IS 5887 A **PRECOAT MEDIA FACT SHEET**

INTRODUCTION

The following discussion is primarily focused on diatomaceous earth and its superior filtration capabilities, however, as there is some recent interest in alternative filter aids, perlite and cellulose will be included by way of comparison to allow an understanding of their relative filtration capabilities. It is the intent of this discussion to provide accurate verifiable information to users, commercial interests and public health officials.

DIATOMACEOUS EARTH

Diatomite is a processed form of diatomaceous earth, (D.E.) a sedimentary deposit of the skeletal remains of diatoms, a group of single celled marine algae. The skeletal remains are microscopic in size and primarily consist of silica along with a few trace minerals. These skeletal remains possess a highly intricate structure, filled with pores and channels making them ideal for extremely fine scale filtration processes. If one were to examine this material microscopically, it would look like a varied mixture of sponges, starfish, and donut shaped structures as well as some others a bit more complicated to describe.

A wide variety of diatomite products are manufactured from diatomaceous earth through milling and calcining (heating processes) to produce a large array of products with different characteristics. Unprocessed D.E. primarily consists of amorphous silica a non crystalline form. Calcining D.E., (making the material more useful as a filtration aid) converts varying proportions of the product to crystalline silica in the form of crystobalite. This is the portion of the product which has been recently been reclassified as a class 1 carcinogen by the IARC (International Association for Research on Cancer). To be more exact, it is only respirable (airborne) D.E. that has been so classified. Skin contact or ingestion is not considered hazardous, in fact the material carries an FDA 21 CFR rating as an incidental food additive as a result of food processing applications. High airborne concentrations can also result in eye irritation.

To put this into perspective, there are a wide variety of environmental and occupational related respirable class 1 carcinogens, a few are listed below:

- **cement dust**
- **drywall dust**
- **masons sand**
- **beach sand**
- **filter sand**
- **granite dust**
- **kitty litter**
- **road dust**
- **hickory sawdust**
- **ash sawdust**

To be sure, many of these substances do not have the light powdery nature of D.E. which results in the material's ability to become airborne and the safe exposure levels for the above materials vary quite a bit. However, D.E. has been used safely in hundreds of industries over the past 50 years. A recent nationwide docket search by our legal council has failed to find a single current case of litigation related to occupational D.E. exposure. As always, read the manufacturer's handling instructions with respect to proper practices as well as the MSDS for optimum safety.

D.E. DISPOSAL

There is presently quite a bit of confusion regarding D.E. disposal. D.E. is not considered a hazardous waste by the federal government under the RCRA (Resource Recovery Act) per 40 CFR sect. 261. It is only considered hazardous when used to filter hazardous materials. In many cases, spent D.E. can be discharged directly to sanitary sewer. A number of states and local authorities prohibit direct discharge due to the high wet density (19-22 lbs/cu.ft.) of the material as it may settle in pipes with inadequate pitch or flow causing blockage problems. This can be alleviated through the use of a D.E. intercepter consisting of a series of screens or bags allowing conventional "dumpster" disposal. As always, consult local regulations.

CELLULOSE

Cellulose or alpha-cellulose is produced by sulfate or sulfite processing of hardwood fiber. It primarily consists of fibers of varied lengths that are milled and graded to produce filter aids of a variety of permeabilities. It is widely used in coarse filtration processes or in the filtration of highly caustic liquids. Due to its fibrous nature it possesses little intricate fine structure of its own and provides filtration utility by virtue of entrapment of particulate matter in the spaces between overlapping fibers. This material is considered non-hazardous except as a nuisance dust.

PERLITE

Perlite is an expanded silaceous rock (silica). It is usually manufactured by milling to a desired particle size, adding 1-3% water and then rapidly heating to about 1600 deg. F, where it pops similar to popcorn. In fact, the particles are similar to popcorn when viewed under a microscope. The result is a low density powder (2-8 lbs./cu ft.) with complex shapes and crevices that can be used for some filtration processes. Fundamentally, perlite performs the solid/liquid separation process differently than DE. The individual perlite particles themselves possess few pore structures as opposed to DE, which by nature of its intricate channel and throat pore structure actually traps and retains particulate matter. Perlite generally traps contaminants in the interstitial spaces between media particles forming a matrix. The material is considered non-hazardous except as a nuisance dust.

TESTING AND DATA ABSTRACT

The following data abstract has been included to allow a meaningful comparison of filtration characteristics between D.E., perlite and cellulose products. Graphs #1 and #2 have been appended to provide a visual presentation of filter aid characteristics. Note that in the tabulated data, swimming pool grade cellulose was not included. Swimming pool grade cellulose typically has a permeability of approx. 6 darcy units. For swimming pool performance graph #2 should be referenced.

TESTING AND DATA ABSTRACT

PREFACE

Like many companies in the filtration industry, we at Filtrex have been often stymied by the general lack of information and widely conflicting claims of various filter aid producers with respect to a given filter aid's particulate removal efficacy. Indeed, the lack of standardization in testing methodologies among filter aid producers give published particle removal efficacy ratings that can differ by a factor of 10 in products that are almost identical with respect to particle distribution, bulk density, and permeability.

Rather than rely on published claims of dubious veracity and unknown testing methodology, we established a testing program to qualify potential filter aids. Building on work done by World Minerals, Inc. and as presented to the American Filtration and Separations Society in April 1999, we developed a testing regimen that has greatly improved our predictive capability with respect to a given filter aid's particle removal performance.

METHODOLOGY

The test results reported below were performed on an "ideal" 1 sq.ft. filter run at 1.5 gpm. The filter is a single septa design of circular form with a 1 sq. ft. area, backed by a flanged conical borosilicate glass collector. The septa is gasketed and removable allowing best weave match to the particle distribution of the media being tested. The septa is supported by a stainless steel screen. The conical collector was chosen as CFD modeling predicted best case flow patterns behind the septa. This is an often overlooked factor in filter design. Glass was chosen as the collector material as it allowed dye trace verification of our CFD modeling.

Tests were run in both pressure and vacuum modes with equal results. Twill and plain weave septas were also used with no discernible difference.

Challenge particulates used were graded milled silica, ISO 12103-1, A1 Ultrafine Test Dust, and Darco #S51 Carbon. These materials were chosen for their varied shapes and known particle size distributions.

The filter aids represented in the data selection had approximate permeabilities of 3 Darcy units. This value being typical of swimming pool D.E. filter grades. While lower permeability materials can improve particulate removal efficacy, characteristic filter headloss curves will be substantially impacted in a negative manner. All filter aids were purchased through standard distribution channels. Precoating was done at all manufacturers recommended application rates. The cellulose materials were given a (15) minute wetting period prior to application to the septa.

Particle sizing methods and equipment used were; optical laser diffraction (Beckman LS Series), Coulter Method (Beckman Z Series). Primary sizing was done with the laser scattering instrument with secondary checking done by Coulter methods. Generally the particle sizing results reported by the (2) methods were within 8% of each other. Where appropriate and convenient, standard Millipore™ gravimetric analysis was employed as a cross check on the primary and secondary sizing methods.

The abstracted data are tabulated below.

RIGID PARTICLE RETENTION

(Size in Micrometers (Microns))

	1	2	3	4	5	6	7	8	9	10	
D.E.	32%	80%	99%								*% Retained*
Perlite	12%	18%	25%	51%	72%	86%	99%				
Cellulose	2%	8%	13%	22%	30%	41%	59%	77%	86%	99%	

(All units rounded to whole numbers)

Notes:

1. Data represented in the above table represents best case results from 11 materials tested.

2. Four cellulose products were tested. One manufacturer's product significantly outperformed the others.

3. The D.E. products tested were all "swimming pool" grade products. Industrial grade products (not represented here) generally have better performance for a variety of reasons. Premium grades of D.E. (acid washed and ultrapure types) can offer significantly greater particle retention at equal permeabilities.

4. The results in the above table should be directly transferable to leaf and plate type filters of good design. Some classes of tubular or candle type filters can produce significantly better particle retention than leaf or plate type filters using equivalent filter aids.

5. Particle retention begins to decrease above 1.5 gpm/sq.ft. No discernible differences were observed between 1 and 1.5 gpm/sq.ft.

6. As an aside, we have tested a wide variety of cellulose products (down to .5 Darcy units) and have never seen 99% particle retention below 8 micron. While an 8 micron removal may seem somewhat of an improvement, the low permeability of this material makes it impractical for swimming pool use.

CONCLUSIONS

The (3) classes of filter aids studied all have characteristic particle retention curves that are (very roughly) linear with respect to permeability. Lower permeabilities give better particle retention and higher permeabilities give lesser particle retention in any given media type.

D.E. is by far the best performer in these tests. Both D.E. and to a lesser extent the perlites have some useful particulate removal capabilities extending into the sub micron region. This is not true of cellulose.

ADDITIONAL COMMENTARY

Not represented in the data tabulation are the various filter media's particle retention with respect to deformable (non-rigid) particles. In swimming pool applications these would typically consist of skin cells or portions thereof, agglomerations of oils/dirt, cosmetics and similar contaminants. These are a major cause of high use late session hazing in a wide variety of aquatics venues. While I will refrain from specific commentary regarding deformable particulate retention (as our studies in this area are ongoing), I will state that D.E. in general has equal or better retention of deformable organics as compared to its rigid particle retention characteristics. This is not true of perlite or cellulose products. To its credit, cellulose does have some interesting oil removal characteristics not present in D.E. or perlite.

NSF APPROVAL OF ALTERNATIVE FILTER AIDS

At the time of this writing there is at least (1) alternative filter aid approved as a D.E substitute (under NSF standard #50) for swimming pool use. It should be noted that the challenge particulate material (U.S. Silica SCS 106) used in testing has a particle distribution which peaks at approx. 20 microns and rapidly declines to less than 5% at the 10-12 micron level. This renders the NSF Std. 50 particulate reduction test largely incapable of evaluating any filter aid at or below the 12 micron level. Given the NSF Std. 50 test conditions, and the known particulate reduction characteristics of the aforementioned filter aids, one would expect very similar turbidity reduction results in the 10-12 micron region.

Any claims made by alternative filter aid manufacturers/marketers of "equal" or "better performance" than D.E. are for the most part specious and ignore the innate physics of the liquid solids separation process. Any responsible claim should carry the caveat that any stated particulate reduction equivalency only extends down to the 10-12 micron removal range.

The above being said, there are D.E. filters on the market (residential and commercial) that (in our opinion) suffer from a variety of design issues that would include poor septa design, improper internal flow patterns, deleterious acoustic/vibrational signatures and excessive flow ratings. In the case of a filter with one or more of the above characteristics, cellulose and to a lesser extent, the perlites can provide better particulate reduction performance than D.E due to superior fine scale bridging capability (not inter-element bridging) leading to greater "filter cake" stability, effectively masking any inadequate design issues. In no case will the alternative filter aids provide better filtration efficacy than when D.E. is used in a properly designed filter.

WATERBORNE PATHOGEN REDUCTION

Of particular interest to public pool and water attraction operators is the ability of D.E. based filtration systems to significantly reduce waterborne pathogens in filter effluent streams, This ability can add a significant additional layer of protection to the bathing public.

While a highly detailed discussion of D.E. based filtration and waterborne pathogen reduction is beyond the scope of this brief, the following paragraphs are offered as general information. Interested parties are encouraged to review the wide variety of papers and publications available from The American Water Works Association, Environmental Protection Agency, Center for Disease Control and The World Health Organization.

In light of the previously presented data, we offer the following "reasonable" expectation of filter performance with respect to common waterborne pathogen reduction.

Assumptions:

1. Filter is of good construction, featuring no inadequacies of design.

2. Flow rates are conservative e.g., 1.5 GPM/sq.ft. or less.

3. Filter aid (D.E.) is of good quality, with a permeability of approx. 3 Darcy units.

4. Filter aid (D.E.) is applied to the septa at a rate of .1 lb/sq.ft. or greater.

5. Pathogen sizes are as follows:

Cryptosporidia oocysts - 3- 4 micron
Giardia Lambia - 10-11 micron
E. coli (typical) - 2 micron

Expectation of pathogen reduction:

- Cryptosporidia oocysts - 99% (2 log)
- Giardia Lambia - 99.9% (3 log)
- E. coli (typical) - 80%

By contrast, the same filter, using a 3 darcy perlite or a 3 darcy cellulose would yield the following expectations of pathogen reduction.

Perlite:

- Cryptosporida oocysts - 25%
- Giardia Lambia - 99% (2 log)
- E. coli (typical) - 18%

Cellulose:

- Cryptosporidia oocysts -12 %
- Giardia Lambia - 99% (2 log)
- E. coli (typical) - 8%

Again, the above are only "reasonable" expectations of filter performance based on particle retention studies perfomed by Filtrex, Inc. and others. Actual performance may vary by filter manufacturer, type, and model.

The testing data and commentary in the above have been provided and reviewed by:

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If there are any questions or comments regarding the information provided herein, please do not hesitate to contact me.

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