

3M™ Nextel™ Ceramic Fibers for High Temperature Dynamic Sealing Applications

This article is not for specification purposes.

Chemical processing plants are known to have some of the most extreme operating conditions. This is especially true for dynamic sealing applications such as tube seals used on ethylene crackers, steam methane reformers and other high temperature processing heater boxes. Typical heater boxes operate at high temperatures, ranging from 900°F to 2100°F (482°C to 1149°C), and sealing of the penetrations is critical to prevent outside air from entering or gases escaping. Due to thermal expansion and contraction, movements of 12 inches or more occur between the metal tubing and the heater box structure during start-up and shut down operations. As a result, dynamic sealing solutions must not only be capable of resisting very high temperatures but must also be flexible enough to survive multiple flexing/bending cycles (10 or more) without failing.

Tube seals must remain intact for at least 3 years and prevent air from passing through the heater box penetrations throughout this lifetime. If a failure should occur in a tube seal, the heater box will experience inefficient air mixing; potentially creating noxious gases which could lead to non-compliance with environmental regulations or create an unscheduled plant shutdown. This could result in supply chain delays and significant financial losses. It is important to select appropriate dynamic sealing materials to ensure a long service lifetime.

3M™ Nextel™ Ceramic Fabrics are made from woven bundles of very fine ceramic (aluminoborosilicate) filaments which are inherently resistant to very high temperatures; up to 2372°F (1300°C). In addition, the small filament diameters (8 to 12 microns) and resistance to embrittlement allows the fibers to remain flexible after exposure to high temperatures.

There are several other industrial fabrics which are being used for lower temperature heater box dynamic sealing applications. The most common materials are based on silica; e.g., leached glass silica and melt glass silica. Coatings (typically vermiculite or chromium) are often applied to these fabrics in order to increase their thermal stability. Although each of these fabric types are resistant to relatively high temperatures, they are not used in high temperature ranges since they are prone to embrittlement, resulting in a loss of strength. The brittleness and loss of strength can lead to fabric breakage and seam failures during flexing.



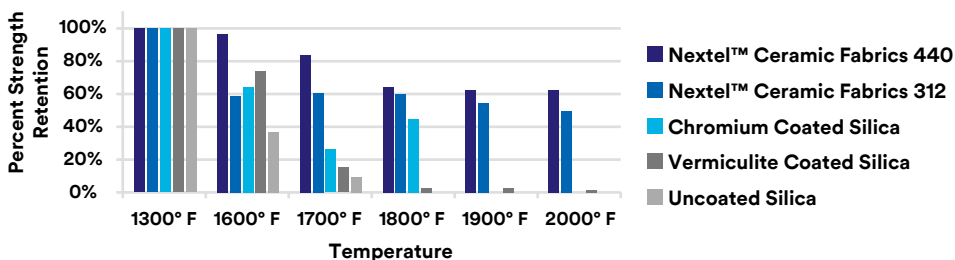
Tube Seal using 3M™ Nextel™ Ceramic Fabric

In one study, the breaking load (tensile strength) and flex endurance of various silica and 3M™ Nextel™ Ceramic Fabrics were measured after long term exposures (100 hours) at several temperatures ranging from of 1300°F (704°C) to 2000°F (1150°C).

The breaking load testing was based on ASTM D5035, and the flex endurance testing was based on ASTM D2176. The fabrics included uncoated leached glass silica, vermiculite coated silica, chromium coated silica, as well as 3M™ Nextel™ Ceramic Fabrics 312 and 440 (high and low boria content aluminoborosilicates respectively).

Figure 1 shows the breaking load strength percent retention (compared to results at 1300°F / 704°C) after 100 hours of exposure at temperatures ranging from 1300°F (704°C) to 2000°F (1093°C).

Figure 1 - Breaking Load Strength Percent Retention



As shown in this graph, the breaking strength of uncoated (leached glass) silica, chromium coated silica and vermiculite coated silica fabrics significantly decreased at temperatures above 1600° F (871° C). Both 3M™ Nextel™ Ceramic Fabrics however, retained 50% or more of their original strength values, even at 2000° F (1093° C).

Table 1 shows the room temperature flex endurance (cycles until failure) after 100 hours of exposure at temperatures ranging from 1600°F (871°C) to 2000°F (1093°C).

Table 1 - Temperature vs Flex Cycles to Failure

	1600° F	1700° F	1800° F	1900° F	2000° F
Uncoated Silica	>50	>50	0	0	0
Chromium Coated Silica	>50	>50	33	0	0
Vermiculite Coated Silica	>50	>50	>50	13	0
3M™ Nextel™ Ceramic Fabrics 312	>50	>50	>50	>50	30
3M™ Nextel™ Ceramic Fabrics 440	>50	>50	>50	36	36

As shown in Table 1, uncoated (leached glass) silica was unable to withstand a single flex cycle before failure after 100 hours at 1800°F (982°C). Chromium coated silica and vermiculite coated silica fabrics showed significant reductions in the number of flex cycles before failure at temperatures above 1800°F (982°C). In contrast, at temperatures above 1800°F (982°C), both 3M™ Nextel™ Ceramic Fabric types managed to survive more than 30 flex cycles. In fact, after 100 hours of exposure at 2000°F (1093°C), only 3M™ Nextel™ Ceramic Fabrics survived.



Tube Seals: 3M™ Nextel™ Ceramic Fabric Inner Layer

Tube seals made with 3M™ Nextel™ Ceramic Fabrics 312 and 440 fabrics have been used at various chemical processing plants for many years. By providing a unique combination of very high temperature resistance and flexibility, the long-lasting performance of 3M™ Nextel™ Ceramic Fabrics makes them well-suited for dynamic seal applications and may offer the lowest long term cost solution as well.

Warranty, Limited Remedy, and Disclaimer: Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. User is solely responsible for evaluating the 3M product and determining whether it is fit for a particular purpose and suitable for user's method of application. User is solely responsible for evaluating third party intellectual property rights and for ensuring that user's use of 3M product does not violate any third party intellectual property rights. Unless a different warranty is specifically stated in the applicable product literature or packaging insert, 3M warrants that each 3M product meets the applicable 3M product specification at the time 3M ships the product. 3M MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY IMPLIED WARRANTY OF NON-INFRINGEMENT OR ANY IMPLIED WARRANTY OR CONDITION ARISING OUT OF A COURSE OF DEALING, CUSTOM OR USAGE OF TRADE. If the 3M product does not conform to this warranty, then the sole and exclusive remedy is, at 3M's option, replacement of the 3M product or refund of the purchase price.

Limitation of Liability: Except where prohibited by law, 3M will not be liable for any loss or damages arising from the 3M product, whether direct, indirect, special, incidental or consequential, regardless of the legal theory asserted, including warranty, contract, negligence or strict liability.

Technical Information: Technical information, recommendations, and other statements contained in this document or provided by 3M personnel are based on tests or experience that 3M believes are reliable, but the accuracy or completeness of such information is not guaranteed. Such information is intended for persons with knowledge and technical skills sufficient to assess and apply their own informed judgment to the information. No license under any 3M or third party intellectual property rights is granted or implied with this information.

Export Control: The 3M product(s) listed here may be controlled commodities under applicable U.S. export control laws and regulations, including, but not limited to, the U.S. International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). These laws and regulations may, among other things, prohibit the export and/or reexport of controlled product(s) to any or all locations outside of the United States without prior U.S. Government export authorization, the sharing of export controlled technical data and services with those anywhere who are not U.S. citizens or U.S. permanent residents, dealings with U.S. Government, United Nations and other "Restricted Parties," and proliferation activities including those that further nuclear, chemical, or biological warfare, missile stockpiling/use, or the use of rockets or unmanned aerial vehicle systems. 3M and purchasers or prospective purchasers of the 3M product(s) shall comply with all applicable export control laws and regulations, which may require obtaining and maintaining applicable export control authorization or licenses, and understand that the ability of a party to obtain or maintain such authorization or license is not guaranteed. The exporter of record has the sole responsibility to determine whether the export or subsequent reexport of the 3M product(s) requires export authorization. An explicit condition to 3M selling or making available the 3M product(s) is the customer's agreement to comply with all applicable trade compliance laws and regulations.



Advanced Materials Division
3M Center
St. Paul, MN 55144-1000 USA
Phone: 1-800-367-8905
Website: 3M.com/ceramics

3M and Nextel are trademarks of
3M Company. Used under license by
3M subsidiaries and affiliates.

Please recycle. Printed in USA. © 3M 2017.
All rights reserved. Issued: 1/17 12135HB
98-0050-0525-5