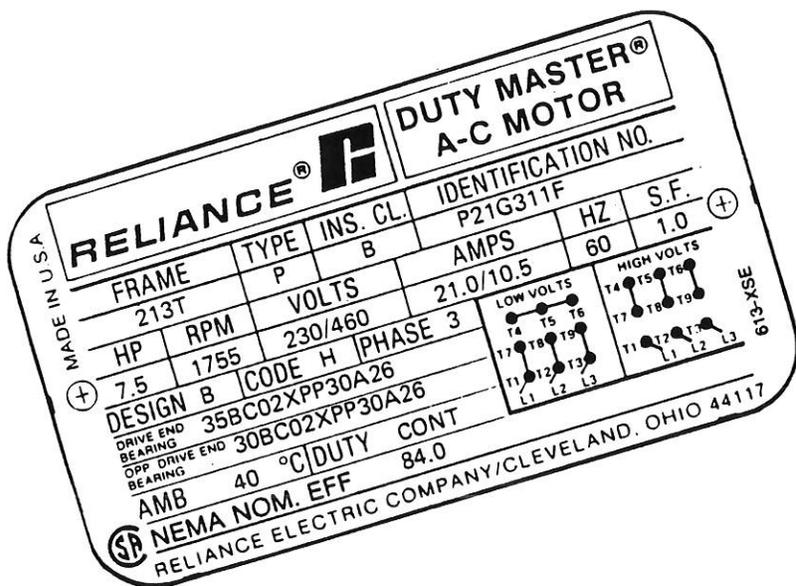




# AFBMA BEARING DESIGNATION



Many motor nameplates have the blank line stamped with the bearing numbers under the AFBMA designation. By means of the AFBMA designation, you can positively identify a bearing without tying it down to a particular manufacturer's part number. The designation serves as a complete specification of the bearing. The alternately grouped figures and letters are identified as shown.

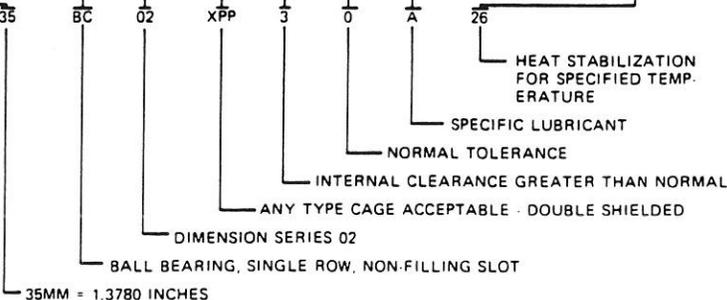
Any bearing supply house given the AFBMA number can supply the proper bearing. The important thing to remember is that the number does not refer to any particular manufacturer be it domestic or foreign.

All Reliance® Standard NEMA T-Frame Motors have the loose internal fit (C-3). Please pay close attention to section 3 designation. Should you have any questions contact your Reliance Electric Sales Office.

IDENTIFICATION CODE FOR BALL AND ROLLER BEARINGS

Basic Number			Supplementary Number						
Section 1			Section 2		Section 3		Section 4	Section 5	
Type and boundary dimensions			Modification of design			Internal fit and tolerances		Lubricants and preservatives	Special requirements
Bore	Type	Outside diameter and width	Cage and separators	Shields and seals	Bearing rings	Internal fit	Tolerances		
				Duplex mounting modification					
0000	AAA	00	A	AA	A	0	0	A	000

EXAMPLE





# BEARING DATA — HORIZONTAL XT A-C MOTORS

Extra Tough A-C Motors: 17,500 hours, B<sub>10</sub><sup>\*</sup> life minimum

Enclosures: TEFC-XT, TEFC-XP-XT, TEAO-XT

Based On: Speed: Highest rated

Load: Nominal load capacities in Table 2 exceeds those created by using smallest diameter belt sheave as defined in NEMA Mg 1-14.43a.

\*B<sub>10</sub> Hrs. — The statistical life expectancy in hours which 90% of all bearings, subject to the same operating conditions, are expected to exceed.

The average bearing life in hours is five (5) times the B<sub>10</sub> hours.

**TABLE 1 — XT BEARING SIZES**

A-C MOTORS		FRONT END			BACK END		RELIANCE PART NO.	
FRAME SIZE	NO. OF POLES	AFBMA SIZE	AFBMA NO.	RELIANCE PART NO.	AFBMA SIZE	AFBMA NO.		
180T	ALL	205	25BC02XPP30A26	416821-2F	206	30BC02XPP30A26	416821-2G	
210T	ALL	206	30BC02XPP30A26	416821-2G	207	35BC02XPP30A26	416821-2H	
250T	ALL	309	45BC03XPP30A26	416821-2FK	309	45BC03XPP30A26	416821-2FK	
280T	ALL	310	50BC03XPP30A26	416821-2FL	310	50BC03XPP30A26	416821-2FL	
320T	ALL	311	55BC03XPP30A26	416821-2FM	311	55BC03XPP30A26	416821-2FM	
360T	4 & More	313	65BC03XPP30A26	416821-2FP	313	65BC03XPP30A26	416821-2FP	
360TS(4)	2	210	50BC02XPP30A26	416821-2L	210	50BC02XPP30A26	416821-2L	
400T	4 & More	316	80BC03XPP30A26	416821-2GC	316	80BC03XPP30A26	416821-2GC	
400TS(4)	2	213	65BC02XPP30A26	416821-2P	213	65BC02XPP30A26	416821-2P	
440T	4 & More	318	90BC03XPP30A26	416821-2GE	318	90BC03XPP30A26	416821-2GE	
440TS(4)	2	213	65BC02XPP30A26	416821-2P	213	65BC02XPP30A26	416821-2P	
445	TY(7)	4 & More	318	90BC03XPP30A26	416821-2GE	222	110RU02M30X26	416822-3AJ
447	TS(7)	2	213	65BC02XPP30A26	416821-2P	213	65BC02XPP30A26	416821-2P
449	TZ(7)	4 & More	318	90BC03XPP30A26	416821-2GE	318	90BC03XPP30A26	416821-2GE

**TABLE 2 — NOMINAL LOAD CAPACITIES OF XT A-C MOTORS — IN POUNDS**

FRAME SIZE	RADIAL LOAD (1)				AXIAL THRUST IN (2)				AXIAL THRUST OUT (3)				"r"(6)	Inches Δ Max.
	3600	1800	1200	900	3600	1800	1200	900	3600	1800	1200	900		
180T	190	240	280	300	210	280	340	390	210	280	340	390	12.5	± 1.7
210T	240	320	370	410	260	360	440	500	260	360	440	500	15.9	± 2.4
250T	540	660	770	860	520	690	830	950	520	690	830	950	18.6	± 2.9
280T	630	740	860	970	870	1140	1390	1580	870	1140	1390	1580	22.0	± 3.2
320T	680	830	970	1080	880	1150	1400	1590	880	1150	1400	1590	24.3	± 3.9
360T(5)	920	1110	1290	1410	890	1160	1410	1600	890	1160	1410	1600	26.6	± 4.2
400T	(4)	1450	1680	1800	(4)	1940	2340	2610	(4)	1940	2340	2610	31.4	± 5.6
440T	(4)	1690	1880	2140	(4)	2320	2810	3150	(4)	2320	2810	3150	35.1	± 6.9

(1) Radial loads listed are radial position 90 degrees from the shaft axis. The above values are with the load located at the end of the NEMA "T" shaft extension.

(2) "Thrust-In" is from the drive end shaft toward the opposite end (front end), no radial load.

(3) "Thrust-Out" is from the opposite drive end to the drive end (back end), no radial load.

(4) Coupled duty only — contact factory for applications other than coupled duty.

(5) Thrust and radial loads for 3600 rpm are for "T" construction only (313 B.E. Brg.); 360TS construction is for coupled duty only (210 B.E. Brg.).

(6) To find max. allowable radial load if not applied at end of shaft, see equation at bottom of page E-15 or E-16.

(7) TZ — special shaft extension — 2.875 x 4.5 coupled duty

TY — oversized core — longer than standard — 3.875 x 8.25 belted duty

TS — standardized short shaft — 2.375 x 4.5 coupled duty

Values listed are intended for general use. Special applications may permit higher than listed loads, if approved by the Product Department.

# BEARING DATA — STANDARD HORIZONTAL A-C MOTORS

Standard A-C Motors: 17,500 hours, B<sub>10</sub>\* life minimum  
 Enclosures: Protected (Open Drip), TEFC, TEFC-XP, TEAO  
 Based On: Speed: Highest rated  
 Load: Nominal load capacities in Table 2 exceeds those created by using smallest diameter belt sheave as defined in NEMA Mg 1-14.43a.

\*B<sub>10</sub> Hrs. — The statistical life expectancy in hours which 90% of all bearings, subject to the same operating conditions, are expected to exceed.

The average bearing life in hours is five (5) times the B<sub>10</sub> hours.

TABLE 1 — STANDARD BEARING SIZES

STANDARD A-C MOTORS		FRONT END			BACK END		RELIANCE PART NO.
FRAME SIZE	NO. OF POLES	AFBMA SIZE	AFBMA NO.	RELIANCE PART NO.	AFBMA SIZE	AFBMA NO.	
140T	ALL	203	17BC02XPPS0A26	416821-2D	205	25BC02XPPS0A26	416821-2F
180T	ALL	205	25BC02XPP30A26	416821-2F	206	30BC02XPP30A26	416821-2G
210T	ALL	206	30BC02XPP30A26	416821-2G	207	35BC02XPP30A26	416821-2H
250T(6)	ALL	209	45BC02XPP30A26	416821-2K	209	45BC02XPP30A26	416821-2K
250T(7)	ALL	309	45BC02XPP30A26	416821-2FK	309	45BC02XPP30A26	416821-2FK
280T	ALL	206	30BC02XPP30A26	416821-2G	310	50BC03XPP30A26	416821-2FL
320T	ALL	207	35BC02XPP30A26	416821-2H	311	55BC03XPP30A26	416821-2FM
360T	4 & More	210	50BC02XPP30A26	416821-2L	313	65BC03XPP30A26	416821-2FP
360TS(4)	2	210	50BC02XPP30A26	416821-2L	210	50BC02XPP30A26	416821-2L
400T	4 & More	213	65BC02XPP30A26	416821-2P	316	80BC03XPP30A26	416821-2GC
400TS(4)	2	213	65BC02XPP30A26	416821-2P	213	65BC02XPP30A26	416821-2P
400T	4 & More	213	65BC02XPP30A26	416821-2P	318	90BC03XPP30A26	416821-2GE
400TS(4)	2	213	65BC02XPP30A26	416821-2P	213	65BC02XPP30A26	416821-2P
445 TY(9)	4 & More	318	90BC03XPP30A26	416821-2GE	222	110RU02M30X26	416822-3AJ
447 TS(9)	2	213	65BC02XPP30A26	416821-2P	213	65BC02XPP30A26	416821-2P
449 TZ(9)	4 & More	318	90BC03XPP30A26	416821-2GE	318	90BC03XPP30A26	416821-2GE

TABLE 2 — NOMINAL LOAD CAPACITIES OF STANDARD A-C MOTORS — IN POUNDS

FRAME SIZE	RADIAL LOAD (1)				AXIAL THRUST IN (2)				AXIAL THRUST OUT (3)				"Y"(8)	Inches ΔMax.
	3600	1800	1200	900	3600	1800	1200	900	3600	1800	1200	900		
180T	190	240	280	300	140	190	230	260	210	280	340	390	12.5	± 1.7
210T	240	320	370	410	190	260	320	360	260	360	440	500	15.9	± 2.4
250T(6)	320	380	450	510	330	430	510	590	330	430	510	590	18.6	± 2.9
250T(7)	540	660	770	860	520	690	830	950	520	690	830	950	18.6	± 2.9
280T	630	740	850	950	210	270	320	370	870	1140	1390	1580	22.0	± 3.2
320T	680	830	970	1080	280	350	420	470	880	1150	1400	1590	24.3	± 3.9
360T(5)	920	1110	1290	1410	380	480	570	620	890	1160	1410	1600	26.6	± 4.2
400T	(4)	1450	1680	1800	(4)	780	920	1020	(4)	1940	2340	2610	31.4	± 5.6
440T	(4)	1690	1880	2140	(4)	780	940	1050	(4)	2320	2810	3150	35.1	± 6.9

- (1) Radial loads listed are any radial position 90 degrees from the shaft axis. The above values are with the load located at the end of the NEMA "T" shaft extension.
- (2) "Thrust-In" is from the drive end shaft toward the opposite end (front end), no radial load.
- (3) "Thrust-Out" is from the opposite drive end to the drive end (back end), no radial load.
- (4) Coupled duty only — contact factory for applications other than coupled duty.
- (5) Thrust and radial loads for 3600 rpm are for "T" construction only (313 B.E. Brg.); 360TS construction is for coupled duty only (210 B.E. Brg.)
- (6) Mark II rolled steel construction.
- (7) Cast iron construction.
- (8) To find max. allowable radial load if not applied at end of shaft, see equation at bottom of page E-15 or E-16.
- (9) TZ — special shaft extension — 2.875 x 4.5 coupled duty  
 TY — oversized core — longer than standard — 3.875 x 8.25 belted duty  
 TS — standardized short shaft — 2.375 x 4.5 coupled duty.

Values listed are intended for general use. Special applications may permit higher than listed loads, if approved by the Product Department.

GREASE SPECIFICATION

SYM	GREASE	REL.SPEC. 4824- @	SPEC. REF.
			LUB. PLATE
A	Chevron BRB No. 2	15-A	.
B @	Aero Shell No. 7	15-B	@ 692-CW
C	Keystone No. 89	15-C	692-E
D	Beacon No. 325	15-D	692-Y
E	Dow Corning DC-33	15-E	692-BG
F	Dow Corning DC-44	15-F	692-E
G #	Shell Alvania No. 2	15-G	None
H	Fluororube Gr. 544	15-H	None
J	Aviation Grease No. 5	15-J	692-CW
K	Chevron BRB No. 2	15-K	♀
L	Andok 260	15-L	692-BF
M			
N			
P			
R			
S			
T			
W			
X			
Y			
Z	None		None

@ Obtain spec. number and spec. write-up from P.R. Weismann when adding new symbols.

\* Specify 692-CT N/P only when BRB No. 2 is used in the following applications:

- Cl. F or higher Enclosed
- Cl. H or higher Protected

\* Specify 692-CZ N/P only when BRB No. 2 is used in the following applications:

- Textile
- Vibration Duty
- Vibrascrew
- Francis Metal

♀ E.P. Additive

Rapid Reversal Duty  
(2 + Rev./Min.)

@ Aero. shell #7 can be used with BRB #2 in brgs. if ambient temp. is not below -20°F.

† Navy motors must be greased with Shell Alvania No. 2.

RE 1372VI Printed in U.S.A.

APPROVED BY	OF	D O.	DATE
C R 178513 179021		MADE BY R.E.W.	
Distribution		APPROVED DATE 3/27/69	3426-1
		Retyped 11/70	

**Table 1  
Grease Specification  
Standard Reliance And AFBMA Greases**

Reliance Grease No. 3426-1	Description	Operating Range		Commercial Name And Manufacturer	AFBMA Symbol	Lube Plate Specified	Substitute Grease Allowed	Remarks
		Low	High					
A	High Temp Petroleum	-20°F	+300°F	Cheverin SRI	H	①		Reliance ③ Standard Grease
C	High Temp Silicone	0°F	+400°F	Keystone Lube Keystone No. 89M	S	692-E	Dow Corn. DC-44	
D	Low Temp Petroleum	-65°F	+225°F	Areo Shell No. 7	L	692-CW		
E	Low Temp Silicone	-100°F	+275°F	Dow Corning DC 33M	R	692-BG	②	
F	High Temp Silicone	0°F	+100°F	Dow Corning DC 44M	S	692-E	Keystone No. 89M	Same Specs As Keystone No. 89 M
G	Med. Temp Petroleum	-20°F	+225°F	Shell Oil Co. Alvania No. 2	M	None	②	
H	Water Repellent			Shell Oil Co. Cyprina No. 3		No Plate		
M		-20°F	+250°F	New Grease				High Radiation Resistance

- ① Refer to A/P 201-2.3 for use of 692-CT and 692-CZ lube plates
- ② Must be reviewed by engr.
- ③ Reliance standard Grease; 140-449T; Insulation Class B and F; Min. Ambient -20°F.

**Table 2  
Service Conditions\***

	Ambient Temperature	Bearing Load	Atmosphere
Standard	0°F to 104°F	Steady	Clean
Severe	-20°F to 120°F	Medium Shock Vibration (less than .44 in/sec.)	Medium Dirt, Abrasives, Corrosion
Extreme Low Temp.	-65°F to 104°F	Heavy Shock Vibration (more than .44 in/sec.)	Heavy Dirt, Abrasives, Corrosion
Extreme High Temp	+50°F to 250°F		

\*Note: Severity of service conditions is dependent on the level of the most damaging parameter at the head of Table 2.

**Table 3  
Grease Selection**

Insulation Class	Minimum Starting Temperature		
	-100°F	-65°F	-15°F
B	I	II	III
F	I		III
H			III D-C Motors IV A-C Motors

**Table 4  
Grease Description**

Type	Identification	Manufacturer
I	Aeroshell No. 7	Shell Oil Company
II	Beacon 325	American Oil Company
III	Chevron SRI No. 2**	Chevron Oil Company
IV	Keystone No. 89	Keystone Division of Pennwalt Corporation

\*\*Alternate type III Greases:  
Regal Premium RB - Texaco  
Dolium - Shell Oil Company

The quantity of grease to be added depends on the size of machine and frequency of relubrication, as indicated in Table 6.

**Table 5**  
Relubrication Periods For Grease Lubricated Equipment

Type Of Bearing	Frame Size	HP	Speed Rpm	Service Conditions		
				Standard	Severe	Extreme**
Ball	48, 56 140T & larger	All 1-7½ 10-40 50 & larger	1800 or less	No Relubrication		2500 hrs/6 months
				10000 hrs/2 yrs*	2000 hrs/6 mos.	1 month
			6000 hrs/1 yr.	1500 hrs/3 mos.	1 month	
			4000 hrs/1 yr.	1000 hrs/3 mos.	1 month	
	48, 56 140T & larger	All	Over 1800 to 3600 incl. (DN less than 250000)	No Relubrication		1 month
				2000 hrs/6 mos.	500 hrs/2 mos.	½ month
Roller (cyl. & sph.)		All	1800 or less 3600	1000 hrs/3 mos. 700 hrs/2 mos.	700 hrs/2 mos. 550 hrs/2 mos.	1 month ½ month

\*The hours indicated are operating hours. The months or years indicated are maximum elapsed time between relubrication.  
\*\*"Extreme" service conditions are rare in actual practice. Corresponding lubrication cycles should therefore be applied with caution. In addition, it is advisable to check with Cleveland Service Dept. for related special instructions.

**Table 6**  
Grease Additions (by volume-in<sup>3</sup>/by weight-oz)

Frame Size	Service Conditions		
	Standard	Severe	Extreme
48, 56, 140	None	None	.5/.3
180-215	1.0/.5	.7/.3	.5/.3
254-449T	1.5/.7	1.1/.5	.7/.4

### STORAGE RECOMMENDATIONS (1)

Bearings or assembled motors should be stored in a clean dry location that is not subjected to large temperature variations (not outdoors) and is free from all vibration. Rotating the motor shaft once or twice a year should be adequate to prevent rusting or corrosion of the bearings. Every three years, the motors should be re-lubricated, and if possible, run for a short period of time.

Several years ago a survey was made of four major bearing manufacturers requesting their recommendations for shelf life of package bearings. As a practical approach to this problem, a shelf life of three years seems reasonable and unmounted bearings in storage for more than three years should probably be

(1) Unless special provisions for severe storage conditions are made such as enclosure in a moisture proof barrier and other special practices.

returned to the vendor for inspection and relubrication. Certainly a policy of first-in, first-out should be rigorously followed.

### SERVICE FOR BEARING PROBLEMS

Reliance maintains an excellent service organization which is willing to assist in areas where bearing difficulties are experienced. All too often the service representative is called in, handed a box containing the rusted, broken, welded, bent and twisted parts of a bearing, and with no prior history, before or during failure, asked "Why did the bearing fail?" In most cases of this type it is impossible to tell the cause of failure or make recommendations for correction.

The greatest assistance that can be given to a service representative is a good clear history of the motor or machine up to the time of failure and as many details as possible of the operation and load at the time of failure. If a bearing has been removed prior to a catastrophic failure, a great deal about the loads and operation can be learned by examination of such a bearing. In the case of an electric motor, it is advisable to save both bearings and grease for inspection. In conclusion, in the event of bearing trouble or failure, the more facts that are available for review, the better the chances are of locating and correcting the trouble.

# Action Guide

Small and Medium A-C Motors

## BEARINGS

### INTRODUCTION

The first roller bearing, it can be said, was invented over 3000 years ago when man first discovered that heavy objects could be moved with greater ease if they were rolled on logs rather than pushed along the ground. The steel bearings, which are familiar to us today, did not come into being until the 1800's when iron and steel became readily available and machines were invented that could mass produce parts accurately and hard enough to construct satisfactory bearings.

The purpose of a bearing is to reduce friction and wear. No bearing is completely without friction and they do wear with use, however, very little friction is produced when starting and running, and if properly installed and maintained, they can outlast the life of the driven machine.

Bearings are used to centrally support the rotating elements of a motor (rotor and shaft) while providing the motor user with a relatively rigid support for the output shaft. As such, the bearing becomes the connection point between the rotating and the stationary elements of a motor.

The most conventional connection is a ball bearing in small and medium size motors. The reasons are multiple. First, ball bearings are mass produced, therefore relatively inexpensive while readily available. Secondly, the ball bearing provides very reliable performance and life when used in a wide variety of applications and also, the self-aligning characteristics of a ball bearing allow the mass production of motor components without the need for prohibitive, selective or matched assembly.

### GENERAL BEARING INFORMATION

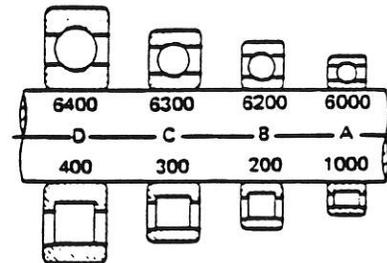
#### Bearing Standards

The dimensions and tolerances for anti-friction bearings have become very standardized. The standards govern inside diameter, outside diameter, width and the precision to which these dimensions are machined. These uniform standards have helped to reduce manufacturing cost, lower selling price and also provide an alternate source of supply for the bearing buyer.

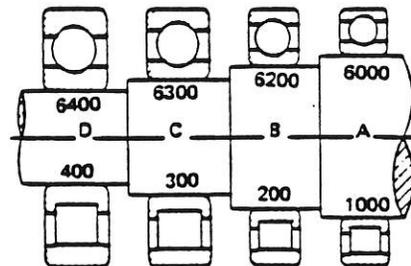
The organizations which have developed their standards throughout the world are the International Standards Organization (ISO) which is worldwide, the Anti-Friction Bearing Manufacturer Association (AFBMA) which is very familiar to us in North America, the Japanese Industrial Standards (JIS) in Japan, and

the Deutsche Industrial Normen (DIN) in Germany.

Most ball bearings are designed to fit into one of four series of standard dimensions for the bore and outside diameter. The following figure demonstrates the increase or decrease in load carrying capacity in relation to the proportions of the bearing bore and O.D. for standard single row ball and roller bearings by series classification. The width dimension may vary depending on the application or requirements for sealing devices, extra radial load capacity and extra grease reservoir. Sealed and double row bearings are an example of width variance.



Comparison of bearings with the same bore diameter



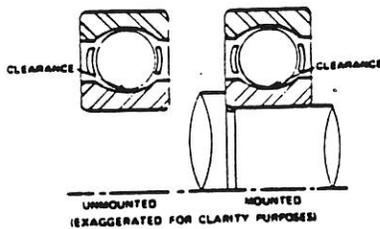
Comparison of bearings with the same outside diameter

#### Duty ratings

- A - Extra light duty
- B - Light duty
- C - Medium duty
- D - Heavy duty

AFBMA also has a standard radial clearance tolerance established for ball bearings. Radial clearance is defined as the total diametrical movement of the unclamped ring when a specified radial load is reversed. Radial ball bearings are usually supplied with a specified radial clearance, which will normally diminish during mounting because of interference fits with the shaft and house. After mounting, the bearing should have a small radial clearance remaining. The AFBMA standards are designated by a suffix after the bearing number as follows:

- C2 — Radial clearance less than standard
- No suffix — Radial clearance is standard
- C3 — more than standard (Reliance Standard)
- C4 — more than C3



Internal Fit

The drawing shown above shows predesignated clearance between the balls and the races.

Points to remember

1. Bearings are normally a press fit on the shaft of the rotating unit. The degree of press stretches the inner race O.D. — this can compress the balls and reduce life.
2. Rotational caused heat can expand the balls and races. To eliminate precompression of balls radial clearance should be allowed.
3. Allows slightly more misalignment without causing ball-race compression.

Four levels of dimensional precision for anti-friction bearings have been established by the AFBMA. They include tolerances for bore, outside diameter, width and radial runout and are as follows in order of low to higher precision:

- ABEC-1 tolerances suitable for general commercial applications such as appliances, automobiles, and construction equipment.
- ABEC-5 tolerances suitable for use in machine tools and high speed electric motors.
- ABEC-7 } for measuring and recording
- ABEC-9 } instruments and other precision equipment applications.

Note: See Page A-12 for AFBMA Nomenclature regarding standards.

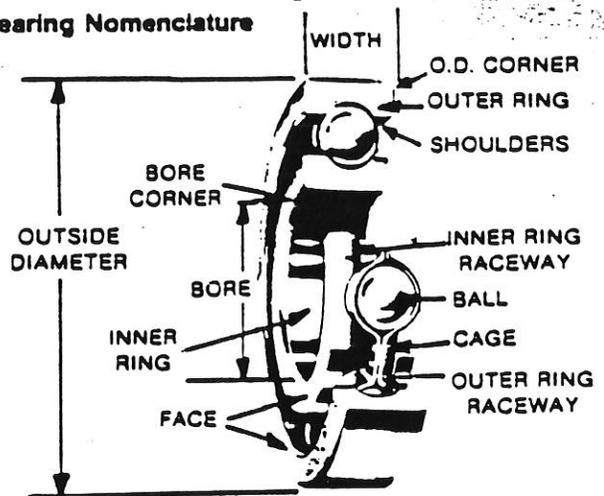
## BEARING TYPES

### Single Row, Deep Groove Ball Bearings

This is sometimes called a Conrad bearing and is listed by AFBMA as type BC (single row radial contact without filling slot). This is the most commonly used bearing in small and medium size a-c induction motors and the most popular type for all ball bearing applications.

The Conrad bearing is assembled by offsetting eccentrically the inner and outer races to allow the insertion of balls (see figure below). The Conrad type bearing therefore has uninterrupted raceways (no filling slot) which permits excellent bearing

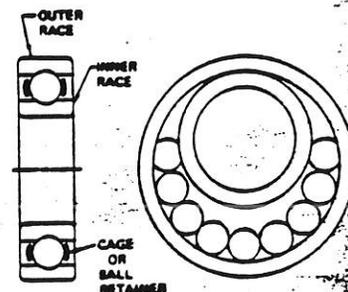
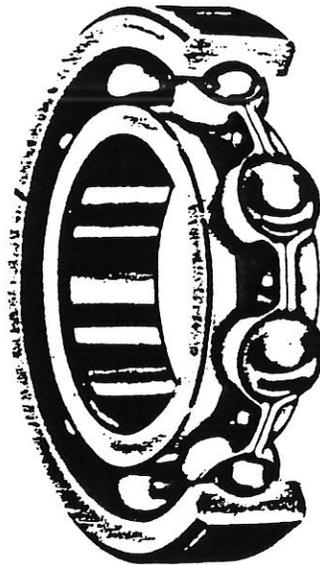
### Bearing Nomenclature



performance under light to moderate radial loads, relatively moderate thrust loads, or combined radial and thrust loads.

Points to remember:

1. Somewhat self-aligning; allows a minor misalignment ( $1/4^\circ$ ) without affecting the bearing operation and life.
2. The bearing is capable of radial and/or moderate thrust loads regardless of direction of load.



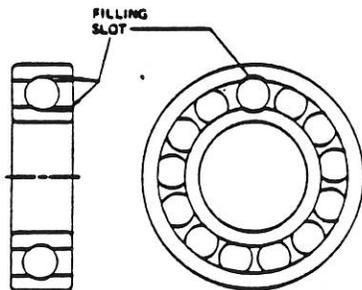
Single Row, Deep Groove Ball Bearing

### Single Row, Maximum Capacity

This bearing is AFBMA type BL (maximum capacity ball bearing with filling slot). It contains a maximum complement of balls which are inserted by means of a filling slot in the inner and outer raceways (see figure below). The addition of these extra balls permits heavier radial loads in moderate speed applications but with only light thrust loads since the balls will be damaged by contact with the filling slot if the angle of contact or axial load is too great. This type of bearing is available in sizes corresponding to the Conrad type, but usage of this bearing is decreasing in general and is not used in Reliance motors.

#### Points to remember:

1. The additional balls increase fatigue capacity over non-filling slot type.
2. Radial load capacity is greater than Conrad type.
3. Bearing is not capable of thrust loads nor angular misalignment.
4. Since bearings are symmetrical, slot direction is difficult to maintain at assembly.



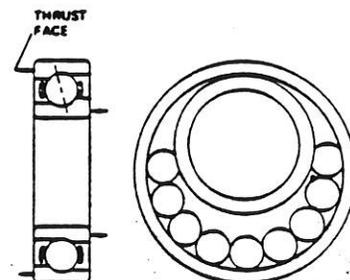
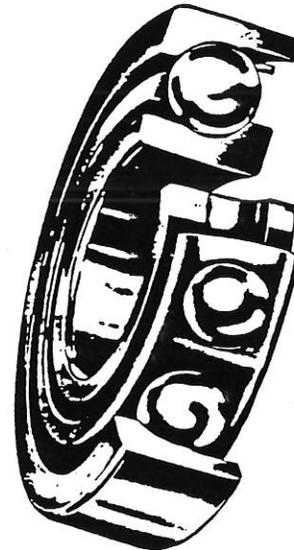
Max. Capacity  
Filling Slot Type, Single Row Ball Bearing

### Angular Contact Ball Bearings

The Angular Contact Ball Bearing is designed to support a thrust load in one direction or a thrust load combined with a radial load. A steep contact angle, assuring the highest thrust capacity and axial rigidity, is obtained by a high supporting shoulder on the inner ring and a similar high shoulder on the opposite side of the outer ring. These bearings can be mounted singularly or, when the side surfaces are flush ground, in multiple, either face-to-face or back-to-back for all combinations of thrust and radial loading. Flush ground bearings can also be tandem mounted to permit sharing heavy thrust loads in one direction among two or more bearings.

#### Points to remember:

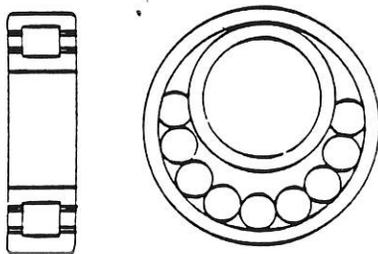
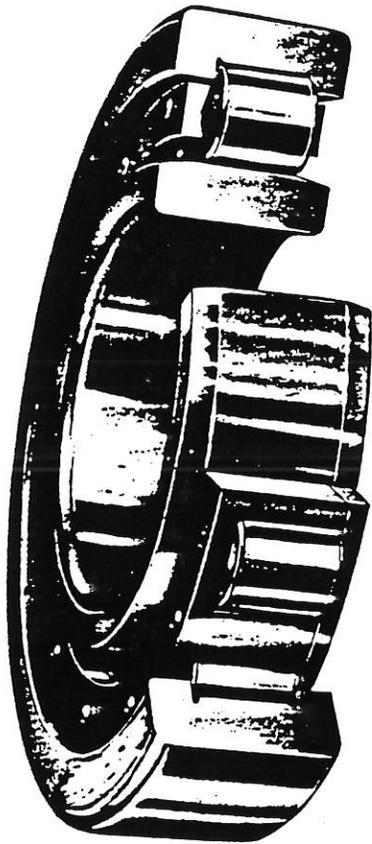
1. Increased thrust capacity over Conrad or Maximum capacity type bearing.
2. Thrust must be in the direction of the thrust shoulder. Thrust in an opposite direction can drive balls over the counterbore shoulder or cause ball damage, and failure.
3. Increased cost of bearing in comparison to single row, non-filling slot.



Angular Contact Ball Bearings

## Cylinder Roller Bearings

The cylindrical roller bearing has a high radial capacity in relation to its size due to the long roller contacts with the rings and are capable of supporting light or locating thrust loads, however, friction is greatly increased under thrust conditions due to sliding of rollers on retaining shoulders and rings of the raceways. The outside diameter of the roller is "crowned" to increased load carrying capacity by eliminating edge loading. Those types which have flanges on only one ring allow a limited axial movement of the shaft in relation to the housing. Bearings which also have a flange on the outer ring can locate the shaft axially provided the axial load is not great.



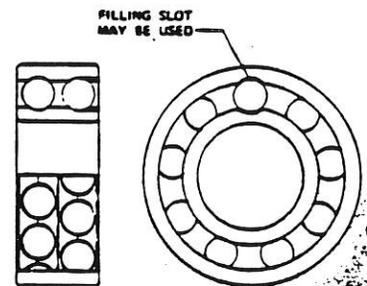
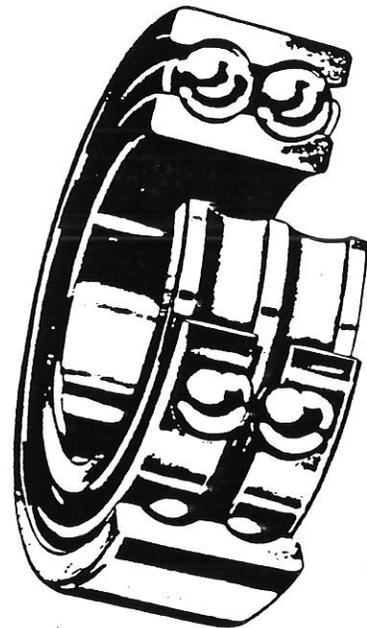
Cylindrical Roller Bearings

## Double Row, Deep Groove

This bearing is AFBMA type BF. It can be made like a Conrad type or a Maximum capacity type bearing (balls added by race eccentricity and/or filling slots). It is used for heavy-duty ball bearing applications with limited space. The bearing consists of two rows of ball bearings which share the same inner and outer ring (see figure below). The width of this bearing is slightly less than twice the width of two single row bearings of comparable size, but would have the same OD and bore diameter dimensions. The ball grooves are usually designed so that contact lines are externally convergent, providing low deflection under thrust loads with good capacity for moment loads.

Points to remember:

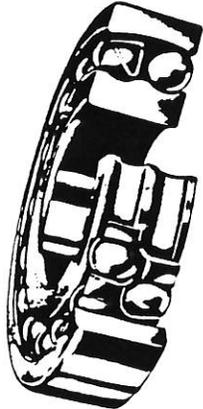
1. Double row of balls provide approx. 50% more radial capacity than single load.
2. Balls may be assembled with an assembly preload between rows which will restrict end play of bearings.
3. Thrust capacities are dependent on type of ball assembly (Conrad or Max. Cap.).



Double Row, Deep Groove Ball Bearings

## Double Row Self-Aligning Ball Bearings

The self-aligning ball bearing, with two rows of balls rolling on the spherical surface of the outer ring, compensates for angular misalignment resulting from errors in mounting . . . shaft deflection . . . and distortion of the foundation. It is impossible for this bearing to exert any bending influence on the shaft . . . a very important consideration in many applications requiring extreme accuracy, at high speeds. Self-aligning ball bearings are recommended for radial loads and moderate thrust loads in either direction.

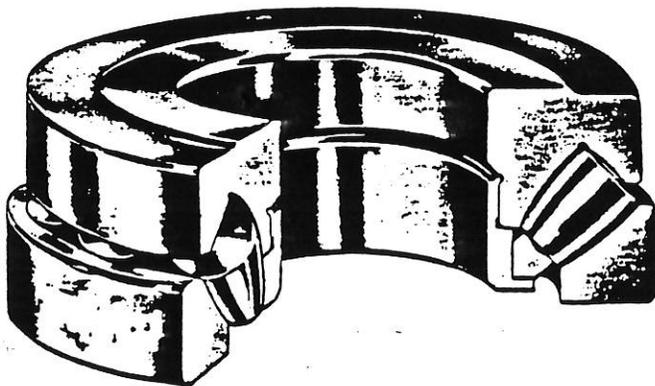


Double Row, Self-Aligning Ball Bearings

## Ball and Roller Thrust Bearings

The ball thrust bearing is designed for thrust load. The load line through the balls is parallel to the axis of the shaft . . . resulting in high thrust capacity and minimum axial deflection. Flat seats are preferred . . . particularly where the load is heavy . . . or where close axial positioning of the shaft is essential.

The spherical roller thrust bearing combines a very high load-carrying capacity (heavy thrust loads or combined loads which are predominantly thrust) with complete self-alignment . . . and can operate at relatively high speeds under heavy loads.



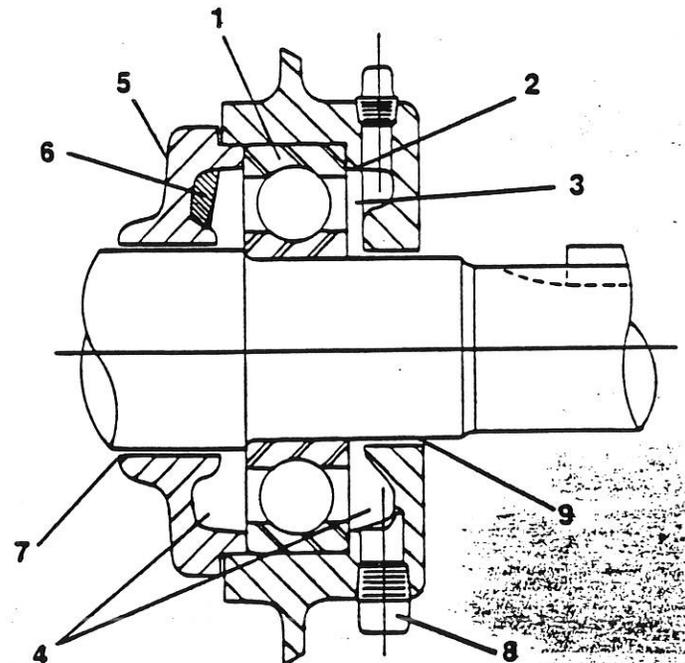
Ball and Roller Thrust Bearings

## Basic Bearing Comparison Guide

	Single Row Conrad Type	Max Capacity	Double Row	Angular Contact	Cylindrical
Radial Load Capacity	2	1	1	2	1
Thrust Load Capacity	3	3	2	1	4
Combined Load Capacity	2	3	2	1	4
Life Expectancy	1	2	1	1	1
Operating Speeds	1	2	3	1	2
Compensation for Misalignment	3	3	3	4	3
Grease Capacity	3	3	2	3	3
Sealing Effectiveness	1	3	2	4	4
Shaft and Housing Rigidity Under Moment Loads	3	3	1	4	4

Excellent	1
Good	2
Fair	3
Unacceptable	4

## RELIANCE PLS - Positive Lubrication System OPEN BEARING CONSTRUCTION



**Cooler Bearing Operating Temperatures** — Open bearing (non-shielded) construction (1) minimizes friction, allowing cooler bearing operation.

**Positive Lubrication/Relubrication in any Mounting Position** — Exclusive grease channeling window (2), with minimum grease path entry (3), channels grease directly into bearing track and avoids premature relief out shaft bore or drain plug.

**Minimizes Corrosion** — Small clearance on either side of grease window uniformly distributes grease to both inboard and outboard reservoirs (4) to protect bearing surfaces during motor storage, idle times and start-up. Bearing system is completely greased during motor assembly.

**Restricts Inboard Contaminants** — Inner bearing cap (5) with anti-churning vanes (6) and close running shaft tolerances (7) minimizes contaminant entry into bearings, and grease migration into motor.

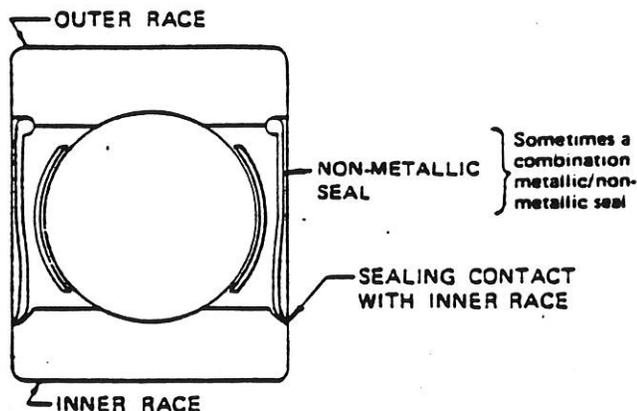
**Prohibits Overgreasing During Lubrication/Relubrication** — Grease relief port (8) accurately indicates completion of lubrication/relubrication. (If port is plugged during lubrication, PLS design will relieve grease along the shaft (9)).

## BEARINGS: SEALED AND SHIELDED

### Sealed Bearing

A "Sealed" cartridge width bearing is a variation of the standard deep grooved Conrad bearing. The construction of the raceway, cage and ball assembly is the same, however, the width of the inner and outer rings is wider to provide adequate room for the mechanical seals as well as capacity for lubricant. The wider area of contact with the shaft and housing gives the bearing greater rigidity than the single row Conrad type. A "Sealed" bearing cannot be re-lubricated.

The construction of this bearing is shown below. It has a flexible nonmetallic member secured to the outer race and makes a light contact on the inner race.



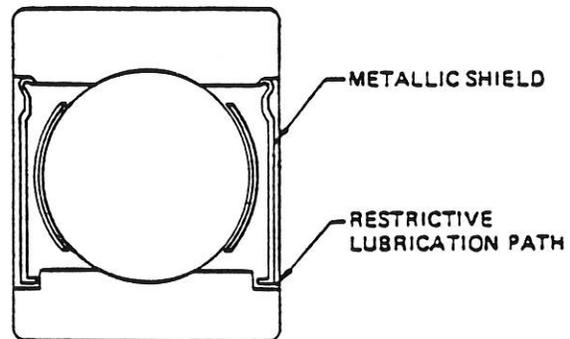
- Advantages:**
1. Entry of contaminants is less likely than an open bearing.
  2. No regular relubrication is necessary nor possible.

### Disadvantages:

1. The bearing life is restricted to the lubrication packed between the seals of the bearing.
2. Sizes available are restricted due to the excessive heating on larger sizes.
3. Maintenance requires replacement of the bearing.

### Shielded Bearing

A shielded bearing is also a variation of the Conrad bearing and is very similar to the sealed type bearing except that the shielded bearing has metallic rather than non-metallic shield. The metal member is secured to the outer race with a close running clearance to the inner race. A shielded bearing can be relubricated.



### Advantages:

1. Retains the lubricant at the rolling elements regardless of the chamber fill.
2. Provides relubrication to the balls by the slinger feeding of inner race.
3. Eliminates large particles from getting into the rolling elements at installation and in operation.

### Disadvantages:

Excessive pressure with no relief provided can force the shield against the cage or balls, thereby, eliminating regreasability or causing immediate failure.

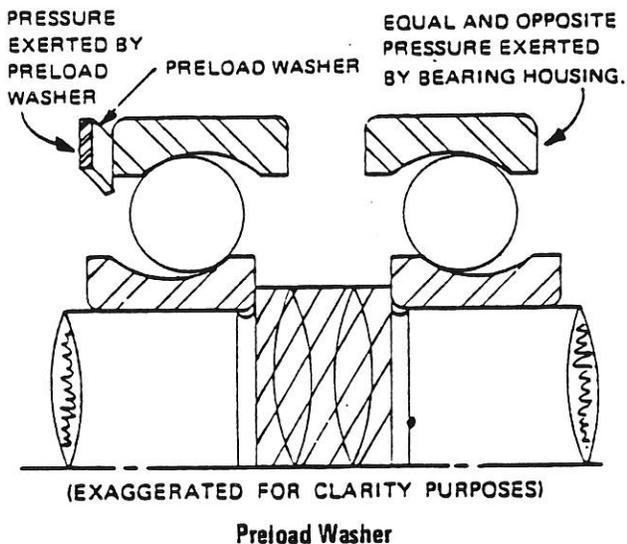
Shielded bearings are used on some Reliance motors.

## PRE-LOAD WASHER

A pre-load washer, sometimes referred to as a wavy washer, is used to provide an axial thrust load by moving the outer race axially to engage the balls and insure good contact. This is done to prevent or minimize ball skidding rather than rolling because of a loose internal fit, especially when the motor is running in a cold state. Skidding tends to prevent ideal full film lubrication which may cause excessive wear of the balls and races and therefore early bearing failures.

The thrust pressure provided by a preload washer is not significant enough to adversely affect the bearing life and as a motor gets hotter in a running state, the pre-load is overcome by the thermal expansion which insures the ball to race contact at all times.

In a horizontal position, the magnitude of the thrust should be great enough to move the complete rotating unit — motor and shaft — to insure both bearings are making contact.



## INNER CAP

An inner cap is provided on most Reliance motors. It is a retainer which fits over the shaft and bolts to the inside of the motor frame to hold the bearing in place. In some cases the cap also acts as a bearing housing with the bearing mounted in the cap which then fits into the end frame of the motor.

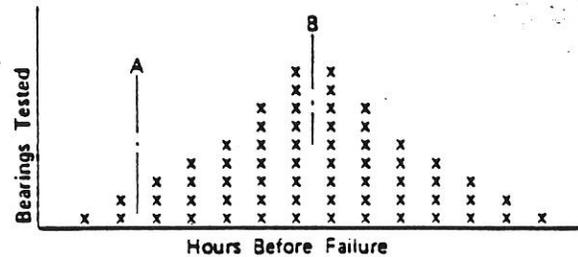
The cap does provide some measure of protection in that it restricts grease from being forced into the motor and winding, and acts as a barrier which restricts any failed bearing components from striking the winding. With small framed motors, due to the small likelihood of the above mentioned problems occurring and the relatively small repair cost to correct these problems, most motor manufacturers do not put inner caps on their small motors.

## BEARING LIFE

The bearing life for Reliance standard motors is 17,500 hours (belted) or 100,000 hours (coupled) L<sub>10</sub> minimum life which is based on the highest rated speed of the motor and a radial load consistent with the smallest dia. belt sheave as defined in NEMA Mg. 1-14.43a (see pages A-301 thru A-303).

L<sub>10</sub> is a statistical expectation of bearing fatigue life. It represents a point at which the 10% rate of failure can be expected for a given bearing run at the same speed (RPM) with a constant load.

A normal statistical distribution of failure would graphically look:



The point at which 10% failure occurs (point A is defined as L<sub>10</sub> hours.)

Point B is the average life and is approximately five (5) times as many hours as the L<sub>10</sub> life. Obviously, many bearings exceed this life.

It should be pointed out that the L<sub>10</sub> calculated life is limited to the fatigue endurance life. Factors of lubrication, temperature, contaminants, etc., are not considered in this process.

Using this basis for comparing motors or for predicting service life can be very misleading since most bearings fail due to other reasons as discussed below.

Note that the bearing life figure for Reliance standard motors is a minimum design calculation and almost all Reliance motor bearings will have a life exceeding this figure unless the bearing is subjected to abnormal conditions. The method of arriving at the bearing design life is very conservative and most motors will have a minimum life many times the tabulated values.

The term B<sub>10</sub> and L<sub>10</sub> are used interchangeably however, L<sub>10</sub> is the current and correct designation.

## CAUSES OF BEARING FAILURES

Almost without exception, the published life of a bearing is the L<sub>10</sub> life based on the fatigue failure of races or rolling elements. Actually, it is very unusual to find a bearing which has failed from this cause.

Confining this discussion to electric motor bearings the most common causes of failure are as follows:

1. Contamination
  - a) Rusting or corrosion
  - b) Dirt
  - c) Abrasive material
  - d) Water (grease washout)
2. Inadequate lubrication
3. Excessive temperature
4. Misalignment
5. Brinelling
  - a) False
  - b) True

6. Bearing fits
  - a) To housing
  - b) To shaft
7. Improper assembly practices.
8. Electric currents
9. Faulty bearing — storage or manufacturing error
10. Overloads

Some common causes of bearing failures are discussed in more detail below.

*Due to fatigue:* The metal of the bearing race way is continually flexing under the extremely high pressure of the balls rolling in the race way. This flexing eventually causes "spalling" which is the flaking of small metal particles from the race way. This condition will spread rapidly until failure.

*Due to dirt or other foreign matter:* Dirt and other hard particles such as metal and chips from abrasive wheels can get into the bearing race ways and be squeezed between the balls and race way. This will cause roughness of the race and ball, and will eventually cause failure. If the particles are the consistency of a very fine dust, they will act like a lapping compound and cause accelerated wear of the races and ball.

*Due to overload bearings:* An overloaded bearing can cause premature spalling, breakdown of lubrication, excessive heat and failure of the bearing. Such an overload can be caused by too tight a fit either on the shaft or in the housing, or by axial thermal expansion of the shaft.

*Due to misalignment:* The misalignment of a bearing will impose overloads on the bearing at points 180° apart from each other and will cause excessive wear on the ball cage which will usually be the first part to fail. The misalignment bearings will run hot and noisy.

## BEARING LUBRICATION

### Grease

The desired lubrication for bearings is oil. Unfortunately, oil presents many problems in sealing, evaporation, space, etc. Therefore, oil and a thickening agent — referred to as a binder, soap or filler — are combined to provide a good self-containing lubricant.

Since grease is somewhat self-containing, it also provides a good sealant and corrosion protection medium for the areas or housing next to the bearings. Do not forget, however, it's the oil that lubricates.

Listed below are the basic standard greases and their characteristics:

#### *Sodium — soap, petroleum — oil:*

Operation in —20° to 200°F temperature ranges, good rust protection in humid ambients and has low torsional resistance.

#### *Lithium — soap, petroleum — oil:*

Operation in —40°F to 200°F temperature ranges, insoluble in water and recommended for high moisture and water ambients.

#### *Lithium — soap, silicone oil:*

Operation in —40°F to 350°F temperature ranges, adequate moisture resistance and restricted in load carrying capabilities. Not recommended for use on d-c motors.

#### *Polyurea — soap, mineral — oil:*

Operation in —40°F to 350°F temperature ranges, good moisture resistance, excellent lubricity and load carrying characteristics (presently used by most major motor manufacturers with the trade name and lubrication identified as "SRI").

There are obviously numerous other synthetic soaps and grease combinations. Each has its own distinct characteristics of load capacity, noise, temperature, water resistance, etc.

See Table 1 for Reliance Standard Greases and AFBMA Greases.

### Grease Selection If Other Than Factory Supplied

Determine service conditions (Table 2) from ambient temperature, type of load, atmosphere.

Select lubricant from Tables 3 and 4. If other than a tabulated lubricant is to be used, be sure that it has an acceptable record for ball and roller bearing service under similar operating conditions, including rust and oxidation resistance, satisfactory noise levels, etc.

Confirm probable compatibility with factory supplied or previously used lubricant, from past experience or from other authoritative sources.

### Relubrication

#### Grease

Unless a special lubrication instruction plate is permanently attached to the motor, relubrication periods should conform to appropriate information from Tables 2 and 5.

**Table 1**  
**Grease Specification**  
**Standard Reliance And AFBMA Greases**

Reliance Grease No. 3426-1	Description	Operating Range		Commercial Name And Manufacturer	AFBMA Symbol	Lube Plate Specified	Substitute Grease Allowed	Remarks
		Low	High					
A	High Temp Petroleum	-20°F	+300°F	Cheverin SRI	H	①		Reliance ③ Standard Grease
C	High Temp Silicone	0°F	+400°F	Keystone Lube Keystone No. 89M	S	692-E	Dow Corn. DC-44	
D	Low Temp Petroleum	-65°F	+225°F	Arco Shell No. 7	L	692-CW		
E	Low Temp Silicone	-100°F	+275°F	Dow Corning DC 33M	R	692-BG	②	
F.	High Temp Silicone	0°F	+100°F	Dow Corning DC 44M	S	692-E	Keystone No. 89M	Same Specs As Keystone No. 89 M
G	Med. Temp Petroleum	-20°F	+225°F	Shell Oil Co. Alvania No. 2	M	None	②	
H	Water Repeilent			Shell Oil Co. Cyprina No. 3		No Plate		
M		-20°F	+250°F	New Grease				High Radiation Resistance

- ① Refer to A/P 201-2.3 for use of 692-CT and 692-CZ lube plates
- ② Must be reviewed by engr.
- ③ Reliance standard Grease; 140-449T; Insulation Class B and F; Min. Ambient -20°F.

**Table 2**  
**Service Conditions\***

	Ambient Temperature	Bearing Load	Atmosphere
Standard	0°F to 104°F	Steady	Clean
Severe	-20°F to 120°F	Medium Shock Vibration (less than .44 in/sec.)	Medium Dirt, Abrasives, Corrosion
Extreme Low Temp.	-65°F to 104°F	Heavy Shock Vibration (more than .44 in/sec.)	Heavy Dirt, Abrasives, Corrosion
Extreme High Temp	+50°F to 250°F		

\*Note: Severity of service conditions is dependent on the level of the most damaging parameter at the head of Table 2.

**Table 3**  
**Grease Selection**

Insulation Class	Minimum Starting Temperature		
	-100°F	-65°F	-15°F
B	I	II	III
F	I		III
H			III D-C Motors IV A-C Motors

**Table 4**  
**Grease Description**

Type	Identification	Manufacturer
I	Aeroshell No. 7	Shell Oil Company
II	Beacon 325	American Oil Company
III	Chevron SRI No. 2**	Chevron Oil Company
IV	Keystone No. 89	Keystone Division of Pennwalt Corporation

\*\*Alternate type III Greases:

- Regal Premium RB - Texaco
- Dolium - Shell Oil Company

**Table 5**  
Relubrication Periods For Grease Lubricated Equipment

Type Of Bearing	Frame Size	HP	Speed Rpm	Service Conditions		
				Standard	Severe	Extreme**
Ball	48, 56 140T & larger	All 1-7½ 10-40 50 & larger	1800 or less	No Relubrication		2500 hrs/6 months
				10000 hrs/2 yrs*	2000 hrs/6 mos.	1 month
				6000 hrs/1 yr.	1500 hrs/3 mos.	1 month
				4000 hrs/1 yr.	1000 hrs/3 mos.	1 month
	48, 56 140T & larger	All	Over 1800 to 3600 incl. (DN less than 250000)	No Relubrication		1 month
				2000 hrs/6 mos.	500 hrs/2 mos.	½ month
Roller (cyl. & sph.)		All	1800 or less 3600	1000 hrs/3 mos. 700 hrs/2 mos.	700 hrs/2 mos. 550 hrs/2 mos.	1 month ½ month

\*The hours indicated are operating hours. The months or years indicated are maximum elapsed time between relubrication.

\*\*"Extreme" service conditions are rare in actual practice. Corresponding lubrication cycles should therefore be applied with caution. In addition, it is advisable to check with Cleveland Service Dept. for related special instructions.

The quantity of grease to be added depends on the size of machine and frequency of relubrication, as indicated in Table 6.

**Table 6**  
Lubrication Volume Table

FRAME SIZE	VOLUME IN CUBIC INCHES	
	1800 RPM And Slower	3600 RPM
48 Thru 140	0.5	0.5
182 Thru 215	0.5	0.5
254 Thru 286	1.0	1.0
324 Thru 365	1.5	1.5
404 Thru 449	2.5	1.0

**STORAGE RECOMMENDATIONS (1)**

Bearings or assembled motors should be stored in a clean dry location that is not subjected to large temperature variations (not outdoors) and is free from all vibration. Rotating the motor shaft once or twice a year should be adequate to prevent rusting or corrosion of the bearings. Every three years, the motors should be re-lubricated, and if possible, run for a short period of time.

Several years ago a survey was made of four major bearing manufacturers requesting their recommendations for shelf life of package bearings. As a

practical approach to this problem, a shelf life of three years seems reasonable and unmounted bearings in storage for more than three years should probably be returned to the vendor for inspection and relubrication. Certainly a policy of first-in, first-out should be rigorously followed.

(1) Unless special provisions for severe storage conditions are made such as enclosure in a moisture proof barrier and other special practices.

**SERVICE FOR BEARING PROBLEMS**

Reliance maintains an excellent service organization which is willing to assist in areas where bearing difficulties are experienced. All too often the service representative is called in, handed a box containing the rusted, broken, welded, bent and twisted parts of a bearing, and with no prior history, before or during failure, asked, "Why did the bearing fail?" In most cases of this type it is impossible to tell the cause of failure or make recommendations for correction.

The greatest assistance that can be given to a service representative is a good clear history of the motor or machine up to the time of failure and as many details as possible of the operation and load at the time of failure. If a bearing has been removed prior to a catastrophic failure, a great deal about the loads and operation can be learned by examination of such a bearing. In the case of an electric motor, it is advisable to save both bearings and grease for inspection. In conclusion, in the event of bearing trouble or failure, the more facts that are available for review, the better the chances are of locating and correcting the trouble.

ITEM	LUBRICATION AREA	LUBRICANT (1)	RELUBRICATION FREQUENCY	MANUAL FOR DETAILS
Motors (Reliance) 180-449 frames	Bearings	Chevron SRI #2 Shell Dolium R Texaco Premium RB	Every 6 mos.	B-3620-11
Motors (Reliance) E5000 & larger	Bearings	Chevron SRI #2	Every 2000 Hrs.	B-3628-5
Motors (Westinghouse)	Bearings	Chevron SRI #2	Every 2000 Hrs.	Westinghouse IL 3130-D2
Voith Couplings	Chamber	Gulf-Gulfcrest 44	Every 15,000 Hrs.	Voith 3.626-6030/78
Concentric Shaft Reducers	Gearcase	AGMA #4 Mobil DTE oil extra heavy Exxon NUTO 76	2500 Hrs. of operation or every 6 mos. whichever occurs first	E-3656
Concentric Shaft Reducers	Backstops	Shell Alvania #1 Shell Aeroshell #7	Every 3 mos.	Formsprag #2219
Parallel Shaft Reducers	Gearcase	Gulf EP Lubricant HD	2000 Hrs. of operation	R5-000-70E
Parallel Shaft Reducers	Backstops	Gulf Harmony 32	2000 Hrs. of operation or every 12 mos. whichever occurs first	Ringspan Backstops
Gear Couplings	Teeth	See manual 499675	6 mos.	499701
Pillow Blocks	Bearings	Roller Brg. grease medium consistency soda soap	Every 30 wks.	499689

Parallel Shaft Backstops

<u>REDUCER SIZE</u>	<u>USED ON</u>	<u>AMOUNT</u>
H2H91	BC2	240 CC
2H317	BC4, BC8, BC9, BC10 BC11, BC12, BC13	240 CC
2H202	BC30, BC31	240 CC
2H202	BC34	170 CC
2H162	BC5, BC6, BC7, BC32	130 CC
2H162	BC33	170 CC

Concentric Shaft Reducers

<u>SIZE</u>	<u>USED ON</u>	<u>AMOUNT (1)</u>
DU600	BC3	25 Qts.
DU800	BC27, BC28, BC29	10 Gal.
DU1000	BC14 thru BC26	20 Gal.

(1) Use appropriate oil level plug for final level & amount.

Concentric Shaft Reducer Backstops (grease) Purge

Gear Couplings (grease)

<u>SIZE</u>	<u>USED ON</u>	<u>AMOUNT</u>
3W	BC3	.8 oz.
3 1/2 W	BC27, BC28, BC29	12 oz.
4W	BC14 thru BC26	16 oz.
4 1/2 W	BC32, BC33	22 oz.
5W	BC5, BC6, BC7	34 oz.
5 1/2 W	BC8, BC9, BC30, BC31, BC34	44 oz.
6W	BC4, BC10, BC11, BC12, BC13	48 oz.
7W	BC2	76 oz.

LUBRICANT QUANTITIES

Motor Bearings (grease)

<u>FRAME SIZE</u>	<u>AMOUNT (CU-IN)</u>
182 thru 215	.75
254 thru 286	1.5
324 thru 365	2.0
404 thru 449	3.0
E5000 thru E6800	Purge
Westinghouse	3

Voith Couplings (oil)/outer wheel drive

<u>SIZE</u>	<u>USED ON</u>	<u>AMOUNT</u>
487	BC5, BC6, BC7, BC32	2.9 Gal.
487	BC33	3.2 Gal.
562	BC34	4.5 Gal.
620	BC8, BC9, BC30, BC31	4.8 Gal.
620	BC4, BC10, BC11, BC12	5.0 Gal.
650	BC2, BC13	7.4 Gal.

Parrallel Shaft Reducers

<u>REDUCER SIZE</u>	<u>USED ON</u>	<u>AMOUNT (1)</u>
H2H91	BC2	59.4 Gal.
2H317	BC4, BC8, BC9, BC10 BC11, BC12, BC13	35.7 Gal.
2H202	BC30, BC31	23.8 Gal.
2H202	BC34	22.5 Gal.
2H162	BC5, BC6, BC7	24.6 Gal.
2H162	BC32, BC33	25.9 Gal.

(1) Approx. amount only—use dipstick

ANTI-FRICTION BEARING FAILURES

The causes of failure on anti-friction bearings are many. A few of the more common causes are described in the following. Thorough examination of a bearing requires careful examination of the lubricant, careful disassembly of the bearing marking all parts to maintain record of their assembled relationship, microscopic examination of rolling surfaces, and visual examination of all other surfaces.

FAILURES DUE TO INADEQUATE OR IMPROPER LUBRICATION

A common cause of early bearing failure is inadequate or insufficient lubrication. The amount of lubricant required by a ball or roller bearing is small. That is why so many of these bearings, unlike the majority of plain bearings, can be lubricated with grease. While the amount required may be small, the quality should be the best obtainable. Reliance recommends Chevron SRI-2.

Lack of lubricant is revealed by a high pitch sound and a rapid rise in temperature. (A rise in temperature can also be the sign of over-lubrication). Failure to correct this fault immediately is apt to be followed by damage of different kinds. Intense overheating will draw the temper of the bearing steel, the parts will become soft and the bearing will fail very quickly. This condition can quickly be recognized by the color of the bearing which in the early stages will be blue. If the bearing is forced to continue to operate, it might seize and result in damage to other parts.

Lack of lubricant may cause wear of the cage accompanied by smearing of the balls or rollers and their tracks in the rings.

Grease whose consistency is too solid, or oil that is too thick, is capable of producing a braking effect powerful enough to make the rolling elements slide. Such sliding will cause smearing of the effected parts and early failure occurs.

-2-

Very rapid starting of a machine is an adverse condition for an anti-friction bearing. Where the load is heavy, a condition such as the one described in the foregoing paragraph occurs. This smearing takes place because of the sliding of the parts before the running temperature has been reached and while the grease is still solid. This is particularly true where bearings operate under low temperature conditions. Where the load is light, the inner race slides or skids on the balls or rollers before they have a chance to rotate and smearing again takes place. Under both conditions, the bearing will continue to operate but will become noisy and eventually will fail.

In addition to laboratory checks, a simple visual observation should be made of the condition of the grease. All greases darken as they deteriorate, and pending failure with a given type of grease may be associated with a particular color. As greases oxidize, they generally become rancid and the odor of a grease in a bearing housing may give some indication of its remaining life. The consistency of the grease should also be observed. If it is extremely dry and channeled and does not seem to be feeding into the bearing, lubrication failure may result for high speed units. If it appears exceptionally soft, it may be feeding into the bearing in too great quantities and causing high friction with a correspondingly high temperature rise.

#### FAILURES DUE TO DIRT AND OTHER FOREIGN MATTER

One of the common causes of bearing failure is dirt. Bearings which fail because of dirt can be recognized in several ways. Generally, fine dirt in a bearing acts as an abrasive and causes lapping of the bearing parts. This can be seen and felt in the ball or roller paths. These paths will be polished as will the balls and rollers. If there are no breaks in the surfaces of the rolling elements and the ball or roller path is clearly defined, then you can be sure that fine dirt was in it during service.

Bearings of the deep-groove type are not as easily examined since the ball paths and the balls cannot be readily seen. A preliminary check can be made by feeling the amount of clearance between the inner and outer races. This can be done by laying the bearing on a flat surface and holding one ring stationary. If the other ring can be moved in a position parallel to the flat surface, wear has taken place. Do not attempt to feel wear in a bearing when holding it in your hands. In this position, it is possible to feel the normal internal clearance which might be mistaken for wear.

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If water or other corrosive agents enter the bearing, wear will occur very quickly. The iron oxide formed by rust is an abrasive and will lap or grind the balls or rollers under-size. Sometimes a bearing will become corroded before it is put in service. A motor or pump or some other machine may be flooded or water may be introduced with the lubricant. In a case of this kind, corrosion pitting will occur and is distinguished by its dark brown color. This pitting will be where the balls or rollers contact the races. It will cause the bearing to be noisy and since the machine has just been put into service, the user will immediately blame the bearing.

If examination of a bearing indicates that wear has taken place, the actual application should be carefully checked. You may find a quantity of hard, gritty particles, such as produced by a grinding wheel or a buffing stand. Seals should be checked thoroughly to make sure that dirt is not going past the seals and into the bearing. The lubricant should be checked as well as the method of lubricating the bearings. Slipshod maintenance methods could be the reason for dirt getting into the lubricant and then passed on into the bearing.

### SEIZING

Seizing is one of the most common forms of damage which is encountered when bearings are first put into service. Rolling elements fail to roll, and the resulting friction generates excessive heat very rapidly. This heating reduces the surface hardness of races and balls or rollers, and the bearing is quickly rendered unfit for use.

Seizing is generally caused by one of three factors: (1) improper clearances among bearing parts, (2) improper lubrication, or (3) excessive load. Any of these conditions can cause seizing, with resulting overheating and bearing damage.

### RUST

Rusting results only from improper care of bearings either in storage, during maintenance, or when a machine is out of use. Relatively few bearings are made from corrosion--resistant materials, and no sealing method can provide absolute protection from moisture. So bearings should always be stored in dry places in their manufacturers' original sealed packaging until needed for installation. When removed during maintenance, they must not be left unprotected from atmospheric condensation.

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The cause of rust which appears in a distinct fingerprint pattern, is perfectly obvious. If unlubricated bearings are handled with moist or perspiring fingers, corrosion may be started which will continue even after greasing. Such rusting is usually unimportant except when it appears on raceways or rolling elements, where it forms microscopic pitting that may form the nucleus for later flaking.

### FRETTING

Fretting occurs where two contacting surfaces, often nominally at rest, undergo minute oscillatory tangential relative motion, which is known as "slip". It may manifest itself by debris oozing from the contact, particularly if the contact is lubricated with oil.

Colour of debris: red on iron and steel, black on aluminium and its alloys.

On inspection the fretted surfaces show shallow pits filled and surrounded with debris. Where the debris can escape from the contact, loss of fit may eventually result. If the debris is trapped, seizure can occur which is serious where the contact has to move occasionally, e.g. a machine governor.

The movement may be caused by vibration, or very often it results from one of the contacting members undergoing cyclic stressing. In this case fatigue cracks may be observed in the fretted area. Fatigue cracks generated by fretting start at an oblique angle to the surface. When they pass out of the influence of the fretting they usually continue to propagate straight across the component. This means that where the component breaks, there is a small tongue of metal on one of the fracture surfaces corresponding to the growth of the initial part of the crack.

### BRINELLING

When a bearing is dropped during assembly, or is subjected to an excessive impact, the rolling elements may be driven against the races hard enough to cause dents at points of contact. This condition is known as brinelling. A related form of brinelling results if driving force is applied through the balls or rollers instead of only to the races. A chattering or skipping movement may produce similar dents or only a graying of the visible polished surfaces. Brinelling causes noisy operation and vibration.

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FALSE BRINELLING

Vibration while bearing is not rotating

It is a peculiar fact that wear known as fretting can occur in a loaded ball or roller bearing when it is not running. This happens when the bearings are exposed to vibration. Under these circumstances, minute sliding movements take place where the rolling elements are in contact with the tracks. The patches of wear that are thus produced can often be recognized because they are separated by a distance equal to that between the rolling elements.