**Notes on Ball Bearings**

**Bearing Nomenclature**

You can learn a lot about a bearing just from its part number.

A typical bearing is the 6203ZZ bearing. This part number can be divided into it's components:

**6203ZZ**

which means:

* Type Code
* Series
* Bore
* Suffix

The type code indicates the type of bearing. While each manufacturer uses their own numbers, there are a few numbers that could be considered standard in the industry.

|  |  |  |
| --- | --- | --- |
| 1 | **Self-Aligning Ball Bearing**  This kind of ball bearing has a spherical outer race, allowing the axis of the bearing to "wander around". This is important because misalignment is one of the big causes of bearing failure. | http://www.gizmology.net/images/bearings_01.gifhttp://www.gizmology.net/images/bearings_11.gif |
| 2 | **Spherical Roller Bearing** | http://www.gizmology.net/images/bearings_13.gif |
| 3 | **Double-Row Angular Contact Ball Bearing**  Designed to take axial as well as radial loads. | http://www.gizmology.net/images/bearings_03.gif |
| 4 | **Double-Row Ball Bearing**  Designed for heavy radial loads. | http://www.gizmology.net/images/bearings_04.gif |
| 5 | **Thrust Ball Bearing**  Intended for exclusively axial loads. | http://www.gizmology.net/images/bearings_05.gif |
| 6 | **Single-Row Deep Groove Ball Bearing**  Typical ball bearing. Handles light axial loads as well as radial loads. | http://www.gizmology.net/images/bearings_06.gif |
| 7 | **Single-Row Angular Contact Bearing**  For axial (one direction only!) as well as radial loads. | http://www.gizmology.net/images/bearings_07.gif |
| 8 | **Felt Seal**  To assure that the entire inside edge of the seal touches the inner ring, the inner ring is enlarged. If a bearing of more normal proportions is required, the outer ring is also enlarged, and the bearing is referred to as a "wide cup" bearing. | http://www.gizmology.net/images/bearings_08.gif |
| 32 | **Tapered Roller Bearing**  This is the kind of wheel bearings used in cars. The rollers are not cylindrical, but conical. They handle large raidal and axial loads. | http://www.gizmology.net/images/bearings_10.gif |
| R | **Inch (Non-Metric) Bearing** | Varies |
| N | **Cylindrical Roller Bearing**  Instead of balls, cylindrical rollers are used. These bearings can handle much more radial load, but can handle much less axial load, than ball bearings. | http://www.gizmology.net/images/bearings_09.gif |
| NN | **Double-Row Roller Bearing**  Handles greater radial loads than standard cylindrical roller bearings. | http://www.gizmology.net/images/bearings_09.gif |
| NA | **Needle Roller Bearing**  Needle bearings are basically roller bearings, but the rollers are much smaller, making the bearing more compact. | Varies |

Type 6, "single-row deep groove", is perhaps the most common type of bearing.

If the bearing is an inch bearing (the first digit in the number is an R), then the size is the digit or digits immediately following the R, in 16ths of an inch. An R8-2RS bearing, for example, has an 8/16th or 1/2 inch bore.

If the first digit is a number, however, it is a metric bearing, and the second digit is the *series*, which reflects the robustness of the bearing. The series are, from lightest to heaviest:

|  |  |
| --- | --- |
| 8 | Extra thin section |
| 9 | Very thin section |
| 0 | Extra light |
| 1 | Extra light thrust |
| 2 | Light |
| 3 | Medium |
| 4 | Heavy |

Yes, they go in that order. Gotta keep things simple, you know.

Each of these series also establishes a relationship between the bore size, outer diameter, and thickness of the bearing, in accordance with ISO standards. I have no idea what they are.

The third and fourth digits indicate the *bore size* in millimeters. Except for 0 through 3, the bore size is simply five times the third and fourth digits together. 0 through 3, however, are different:

|  |  |
| --- | --- |
| 00 | 10mm |
| 01 | 12mm |
| 02 | 15mm |
| 03 | 17mm |

If there is no fourth digit - for example, a 608 bearing, a common roller skate bearing - then the size is the last digit in millimeters.

The last letters indicate something special about the bearing. For example:

|  |  |
| --- | --- |
| Z | Single shielded |
| ZZ | Double shielded |
| RS | Single sealed |
| 2RS | Double sealed |
| V | Single non-contact seal |
| VV | Double non-contact seal |
| DDU | Double contact seals |
| NR | Snap ring and groove |
| M | Brass cage |

And then there are the completely off-the-wall bearing numbers, like 499502H. I have no idea what that number is supposed to mean, but it applies to what is basically an R10-2RS bearing, only a bit thicker and with a groove and snap ring.

**Examples**

**Common Skate Bearings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Bore (mm)** | **O.D. (mm)** | **Width (mm)** |
| 608 | 8 | 22 | 7 |
| 627 | 7 | 22 | 7 |
| 688 | 8 | 16 | 4 |
| 698 | 8 | 19 | 6 |

All these bearing numbers start with 6, which tells us they're *Single-row deep groove ball bearings*. The second digits tell us the robustness of the bearings. The last two, in series 8 and 9, are very thin and lightweight bearings, while the first, in series 0, is an "extra light" bearing without being abnormally thin. The third bearing, in series 2, is the most robust of all, being merely "light".

**Light vs Heavy Comparison**

Consider the following three bearings:

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Bore mm** | **O.D. mm** | **Thickness mm** |
| 6010-2RS | 50 | 80 | 16 |
| 6210-2RS | 50 | 90 | 20 |
| 6310-2RS | 50 | 110 | 27 |

We can see from the part numbers that they're all 50mm single-row deep groove ball bearings. However, we can also see that they're each a different series; specifically, Extra Light, Light, and Medium. Compare the O.D. and thickness of each bearing, and you can see how the Extra Light bearing (series 0) is the smallest, and the Medium Bearing (series 3) is the largest. The larger bearing can take much more load than the smaller bearing, though how much depends on the manufacturer and the RPM the bearing is run at.

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Bore mm** | **O.D. mm** | **Thickness mm** |
| 6904-2RS | 20 | 37 | 9 |
| 6004-2RS | 20 | 42 | 12 |
| 6204-2RS | 20 | 47 | 14 |
| 6304-2RS | 20 | 52 | 15 |

These are all 20mm single-row deep groove ball bearings of different series. The first, of series 9, is a "very thin section" bearing, meaning it is much thinner than usual - it is only 25% as thick as its O.D., while the others are approximately 30% as thick as their O.D.

**Common Bearing Dimensions**

**Extra Light Bearings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Bore mm** | **O.D. mm** | **Thickness mm** |
| 6000-2RS | 10 | 26 | 8 |
| 6001-2RS | 12 | 28 | 8 |
| 6002-2RS | 15 | 32 | 9 |
| 6003-2RS | 17 | 35 | 10 |
| 6004-2RS | 20 | 42 | 12 |
| 6005-2RS | 25 | 47 | 12 |
| 6006-2RS | 30 | 55 | 13 |
| 6007-2RS | 35 | 62 | 14 |
| 6008-2RS | 40 | 68 | 15 |
| 6009-2RS | 45 | 75 | 16 |
| 6010-2RS | 50 | 80 | 16 |
| 6011-2RS | 55 | 90 | 18 |
| 6012-2RS | 60 | 95 | 18 |
| 6013-2RS | 65 | 100 | 18 |
| 6014-2RS | 70 | 110 | 20 |
| 6015-2RS | 75 | 115 | 20 |

**Light Bearings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Bore mm** | **O.D. mm** | **Thickness mm** |
| 6200-2RS | 10 | 30 | 9 |
| 6201-2RS | 12 | 32 | 10 |
| 6202-2RS | 15 | 35 | 11 |
| 6203-2RS | 17 | 40 | 12 |
| 6204-2RS | 20 | 47 | 14 |
| 6205-2RS | 25 | 52 | 15 |
| 6206-2RS | 30 | 62 | 16 |
| 6207-2RS | 35 | 72 | 17 |
| 6208-2RS | 40 | 80 | 18 |
| 6209-2RS | 45 | 85 | 19 |
| 6210-2RS | 50 | 90 | 20 |
| 6211-2RS | 55 | 100 | 21 |
| 6212-2RS | 60 | 110 | 22 |
| 6213-2RS | 65 | 120 | 23 |
| 6214-2RS | 70 | 125 | 24 |
| 6215-2RS | 75 | 130 | 25 |
| 6216-2RS | 80 | 140 | 26 |

**Medium Bearings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Bore mm** | **O.D. mm** | **Thickness mm** |
| 6301-2RS | 12 | 37 | 12 |
| 6302-2RS | 15 | 42 | 13 |
| 6303-2RS | 17 | 47 | 14 |
| 6304-2RS | 20 | 52 | 15 |
| 6305-2RS | 25 | 62 | 17 |
| 6306-2RS | 30 | 72 | 19 |
| 6307-2RS | 35 | 80 | 21 |
| 6308-2RS | 40 | 90 | 23 |
| 6309-2RS | 45 | 100 | 25 |
| 6310-2RS | 50 | 110 | 27 |

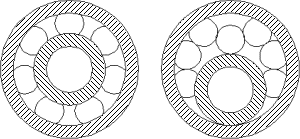
**Inch Bearings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Bore inch** | **O.D. inch** | **Thickness inch** |
| SR3-2RS | 0.1875 | 0.5000 | 0.1960 |
| R4-2RS | 0.2500 | 0.6250 | 0.1960 |
| R4A-2RS | 0.2500 | 0.7500 | 0.2813 |
| R6-2RS | 0.3750 | 0.8750 | 0.2813 |
| R8-2RS | 0.5000 | 1.1250 | 0.3125 |
| R10-2RS | 0.6250 | 1.3750 | 0.3438 |
| R12-2RS | 0.7500 | 1.6250 | 0.4375 |
| R14-2RS | 0.8750 | 1.8750 | 0.5000 |
| R16-2RS | 1.0000 | 2.0000 | 0.5000 |
| R20-2RS | 1.2500 | 2.2500 | 0.5000 |
| 1601-2RS | 0.1875 | 0.6875 | 0.3125 |
| 1602-2RS | 0.2500 | 0.6875 | 0.3125 |
| 1605-2RS | 0.3125 | 0.9063 | 0.3125 |
| 1603-2RS | 0.3125 | 0.8750 | 0.3438 |
| 1604-2RS | 0.3750 | 0.8750 | 0.3438 |
| 1614-2RS | 0.3750 | 1.1250 | 0.3750 |
| 1606-2RS | 0.3750 | 0.9063 | 0.3125 |
| 1615-2RS | 0.4375 | 1.1250 | 0.3750 |
| 1607-2RS | 0.4375 | 0.9063 | 0.3125 |
| 1620-2RS | 0.4375 | 1.3750 | 0.4375 |
| 1616-2RS | 0.5000 | 1.1250 | 0.3750 |
| 1621-2RS | 0.5000 | 1.3750 | 0.4375 |
| 1633-2RS | 0.6250 | 1.7500 | 0.5000 |
| 1623-2RS | 0.6250 | 1.3750 | 0.4375 |
| 1638-2RS | 0.7500 | 2.0000 | 0.5625 |
| 1630-2RS | 0.7500 | 1.6250 | 0.5000 |
| 1641-2RS | 1.0000 | 2.0000 | 0.5625 |
| 1652-2RS | 1.1250 | 2.5000 | 0.6250 |
| 1658-2RS | 1.3125 | 2.5625 | 0.6875 |

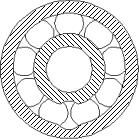
**Other Stuff**

Ever wonder how they assemble ball bearings? There are two ways.

The typical ball bearing, called a Conrad bearing. There is enough space between the balls that if they're all pushed over to one side, the inner ring can be pushed to the opposite side, into the space left by moving the balls. This increases the space on the side where the balls are, letting them be removed. The bearing cage usually keeps the balls evenly spaced so this doesn't happen by accident.

  
*Conrad Type Bearing Assembly*

The other kind of ball bearing is called a maximum capacity bearing, and has a special notch cut in the side of the rings, into which the balls are placed during assembly. As a result of this notch, the axial loads this kind of bearing can take are quite small, and must be in combination with a large radial load. However, the increased number of balls that can be fit into the bearing means the maximum capacity type bearing can handle a larger radial load.

  
*Maximum Capacity Bearing*

**Design Life**

The design life of a bearing depends on **rated load** and the **equivalent radial load**.

**Deep Groove: L10 = (C/P)n**

The **rated load, C**, is the load at which 10% of bearings fail after one million revolutions. The manufacturer will provide this number. One million revolutions may sound like a lot, but it's not. A car engine typically has one million revolutions on it after only eight hours.

The **equivalent load, P**, is a combination of axial load and radial load, times some factor to account for shock loading, acceptable noise levels, lubrication quality, cleanliness, speed, temperature, etc. Calculating it can be a pain.

The exponent, **n**, is 3 for radial bearings, and 3.33 for thrust bearings. This large an exponent means that doubling the load on a bearing will decrease its life by a factor of *eight* or *ten*, depending on the type of bearing. Don't overload your bearings!

The formula for calculating equivalent load is

**P = (XFr + YFa) × s**

where Fr is **actual radial load**, Fa is **actual axial load**, X is the **static radial factor**, and Y is the **static axial factor**, and s is the **service factor**, which varies from 1 on up. If Fa is zero (no axial load) you can ignore all this folderol, and P = Fr. Likewise, if Fr is zero (no radial load), then P = Fa.

Calculating X and Y is so complicated that I avoid it when I can - by using separate thrust and radial bearings, by assuming X is 1 and Y is 3 (values which far exceed anything realistic), or by using software. SKF has an online bearing calculator [here](http://www.skf.com/skf/productcatalogue/jsp/calculation/calculationIndex.jsp?&maincatalogue=1&lang=en).

If you really want to try calculating X and Y, start [here](http://www.dynaroll.com/catalog/pag023.htm#eload).

**Sources**