3M Science. Applied to Life.™

Go the distance.

3M™ Silicon Nitride Fuel Pump Rollers

Improving engine performance and durability

- High strength and reliability
- Contact fatigue resistance
- High elastic modulus
- Light weight (60% lighter than steel)
- Tribological compatibility with metals (low coefficient of friction and excellent wear resistance)

In recent years, diesel engines have been increasingly subjected to higher fuel pressures and compressive loads as automotive manufacturers seek to meet stringent fuel economy and emissions standards. This industry trend places unprecedented stress on fuel pump rollers – and the commonly used steel components are failing early.

3M™ Silicon Nitride Fuel Pump Rollers, manufactured by Ceradyne Inc., a 3M company, offer a more durable alternative to conventional rollers. These high-strength ceramic rollers are specially engineered to handle high contact stress levels in diesel fuel environments. 3M silicon nitride fuel pump rollers provide superior mechanical reliability at high speeds and loads – helping automotive OEMs meet the high pressures required to achieve emission standards.

Lightweight, high-strength ceramics

3M fuel pump rollers are made from 3M™ Silicon Nitride 147-31N, a tough, lightweight ceramic material offering high stiffness and high Hertzian contact strength. 3M silicon nitride was selected for this application because – unlike metal and coated metal – it resists abrasion, helping extend component lifetime. At the same time, it allows the pumps to operate at higher pressure: 3M fuel pump rollers operate at contact stress levels of 1.1 to 1.6 GPa (160,000–230,000 psi), and the silicon nitride material can withstand Hertzian stresses up to 2.4 GPa (350,000 psi) or more.

Rolling contact fatigue behavior of 3M™ Silicon Nitride 147-31N (Not for specification purposes)

Test Type	Stress (GPa)	Cycles (test time)	Result
Rig test production component	1.1	2.45×10^9 (3000 hours)	Suspension, no failure
Rig test production component	1.6	6.36×10^8 (2000 hours)	Suspension, no failure
Rig test production component	1.5–2.4	6.3×10^7 (1000 hours)	Suspension, no failure
RCF machine	6.07	Characteristic Life 4.94×10^7 (95.7 hours)	Weibull Slope 1.2
RCF machine	6.41	Characteristic Life 4.31×10^7 (83.3 hours)	Weibull Slope 1.2

3M silicon nitride also exhibits reduced friction when in contact with either cast iron or steel – allowing 3M fuel pump rollers to operate at higher speeds and stress levels with less lubrication than metal rollers.

Processing

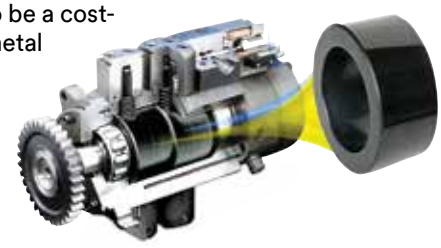
3M silicon nitride materials and components are produced at fully dedicated manufacturing plants in the U.S. and Germany, using unique compositions and processing techniques. 3M silicon nitride 147-31N is processed by gas pressure sintering, which results in a fully dense and nonporous microstructure of interlocking needle-shaped grains. This, combined with the natural toughness of silicon nitride (with a fracture toughness of 6 $MPam^{½}$), provides outstanding contact fatigue resistance and mechanical reliability.

We use a patented grinding process and high-precision superfinishing and honing operations to machine OD/ID crown profiles on roller bearing elements. These grinding and crowning operations allow us to produce fully integrated silicon nitride replacements for steel counterparts.

Applications

Manufacturers around the world are successfully using 3M silicon nitride components in both oil lubricated and diesel fuel environments. 3M fuel pump rollers have provided solutions to specific problems in high-volume, heavy-duty diesel applications – such as high contact stresses combined with tribological wear, corrosion and lubrication problems.

Designed for common rail fuel pumps in both heavy- and light-duty diesel engines, 3M fuel pump rollers can help increase system capabilities and performance. They can be used to replace metal components in order to help resolve warranty problems with excessive wear, scuffing and galling. 3M silicon nitride has also proven to be a cost-effective alternative to metal components when the lifecycle cost of the system is taken into account.



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