



## **Silicon Nitride for Cam Rollers and Other High Contact Stress Applications in Modern Diesel Engines**

By

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The need for more efficient diesel engines combined with increasingly stringent emissions standards have resulted in increased cylinder operating pressures and fuel injection pressures. These conditions result in higher contact stresses in key components, such as cam rollers, which can result in wear, galling, micro welding and finally, failure of metal components. New material options are required to solve these problems.

Ceralloy® 147-31N Silicon Nitride is a strong, tough, lightweight, wear resistant ceramic material. This material was developed in the 1970's for use in gas turbine engines and was commercialized in the 1990's for use in hybrid roller bearings and other industrial wear applications. In the past years, Ceradyne, Inc. has commercialized Silicon Nitride components to replace steel rollers and has solved major warranty problems associated with the wear and galling of metal cam rollers and rollers in high pressure fuel pumps.

Ceralloy® 147-31N Silicon Nitride has unique tribological and physical properties (low weight combined with high strength and contact fatigue resistance) that allow its use under high contact stresses, often exceeding 300 GPa.

To understand the benefits of Silicon Nitride cam rollers, one must first understand the failure mode of metal cam rollers. A metal cam roller system for heavy-duty diesel engines consists of a steel roller with a bronze pin. The metal roller runs against a steel cam. The failure begins as the bronze pin wears. The wear is accelerated because bronze is a relatively soft metal. The wear of the pin makes it more difficult for the metal roller to rotate. This then results in skidding against the cam lobe and ultimately scuffing, micro welding and galling of both the cam roller and the cam lobe. Fatigue failure will follow. Higher contact stresses of new diesel engines will accelerate the above process.

A Silicon Nitride based system consists of a Silicon Nitride cam roller and a hardened steel pin. The use of a harder pin material eliminates the root cause of failure in the metal cam roller system, the bronze pin. The use of a Silicon Nitride cam roller eliminates the problem of wear and galling of the metal roller. Silicon Nitride has a very low coefficient of friction versus steel (approximately 0.05 lubricated) and a very low mass (3.2 grams per cubic centimeter, 60% lighter than steel) which gives the Silicon Nitride cam roller a lower moment of inertia, making it easier to rotate against the cam and reducing the chance of skidding against the cam lobe.

Silicon Nitride is very compatible with steel from a wear standpoint. The measured wear of a steel pin in a Silicon Nitride cam roller system is over 95 percent lower than the corresponding wear with a steel roller and bronze pin. No micro welding will occur with the Silicon Nitride cam roller system because of the dissimilarity of materials. Silicon Nitride cam roller systems eliminate the major failure modes of metal cam rollers, and are proven to reduce cam lobe wear and increase cam lobe life, even at higher contact stresses. Additionally, Silicon Nitride has a better rolling contact fatigue life than bearing steels, resulting in a system with improved reliability.

The reliability of Silicon Nitride has been demonstrated by the fact that over two million rollers are currently in engines with no reported field failures caused by material related problems. This excellent mechanical reliability is due to Ceradyne's unique processing techniques that result in no porosity on wear surfaces. The absence of porosity eliminates the major cause of contact fatigue failure.

Ceralloy® 147-31N Silicon Nitride components produced by Ceradyne are currently in production for the following applications:

- Cam Roller for Unit Injector Fuel Pumps for Class 8 Diesel Engines
- Cam Rollers for Intake and Exhaust Valves for Class 8 Diesel Engines
- Rollers for Common Rail, and other High Pressure Fuel Pumps for Light Duty Diesel Engines, as well as Very Heavy Duty Marine and Locomotive Diesel Engines.

The cost of Silicon Nitride components is significantly higher than steel components. Ceradyne has addressed and continues to address this by minimizing the cost of raw materials through the use of its unique Sintered Reaction Bonded Silicon Nitride processing route. This combined with improvements in our continuous and semi continuous ceramic processing and grinding procedures have reduced and continue to reduce the cost difference between Silicon Nitride and metal. Most importantly, Silicon Nitride components are justified on the basis of the life cycle and performance improvements compared to metal components. For example, engine life costs can be reduced because problems related to fatigue in metal rollers or cam lobes during the warranty life of an engine do not arise when the ceramic alternative is used.

In conclusion, Ceralloy® 147-31N Silicon Nitride is a cost effective material solution that has eliminated wear and galling of the cam rollers and the adjoining cam lobe, or pump rollers and the adjoining metal components. The use of Silicon Nitride components has eliminated warranty problems in these applications and has resulted in increased engine reliability.

For further information about other Silicon Nitride applications, please visit Ceradyne's web site at [www.ceradyne.com](http://www.ceradyne.com) or contact:

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DDC Series 60 Rocker Arm Assembly with Ceradyne's Ceralloy® 147-31N Silicon Nitride Cam Roller



Ceradyne's Ceralloy® 147-31N Silicon Nitride Cam Rollers and Rolling Elements