GET OUT OF THE STONE AGE

Introduction

I would like to thank Mike Mele of J. Andrew Lange for arranging my appearance before you, and thanks also to Tony Ziccardo, Rich Lyons and Gary Robinson for the courtesy and hospitality extended to all of us here today. I would also like to thank Dave Redmon of Redmon Engineering in Milwaukee Wisconsin, Gerry Shell of GSEE, Inc in LaVergne Tennessee, and Richard Brenner of the EPA who assisted me with data for this presentation.

The decision to install membrane or ceramic diffusers has always been a difficult one. Common perceptions are that ceramics clog, but membranes shrink and creep and crack. To add to that, sales pressure is placed on the customer by the major suppliers of diffusers to go one way or the other

Both membranes and ceramics foul over time, however ceramics foul more quickly. New ceramic diffuser media has lower headloss than most new EPDM membrane media, however membrane headloss can be controlled by orifice size and spacing. but Membrane media is less expensive to produce than ceramic media, and also provides a lifetime of lower operating costs as a benefit of its reduced fouling rate.

The cities of Phoenix and Los Angeles recently tendered for membrane aeration systems to replace their existing ceramics. Milwaukee Wisconsin, which first installed ceramic plates initially in 1926, recently ordered 280,000 new ceramic discs. The decision may have been well advised, but it is well known that the Lake Michigan water supply has very low solids content. Buildup on the diffusers is less scummy and there is less of it.

What I will show you today is that ceramic diffusers do indeed clog in most wastewaters, and that clogging costs wastewater treatment plants dearly in terms of power cost and cleaning cost. In low load aeration tanks, and with today's nitrifying regulations, with water that is not hard, and with a low solids content, ceramic diffusers can work well and require little maintenance to maintain steady backpressure and high OTE. Such pristine conditions are rare.

For at least 60-70% of municipal installations, I believe that membrane diffusers offer more advantages than do ceramics. The greatest advantages are to be found in plants that turn diffusers on and off with relative frequency, since they are much less likely than ceramics to foul in that situation, and because they provide a check valve to prevent water and precipitates from entering the piping system. There are also advantages for those plants that have high loading or industrial wastes where biological fouling would otherwise be likely to raise the backpressure or drop the OTE of ceramics. Finally, membranes allow greater turndown than ceramics, allowing improved overall operating efficiency when low airflow is desired.

I would like to discuss the methods by which diffused aeration systems can be measured, and will define some common terms. Then I will describe ceramics, their characteristics, and their behavior in clean and dirty water as documented over the past 2 decades. I will explain why ceramics clog, how to clean them, the wasted energy spent between cleanings, and the cost of cleanings.

Then because this talk is designed to get you to think twice about membranes, I would like to go into some depth into the making of a membrane diffuser, and how today's 3rd and 4th generation membranes differ from those of even a few years ago. That section will end with a Caveat Emptor, which I feel is necessary because not all membrane diffuser makers in business today are equal and there are still a number of peddlers of 1st and 2nd generation membranes on the market.

Methods of Evaluation of Diffusers and Definitions of Common Terms

Ceramic Description

The Fine Pore Aeration Manual published by the EPA defines ceramics as irregular or spherically shaped mineral particles that are sized, blended together with bonding materials, compressed into various shapes, and fired at an elevated temperature to form a ceramic bond between the particles. The result is a network of interconnecting passageways through which air flows.

The materials most commonly used today to make ceramic diffusers is alumina, which is produced from bauxite and also a lesser amount of vitreous silicate. Older versions of ceramic diffusers were made with silicon dioxide which was found not to be as strong as alumina, however the performance of both materials has been quite similar.

Ceramic diffusers have been manufactured in the dome, plate, tube and disc shapes, however the most commonly marketed version today is the disc. The discs are typically 9" in diameter, although they are made in sizes from 7" to 20" diameter. The thickness of the media is from ¾" to 7 ½".

Membrane Description

Membranes are available in various materials and thicknesses, from to 5-8 mm. Membrane materials include Ethylene Propylene Dimer (EPDM) which is the most common type, as well as Urethane and Silicone. The main ingredient in an EPDM membrane, which is the most commonly used type, is EPDM, however natural rubber, Carbon black, ash, organic additives, peroxides and plasticizers are used as well in varying proportions.

Tube membranes come from rubber chunks that are forced against a flared die that looks like a bullet. They are then extruded and placed on mandrels to control the I.D during cooling, since the rubber has no strength while it is cooling. Tube membranes come in lengths of 500mm (20"), 600 mm (24"), 30", 36" and 1 M standard sizes

Disc membranes are either injection or compression molded and come in sizes 7", 9", 10", 12" and 20".

SCFM airflow per diffuser – 9” Ceramic discs are designed to handle 1-2 SCFM per diffuser. 9” Membrane discs are designed to handle 1.5 to 2.5 SCFM per diffuser. Design flow for ceramics is 0.5 SCFM to 1 SCFM, and they cannot go any lower due to flux rate cleaning. After a few minutes at zero flow they tend to foul out. Membranes can go to shutoff, meaning efficiency savings.

Cost of manufacture of diffuser media – High quality ceramic discs cost diffuser assembly companies approximately more per piece to manufacture than high quality EPDM membranes.

Cost of operation – Cost of transferring a defined quantity of oxygen to an aeration tank

Bubble Release Vacuum (BRV) – Specific permeability of diffuer media as measured in inches of water column. In other words, resistance to bubble formation at a given point on the diffuser media at a given airflow. Usually in a fouled diffuser the BRV will show that certain areas are more fouled than others where a DWP test will give no indication of fouling pattern.

Dynamic Water Pressure (DWP) – Pressure differential across the entire diffuser when under water. It is a measure only of the resistance of the passage of air. DWP is measured in inches of water column at a given flow rate. A new ceramic disc (media only – not including restricting orifice) operating at 1.5 standard cubic feet per minute of air will have a DWP of approximately 6.5” Aq. A new membrane diffuser (media only) will have a DWP of approximately 6.5-12” Aq, depending on the punch pattern and quantity.

Alpha – A ratio of oxygen mass transfer in process water to clean water. As most waste waters inhibit oxygen transfer, alpha is usually less than 1, and is most commonly between .5 and .85, depending on the process and aerator.

Alpha fouling – Represents a combination of the reduction that diffuser fouling or aging plus process water conditions have on oxygen transfer

Type I fouling – Diffuser pore clogging, usually caused by organics. This can be caused by air side clogging, related to dirty pipes or unfiltered air, or due to precipitates on the liquid side such as metal hydroxides and carbonates. It can also result from oils from blowers or air filters, construction debris left uncleaned, or by dried wastewater solids that enter the diffuser through leaks. Such fouling typically raises DWP but has little impact on oxygen transfer efficiency. This type of fouling will cause blower motor amp ratings to rise if the blower is a positive displacement type, and will cause a surge condition in a centrifugal type. The result of this type of fouling is usually a burned out motor or overheated bearing set, and rising energy costs. This is significant since supply of oxygen in treatment plants consumes 50-90 percent of total plant energy requirements. A 10% increase in motor amps = a 5-9% increase in total plant energy costs.

Type II fouling – Formation of a layer of biofilm on the surface of the diffuser. Calcium and Phosphorous are often major components of this film, and on the surface it is a mixture of organic and inorganic matter. Often deep within the ceramic element inorganic foulants can be found.

Thin layers of biofilm on the surface may have little or no effect on oxygen transfer, BRV or DWP, however many plants with heavy loading experience high rates of type II fouling. Thick agglomerations of biofilm on the diffuser surface gives bubbles a place to coalesce after passing through the diffuser media. This results in larger bubbles, and lower oxygen transfer, though headloss is unaffected. Type II fouling will have little effect on blower performance or energy consumption but the plant’s ability to reduce BOD is handicapped. A centrifugal blower with a DO meter will never indicate this type of fouling. The only way most operators find out about this type of fouling is if they have a VFD on their Positive Displacement blower, and they keep having to increase the speed of the blower to keep the DO constant.

Type II fouling is most aggressive when blowers are shut off or are providing very low flow while the tank is full of wastewater. This type of situation may occur intentionally in the nitrification/denitrification process, or during power interruptions or blower failures.

DWP/BRV Ratio – An effective way to show the relative amount of fouling and also give an indication of type II of fouling. A ratio of 0.3 or less is a sign of significant type II fouling. A ratio of 0.6 or greater indicates that type II fouling is light.

Causes of fouling - Uneven air distribution in the diffuser, which can be determined by BRV, low or zero airflow rate through the diffuser, high organic loading, high temperature, low dissolved oxygen content, low permeability diffusers, and the presence of industrial wastes. The most significant fouling takes place when the aeration system is shut off for a certain period of time for maintenance or during nitrification/denitrification.

Fouling in different types of tanks – The degree of fouling that takes place in a basin depends on the level of mixing that exists in that basin. For example, in aeration tanks which are significantly longer than they are wide, operating as plug-flow basins, the diffusers closest to the influent are much more likely to foul than the diffusers further down the basin. And that fouling is most likely to be type II, which significantly reduces oxygen transfer close to the influent channel.

Square shaped tanks, or those with a smaller ratio between length and width, are likely to have diffusers that foul evenly.

According to a paper given by Prof. William Boyle of the University of Wisconsin, there it is not possible to confirm a direct correlation between strength and composition of wastewater and fouling. Sludge retention time, F/M loadings, airflow rates and time-in-service all account significantly for fouling, as well.

Ceramic Cleaning Systems – Presently, packaged in-situ gas cleaning systems are commonly sold together with ceramic diffuser systems. They are also offered with some membrane systems, however their necessity and function in such systems is questionable.

The gas most commonly used is Muriatic Acid, with 10% to 14% HCl which is applied for periods of 30 minutes to a grid of ceramic diffusers in-situ. The airflow rates are raised to close to the maximum to physically assist the acid in removing foulants. The gas reacts with water within the ceramic element to produce hydrochloric acid in concentrations up to 28%. Other methods used include a 5% bleach solution and formic acid.

HCl and Bleach have also been used Ex-situ, often in accordance with the well known Milwaukee method, which an in-situ process using a high airflow, close range 60 PSI water hosing of the diffusers, immersion in a 14% HCl acid bath with 30 minute soak, and final hosing as above after acid treatment.

In some cases, some form of acid cleaning together with hosing is successful in returning the diffusers close to their original OTE and headloss after fouling. According to one EPA study the average diffuser cleaning returns the diffusers to 80-90% of original performance level. The difference may be attributed to some negative effects of cleaning and its incompleteness. Hosing can cause small particles to lodge deep inside of the ceramic element's pores, increasing BRV and DWP, and acid cleaning alone is not completely successful in removing Type II fouling. It has not been as successful in removing granular material such as silica that is incorporated in Type II foulants imbedded within or on the wastewater surface of the diffuser.

The Sanitaire gas cleaning patent claims that cleaning should be done continuously to prevent buildup. That means once a week or twice a week. Dave Redmon of Redmon Engineering commented that he has never known anyone to use the gas cleaning as the preventative tool it was designed to be. Once a ceramic pore is closed, it is closed forever and no amount of in-situ acid or high flow will dislodge it. Entrained acid in air acts just like air. It follows the path of least resistance, passing through partially clogged and unclogged pores.

Cost of cleaning ex-situ– A study was published by the EPA in 1994 using research done by Southern Methodist University on the cost of cleaning a ceramic diffuser system. They arrived at the following time & cost requirements:

Tank dewatering – 4 to 6 man-hours
Tank cleaning – 20 man-hours per 1000 diffusers
Low pressure hosing – 20 man-hours per 1000 diffusers
Inspection and repair – 10 man-hours per 1000 diffusers

1000 ceramic elements would treat approximately 1.5 MGD. The total time required for a low pressure hosing cleaning would be 58 man hours. At $7.50 per hour x 2.1 (indirect costs including benefits) = $913.50 x efficiency factor of 1.3 = $1187.55 or $1.19 per dome. The 2.1 factor includes supervision, administration, payroll and benefit costs, and the 1.3 factor relates the time spent cleaning domes to the total hours worked by the individual including preparation breaks and washup.

Acid washing time was estimated at 60 man-hours per 1000 domes or total of $2.40 per diffuser in labor costs, plus the cost of acid and protective wear. At .1 lb HCl per diffuser, assuming $2/lb for HCl, the total acid cost would be $200. Hosing plus acid cleaning ex-situ would cost $3778 or $3.79 per diffuser.

Cost of cleaning in-situ – Costs involved in cleaning include the cost of the service, but also equipment, which includes stainless tubing, a clamping system, and a control box. There is also a substantial license fee involved.

The cost of cleaning an Upstate New York 25 MGD plant is approximately $5000 per cleaning. This includes travel time of the service that performs the cleaning, and this plant is located within 1 hour of the service provider for NY State. Other locations in the state may have higher pricing for this reason.

The cost of equipment installation including stainless piping, controls, etc.. for an Albany area plant was also approximately $5000.

License fees for use of the gas cleaning system in the United States are around $5 per diffuser.

For a 25 MGD plant with 15,000 diffusers that cleans once per month, cleaning costs, with license fee and equipment, assuming no maintenance, over a 5 year period cleaning would cost $25 per diffuser, or $380,000. That works out to $76,000 per year, or $5 per diffuser per year. Please remember a new ceramic element costs the manufacturer slightly less than that.

Effect of fouling on energy cost – Type I

One ceramic manufacturer recommends cleaning diffusers when DWP headloss increases 8” Aq. Another recommends it at any point up to an increase of 25” Aq. At an 8" Aq rise in headloss in a 1000 diffuser tank, using a blower rated 2000 CFM at 8 PSIG, and additional 8" Aq headloss adds 27 cents per hour of energy cost. Running continuously, the added cost of that 8" headloss is $2354 per year.
In 1989 the EPA compared the effects of Type I and Type II fouling in average plants, and made recommendations based on their case studies. Assuming Type I fouling, in an average wastewater treatment plant, headloss would increase 1” Aq DWP per month. Using a 4cent/KWh cost of energy, they could justify only 1 cleaning per year when considering the cost of energy vs. headloss and raised HP. At today’s energy cost of 12 cents per KWh, diffuser cleaning for Type I fouling as described above can be justified 3-4 times per year.

Effect of Fouling on Energy Cost - Type II

For the Type II fouling, they found that the average plant was experiencing a loss of 5% OTE per month to a maximum of 30% per year. At that time based on 4 cents per KWh, they determined the optimal cleaning frequency was 4 times per year. At today’s energy costs assuming the same 5% OTE loss a monthly cleaning would be recommended.

It is only fair to mention that the average new ceramic diffuser has a slightly higer OTE than the average new membrane diffuser. In the first 6 months of study which is being conducted by Redmon Engineering of Milwaukee, a new generation high quality membrane disc is being compared with a new ceramic disc installation in a low loading plant in Green Bay, Wisconsin. The blowers have run continuously and air supply to the diffusers has not been interrupted. The water is also not considered to be hard. In these circumstances, there has been only slight fouling to the ceramic diffusers, reducing their OTE to approximately the same as the membrane discs, which have not fouled at all. In such cases, the above cost analysis certainly cannot be applied. Backpressure of the ceramic diffusers in that study has been maintained, as well.

Incentives to sell ceramics – There are very few makers of ceramic diffused aeration systems left. In particular, there is one major company that sells most diffusers in the country, whether ceramic or membrane, since major consolidations took place last year. This company's agents have a tremendous incentive to promote ceramics over membranes. They have very little competition because that factory holds many patents in the ceramic business, specifically pertaining to the gas cleaning system. The agents of ceramic diffuser makers will typically try to sell the gas cleaning system to the municipality as well as their "services" to operate & maintain it.

The same opportunities do not exist with membranes, since acid/gas cleaning is not proven to be necessary with membranes.

Membrane fouling- In the EPA's report on Fine Pore Aeration systems published in 1989, they identified fouling as a phenomenon that affects ceramic and membrane diffusers. At that time, the most commonly available membrane diffuser was the Parkson Wyss FlexATube, which had a perforated plasticized PVC sheath, whose fouling and performance cannot be considered consistent with today's high quality

EPDM membranes. The Wyss diffusers suffered the same fate as the Sock diffusers which were made of plastic, and had been sold through the 1970s. Over a short period of time, plasticizer seeped out of the membrane, causing hardening and shrinkage of the diffuser. The direct effects of that were cracking and membrane failure, but symptoms noticable in advance of that were membrane weight loss, higher durometer readings (hardness), lower OTE due to stretched aperatures, and lower headloss.

The EPA also studied some EPDM tubes, which were mostly of European make. They found similar problems with the EPDM, although the extent of the OTE loss was less.

Membrane fouling includes loss of plasticizer, hardening or softening of the material, loss of dimensional stability caused by creep or "tiring" of the material, absorbtion or exchange of oils from or with the wastewater, and chemcial exposure.

Membranes are subject to some Type I & II fouling, which is most commonly caused when the air supply is shut off. A few droplets of water can seep into an unclosed slit in the membrane and create a 1/8” or 1/16” diameter wet spot. When the diffuser is turned back on, the water evaporates and the solid is left behind.

In the 6 month study mentioned above being conducted by Redmon Engineering, niether fouling of type I nor type II has taken place on the membrane diffusers.

Application of Membrane Materials-

EPDM membranes are recommended for most types of sewage. When used with a polypropylene base, they can be used in a tank with ozone and metal hydroxides as well. Their main weaknesses are excessive heat above 80C, fats, greases and oils.

Urethane membranes work very well in industrial or agricultural lagoons where the oil and grease content is high. Dairy waste and pulp and paper are also common applications for Urethane. The disadvantages are that it has an even lower

temperature tolerance than EPDM, and it is not easy to punch or seal in a diffuser body.
Silicone has been tried in Europe with little success. It is resistant to heat, fat and oils, but the material is very soft and rips easily.

Punch patterns - Both disc and tube membranes can be punched in a variety of ways. Disc patterns include circular punch all around, which gives a high OTE, low headloss, and the maximum number of punches, but puts a moderate amount of stress on the membrane. Alternately the membrane can be punched in 4 perpendicular sections, which offers a slightly lower OTE & higher headloss. Slit size is also important. Size ranges from 0.5 mm to 2 mm. 0.5 mm gives high OTE but at a high headloss. 2 mm gives a low headloss but significantly lower OTE. Most discs are punched 1 mm.

Membrane tubes are punched all around, with the exception of 2 sections which are no more than 1" wide. In North America, tubes are usually punched 2 mm. In Europe, they are punched to 1mm. Tubes can be punched on both sides, or only on top.

Composition - Many things can be added to membranes to accomplish a certain goal.

Peroxide curing, which is used by Nopol of Finland gives a membrane a very high temperature resistance. The problem is that the same process reduces membrane strength and increases ripping.

Carbon Black can be added, and should be in concentrations of at least 3% to provide resistance to Ultraviolet rays. Other organic UV stabilizers can be used, in addition to or instead of carbon black.

Some foreign companies, predominantly from Asia, use high concentrations of natural rubbers such as Viton and Sanoprene in their membranes. Such rubbers have been shown to lose plasticizers and fail quickly and are not recommended.

Plasticizer & oil content- The EPA Fine Pore Aeration manual claims that the disadvantage of thermoplastic and elastomeric media is that they can experience physical property changes over time. The main focus of membrane engineering over the past 10 years has been to change that.

Compression molding cuts a membrane from roll material into the shape of a disc element. The membrane is then punched. Injection molding involves pouring molten rubber into a mold and cooling. Compression molded membranes in controlled manufacturing can keep plasticizer content to under 15% extractable oil. Injection molded membranes contain 30-35% oils & plasticizers. Controlled is the operative word because manufacturers of membranes like to include oils to give a better looking product with a quicker cycle time. Compression molding also improves uniformity of membrane. Typical compression molded membrane uniformity is 95% compared to 75% for injection molded types.

Due to the nature of the process, compression molding requires the use of less plasticizer to keep the press machine operating than does injection molding. The increased plasticizer content used in the production of injection molded membranes is said to seep out of the membrane during immersion, causing creep, increased hardness, reduced OTE, and cracking over time.

Standardization of sizes - According to Gerry Shell of Gerry Shell Environmental Engineering, who has done a great deal of research on membrane discs and tubes in the past decade, the tendency is toward tubes of 30" to 1 M length, which are 60-70 mm in diameter. He claims that the proportional efficiency of larger diameter tubes is questionable, since little or no air is released from the bottom of tubes.

As we discussed, disc membranes come in sizes 7", 9", 10", 12" and 20". Mr. Shell explained that 7" and 9" discs are preferable to larger sizes, since the stress on the membrane center and seal around the edges in smaller diameters is exponentially less than the stresses in larger membrane disc diffusers. Multiple failures of 12" and 20" diameter disc diffusers have been documented.

Standardization is needed in the membrane diffuser industry to assist consumers in selecting product and getting spares at a reasonable price. This year 2 companies introduced disc diffusers that are the same size as Sanitaire, and have similar headloss and OTE characteristics. This means these 2 brands could be used in the same tank as Sanitaire diffusers, or as membrane replacements for their diffusers.

Previously each disc diffuser was of a different shape or size. An EnviroQuip membrane would fit only an EnviroQuip holder, and a Sanitaire membrane would fit a Sanitaire holder, etc…and different headloss characteristics would make it difficult to put mixed brands in the same tank.

The membrane diffuser industry has progressed to the point where high quality membrane diffusers are available from 3 vendors with the same size disc, same membrane composition, and same performance characteristics.

Today there are still oddball sizes such as 7", 12" and 20" diffusers for sale, as well as 9" diffusers that are not interchangeable with anyone else's, and you may be able to find such diffusers at low prices. However beware of replacement parts cost and modularity as you would have to replace entire grids at a time if you switched brands. In addition you would have to buy all parts from that one vendor.

Tubular diffusers also come in many shapes and sizes. The most commonly sold sizes in the U.S. are 62mm diameter, 65mm diameter, and 94 mm diameter.   62mm tubes use 2" PVC schedule 40 pipe as their base. 65mm use a specially extruded tube, and 94mm tubes use 3" Schedule 80 PVC as their base. It is usually best to stay with standard products that are easily replaced. The 62 mm size is preferred due to its relatively high efficiency compared to larger diameter tubes.

Check valve function of membranes - Membranes expand when air is turned on, and each hole is a variable aperature. The higher the airflow, the greater the size of the opening. When the airflow is turned off, the membrane relaxes against the base, assisted by the downward force placed upon it under many feet of water. The membrane conforms to the support and seals, preventing most backflow of liquid into the diffuser.

Fallacy of the "I" slit - Straight looking slits are the result of a sharp set of punching knives. "I" shaped slits result from dull knives and are to be considered failed and stressed. The 45 degree lines of the "I" are stress lines on rubber that has failed in that location. A number of diffuser makers are promoting the "benefits" of "I" slits against the wishes of their very embarassed German membrane maker!

Rubber compounding should be controlled and tested, and membranes should be subject to a die T test, also known as the "trouser test" which simulates the ripping of a pair of trousers at the seam and measuring the the force per inch to pull it apart. An average rating is between 50-60 pounds per inch. Our membranes have a die T of 110 pounds/inch, which is a good way to predict how a membrane will function under stress.

Summary - When selecting aeration equipment, please keep in mind that as boring as diffusers may appear, the supply of oxygen for aeration is the single largest energy consumer at an activated sludge wastewater treatment plant, making up 50 to 90% of total energy requirements.

Today we have covered the two competing products in the market, which are ceramic and membrane fine bubble diffusers.

Ceramic diffusers, we discussed, have high OTE and low headloss in clean water and under pristine wastewater conditions, which may be suitable for some plants. But in field studies, especially where on/off cycling of diffusers is required, or in industrial or high loading plants, ceramic diffusers have been shown to foul significantly. This causes SOTE reduction, increased headloss and power consumption. Cleaning the diffusers with acid was shown to be an risky and costly operation. The hidden labor costs of frequent hosing & ex-situ cleaning were shown to be prohibitive.

Membrane diffusers have performed better in high loading and on/off cycling treatment plants. They are subject to much less fouling than ceramics under almost every circumstance, if the diffuser membrane material is chosen wisely. They are recommended by the E.P.A. in cycling plants, and by both independent engineers quoted in this presentation, Dave Redmon and Gerry Shell in most plants. Proper selection of membrane diffusers will provide 7-10 years of life in most plants, which is less than the life of ceramics that are well maintained. Few ceramics are. When membranes significantly reduced maintenance and lower energy costs are considered, membranes are the right choice for a majority of plants.

When selecting a membrane diffuser, do so as an informed consumer. Select only recent generation membranes. These are the ones that are compression molded, have low oil/plasticizer content and high EPDM compound percentage, and are made in a standard size such as a 9" disc or 2" diameter tube whose membrane can be interchanged with the products of at least 2 other companies. Choose slit size and patterns based on your treatment plant's specific needs, whether that is increased oxygen transfer, or low headloss. And finally, choose the elastomer which best suites your application, which would be Urethane for greasy industrial wastes or EPDM for sewage.

Stamford Scientific International manufactures fine bubble membrane diffusers in Poughkeepsie, New York. We make 9" discs, and 2" and 3" diameter tubes of various lengths using EPDM and Urethane membranes. We also make membrane replacements for Sanitare & EDI ceramic and membrane diffusers.

Thank you.