Rene 41 Waspaloy	L-605	6Al 4V 3Al 2.5V	Al Bronze Beryllium Copper	2024 6061 7075	4130 4140 4340 52100 Maraging 300
ROD END/ LINK BODY	303, 316, 321 410, 416 PH13-8Mo 15-5PH 17-4PH A-286 AM-355	Inconel® 718 Inconel® X-750 Rene 41 Waspaloy	MP159® L-605	6Al 4V		2024 7075	1018 4130 4340 Maraging 250 8620
SLEEVE BEARINGS	321 410, 416 430, 440C PH13-8Mo 15-5PH 17-4PH BG42®	Inconel® 718 Inconel® 625 Rene 41 Waspaloy	L-605	6Al 4V	Al Bronze Al-Ni Bronze Beryllium Copper	2024 6061 7075	4130 4140 4340 9310

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 INCONEL® is a registered trademark of Inco Alloys International, Inc. and The International Nickel Company, Inc.  
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 NITRONIC® is a registered trademark of AK Steel Corporation.  
 STELLITE® is a registered trademark of Kennametal, Inc.  
 BG42® is a registered trademark of Latrobe Steel Company.

## Self-Lubricating Liner Systems

Self-lubricating plain bearings incorporate a liner that includes polytetrafluorethylene (PTFE) on the bearing surface. The selection of a bearing liner system is based on factors of load, temperature, speed of oscillation, and the directional nature of the load.

NHBB uses three basic constructions for PTFE liner systems: laminates, woven materials, and metallic-backed composites (see 19, 20, and 21). Each PTFE liner system (except the DU® bearing material which is mechanically

retained) is bonded to the race surface and during use, PTFE transfers to the mating ball surface, forming a lubricating film that is continually replaced throughout the life of the liner material.

PTFE liner systems can also be applied to customer-supplied parts. Flat surfaces, cylindrical O.D.'s, cylindrical I.D.'s, spherical surfaces, and special configurations are routinely lined by NHBB's custom lining department by means of standard hard tooling or autoclave bonding.

### LINER CONSTRUCTION LAMINATES

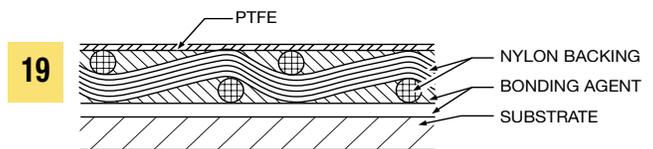
Laminates consist of an open weave backing fabric such as nylon, a porous PTFE bearing sheet, and a thermosetting phenolic adhesive bonding agent. The porous PTFE fabric is compressed into the backing fabric and impregnated with adhesive. Laminate construction is shown in 19.

### WOVEN MATERIALS

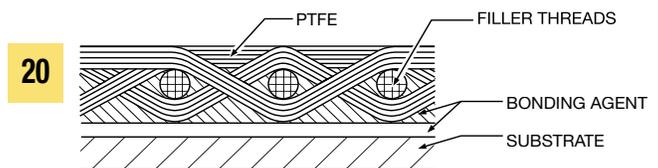
Woven materials consist of PTFE threads inter-woven with high strength fillers such as nylon, Polyester or fiber-glass threads. The majority of the PTFE threads are on the bearing surface while the high-strength filler material supports the PTFE and acts as a bonding surface. As with laminates, the adhesive agent is a thermosetting phenolic. Woven material construction is shown in 20.

### METALLIC-BACKED COMPOSITES

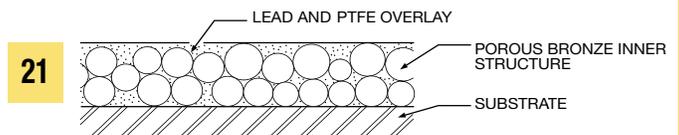
Metallic-backed composites consist of a steel backing, a porous bronze inner structure, and a PTFE and lead overlay. In addition to using bonding techniques, this liner type can also be mechanically retained. Metallic-backed composite construction is shown in 21.



Laminate Construction



Woven Construction



Metallic-Backed Composite Construction

## Self-Lubricating Liner Systems

**TABLE 3: Self-Lubricating PTFE Liner Systems**

Liner Type	AD/AD (L) or AK	K	D	DD
Liner Model	L-1291/L-1420	X-1820	L-1276	X-1470
Construction	PTFE/Nylon Laminate	PTFE/Nylon Weave	PTFE/Polyester Weave	PTFE/Polyester Weave
Thickness	.010-.012	.013-.015	.013-.015	.016-.018
Temperature	-65° to 400°F	-65° to 400°F	-65° to 250°F	-65° to 250°F
Static Limit Load	75000 psi	75000 psi	75000 psi	75000 psi
Typical Performance	37500 psi At ±25° and 10 cpm, .0045 wear max. at 25000 cycles	37500 psi at ±25° and 10 cpm, .0045 wear max. at 25000 cycles	Contact NHBB Engr. Dept.	Contact NHBB Engr. Dept.
Dynamic Capabilities	Light to heavy, uni-directional or alternating loads. Low speed, intermittent to continuous misalignment, intermittent to continuous oscillation	Light to heavy, uni-directional or alternating loads. Low speed, intermittent to continuous misalignment, intermittent to continuous oscillation	Light to medium, alternating or reversing loads. Medium to High speed, intermittent to continuous misalignment, intermittent to continuous oscillation	Light to medium, alternating or reversing loads. Medium to High speed, intermittent to continuous misalignment, intermittent to continuous oscillation
Typical Uses	Fixed wing aircraft, rotary wing aircraft and jet engines. Control, support and actuation bearings	Fixed wing aircraft, rotary wing aircraft and jet engines. Control, support and actuation bearings	Rotary wing aircraft and landing gear	Rotary wing aircraft and landing gear
Comments	Intermittent use to 500°F	Intermittent use to 500°F	Good stick/slip properties. Good for vibratory conditions	Good stick/slip properties. Good for vibratory conditions. Extended life over D liners due to additional thickness
Liner Type	HS	AT	HT	DU® bearing material
Liner Model	L-1340	X-1118	L-1390	
Construction	PTFE/Polyester Weave	PTFE/Fiberglass Weave	PTFE/Fiberglass Weave	PTFE/Lead Bronze Composite
Thickness	.013-.015	.010-.012	.012-.014	.028-.030
Temperature	-65° to 250°F	-65° to 250°F	-65° to 625°F	-65° to 550°F
Static Limit Load	75000 psi	75000 psi	75000 psi	58000 psi
Typical Performance	(Contact NHBB)	25000 psi at ±25° and 10 cpm, .006 wear max. at 5000 cycles	12500 psi at ±25° and 10 cpm, .0045 wear max. at 25000 cycles	5000 psi at ±25° and 10 cpm, .0030 wear max. at 25000 cycles
Dynamic Capabilities	Light to medium, unidirectional loads. High speed, intermittent to continuous misalignment, intermittent to continuous oscillation	Light, uni-directional loads. Low speed, intermittent to continuous misalignment, intermittent to continuous oscillation	Light to medium, uni-directional or alternating loads. Low speed, intermittent to continuous misalignment, intermittent to continuous oscillation	Light, uni-directional or alternating loads. Low to high speed, intermittent to continuous misalignment, intermittent to continuous oscillation
Typical Uses	Rotary wing aircraft	Landing gear support and actuation bearings	Jet engine bearings and bushings	Rotary and fixed wing aircraft bearings and hinge bushings
Comments	DH (L-1480) liner offers same operating conditions but with a liner thickness of .018	Good stick/slip properties	Recommended for long term high temperature use, 450° to 625°F	

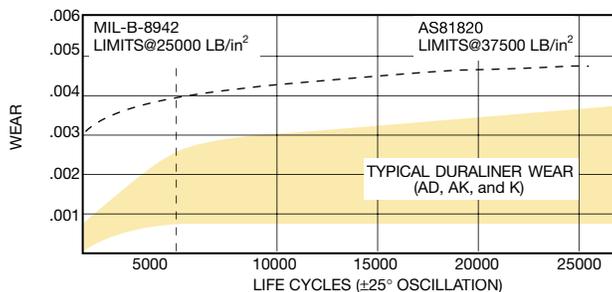
## AD, AK AND K LINER SYSTEMS (DURALINERS)

NHBB's, AD, AK and K liner systems consist of PTFE, Nylon and a thermosetting phenolic resin. The AD, AK and K liners are suitable for many fixed wing aircraft applications, such as actuators, hinges, and control bearings, where oscillation angles vary considerably but at slow oscillation speeds.

The AD, AK and K liners are qualified to AS81820 and AS81934. To qualify to AS81820, a lined bearing will be tested at room temperature for 25,000 cycles of  $\pm 25$  degrees at 10 cpm and at 37500 psi. Maximum allowable wear is 0.0045. When tested at elevated temperature requirement, the allowable wear is 0.006. When tested at  $-65^{\circ}\text{F}$ , the load is reduced to 75% of the room temperature requirement, and the allowable wear is 0.008. AS81820 also has a test requirement for bearings to be immersed in various fluids for 24 hours at  $160^{\circ}\text{F}$ , removed from the fluid, and dynamically tested at 75% of the room temperature load requirement. NHBB's AD, AK and K liners consistently exhibit less wear than specifications allow. See 22 for typical liner performance at ambient temperature.

The AD, AK and K liners are capable of operating for long durations when exposed to  $350^{\circ}\text{F}$  and short durations up to  $500^{\circ}\text{F}$ .

Tests reveal that the AD liner meets most vacuum outgassing requirements of space applications.



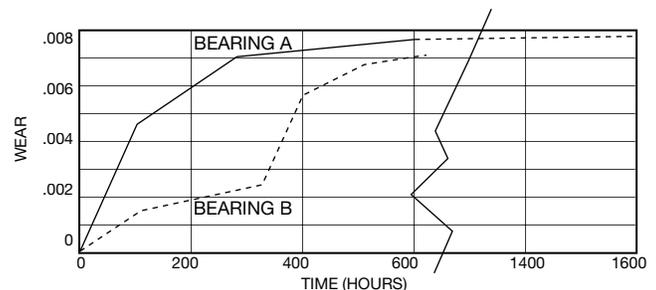
**22** Typical Performance of AS81820 Liner Systems (Life Cycles  $\pm 25^{\circ}$  Oscillation)

## D AND DD LINER SYSTEMS

NHBB's D and DD liner systems consist of a PTFE and Dacron weave coated with a thermosetting resin. The D and DD liners differ in the thickness of the liner. The DD liner has a liner thickness of .017 (Ref) and the D liner has a thickness of .014 (Ref). The additional liner thickness offers additional bearing liner life.

The D and DD liners were developed to accommodate alternating and reversing loads typically found in rotary wing applications where there are relatively low loading (approximately 2,000 psi) and the speed of oscillation is relatively high (approximately 300 cpm). See 23 for typical DD bearing life in a wet, reversing and alternating load test environment.

Current applications for the D and DD liners include landing gear shock struts, main and tail rotor pitch control link bearings, and damper bearings.



### Test Conditions, DD Liner

Bearing	Ball Diameter	Race Width	Osc.	CPM	Stress	PV@	
						Max. Load	Contamination
A	1.500	.797	$\pm 10^{\circ}$	300	0 $\pm 2000$ psi	26200	Water
B	1.500	.797	$\pm 10^{\circ}$	300	2000 psi $\pm 2000$ psi	52400	Water

**23** Typical Performance of the DD Liner System (Reversing Load)

## Self-Lubricating Liner Systems

### HS LINER SYSTEMS

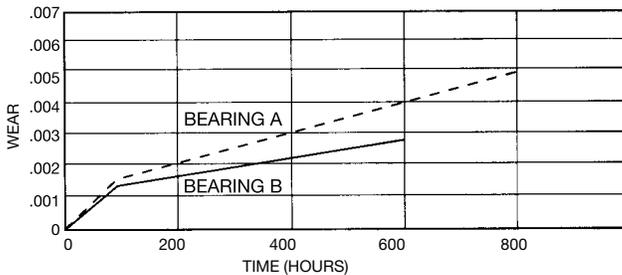
NHBB's HS liner system consists of a PTFE and Polyester Weave coated with a high temperature thermosetting resin. The HS liner has a thickness of .014 (Ref.).

The HS liner was developed to accommodate rotary wing aircraft applications in which high speeds (approximately 300 to 1500 cpm) and light uni-directional loading (approximately 2,000 psi) conditions exist. See 24 for typical HS bearing life in a wet, uni-directional load test environment.

The DH liner is available for applications similar to HS but requiring a thicker liner .018 (Ref.). For additional information, please contact NHBB's Applications Engineering Department.

### HIGH TEMPERATURE (HT) LINER SYSTEMS

NHBB HT liner systems are PTFE and fiberglass woven cloth that are impregnated with a high temperature polyimide resin. The HT liner is suitable for engine applications such as found in variable stators for fans and compressors, throttle linkages, vane guide sleeves and actuators in and around the engine. These applications require liner systems that can accommodate temperature up to 625°F. While the loading and motion are similar to fixed wing conditions, the high temperatures require a greater temperature resistant adhesive such as that used in the HT liners. The HT liner system is designed to meet higher operating temperatures but at reduced loads to



### Test Conditions, HS Liner

Bearing	Ball Diameter	Race Width	Osc.	CPM	Stress	PV	Contamination
A	.656	.312	±6°	1500	2000 psi	34400	Water and dust
B	1.500	.797	±10°	300	2000 psi	26200	Water and dust

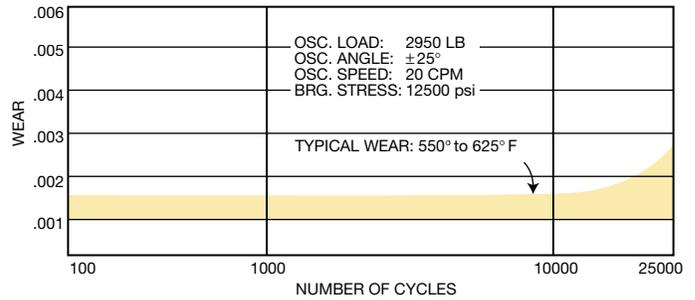
**24** Typical performance of the HS liner system (uni-directional load)

those required for fixed wing applications (AS81820). 25 shows the typical performance of the HT liner system at 12500 psi loading at 550 to 625°F at 20 cpm.

### LINER SYSTEM WITH DU® BEARING MATERIAL

The liner system with DU® bearing material consists of a low carbon steel sheet coated with a mixture of PTFE, lead, and sintered bronze.

Bearings with liner systems containing DU® bearing material can be used in applications up to 550°F, but significant life-reduction factors must be applied.

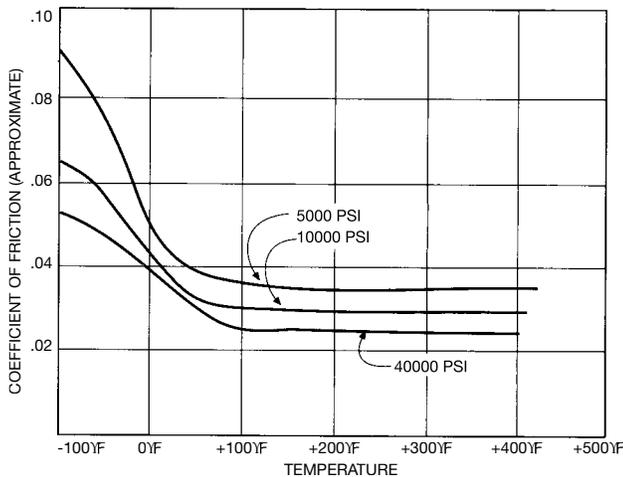


**25** Typical performance of the HT liner system (oscillation under radial load, wear vs. life)

## CHARACTERISTICS OF SELF-LUBRICATING PTFE LINED BEARINGS

1. Modulus of elasticity:  $4.5 \times 10^5$  psi.
2. Coefficient of thermal expansion:  $11.6 \times 10^{-6}$  in/in/°F.
3. Low coefficient of friction ranging from approximately .02 to .10. As shown in 26, the coefficient decreases as load and temperatures increase. However the coefficient also increases as surface speed and mating surface roughness increase.
4. Non-corrosive.
5. Resistant to most chemicals, greases and oils, however wear rates may increase when movement takes place under contaminated conditions.
6. Non-conductive and non-magnetic.
7. Wear rates remain low and relatively constant after an initial run-in period.
8. Continues to function satisfactorily with wear as high as .010.

## TORQUE



### 26 Effect of temperature and load on coefficient of friction

PTFE-lined spherical bearings are typically specified with preload between the ball and race in terms of no load rotational breakaway torque (inch-pounds or inch-ounces). This is the torsional force required to initiate rotation between the ball and race. Bearings can also be manufactured with a misalignment torque requirement.

The standard method for checking no-load rotational breakaway torque is described in Military Specification AS81820. The procedure is to hand-rotate the ball to initiate movement. Then the race is locked on a torque meter. The outer race is held in such a manner as to minimize bearing distortion and the resultant effect on the bearing preload. Torque is gradually applied to the ball. The torque required to start the ball moving is then recorded.

NHBB uses the same method to check torque, except that the ball is locked on the torque meter and the race is rotated.

Breaking the ball free from the race before checking torque is very important. Because of preload between the ball and race, the liner, under compression, slowly conforms to the microscopic surface irregularities of the ball. To initiate rotation after a period of time, all of the microscopic liner projections into the ball surface must be sheared off. Once this has been accomplished, the torque reverts back to its rated value. All torque testing should be performed with the outer race restrained in such a manner as to minimize bearing distortion and the resultant effect on the torque reading obtained. Torque readings can vary appreciably as the result of incorrect or excessive clamping, presence of contaminants, excessive speeds and differences in atmospheric conditions.

**Rotational Breakaway Torque** is the highest value attained just prior to ball movement. The ball should be hand rotated through several revolutions immediately before testing.

**Rotational Torque** is the value required to maintain 2 rpm rotation of the ball about its centerline.

**Misalignment Torque** is the value required to move the ball in a mode other than rotation about the bore centerline.

## Self-Lubricating Liner Systems

### TORQUE CALCULATION

The prediction of spherical bearing torque is more difficult than that of rolling element bearings. Friction coefficients of the sliding surfaces in these bearings vary depending on temperature and load. Torque at various loads is estimated by using the following formula:

$$T = \mu \times F \times R$$

Where:

T = torque, lbf-in

$\mu$  = friction coefficient (26)

F = load in lbf

R = one-half of ball diameter for spherical bearings turning on ball; or one-half the bore diameter for plain journal bearings or spherical bearings turning on bore

### SURFACE FINISH AND HARDNESS

Surface finish and hardness for the surfaces running against a PTFE liner are important for maximum liner life, whether on the shaft, ball, or other running surface.

For maximum life, NHBB recommends a finish of  $8 R_a$  maximum, achieved by lapping, buffing, or honing after grinding. Anything higher than  $8 R_a$  will reduce life.

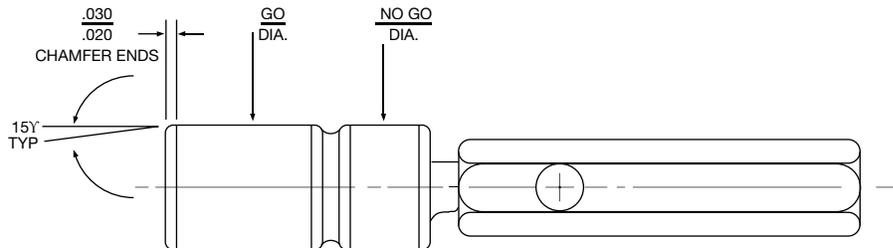
Hardness should be  $R_c50$  minimum. As hardness drops below  $R_c50$ , the mating surface begins to wear.

### GAGING LINED BORES

Conventional bore measuring equipment such as air gages, inside micrometers, etc., will often indicate an apparent oversize condition when used in measuring fabric-lined sleeve bores. Texture and resiliency of the fabric liner, as well as the contact pressure exerted by the gaging instruments all contribute to the probability of obtaining a false reading.

The most widely accepted method for inspecting lined sleeve bores is with the use of functional plug gages (see 27). The diameter of the “go” member should be the minimum bore diameter specified and that of the “no-go” should be the maximum bore diameter specified. The “go” member should enter freely or with light to moderate force. The “no-go” member should not enter with light force but entry under moderate to heavy force is acceptable.

All edges of gage members should have a radius of .03 minimum, and surface finish of the gage should not exceed  $8 R_a$  in order to prevent damage to the fabric when inspecting.



**27** Plug Gage

## FACTORS AFFECTING THE SELECTION, PERFORMANCE AND EVALUATION OF PTFE LINED SPHERICAL, ROD END AND SLEEVE BEARINGS

An answer to situations where the performance envelope cannot be covered by metal-to-metal bearings is to consider PTFE lined bearings. Here, the lubricant configuration is such that it functions as the load carrying element of the bearing, as represented by the liner systems currently in use. PTFE bearings may be specified under all or some of the following situations:

1. Where lubrication is undesirable, difficult to perform, or impossible.
2. Where loads are high and angular movement is low.
3. Where space is limited.
4. Where vibration is present.
5. Where temperature of the environment renders greasing unfeasible.
6. Where a joint must remain static for an extended period of time before movement is initiated.
7. Where friction in a greased bearing would be so high as to render the joint area useless after a limited number of cycles or impose an unacceptable fatigue situation.
8. Where, in static joints, fretting is a problem.

While PTFE lined bearings can do an excellent job in many areas, there have been areas of misapplication. Also, there exist some misunderstandings regarding life and failure as applied to hardware of this type. Following are important clarifications concerning these products:

1. The PTFE lined bearing starts life with a finite rotational pre-load torque or clearance.
2. This rotational pre-load torque always decreases with bearing usage and clearance always increases with usage.
3. A bearing may be said to have failed if the rotational pre-load torque drops below some specified value. This is always a systems application characteristic.
4. A bearing may be said to have failed when the clearance generated by wear exceeds some specified value. This, again, is always some specified systems characteristic.
5. A bearing may be said to have failed if the liner wears through enough to permit the ball to contact the race.

6. No bearing, including PTFE lined bearings, will last forever. The "lifetime" lubrication concept applies to the bearing alone, not to the end usage item.
7. The presence of liner debris on a bearing is not a definitive indication of failure.
8. PTFE lined bearings tend to telegraph their impending failure by increased radial and axial play.

When evaluating the probable service life of a PTFE lined bearing application, there are some factors that do not appear in the  $PV = K$  relationship, (see page 82). Some considerations for a given application might include:

1. Surface sliding speed
2. Maximum ambient temperature
3. Size of the heat sink
4. Acceptable friction levels
5. Load per unit of area, or liner stress level
6. Mode of load application; i.e., the duty cycle
7. Service alignment accuracy, particularly with respect to sleeve and flanged bearings
8. Surrounding atmosphere
9. Tolerable wear rate
10. Surface finish of the bearing mating shaft and the shaft material

Cost is not included in the above list since it does not affect the serviceability of any bearing. Higher individual bearing costs may result in a more economical or lower priced finished assembly.

## Grease and Dry Film Lubricants

TABLE 4: Grease Lubricants

Type	Specification	Composition	Temperature Range	Use and Remarks
Grease, aircraft and instrument, gear, and actuator screw	MIL-PRF-23827	Lithium soap, ester oil, anti-rust and E.P. agents	-100° to +250°F	General purpose grease. Extreme pressure (E.P.) properties, good water resistance
Grease, MoS <sub>2</sub> , for high and low temperatures	MIL-PRF-21164	Same as MIL-PRF-23827, except 5% MoS <sub>2</sub> added	-100° to +250°F	Similar to MIL-PRF-23827 but has added MoS <sub>2</sub> for extra E.P. properties and anti-wear action under marginal lubrication conditions
Grease, Aircraft	MIL-PRF-81322	Synthetic oil and thickener	-65° to +350°F	High temperature grease

The selection of lubricants is based on bearing materials, design, environment, and operating conditions. The following sections describe grease and dry film lubricants and list the most commonly used types.

### Grease

Grease is an oil to which a metallic soap, synthetic filler, thickener, or a combination of these has been added to prevent oil migration from the lubrication site. The operative properties of grease depend almost wholly on the base oil.

Grease lubricants can be used on metal-to-metal spherical and rod end bearings such as a steel ball against a steel race, a steel ball against an aluminum bronze race, and a beryllium copper ball against a steel race.

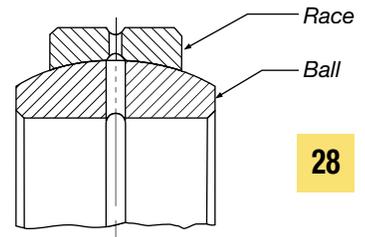
The three most common grease lubricants used with NHBB bearings are shown in table 4. Grease-lubricated bearings are usually furnished with lubrication holes and grooves, and, in the case of rod ends, lubrication fittings for periodic relubrication. These bearings have a tendency to gall unless lubrication is very frequent and loads are reversing so that the grease is not squeezed out of the load area.

In applications with uni-directional loading, the grease will quickly be squeezed out of the bearing area. In these applications, dry film can be used. The use of PTFE also should be investigated.

NHBB grease lubricants are suitable for most airframe applications. If bearings will be required to operate in unusual conditions (for example, high vacuum, radiation, or near chemicals such as phosphate ester fluids or propellants), please consult the NHBB Applications Engineering Department before ordering.

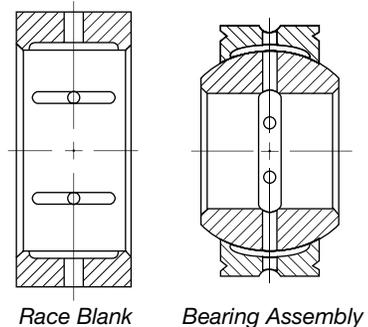
28 illustrates a lubrication network which provides for lubricating both the ball/race and the ball/shaft (or pin) interfaces.

Further, relubrication can be accomplished via the race housing or the ball shaft or pin. If relubrication is to be done via the race housing, and no lubrication is required in the ball bore, lube holes and I.D. lube groove in the ball may be omitted. Conversely, if relubrication is to be done via the shaft or pin, lube holes and O.D. groove in the race may be omitted.



28

29 shows a transverse lube groove configuration for use on medium to large size spherical bearings in critical applications where lubrication demands are more extreme. The transverse grooves are machined into the cylindrical race blank prior to swaging. These bearings are often bushed with copper alloy sleeves which in turn may incorporate transverse or equivalent lube groove patterns to provide for maximum possible lubrication.



29 Lube Groove Size and Depth Exaggerated for Clarity

**TABLE 5: Dry Film Lubricants**

Type	Specification	Lubricant	Binder	Temperature Range	Use and Remarks
Solid film, heat cured, corrosion inhibiting	MIL-PRF-46010 Type I	MoS <sub>2</sub> (no graphite or powdered metals), and corrosion inhibitors	Organic resins	-65° to +450°F	Good wear life. Used for most bearing applications other than extreme temperature situations
Solid film, heat cured, corrosion inhibiting	MIL-PRF-46010 Type II	MoS <sub>2</sub> (no graphite or powdered metals), and corrosion inhibitors	Organic resins	-90° to +400°F	Similar to MIL-PRF-46010, TY I except that it will provide added corrosion protection to substrate. Must have phosphate coating pretreatment for effective use on steel
Solid film, extreme environment	MIL-PRF-81329	MoS <sub>2</sub> and other solid lubricants	Inorganic binders	-300° to +1200°F	To be used in extreme environments, i.e., vacuum, liquid oxygen, high temperatures. Wear life not as good as resin-bonded types

**DRY FILM**

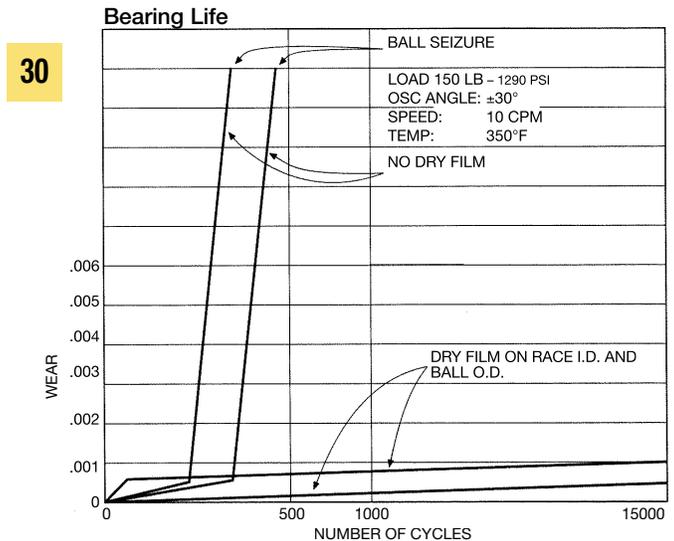
Dry film lubricants consist of MoS<sub>2</sub> and small quantities of other materials such as graphite or powdered metals. These are bonded to the bearing race I.D., and often the ball O.D. and bore, by either organic resins or inorganic binders (phenolic, sodium silicate, or other glass compositions). Hardening or curing is achieved by baking at temperatures ranging from 300° to 1000°F depending upon the binding material.

NHBB can apply dry film lubricants to all metal-to-metal spherical and rod end bearings.

The three most common dry film lubricants used with NHBB bearings are shown in table 5. The advantages of dry film include good tenacity, low coefficient of friction (0.05 to 0.25), and resistance to high bearing pressure (up to 90000 psi on hard substrates). Dry film, however, is not as predictable as PTFE liners regarding wear characteristics.

30 illustrates the difference in bearing life between dry film lubricated bearings and bearings that have not been lubricated.

NHBB dry film lubricated bearings are generally used in aircraft and engine applications in which extreme temperature conditions exist (-300° to +1200°F).



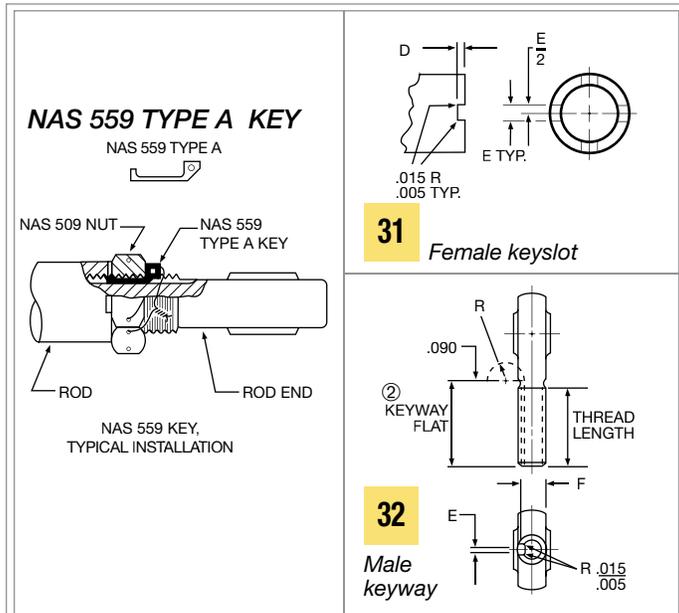
*Dry Film Lubricated vs. Non-Lubricated Bearings*

**Commonly Used Dry Films**

Product	Specification	Temperature Range
Everlube® 967		-300° to +750°F
Lubeco M-390		-65° to +500°F
Surf-Kote® LBO-1800-G		-65° to +1100°F
Molykote® 106		-321° to +450°F
Everlube® 811	MIL-PRF-81329	-300° to +750°F
Vitrolube 1220		-400° to +700°F

EVERLUBE® is a registered trademark of Metal Improvement Company, LLC  
 MOLYKOTE® is a registered trademark of Dow Corning Corporation  
 SURF-KOTE® is a registered trademark of Hohman Plating & Mfg. INC.

## Locking Devices, Keys and Keyways



### Notes:

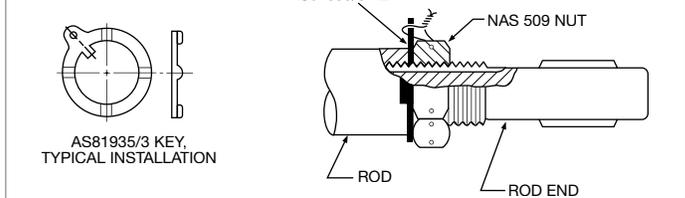
#### NAS 559 TYPE A KEY

- ① The keyways and keyslots used in conjunction with these keys are shown in **31** and **32**. The NAS 559 keys are available for thread sizes 1/4 through 2-1/4 inches.
- ② Keyway flat may vary from standard on smaller size rod ends but shall extend at least beyond minimum thread length in all cases.

Thread Size ①	(D) +.005 -.000	(E) +.005 -.000	(F) +.000 -.005	(R) ±.010
.250	.056	.062	.201	.255
.312	.056	.062	.260	.255
.375	.056	.093	.311	.255
.437	.069	.093	.370	.255
.500	.069	.093	.436	.255
.562	.077	.125	.478	.255
.625	.077	.125	.541	.255
.750	.077	.125	.663	.255
.875	.086	.156	.777	.318
1.000	.094	.156	.900	.318
1.125	.094	.187	1.010	.382
1.250	.116	.187	1.136	.382
1.375	.116	.250	1.236	.445
1.500	.116	.250	1.361	.445
1.625	.129	.250	1.477	.445
1.750	.129	.312	1.589	.508
1.875	.129	.312	1.714	.508
2.000	.129	.312	1.839	.508
2.125	.129	.312	1.955	.508
2.250	.129	.312	2.080	.508

Keys as represented here are metallic locking devices which, when assembled into keyways and keyslots, prevent relative motion between mating components of bearing linkage assemblies. NHBB does not manufacture keys, nuts or lock wire as separate items. These items are readily available from other sources. Keyways and keyslots are optional. To specify, add suffix "W" to NHBB catalog rod end part number.

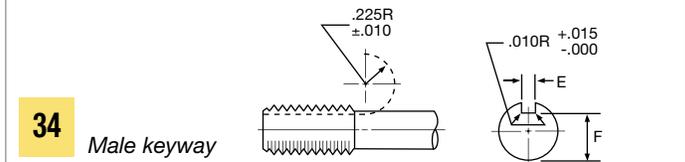
### AS81935 KEY



### Notes:

#### AS81935 KEY

- 1. AS81935/3 keys are used on AS81935 sizes -03 through -08 when optioned. The keyways and keyslots used in conjunction with these keys are shown in **33** and **34**.
- ② AS81935/3 keys are available for thread sizes 1/4 through 1/2 inches.



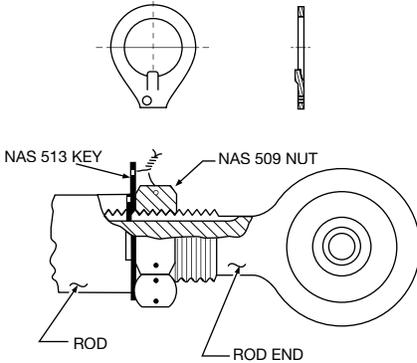
### Notes:

#### AS81935 KEY

- 1. AS81935/3 keys are used on AS81935 sizes -03 through -08 when optioned. The keyways and keyslots used in conjunction with these keys are shown in **33** and **34**.
- ② AS81935/3 keys are available for thread sizes 1/4 through 1/2 inches.

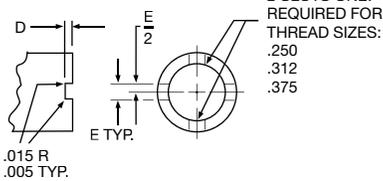
Thread (Male) ②	(E) +.005 -.000	(F) +.000 -.005
1/4-28UNJF-3A	.062	.207
5/16-24UNJF-3A	.062	.268
3/8-24UNJF-3A	.093	.319
7/16-20UNJF-3A	.093	.383
1/2-20UNJF-3A	.093	.445

### NAS 513 KEY

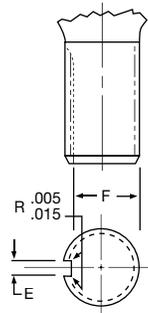


Thread Size ③	(D) +.005 -.000	(DD) ② +.005 -.000	(E) +.005 -.000	(F) +.000 -.005
.250	.056	.110	.062	.201
.312	.056	.110	.062	.260
.375	.056	.110	.093	.311
.437	.069	.110	.093	.370
.500	.069	.110	.093	.436
.562	.077	—	.125	.478
.625	.077	.125	.125	.541
.750	.077	.125	.125	.663
.875	.086	.156	.156	.777
1.000	.094	.156	.156	.900
1.125	.094	—	.187	1.010
1.250	.116	—	.187	1.136
1.375	.116	—	.250	1.236
1.500	.116	—	.250	1.361
1.625	.129	—	.250	1.477
1.750	.129	—	.312	1.589
1.875	.129	—	.312	1.714
2.000	.129	—	.312	1.839
2.125	.129	—	.312	1.955
2.250	.129	—	.312	2.080

(DD optional) ②



**35** Female Keyslot



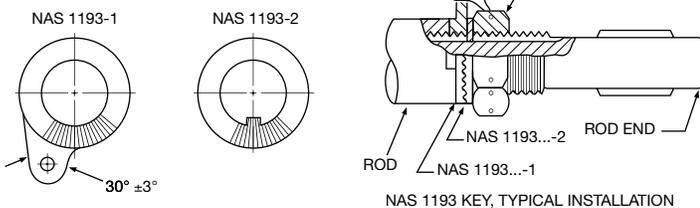
**36** Male Keyway

#### Notes:

##### NAS 513 KEY

- 1. NAS 513 keys are used on AS81935 sizes -10 through -16 rod ends when optioned. The keyways and keyslots used in conjunction with these keys are shown in **35** and **36**.
- ② For female rod ends with deep square slot keyslot option AS81935 designation "W", the slot depth is modified as detailed in **35**. This deep slot "W" is also compatible with NASM14198, SAE-AS14227, NAS 1193 and NAS 559 keyways.
- ③ NAS 513 keys are available for thread sizes 1/4 through 2-1/4 inches.

### NAS 1193 KEY



#### Notes:

##### NAS 1193 KEY

- 1. NAS 1193 keys are for positive indexing. They are used in applications in which a fine adjustment is required, within .001.
- 2. These keys can be used in conjunction with NAS 513, NAS 559 and AS81935/3 keyways or keyslots and are available for thread sizes 1/4 through 2-1/4 inches.

## Sealed Bearings

For applications in which airborne or fluid contaminants threaten the useful life of spherical or rod end bearings, NHBB offers a combination metal shield and silicone seal to isolate and protect bearing surfaces.

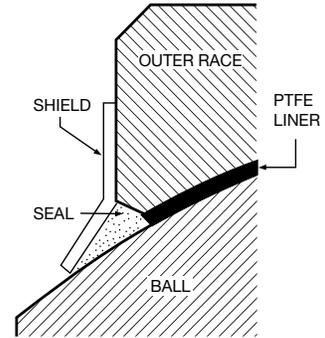
The NHBB sealing system (37) comprises a pair of .010 (Ref.) stainless steel (or any other compatible weldable metal) shields and molded wedge-shaped silicone rubber seals. This seal system design does not significantly increase the weight of the bearing.

The shields are welded to the outer race of the bearing so that the seals are seated at the juncture of the ball and the race. As ball movement occurs, the seals wipe contaminants from the ball surface. This self-cleaning action prohibits most contaminants from reaching the load bearing area. Seals do not reduce the load bearing area or change the load rating of a bearing.

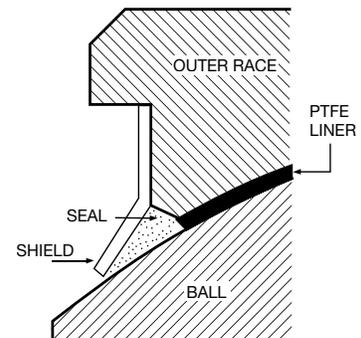
NHBB sealed bearings have been subjected to extensive dynamic testing by major aircraft manufacturers for resistance to contamination by MIL-H-5606 hydraulic oil and SAE AS 8243 de-icing fluid. Sealed bearing wear after 25,000 cycles was considerably less than unsealed bearing wear.

NHBB can seal any size metal-to-metal or self-lubricated bearing. The seal typically does not affect external mounting dimensions or dimensionally affect function on V-groove installations. Form, fit, and function interchangeability are maintained. However, a seal does reduce misalignment capability. NHBB seals can be used with bearings having staking grooves in the outer race, as well as with bearings having chamfered outer race configurations. For information on seal damage prevention when installing in counter bores that may contact the race face, contact NHBB Applications Engineering.

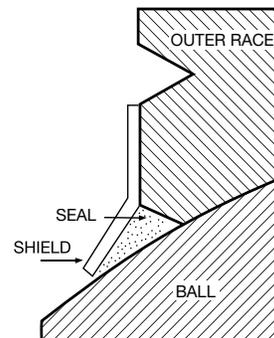
### Sealed PTFE Lined Bearing



### Recessed Seal Design



### Sealed Metal to Metal Bearing



37

NHBB Bearing Seal

## Bearing Installation and Retention

Installation and retention details are important considerations when designing a bearing. Features such as pins or bolts, housings, corrosion resistance, installation method, and retention methods must be considered to ensure optimum bearing performance.

**38** This typical bearing installation, which is staked into the housing, is assembled with a mating clevis, bolt, nut, washers, and plain and flanged bushings.

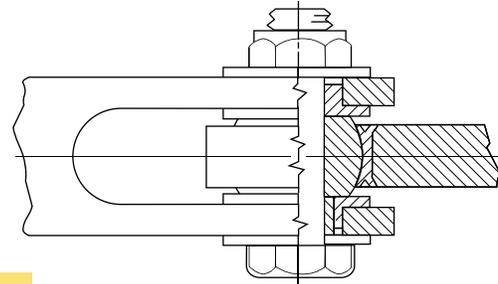
In most applications, the bolt is preloaded with the nut to clamp up the ball and force the ball to rotate on the race I.D. Caution must be exercised when clamping the ball. Excessive force expands the ball and will bind it in the race. If the ball is not clamped up, motion will usually take place on the bore, in which case the bolt, the bearing bore, or both must have suitable surfaces for this motion.

### THE PIN OR BOLT

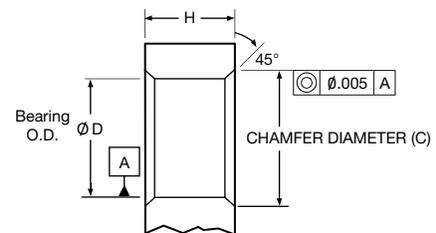
In addition to carrying the structural loads through the joint, the pin or bolt may function as a journal, and must therefore meet the multiple requirements of adequate strength, minimum wear, low friction, and corrosion resistance. In these instances, the following provisions for relubrication should be made:

1. PTFE line the bearing bore or the pin or bolt O.D.
2. Dry film the bearing bore and/or the pin or bolt O.D.
3. Introduce lubrication holes and grooves in the pin or bolt or the ball members

Suggested pin materials are 17-4PH and PH13-8Mo stainless steel, and 4130/4340 steel chrome plated .002 thick. Pins, either bare or plated, should be heat treated to the required shear strength (108,000 psi Ref.) and ground and polished to the required dimensions with a surface finish of 8  $R_a$  or better. The recommended fit between the pin or bolt and the bearing bore is line-to-line to .001 loose.



**38** Typical Bearing Installation



**39** Chamfered Size Calculation for V-Groove Retention

#### Chamfer Dia.

$$(C) = D + [H - T + (2 \times E)]$$

(Tolerance + .008/ - .007)

H = average housing thickness

T = average outer race width

E = average V-groove depth in race, depending on groove.

V-Groove Size*	Avg. Groove Depth (E)
A	.023
B	.033
C	.053
D	.073

\*See **46** for groove dimensions, page 75.

## Bearing Installation and Retention

### HOUSINGS

The housing into which the bearing is mounted must be designed to ensure the structural integrity of the bearing. The recommended housing dimensions are as follows:

1. Bearing-to-housing fit: .0002 tight to .0008 loose.
2. Bore finish: 32 R<sub>a</sub>.
3. Round within the bore diametral tolerance.
4. Bore aligned perpendicular to housing faces within .002 for sleeve bearings only.
5. Housing width: .005 tolerance (for staking purposes).
6. For V-groove retention the housing bore is chamfered. Chamfer size is calculated as shown in 39, page 71.
7. For housing stake and bolted plated retention, break edges .005 max on both sides.

The recommended shaft and housing sizes are based on an operating temperature range of -65° to 350°F. At elevated temperatures, allowances must be made for different coefficients of expansion for the various shaft, bearing, and housing materials. In general, the mating components should be adjusted to provide the recommended fit at operating temperature. In addition, internal bearing fit-up between the ball and race may be required (either additional internal clearance or decreased torque) to ensure proper operation over a broad temperature range.

The use of heavy interference fits between a bearing and housing is not generally recommended because it reduces internal clearance. If the application requires a heavy interference fit, the assembly of the bearing and housing must be accom-

plished by use of temperature differentials to prevent galling of the bearing or housing. The temperature differentials are dependent on the amount of press fit. After assembly, the bearing usually cannot be replaced because of galling during pushout. When using interference fits, the internal ball to race fit-up must allow for the contraction of the race (which can be up to 100% of the interference fit, depending on housing material, heat treatment, and size). For fit-ups on sleeve bearings see pages 47 and 49.

### CORROSION RESISTANCE

A bearing, housing, or shaft interface is a likely place for various forms of corrosion to develop. Corrosion may be initiated or accelerated by wear (fretting) or caused by the galvanic action of dissimilar metals in the presence of an electrolyte. Control of galvanic corrosion can be established by isolating and protecting the active metal surfaces. When corrosion resistant materials are used for bearings, pins or bolts and housings, there is little problem with galvanic corrosion. When dissimilar, noncorrosion resistant materials are used, precautions must be taken to protect bearings, shafts, and housings used in contact with other metals or with the atmosphere. Table 6 shows various bearing, shaft, and housing materials, with finishing precautions necessary to combine them to make a complete design. In addition to these recommendations, the bearing O.D. and housing bore are sometimes coated with zinc chromate primer according to TT-P-1757, epoxy primer according to MIL-PRF-23377, or sealant according to MIL-PRF-81733.

TABLE 6: Treatments to Prevent Galvanic Corrosion

Bearing Material (Bore and O.D. Surface)	Housing or Shaft Material				
	Aluminum Alloys	Low Alloy Steels	Titanium	Corrosion Resistant Steels	Super-Alloys
Aluminum alloys	A	A, C	A	A, C	A, C
Bronze and brass	A, C	C	S	S	S
Bronze and brass cadmium plated	A	C	—	S	S
52100 and low alloy steels	A, C	C	—	C	C
440C stainless steel	A, C	C	S	S	S
440C with wet primer	A	C	S	S	S
Corrosion resistant steels, 300 series (17-4PH, 15-5PH, PH 13-8Mo, etc.)	A, C	C	S	S	S
Superalloys (Rene 41, etc.)	A, C	C	S	S	S

— = Incompatible A = Anodize aluminum per MIL-A-8625, Type II, or Alodine per MIL-C-5541

C = Cadmium plate per Fed-Spec QQ-P-416

S = Satisfactory for use with no surface treatment required

## INSTALLATION

The installation of a bearing or sleeve into a housing bore is a simple operation when done properly. Alignment of the bearing or sleeve to the housing bore is critical to prevent a cocking motion during insertion, which can damage or ruin the bearing or housing. Temperature differential installation is recommended.

## SPHERICAL BEARING INSTALLATION

Use of an arbor press or hydraulic press is recommended. Under no circumstances should a hammer or any other type of shock-inducing impact method be used. A suitable installation tool (as shown in 40) is advised. A guide pin aligns the ball in a 90° position, but all force is applied to the outer race face only. A lead chamfer or radius on either the bearing or housing is essential.

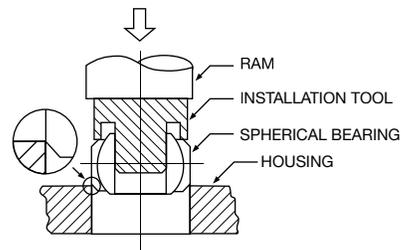
## LINED SLEEVE BEARING INSTALLATION

The same general procedure as outlined for spherical bearings should be followed (see 41). In the case of fabric lined bores, however, it is mandatory that both the insertion tool guide pin and the mating shaft have ends free of both burrs and sharp edges. A .030 (min.) blended radius or 15° lead (as shown in 41) is recommended, since it is virtually impossible to install a sharp edged shaft without inflicting some damage to the fabric liner. For maximum support of the fabric lined bore, the effective length of the insertion tool guide pin should exceed the sleeve bearing length.

## RETENTION METHODS

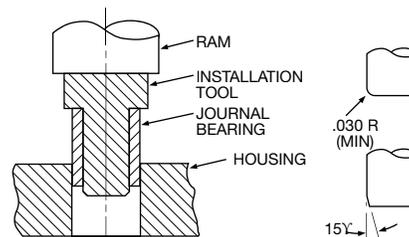
Bearing retention in a housing can be accomplished by any one of the methods listed in table 7. To determine the best method, several factors must be taken into account, such as

effect on bearing internal clearance and torque, effect on housing residual stress, thermal expansion, added space and weight, retention capability, housing damage during bearing replacement, and number of times a bearing can be replaced. The four retention methods listed in table 7 are the most commonly used. Other methods do exist, such as adhesive bonding, snap rings, and threaded cover plates, but they should be used only as a last resort.



40

Spherical Bearing Installation



41

Sleeve Bearing Installation

TABLE 7: Characteristics of Recommended Retention Methods

Method	Effect on Bearing Internal Clearance	Effect on Housing Residual Stress	Added Space and Wt.	Retention Capability Requirements	Can Replacement Damage Housing?	Possible No. of Replacements
Threaded Bearing Retainer	None	None	None	Medium	No	No limit
Bolted Retainer	None	None	High	High	No	No limit
V-Groove Stake	None	None	None	Medium	No	No limit
Housing Stake: Continuous or Interrupted	High	High	None	Low	Yes	None

## Bearing Installation and Retention

### THREADED RETAINER RETENTION

Threaded bearing retainers, as shown in 42, offer an excellent bearing retention method due to ease of bearing replacement, high axial thrust load capabilities, and ease of assembly in areas where accessibility to conventional staking would be difficult.

### BOLTED PLATE RETENTION

For high retention capability and ease of bearing replacement, the bolted plate method, as shown in 43, is recommended. However, space requirements and weight will increase.

### HOUSING STAKE RETENTION

Housing stake retention, as shown in 44, has many shortcomings when compared to V-groove staking. The major consideration is race contraction, which adversely affects internal fit-up. Housing stake retention should be used only when there is insufficient space on the race face for a V-groove or the race material is not ductile. When mounting, the bearing and its housing are supported by an anvil while the staking tool is forced into one side of the housing near the edge of the bearing. This action displaces a small amount of the housing material over the race chamfer. The opposite side of the housing is then staked in the same manner.

### V-GROOVE RETENTION

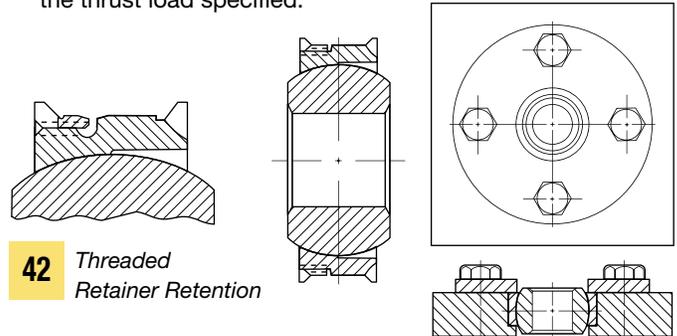
V-groove retention, as shown in 45, is the most widely used and recommended. The bearing outer race has a small groove machined into each face, which leaves a lip on the race O.D. corners. With the use of staking tools, these lips are swaged (flared) over the chamfered edges of the housing.

The prerequisites for good V-groove staking are proper size housing chamfers, staking tools that match the V-groove size, and the availability of a hydraulic or pneumatic press capable of applying the staking force. To use V-groove staking successfully, the following conditions must be met:

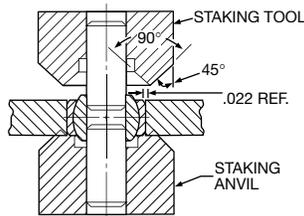
1. Race hardness:  $R_{c40}$  max.
2. Sufficient space on the race face for machining a groove.  
For V-groove sizes, see 46.
3. V-groove size capable of carrying the axial load, see 47.

### STAKING PROCEDURE

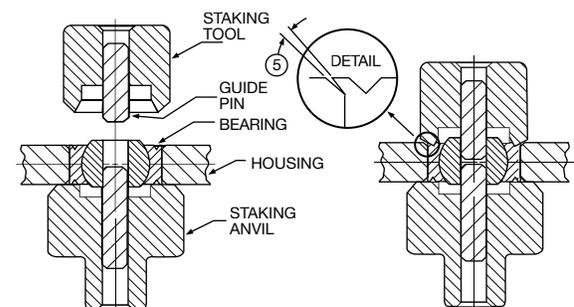
1. Install bearing into housing per 40 and position it symmetrical about housing centerline within .005.
2. Mount bearing and top anvil over bottom anvil guide pin as shown in 45.
3. A trial assembly should be made for each new bearing lot to determine the staking force necessary to meet the axial retention load required. Excessive force should be avoided since this may result in bearing distortion and seriously impair bearing function and life. (See table 8 for recommended Staking Force, page 75).
4. Apply the staking force established by trial assembly, rotate assembly  $90^\circ$  and re-apply force.
5. After staking, a slight gap may exist between race lip and housing chamfer as shown in detail in 45. This gap should not be a cause for rejection providing the bearing meets the thrust load specified.



42 Threaded Retainer Retention



44 Housing Stake Retention



45 V-Groove Staking Method

## STAKING FORCE

The staking force equals the product of the bearing O.D. and a constant for each groove size (see table 8). For example, a bearing with a "B" size V-groove and 1.500 O.D., the staking force will be 1.500 X 12,000 lbs. = 18,000 lbs.

These staking forces are valid for outer race materials having an ultimate tensile strength of 140,000 psi.

Staking forces for other materials are proportional to the ultimate tensile strength of the materials as compared to 140,000 psi.

These staking forces should be used as a general guide to establish a starting point. Lower forces may be adequate or higher forces may be necessary depending on staking technique and axial load requirements.

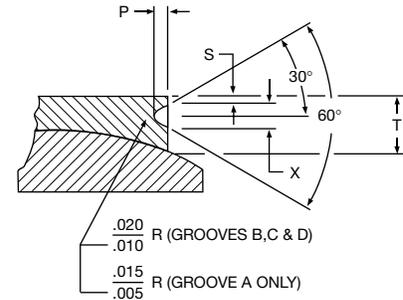
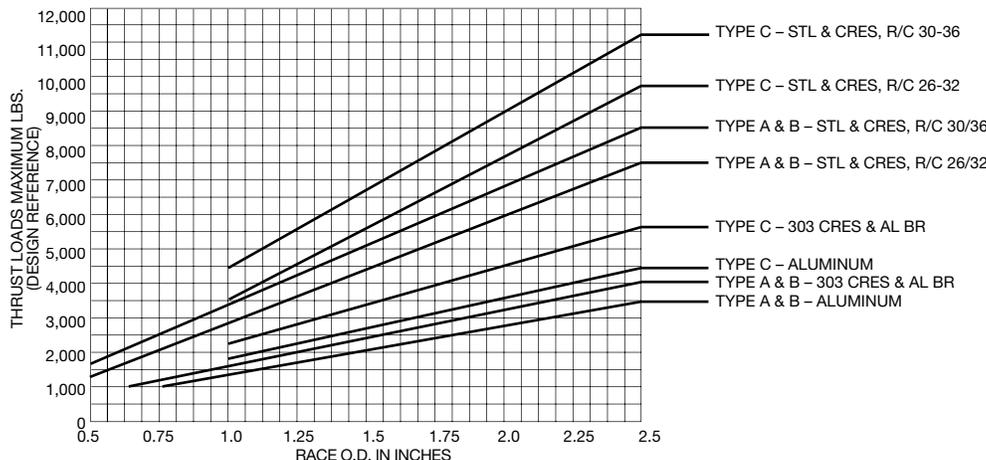
As a rule, only the amount of force required to get the desired amount of retention should be used.

The use of proper fits and staking techniques should not cause significant changes in bearing preload.

As a minimum, the first and last article staked should be proof-tested. 48 shows a method for proof-testing staked bearings for axial retention. This is the generally accepted method for checking retention used by bearing and air frame manufacturers.

47 shows allowable design thrust loads for bearing O.D.'s. The loads shown should be obtainable using staking tools with 45° outside angles.

### 47 Thrust Loads Based on 46 Groove Types and Materials Specified.



### 46 V-Groove Sizes

#### V-Groove Sizes

Groove Size	P +.000 -.015	S +.000 -.010	X +.000 -.010	T Min.*
A	.030	.020	.045	.075
B	.040	.030	.055	.125
C	.060	.030	.080	.156
D	.080	.045	.105	.188

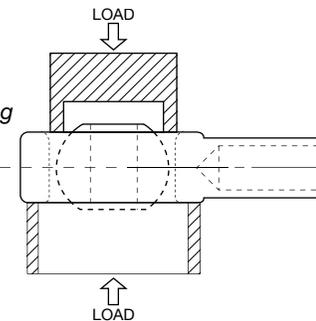
\*For PTFE lined bearings, add single liner thickness to "T Min."

TABLE 8: Staking Force

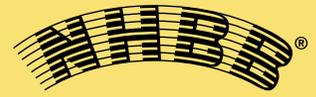
Groove Size*	Lbs.
A	7700
B	12000
C	17700
D	25800

\*See 46 for groove sizes.

### 48 Staked Bearing Proof Testing Method







## Staking Tool Sets – Ordering Information

Hydraulic (Anvil) staking tools are available for all NHBB standard and special spherical bearings with staking grooves. Each set consists of one staking (flaring) tool and one staking anvil, both with guide pins installed. For spherical bearings in this catalog, order staking tool sets by the part numbers below.

For special (non-catalog) bearings or larger sizes, consult NHBB.

NHBB Part Number	Bore	Staking Tool Part Number
ADB(J)V	3	STN 0003
ADB(J)V(L)	4	STN 0004
HT(J)V(L1)	5	STN 0005
AG(J)V	6	STN 0006
AG(J)V300	7	STN 0007
HSBG(J)V	8	STN 0008
AHT(J)V	9	STN 0009
AHET(J)V	10	STN 0010
ABG(J)V(L)	12	STN 0012
ABG(J)V-501(L)	14	STN 0014
ADBL(J)V		
HTL(J)V(L1)		
ADW(J)V	3	STW 0003
AW(J)V	4	STW 0004
ADW(J)V(L)	5	STW 0005
WHT(J)V(L1)	6	STW 0006
ADWL(J)V	7	STW 0007
ADWL(J)V(L)	8	STW 0008
WHTL(J)V(L1)	9	STW 0009
	10	STW 0010
	12	STW 0012
	14	STW 0014
	16	STW 0016
ADBY(J)V	3	STY 0003
ASBY(J)V	4	STY 0004
ADBY(J)V(L)	5	STY 0005
	6	STY 0006
	7	STY 0007
	8	STY 0008
	9	STY 0009
	10	STY 0010
	12	STY 0012
	14	STY 0014
	16	STY 0016
	20	STY 0020
	24	STY 0024

EXAMPLES: NHBB P/N	STAKING TOOL
1. ADB10V	STN 0010
2. ABG8V (L)	STN 0008
3. ADW5V	STW 0005
4. ADBY6V	STY 0006

## Load Ratings and Misalignment Capabilities

### DEFINITIONS FOR ROD END AND SPHERICAL BEARING TERMINOLOGY

#### Radial Load

A load applied normal to the bearing bore axis (see 51A).

#### Axial Load

A load applied along the bearing bore axis (see 51B).

#### Static Load

The load to be supported while the bearing is stationary.

#### Dynamic Load

The load to be supported while the bearing is moving 52.

#### Static Radial Limit Load

That static load required to produce a specified permanent set in the bearing. It will vary for a given size as a function of configuration. It may also be pin limited, or may be limited as a function of body restraints as in the case of a rod end bearing. Structurally, it is the maximum load which the bearing can see once in its application without impairing its performance.

#### Static Radial Ultimate Load

That load which can be applied to a bearing without fracturing the ball, race or rod end eye. The ultimate load rating is usually, but not always, 1.5 times the limit load. Plastic deformation may occur.

#### Static Axial Limit Load

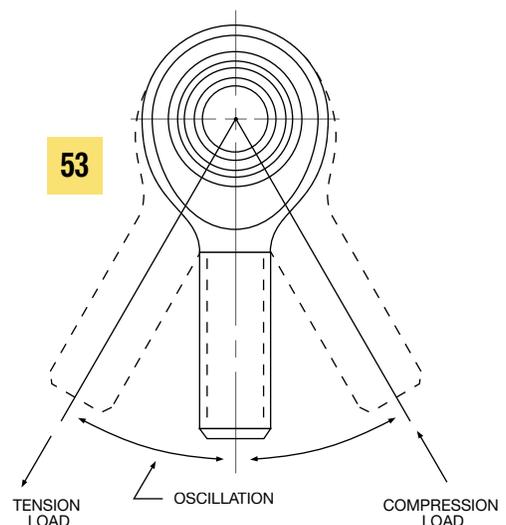
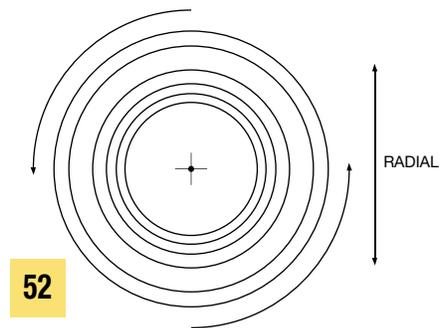
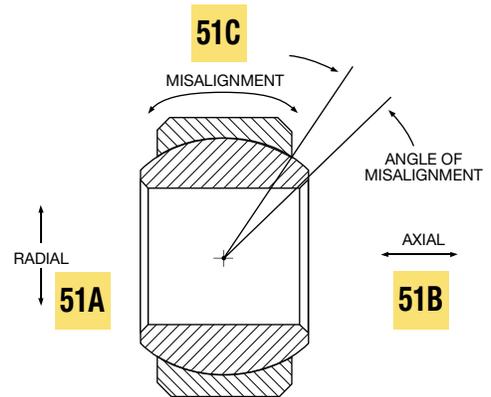
That load which can be applied to a bearing to produce a specified permanent set in the bearing structure. Structurally, it is the maximum load which the bearing can see once in its application without impairing its performance.

#### Static Axial Ultimate Load

That load which can be applied to a bearing without separating the ball from the race. The ultimate load rating is usually, but not always, 1.5 times the limit load.

#### Axial Proof Load

That axial load which can be applied to a mounted spherical bearing without impairing the integrity of the bearing mounting or bearing performance. It is always less than the static axial limit load. Bearing movement after proof load is usually .003 or less. See the Bearing Installation and Retention section for further information beginning on page 75.



### Rotation

Is the relative angular displacement between the ball and race that occurs within the plane perpendicular to the axis of the ball bore (see 53). The direction of rotation is about the axis of the ball bore.

### Misalignment

Is the relative angular displacement between the ball and race that occurs within any plane that coincides with the axis of the ball bore (see 51c). The direction of misalignment is about any axis perpendicular to the ball bore.

### Oscillating Radial Load or Dynamic Load

The uni-directional load produces a specified maximum amount of wear when the bearing is oscillated at a specified frequency and amplitude. This rating is usually applied to self-lubricating bearings only. The dynamic capability of metal-to-metal bearings depends upon the degree and frequency of grease lubrication, and that of dry film lubricated bearings upon the characteristics of the specific dry film lubricant applied.

### Radial Play

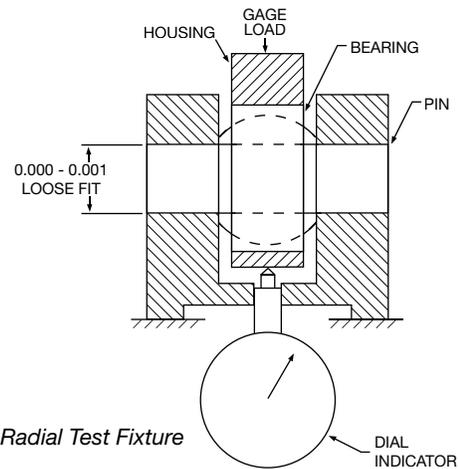
Radial play (or radial clearance) is the total movement between the ball and the race in both radial directions less shaft clearance (when applicable). Industry specifications have established the gaging load at  $\pm 5.5$  lbs., and this is now considered as the industry standard (see 54 and 55). Unless otherwise specified, the industry wide standard for metal-to-metal spherical bearing and rod end radial clearance is “free-running to .002 max.” Radial play is sometimes referred to as “Diametral clearance.” The two terms are synonymous.

### Axial Play

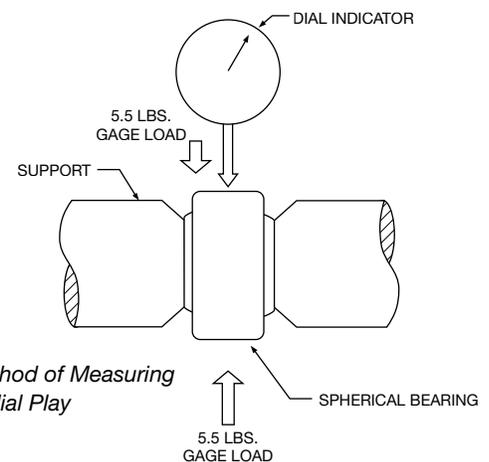
Axial play (or axial clearance) is the total movement between the ball and the race in both axial directions (see 56). The gaging load is again  $\pm 5.5$  lbs. Axial play is a resultant, being a function of radial play, of ball diameter and race width. The ratio between radial and axial play varies with bearing geometry.

### Fatigue Load of Rod Ends

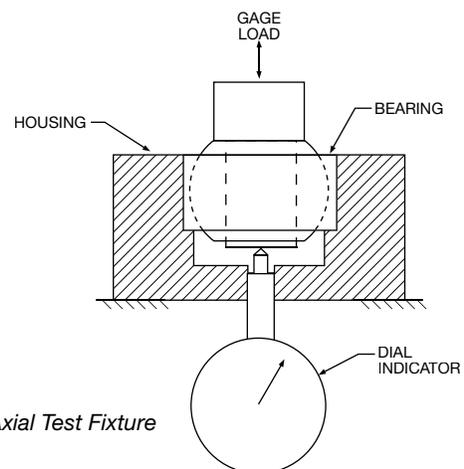
Aerospace Standard series rod end bearings AS81935 must be capable of withstanding a minimum of 50,000 cycles of loading when tested as follows: The loading must be tension-tension with the maximum load equal to the fatigue loads listed on the NHBB drawing of the ADNE and ADN series rod end bearings. The minimum load must be equal to 10% of the fatigue loads.



54 Radial Test Fixture



55 Method of Measuring Radial Play



56 Axial Test Fixture

## Load Ratings and Misalignment Capabilities

### LOAD RATINGS

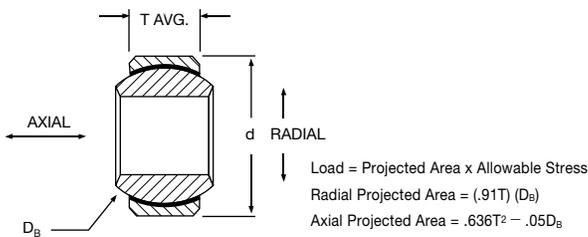
The load rating of a bearing is determined by the dimensions and strength of its weakest component. External factors, such as mounting components, pins, bolts, and housings are not considered part of a bearing when load ratings are investigated but should be considered separately.

### SPHERICAL BEARING LOAD RATINGS

The weakest part, or load-limiting area, of a spherical bearing is its race. For this reason, formulas have been developed that use the race to calculate static load ratings based on size and material strength. The static load rating formulas for self-lubricating and metal-to-metal spherical bearings are shown in 57 and 58. These formulas will yield approximate ratings, which should be used as ballpark numbers for bearing design.

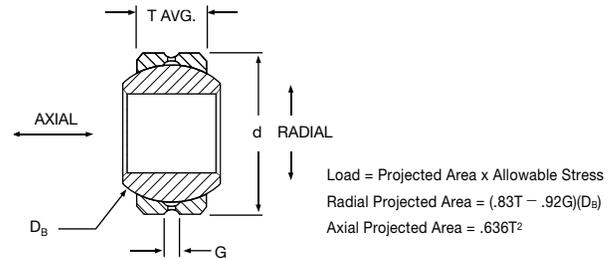
The allowable radial stress values given in the tables were determined from the ultimate tensile strength specifications for various race materials. Allowable axial stress values were derived from material yield strengths.

#### Allowable Stress - PTFE-Lined Bearings



#### 57 Static Load Rating Formulas for Self-Lubricating Spherical Bearings

#### Allowable Stress - Metal-to-Metal Bearings



#### 58 Static Load Rating Formulas for Metal-to-Metal Spherical Bearings

#### Allowable Stress PTFE Lined Bearings (psi)

Race Material	Radial		Axial	
	Ultimate	Limit	Ultimate	Limit
17-4PH, R <sub>C</sub> 28 MIN	112500	75000	67500	45000
ALUM 2024-T351	60000	40000	36000	24000

#### Standard Groove Sizes

Bearing Size Bore Code	G Width
3 & 4	.062
5 - 10	.078
12 - 16	.094
20 & above	.109

#### Allowable Stress Metal-to-Metal Bearings (psi)

Race Material	Radial		Axial	
	Ultimate	Limit	Ultimate	Limit
17-4PH, R <sub>C</sub> 32-36	150000	100000	125000	83000
4130 R <sub>C</sub> 32-36	150000	100000	125000	83000
A286 (AMS 5737)	140000	93000	95000	63000
AMS 4635 and ASTM B 50/B150M	75000	50000	45000	30000

## ROD END BEARING LOAD RATING

Rod end bearing load ratings can be generated only after carefully determining the load restrictions that each element of the rod end bearing imposes on the entire unit. In order to generate a frame of reference, consider the rod end bearing as a clock face, with the shank pointing down to the 6 o'clock position. The limiting factors in rating a rod end bearing are as follows:

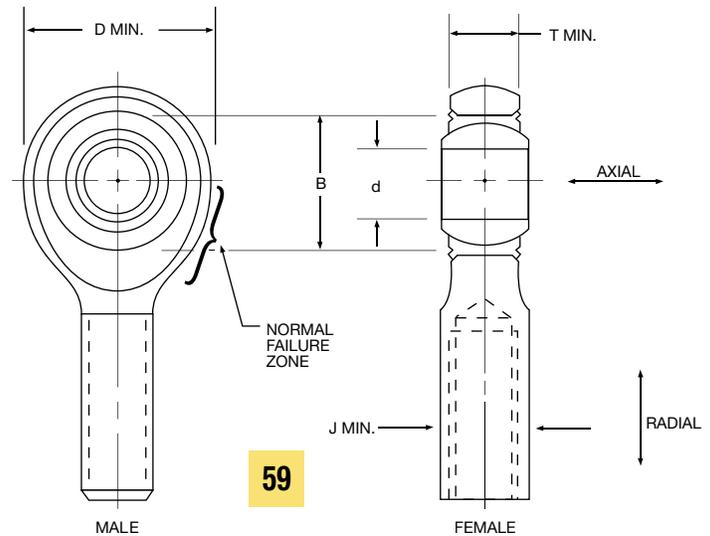
1. The double shear capability of the bolt passing through the ball bore.
2. The bearing capability, a function of race material or self-lubricating liner system.
3. The rod end eye or hoop tension stress in the 3 o'clock-9 o'clock position.
4. The shank stress area, as a function of male or female rod end configuration.
5. The stress in the transition area between the threaded shank transition diameter and the rod end eye or hoop.

Most rod ends will fail under tension loading in about the 4 o'clock-8 o'clock portion of the eye or hoop. The Net Tension Area (NTA) can be found as follows:

$$NTA = .008726 \times D^2 \times \sin^{-1} \left( \frac{T}{D} \right) + \frac{T}{2} \sqrt{D^2 - T^2} - B \times T$$

Solve the  $\sin^{-1} \left( \frac{T}{D} \right)$  in units of degrees, not radians.

This simple rod end load rating formula does not take into consideration such variables as special body shapes, thin race sections, hardness variation, lubrication holes, grooves, and hoop tension, which could significantly affect the load rating. Contact NHBB Applications Engineering for assistance in determining the load rating for specially designed Rod Ends and Sphericals.



59

The shank stress area (SSA) is a function of being either male or female, as follows:

For the male:

$$SSA = (\text{minor thread diameter})^2 \frac{\pi}{4}$$

For the female:

$$SSA = [J^2 - (\text{major thread diameter})^2] \frac{\pi}{4}$$

Pin shear stress (PSS) for load "F" is as follows:

$$PSS = \frac{2F}{\pi d^2}$$

The axial load capability of a rod end is a function of the following:

1. The retention method used to mount the bearing in the rod end eye. See the Bearing Installation and Retention section for further information beginning on page 71.
2. The axial load capability of the bearing element.
3. The bending moment, if any, placed on the rod end.

## Load Ratings and Misalignment Capabilities

### PV Factor

While not a type of loading, the PV factor is very useful in comparing and predicting test results on high speed-low load applications such as helicopter conditions.

PV is the product of the stress (psi) and the velocity (fpm) applied to a bearing. Caution must be advised when considering extreme values of psi and fpm. The extreme must be considered individually, as well as together.

Because the PV factor is derived from the geometry and operating conditions of a bearing, it serves as a common denominator in comparing or predicting test results. For this reason PV values are included in the wear curves of 22 and 23 (page 61) in the Self-Lubricating PTFE Liner Systems section, page 60.

The formula for determining the PV value for a spherical bearing is as follows:

$$PV = (\infty) (\text{cpm}) (D_B) (\text{psi}) (.00073)$$

Where:

$\infty$  = total angular travel in degrees per cycle  
(ie.  $\pm 25^\circ = 100^\circ$  total travel)

cpm = cycles per minute (oscillation rate)

$D_B$  = ball diameter

psi = bearing stress

### Dynamic Oscillating Radial Load

The dynamic oscillating radial load ratings given in this catalog for ADB, ADW, ADBY, ADB-N, ADW-N, ADBL and ADWL series self-lubricating spherical bearings are based on testing in accordance with AS81820. For conditions other than those specified by AS81820 contact NHBB Applications Engineering.

## NHBB TESTING CAPABILITIES

### Mechanical Test Equipment

NHBB has a variety of equipment to test spherical and rod end bearings under diverse conditions. NHBB performance data exceeds military and individual manufacturers' design requirements. Maximum capabilities of NHBB testing machines are shown in table 9.

### Polymer Test Equipment

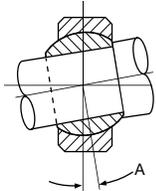
NHBB has the following thermal analysis (TA) equipment to support and control the quality of composites/polymers through analytical techniques that measure the physical and mechanical properties as a function of temperature and time:

1. Differential Scanning Calorimeter (DSC)
2. Thermogravimetric Analyzer (TGA)
3. Dynamic Mechanical Analyzer (DMA)
4. Thermomechanical Analyzer (TMA)
5. Thermo-Oxidative Stability Test (TOS)
6. Acid Digestion System
7. Fourier Transform Infrared Spectroscopy (FTIR)

TABLE 9: NHBB Testing Capabilities

	Force
Material Testing (Universal Testing Machine)	110,000 Lbs.
Static Compression/Tension	200,000 Lbs.
Low Speed Oscillation (up to 50 cpm)	
Uni-directional Loading	
(1 machine, 2 station) (700°F)	20,000 Lbs.
(1 machine, 2 station) (700°F)	70,000 Lbs.
Moderate To High Speed Oscillation	
Uni-directional Load (room temp.)	
(1 machine, 2 station) (1000 cpm)	1,000 Lbs.
(1 machine, 2 station) (1500 cpm)	1,000 Lbs.
(1 machine, 6 station) (200-600 cpm)	8,000 Lbs.
Low Speed Oscillation	
Reversing or Alternating Load (room temp.)	
(1 machine, 2 station) (up to 50 cpm)	40,000 Lbs.
High Speed, Oscillation	
Reversing and Alternating Load (room temp.)	
(2 machines, 1 station each) (400 cpm)	2,500 Lbs.
Airframe Track Roller	
Testing Machine (roller against flat plate)	60,000 Lbs.

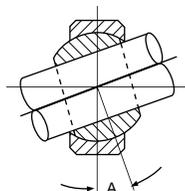
## FORMULA FOR DETERMINING MISALIGNMENT OF ROD END & SPHERICAL BEARINGS



**60**  $A = \sin^{-1} \frac{W}{E} - \sin^{-1} \frac{T}{E}$

### 60 Standard Method

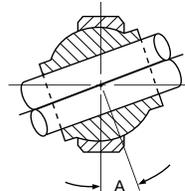
Most standard rod end and spherical bearing misalignment angles specified in NHBB catalogs are based on this method.



**61**  $A = \cos^{-1} \frac{B}{E} - \sin^{-1} \frac{T}{E}$

### 61 Design Reference

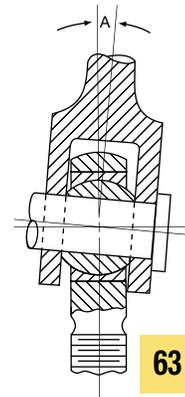
This method may be used as design reference for installation purposes, but should not be used as a functioning misalignment under load.



**62**  $A = \cos^{-1} \frac{S}{E} - \sin^{-1} \frac{T}{E}$

### 62 High Misalignment Series Method

(Neck balls only)



**63**  $A = \sin^{-1} \frac{W}{D} - \sin^{-1} \frac{T}{D}$

### 63 Rod End Clevis Misalignment

## HOW NHBB SPECIFIES CATALOG BEARING AND ROD END MISALIGNMENT

The misalignment angle of a rod end or spherical bearing refers to the angle between the ball centerline and the outer member centerline when the ball is misaligned to the extreme position allowed by the clevis or shaft design, as applicable.

NOTE: Since angle "A" applies equally on both sides of the centerline, it follows that total misalignment of the bearing is double the value obtained for "A".

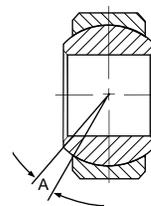
60 through 63 illustrate varying types of bearing misalignment and a formula for calculating each

Where:

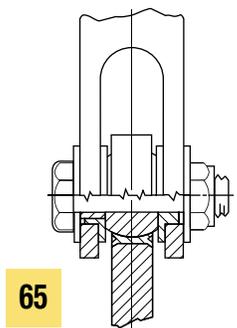
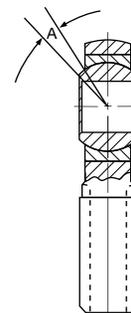
A = angle of misalignment	B = bore of ball
D = head diameter (rod end)	E = ball spherical diameter
S = shoulder diameter (neck ball)	T = housing (race) width
W = width of ball	

64 illustrates how misalignment angles for standard ball spherical bearings and rod ends are represented in NHBB catalogs. The misalignment angle is calculated per 60 formula. Neck ball (high misalignment) bearings and rod ends are represented in the same manner, but are calculated per 62 formula.

NHBB prefers not to use rod end clevis misalignment for the following reason. The rod end clevis misalignment formula presupposes a clevis configuration as shown in 63 in which the clevis slot and ball faces are of equal width and in direct contact. In aircraft applications the configuration shown in 65 is



**64**



**65**

Typical Rod End/Clevis Installation

more typical than that of 63. As pictured in 65, the clevis slot is wider than the ball to permit installation of flanged bushings and/or spacers. This results in a higher but more variable misalignment capability, and the angle of misalignment becomes a function of the user's bushing flange or spacer diameter instead of the fixed rod end head diameter.

## Bearing Selection Factors

### ROLLING ELEMENT BEARINGS

1. Low load – high speed bearings should usually be antifriction rolling element bearings, except for lubricated sleeve bearings under very low load and constant rotation rather than oscillatory.

### METAL-TO-METAL SPHERICALS AND ROD ENDS

1. These are recommended for most joints which are primarily static, need only periodic lubrication and require a minimum of permanent set under high loads.
2. They are also recommended for some moving applications such as landing gears, where most of the motion occurs under low loading, but where the bearing is nearly static under the high impact loads when the gear is locked.
3. Hardened 52100 or 440C balls with heat-treated outer races of either chrome-moly, alloy steel, or precipitation hardened stainless steel are recommended when loads are very high in relation to the available envelope.
4. Aluminum bronze races are less apt to seize or gall under vibratory conditions or if lubrication conditions are minimal, providing the required maximum load capacity is not too great (the load capacity is usually about 1/2 that of the heat treated steel race bearings). In general, materials containing an appreciable amount of copper are good bearing materials.
5. A beryllium-copper ball operating against a heat treated stainless steel race is an excellent combination for dynamic oscillating conditions under very high loads, providing adequate lubrication is present. This requires either an automatic lube system or frequent maintenance provisions.
6. Metal-to-metal spherical bearings and rod ends are often fitted with aluminum-nickel-bronze sleeves in the ball bore, with lubrication provisions, so that the relative motion and resulting wear take place between the shaft and the sleeve, with only misalignment taking place at the ball spherical surface. This allows replacement of the sleeves without replacement of the expensive portion of the bearing.
7. For extremely high load carrying capacity in a limited envelope, spherical bearings with both ball and swaged outer race made of heat-treated maraging steel of 300ksi tensile strength are sometimes used, and can be formed by a special processing procedure.
8. Special types of metal-to-metal sphericals such as loader slot bearings, fractured outer race bearings, or snap-assembled bearings (page 54 and 55) are used for some applications where very hard inner and outer races are desirable for wear and strength reasons, but require special geometry (a relatively narrow ball).
9. Spherical and rod end bearings for both high temperature and cryogenic applications are available using special materials such as the INCONEL® alloys, STELLITE® alloys and other cobalt alloys, A-286, Rene 41 and others. Special dry film lubricants or silverplating in the race I.D. are sometimes used in these bearings.
10. Two-piece swage-coined rod ends (page 56 **11**) should be used primarily for applications which require high load carrying capacity in a basically static condition with some misalignment capability, since the rod end body cross-sectional area available to carry tension is greater than with a 3-piece rod end, the insert outer race area having been replaced by body area. However, ball-to-race conformity is usually poor, hence rapid wear and/or fretting and galling can occur under dynamic or oscillating loading.
11. Two-piece Mohawk rod ends (page 56 **12**) for commercial use or non-critical applications are available. The Mohawk design has better ball-to-race conformity than the 2-piece swage-coined design and can be used in dynamic applications but only at relatively low loads.
12. Most metal-to-metal bearings are designed with a small radial clearance to facilitate assembly with the mating part and assure that the bearing does not bind up if assembled into its housing with an interference fit. However, they may be made with a preload, providing there is a fairly large tolerance on this preload, for applications where absolutely no play can be tolerated.

INCONEL® is a registered trademark of Inco Alloys International, Inc. and The International Nickel Company, Inc.

STELLITE® is a registered trademark of Kennametal, Inc.

### **SELF-LUBRICATING PTFE TYPE LINED SLEEVES, SPHERICALS AND ROD END BEARINGS**

1. These consist of a relatively thin composite liner containing PTFE (polytetrafluoroethylene) as a lubricant and bonded to a metallic backing material.
2. They are recommended for applications requiring considerable oscillation and misalignment under very heavy loads and where frequent lubrication is undesirable or impossible. To gain full life from these bearings, a wear of about .005 from the liner surface must be tolerable.
3. This type is especially suited for hydraulic actuators, many aircraft landing gear door applications, vibration damping devices, hinge and actuation link bearings for control surfaces, sliding guide bearings for flaps and leading edge slats, and power control system drive linkage bearings, along with many others not mentioned.

### **CHECK LIST OF FACTORS TO BE CONSIDERED BY THE APPLICATIONS ENGINEER IN SELECTION OR DESIGN OF SPHERICAL BEARINGS**

1. Bearing envelope requirements and/or restrictions
2. Weight limitations
3. Whether used in a static or dynamic application
4. For sleeve bearings, whether the shaft is oscillating or rotating continuously in one direction or both directions
5. Loading:
  - (A) Maximum static radial or axial
  - (B) Maximum and normal dynamic
  - (C) Reversing or uni-directional
  - (D) Shock or vibratory conditions
6. Relative movement
  - (A) Angle of oscillation
  - (B) Velocity in terms of rpm or cycles per minute
  - (C) Required angle of misalignment
  - (D) Load-velocity phase relationship
7. Allowable wear
8. Life requirement, preferably in number of cycles
9. Operating temperature range
10. Preload or clearance requirements
11. Lubrication methods, accessibility, and frequency of maintenance available
12. Environmental conditions including exposure to dirt, moisture and other contaminants
13. Installation requirements, including staking methods, housing and shaft fits, etc.

For additional considerations, please consult NHBB Applications Engineering staff.

## Specifications Compliance

NHBB complies with many government specifications in the manufacture of its products. The most common of these specifications are listed in table 10.

NHBB also complies with most of the major aerospace manufacturers specifications regarding procedures such as plating, testing, and heat treating.

**TABLE 10: Specifications Compliance**

<b>Plating, Coating and Surface Treatment</b>	
Alodine	* SAE AMS-C-5541
Anodize (Chromic)	SAE AMS-A-8625 Type I Class 1
Anodize (Sulphuric)	* SAE AMS-A-8625 Type II Class 1
Anodize (Hard)	* SAE AMS-A-8625 Type III Class 1
Cadmium	* SAE AMS-QQ-P-416 Type I Class 3 (Races)
Cadmium (Supplementary Chromate Treatment)	* SAE AMS-QQ-P-416 Type II Class 2 (Bodies)
Cadmium (Vacuum Deposited)	SAE AMS-C-8837
Chromium	* SAE AMS-QQ-C-320 Class 2 (.0002" to .0005" thickness)
Chromium	AMS 2406
Nickel (Electroless)	SAE AMS-C-26074
Nickel (Electrodeposited)	SAE AMS-QQ-N-290
Passivate	AMS QQ-P-35 or ASTM-A 967
Silver	AMS 2410
Zinc (Chromate Primer)	TT-P-1757
<b>Heat Treatment</b>	
Steel, Alloy and Stainless	SAE-AMS-H-6875
Aluminum	SAE-AMS-H-6088
Beryllium Copper	SAE-AMS-H-7199
Titanium	AS-H-81200
<b>Non-Destructive Testing</b>	
Fluorescent Penetrant	ASTM-E-1417
Magnetic Particle	ASTM-E-1444
Ultrasonic	SAE AMS STD 2154
<b>Quality Control</b>	
Quality Systems	ISO 9001
Aerospace Quality Systems	AS 9000
Sampling Procedures and Tables for Inspection by Attributes	ANSI/ASQE Z 1.4
<b>Machining</b>	
Threads, Rolled or Turned	AS 8879 and MIL-S-7742
<b>Marking and Packaging</b>	
Military Packaging	MIL-STD-129
Marking	MIL-STD-130
Preservation	MIL-DTL-197

\*NHBB Standards



# Inch/Metric Conversion Table

**TABLE 11: Inch/Metric Conversion Table**

Fraction	Inch Decimal	mm	Fraction	Inch Decimal	mm	Fraction	Inch Decimal	mm	Fraction	Inch Decimal	mm
	0.00004	0.001	17/64	0.2656	6.746		0.6693	17.		1.3780	35.
	0.00039	0.01		0.2756	7.	43/64	0.6719	17.066		1.4173	36.
	0.0010	0.025	9/32	0.2812	7.1437	11/16	0.6875	17.4625	1 1/2	1.5000	38.1
	0.0020	0.051	19/64	0.2969	7.5406	45/64	0.7031	17.859		1.5354	39.
	0.0030	0.0762	5/16	0.3125	7.9375		0.7086	18.		1.5748	40.
	0.00394	0.1		0.3150	8.	23/32	0.7187	18.256		1.6535	42.
	0.0050	0.1270	21/64	0.3281	8.334	47/64	0.7344	18.653	1 3/4	1.7500	44.45
	0.00984	0.25	11/32	0.3437	8.731		0.7480	19.		1.7717	45.
	0.0100	0.254		0.3543	9.	3/4	0.7500	19.05		1.8898	48.
1/64	0.0156	0.396	23/64	0.3594	9.1281	49/64	0.7656	19.446		1.9685	50.
1/32	0.0312	0.793	3/8	0.3750	9.525	25/32	0.7812	19.843	2	2.000	50.8
	0.03937	1.	25/64	0.3906	9.9219		0.7874	20.		2.0472	52.
3/64	0.0469	1.191		0.3937	10.	51/64	0.7969	20.240		2.1654	55.
	0.0591	1.5	13/32	0.4062	10.318	13/16	0.8125	20.6375		2.2047	56.
1/16	0.0625	1.5875	27/64	0.4219	10.716		0.8268	21.	2 1/4	2.2500	57.15
5/64	0.0781	1.984		0.4331	11.	53/64	0.8281	21.034		2.3622	60.
	0.0787	2.	7/16	0.4375	11.1125	27/32	0.8437	21.431	2 1/2	2.5000	63.5
3/32	0.0937	2.381	29/64	0.4531	11.509	55/64	0.8594	21.828		2.5197	64.
	0.0984	2.5	15/32	0.4687	11.906		0.8661	22.	2 3/4	2.7500	69.85
	0.1000	2.54		0.4724	12.	7/8	0.8750	22.225		2.8346	72.
7/64	0.1094	2.778	31/64	0.4844	12.303	57/64	0.8906	22.621		2.9528	75.
	0.1181	3.	1/2	0.5000	12.7		0.9055	23.	3	3.0000	76.2
1/8	0.1250	3.175		0.5118	13.	29/32	0.9062	23.018		3.1496	80.
	0.1378	3.5	33/64	0.5156	13.096	59/64	0.9219	23.416	3 1/4	3.2500	82.55
9/64	0.1406	3.571	17/32	0.5312	13.493	15/16	0.9375	23.8125	3 1/2	3.5000	88.9
5/32	0.1562	3.968	35/64	0.5469	13.891		0.9449	24.		3.5433	90.
	0.1575	4.		0.5512	14.	61/64	0.9531	24.209	3 3/4	3.7500	95.25
11/64	0.1719	4.366	9/16	0.5625	14.2875	31/32	0.9687	24.606		3.9370	100.
	0.1772	4.5	37/64	0.5781	14.684		0.9843	25.	4	4.0000	101.6
3/16	0.1875	4.7625		0.5906	15.	63/64	0.9844	25.003	4 1/4	4.2500	107.95
	0.1969	5.	19/32	0.5937	15.081	1	1.0000	25.4		4.3307	110.
13/64	0.2031	5.159	39/64	0.6094	15.478		1.0630	27.	4 1/2	4.5000	114.3
7/32	0.2187	5.556	5/8	0.6250	15.875		1.1024	28.		4.7244	120.
15/64	0.2344	5.953		0.6299	16.		1.1811	30.	4 3/4	4.7500	120.65
	0.2362	6.	41/64	0.6406	16.271	1 1/4	1.2500	31.75	5	5.0000	127.
1/4	0.2500	6.35	21/32	0.6562	16.668		1.2992	33.	5 1/2	5.5000	139.7

**TABLE 12:  
Conversion Factors  
for The U.S.  
Customary System  
(USCS) and  
The International  
System of Units (SI)**

	USCS to SI	SI to USCS
Length	1 in = 25.4 mm	1 mm = 0.0393701 in
Surface Texture	1 μ in = 0.0254 μm	1 μm = 39.3701 μ in
Area	1 in <sup>2</sup> = 645.16 mm <sup>2</sup>	1 mm <sup>2</sup> = 0.00155 in <sup>2</sup>
Volume	1 in <sup>3</sup> = 16.3871 cm <sup>3</sup>	1 cm <sup>3</sup> = 0.0610237 in <sup>3</sup>
Mass	1 lb = 0.45359 kg	1 kg = 2.20462 lb
	1 oz = 28.3495 g	1 g = 0.035274 oz
Density	1 lb/in <sup>3</sup> = 27.6799 g/cm <sup>3</sup>	1 g/cm <sup>3</sup> = 0.036 lb/in <sup>3</sup>
Force	1 lbf = 4.44822 N	1 N = 0.224809 lbf
Moment of Force (Torque)	1 lbf in = 0.112985 Nm	1 Nm = 8.85 lbf in
Stress	1 lbf/in <sup>2</sup> = 0.00689 N/mm <sup>2</sup>	1 N/mm <sup>2</sup> = 145.038 lbf/in <sup>2</sup>

## Fahrenheit/Celsius Conversion Table

The numbers in center column refer to the temperatures either in Celsius or Fahrenheit which need conversion to the other scale. When converting from Fahrenheit to Celsius, the equivalent temperature will be found to the left of the center column. If converting from Celsius to Fahrenheit, the answer will be found to the right.

TABLE 13: Fahrenheit/Celsius Conversion Table

°C	°C/°F	°F
-79	-110	-166
-73	-100	-148
-68	-90	-130
-62	-80	-112
-57	-70	-94
-51	-60	-76
-45	-50	-58
-40	-40	-40
-34	-30	-22
-29	-20	-4
-23	-10	14
-17.7	0	32
-17.2	1	33.8
-16.6	2	35.6
-16.1	3	37.4
-15.5	4	39.2
-15.0	5	41.0
-14.4	6	42.8
-13.9	7	44.6
-13.3	8	46.4
-12.7	9	48.2
-12.2	10	50.0
-6.6	20	68.0
-1.1	30	86.0
4.4	40	104.0
9.9	50	122.0
15.6	60	140.0
21.0	70	158.0
26.8	80	176.0
32.1	90	194.0
37.7	100	212
43	110	230
49	120	248
54	130	266
60	140	284
65	150	302
71	160	320
76	170	338
83	180	356
88	190	374

°C	°C/°F	°F
93	200	392
99	210	410
104	220	428
110	230	446
115	240	464
121	250	482
127	260	500
132	270	518
138	280	536
143	290	554
149	300	572
154	310	590
160	320	608
165	330	626
171	340	644
177	350	662
182	360	680
188	370	698
193	380	716
199	390	734
204	400	752
210	410	770
215	420	788
221	430	806
226	440	824
232	450	842
238	460	860
243	470	878
249	480	896
254	490	914
260	500	932
265	510	950
271	520	968
276	530	986
282	540	1004
288	550	1022
293	560	1040
299	570	1058
304	580	1076
310	590	1094

°C	°C/°F	°F
315	600	1112
321	610	1130
326	620	1148
332	630	1166
338	640	1184
343	650	1202
349	660	1220
354	670	1238
360	680	1256
365	690	1274
371	700	1292
376	710	1310
382	720	1328
387	730	1346
393	740	1364
565	1050	1922
571	1060	1940
576	1070	1958
582	1080	1976
587	1090	1994
593	1100	2012
598	1110	2030
604	1120	2048
609	1130	2066
615	1140	2084
620	1150	2102
626	1160	2120
631	1170	2138
637	1180	2156
642	1190	2174
648	1200	2192
653	1210	2210
659	1220	2228
664	1230	2246
670	1240	2264
675	1250	2282
681	1260	2300
686	1270	2318
692	1280	2336
697	1290	2354



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