

SELECTION

S-2000 SPHERICAL ROLLER BEARINGS

DODGE Spherical Roller Bearings have the capacity to carry heavy radial loads and combined radial and thrust loads. The maximum recommended load which can be applied is limited by various components in the system such as bearing, housing, shaft, shaft attachment, speed and life requirements as listed in this catalog. DODGE spherical roller bearings have been applied successfully even when these limits have been exceeded under controlled operating conditions. Contact DODGE Application Engineering (864-281-2195) for applications which exceed the recommendations of this catalog.

L₁₀ Hours Life - The life which may be expected from at least 90% of a given group of bearings operating under identical conditions.

$$L_{10} \text{ Life, Hours} = \left(\frac{C}{P}\right)^{10/3} \times \left(\frac{16667}{\text{RPM}}\right)$$

Where: C = Dynamic Capacity (Table 1 on page 10) lbs.
P = Equivalent Radial Load, lbs.

GENERAL

Heavy Service - For heavy shock loads, frequent shock loads, or severe vibrations, add up to 50% (according to severity of conditions) to the Equivalent Radial Load to obtain a Modified Equivalent Radial Load. Consult DODGE Application Engineering for additional selection assistance.

Thrust load values shown in the table below are recommended as a guide for general applications that will give adequate L₁₀ life. Spherical bearings require a radial load at least equal to the thrust load for proper operation. If the thrust load exceeds this limit, consult Application Engineering. Where substantial radial load is also present, it is advisable to calculate actual L₁₀ life to assure that it meets the requirements. The effectiveness of the shaft attachment to carry thrust load depends on proper tightening of the set screws, shaft tolerance and shaft deflections. Therefore, it is advis-

able to use auxiliary thrust carrying devices such as shaft shoulder, snap ring or a thrust collar to locate the bearing under thrust loads heavier than shown below, or where extreme reliability is desired.

RPM	20-200	201-2000	over 2000
RECOMMENDED THRUST LOAD	C/20	C/40	C/60

The shaft tolerances recommended below are adequate for normal radial and radial/thrust load applications. The radial load is limited by the attachment to the shaft (see Table 1). Where the applied radial load (FR) exceeds this limit (maximum allowable slip fit radial load), a snug-to-light press fit of the shaft is required. Since the allowable load, especially at a low speed, is very large, the shaft should be checked to assure adequate shaft strength.

The magnitude and direction of both the thrust and radial load must be taken into account when selecting a housing. **When pillow blocks are utilized, heavy loads should be directed through the base. Where uplift loads are involved, see Table 5 on page 14 and for maximum values.** Where a load pulls the housing away from the mounting base, both the hold-down bolts and housing must be of adequate strength. Auxiliary load carrying devices such as shear bars are advisable for side or end loading of pillow blocks and radial loads for flange units.

SHAFT TOLERANCES

SHAFT SIZE	S-2000, SN-2000, UNISPHERE II
UP TO 1-1/2"	+ .0000 - .0005"
1-9/16 TO 4"	+ .000 - .001"
4-7/16 TO 5"	+ .000 - .0015"

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BEARING SUPPORTING RADIAL LOADS ONLY

1. Define L_{10} Life Hours desired.
2. Establish bearing radial load, F_R
($F_R = P$ for Pure Radial Load Conditions). The DODGE program BEST™* can be used to find application loads.
3. Establish RPM.

Using the easy selection Table 2 on page 11, find, under the RPM column, the equivalent radial load that equals or is slightly higher than the application radial load for the desired life. The shaft size on the far left will be the minimum shaft size that you can use for your application.

If the desired life is different than the values shown on the chart, use alternate Method A shown below.

- Example: 1. L_{10} Life = 30,000 Hours
 2. Radial load = 4000 lbs.
 3. RPM = 1,000

At the intersection of the 1,000 RPM column and the 30,000 hours L_{10} life row, the equivalent radial load of 4011 lbs. exceeds the 4000 lbs. radial load for shaft size 2-7/16". A bearing with bore 2-7/16", or larger, may be used for this application.

ALTERNATE METHOD A - SELECTING A BEARING FOR AN L_{10} LIFE VALUE NOT SHOWN IN THE EASY SELECTION CHART.

The L_{10} life equation can be rearranged so that the bearing dynamic capacity C is identified in terms of L_{10} , RPM and P

$$C = \left(\frac{L_{10} \times \text{RPM}}{16667} \right)^{0.3} \times P$$

($P = F_R$ for Pure Radial Load Conditions)

Since the L_{10} , RPM and P are known, solve for C . Select from the dynamic capacity column on Table 1 on page 10 the C value equal to or greater than the C value just calculated. The bore size on the far left represents the proper bore size selection. Check that the application RPM does not exceed the MAX. RPM on Table 1. Also check that the radial load does not exceed the Maximum Allowable Slip Fit Radial Load shown on Table 1. If it does, a line-to-line to light press fit of shaft is required. When selecting an L_{10} life of less than 30,000 hours, particular attention must be paid to shaft deflection and proper lubricant selection.

SELECTING BEARINGS SUPPORTING COMBINATION RADIAL AND THRUST LOADS

When a bearing supports both a radial load and a thrust load, the loading on the two rows is shared unequally depending on the ratio of thrust to radial load. The use of the X (radial factor) and Y (thrust factor) from Table 1 converts the applied thrust load and radial loads to an equivalent radial load having the same effect on the life of the bearing as a radial load of this magnitude.

$$\text{The equivalent radial load } P = XF_R + YF_A$$

Where:

- P = Equivalent radial load, lbs.
- F_R = Radial load, lbs. (see Table 1 for allowable slip fit maximum load)
- F_A = Thrust (axial) load, lbs.
- e = Thrust load to radial load factor (Table 1)
- X = Radial load factor (Table 1)
- Y = Thrust load factor (Table 1)

★The DODGE Bearing Evaluation and Selection Technique (BEST) is a menu driven computer program that calculates bearing loads, fatigue life and operating temperature for a two bearing shaft system based on user supplied input parameters. To order, call (864) 297-4800

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To find X and Y, calculate F_A/F_R and compare to **e** for the selected bore size. Determine X and Y from Table 1 on page 10 depending on whether F_A/F_R is equal to or less than **e**, or F_A/F_R is greater than **e**. Substitute all known values into the equivalent radial load equation. P (equivalent radial load) can be used in the life formula to determine L_{10} , or it can be compared to the allowable equivalent radial load ratings for the speed and hours life desired in the easy selection Table 2 on page 11

SELECTING BEARINGS SUPPORTING ONLY THRUST LOADS

Spherical Roller Bearings generally are not recommended for pure thrust load applications. However, they will perform satisfactorily under very light pure thrust loads. Consult DODGE Application Engineering (864-281-2195).

SELECTING LUBRICATION

DODGE S-2000 spherical roller bearings are lubricated at the factory with Shell Alvania #2 grease. Shell Alvania #2 grease is a superior industrial grease using a lithium hydroxystearate thickener and highly refined base oil. This grease will adequately handle low and medium speeds with low and medium loads at normal temperatures as defined on Table 4 on page 13. For very low and high speeds, for heavy loads and for low and high temperatures, special greases must be used. Contact DODGE Application Engineering (864-281-2195). DODGE engineers will recommend bearings and

lubricants for the above unusual conditions. DODGE also has the expertise to custom design and build special bearings for your needs. The only maintenance requirement for DODGE Unitized roller bearings is periodic relubrication at regular intervals as outlined in the appropriate instruction manuals.

MISALIGNMENT CONSIDERATIONS

In nearly all applications, good design practice requires two bearings supporting the shaft. In cases where three or more bearings are installed, unless precautions are taken to line the bearings up both vertically and horizontally, it is possible to induce heavy loads. In the case of two bearings, alignment is not as critical, especially with DODGE Unitized Spherical Roller Bearings. S-2000 bearings are designed to allow a maximum of $\pm 1^\circ$ of static and dynamic misalignment. However, for optimum seal performance, misalignment should be kept under $\pm 0.5^\circ$. To ensure good alignment, mounting surfaces must be checked for flatness and must lie in the same plane. When tightening base bolts, each bolt should be alternately tightened in incremental torque values until full torque is achieved to prevent the angular shifting of the pillow block that occurs when one bolt is tightened to its full torque. Shimming may be required to minimize misalignment.

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Table 1: S-2000 Spherical Roller Bearings

Shaft Size Inches	Basic Bearing Description	e	$F_A/F_R < e$		$F_A/F_R > e$		Max. Allowable Slip Fit Radial Load F_R^* Pounds	Dynamic Capacity (C) Pounds	Maximum Grease Speed		Maximum Expansion Capability Inches
			X	Y	X	Y			Labyrinth** RPM	TRIDENT RPM	
1-3/8 1-7/16 1-1/2	22208	0.28	1.0	2.4	0.67	3.6	3,750	20,800	3,600	2,900	3/16
1-11/16 1-3/4	22209	0.26	1.0	2.6	0.67	3.9	3,750	20,800	3,360	2,460	1/4
1-15/16 2	22210	0.24	1.0	2.8	0.67	4.2	4,000	22,000	3,180	2,200	1/4
2-3/16	22211	0.23	1.0	2.9	0.67	4.3	4,860	27,000	2,700	1,950	1/4
2-7/16	22213	0.24	1.0	2.8	0.67	4.2	6,840	38,000	2,250	1,740	1/4
2-11/16 2-15/16 3	22215	0.22	1.0	3.1	0.67	4.6	7,500	41,500	2,040	1,490	1/4
3-7/16	22218	0.23	1.0	2.9	0.67	4.3	11,500	64,000	1,560	1,280	1/4
3-15/16	22220	0.24	1.0	2.8	0.67	4.2	14,400	80,000	1,320	1,075	5/16
4-7/16	22222	0.25	1.0	2.7	0.67	4.1	18,400	102,000	1,200	990	3/8
4-15/16	22226	0.26	1.0	2.6	0.67	3.9	25,700	143,000	1,020	870	3/8

* If load exceeds the maximum allowable slip fit load, line- to-line to light press fit of shaft required. Maximum slip fit radial loads apply if recommended shaft sizes are used.

** Maximum grease speed is dependent on load and ambient conditions, consult DODGE Engineering.

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Table 2: Easy Selection Table for S-2000 Double Row Spherical Roller Bearings

Shaft Size Inches	L ₁₀ Life Hours	Allowable Equivalent Radial Load Rating (lbs.) at Various Revolutions per Minute																
		50	100	150	250	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,500	2,750	3,000	3,250	3,500
1-3/8 to 1-1/2	10,000	7,498	6,090	5,393	4,626	3,758	3,327	3,052	2,855	2,703	2,581	2,479	2,393	2,319	1,487	2,195	2,143	2,096
	30,000	5,393	4,380	3,878	3,327	2,703	2,393	2,195	2,053	1,944	1,856	1,783	1,721	1,668	1,487	1,579	1,541	1,508
	40,000	4,947	4,018	3,558	3,052	2,479	2,195	2,014	1,883	1,783	1,703	1,636	1,579	1,530	1,487	1,448	1,414	1,383
	60,000	4,380	3,558	3,150	2,703	2,195	1,944	1,783	1,668	1,579	1,508	1,448	1,398	1,355	1,316	1,282	1,252	1,224
	100,000	3,758	3,052	2,703	2,319	1,883	1,668	1,530	1,431	1,355	1,293	1,243	1,199	1,162	1,129	1,100	1,074	1,051
1-11/16 to 1-3/4	10,000	7,498	6,090	5,393	4,626	3,758	3,327	3,052	2,855	2,703	2,581	2,479	1,579	2,319	2,253	2,195	2,143	
	30,000	5,393	4,380	3,878	3,327	2,703	2,393	2,195	2,053	1,944	1,856	1,783	1,579	1,668	1,621	1,579	1,541	
	40,000	4,947	4,018	3,558	3,052	2,479	2,195	2,014	1,883	1,783	1,703	1,636	1,579	1,530	1,487	1,448	1,414	
	60,000	4,380	3,558	3,150	2,703	2,195	1,944	1,783	1,668	1,579	1,508	1,448	1,398	1,355	1,316	1,282	1,252	
	100,000	3,758	3,052	2,703	2,319	1,883	1,668	1,530	1,431	1,355	1,293	1,243	1,199	1,162	1,129	1,100	1,074	
1-15/16 to 2	10,000	7,930	6,441	5,704	4,893	3,975	3,519	3,228	3,019	2,859	2,729	1,730	2,531	2,452	2,383	2,322		
	30,000	5,704	4,633	4,102	3,519	2,859	2,531	2,322	2,172	2,056	1,963	1,730	1,820	1,764	1,714	1,670		
	40,000	5,232	4,250	3,763	3,228	2,622	2,322	2,130	1,992	1,886	1,801	1,730	1,670	1,618	1,572	1,532		
	60,000	4,633	3,763	3,332	2,859	2,322	2,056	1,886	1,764	1,670	1,594	1,532	1,479	1,433	1,392	1,356		
	100,000	3,975	3,228	2,859	2,452	1,992	1,764	1,618	1,513	1,433	1,368	1,314	1,269	1,229	1,194	1,164		
2-3/16	10,000	9,733	7,905	7,000	6,005	4,878	4,319	3,962	3,706	3,508	2,210	3,218	3,106	3,010				
	30,000	7,000	5,686	5,035	4,319	3,508	3,106	2,850	2,665	2,523	2,210	2,315	2,234	2,165				
	40,000	6,421	5,216	4,618	3,962	3,218	2,850	2,614	2,445	2,315	2,210	2,123	2,050	1,986				
	60,000	5,686	4,618	4,089	3,508	2,850	2,52	2,315	2,165	2,050	1,957	1,880	1,815	1,758				
	100,000	4,878	3,962	3,508	3,010	2,445	2,165	1,986	1,857	1,758	1,679	1,613	1,557	1,508				
2-7/16	10,000	13,698	11,126	9,852	8,452	6,865	6,079	5,576	5,215	3,258	4,714	4,529	4,372					
	30,000	9,852	8,002	7,086	6,079	4,938	4,372	4,011	3,751	3,258	3,391	3,258	3,144					
	40,000	9,037	7,340	6,500	5,576	4,529	4,011	3,679	3,441	3,258	3,110	2,988	2,884					
	60,000	8,002	6,500	5,755	4,938	4,011	3,551	3,258	3,047	2,884	2,754	2,646	2,554					
	100,000	6,865	5,576	4,938	4,236	3,441	3,047	2,795	2,614	2,475	2,363	2,270	2,191					
2-11/16 to 3	10,000	14,959	12,151	10,759	9,230	7,497	6,639	6,090	3,758	5,392	5,149	4,946						
	30,000	10,759	8,739	7,738	6,639	5,392	4,775	4,380	3,758	3,878	3,703	3,558						
	40,000	9,870	8,017	7,098	6,090	4,946	4,380	4,01	3,758	3,558	3,397	3,263						
	60,000	8,739	7,098	6,28	5,392	4,380	3,878	3,558	3,327	3,150	3,008	2,890						
	100,000	7,497	6,090	5,392	4,626	3,758	3,327	3,052	2,855	2,703	2,580	2,479						
3-7/16	10,000	23,070	18,739	16,592	14,235	11,562	10,238	9,392	5,795	8,316								
	30,000	16,592	13,477	11,934	10,23	8,316	7,363	6,755	5,795	5,981								
	40,000	15,220	12,363	10,947	9,392	7,628	6,755	6,196	5,79	5,486								
	60,000	13,477	10,947	9,693	8,316	6,755	5,981	5,486	5,131	4,858								
	100,000	11,562	9,392	8,316	7,134	5,795	5,131	4,707	4,402	4,168								
3-15/16	10,000	28,837	23,423	20,741	17,794	14,453	12,798	7,745	10,979									
	30,000	20,741	16,847	14,917	12,798	10,395	9,204	7,745	7,897									
	40,000	19,026	15,454	13,684	11,739	9,535	8,443	7,745	7,244									
	60,000	16,847	13,684	12,116	10,395	8,443	7,476	6,858	6,414									
	100,000	14,453	11,739	10,395	8,918	7,244	6,414	5,884	5,503									

Only the labyrinth seal (L seal) may be used to the right of the heavy line.
 In the light shaded area, a line-to-line to light press fit on the shaft is required.
 For applications in the dark shaded area, the maximum load for the specific speed is shown. The load does not correspond to the L10 shown at the left.

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Table 2: Easy Selection Table for S-2000 Double Row Spherical Roller Bearings (cont')

Shaft Size Inches	L ₁₀ Life Hours	Allowable Equivalent Radial Load Rating (lbs.) at Various Revolutions per Minute																
		50	100	150	250	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,500	2,750	3,000	3,250	3,500
4-7/16	10,000	36,768	29,865	26,444	22,687	18,427	10,765	14,968										
	30,000	26,444	21,479	19,019	16,317	13,253	10,765	10,765										
	40,000	24,258	19,703	17,447	14,968	12,158	10,765	9,875										
	60,000	21,479	17,447	15,448	13,253	10,765	9,532	8,744										
	100,000	18,427	14,968	13,253	11,370	9,236	8,178	7,502										
4-15/16	10,000	51,547	41,869	37,074	31,806	25,835	15,092	20,984										
	30,000	37,074	30,113	26,664	22,876	18,581	15,092	15,092										
	40,000	34,008	27,623	24,460	20,984	17,045	15,092	13,844										
	60,000	30,113	24,460	21,658	18,581	15,092	13,364	12,259										
	100,000	25,835	20,984	18,581	15,941	12,948	11,465	10,517										

Only the labyrinth seal (L seal) may be used to the right of the heavy line.

In the light shaded area, a line-to-line to light press fit on the shaft is required.

For applications in the dark shaded area, the maximum load for the specific speed is shown. The load does not correspond to the L₁₀ shown at the left.

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Table 3: S-2000 Maximum Axial Expansion

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BORE SIZE (INCHES)	MAXIMUM EXPANSION (INCHES)
1-1/8 to 1-1/2	1/8
1-5/8 to 1-3/4	1/4
1-7/8 to 2	1/4
2-3/16 to 2-1/4	1/4
2-3/8 to 2-1/2	1/4
2-11/16 to 3	1/4
3-3/16 to 3-1/2	1/4
3-11/16 to 4	5/16
4-7/16 to 4-1/2	3/8
4-15/16 to 5	3/8

Table 4: Definition Of Operating Conditions For Unitized Spherical Roller Bearings

LOW SPEED MEDIUM SPEED HIGH SPEED	UP TO 20% OF MAX. RPM (TABLE 1) OVER 20% TO 80% OF MAX. RP MOVER 80% OF MAX. RPM
LIGHT LOAD NORMAL LOAD HEAVY LOAD	UP TO 8% OF C (TABLE 1) OVER 8% TO 18% OF C OVER 18% OF C C = DYNAMIC CAPACITY
LOW TEMPERATURE MEDIUM TEMPERATURE HIGH TEMPERATURE VERY HIGH TEMPERATURE	-20 to -100°F OVER 20°F TO 200°F OVER 200°F TO 300°F OVER 300°F TO 450°F

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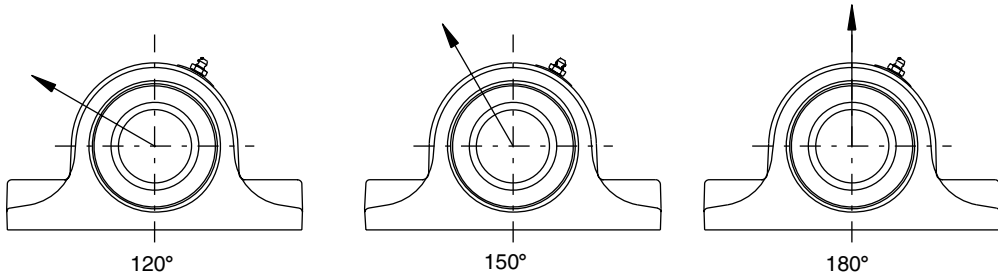


Table 5: S-2000 Housing Rating, 2-Bolt, Cast Iron*

Bore Size	Maximum Recommended Housing Cap Loads, lbf		
	120°	150°	180°
1-1/8 to 1-1/2	2110	2640	3100
1-5/8 to 1-3/4	2380	2980	3500
1-7/8 to 2 SM	3130	3910	4600
2 LG to 2-3/16	3330	4160	4900
2-3/8 to 2-1/2	3330	4160	4900
2-11/16 to 3	4420	5520	6500
3-3/16 to 3-1/2	4620	5780	6800
3-11/16 to 4	7500	9350	11000

* When utilizing heavy cap loads on pillow block housings, the installation must adhere to the following procedures:

1. The pillow block base bolts must be of high strength (Grade 8) bolts and properly tightened to mounting structure.
2. Stop bars (shear strips) should be used against the plummer block where side loads are encountered.
3. In all cases where loads are heavy, the L10 life of the bearing should be checked for proper selection and life requirements.

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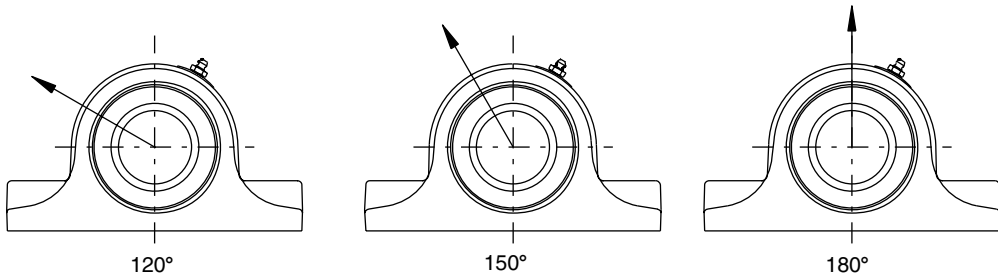


Table 6: S-2000 Housing Rating, 4-Bolt, Cast Iron*

Bore Size	Maximum Recommended Housing Cap Loads, lbf		
	120°	150°	180°
1-15/16	3200	4000	4700
2-3/16	3300	4100	4800
2-3/8 to 2-1/2	3810	4760	5600
2-11/16 to 3	4620	5780	6800
3-3/16 to 3-1/2	4700	5870	6900
3-11/16 to 4	7500	9350	11000
4-7/16	9900	12330	14500
4-15/16	13400	16750	19700

* When utilizing heavy cap loads on pillow block housings, the installation must adhere to the following procedures:

1. The pillow block base bolts must be of high strength (Grade 8) bolts and properly tightened to mounting structure.
2. Stop bars (shear strips) should be used against the plummer block where side loads are encountered.
3. In all cases where loads are heavy, the L10 life of the bearing should be checked for proper selection and life requirements.

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