

# TECHNICAL WHITE PAPER



## Linear Bearing and Guide Bar Designs for Weight Stack and Fitness Equipment Applications

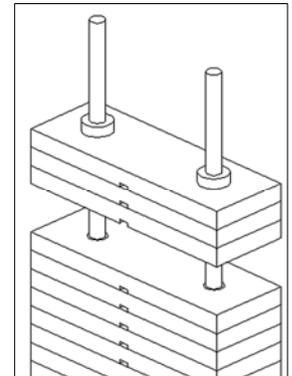
### Contents:

- Introduction
- Basic Requirements of Weight Stack Applications
- Bearing Design Options
- Performance Advantages/Disadvantages
  - Consistently smooth motion
  - Repeatable tolerances and ease of assembly
  - Maintenance and replacement
- Conclusions



### - Introduction:

Over the last several years, society has become more and more health conscious and the field of specialized fitness equipment has grown by leaps and bounds. Along with that growth has come the proliferation of various designs and configurations for both the equipment and the guide mechanisms. In today's market, the fastest growing segment of focused equipment is that designed to meet a woman's or senior's express needs for smooth consistent motion and feel. Specifically in this paper we will discuss the various components used in weight stack and fitness equipment applications and arrive at qualified solutions for the best system.



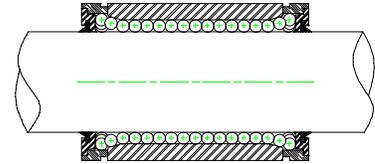
### - Basic Requirements of Weight Stack Applications:

1. Consistently smooth motion  
The more consistent the feel of motion is to a user, the higher their perception of its quality will be. Consistent motion is the product of the bearings Coefficient of Friction (COF). Changes in the COF translate into an inconsistent feel.
2. Repeatable tolerances and ease of assembly  
In the manufacturing, assembly, and usage of fitness equipment, having tolerances that result in repeatable processes and performance is critical. Overall time and cost savings help to provide a competitive advantage.
3. Minimum of maintenance  
Once a piece of fitness equipment has left the factory for a fitness center or health club, there are no guarantees that anyone will ever perform the maintenance required. The long-term performance of that equipment then reflects on the manufacturer regardless of how well it has or has not been cared for on site.

## - Bearing Design Options:

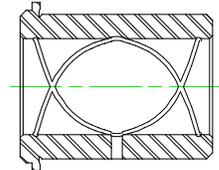
### 1. Linear rolling element bearings

An assembly of multiple components made up of recirculating balls and the hardened steel bearing tracks that they run against contained in either a steel or plastic retaining shell.



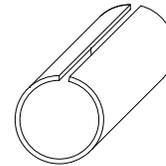
### 2. Bronze bushings

A wide variety of solid bronze, oil impregnated, bronze plated, and plugged with graphite bushings are available.



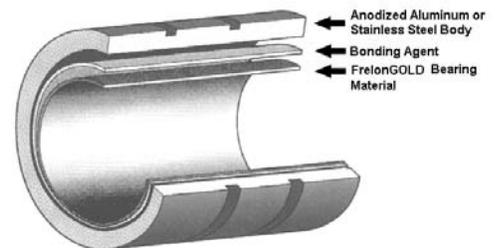
### 3. Solid plastic bearings

A wide variety of materials such as nylon, delrin, teflons, etc. can be molded or machined for bearing applications.



### 4. Simplicity® self-lubricating bearings

A one piece bearing with a Teflon® based bearing material bonded to an aluminum outer shell.



## - Performance Advantages / Disadvantages:

### 1. Consistently smooth motion

#### a. Ball bearings

At initial installation, ball bearings generally supply consistent motion and the lowest coefficient of friction available, provided that they are lubricated and mounted properly. The drawback is that they are also the most susceptible to outside influences. If they are not mounted properly, they will operate in an overloaded condition resulting in premature failures. Any dust, dirt, or contamination that enters the bearing at the time of assembly or over its life can cause the balls to skid or even lock in position. This will result in a flat spot on the ball and damage to both bearing and shafting that can be felt by the user when actuating the weight stack and ultimately end in complete system failure.

#### b. Bronze bushings

Bronze bushings are the least reliable option for providing consistent motion. The metal-to-metal contact created requires that lubrication be present at all times. As the lubricant ages and dissipates, an erratic sticky feel is translated to the user when the weight stack is set in motion. In addition, metal-to-metal contact results in galling of the shafting and complete system failure.

#### c. Solid plastics

Various plastics can provide a consistent feel as the weight stack is actuated. However, they are very susceptible to environmental conditions and contamination. Any change in running clearance due to thermal expansion, humidity, moisture, etc., will result in less running clearance for the bearing. This translates to increased force required by the user in moving the weight stack and a highly inconsistent feel to the overall system.

d. Simplicity bearings

FrelonGOLD® is a self-lubricating bearing material that is designed to run without external application of grease or oils. That, along with the fact that the material properties remain unchanged, means that the coefficient of friction and its translation to feel by the operator are the same from the day of installation through out the life of the bearing.

**2. Repeatable tolerances and ease of assembly**

a. Ball bearings

Ball bearing tolerances are generally of a high quality. They are designed however to be placed on the shaft in a “preloaded” condition. This means that there is a preset amount of pressure applied to the balls as they make contact with the shafting. This assembly of can be a tricky process. Quite often balls will fall out of or be forced from the raceways during the process. Replacing the balls in the bearing tracts is a tedious time consuming process. When they are reassembled, there is a high risk of contamination being introduced into the bearing ultimately resulting in an inconsistent feel in the system and early failure. Other times, the balls are simply not replaced and the bearing is installed to operate at a decreased load and life capacity.

b. Bronze bushings

Bronze bushings will provide consistent tolerances and ease of assembly; however, the tolerance between shaft and bushing will be greater. This is to allow for the required lubrication. In addition, this clearance can result in play or a loose feeling that is translated to the user.

c. Solid plastics

Since plastics are greatly affected by the environment around them, they must be designed with greater clearances between the bearing and shaft to allow for changes. This will usually result in even greater play or looseness than a bronze bushing. In addition, plastic bearings are usually simply injection molded with no machining afterwards to qualify surfaces. Often they are slotted for “easier” manufacture and installation, but this design results in even greater variation in tolerances.

d. Simplicity bearings

These composite bearings are finish ground on both the I.D. and O.D. resulting in very exacting tolerances to less than .0005”. They are not preloaded like a ball bearing, but maintain a consistent running clearance of less than .001” over the entire length of the bearing / shaft interface. Also, since they are not subject to great changes in the environment, there is no need for high clearances between the shaft and bearing surface. These tolerances ensure a uniform fit and feel for all assembly and manufacturing processes.

**3. Maintenance and Replacement**

a. Ball bearings

Ball bearings require on going maintenance to insure that the correct amount of lubrication is present. If they are not maintained, the resulting metal-to-metal contact of the balls to the shaft and bearing tracks will destroy the system resulting in the need for total replacement.

b. Bronze bushings

Bronze bushings as well require on going maintenance to insure that the correct amount of lubrication is present. If they are not maintained, there will also be metal-to-metal contact that will result in the galling of the bearing and shafting destroying the system and resulting in the need for total replacement.

c. Solid plastics

In the correct environment, plastic bearings will normally operate maintenance free. However, when placed in a location where outside influences change the bearing size or characteristics, they will create problems such as binding and require outside lubrication or maintenance to again operate correctly.

d. Simplicity bearings

Simply put, Simplicity bearings operate maintenance free. Their design makes them self-lubricating for life and there is no need for external lubrication. They will operate over a wide range of conditions without feeling the effects of the environment. They will not catastrophically fail and damage the shafting because there is no metal-to-metal contact. In addition, automated life testing has shown the FrelonGOLD™ bearing material to only wear less than .002" in 125 million inches of travel. Assuming an average 40" stroke for a lift or extension machine, that translates to 3,125,000 lift cycles with minimal wear and no maintenance to the bearing.

**Conclusion:**

While the various options for bearing designs in weight stacks and fitness equipment offer some advantages at certain stages of the products life, only the Simplicity self-lubricating linear bearings provide consistent results in all the required areas.

Consistency in motion is built into the design with the bearing material FrelonGOLD™ that has the same frictional characteristics for the life of the bearing. Quality and repeatability of fit and function are present through the entire manufacturing, assembly, and usage life cycle. At the same time, with the Simplicity bearing, in field maintenance issues, failures, and replacements are eliminated, becoming a thing of the past.

© Copyright 2009 PBC Linear™

**LINEAR MOTION SOLUTIONS**

6402 E. Rockton Road Roscoe, IL 61073, USA

(800) 962-8979 • [www.pbclinear.com](http://www.pbclinear.com)