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A case study on the advantages of metal fiber media for aircraft hydraulic filtration

CONTENT

WHITE PAPER

A case study on the advantages of metal fiber media for aircraft hydraulic filtration

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Metal fibers – fiber material with a diameter range of 1 to 100 microns – exist in many forms, alloys and sizes. Metal fiber structures and products display excellent porosity, electrical, thermal, corrosion and mechanical properties. Each of these properties makes them suitable for a wide range of specific industrial applications, including filtration, heat-resistant textiles and conductive plastics. This white paper focuses on the use of metal fibers in aircraft hydraulic fluid filtration systems.

AVIATION HYDRAULIC FLUID FILTER MEDIA

Hydraulic systems are the driving force for many aircraft components. Any malfunction can be catastrophic. Moreover, replacing components is extremely expensive. It is therefore critical to keep these systems clean and in perfect working order.

To remove contaminants from the hydraulic fluid, in-line filters are necessary. In aircraft hydraulic systems, filtration of the hydraulic oil is traditionally performed by filtration media based on glass fiber or cellulose fiber.
However, due to the poor durability and lack of integrity of these traditional filter media, hydraulic systems suffer significant maintenance problems associated with excessive wear and tear, which leads to unnecessary expense for the aircraft operator and potential operational safety risks.

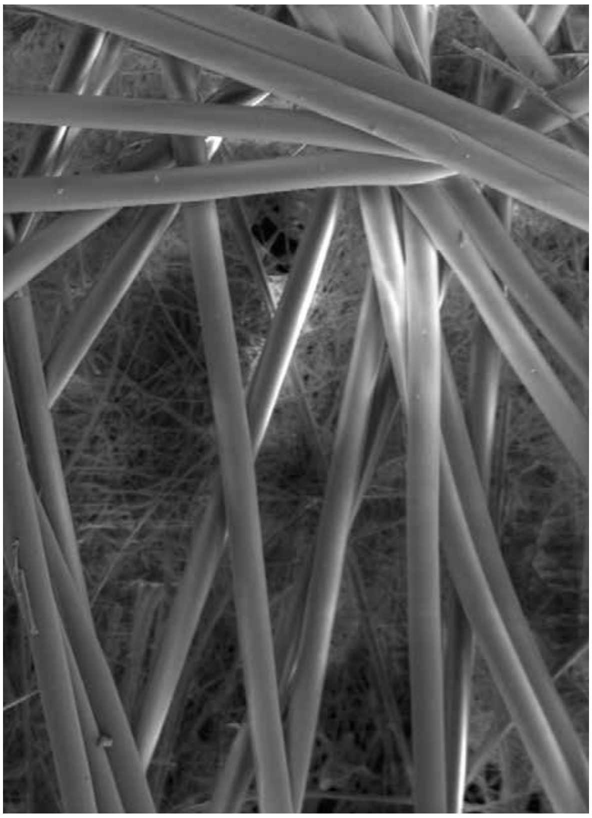
REASONS FOR CONTAMINATION IN TRADITIONAL HYDRAULIC FLUID FILTER MEDIA

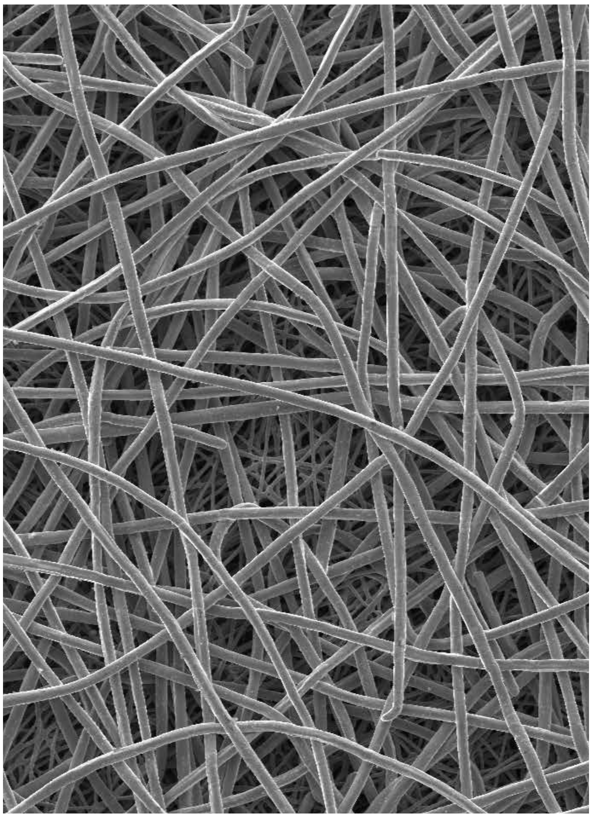
Continually high levels of contamination of their aircraft hydraulic systems was costing the US government millions of dollars in downtime, repair and overhaul costs, and leading to the risk of impaired safety. They therefore embarked on a project to discover what was causing this contamination.

Several US aircraft operators were using traditional cellulose fiber and glass fiber based filter elements. The conditions of the filter housing were measured

This is a close-up of particulate material in hydraulic fluid from a glass fiber filter. The smallest particle is 20µm while aircraft hydraulic systems require absolute filter ratings of 5µm.

ref: US AED


Microscopic picture of glass fiber filter media.


Microscopic picture of metal fiber filter media.

during flight, and then recreated in an aerospace laboratory. The key observation was that dynamic conditions (flow change, vibration, pump ripple) were causing the release of the trapped contaminants from the filter material back into the hydraulic fluid.

The reason is that glass fiber media is held together by binders; a structurally weak point of the fiber media. The fluctuations of fluid flow, and the vibrations in the aircraft hydraulic systems, cause the glass fiber media to shed fibers and binder material. These contaminants are then released into the hydraulic fluid, with unfortunate consequences.

ADVANTAGES OF METAL FIBERS COMPARED TO TRADITIONAL GLASS FIBERS

Using metal fibers instead of traditional glass fibers as filtration media leads to several advantages. Specifically, improvements in both mechanical and electrical properties leads to the following areas of improved filtration performance:

- Metal fiber filters consist solely of metal. No binder is used in this media, as the metal fibers stick together with sintered bonds. This results in a strong and fixed structure. As there is no binder, there is no deterioration of filter performance caused by degradation, which occurs with glass fiber and cellulose fiber based media.
- No particle shedding occurs while in use. In traditional glass fiber filters, fiber shedding can actively contaminate the oil in the hydraulic system, leading to premature replacement of the oil and filtration system, and of all hydraulic parts affected by the filter degradation.
- Replacing glass fibers by metal fibers significantly improves fluid cleanliness levels.

- The metal fiber filter media performs extremely well in the dissipation of static charges, decreasing the risk of explosion, oil degradation and general damage to the aircraft.

The combined effect of all these advantages leads to significantly reduced maintenance cost of the hydraulic system.

COMPARISON OF PROPERTIES OF TRADITIONAL GLASS FIBERS AND METAL FIBERS

From Figure 1, it can be observed that, when comparing porosity, flow rates, pressure drop, dirt holding capacity, corrosion resistance and pleatability, performance of both metal fiber and glass fiber is about equally good.

However, for the same performance, metal fiber material has a much higher temperature resistance, shows much better shock, pulse and vibration integrity in dynamic conditions, does not involve a binder, is mechanically stronger, and shows better dissipation of static electricity.

Figures 2 and 3 show the relation between glass fiber filter media and metal fiber filter media (Bekaert's Bekipor®) in five different dynamic test methods. One can clearly see that, regardless of the test method, the particle size of the contaminant is significantly smaller, resulting in a higher level of cleanliness.

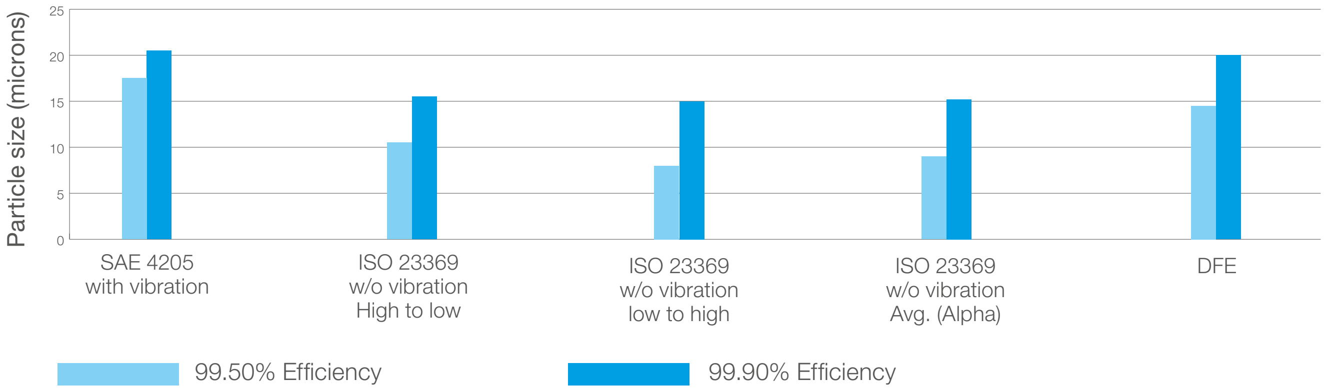
Media Comparison	Sintered Metal Fiber	Glass Fiber
Porosity	50 - 90%	50 - 90%
Flow rate liquid	●●●	●●●
Low pressure drop	●●●	●●●
High dirt holding capacity	●●●	●●●
Thickness	0.18 - 2.0 mm	0.3 - 1.0 mm
Maximum temperature resistance	To 1000° C	180° C
Corrosion Resistance	●●●	●●●
Shock, pulse and vibration integrity	●●●	●○○
Mechanical strenght	●●●	●○○
Pleatability	●●●	●●●
Static dissipation	●●●	●○○

Figure 1. Comparison of key properties of two types of fiber used in aviation hydraulic filter media.

Glass fiber media

ref: US AED

Particle size results, comparison per test method



Tables per NAS 1638 Cleanliness class 00 tot 12

US UH-60 Blackhawk helicopter contamination level with glass fiber media filter elements

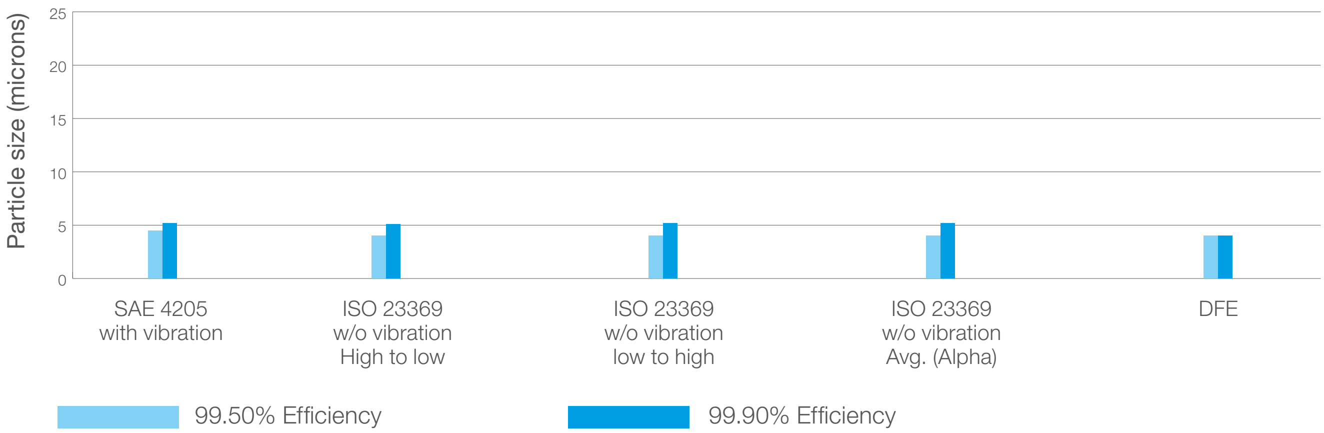
Particle size um	00	0	1	2	3	4	5	6	7	8	9	10	11	12
5-15	125	250	500	1000	2000	4000	8000	16000	32000	64000	128000	256000	512000	1024000
15-25	22	44	89	178	356	712	1425	2850	5700	11400	22800	45600	91200	182400
25-50	4	8	16	32	63	126	253	506	1012	2025	4050	8100	16200	32400
50-100	1	2	3	6	11	22	45	90	180	360	720	1440	2880	5760
Over 100	0	0	1	1	2	4	8	16	32	64	128	256	512	1024

Figure 2. Particle size of glass fiber media under five different dynamic test methods.

Bekipor® Metal fiber media

ref: US AED

Particle size results, comparison per test method



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50-100	1	2	3	6	11	22	45	90	180	360	720	1440	2880	5760
Over 100	0	0	1	1	2	4	8	16	32	64	128	256	512	1024

Figure 3. Particle size of Bekipor® metal fiber media under five different dynamic test methods.

USE CASE:
IMPROVE RELIABILITY AND SAVE COST IN HELICOPTER FLEET

After discovering the inherent problems with traditional glass fiber filters, a US based operator of helicopters looked into the possibility of using metal fiber-based filter media for their hydraulic fluid filtration systems.

A comparison of the performance of legacy glass fiber filters and metal fiber filters was therefore carried out on 120 helicopters of the fleet, flown for 36,000 hours.

Figure 4 shows that the number of filter failures reduced tenfold when metal fiber media was used. This is because the metal fibers are much stronger than glass fibers, and retain the trapped contaminant until the element is replaced.

Figure 5 shows that a significant increase in Mean Time Between Failure was also observed. This is a logical consequence of the reduced number of failures.

Legacy filters vs metal fiber filters

ref: US AED

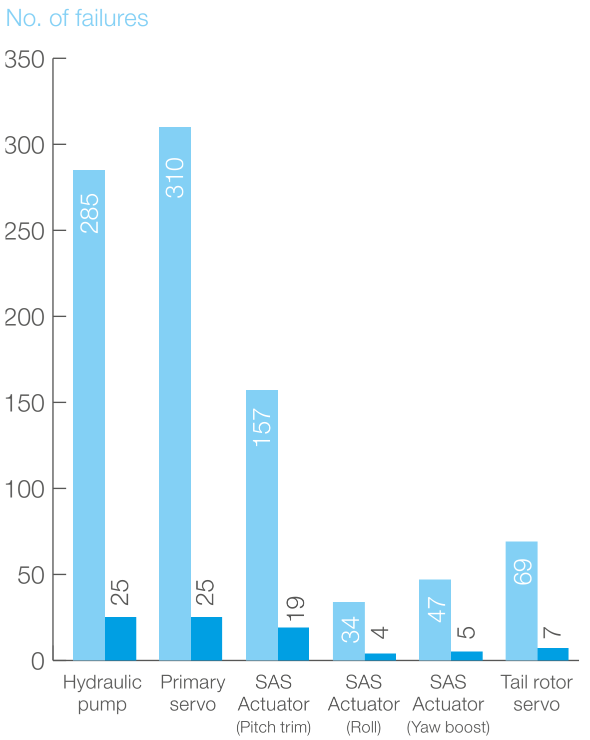

Figure 4. Comparison of the number of component failures of glass fiber vs. metal fiber filters.

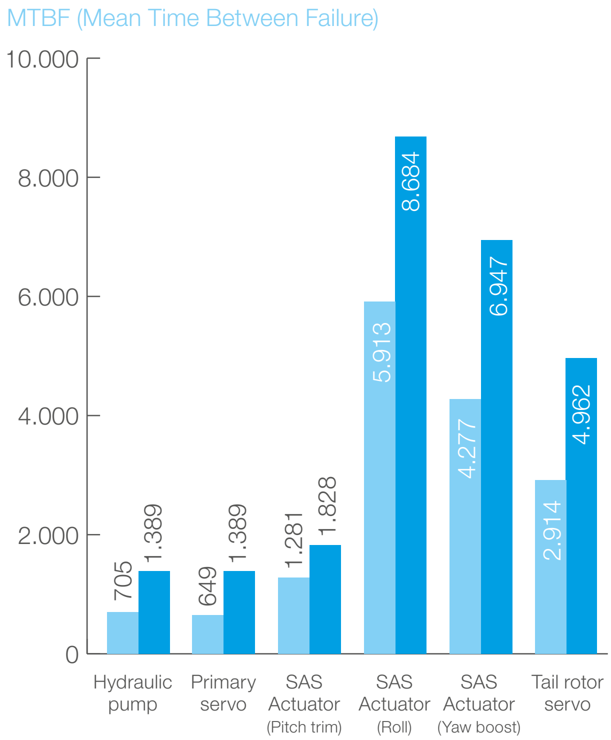

Figure 5. Comparison of the Mean Time Between Component Failure of glass fiber vs. metal fiber filters.

Legacy filters   Bekipor® metal fiber filters

In Figure 6 it's clear that a major cost saving (over 4 million USD per 100 flight hours) can be achieved through the use of metal fiber filter media rather than glass fiber.

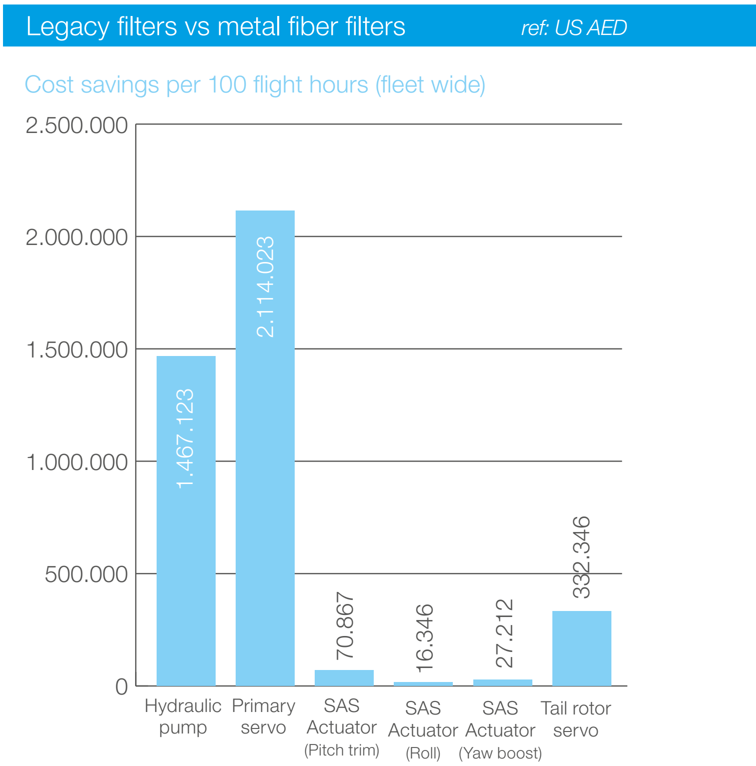

Figure 6. Cost savings achieved through the use of metal fiber filter media.

CONCLUSION

Hydraulic fluid filtration systems based on metal fibers display a significantly improved performance and durability along with reduced operating costs compared to traditional glass fiber and cellulose fiber media. They show increased mechanical strength and electrical dissipation, reduced particle shedding, and improved cleanliness levels of the hydraulic fluid.

Tests have demonstrated that metal fiber filters, can reduce failures in hydraulic components tenfold, with a corresponding doubling of the Mean Time Between Failure, which lowers the risk of fatal accidents and significantly reduces maintenance and repair costs for fleet operators.

For these reasons, metal fiber media are being increasingly used for aviation hydraulic fluid filtration systems instead of traditional glass fiber media. One such product is Bekaert's Bekipor® metal fiber, which maintains its efficiency and integrity of structure throughout its lifetime thanks to strong, sintered bonds, and its high resistance to shock, vibration and pulsing flows. It is proven in Dynamic Filtration Efficiency Testing (DFE) and operational trials.

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is Technology Manager at Bekaert Fiber Technologies. His Global R&D team focusses on metal fibers for Filtration, Conductive plastics and Business Development opportunities. Before starting his career with Bekaert, Mr. De Baerdemaeker worked as R&D Team leader at the Ghent University where he also graduated as Ph.D. Physics. He also worked as Post-Doctoral Fellow at the Center for Materials Research at Washington State University.

Aurélie Goux
Aurélie is Global Product Development Manager at Bekaert. Her field of expertise is metal fiber media development for filtration applications. Ms. Goux has a Ph.D. in chemistry from the University Pierre and Marie Curie in Paris, France. Previously, she worked as a post-doctoral fellow at the Leibniz Institute for Solid State and Materials Research at Dresden, Germany and at the University Henri Poincaré in Nancy, France. Before she joined Bekaert in 2011, Aurélie worked as a R&D consultant at TMC Chemical in Eindhoven, The Netherlands.

Paul Hulme
Paul is Market Manager Filtration Products at Bekaert and is active in the North American market. His focus is mainly on aerospace polymer & semiconductor industries. He is also involved in new market identification and development. Mr. Hulme holds a degree in Mechanical Engineering and is a graduate from the Chartered Institute of Marketing. He has worked as an aerospace engineer and has over 20 years of sales and marketing experience in Europe and North America.

Jeffrey Mothersbaugh
Jeffrey is Sales and Applications Engineer in Aerospace Hydraulics at Bekaert. He holds a B.S. degree in Mechanical Engineering from Youngstown State University and has worked in aerospace filtration both as a Filter Designer as well as in Technical Sales for over 30 years. Jeffrey is a retired LCDR from the US Navy with 24 years of service as an Intelligence Officer and earned the Naval Achievement Award three times and the Naval Commendation Medal. He is currently the Chairman of the SAE A6C-1 Aerospace Filtration and Contamination Panel.

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Bekaert is a world market and technology leader in steel wire transformation and coating technologies. To be the preferred supplier of steel wire products and solutions, we consistently deliver superior value to our customers worldwide.
Bekaert (Euronext Brussels: BEKB) was established in 1880 and is a global company with approximately 30 000 employees worldwide.

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