ROLLON®
LinearEvolution

HARDNESS SOLUTIONS IN LINEAR MOTION RAILS

When it comes to linear motion rails, a high hardness value is critical. With unhardened surfaces, the sooner the rail will become susceptible to damage—much like how potholes will develop on a road after it bears the loads of passing cars and trucks. Unfortunately, some rail manufacturing processes don't impart sufficient hardness to the rails.

To gain maximum life for your linear guide, you'll want to consider the hardening process, the material being hardened and how to finish the rail in order to optimize its performance. Otherwise, if hardness doesn't extend to a sufficient depth, the component won't be able to withstand heavy loads over the course of its lifetime, which can result in time-consuming and costly downtime for your system.

Not all hardening processes, materials and finishes are created equal, however. By keeping the following options in mind, quality manufacturers can make the best linear rail for your industrial application.

THE IMPORTANCE OF INDUCTION HARDENING. To harden their rails, often a manufacturer can use nitriding, a heat treating process that diffuses nitrogen into the surface of a metal (typically low-carbon, low-alloy steels), creating a case-hardened surface with thicknesses between 0.2 and 0.3 mm. When you consider the kinds of heavy loads that are applied to industrial raceways in warehouse automation, robotic cells, railway, machine tools and more, rails that have thin nitrided surfaces will tend to crack under load.

RAILWAY APPLICATIONS

Telescopic guides and linear rails are used in many parts of trains. When a train is running, the balls and bearings in the doors and battery boxes, for example, are subject to hours of constant vibration while remaining in the static position. For these reasons, a bearing with insufficient hardness levels can easily become damaged or crack. In an industry where passenger safety is paramount, only induction hardened rails can stand up to the ongoing vibration trains experience. By avoiding the need to shut down an entire train for repairs, these sturdy components also help railcar manufacturers avoid troublesome and costly downtime.

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HARDNESS CORRECTION

A typical 440C stainless steel linear bearing can only be hardened in the raceway area to Rc = 54, reducing its dynamic load capacity by 22% compared to a harder E5200 steel.

FORMULA:

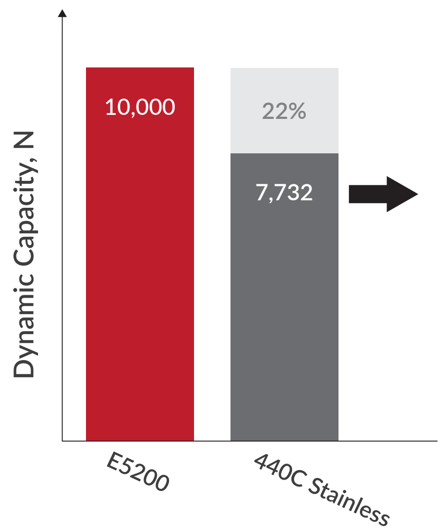
$$C' = C\left(\frac{Rc}{58}\right)^{3.6}$$

WHERE:

C′ = Corrected basic dynamic capacity, N

C = Basic dynamic capacity, N

R_c = Rockwell C scale hardness value < 58



HARDNESS CORRECTION:

$$C' = C\left(\frac{54}{58}\right)^{3.6}$$

$$= 7{,}732 \text{ N}$$

To avoid bearing failure, it's important to know the location of the point of stress between the bearing and the rail. The maximum stresses, which are called Hertzian contact stresses, aren't on the surface at all, but beneath it. For that reason, a rail's hardened layer needs to extend deep enough below the surface—something many nitriding processes simply cannot achieve. That's where induction hardening comes in.

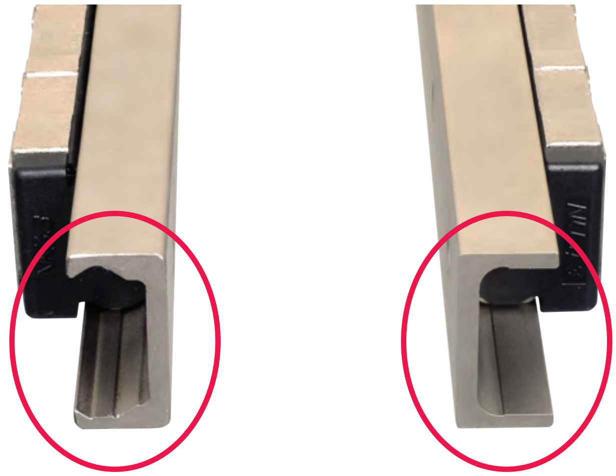
LUBRICATING YOUR HARDENED RAIL

A lack of effective lubrication on the surface of your linear bearing can reduce its lifespan by a factor of 10. Although lubrication is something you can't avoid, you can choose bearings that have minimal lubrication needs by design, such as those with well-sealed rolling elements. Rollon's Compact Rails, for example, integrate sealed rolling elements that require only a small amount of external lubrication every 50,000 cycles. The raceway, ball bearings and lubricant are all contained inside the outside housing of the roller, minimizing the need to add lubrication between the roller and profiled rail.

Rather than creating a case-hardened surface, induction hardening creates a zone around the raceway with effective depths up to 5 mm depending on the specification and cross-section of the part, successfully encompassing the maximum point of stress located beneath the rail's surface. In this form of heat treatment, the metal first undergoes induction heating, a non-contact process that uses an electric current to create heat in the surface layer of a conductive material. The surface layer is then quenched, causing it to undergo a martensitic transformation and become harder than the base metal.

Compared to gas furnace heating and other conventional heat treatments, induction hardening offers several advantages, including fast heating rates, low energy consumption and cost savings. It also refines the structure and mechanical properties of the treated parts. As a result of this process, an induction hardened rail can operate under heavy loads with no damage to the raceways over the course of its lifetime. In properly sized linear bearings, typical life ratings range from thousands to hundreds of thousands of kilometers of travel, allowing for one-piece flow, rather than batch processes.

Because the subsurface stresses on a loaded raceway can hit 500,000 psi, both rail hardness and hardness depth are critical values to measure during the induction hardening process. A rail's hardness depth will vary, as will the rail's overall size, based on the requirements of your application. Small models, such as Rollon's size 18 Compact Rail, integrate a hardness depth of 2 mm. By contrast, large rails, such as Rollon's size 63 Compact Rail, feature a hardness depth between 4 and 5 mm.



Compact Rail

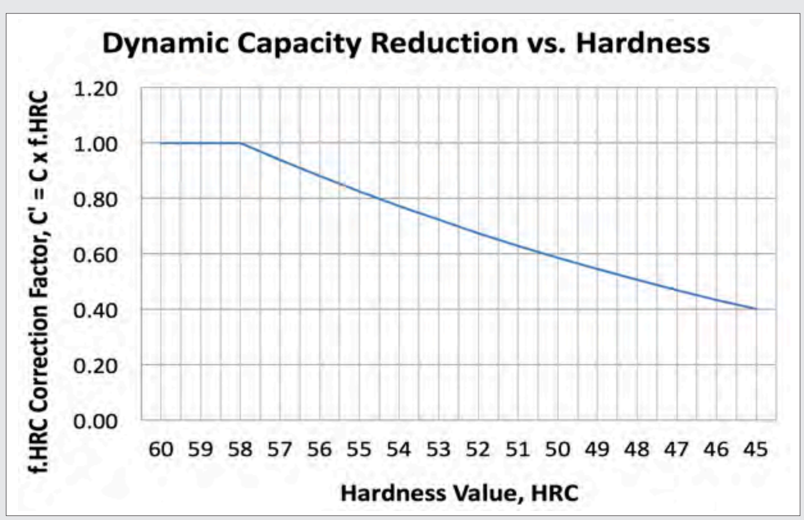
USING HIGH-QUALITY STEEL. Achieving hardened rails doesn't just boil down to the hardening process. You also need to be aware of what you're hardening. To achieve hardness levels that can stand up to the daily grind of industrial applications, high-quality linear motion rails need to be made from high-quality material in the form of precise composition clean steel with a high carbon content. The use of high-carbon steel allows induction hardening to bring out the natural properties of the metal, including its yield strength, malleability and toughness, which in turn increases the bearing's strength and durability under variable loading conditions.

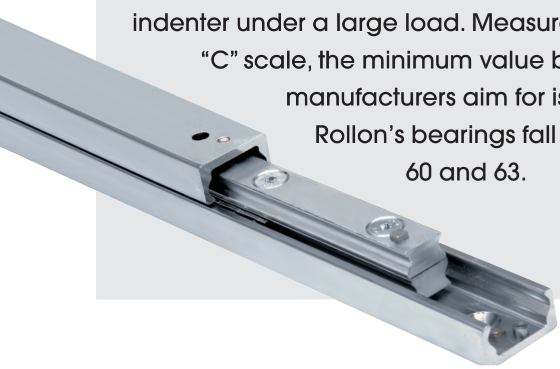
Most steels with carbon content higher than 0.4 percent are suitable for induction hardening, including E52100, a high-carbon (1.1 percent), low-alloy steel known for its use in bearings and other highly stressed components in rolling contact applications.

RAIL FINISH. Once a raceway undergoes induction hardening, its surface can be further machined to improve its anti-friction capabilities. Rollon performs a surface and honing grinding operation on its raceways to give them a smoother surface, guaranteeing the system will run efficiently and with minimal noise. In certain applications,

MEASURING HARDNESS VALUES

Hardness is defined as a material's resistance to deformation, indentation or penetration. One of the ways it can be measured is with the Rockwell hardness test, which involves measuring the depth of penetration of an indenter under a large load. Measured on a "C" scale, the minimum value bearing manufacturers aim for is 58 HRC. Rollon's bearings fall between 60 and 63.





low-noise bearings can be especially important. In medical imaging systems, for example, bearings have to operate smoothly and quietly, not just for the sake of image quality, but also for the sake of patient comfort.

Grinding also makes hardened raceways more precise; if two raceways aren't parallel, then their running quality is affected. Typically, surface finishes range in microinches from about 4 to 8 R_a (microinches). By contrast, grinding cannot be performed on raceways that undergo nitriding and other similar processes. Because the resulting case-hardened surface is so thin, grinding would remove the hard coating entirely.

Induction hardening and subsequent grinding and honing remove tool marks and high spots, allowing the surface to retain its hardness depth over the life of the rail. The extra

AN UP-AND-COMING ROLE IN 3D PRINTING

Hardened rails are gaining ground in the industrial 3D printing industry, which started out using lower quality rails and bearings. In addition to large industrial printers, the industry is expanding to include higher quality table-top hardware. These machines now require precise yet robust bearings that can stand up to industrial demands without needing to be replaced. The accuracy and repeatability of high-quality linear bearings is increasingly required for 3D precision parts.

smoothness, along with the hardness, both work to extend the life of the rail/bearing system. On nitrided rails, the surface finish, and thus the hardness, both disappear over time, leading to both coating and hardness failure.

CONCLUSION. When specifying a linear rail for your industrial application, the following characteristics indicate optimal levels of surface hardness, ensuring your bearing will operate under heavy loads with minimal wear over the course of its lifetime:

- **Induction hardened raceways.** This heat treating process brings out the tough natural properties of steel, creating a thick zone around the raceway and ensuring hardness levels are achieved at critical depth and effective hardness.
- **Material purity.** To achieve maximum hardness levels, rails should be made from high-quality, high-carbon composition steel that is specifically made for bearing applications.
- **Additional surface finish.** Induction hardened rails that undergo surface grinding will be smoother and more precise, optimizing their running quality.

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