ENVIRONMENTAL WEAR TESTING OF NONMETALLIC MATERIALS FOR COMPRESSOR APPLICATIONS

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ABSTRACT
A full-size prototypical test facility was designed and built to test nonmetallic materials in support of reciprocating compressor applications. Conventional test rigs utilize a pin-or ring-on-disk configuration to produce wear data in rotary motion under relatively low applied loads. In contrast, the subject test facility is constructed around a 9-inch (23-cm) stroke compressor frame. The test specimen and counterface configurations are similar to compressor packing rings and piston rods, respectively, and specimens are spring-loaded to variable levels encompassing actual compressor conditions.

Testing to date has been performed at 500 rpm, 200°F (93°C), and three different load levels [65, 130 and 195 psi (450, 900 and 1350 kPa)]. Material wear rate in air versus specimen pressure reveals a linear relationship with a slope of approximately 0.12 mils/day/psi (0.44 µm/day/kPa). The wear performance of six different materials has been ranked in air. Future testing will focus on creating a database for material wear rates in air and nitrogen.

INTRODUCTION
Reciprocating compressors utilize nonmetallic materials for gas sealing applications (e.g., piston rings and piston rod packing rings). Wear of nonmetallic materials in these applications is a concern due to a lack of industry standards for material specification, testing and application; material variability; wear-limited service life; and associated costs. It is estimated that generic carbon-filled polytetrafluoroethylene (PTFE) packing rings in a 4-cylinder compressor have a useful lifetime of 6-8 months and cost approximately $20-100k to replace including parts, labor and lost revenue. Of course, unplanned shutdowns and failures can result in much greater costs.

Typical laboratory wear test facilities are inadequate to simulate compressor conditions. Most wear testing is performed with rotating pin- or ring-on-disk test rigs, which lack environmental and temperature control capability. While these facilities can produce useful data for studying the wear of nonmetallic materials, they are not representative of compressor applications in terms of motion (rotating versus reciprocating), specimen and counterface size and configuration, and specimen pressures [test rigs typically are limited to <20 psi (<140 kPa)].

A full-size prototypical test facility was designed and built to provide wear data on nonmetallic materials under nonlubricated reciprocating compressor conditions. This facility will be used to develop test/application methodology and improved technical understanding for environmental wear of nonmetallic materials. It will also be valuable in correlating data obtained with less prototypical laboratory equipment to actual compressor service.

EXPERIMENTAL PROCEDURE

Materials
Six different materials (5 grades of filled PTFE and an acrylamide) have been tested to-date (Table 1). These include packing ring and piston ring materials designed for lubricated and nonlubricated service conditions. Future plans include expanding the test matrix to include all candidate nonmetallic materials for compressor applications.

TABLE 1
TEST MATERIALS

MATERIALS	DESCRIPTION
Grade A	General purpose grade of carbon-filled PTFE.
Grade B	General purpose grade of carbon-filled PTFE recommended for low pressure lubricated applications.
Grade C	Medium-to-high carbon graphite filled PTFE recommended for low pressure lubricated applications.
Grade D	Medium filler of two carbon materials and glass fiber recommended for nonlubricated applications.
Grade E	Fiber reinforced PTFE. Fibers appear to be polymeric with a high level of phosphorous.
Acrylamide	Carbon/graphite fiber reinforced acrylamide.

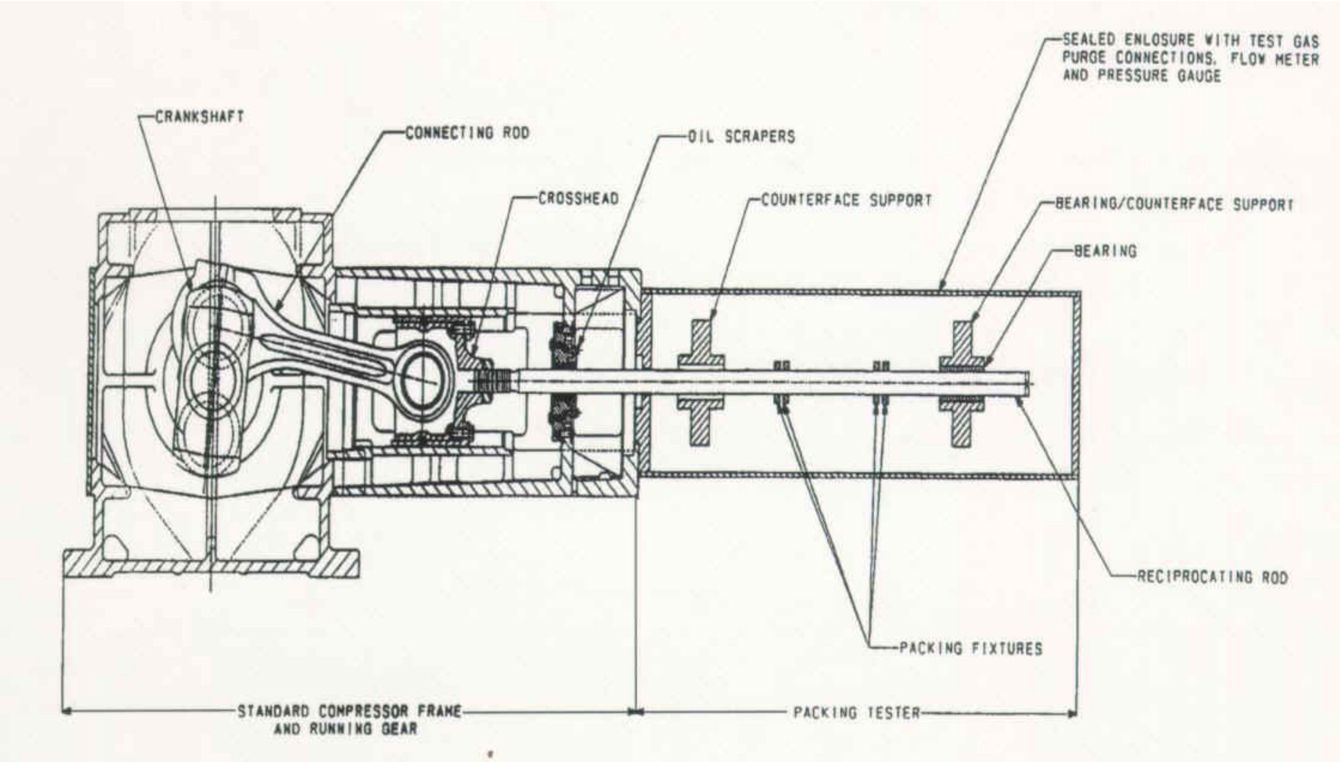
The Grade A and B carbon-filled PTFE materials have been employed as test standards. By including at least one specimen of these grades in a test run (4 specimens total), the validity of the data can be checked by comparison to previous results.

Environments
All testing reported herein was performed in air. A compressed air supply was employed to somewhat minimize humidity variations that are expected to

significantly affect wear rates. The dew point of the air used for this test program is estimated to be 18 to 32EF (-8 to OEC) and is somewhat dependent on ambient temperature. The compressor air passes through a carbon filter to remove any oil or other contaminants. Testing is conducted at atmospheric pressure.

Equipment and Procedure

Schematic diagrams detailing the reciprocating wear test facility are presented in Figures 1-4. It features a full-size, single-throw compressor frame with a 9-inch (23-cm) stroke. A 60 HP (45 kW), variable speed (1200 rpm, maximum) motor is employed to drive a shaft on which four packing fixture assemblies are mounted. The purpose of each packing fixture assembly is to spring load and locate a nonmetallic test specimen against one of two stationary counterfaces. Spring loading is accomplished with one to three springs per packing fixture assembly resulting in a near constant specimen-to-counterface pressure of 65, 130 or 195 psi (450, 900 or 1350 kPa). Additional load control is possible by changing the spring design (i.e., spring constant). The test specimen geometry is typical of a compressor piston rod packing ring segment. Similar to compressor piston rods, the two counterfaces are 2-inch (5-cm) diameter hardened (55-60 HRC) Type 4140 steel rods with a surface finish of 8-16 •in (0.20-0.41 microns). The counterface rods are hollow permitting the internal flow of cooling/heating water. Water temperature is continuously controlled within +/- 10EF (+/- 6EC) and monitored at eight locations (inlet, outlet and 3 locations on each counterface) using fixed thermocouples. The test chamber is slightly pressurized with a gaseous test environment (e.g., air or nitrogen). A pressure gauge and flow meter are employed to monitor the test environment.



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