Pall Corporation

Technical White Paper

Overcoming Electrostatic Charge Generation - Incorporating a Novel Filter Media

Pall Scientific & Laboratory Services

Several methods have been investigated to oil-lubricated charge generation in oil-lubricated systems and prevent damage that can occur if the electrostatic discharge operates unchecked. One method involves adding an antistatic additive (ASA) to the liquid, but it has been restricted to fuel applications. Because filters can play a role in electrostatic charge generation, other methods used various materials in the construction of the filter element to offset the charge generated by one layer, or the use of conducting layers and metal meshes, but the results prove to be system-dependent. The approach taken by Pall Corporation involves designing the filter material to generate and accumulate significantly less charge (antistatic element).

This is the second instalment of a two-part series. This article discusses a program to develop a filter media to significantly reduce both the charge generation by the filter and the accumulated charge on the filter, hence eliminating potential filter damage and minimizing the migration of charge into the downstream fluid.

Experimental Study of Filter Media Charging

It was necessary to determine the effects different filter materials would have on charge generation. The tests were performed on flat-sheet media so that combinations of media could be quickly tested to select the more promising ones for later full-scale filter element testing. Two test stands were created for the study. The media test rig was built with a nonconductive housing to isolate the filter material from the rest of the system. Therefore, the charge generated on the material and the charge passed downstream could be measured without the possibility of being lost through discharge to ground. The oils tested (Table 1) represent a large sample of the available oils, which contain key characteristics believed to affect the rate of charging. The main oil used in testing was turbine lube oil due to its high dielectric strength and low conductivity. The synthetic polyalphaolefin (PAO)-based oil, MIL-PRF-83282, was also tested as an alternative to the mineral oils that comprised the majority of the testing.

Product		Turbine Lube Oil	Hydraulic Oil A	Hydraulic Oil B	Hydraulic Oil C	MIL-PRF-83282
Base Fluid		Group I	Group I	Group I	Group II	PAO with 33% diester
Additive Type		R & O	Antiwear	Antiwear	Antiwear & Antioxidant	Antiwear
	P	-	0.05%	0.05%	0.02%	0.30%
	Zn	-	0.08%	0.08%	0.03%	-
	S	-	0.06%	0.06%	0.05%	-
Viscosity	cSt@ 40º C	29	32	46	47	14
	Viscosity Index	100	95	95	105	132
Dielectric Strength	kV	27.3	15.6	15.4	23.8	15.5
Water Content	ppm	11.01	95	117.5	91.8	68.82
Conductivity (in test stand)	(pS/m)	39 (38° C)	1460 (38° C)	815 (30° C)	264 (30° C)	40 (30° C)

Table 1. Characteristics of Tested Oils.

	Turbine Lube Oil	Hydraulic Oil A	MIL-PRF-83282	Hydraulic Oil A
Comments	Charge is stable with time, or decrease slightly	Nonlinear increase of charge with increase of flow	Opposite sign of charging as mineral oils. Charge has tendency to decrease with time	Charge has tendency to increase with time. Significant variation in charging day to day
Standard Glass Fiber based Material	High charging	Charge is lower than for turbine lube oil	Magnitude of charge is slightly less than in turbine lube oil	Charge is comparable to turbine lube oil
New Antistatic Material	Charge is lower than all other media	Charge is lower than all other media	Charge is lower than all other media	Charge is lower than all other media

Table 2. Flat-sheet Test - Charging Characteristics with Different oils.

The first material tested was a standard glass fiber (GF)-based filtration material, a common material used in hydraulic and lube filter elements. This was tested against several types of media, including proprietary antistatic or electrostatic dissipative (ESD) materials developed by Pall Corporation laboratories, which were designed to reduce the charge generated by the media. This analysis used five oils (Table 1) and was set up to measure the charge generated on the filter material. The first set of tests used only the turbine lube because of its representative characteristics. The results show that the standard GF material generated a current significantly higher than the new antistatic material. The test was run again using different oils to compare the results to the turbine lube oil, and to determine whether the materials would produce the same charging patterns (Table 2). Although several experimental media produced a reduction in the charge generation, the new antistatic material showed the minimum charge under all conditions.

Because of differences in the charge of flat-sheet and pleated cartridge materials, due to different flow patterns, material thickness and discharge to the filter housing, the isolated flat-sheet testing did not mimic practical applications. Therefore, a test stand was built to test the charge generated by full-size filter elements that would more closely mimic the true in-field working conditions (Figure 1). The stand consisted of a standard grounded metal filter housing to hold the filter element, and a charge collector to measure the charge downstream. After testing, the media were examined for evidence of electrostatic activity and damage.

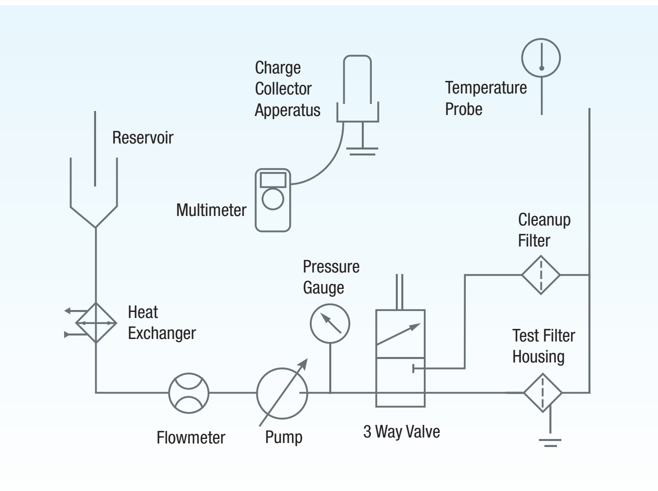

Figure 1. Pleated Filter Test Stand

Two filter configurations were tested. The flow would either start outside the filter and flow in (out-to-in) to a grounded metal core, or start inside the filter and flow out to a grounded metal support sleeve.

The tests studied the effect of flow rate with turbine lube oil on the generated charge passing downstream of the filter media (Figure 2).

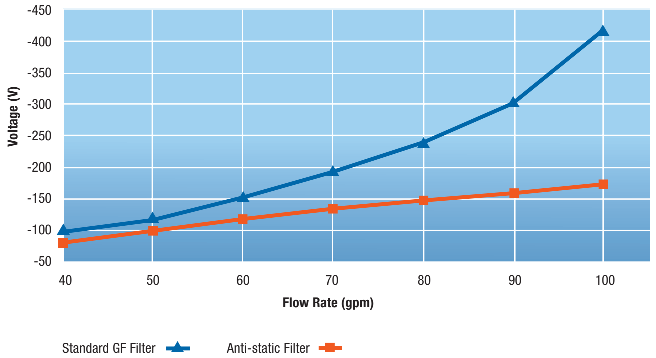

Figure 2. Pleated Element Testing - Downstream Oil Charge - In-to-out Flow

A second type of filter housing was then used to measure the charge generated in the downstream oil by out-to-in type filters (Figure 3).

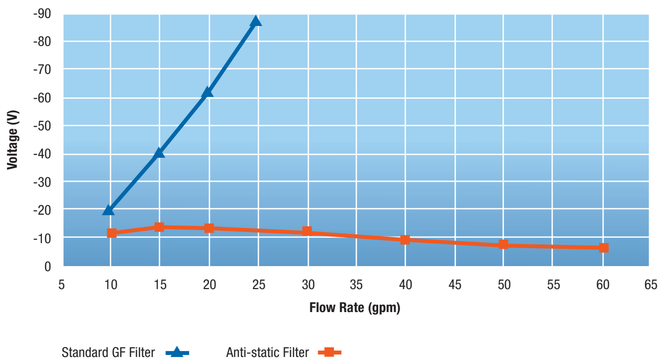

Figure 3. Pleated Element Testing - Downstream Oil Charge - Out-to-in Flow

It is not possible to directly compare these two sets of results due to the different filter sizes and charge collectors. Therefore, it can only be concluded that the antistatic filter produced substantially less charge than the standard GF filter, regardless of the filter or test configuration.

Field Trials

Field trials were conducted with systems utilizing various flow conditions, oil types and additive packages. Testing was performed with combinations of filter materials, rating in terms of their charge generation value and comparing their performance to the new antistatic material. The systems studied were selected because they were experiencing electrostatic discharge and using GF material from multiple manufacturers as well as GF filter material with a fine, conductive, nonwoven material and two grades of standard GF filter material with a metal mesh.

Field Trial 1: The first field tests were conducted on a hydraulic system at a transformer radiator manufacturing plant, measuring the downstream oil charge with the cartridge charge collector setup connected to a port on the filter housing, downstream of the filter media. Visual and auditory tests were conducted in the reservoir because the plant workers had complained about sparking believed to be caused by electrostatic discharge at the filter/fluid interface. Both the antistatic and the standard GF filters were tested. The tests showed that the antistatic material reduced the downstream oil charge to a negligible amount, and eliminated the discharging seen and heard within the reservoir that occurred with standard GF filters.

Field Trial 2: The second set of field tests were conducted on an injection molding machine hydraulic system and involved three styles of filter media: standard GF material, standard GF material with a conductive nonwoven material, and the new antistatic material. The tests also included visual examinations for possible effects of electrostatic discharge as well as auditory tests. The auditory tests were conducted on the filter housing and included checking for clicking sounds.

The standard GF filters were the only material that exhibited either clicking sounds from the filter housing and/or visible burn marks on the plastic filter end caps. Additionally, the standard GF filter showed a downstream potential of 12 to 14V. The new antistatic material was the only one that showed lower voltages than the standard GF fiber, with 4 to 5V measured, while the GF filter with conductive layer was measured at 14 to 16V. No audible clicking or burning was observed when either the antistatic or conductive layer elements were employed.

Field Trial 3: Testing was conducted on a paper mill hydraulic system using both the GF filter material with conductive layer, and the antistatic filter material. Using the cartridge charge collector, the downstream voltages were measured at different flow-rates through the collector at the same system flow. At the maximum flow measured, the antistatic filter showed a 98 percent reduction in the voltage measured downstream.

Field Trial 4: The fourth set of tests were run at a power plant on a power generation lube system. Testing was performed on a different GF filter than previously tested, one supplied by another manufacturer. This new GF filter had a metal mesh downstream of the filter material. Two different grades of the filter were used; b15 ^{3}200 and b41 ^{3} 200, both of these coarser than the antistatic filter tested previously, b3 ^{3} 200, per ISO 16889. Earlier experience indicated that the coarser filters should give substantially lower charging values. Testing showed that even these coarser filters, with a metal mesh, charged to high values. The measured voltage differences between the fine and coarse media showed a reduction in the values, where the finer filter were of similar level to the coarser filter, which still exhibited sparking.

Findings

As a result of this investigation, the following conclusions can be drawn:

1. Electrostatic charge may be a problem in the filtration industry due to the potential for discharging whenever hydrocarbon oils or other nonconductive fluids pass by nonconductive filtration material.
2. Using grounded filter housings and pipelines is a preventive safety measure that can reduce external discharging. It does not stop fluid charge generation or internal damage to the filter or other system components caused by sparking.
3. Experimental analysis of electrostatic charging in GF-based material filtration with different types of lubrication oil suggests the following:
   - All standard GF filters exhibit electrostatic charging characteristics, regardless of the manufacturer.
   - Mineral oils generate positive charge on the filtration materials while a negative charge is carried downstream by the oil. Synthetic oils show the opposite: negative charge on the filtration material and positive charge in the downstream oil.
   - The filter materials that show a higher charge generation in the isolated system also show higher charge and material damage in the practical filtration system with grounded filter housing and pipelines.
4. The antistatic filter was developed to eliminate potential electrostatic charge problems in filtration of hydrocarbon fluids by preventing or significantly reducing charge generation and its accumulation. With the antistatic filter, even low-conductivity fluid caused no material damage, and the charge measured in the downstream fluid was lower than the charge generated through filtration with standard GF materials. Field trials suggested successful performance of the antistatic filter material and correlated well to the laboratory tests.

Related Reading

Bensch, L. and Day, M. "Electrostatic Charge Generation in Hydraulic and Lubrication Systems." *Practicing Oil Analysis magazine*, November-December 2005.

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