

Chemical and Thermal Stability of Non-Woven Liquid Filtration Media

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Abstract

There are a wide range of industries that use non-woven media for liquid filtration applications. They range from food and beverage, biological material, potable water, hydraulic oils, fuels, solvents, acids and bases. Each application is run at different pressures, temperatures and chemical concentrations.

Nonwoven liquid filtration media can be characterized as thermally or resin bonded. In both types of bonded media, the polymers used are susceptible to thermal and chemical attack and can swell, fracture and/or soften. The physical attack to the polymer structure can change the filtration performance. This change in can be gradual or sudden based on the concentration, exposure time, temperature and additives.

The majority of resin bonded media utilize thermoplastic materials which do not have broad chemical resistance and flow when heated. Thermoset binders are used in applications that require higher thermal and chemical resistance. Thermosetting polymers must undergo a chemical change to produce a network or thermoset polymer. They can not be dissolved or continuously deformed because they tend to decompose at a lower concentrations and temperatures. This paper will evaluate the chemical and thermal stability of resin bonded media when exposed to a range of hydraulic fluids.

Keywords: Liquid Filtration, Nonwoven Media, Chemical Resistance, Thermal Stability

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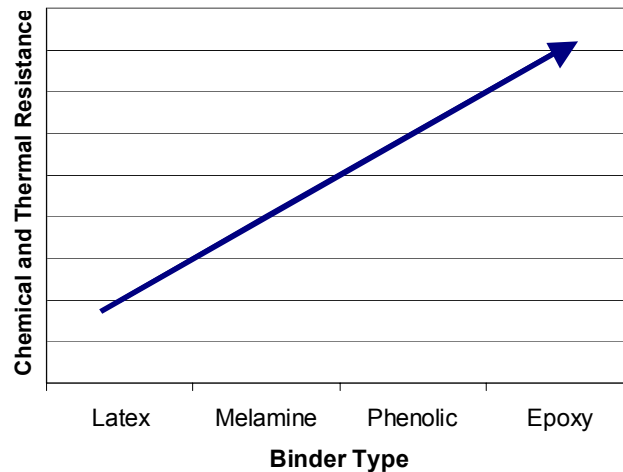
Nonwoven media are used in many different industries and applications with each having a wide range of operating conditions. Nonwoven liquid filtration media are thermally or resin bonded and use polymers that are susceptible to thermal and chemical attack. The polymers can swell, fracture and/or soften which may change the filtration performance. The change in filtration performance can be gradual or sudden based on the concentration, exposure time, temperature and additives.

Thermoplastic binders used in resin bonded systems are often generically called latex but there are many different types with a range of chemical and thermal resistances. In general thermoplastic binders are good film formers and flow and are good at coating fibers or webs. They are flexible but soften when exposed to heat, which can be an advantageous or a disadvantage depending on the application. Many thermoplastic binders add crosslinking polymers to improve their chemical and thermal stability. When thermoplastic resins are crosslinked they may have a crosslinking bond every 50 to 100 carbon molecules.

Thermoset binders are used in applications that require higher thermal and chemical resistance. These polymers undergo a chemical change to produce a network or thermoset polymer. Thermoset binders are highly crosslinked, which produces a glassy or crystalline structure with no T_g. Thermosets will not soften or flow in the presence of heat. They can not be dissolved or continuously deformed because they will begin to decompose at lower concentrations and temperatures.

Wetlaid media are generally produced on a paper machine with cellulose, synthetic or glass fibers. They typically contain latex type binders which do not have broad chemical and thermal compatibility. Applications that require improved chemical compatibility use thermoset binders such as phenolics, melamines or epoxies. Phenolic binders are generally added in a post coat and cure step. The biggest downside to phenolic binders is flammability and waste disposal. Melamine and epoxy based binder systems can be applied in-line on a wetlaid process but are generally more costly than phenolics. Figure 1 shows the relative chemical and thermal compatibility of various wetlaid binders.

Figure 1



Resin bonded microglass media are used in a number of industries that utilize aggressive temperatures and chemicals including; biopharmaceutical, coalescing, automotive and fluid power. Biopharmaceutical fermentation processes require sterile air and liquids to be feed into the bioreactor. These filters are generally steam sterilized to ensure sterility which can be a problem for many filters that contain thermoplastic components. The fermentation by products are removed from the process stream during a series of clarification and purification steps. The final product is sterile filtered and those filters must also be sterilized. Coalescing applications, such as, water removal from diesel or aviation fuels and oil removal from air in a compressed gas stream utilize fluids and temperatures that can cause swelling and weakening of filter media with thermoplastic components. Swelling will increase the pressure drop of filter, which combined with a weakened structure will cause loss of efficiency and potential premature failure.

There are many fluids used in hydraulic systems but they can be broken down into three categories; petroleum based oils, fire resistant fluids and biodegradable fluids. Petroleum based fluids are the most common. They are widely used due to their low cost, good lubricity and low toxicity. They are not generally used straight but are combined with corrosion, rust, foaming and wear inhibiting agents. There are generally two different types of fire resistant hydraulic fluids: phosphate esters and fluids with a high water content.

Phosphate esters are widely used in aerospace applications due to their good fire resistance and their ability to work over a wide range of temperatures. Phosphate esters are aggressive fluids that attack many polymers. High water based fluids come in three different types: oil in water emulsions, water in oil emulsions and water glycol. The oil in water emulsions typically contain 95% water and 5% oil with oil droplets dispersed throughout the water. The water in oil emulsions are between 40% and 60% water dispersed in oil. Due to their high oil content the fire resistance of these fluids is lower than the other types. Water glycol fluids typically contain 40% water and 60% glycol. This fluid is widely used since it has excellent fire resistance and can be used at lower temperatures because of the antifreeze properties of the glycol.

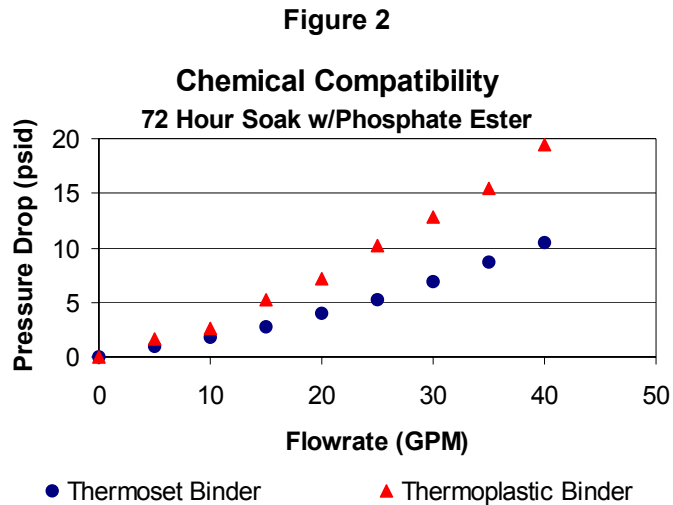
Biodegradable fluids are increasing in use, especially in Europe, due to concerns about the environmental impact of leaks and spills. The two most widely used biodegradable hydraulic fluids used are synthetic based diesters and vegetable based oils.

Chemical and Thermal Compatibility

A microfiberglass based wetlaid nonwoven filter media that is typically used in hydraulic filtration applications was tested for compatibility with different hydraulic fluids according to ISO 2943. A brief overview of the test method is listed below.

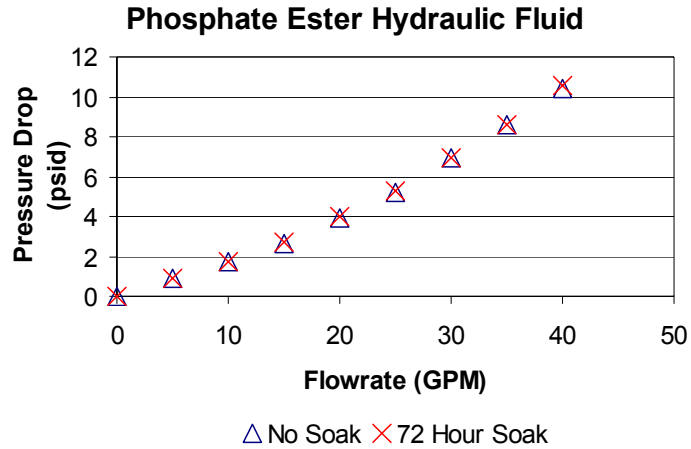
The filter is tested for fabrication integrity and failure of the element to exhibit a minimum bubble point, which is designated by the manufacturer, will eliminate that unit from testing. The element is rinsed in the test fluid to remove any previous test fluid. The filter is immersed in the desired test fluid for at least 72 hours. The immersion should be continuous and at a temperature at least 15C above the highest recommended operating temperature. The elevated temperature is used to accelerate a long life test at standard operating temperatures.

Six filters were produced with microfiberglass based hydraulic filter media. Three of the filters contained media that used a thermoplastic binder system and three filters contained media with a thermoset binder. All six filters were soaked in phosphate ester at elevated temperatures for 72 hours and tested. Figure 2 is a plot of the pressure drop over a wide range of flowrates.



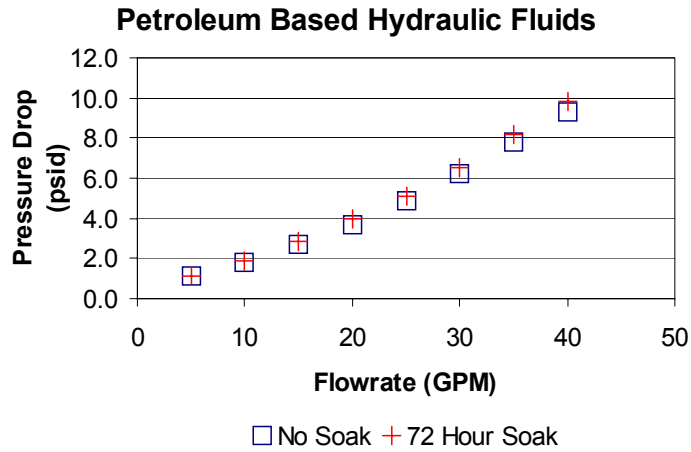
The thermoplastic binder exhibited on average an eighty-one percent higher pressure drop compared to the thermoset binder. Three additional filters with the same thermoset binder were tested using phosphate ester based hydraulic fluid but were not presoaked in the fluid at elevated temperature. Figure 3 compares the pressure drop of the filters at long and short exposure times.

Figure 3



The average increase in pressure drop between the two sets of filters was 1.2%. That compares to a 5.1% increase in average pressure drop for filters soaked in a standard petroleum based hydraulic fluid at elevated temperature and filters with a short exposure during the test. Figure 4 compares the pressure drop increase of the two sets of filters with a standard petroleum based hydraulic fluid.

Figure 4



Water glycol based hydraulic fluids also present a compatibility problem with many types of media. A set of filters with the same thermoset binder was tested for pressure drop increase with and without prolonged exposure to a water glycol based hydraulic fluid. The average increase in pressure drop between the two sets of filters was three percent. Figure 5 is a plot of the average pressure drop increase over a range of flowrates with the water glycol based hydraulic fluid.

Figure 5

Water/Glycol Hydraulic Fluid

