B20 to B100 Blends as Heating Fuels

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Evaluation of Oil Burner Pumps Under Operating Conditions

The work reported in Section 1 of this report addresses the basic interaction between burner pump elastomers and biodiesel blends. As an alternative method of exploring the question of the use of commonly available oil burner pumps cycling tests of actual pumps with and without biodiesel blends were also explored. This section provides a description of these cycling tests.

In-Lab Cycling Tests

In a separate project, over the 2010-2013 timeframe, the operational reliability of the most common oil burner pump type, representing over 80% of the U.S. market, was evaluated in a series of tests at Penn State University. This involved rack of pumps operating under controlled cycling conditions of 5 minutes on, 1 minute off. The fuel in these tests was recirculated from 5-gallon containers. The base fuels for these tests included both “conventional” high sulfur heating oil (~ 1500 ppm) and ultralow sulfur (ULS) heating oil (15 ppm). Biodiesel blend levels ranged from B0 to B20. The key focus in this work was on pump shaft lip seal leakage and a detailed metric to quantify observed leakage was developed by the pump manufacturer for use in these tests. Figure 2-1 provides a photo of the pump setup. In the final round of these tests, 42 pumps were run and blend levels used included B0, B12, and B20. Seven pumps were run at each blend level and total run time for each pump was 7,000 hours. Quality of all fuels was monitored throughout the project to insure the fuel had not degraded significantly during the test due to the stressing of the fuel in the test. Acid number was considered the primary criterion for this. High acid numbers were not observed, and thus the test considered acceptable from that standpoint.

Figure 0-1 Pumps under test at Penn State University

Under the test conditions, all pumps were found to leak very slightly. In an analysis of the results using success criteria provided by the manufacturer, it was found that the pumps with biodiesel had lower leak rates over the course of the test than did the pumps without biodiesel.

While the pump study above covered most of those in the market, the majority of the remaining pumps in the market have carbon face seals vs. lip shaft seals. It was also desired to confirm performance with these carbon face seal pumps. Under a separate project, additional testing of carbon face seal pumps was also completed at BNL. For these tests, the pump racks from the Penn State test were moved to BNL. The pumps used in the tests at BNL were from two different manufacturers which both use carbon-face type shaft seals.

This test included a total of 42 pumps and the run period was 11 months. With a 5 minute on/1 minute off period over 8,030 hours this yields 80,000 on/off cycles. The biodiesel level was B0, B12, and B20. There were 7 pumps at each biodiesel level and the base fuel for all tests was ultralow sulfur heating oil (15 ppm). In contrast to the tests at Penn State with the lip seal pumps (similar time period and cycling pattern) no leaks were observed in the tests with these pumps with either B0 or the biodiesel blends. Figure 2-2, shows for example the shaft seal area, post-test for one of the pumps tested at BNL with carbon face seals.

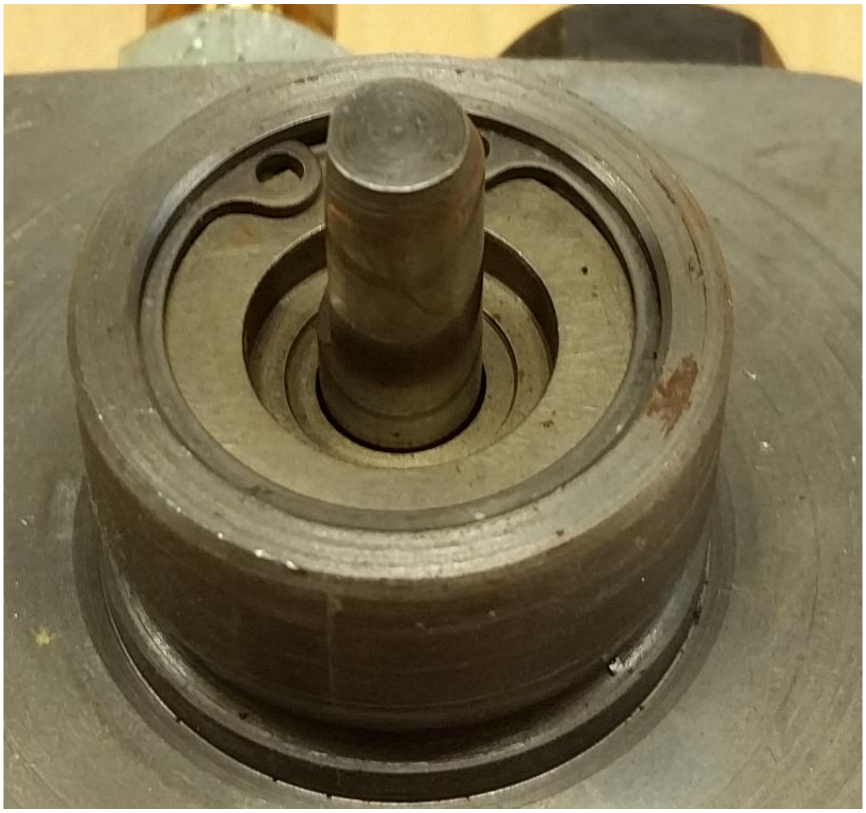


Figure 0-2 Photo of pump with a carbon face seal after 11 months of testing with biodiesel.

In this testing, and the same fuel was recirculated for the entire test but the fuel was allowed to recirculate for the entire test and only checked at the completion of the test period. For all fuel samples measurements were made of the acid number (TAN) following completion of the tests. For some of the biodiesel blends in this test the TAN was found to be quite high at the completion of the test– on the order of 12. This indicated the test was quite severe to the point of depleting the fuels oxidation reserve which allowed fuel oxidation and acid formation. The TAN of the pumps run with the base fuel was the lowest, in all cases under 1. The fuel was not changed during the 11-month test, representing a significant stress. It was noted that even with the fuels which did degrade during this severe test—to the point of elevated high acid values which could potentially cause leakage with NBR lip seals—the carbon face seals did not experience leakage.

Evaluation of Pumps from the Field

In another approach to evaluating the impact of biodiesel, fuel pumps were collected from service companies which had been using biodiesel blends. Two sources participated in this. The first is a Long Island fuel marketer which has been marketing B20 blends to thousands of homes for at least 5 years. The second is a New York City-based company which has been marketing B100 to mostly commercial buildings since roughly 2010. In this study the received pumps were disassembled when received and inspected with a focus on the condition of the lip shaft seal. None of the received pumps had carbon-face seals.

Figure 2-3 illustrates, for example, a partially disassembled pump which had operated in the field for 3 years with B20. This pump was removed from service for this project and, as with all of the field pumps evaluated in this study it was operating well at the time of removal.

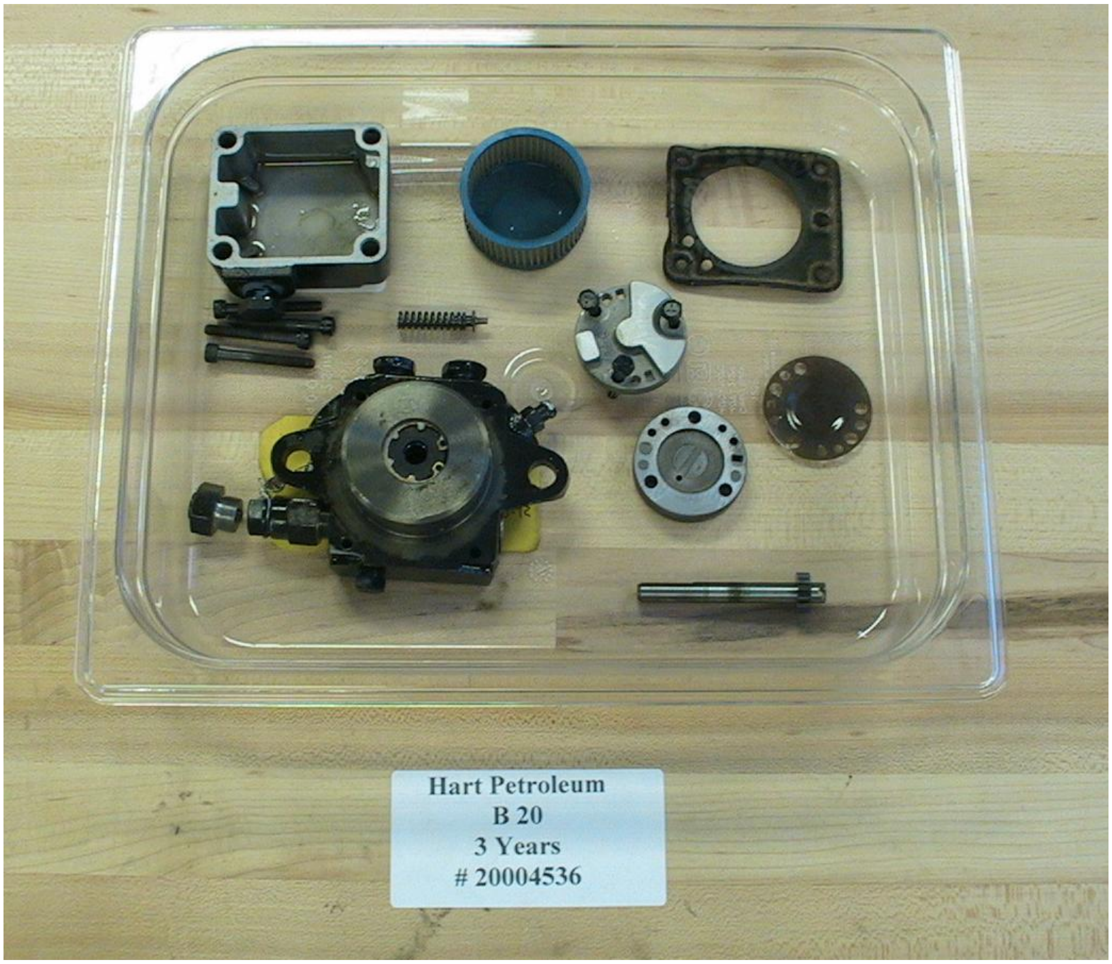


Figure 0-3 Partially disassembled pump. Field operation - 3 years, B20.

As with the lab long term run studies, the focus of this inspection has been on the lip-style shaft seal. Figure 2-4 provides a photo of this seal. Figure 2-5 is a sketch of the seal and Figure 2-6 shows a low magnification microscope image of the sealing edge of a new seal.

Figure 0-4 Photo of a new oil pump shaft seal.

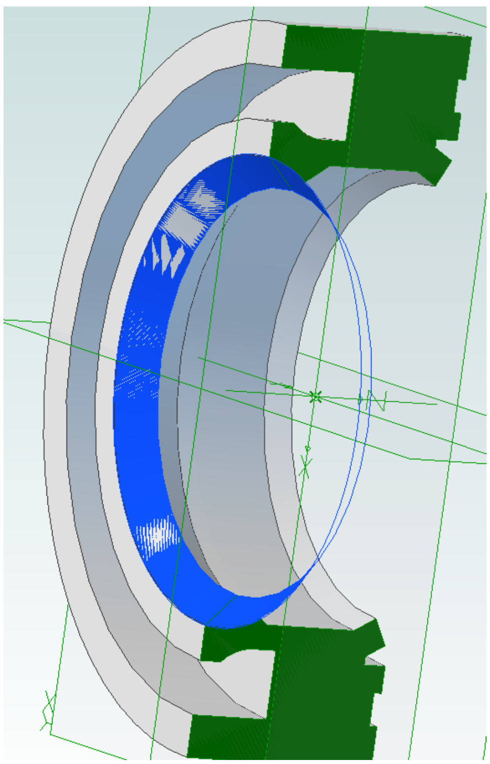


Figure 0-5 Sketch of oil pump shaft seal.

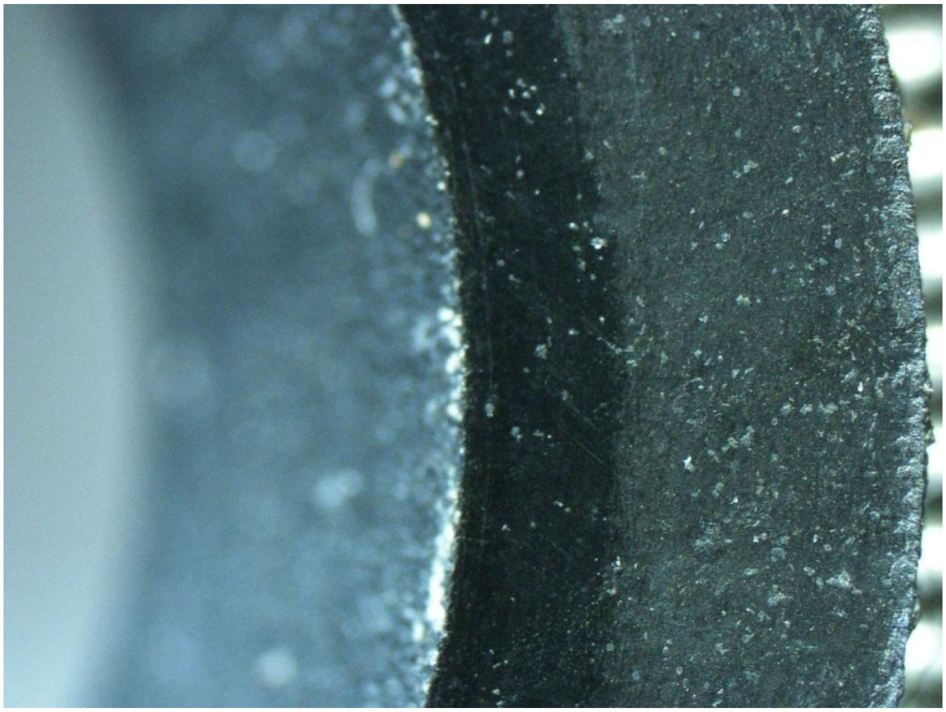


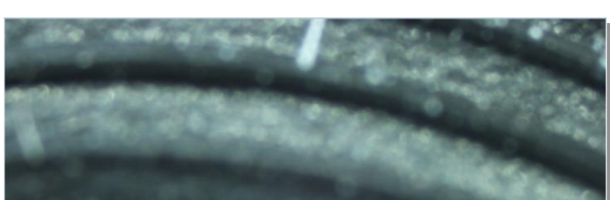
Figure 0-6 Image of the sealing edge of a new oil burner shaft seal.

This seal, as is common with lip seals, has two lips. The inner one is the sealing surface and the outer one acts as a dust barrier. The blue surface on the drawing in Figure 2-5 is the inner face of the sealing lip. This faces the interior of the pump and is well "flushed" by the pumped oil.

Figure 2-7 shows the inner and outer faces of the sealing lip of the pump seal which had been using B20 in the field for 3 years. This study showed no significant damage relative to a new seal.

Figure 2-8 shows the edge of a seal from a pump which had been using B100 for 6 months in the field. Again, there is no significant sign of damage to the sealing edge.

Figure 2-9 shows the edge of a seal from one of the pumps used in the tests at Penn State University using the baseline B0. In this case there is clear indications of damage to the pump seal and this is likely the reason why some shaft leakage was observed during the Penn State tests. This result shows that the fast-cycling during the in-lab testing provides more stress on the shaft seal than normal operation in the field. From the Penn State tests, no significant difference could be noted in the appearance of the shaft seals based on fuel used.



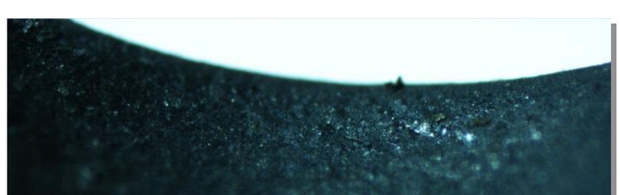


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Figure 0-8 Image of the sealing edge of a shaft seal from a pump after six months of field operation on B100.

Figure 0-9 Image of the sealing edge of a shaft seal from one of the pumps in the Penn State long term test. This pump operated with a B0 blend.

Conclusions

Overall, from the work described in this section, there was no strong correlation between biodiesel blend level and pump shaft seal degradation or failure impact between B0 and biodiesel blends up to B20. One important observation was that the pump seals in the lab test showed degradation and impacts for both B0 and biodiesel blends that were not observed with the pumps exposed to B0 or biodiesel blends in the field for years evaluated in this study. This again is most likely due to the fast-cycling testing which places more stress on the shaft seal than normal operation in the field.