

A L K A L I N E C L E A N E R



R E C Y C L I N G H A N D B O O K



OSMONICS
Filtration and Separations Group

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INTRODUCTION TO ALKALINE CLEANING

Aqueous based, alkaline cleaning processes are emerging as the dominant method for parts cleaning and degreasing in the metal working industry. Such cleaning agents are reported to produce surfaces as clean or cleaner than solvent degreasing since they do not leave behind residual soils, a common problem with solvent degreasing. Alkaline cleaners also are becoming more popular because the environmentally unfriendly solvents (e.g. trichloroethylene, methylene chloride), used widely for vapor degreasing, are legislated out of use. In addition, alkaline cleaners are considered safer to use and are environmentally more acceptable than solvent degreasers.

Alkaline cleaners are very effective for removing unpigmented oils, greases and cutting or grinding fluids from metal parts in both immersion and spray washer cleaning systems. They are moderately effective for removing soils containing pigmented drawing compounds such as zinc oxide, flour, graphite and stearates.

This handbook is designed to explain the fundamentals of aqueous cleaning and to help users improve cleaning quality and consistency while saving money through recycling.

FUNDAMENTALS OF ALKALINE CLEANING

What are the typical components of commercial alkaline cleaners?

Most commercial alkaline cleaners are formulated by mixing three major components in various ratios: 1) alkalinity builders, 2) organic or inorganic additives and 3) surfactants (e.g., detergents).

How do alkaline cleaners work?

Alkaline cleaners employ both chemical and physical cleaning mechanisms. The cleaner's chemical action, a function of its alkalinity, saponifies (hydrolyze's) certain soils such as animal/vegetable oils (e.g., fats) to produce water soluble soaps. The cleaner's physical action (a function of the surfactant used in the cleaner formulation) reduces the surface tension of the soils thereby emulsifying and lifting them away from the object. (See Figure1)

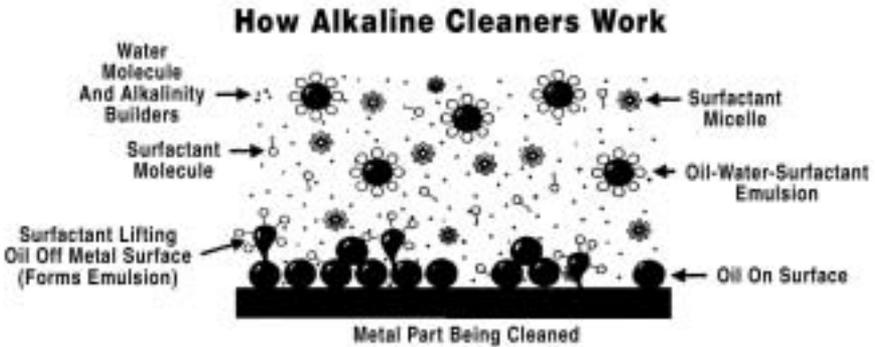


Figure 1

The surfactant molecules dissolved in the water are found both in free and aggregate forms. The surfactant aggregates are called micelles. The ratio of free surfactants to surfactant micelles mainly depends upon the type of surfactant, the surfactant concentration and the solution temperature. If the aqueous surfactant mixture is turbid (cloudy), there is a significant level of large micelle formation. Such solutions can be cloudy at room temperature or can become cloudy at elevated temperatures. If a surfactant mixture is cloudy at room temperature, the surfactant level is above its Critical Micelle Concentration (CMC). If a surfactant solution is clear at room temperature and becomes cloudy at an elevated temperature, the solution has reached its designed Cloud Point. Often, cleaners are used at temperatures near their Cloud Point to minimize foaming and to increase cleaner activity.

What roles do alkalinity builders play in the cleaning process?

The most common alkalinity "builders" include sodium metasilicate, sodium or potassium hydroxide, sodium bicarbonate and different forms of sodium phosphate. Such builder

FUNDAMENTALS OF ALKALINE CLEANING

increase the alkalinity (pH) of the cleaner helping to penetrate oil and soil deposits on the part being cleaned and also to hydrolyze animal/vegetable oils. Some builders act as buffers to maintain alkalinity at steady state levels (e.g., sodium bicarbonate and sodium phosphate).

Additionally, Sodium metasilicate and sodium phosphate are used to protect certain metals (e.g. aluminum, brass, bronze, iron) from the corrosive action of alkali salts as the part is being cleaned by binding to the etched ionic surface of the metal.

What other types of additives are used in cleaner formulations?

Typical additives include rust inhibitors, antifoams and chelating agents (e.g. sodium gluconate, sodium citrate and tetrasodium ethylenediamine tetracetate (EDTA)). The main purpose of the chelating agents is to reduce the effect of water hardness by binding metal ions such as Ca, Fe, Al, Mg and Cu.

What types of surfactants are used in cleaner formulations?

Surfactants are used to lift and emulsify oils and soils from the parts being cleaned. They comprise the bulk composition of most alkaline cleaners. Typically, anionic (negatively charged) and nonionic (neutral) surfactants are used in formulations for immersion cleaning baths. Nonionic surfactants and Amphoteric (Zwitterionic; either positively or negatively charged) surfactants are used in formulations for spray cleaners given their low foaming characteristics. Cationic (positively charged) surfactants are rarely used due to high relative costs.

RECYCLING ALKALINE CLEANERS BY MEMBRANE FILTRATION

What are the limitations of current alkaline wash processes?

Unlike vapor degreasing methods, which by their very operation recycle clean active solvent, the typical alkaline cleaning process is a batch operation. As such, oils and soils accumulate in the cleaner holding tank and interfere progressively with the ability of the cleaner to work effectively. Since the cleaning capacity will be exhausted by accumulated oils and soils long before all alkalinity builders and surfactants are consumed, the batch cleaning process results in both high cleaner replacement costs and excessive oily waste disposal costs.

The disposal problem also applies to “biodegradable” cleaners, since contamination by waste oils prohibits discharge to the drain.

More importantly, the quality of the cleaning operation is not consistent from the beginning to the end of the batch cleaning cycle. Ultimately, this variability in cleaning can have significant impact on part cleanliness, overall quality and corresponding part rework costs.

RECYCLING ALKALINE CLEANERS BY MEMBRANE FILTRATION

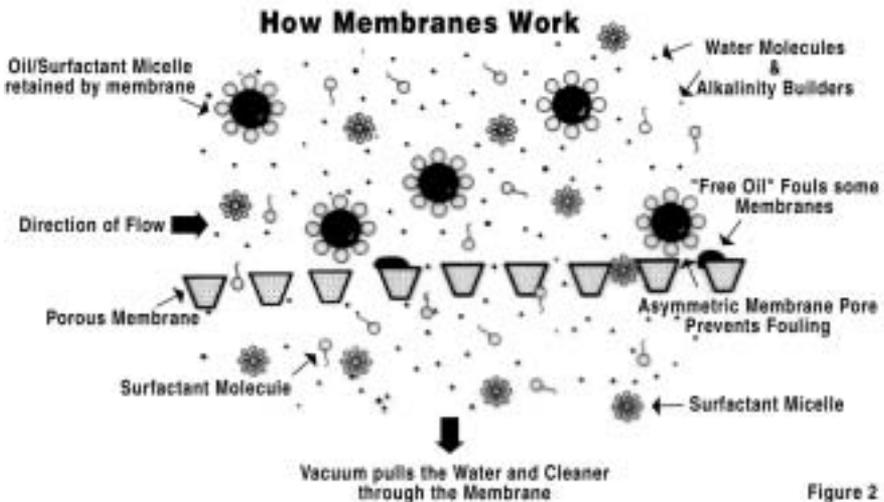
What are the advantages of aqueous cleaner recycle by ultrafiltration via a membrane?

The ability to recycle aqueous cleaners using ultrafiltration has many benefits to the parts washing process, including:

- Greatly improved cleaning quality and consistency leading to lower part rework costs
- Net cost savings through waste minimization and reduced labor
- Lower operating costs by significantly reducing cleaner usage rate
- Higher quality surface treatments (especially important for electroplating and painting)

How does a membrane filter work?

Figure 2 illustrates how a membrane filter works to recycle alkaline cleaners. Essentially, the membrane acts as a barrier to the free floating and emulsified oil phases, but passes the free surfactants, alkalinity builders and water through its pores.



How does a membrane filtration system work?

Membrane filters are packaged into a variety of cartridge configurations and are integrated into process systems as shown in Figure 3. The feed solution is pumped through the filter cartridge and is split into two streams: 1) permeate or filtrate (fluid passing through the membrane), and 2) retentate (fluid retained by the membrane). The permeate stream, which is now free of oils and suspended solids, is recycled back to the parts washer. The recirculation of the retentate stream, which is kept in or recycled back to the process or

RECYCLING ALKALINE CLEANERS BY MEMBRANE FILTRATION

working tank serves to keep solids in the feed from depositing on the membrane surface. The function of this constant flow across the filter surface is critical to sustaining stable output rates from the system.

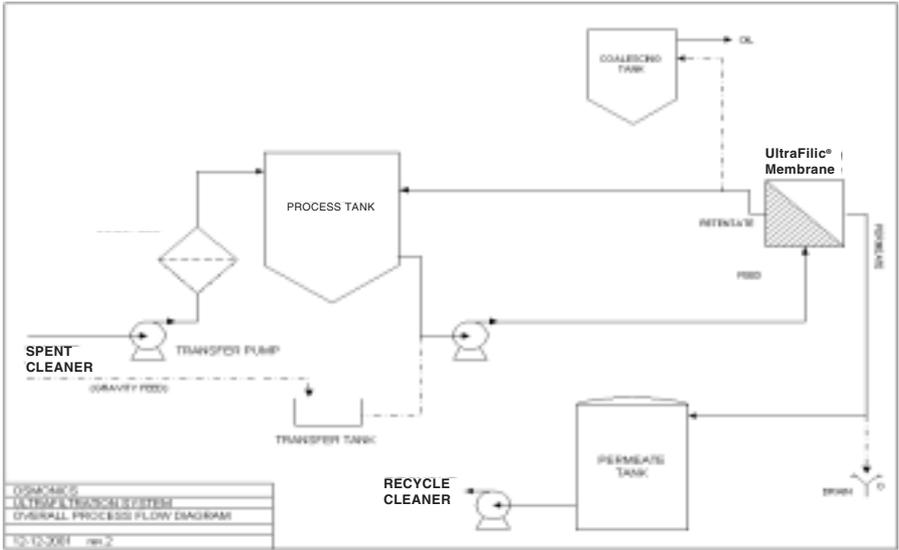


Figure 3

What oil levels can I expect to maintain in my parts washer?

Since the ultrafiltration system is designed to continuously remove the oil and soil from the parts washer sump and continuously recycle regenerated cleaner to the washer sump, steady state oil levels are maintained at low levels in the parts washer. By performing a mass balance on the oil levels within the parts washer, time-dependent oil concentration profiles can be obtained. According to this analysis as shown in Figure 4, low steady state oil levels can be maintained by filtering as little as half the washer volume per day. This indicates that relatively small, economical filtration systems can be used for recycling while providing excellent value and washer performance.

The actual oil level maintained in the washer will be a function of the filtration system's output, parts washer dump frequency, and the amount of oil transferred into the tank on a daily basis. The following equation is used to size the filtration system with the objective of maintaining a working oil level in the parts washer at 20% of its peak oil level.

$$\text{Filtration System Capacity} \frac{\text{(Gallons or liters)}}{\text{Day}} = \frac{5 \times \text{Parts Washer Volume (Gallons or liters)}}{\text{Parts Washer Dump Frequency (Days)}}$$

RECYCLING ALKALINE CLEANERS BY MEMBRANE FILTRATION

■ No Filtration vs. Continuous Filtration

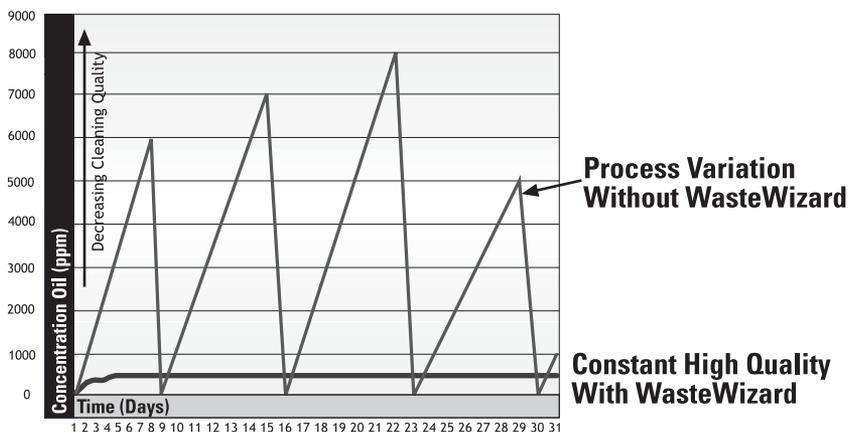


Figure 4

How much money can I save by recycling my alkaline cleaner?

As a sample cost calculation, let's assume that a given washer is operated at a detergent concentration of 5-v/v%; disposed of every 2 weeks; and operated 50 weeks per year. Assuming a typical cleaner cost at \$10 per gallon (0.004 m3d) of concentrate and a waste disposal cost of \$1 per gallon (0.004 m3d) of waste, the yearly operating cost for this washer is \$36 per gallon (0.004 m3d) of washer sump capacity per year. For a 300-gallon (1.14 m³) washer the net operational expenses would approach \$12,000 (the costs of capital excluded). By recycling this cleaner, the annual operating costs could be reduced to less than \$1,000 while improving overall cleaning quality and consistency. Similarly, the annual savings generated by recycling a 5,000-gallon (19 m³) washer could exceed \$200,000.

Will the recycle process affect the quality of parts cleaning operation?

Recycle systems allow part washers to operate at low steady state oil levels resulting in parts which are cleaned consistently to higher levels. Consequently, secondary surface finish operations (e.g. painting, electroplating, etc.) produce higher quality parts together with lower rework rates. These benefits can result in even greater cost savings than those realized by minimizing cleaner usage and disposal volumes.

Since numerous cleaners exist in the market, each differing in composition and complexity, developing a process to recycle an aqueous cleaner is challenging. Defining a recycling approach can be simplified, however, by first understanding the fundamentals of the aqueous cleaning process.

TEST METHODS USED TO VALIDATE CLEANER RECYCLABILITY

What tests are used for determining cleaner activity?

A number of tests are used to judge cleaner activity. Such tests include pH titration to measure free and total alkalinity, conductivity, refractometry, extraction and titration to measure surfactants, chemical oxygen demand (COD) analysis to measure the organic concentration level, liquid chromatography and Fourier Transform Infrared Spectroscopy (FTIR) to qualitatively ‘finger print’ the broad chemical composition of a cleaner. The tests in Table 1 are used routinely to assay for cleaner activity.

What is the best method for determining if a cleaner is recyclable?

Osmonics has developed a procedure to determine rapidly the recyclability potential of alkaline cleaners. The tests are performed on virgin cleaner. Major aspects of the test are as follows:

- Determine if the cleaner solution turns cloudy or forms large micelles (i.e. do the surfactants self-aggregate and form particles large enough to scatter light) at its use concentration.
- Determine if the cleaner solution is above its Cloud Point (i.e., turns cloudy) at its use temperature.
- Filter the cleaner solution **10 times** at temperatures above and below the solution’s Cloud Point.
- Quantify Alkalinity Transmission (Free and Total Alkalinity analysis).
- Quantify Surfactant Transmission (COD) analysis. If Surfactant Transmission is greater than 75%, the cleaner is recyclable.

Ultimately, judgment of the recycled cleaner’s integrity is based on its ability to adequately clean soiled object.

TEST METHODS USED TO VALIDATE CLEANER RECYCLABILITY

Table 1

TEST	DEFINITION
<p>Surfactant Titration:</p> <p>Comments:</p>	<p>Measurement of active Surfactant in Feed</p> <p>The total amount of surfactant is determined by an extraction/titration method. In general, each surfactant requires a special extraction/titration method. Therefore, accurate measurement of mixed surfactant with a single test is unreliable.</p>
<p>Free Alkalinity:</p> <p>Comments:</p>	<p>Measurement of free, unreacted alkalinity builder in the Alkaline Cleaner.</p> <p>Used routinely to titrate cleaner activity, but does not measure surfactant levels, Is an inaccurate method to determine cleaner activity if dominant cleaning mechanism is surfactant removal of oil but not alkaline hydrolysis of oil.</p>
<p>Total Alkalinity:</p> <p>Comments:</p>	<p>Measurement of free alkalinity plus the alkalinity consumed in the process i.e., alkalinity builders lost to:</p> <ol style="list-style-type: none"> 1. Sludge formation with water hardness and dissolved metal ions. 2. Hydrolysis of animal or vegetable based oils. <p>Used routinely to titrate total cleaner consumed, but does not measure surfactant levels. Is an inaccurate method to determine cleaner activity if dominant cleaning mechanism is surfactant removal of oil but not alkaline hydrolysis of oil.</p>
<p>Conductivity:</p> <p>Comments:</p>	<p>Measurement of the total ionic content in a feed (i.e., sodium metasilicate & other salts)</p> <p>Does not measure surfactant activity or distinguish effectively between free and total alkalinity.</p>
<p>Refractometry:</p> <p>Comments:</p>	<p>Indirectly measures concentration of dissolved components, which influence the refractive index of sample.</p> <p>Can be used sometimes to monitor surfactant levels in a feed sample. Caution: Analysis accuracy is strongly influenced by presence of suspended solids, which refract light and are removed by filtration.</p>

TEST METHODS USED TO VALIDATE CLEANER RECYCLABILITY

Table 1 (cont.)

TEST	DEFINITION
<p>FTIR:</p> <p>Comments:</p>	<p>Measures presence of all surfactant in sample using Infrared Spectroscopy.</p> <p>Finger prints presence of all organic components in a sample. Semi-quantitative.</p>
<p>HPLC:</p> <p>Comments:</p>	<p>Separates all surfactants in sample using various chromatographic techniques.</p> <p>Is difficult to measure concentrations quantitatively, but can be highly accurate. Good resolution of all components in sample requires extensive methods development.</p>
<p>Biological Oxygen Demand (BOD):</p> <p>Comments:</p>	<p>Measurement of the Biodegradable Organics present in a sample.</p> <p>Is very dependent on the sample preparation and yields information on the biodegradable portion of the sample.</p>
<p>Total Organic Carbon (TOC):</p> <p>Comments:</p>	<p>Measurement of total organic content in a sample (includes surfactant and oil in contaminated samples).</p> <p>Is a good generic method to measure total surfactant concentration in permeate. Will be slightly skewed due to the presence of small quantities of dissolved oils. Is a good method to examine surfactant transmission (post filtration) of a virgin cleaner sample since no oils are present to interfere with analysis.</p>
<p>Chemical Oxygen Demand (COD):</p> <p>Comments:</p>	<p>Measurement of organic and certain metal content in a sample (includes surfactant and oil in contaminated samples).</p> <p>Is a good generic method to measure total surfactant concentration in permeate. Will be slightly skewed due to the presence of small quantities of dissolved oils. Is a good method to examine surfactant transmission (post filtration) of a virgin cleaner sample since no oils are present to interfere with the analysis.</p>

SUPERIOR TECHNOLOGY AND PROCESS KNOW-HOW

The Osmonics Advantage

The development of a successful recycle strategy is a complex exercise requiring a thorough understanding of cleaner chemistry, water chemistry, cleaning processes, and the fundamentals of membrane filtration and system design.

Osmonics combines this key expertise through extensive experience and testing and is considered to be the leader in marketing turnkey systems for recycling aqueous cleaners.

Osmonics offers to its customers:

A full line of automated, easy-to-use systems and state of the art hydrophilic polymeric filters that resist oil fouling.

What are the standard capacities and features of the WasteWizard® recycle systems?

The systems are totally automated to enable continuous, trouble-free operation. The automation package includes performance monitoring of the filtration cycle, an automatic wash cycle and safety override features (such as high temperature switches) to trigger system shut down. A full range of systems has been pre-engineered and sized to fit the most common washer sumps (50 to 1,000 gallons; 0.19 to 3.8 m³).

WasteWizard® series Industrial Fluid Recycling Systems



MEMBRANE PROPERTIES' IMPACT ON RECYCLABILITY

Why are Osmonics membranes considered to be the best membranes available for alkaline wash recycle applications?

The most important key to the successful recycling of alkaline cleaners is the membrane. Osmonics offers polymeric membranes to address the broad range of cleaners encountered in the aqueous cleaning market. Osmonics polymeric membranes are made of polyacrylonitrile (PAN) and are covered by U.S. Patent #4,906,379. This membrane has four properties that enable their superior performance:

MEMBRANE PROPERTIES' IMPACT ON RECYCLABILITY

- The surface chemistry of the membranes have been engineered to uniquely resist fouling (plugging) by both free floating and emulsified oils;
- The membrane matrix is physically and chemically stable toward a broad range of pH and aggressive solvents;
- The pore size and morphology of the membranes have been designed to ensure complete passage of all cleaner components while retaining greater than 99.9% of the oils;
- The membranes have exceptional temperature tolerance.

Why is membrane chemistry so important?

The surface of Osmonics patented PAN membrane (UltraFiliC®) is chemically modified to be extremely hydrophilic (i.e. water adsorbing and oil repellent). In practice this hyper-hydrophilic surface resists fouling by free oils, emulsions and other hydrophobic solutes and achieves very efficient rates of filtration for extended periods of time. The ability of this membrane to process waste streams containing free-floating as well as emulsified oils is a key performance advantage over all other ultrafiltration membranes.

Conventional membranes made of more hydrophobic materials such a polypropylene (PP), polyvinylidene difluoride (PVDF or polysulfone (PS) foul readily in the presence of even low concentrations of free oils. Osmonics UltraFiliC® membranes are 20 times more hydrophilic than are PP, PS, or PVDF membranes.

Such differences in hydrophilicity can be seen by examining contact angles formed by a water droplet on the membrane surface (see Figure 5). Smaller contact angles indicate greater driving forces for water to adsorb to the surface and for oil to be repelled. Conversely, the greater the contact angle the greater the driving force for oil to be adsorbed by the surface and for membrane fouling to occur.

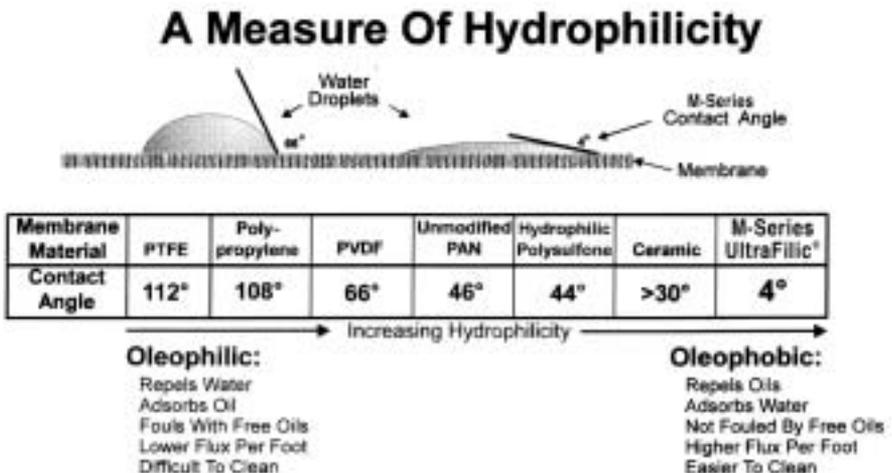


Figure 5

MEMBRANE PROPERTIES' IMPACT ON RECYCLABILITY

Why is membrane chemical stability important?

Chemical stability is key to sustaining long term reliable performance in such an aggressive application. Osmonics' UltraFlic® membranes are chemically crosslinked to maintain performance properties (porosity and pore size distribution) over a broad range of pH (1-11). The membrane is even resistant to a wide range of aggressive solvents that might be present in aqueous wash solutions (e.g., chlorinated hydrocarbons, ketones, amides, etc.) including those that normally dissolve PAN.

Why is membrane pore size and morphology important?

The pore size of a membrane must be selected such that all active components in the cleaner flow through the membrane while the oils are removed. Additionally, the membrane morphology must be designed to inhibit the physical plugging of the filter by suspended colloidal materials. The complex nature of different cleaner chemistries and the respective contaminating soils makes achieving this requirement quite challenging. Here Osmonics manufactures ultrafilters with pore sizes in the 0.5 micron range. This ensures a proper match of membrane to cleaner for successful recycling. In addition to proper porosity, Osmonics membranes have an asymmetric morphology, which inhibits plugging by colloidal foulants.

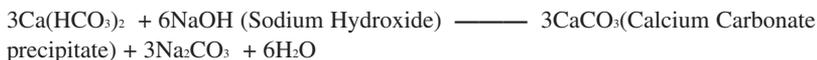
Such robust chemical properties allow the membrane to successfully endure the harsh process environment of parts washing facilities.

SERVICE WATER QUALITY AND CLEANER COMPOSITION

If I use hard water to make up my alkaline cleaning solutions, what will happen?

Calcium or other multivalent Ions (e.g., Mg, Al, Fe) in the make-up water will react with the Alkalinity Builder (e.g., hydroxide, silicate and phosphate ions) and form insoluble metal hydroxide, metal silicate or metal phosphate sludges. The impact of these cross-reactions is the loss of 'Free Alkalinity' required for effective hydrolysis of the oils and soils from the parts being cleaned. High water hardness also inhibits the ability of surfactants to emulsify oils. Experience has shown that in severe cases, up to 100 percent more cleaner is used in hard water applications.

Example 1: Hardness will react with sodium hydroxide an alkalinity builder as follows:

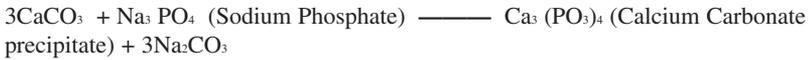


Example 2: Aluminum etched from a metal part will react with sodium hydroxide an alkalinity builder as follows:



SERVICE WATER QUALITY AND CLEANER COMPOSITION

Example 3: Hardness will react with sodium phosphate an alkalinity builder as follows:



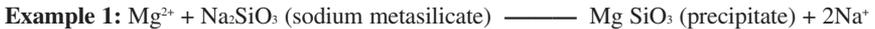
If my cleaner has a chelating additive, do I need to soften the water supply anyway?

Typically, the dosage of the chelating agent is low and capable of performing only minor chelating duties. Since hardness values vary from region to region, well to well, and even seasonally, the use of chelating agents to minimize the effect of hardness on cleaner activity is insufficient. It is therefore recommended practice always to soften and/or apply reverse osmosis (RO) treatment to the water supply to the cleaning system as a means of minimizing scale and sludge formation. Such operational practices also will significantly reduce cleaner consumption.

Why is it believed that silicate cleaners are not recyclable by filtration?

Sodium metasilicate has a high solubility in water at pH levels above 10. At pH levels below 10, or in the presence of metal ions dissolved in the cleaner bath (e.g., calcium, iron, aluminum, magnesium or copper), the metasilicate will form an insoluble precipitate (sludge).

Reactions with hard water



Divalent and trivalent ions will be present in the bath if the metal part is etched by the cleaner or if hard water is used to make up the cleaner. The pH of the cleaning solution will drop if it is not buffered or if it sufficiently diluted (e.g., when rinsing the membrane system during a cleaning cycle). The negative impact of such sludges upon the performance of a filtration system can be severe.

Once precipitated, the level of consumed silicate is measured as the difference between Total and Free Alkalinity. It is a common mistake to interpret reduced total alkalinity levels post filtration negatively. However, since the precipitated silicates are no longer useful, removal by filtration will improve the effectiveness of the cleaning fluid. The real issue is not the filtration system's ability to recycle the cleaner, but the loss of cleaner activity due to sludge formation caused by interactions between the cleaner and dissolved metal ions.

How can I minimize the build up of solids in my cleaning tank and ultrafiltration recycle system?

Proactive steps can be taken to eliminate or minimize the formation of sludges in the parts washing system.

SERVICE WATER QUALITY AND CLEANER COMPOSITION

- First, the service water to the parts washing system must be softened or deionized (with reverse osmosis filtration or ion exchange resins) to remove the metal ions that contribute to hardness (e.g., calcium, magnesium, etc.). Soft water will not react with the alkalinity builders to form insoluble precipitates.
- Second, filter the cleaning fluid to 10 micron as it is transferred from the washer to the filtration working tank.
- Third, use a settler/coalescer tank to remove solids and bulk oils.
- Fourth, use cleaners that cause minimal etching of parts (typically, lower pH cleaners).
- Fifth, use silicate and phosphate-free cleaner.

Is it true that alkaline cleaners are not recyclable by filtration because the surfactants are retained by the filter?

The size of the pores in filters typically used to recycle alkaline cleaners range from 500 to 2000 Angstroms (0.05 to 0.2 microns). Most surfactant molecules are less than 10 Angstroms.

Clearly, free surfactants will be transmitted easily through the filters described above. Similarly, alkalinity builders and chelating agents are even smaller molecules than surfactants and are easily transferred through the membranes used for cleaner recycle. It should be noted, however, that cleaner levels will be reduced due to 'drag out' by the parts being cleaned and due to emulsification of the oils and other soils. Such losses can be compensated for by simply adding small quantities of the cleaner to the parts washer.

Since silicated cleaners cross-react with inorganic ions such as aluminum and calcium, will silicated cleaners cross-react with inorganic (ceramic) membranes?

Most inorganic membranes are made of aluminum or zirconium oxide. While zirconium membranes have been shown to resist fouling by silicates, it appears that silicates will cross react with aluminum oxide membranes forming a permanent scale on the aluminum oxide surface. Such fouling will be chemical in nature and difficult to reverse. Since many competitive membrane systems use aluminum oxide ceramic membranes, users should be cautious when using such systems for silicated cleaners. The following chemical reaction is likely to occur:



CLEANER COMPOSITION AND PROCESS TEMPERATURE

If I make up a fresh solution of cleaner and heat it to its operating temperature, the solution turns cloudy. Why?

A number of surfactant packages exhibit a Cloud Point as the solution temperature is increased. In simple terms, elevated temperatures will cause some of the surfactants in the solution to self-associate and form micelle particles large enough to refract light (thus giving the cloudy appearance). A number of spray wash cleaners are formulated

CLEANER COMPOSITION AND PROCESS TEMPERATURE

to exhibit cloud points at their operating temperature in order to reduce foaming during application from the high pressure nozzles and improve cleaning effectiveness.

What happens if I filter a surfactant solution at a temperature above its cloud point?

The size of the surfactant aggregate can approach the size of an oil-surfactant micelle. Distinguishing between a surfactant-surfactant and oil-surfactant micelle based on size can be difficult. Consequently, choosing a filter to remove oils from the cleaning tank while not removing surfactant micelles is complicated. When a surfactant solution that exhibits a cloud point is filtered using a membrane that will retain the contaminating oil, typically 10 to 30% of the surfactants will be retained by the filter. Since the cloud point phenomenon (i.e. aggregation) is reversible, filtering the solution after a simple temperature adjustment to below the cloud point will result in disaggregation with surfactant recoveries of greater than 90%.

CLEANER NAME	% TRANSMISSION BELOW CLOUD POINT*	% TRANSMISSION ABOVE CLOUD POINT*
Brulín 815 GD	97.0%	98.5%
Daraclean 212	100.0%	91.0%
Daraclean 283	100.0%	77.0%
Detrex 410098	98.5%	78.0%
DuBois Sprex AC-6	100.0%	100.0%
Oak Kleen 309	97.0%	76.0%
Parker Amchem 319-LP	92.0%	64.0%
Parker Amchem 319-OX	99.0%	60.0%
Parker Amchem TD-1383-BK	52.0%	7.0%
Parker Amchem TD-1414-FI	93.0%	51.0%
Parker Amchem TD-1308-TT	82.0%	60.0%
Betz Kleen 4000	99.0%	57.0%
Betz Kleen 4005	96.0%	67.0%
Betz Kleen 4010	96.0%	80.0%
Oakite Inpro-Clean 3800	99.0%	87.0%
Oakite Inpro-Clean 2500	99.0%	89.0%
Oakite Inpro-Clean 1300	99.0%	59.0%

* Transmission data based on COD levels of feed and permeate.

What does it mean when a fresh solution of cleaner exhibits a cloud point at room temperature and at the operating temperature?

A small number of surfactant packages are formulated to form micelles at the working concentration over a broad temperature range. In simple terms, elevated surfactant levels

RECYCLABILITY VALIDATION

will cause some of the surfactants in the solution to self-associate and form micelle particles large enough to refract light (thus giving the cloudy appearance). The surfactant concentration at which this turbidity occurs is called the Critical Micelle Concentration (CMC).

Alternatively, if the make-up water for the cleaner is excessively hard, the cleaner solution will turn turbid due to the formation of the metal precipitates discussed above.

What happens if I filter a surfactant solution formulated above its critical micelle concentration?

As previously noted, the size of the surfactant aggregate can approach the same size as an oil-surfactant micelle; distinguishing between a surfactant-surfactant and oil-surfactant micelle based on size can be difficult. Consequently, choosing a filter to totally remove oils from the cleaning tank while not removing any aggregated surfactants is virtually impossible. When a surfactant solution formulated above its Critical Micelle Concentration is filtered using a filter that will retain the contaminating oil, 10 to 90% of the surfactants may be retained by the filter.

What happens if the ultrafiltration process reduces the surfactant level in my cleaning tank?

Alkaline cleaners are formulated to operate under batch conditions. As such, they must work at the high oil concentrations encountered at the end of the batch cleaning cycle. Since the ultrafiltration process keeps the oils from accumulating in the parts washer, lower surfactant levels will be required to clean the parts to high standards. Therefore, if the filtration process maintains greater than 75% of the target surfactant level in the cleaner sump, the parts washing process will perform exceedingly well.

What is indicated when I use alkalinity to judge recyclability and observe alkalinity reductions across the membrane?

Free Alkalinity is the measurement of all active acid titratable compounds in the sample, including free (i.e., unreacted) silicates, hydroxides, phosphates and carbonates. Total Alkalinity measures all active (Free Alkalinity) and inactive acid titratable compounds in the sample, including hydrolyzed oils and metal silicate, hydroxide and phosphate sludges.

When a cleaner bath is filtered, the active components contributing to Free Alkalinity are transmitted through the membrane while the inactive sludges are retained by the membrane. Therefore, comparing the Total Alkalinity of the permeate to the feed will show Alkalinity reductions. The percentage level of Total Alkalinity reduction generated by the membrane is an indication of Alkalinity Builder consumption due to sludge formation or oil hydrolysis. Conversely, comparing the Free Alkalinity of the permeate to the feed will show approximately no Alkalinity reductions because the feed constituents that contribute to the free alkalinity level are water soluble, are very small molecules (<10 Angstroms) and pass readily through the membrane. Typically, the ratio of Total to Free Alkalinity is used to gauge bath effectiveness and life (a value of 1 represents an

ideal virgin solution). From the example below it is shown that the ratio is improved by filtration (1.46 before and 1.28 after filtration).

	FREE ALKALINITY			TOTAL ALKALINITY		
	Feed	Permeate	% Retention	Feed	Permeate	% Retention
Virgin Cleaner*	2.55	2.55	0%	3.30	3.30	0%
Spent Cleaner*	3.9	3.9	0%	5.7	5.00	12%

* Transmission data based on COD levels of feed and permeate.

Should I achieve better cleaning results if I remove the precipitated alkalinity builders from my cleaner tank by ultrafiltration?

Significantly better cleaning results should be achieved by removing the suspended solid precipitates from the cleaning bath. Accumulation of such sludges in the cleaner sump and washer system will interfere with the cleaning process by depositing onto freshly cleaned parts.

What if I use microfilters to recycle my cleaner?

A number of microfilters (mainly Ceramics and Polypropylene) are sold today to recycle alkaline cleaners. The major issue with such filter types is their symmetrical, large pore morphology. This structure has been designed to entrap fine particles within in the membrane matrix and ultimately will plug irreversibly. Typically, filters of this type require frequent back flushing to eject particles from within the membrane matrix. This approach, however, is unreliable and results in permanent membrane fouling and/or frequent rigorous cleaning. Over time, the irregular structure of the filter matrix permanently traps solids and performance is lost.

Since free oil severely fouls hydrophobic membranes like polysulfone, polyvinylidene fluoride and polypropylene, why not just skim off the free oils before filtering?

Free oil always will be present in oily waste feed streams being processed by membrane filtration for the following reasons:

- Free Oil Skimming Technologies do not achieve 100% retention of ‘free oil’
- As an oily emulsion is concentrated, ‘free oils’ break out of the emulsion and tend to adsorb to such membranes
- The oily emulsion boundary layer adjacent to the membrane surface is highly concentrated and releases ‘free oils’ directly onto the membrane.

It is, therefore, important to use a membrane such as Osmonics UltraFiloc[®], which is not fouled by ‘free oils’.

For More Information:

Call **Osmonics Filtration and Separations Group at**
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