ECOSORB®

Odor Control Solutions

ENGINEERING MANUAL

OMI Industries
Phone: 847-304-9111
Fax: 847-304-0989
www.omi-industries.com

March 2014

This manual is provided as a technical guide for the design engineer and the Ecosorb® distributor who specifies odor control solutions.

This manual includes:

- **Section 1:** Technical information about Ecosorb®
- **Section 2:** An overview of odor generation and characteristics
- **Section 3:** A general odor control overview and summary of various methods of Ecosorb® application
- **Section 4:** An in-depth look at the more common techniques of delivering Ecosorb®
- **Section 5:** Reference materials and industry bulletins

Section 4 will assist the engineer in specifying systems, selecting equipment, and designing effective odor control systems using typical approaches. This manual is prepared with the assumption that the user is technically competent in basic fluid dynamics and component selection.

Given Ecosorb®'s versatility, it is impractical to think that all possible solutions can be addressed. Thus, we have included those that are the most common and require some level of engineering design. Ecosorb®'s numerous applications cause the development of new and often times more effective systems. This manual will be updated when necessary to include newly developed systems and improvements to current application methods.

SECTION 1

ECOSORB ODOR NEUTRALIZER PRODUCT SECTION

ECOSORB® ODOR NEUTRALIZER PRODUCT SECTION

INTRODUCTION

Growing environmental concerns are creating questions regarding the quality of our soil, the water we drink, and the air we breathe. Of particular concern to many industries is the prevalence of odor emissions surrounding wastewater facilities, manufacturing plants, landfills, and other sites where malodorous gases collect. Odors are basically gaseous chemicals detected by the human olfactory organs and while the like or dislike of a particular smell is purely subjective, certain odors are generally agreed to be offensive or harmful to all.

As a result, many devices have emerged to satisfy the demand for better control of offensive odor emissions. Unfortunately, many solutions fall short in one of two categories, either they act as mere masking agents and do not address reactions with the malodorous gasses, or as they eliminate odors they may introduce hazardous compounds into the very areas they “clean.”

Ecosorb® odor control products offer odor control through a number of functional mechanisms that yield odor neutralization without using masking fragrances. They are applied most often via airborne treatment as described in the “Methods of Application” section of this manual. The products consist of a proprietary formulation of several essential oils and food grade surfactants. They are biodegradable and totally safe to people, animals and plant life. Please refer to the Material Safety Data Sheets and the various third party lab test reports included in Section 5.

Originally there was only one Ecosorb® blend, that consisted of the industrial strength version known as Ecosorb® 606 and its lesser strength derivatives known as Ecosorb® 505 and 404. These products contained the same active ingredients with varying intensities. Ecosorb® 606 and its derivatives are broad spectrum, applicable in multiple industries, and contain only the natural fragrance of the active ingredients.

Recently, OMI Industries responded to market requests by developing Ecosorb® 606AB (Apple Blossom) and Ecosorb® 606O (Orange). These “scented” versions of the Ecosorb® product provide the user with an odor neutralizer that also deposits a substitute odor into the process air. Instead of neutralizing the malodor thereby yielding no odor, these new products neutralize the malodor and leave a subtle scent behind. Little attention is given in this manual to Ecosorb® 606AB and 606O. The methods of delivery and neutralization mechanisms are the same as Ecosorb® 606.

A new Ecosorb® product was introduced in 1999. This product was developed specifically for application into the styrene market and is known as Ecosorb® 206. Testing shows this product to be an effective styrene odor neutralizer and to be more effective on organics similar to styrene than Ecosorb® 606. Attention will be given to Ecosorb® 206 herein. When this manual refers to mechanisms and application systems that pertain to both 606 and 206, we will refer to the materials simply as Ecosorb® products. When relating to topics specific to one product or the other, we will identify the appropriate product.

In 2001 OMI Industries embarked on a development program to create a new line of products, products that did not contain water and could be used as an additive into compounds that are not water tolerant. This successful development program yielded the Ecosorb® additive line of products, most notably the Asphalt Additive, but also products that are compounded into recycled rubber, machining cooling oils, various plastics and the like. Given this is an Engineering Manual; there is not a significant amount of engineering required for the additive. However we do dedicate a small section to information relative to Ecosorb® Additive Products.

In 2011, OMI Industries introduced a modified version of Ecosorb® 606 and 505 referred to as 606G and 505G. These products bring to market the same intensity of broad spectrum odor control capabilities as the original products with the addition of components directed specifically at liquid waste greases, fats, volatile fats, and the like. The mechanisms of odor control pertinent to these market specific products is consistent with the standard versions.

ESSENTIAL OILS

An essential oil is the predominately volatile material isolated by some physical process from an odorous single-species botanical. Over 3,000 oils are identified from the vast number of plant species and several hundred are commercialized. Of these, some are extremely rare and produced in only kilogram quantities, e.g., violet oil, concretes (flower extracts), and angelica root oil.

Essential oils are derived from various plant parts, such as leaves, fruit, bark, root, grass, wood, heartwood, gum, balsam, berries, seed, flowers, twigs, and buds. These plant parts are processed to yield their quintessence or essential oils, which are mostly devoid of cellulose, glycerides, starches, sugars, tannins, salts, and minerals, which also occur in these botanicals.

Essential oils are used as such for flavors and fragrances. But products derived from, or based on essential oils have large volume usage for specific applications. Essential oils are concentrated, rectified, extracted, or chemically treated to further isolate vital components, purify, adjust properties, or increase the concentration of significant flavor or fragrance components. The versatility of essential oils for odor control has made them an acceptable and effective technique.[i] The correct blending and selection of the oils are a science unto itself.

Fluctuations in the cost and availability of natural oils and the high cost of some oils have induced users to seek substitutes. Nonetheless, there is a trend away from synthetic oils because complete duplications are in most cases not technically, aesthetically, or economically possible.[ii]

Science once believed essential oils were only good as masking agents and had no potential to actually neutralize odor. However, testing indicates that certain essential oils have the ability to cancel out particular malodors. For example, oil of wintergreen will neutralize rank tobacco odors and juniper oil cancels the odor of rancid butter and milk fats.

Not only is the type of oil important but also where that oil is produced since similar oils do not necessarily have the same chemical content. Melaleuca Alternifolia (tea tree oil), for example, is found on three continents. However, the therapeutic effect needed for the production of pharmaceuticals is only found in the oils produced in the Lismore area of New South Wales, Australia. It has become evident that this is true of many essential oils used in odor control.

Because of the science involved when using essential oils for non-masking odor control, the properly designed blend of oils is necessary to assure functionality. The full mechanics of how essential oils work is quite complex. However, using Ecosorb® water based products for airborne treatment and topical applications performance basically becomes a function of weak electrostatic bonding, adsorption, absorption, gas phase solubility enhancements, and acid base reactions. The oils are mixed with water and sprayed into the air or onto odorous materials. It is believed the mix in these droplets separate and the oils form a thin film over the water droplet itself and inside the droplet. The exterior “skin” formed by the oils creates an electrostatic charge over its outer surface. This charge attracts the odor molecules onto and into the droplet. Although the water droplet is quite minute, it is still large enough to capture the malodor molecules, and affect the neutralization process.

---

[i] “Odor and VOC Control Handbook”, Harold J. Rafson, 1998, McGraw Hill, p. 8.20

[ii] “Concise Encyclopedia of Chemical Technology”, Kirk-Othmer, 1985, John Wiley & Sons, Inc.

ECOSORB® THE PRODUCT

In typical airborne applications of Ecosorb® products, the atomized or vaporized material is carried into the atmosphere where it attracts, or is attracted to, whatever is in the atmosphere; whether it is a pleasant odor, malodor, or particulate.

Research has shown a number of mechanisms come into play when Ecosorb® products are applied for odor neutralization type odor control. These mechanisms, as a minimum, have been identified as follows:

1. Adsorption
2. Absorption
3. Solubility enhancement
4. Distribution constant enhancement
5. Reaction

Extensive laboratory testing shows that reactions between Ecosorb® 606 and malodor compounds occur. Ecosorb® 606, being a blend of essential oils, develops into an acid buffer. This buffer can react with both weak acids and bases. The reaction varies with the gas. In the case of basic gases such as amines, lab tests identified an acid base reaction. In the case of acidic gases, an acid-base reaction was observed and there is evidence of ion transfer with additions across double bonds within the product. In both cases, the result is a non-volatile organic salt. For a more in-depth look at these reactions, please refer to the technical paper provided in Section 5 entitled, Control of Malodors Using Ecosorb®. For independent laboratory evidence of reactions causing gas reduction, refer to the Southern Petroleum Laboratory test reports in Section 5.

Using the blend of essential oils in Ecosorb® is an advantage because we can control the full spectrum of odors and not leave any peripheral odors or odorous by-products. Although essential oils are capable of working on most gases, there are instances where they may not be economically feasible for use as an odor control. These situations include atmospheres where the gases contain heavy aromatics, strong acids, and strong alkalis. The weight and solubility of heavy aromatics sometimes make it difficult to control their odor in high contamination levels. Atmospheres containing large doses of strong acids and alkali also appear to reduce the effectiveness of the oils by destabilizing the bonding between the oil particles.

Because of the various specific gravities and flash points of the oils, the oils will begin to separate at high temperatures. This marginally reduces their effectiveness. However, we have situations where Ecosorb *has been* successfully injected into exhaust flues where the gas emissions are measured at *approximately 425°F and an amazing 1100°F.*

There are many factors, which will affect the amount of Ecosorb® required to control a situation.
To measure the potential effectiveness of Ecosorb® on a particle you have to look at:

1. Parts per million (ppm)
2. Air Flow
3. Solubility
4. Molecular Weight
5. Molecular Density
6. Make up (organic/inorganic)

SOLUBILITY

Reaction is not the only mechanism through which Ecosorb® controls odors. In fact, it is not the first mechanism. Before Ecosorb® can react with gasses, the malodor gases must be dissolved into the atomized droplet containing Ecosorb®. The first mechanism in odor control using Ecosorb® is solubility. Industrial malodor gasses vary in terms of solubility in water. This variation ranges from "very slightly soluble" such as styrene to "very soluble" such as ammonia. Generally speaking, Ecosorb® increases the solubility of most malodor gasses.

Once the gas is dissolved (absorbed) into the atomized droplets, "Henry's Law" takes affect and a percentage of the gas wants to leave the droplet and form a state of equilibrium. We refer to the ability of the liquid to hold the gas as the "distribution constant." It was proven in the laboratory that Ecosorb® enhances the ability of an aqueous solution to hold liquid, thereby favorably affecting the distribution constant. Therefore, Ecosorb® increases the solubility of the gas into the aqueous solution and increases the ability of the liquid to contain the gas.

Laboratory testing relative to the solubility of a few common industrial gasses was performed under the direction of OMI. Section 5, Reference Materials, contains reports that address the solubility effects of the product. The report, "Control of Malodors Using Ecosorb®," addresses acidic and basic gasses in Ecosorb® 606. The subject of styrene solubility and its distribution constant can be found in the report entitled "The Use of Ecosorb® 206 in Controlling Styrene Odors." Finally, a study specific to the solubility of benzene is reported in "Effect of Ecosorb® 206 on the Solubility of Benzene."

ECOSORB® 206, STYRENE, AND OTHER NEUTRAL HYDROCARBONS

ECOSORB® 206 was developed specifically with the solubility of styrene in mind. Styrene odors associated with the composites industry and regulatory pressure within that industry influenced Odor Management, Inc. to develop a product targeted specifically for control of styrene odors.

Ecosorb® 206 differs slightly from Ecosorb® 606 in oils that make up the blend. It is slightly more volatile and acidic than 606. The toxicity, health, and safety characteristics are equivalent to 606; it is safe. The product has a noticeably different natural fragrance while still remaining similar in fragrance. Application methods of the two products are identical.

Ecosorb® 206 was designed to enhance the solubility of styrene in an aqueous solution. It was not designed to react with styrene. Since reactions are only a piece of the odor control puzzle, we believed that if we could absorb and adsorb more styrene into an atomized aqueous solution of the new Ecosorb® product, then we could affect odor control by removing the atomized droplets from the air. This concept proved true; however, we also discovered that a reaction with styrene does exist. Further investigation determined that the oxidation reaction takes place between styrene and water, but that styrene does not readily dissolve in water. By measurably increasing the amount of styrene that dissolves

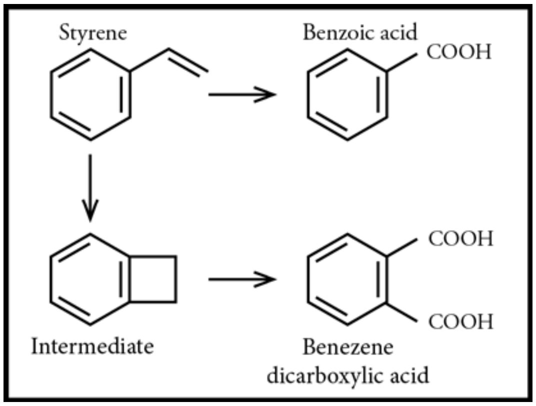


Figure 1.1: Degradation of Styrene in Ecosorb® 206 solution

into water containing Ecosorb® 206, we can capture and hold significant amounts of styrene and react it causing identifiable byproducts. For more details, please refer to “The Use of Ecosorb® 206 in Controlling Styrene Odors” located in Section 5.

Even though Ecosorb® 206 was designed for styrene applications, we also found it is more effective on compounds with which 606 has the most trouble, such as the BETX series. Generally speaking, when dealing with neutral hydrocarbon compounds, Ecosorb® 206 is the product of choice.

Because of its acidity, Ecosorb® 206 is not recommended for applications involving acidic gasses.

MATERIAL SAFETY DATA SHEET (MSDS)

Through OMI in-house testing, plus testing by independent laboratories, OMI has examined all of the Ecosorb® products to provide the information for our MSDSs and the GHS Safety Data Sheets. Having tested the products, OMI can state *“The products are not considered hazardous according to the Federal Hazard Communication Standard.”* (MSDS Section 3. Hazards Identification). OMI can also point to the fact that Ecosorb® products do not contain any hazardous Volatile Organic Compounds (VOCs). The “Percent Volatile” Section of MSDS Section 9 “Physical/Chemical Properties” shows the percent volatile measures approximately 1.4%, but our corroborative testing by Pace Laboratories and Chemical Waste Management to EPA Guidelines 8260 and 624 show that none of the volatiles tested for are in Ecosorb® products.

HUMAN TOXICITY

Industry is more aware of personal and environmental dangers from the use of chemicals. OMI has had studies completed to assure our clients that Ecosorb® products are safe to use personally and for the environment. These reports can be found in Section 5, Reference Materials.

Tox Monitor Laboratories in Chicago tested Ecosorb® 606 and Ecosorb® 206 to the following EPA Guidelines:

OPPTS 870.1100 Guideline	Acute Oral Toxicity Study
OPPTS 870.1200 Guideline	Acute Dermal Toxicity Study
OPPTS 870.1300 Guideline	Acute Inhalation Toxicity Study
OPPTS 870.2400 Guideline	Acute Eye Irritant/Corrosion Study
OPPTS 870.2500 Guideline	Acute Skin Irritation Study
OPPTS 870.2600 Guideline	Dermal Sensitization Study

In all cases, Ecosorb® received the safest possible classification.

FISH TOXICITY

T.R. *Wilbury Laboratories* conducted fish toxicity testing on Ecosorb® in April 1993. These tests were performed to establish any potential problems from the spillage or use of Ecosorb® in an exposed water stream.

The tests performed included:

EPA Method 72-2	Daphnia Magna
EPA Method 72-1	Fathead Minnow
EPA Method 72-1	Rainbow Trout
EPA Method 797-1300	Daphnia Magna
EPA Method 797-1400	Fathead Minnow
EPA Method 797-1400	Rainbow Trout

These tests proved that Ecosorb® was completely non-toxic to marine life. The letter associated with this report can be found in Section 5, Reference Materials.

VOC ANALYSIS

EPA and state regulatory bodies are becoming more and more stringent relative to Volatile Organic Compounds (VOC) emissions. Ecosorb® was tested to EPA Method 8260 and EPA Method 624. In both tests, there were no harmful VOCs detected.

However, Ecosorb® contains natural active ingredients that are organic and volatile. Ecosorb® 206 and 606 were tested according to United States Environmental Protection Agency (US EPA) Method 24, in part "Determination of Volatile Matter Content." It was determined that undiluted Ecosorb® 606 contains about 1.42% volatile matter content and Ecosorb® 206 contains about 1.5% volatile matter content. In application, these products are usually diluted thereby reducing these percent contents.

GAS TESTING

OMI has tested a range of gases that are found to be common nuisance odors in industry. These gases include:

- Hydrogen sulfide
- Sulfur dioxide
- Ammonia
- Ethyl mercaptan
- Methyl mercaptan

Ecosorb® exhibited a dramatic effect on each gas. Most notably sulfur dioxide, ethyl mercaptan and methyl mercaptan were reduced by over 97% on contact.

The results of current testing are shown in Table 1.1. Since there were no established testing procedures for our requirements, OMI developed our own methods.
The method of testing is best described as:

- The subject gas is introduced, using a pure gas permeation tube, into a constant air stream flowing into and out of a reaction chamber. Once a constant gas rate is maintained in and out of the reaction chamber, a brief spray of Ecosorb® is introduced.

- Exit samples are taken immediately upon the introduction of Ecosorb® and periodically thereafter. Samples are analyzed using gas chromatography, except in the case of ammonia where a colorimetric sensor is used.

- The reader will note a gradual increase in hydrogen sulfide, sulfur dioxide, and ammonia after the introduction of Ecosorb®. This is caused by a residual effect of the brief product introduction on the constant incoming gas.

Table 1.1: Ecosorb® contact testing with identified gases

	ppm/vol. Perm Tube	ppm/vol. Reactor Out	Contact	4 minutes	18 minutes
Hydrogen sulfide	36	36	20.04	36	
Sulfur dioxide	26	26	< 0.01	4.4	
Ammonia	97	97	68	8	38
Ethyl mercaptan	3.92	3.92	< 0.1		< 0.1
Methyl mercaptan	3.2	3.2	< 0.01		< 0.1
Testing completed by independent laboratories. Full test methods and results are provided in Section 5.					

PRODUCT SPECIFICATIONS ECOSORB® 606

The odor-neutralizing product shall meet or exceed the following requirements:

1. Shall be a water-based formulation designed to neutralize malodors associated with wastewater treatment, composing, landfills and lechate, industrial processes, refinery and petrochemical processing, and other related or similar odors.

2. Shall be non-hazardous according to Federal Hazard Communication Standard (29 CFR 1910-1200).

3. Shall function as an atmospheric odor neutralizer and contain no disinfectants or other ingredients designed for contact anti-bacterial activity.

4. Shall have non-descript odor and shall not be a masking agent and shall not depend on a heavy scent to cover up.

5. Shall be documented to reduce malodorous compounds such as hydrogen sulfide, ammonia, sulfur dioxide, ethyl mercaptan, and methyl mercaptan.

6. Will have been demonstrated on site at the subject facility and approved by the appropriate management.

7. Shall contain no volatile organic compounds as determined by EPA Methods 8260 and 624.

8. Shall be non-toxic according to the following test procedures.

Acute Eye Irritation	EPA Guideline OPPTS 870.2400
Acute Oral Toxicity	EPA Guideline OPPTS 870.1100
Acute Inhalation Toxicity	EPA Guideline OPPTS 870.1300
Acute Dermal Toxicity	EPA Guideline OPPTS 870.1200
Dermal Sensitization	EPA Guideline OPPTS 870.2600
Acute Skin Irritation	EPA Guideline OPPTS 870.2500
Daphnia Magna	EPA Guideline OPPTS 72-2
Fathead Minnow	EPA Guideline OPPTS 72-1
Rainbow Trout	EPA Guideline OPPTS 72-1
Daphnia Magna	EPA Guideline OPPTS 797-1300
Fathead Minnow	EPA Guideline OPPTS 797-1400
Rainbow Trout	EPA Guideline OPPTS 797-1400

9. Shall have no flash point.

10. Shall have compound authorization by the USDA.

11. Shall have a

    - Boiling point of approximately 210° F (99° C)
    - Specific gravity of approximately 0.99
    - pH of 5.5 to 6.8
    - Shall be less than 1.5% volatile per US EPA Method 24
    - Shall be water soluble

12. Shall not contain any nitrogenous substances.

13. Shall contain no more than 0.50% non-toxic, food-grade emulsifiers and/or surfactants.

SECTION 2
ODOR GENERATION AND CHARACTERISTICS

ODOR GENERATION AND CHARACTERISTICS[1]

ODOR

Odor is defined as a sensation resulting from stimulation of the olfactory organs, whereas "an odor" is the experience of perceiving a smell. The property of a substance that affects or stimulates the sense of smell is called an "odorant" or "osmogene." The chemical and physical structure and characteristics of the molecules of most odorous substances produce the stimuli to the olfactory sensory cells that are responsible for "smell."

Many people are incapable of detecting some specific odors, but are very sensitive to others. Some odor-bearing substances in weak concentrations cause more intense olfactory response than when in strong concentrations. For instance, hydrogen sulfide (H_2S) in low concentrations is easily detectable; but in concentrations greater than 400 ppm, H_2S overcomes the olfactory senses and is thus odorless to humans as well as quite deadly. These and many more characteristics of odor production by plants and animals and the variability of various receptors to the same odors have made odor control a very difficult problem for engineers.

Below are a few facts of interest about odors.

- Individual substances sometimes exhibit different and highly characteristic odors.
- Similar substances sometimes have very different odors.
- Some substances have several possible odors, although this normally depends on the substance concentration.
- Substances of high molecular weight are usually not perceived odorous and are neither volatile nor soluble.
- The sense of smell is rapidly fatigued by some odorants, but not all.
- Two or more odors can cancel each other. Both mixed together can be imperceptible (Zwaardemaker pairs).
- Many products of depolymerization are acutely malodorous (for example, trimethylamine and skatole).
- Nearly all odors can be arrested, worsened, canceled, or neutralized.

Below are some general characteristics of odorous molecules that should be remembered in rendering decisions on odor prevention or control.

- Compounds of different constitutions may have similar odors.
- Compounds of very similar constitutions may have different odors.
- No element that occurs free in nature is odorous under normal conditions.
- Seven of the elements not free in nature are odorous. They are fluorine, chlorine, bromine, iodine, phosphorus, arsenic, and oxygen (as ozone).
- Polymerization reduces or destroys odor whether in elements or in compounds.

---

[1] "Odor Control for Wastewater Facilities," Water Environment Federation, Manual of Practice No. 22, 1993 Edition.

- The odor of amines is more ammoniacal when concentrated than when diluted. The fishy odor is stronger in diluted solutions than in concentrated solutions.
- Nitrogen compounds frequently have an "animal" odor. Compounds not containing nitrogen do not ordinarily have an "animal" odor.
- An oxygen linkage is frequently associated with a pleasant odor (for example, esters, lactones, and nitrates).
- Many reduced sulfur compounds, particularly where the sulfur is divalent, have offensive odors (for example, mercaptans).
- The general conclusion is that odor is determined by the structural arrangement of the molecule.
- The great difficulty is with the subjective nature of odor classification.

PRINCIPAL ODOR SOURCES

Odor-producing substances found in domestic wastewater and sludge as well as some that originate from the smaller industries associated with urban life, are listed in Table 2.1 with some of their more important characteristics. Osmogenes detectable by man are usually produced as a result of biological activity. Most of these substances result from the anaerobic decomposition of organic matter containing sulfur or nitrogen. Gas produced from domestic wastewater is sometimes called sewer gas and commonly includes hydrogen sulfide, ammonia, carbon dioxide, and methane. Often sewer gas includes highly odorous indoles, skatoles, mercaptans, amines, and others.

Malodorous substances can be generated in any location in a wastewater collection or treatment system where anaerobic wastewater or solids can become deposited as scum or sludge. Deposits of scum or sludge do not permit a sufficient inward diffusion of oxygen for them to stay aerobic and odor-free very long.

Odorous substances tend to be adsorbed on dark, coarse, porous surfaces, and these surfaces then emit odors for long periods into what seems to be clean rooms. Walls and ceilings of a facility, and even the clothing of employees, can adsorb and carry odors long after the odorous substances have apparently been removed.

Table 2.1: Odorous Substances (Osmogenes)

	Formula	**Characteristic Odor**	**Odor Threshold (ppm)**	**Recognition Threshold (ppm)**	**Molecular Weight**
Acetaldehyde	$CH_3{\cdot}CHO$	Pungent, fruity	0.004	0.21	44.05
Allyl mercaptan	$CH_2{\cdot}CH{\cdot}CH_2{\cdot}SH$	Strong garlic, coffee	0.00005	---	74.15
Ammonia	NH_3	Sharp, pungent	0.037	46.8	17.03
Amyl mercaptan	$CH_3{\cdot}(CH_2)_3{\cdot}CH_2{\cdot}SH$	Unpleasant, putrid	0.0003	---	104.22
Benzyl mercaptan	$C_6H_5{\cdot}CH_2{\cdot}SH$	Unpleasant, strong	0.00019	---	124.21
Butylamine	$C_2H_5{\cdot}CH_2{\cdot}CH_2{\cdot}NH_2$	Sour, ammonia-like	---	0.24	73.14
Cadaverine	$H_2N{\cdot}(CH_2)_5{\cdot}NH_2$	Putrid, decaying flesh	---	---	102.18
Chlorine	Cl_2	Pungent, suffocating	0.01	0.314	70.91
Chlorophenol	$Cl\ C_6H_5O$	Medicinal, Phenolic	0.00018	---	128.55
Crotyl mercaptan	$CH_3{\cdot}CH{:}CH{\cdot}CH_2{\cdot}S$	Skunk-like	0.000029	---	90.19
Dibutylamine	$(C_4H_9)_2NH$	Fishy	0.016	---	129.25
Diisopropylamine	$(C_3H_7)_2NH$	Fishy	0.0035	0.085	101.19
Dimethylamine	$(CH_3)_2NH$	Putrid, fishy	0.047	0.047	45.08
Dimethyl sulfide	$(CH_3)_2S$	Decayed vegetables	0.001	0.001	62.13
Dipheny sulfide	$(C_6H_5)_2S$	Unpleasant	0.000048	0.0021	186.28
Ethylamine	$C_2H_5{\cdot}NH_2$	Ammoniacal	0.83	0.83	45.08
Ethyl mercaptan	$C_2H_5{\cdot}SH$	Decayed cabbage	0.00019	0.001	62.1
Hydrogen sulfide	H_2S	Rotten eggs	0.00047	0.0047	34.1
Indole	$C_2H_6\ NH_2$	Recal, nauseating	---	---	117.15
Methylamine	$CH_3\ NH_2$	Putrid, fishy	0.021	0.021	31.05
Methyl mercaptan	$CH_3\ SH$	Decayed cabbage	0.0011	0.0021	48.1
Ozone	O_3	Irritating above 2 ppm	0.001	---	48
Propyl mercaptan	$CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}SH$	Unpleasant	0.000075	---	76.16
Putrescine	$NH_2\ (CH_2)_4\ NH_2$	Putrid, nauseating	---	---	88.15
Pyridine	C_6H_5N	Disagreeable, irritating	0.0037	---	79.1
Skatole	C_9H_9N	Fecal, nauseating	0.0012	0.47	131.2
Sulfur dioxide	SO_2	Pungent, irritating	0.009	---	64.07
Tert-butyl	$(CH_3)_3C{\cdot}SH$	Skunk, unpleasant	0.00008	---	90.19
Thiocresol	$CH_3{\cdot}C_6{\cdot}H_4{\cdot}SH$	Skunk, rancid	0.0001	---	124.21
Thiophenol	C_6H_5SH	Putrid, garlic-like	0.000062	0.28	110.18
Triethylamine	$(S_2H_5)_3N$	Ammoniacal, fishy	0.08	---	101.19

HYDROGEN SULFIDE

Hydrogen sulfide (H_2S) is the most commonly known malodorous gas emanating from domestic and industrial wastewater collection and treatment facilities and industrial/chemical processes. It is highly soluble (2,800 mg/ l at 30ºC to 5,650 mg/l at 5ºC) in normal domestic wastewater.

In addition to its rotten-egg odor, H_2S can cause highly corrosive conditions and is an extremely toxic substance. The walls and crowns of sewers or closed tanks often have droplets of attached spray or condensation on the surface. Water (such as condensed water vapor in the form of dew or droplets) saturated with H_2S as a result of bacterial action forms sulfurous acid (H_2SO_3) and some sulfuric acid (H_2SO_4), both of which are very corrosive to paint, concrete, metals, and other materials.

The toxicity of H_2S is on the same order of magnitude as hydrogen cyanide (HCN), and death may result when exposed to an H_2S concentration of 225 ppm by volume in the air. The maximum TLV permissible for an 8-hour working period for H_2S is 10 ppm.[1] Hydrogen sulfide is treacherous because a person's ability to sense large concentrations is quickly lost. If the person ignores the first notice, the olfactory senses will become numbed and will no longer give warning. The results may be fatal.

The toxicity of H_2S is on the same order of magnitude as hydrogen cyanide (HCN), and death may result when exposed to an H_2S concentration of 225 ppm by volume in the air. Hydrogen sulfide is treacherous because a person's ability to sense large concentrations is quickly lost. If the person ignores the first notice, the olfactory senses will become numbed and will no longer give warning. The results may be fatal.

ODOR TRANSMISSION

Odor transmission requires a sender, a carrier, and a receiver. The olfactory senses are the human's receiver. Air currents act as the carrier of odorous vapors and gases.

All substances with vapor pressure have the potential to emit odors—that is, to act as senders. A person's limited receiving apparatus does not pick up most odorous messages. Rather, people are most sensitive to unusual odors, or odors associated with the unknown, with what is feared, or with what is disliked. Osmogenes use the previously described forms of energy as the carrier of the odor message or stimuli. The degree to which senses can pick up an odor depends on the concentration of the osmogenes, distance from the osmogene, air current strength, and the condition of the individual detecting the odor.

Odor vectors may be stationary objects with adsorbed osmogenes or may be airborne particles. Adsorbed odors can continue to be the source of odor, sometimes for years. For example, clothes often will retain an odor despite heavy washing with detergents and bleach. Similarly, buildings formerly occupied by a malodorous industry will continue to emit odors from apparently clean surfaces. Ventilation ducts in a closed system will continue to emit odors for a long time if not adequately filtered and continuously diluted with fresh air.

---

[1] "2000 TLVs and BELs," American Conference of Governmental Industrial Hygienists (ACGIH), latest edition. (Handbook discusses threshold limits for chemical substances/physical agents and biological exposure indices. These are the exposure limits used world-wide as the maximum limits for SHE regulations.)

ODOR EFFECTS ON THE HUMAN ENVIRONMENT

People can distinguish more than 5,000 odors. Odors can alter or create moods. It was proved that odors can cause increased heart rates, respiration, blood pressure, and even pain. Moreover, continued exposure to an odor can eventually cause atrophy of the olfactory apparatus. The odor key is locked into memories of past events and tends to cause recall of both pleasant and unpleasant happenings.

Humans no longer depend on odors to warn them of danger or to make them aware of the location of food, their mates, or their children. However, odors are still an important part of life. The increasing population and its concentration in urban areas resulted in an accumulation of odors that are not as dispersed as they were a century ago when a large proportion of the population was rural and population densities were less.

People associate some odors with human excrement, spoiled food, disease, or other unpleasantness. When such odors are present, people often become uncomfortable, unhappy, or fearful. Other osmogenes cause aromas, scents, or fragrances to bring pleasant or neutral thoughts and feelings to the person perceiving them.

SECTION 3

ODOR CONTROL OVERVIEW

ODOR CONTROL OVERVIEW

INTRODUCTION TO ODOR ABATEMENT TECHNOLOGY

Odors are a by-product of many product processes. Because odor control is usually an expense rather than a revenue item, it is often the last problem addressed by an odor producing operation and often only after pressure is brought to bear by the public or government agencies.

Ecosorb® presents the user with an alternative to the more traditional approaches of odor control, which in some cases can actually pose danger to the worker and the environment while not always being totally effective. Ecosorb® is a broad based product that is environmentally safe, user friendly, functionally very effective, and cost effective.

One needs to distinguish between odor control and emissions control; they do differ. An article reprint, found in Section Five, addresses this differentiation. With odor control we tend to deal with nuisance odors that are disturbing neighbors, employees, or both. These odors are gases and as such, should be measured with instrumentation. However, when treating malodorous gases with Ecosorb®, it is highly likely the gases remain measurable. For a short time, one will not smell the malodor but can measure them with instrumentation. The nose is the best odor control instrument.

In emissions control, we may be looking at odor control as a byproduct. It usually involves removing emission gases from a process air stream before the air is released into the atmosphere. Emission control will always involve some form of monitoring and/or measuring instrumentation.

The measurement of gases during odor control can and does become an issue. One example involves a municipality specifying that a contractor doing sewer work cannot allow nuisance odors to leave a job site while in the same odor control specification they specify H_2S levels be below a certain parts per million level measured at the perimeter of the job site. It is one thing to say the job shall not become an odor nuisance to the neighbors; it is something else to specify a gas level.

The most popular abatement equipment available is[1]:

- Chemical Scrubbers
- Ozone
- Thermal & Catalytic Converters
- Odor Neutralization
- Adsorption - Activated Carbon
- Biological Filters
- Incinerators

All but the last system involves costly capital equipment, has costly recurring expenses, and is not 100% efficient in odor control. Although they are very effective against odors and emissions in specific spectrums, they are not broad spectrum in their ability to control malodors.

---

[1] Copyrighted and reprinted with permission from OCI (Pty) Ltd., South Africa, 1999.

Chemical Scrubbers

Scrubbing systems work in tandem with acids, caustics, oxidizers and surfactants to aid in eliminating odors. The chemical scrubber system is considered a "controlled environment" in which odors are negated by introduction to a variety of highly reactive chemicals.

The mechanics of a scrubber can be monitored and carefully controlled. The discharge to the environment can be maintained at a necessary level, but careful design considerations must take into account the inherent exhaust gas. Many applications have a tendency to create a "chlorination" effect, which produces chlorine gas from the chemical reaction. Some of the newer technology scrubbers use a nickel catalyst to eliminate chlorination and to speed up reaction time; but this places an additional cost on the unit.

It is often necessary to use construction materials such as stainless steel or special composite compounds to construct the scrubber vessel because of the reactive nature of the chemicals used in odor control applications. This adds to the overall capital cost.

Scrubbing systems are very popular since they are well-understood technology and there are standard "text book" designs. They are expensive to build and operate and must be designed for a specific application. Systems can range from a single vessel to a multi-vessel unit, with different chemicals in each vessel, and must be operated by trained production personnel.

Adsorption ***(Adsorb is defined as "condense and hold onto the surface.")***

Adsorption is a process by which organics are retained on the surface of granular solids. One suitable medium that achieves this is "activated carbon," which is very porous and has a large surface to volume ration. Gas particles penetrate the pores of the adsorbent and are captured on the large surface area available for adsorption. Materials such as Activated Carbon, Zeolite and Silica Gel may be used as adsorbents.

It is important to understand that activated carbons are not all the same. Care must be taken to select the correct carbon grade for the proposed duty or application. Activated carbon is made from various materials and varies considerably in the "surface area to mass ratio" as well as in price. Below are several forms of activated carbon.

- Coconut shell – Micropored (1600 m^2/g) and used for small molecular weight species and low concentrations.
- Wood & Peat – Meso/macropored (1200 m^2/g) and suitable for large molecular weight species and high concentrations.
- Coal & Coke – Between wood and shell and is the lowest cost and most common.
- Activated carbon made from bone is used for specific applications.

Activated Carbon is the most common adsorbent for organics removal. Carbons are commonly used to remove sulfur bearing compounds, aldehydes, and ketones. They are one of the few processes recommended for removing toxic compounds such as pesticides, DME, and heavy metals such as lead and mercury. Charcoal is ineffective on compounds such as ammonia and urea. Activated charcoal is reversible in nature, which allows the odor to return if the activated charcoal is heated, even in ambient conditions.

Be aware of several important parameters when designing an adsorption system, especially where more than one organic is to be adsorbed. They are:

- The effect of "preferential adsorption," which can dramatically change design parameters and lower overall unit efficiency.
- The generation of heat within the unit. These units are prone to internal fires.
- The actual contact or resident time is critical to the design.
- The spent media disposal costs must be considered, especially when dealing with saturated toxic compounds since these usually require total encapsulation, which is extremely expensive.

Activated carbons are suitable for impregnating with chemicals to control a specific odor. This process, known as "chemisorption" is a combination of both a**d**sorption (capture and held at the surface by weak forces of inter-molecular attraction) and a**b**sorption (where the odor is chemically converted).

Ozone

Ozone is one of the most powerful oxidants known to man. Ozone is composed of three atoms of oxygen (O_3) bound together. Ozone is not stable and is very reactive with other elements since O_3 wants to become O_2. Ozone is described (Encyclopedia Britannica) as an irritating, pale blue gas that is explosive and toxic, even at low concentrations. It is used as a bleaching agent for organic compounds, as a strong germicide to sterilize drinking water, and to remove objectionable odors and flavors.

Ozone generators are available to the market but are not accepted by the majority of odor control equipment designers. They are effective for a narrow spectrum of odor control and do not cover the full spectrum of organic and inorganic odors.

Due to its toxicity, a well-designed ozone odor control system should consist of an ozone generator, an ozone meter, and an ozone destroyer, making the system very expensive. The unit design must produce a stable gas, and on larger systems this requires an oxygen supply, making medium to large systems very expensive to purchase and operate. Ozone is better suited to the treatment of process effluents, than to malodor treatment.

Biological Filters

It is well known that a range of microorganisms have the ability to oxidize odorous compounds and much work has been done over the past few years on this type of odor abatement equipment.

The biofilter consists of a large container packed with a suitable fill–usually consisting of bark, twigs, pine needles and such media that have been saturated with micro-organisms. The odorous air stream is passed through the fill and the pollutant is digested, yielding carbon dioxide, water and mineral salts.

The design needs to consider factors such as the removal of dust, grease and inorganic matter from the air stream prior to entering the unit. The supply airflow and temperature must be constant since surges can kill the bacteria, as can large concentrations of gases. The units are operated at 100% humidity to keep the fill saturated, allowing the bacteria to work.

A biofilter is a large unit, designed to treat the entire airflow. A small flow rate requires a unit the size of a large shipping container. Biofilters operate at about 95% efficiency and need to have the fill replaced every 3-6 months. Newer units can be modified to include a special fill material and a carefully selected bacteria strain to offer 98% efficiency. These units can last up to 3 years without changing the fill but are more expensive.

Biological Oxidation (Scrubber)

A typical bioscrubber is an advanced biofilter and consists of an adsorption column (vertical vessel) and one or more (usually several) bioreactor stages in which much of the biological oxidation takes place. The air to be treated must first be pretreated in a scrubber (or filter) to eliminate entrained dust and to bring it within the temperature range of 50-104°F (10-40°C), which is suitable for the microorganisms to start reacting.

The bioscrubber is designed to operate at a linear velocity of about 2.6 ft/sec (0.8 m/s), with a packing residence time of about 1.6 seconds, a liquor circulation rate of about 120-144 lbs/ft^2 (5-6 kg/m^2) and a liquor residence time in the reaction tank of about 50-60 minutes, This makes the plant quite large for relatively small flow rates.

The reaction tanks have to be aerated and supplied with the nutrient solution. The microbial mass primarily remains in the circulation liquor since the circulation rate is sufficiently fast to prevent build-up on the packing. However, build-up is still possible and need to be removed periodically. Some of the accumulating microbial mass also needs to be removed from the circulating liquor, usually by flotation.

Experience with biological scrubbers is somewhat mixed while long term, large-scale plants are somewhat limited. The unit requires careful selection of the bacterial strain, which is laboratory developed and enhanced for optimal performance. These units require more skilled attention than the average odor abatement unit, and have only been successful when operated within the design parameters by skilled and trained staff. This type of plant is very expensive to build and operate.

These units are suitable for aromatic type odors such as methylene chloride, ketones, alcohols, ethers and chlorinated aromatics, VOC and hydrocarbons. They are capable of reducing these odors down to parts per billion (ppb) levels if they are well designed and operated.

Thermal & Catalytic Converters

Designers of these units claim that this is the most important waste gas purification technology available. However, there are skeptics. The system takes odorous gases and burns them, supposedly destroying the process odors. In fact, they can introduce a host of toxins and noxious substances into the air.

A better process is to burn the odorous waste gas and then convert these dangerous gases into harmless substances by reacting them with specific catalysts. At certain temperatures, chlorine and hydrocarbon emissions form dioxins and furan. The waste gas is destroyed in a furnace-type process and the exhausted hot gases are dosed with a reaction solution that is usually ammonia-rich urea (that also cools the gas) and then fed into a separate vessel and reacted with catalysts to neutralize any toxins.

There has been a lot of development for different catalytic mediums, mainly for mediums such as "reduction" and "oxidation" catalysts. The gas is passed over (or through) these catalysts, converting residual gases into harmless compounds, usually carbon dioxide, nitrogen and water. One problem, even for well designed and operated systems is the problem of catalyst saturation and sterilization.

Incineration

National, regional and municipal departments as well as industries that create toxic waste are frequently confronted with the problem of waste disposal. This is because previously available low cost disposal practices, such as landfill sites and registered toxic dumps, are filling quickly so charges are rising and some disposal methods are no longer acceptable.

The process of destroying process and industrial waste by the incineration method can create toxins and more odors. The industrial waste gas to be destroyed is subjected to very high temperatures, usually around 1472°F (800°C). These gases are then subjected to conversion of the molecules with a resultant breakdown by the heat. This process changes the odor from a potent to a less potent form. In some cases, the injection of additional air is required but this can cause the lighter volatile gases to be released from the waste gas.

In addition to the danger of the heat involved, the method is very expensive, not always entirely effective, and generally introduces oxides and chlorinated odors into the atmosphere. The solution is to fit the incinerator with an afterburner, raising the temperature to about 2012°F (1100°C)—a very costly addition.

The incineration process is effective against organic odors, but less effective on hydrogen sulfide and ammonia odors.

Chemical Odor Neutralization –Airborne Applications

Chemical odor neutralization offers an economical alternative to other processes. Chemical odor control combines physical absorption with a sensory change to the olfactory receptor. The olfactory receptor is responsible for odor perception and recognition. Chemical neutralization changes the odor molecule's structure, effectively modifying it. And unlike chemical masking agents or perfumes that superimpose a pleasant fragrance on an unpleasant odor, odor neutralizers absorb and convert malodors resulting in no odor at all!

The performance of a chemical odor neutralizer is based on the type of odorous compounds, their concentrations, and the human threshold limit to detect the odors. OMI manufactures basically two aqueous emulsion products for airborne applications (non-additive): one broad spectrum product for most odors, including acids, bases and neutral compounds, and one specifically designed for styrene malodors and which has proven itself to be the more effective on most hydrocarbon (organic) compounds.

Ecosorb® eliminates a host of common malodors on contact including: H_2S, ammonia, sulfur dioxide, ethyl and methyl mercaptans, amines, styrene, and other less soluble odors.

Ecosorb® is a propriety formulation of several essential oils and a small amount of food grade surfactant. It is completely biodegradable, and safe to people, animals, and plant life. It is USDA (United States Department of Agriculture) approved and was tested against all the requirements of the US EPA (United States Environmental Protection Agency) standards for skin, oral and respiratory toxicity tests. Ecosorb® will not add VOCs to an emission source, nor will it react with other chemical compounds to create an air pollution problem.

Ecosorb® is an odor neutralizer. It is most often diluted with potable water and applied via atomization as a very fine mist directly into the odorous gas stream. The essential oils in the droplets combine to form a thin, electro statically charged film around each droplet. The make-up of this film attracts molecules that form the offensive odor. Odorous molecules are attracted and attach to the droplets where they are captured and neutralized by the essential oil mixture.

Ecosorb® application equipment is uncomplicated in construction and easy to operate, whether the application is out in the open, inside a building, in a duct system, discharging via a stack, or captured and cleaned inside a designed misting scrubber. The equipment is low maintenance and there is no storage, handling, or disposal of hazardous chemicals. Ecosorb® offers a cost effective and safe solution to most odor problems.

Odor Neutralization Additives

Odor neutralizing additives have been developed for various compounds. Many are specific in nature relative to what they are intended to control. For instance, an amine based additive has been tried in the asphalt industry to control the odors of hydrogen sulfide emitting from the asphalt. The result yields the unfriendly odor of ammonia.

Ecosorb® additives have been developed to neutralize the odors emitting from compounds that are not water tolerant. They are not designed with specific gasses in mind although some attention must be given by the engineer to the content of the host compound and its physical properties.

The mechanisms through which the Ecosorb® additives function are complicated and proprietary. There does exist some overlap in functional mechanism with the airborne application products, however the primary mechanism is suppression of odorous emission from the host compound.

METHODS

Ecosorb® does not require complex, specially designed equipment to administer the product into an odorous environment because it is multifunctional, broad based and completely non-hazardous. But system engineering is important. Whether the requirement is for dripping, fogging, dosing, injecting, or scrubbing, easy-to-use application equipment is available from many manufacturers and can be provided by your Ecosorb® distributor.

There are many effective methods to deliver Ecosorb® into an atmosphere to control malodor. The most suitable method will be determined by several factors such as:

- The type of odor to be controlled
- The source of the odor emission
- The size of the area to be controlled
- The possible presence of an existing odor control hardware system
- Ambient or process gas conditions
- Location of the target that needs to be protected from the odors (usually people)
- The flexibility of engineering facilities

Ecosorb® aqueous products (non-additive) are most effectively applied when atomized into odorous process air or open air near the source of a malodor. Since Ecosorb® is not a masking agent, the main challenge is applying it effectively so that it is capable of performing the odor neutralization. The challenge is not the neutralization act itself. Consider how the product works when atomized into odorous air. The malodor molecules and the droplets of Ecosorb® must come into contact with one another or be near enough for the electrostatic attraction to take over. Ultimately, the malodor must adsorb onto the droplet skin and/or be absorbed by the solubility mechanism of the odor control process. If enough malodor molecules remain free within the air above the odor threshold of the gas, the odor will not be controlled.

You will notice we use the term “atomized” not “sprayed.” The efficiency of Ecosorb® increases with the reduction in applied droplet size. For airborne application, it is best to target a droplet size of less than 25 microns with less than 10 microns most desirable. Therefore, to improve product efficiency and optimize consumption rates, one must pay attention to application atomization. Simple spray equipment will cause the product to be less effective and result in a higher consumption rate. (See “Atomization Nozzles” later in this section.)

The following example explains the importance of small droplet size in the performance of the odor control system. Consider the difference in surface area between 10-micron and 1000-micron droplets. The ratio of the diameters is 100. The surface generated changes as the square of that ratio, or for the same amount of liquid, 10-micron droplets will generate 10,000 times the amount of surface area as 1000-micron droplets. For a fixed volume of liquid, there are more droplets and surface area available to absorb the odor molecules.

Dr. Donald Wilkinson of Delaware State University (USA) developed a model that considers the primary variables of Ecosorb® odor control technology. Solubility is the first mechanism in odor control. Because of the way Ecosorb® works, the malodor gas must be solubilized into the atomized droplets of

Ecosorb® for a reaction to occur. The efficiency in removing malodors is proportional (˜) to the solubility of the malodor. Or stated another way, we can improve removal efficiency by increasing solubility of the atomized droplet.
Manipulating the following variables does this.

1. Increase the concentration of Ecosorb® [CONC] (dosage rate)
2. Decrease the size of the atomized droplet [SIZE]
3. Increase the contact between malodor and droplet [TIME]
4. Increase velocity of droplets and therefore impact velocity [VEL]
5. Change polarity of the droplet [POL] (we usually have little control here)

These relationships can be summarized as follows:

$$\text{SOLUBILITY } \frac{[\text{CONC}]\ [\text{TIME}]\ [\text{VEL}]\ [\text{POL}]}{[\text{SIZE}]} \text{ EFFICIENCY}$$

Ideally we want a high concentration of Ecosorb®, a long contact time, and a small, high velocity droplet. Unfortunately, this is not always the case and one needs to optimize the variables that are controllable in order to make up for those that cannot be controlled.

The types of delivery apparatus can vary from a simple fogging machine carried around from site-to-site to complex metering, injection and recovery systems used in large scale air handling systems. Ecosorb® can be applied numerous ways to numerous settings including oil refineries, wastewater treatment plants, processing plants, landfills, and industrial plants of all kinds. Because of Ecosorb®'s application flexibility, existing odor control hardware can occasionally be adapted to disperse the product to required areas. This adaptation further reduces capital costs by keeping existing equipment from becoming redundant.

Indoor, Ecosorb® can be diluted and applied topically, in atomized phase or vapor phase to eliminate malodors in confined composting, water treatment, sludge treatment, solid waste handling, and industrial process areas. An Ecosorb® program is an inexpensive solution that provides a more pleasant, productive work environment.

Outdoors, Ecosorb® controls odors from aeration ponds, lagoons, sludge pits, landfills, remediation sites, and industrial sites. Ecosorb® systems are highly effective in breaking down odors and eliminating foul fumes that may travel to surrounding areas. It is a very cost effective form of treatment.

Ecosorb® often replaces air scrubbers and other more elaborate odor control equipment used to deodorize stack emissions. Where scrubbers are installed, Ecosorb® can be used as a safe, effective odor control substitute for potentially hazardous sodium hypochlorite, caustic, or blended cleansing solutions. It can also be used as a secondary polishing agent. Little equipment alteration is necessary to quickly install an Ecosorb® system in almost any plant.

Below describes a variety of application hardware and delivery apparatus that gives the design engineer a starting point to examine potential application systems.

Atomizing nozzle

The use of atomizing nozzles is has been the most common form of dispersing diluted product into an atmosphere. Several manufacturers have nozzles available to atomize Ecosorb® to an adequate droplet size for reasonable product efficiency. Nozzle performance varies from one type to another. Once Ecosorb® is atomized, it is dispersed into an air stream and given the opportunity to find and react with the malodor.

Nozzles can be used indoors fixed to walls, scaffolding, or framework. They can also be assembled within a scrubbing system, air handling system or emission stack using either a string of nozzles or a cluster system. Nozzles can be attached to building perimeters, building openings, load out transfer areas, or hung loosely around odor producing process areas. Nozzle systems are also used on perimeter fencing as a last resort to control odors that are escaping from many points within a site.

Simple nozzle systems, both high-pressure hydraulic and air-operated, can be adapted to suit most industrial applications where a fixed/continuous source of odor control is required. Often a larger number of nozzles or nozzles with a greater delivery rate can be installed to expand a system.

Portable atomizers

Hand pumped atomizers (used in agriculture and pest control) can be used to deliver Ecosorb® to areas where constant odor control may not be required, for simple topical applications, and where power may not be available. Small electric handheld atomizers of varying capacity can be used to deodorize small and large localized areas. The use of hand pumped atomizers with portable fogging machines offers the consumer maximum portability and coverage with a minimum of outlay.

Hollow bladed fan

The hollow bladed fan is a unique product designed as a humidifier for the agricultural industry but with the capacity of dispersing a diluted or concentrated form of Ecosorb® into open air. The fan system is available with an oscillator to ensure the even disbursement of Ecosorb®.

The hollow bladed fan system is primarily used in enclosed areas of up to 3,000 square feet and can be installed in series with other fans to cover larger areas. These units have also been used in wet wells or sewage treatment stations. This practice has grown in popularity due to the simplicity and reliability of the fan system.

Vapor phase systems

True vapor phase odor control systems provide a simple, effective method for transforming Ecosorb® into a vapor state that can be easily transmitted into malodorous situations. These systems vaporize up to 100% of the Ecosorb® for maximum product utilization. In addition, they do not use large amounts of water. This is very important in instances where added moisture and humidity is unacceptable. Nozzle systems, and to a lesser extent fan systems, add visible moisture to the process air. A true vapor phase system will add the least amount of moisture while doing an excellent job of delivering Ecosorb®. Vapor phase systems can be used both indoor and outdoor where the odor source is easily isolated.

Scrubbing systems

Ecosorb® can replace a wide range of odor control chemicals used in scrubbing systems. Ecosorb® offers an environmentally friendly substitute to dangerous chemicals currently used in the majority of scrubbers since it is non-toxic, biodegradable and safe to use.

Prior investigation of relevant odor control regulations and odor control requirements may save a company millions of dollars by not installing costly scrubbing systems in the plant. It is possible that a simple injection or fogging process utilizing Ecosorb® will allow the company to meet or exceed local odor emission regulations while saving extensive costs.

In all cases, Ecosorb® should be evaluated as an independent odor control method. A simple process that uses inexpensive current technology may control situations formerly requiring large capital outlay. When selecting your equipment, we suggest that you refer to Tables 3.3, 3.4, and 3.5 to ensure material compatibility and equipment longevity.

Tables 3.1 and 3.2 contain examples of equipment currently used to solve various odor problems. These are guidelines only as each application drives the correct equipment selection.

Table 3.1: Typical applications and delivery equipment

	Portable Fogger	**Compressed Air Atomization**	**Hydraulic High Pressure**	**Hollow Bladed Fan**	**Wide Swath Sprayer**	**Vapor Phase System**
Air Handling Systems		X	X			X
Building Fire Clean Up	X	X	X	X		X
Chemical Processes		X	X			X
Chemical Spills	X	X		X	X	
Clarifiers		X	X			X
Composting		X	X		X	
Explosive Environments		X	X	X		
Composite Fabrication		X		X		X
Food Processing Areas				X		X
Head Works		X	X	X		X
Industrial Oily Waste Processing		X		X		X
Landfills			X		X	
Livestock Pens		X	X	X		X
Paint Booths		X	X	X		X
Paper and Pulp Mills		X	X	X		X
Ponds and Lagoons			X			
Pump Stations		X	X	X		X
Refineries		X	X			
Rendering Plants		X	X	X		X
Screens		X	X			
Scrubbers		X	X			X
Septage Handling		X	X			
Sludge Dewatering		X	X	X		X
Soil Remediation			X		X	
Solid Waste Transfer Station		X	X	X		X
Wet and Dry Wells		X	X			X

Table 3.2: Application apparatus

Application Apparatus	Situation
Hand Pump Atomizer	Odors emitting from small areas that do not require constant treatment.
Electric Portable Atomizer	Small areas requiring regulated use.
Agricultural Wide Swath Sprayer	Landfill operations and other large moving target applications such as soil remediation.
Hollow Bladed Fans	Atomization of enclosed areas and/or where adding moisture to the air is undesirable (such as foundries and composites fabrication facilities).
High-Pressure Atomizing Nozzle Systems	Wastewater, open air applications, stacks, and enclosed odor intense areas, where ambient moisture addition is not a problem.
Pneumatic Atomization Nozzle Systems	An industrial and wastewater application, where adequate compressed air is available and ambient moisture addition is not a problem.
Vapor Phase Atomization System	Indoor, outdoor, plus some duct and stack applications, where odor sources can be isolated and moisture addition is undesirable.

Table 3.3: Compatibility of tubing and pump heads with Ecosorb®

Material	Compatibility
Neoprene Tubing	Unsatisfactory
C-Flex Tubing	Satisfactory
Silicone Tubing	Unsatisfactory
Tygon Tubing	Unsatisfactory
Viton Tubing	Satisfactory
Polycarbonate Pump Head	Satisfactory
Polyphenylene Sulfide Pump Head	Satisfactory

Table 3.4: Chemical resistance of resins to Ecosorb®

Resin	Resistance
Low density Polyethylene	Not recommended
High Density Polyethylene & Cross Linked High Density Polyethylene	Not recommended for long term exposure >60days.
Polypropylene/Polyallomer	Some effects after 7 day exposure
Polymethylpentene	Some effects after 7 day exposure
Polymethylmethacrylate	Not recommended
Polyvinyl Chloride	Some effects after 7 day exposure
Acetyl (Polyoxymethylene)	Some effects after 7 day exposure
Nylon (Polyamide)	No damage after 30 day exposure
Polycarbonate	No damage
Polysulfone	Not recommended
Tetrafluoroethylene (Teflon)	No damage
Polypropylene	No damage
Ethylene Tetrafluoroethylene Tefzel	No damage
Ethylene Chlorotrifluoroethylene Copolymer Halar	No damage
Perfloroalkoyl Teflon	No damage
Polyurethane	Not recommended
Ployvinylidene Fluoride	No damage after 30 day exposure
Polystyrene	Not recommended

Table 3.5: Compatibility of Ecosorb with common construction materials.

Material	Compatibility
Epoxy	Excellent
Acetal (Delrin)	Not recommended
Phenolic	Excellent
Nylon	Moderate effect
Stainless Steel 316 & 440	Excellent
Cast Bronze	Fair
Carbon/Ceramic	Excellent
Seals	
Viton	Excellent
Buna	Fair
Neoprene	Not recommended
Nitrile	Fair
Natural Rubber	Not recommended
Hypalon	Not recommended
Kel F	Not recommended
Tygon	Not recommended
Silicone	Not recommended
Ceramic	Excellent
Carbon/Graphite	Fair

Ecosorb®Additives

Ecosorb® additive products are designed for direct addition into odorous compounds that are not water tolerant. The Ecosorb® aqueous emulsion products, while designed primarily for airborne applications, have been used as additives and in topical applications, but will simply not compound into many materials such as resins, bituminous products, fuel oils, plastics and the like. It is in these applications where the additive specific products find use. While the aqueous emulsion Ecosorb® products contain essential oils, water and a small amount of food grade surfactant, the additive products contain similar essential oil blends, no water and surfactants, but instead an environmentally friendly, biodegradable, plant based dilutant.

The dosage rate for these odor neutralizing additives varies with the compounds into which they are added, the use application, and the strength of the additive. For example, a metal casting resin with the need to control the odors of an amine based catalyst receives a dosage of a relatively strong additive at a rate of 0.5% to 1% of the total resin weight. The lesser strength Ecosorb® Asphalt Additives typically are added to the liquid asphalt binder at a rate of 1 part to 10,000 parts of binder (100ppm).

Typical examples of industries, where the Ecosorb® additives are used, are metal casting, paving asphalt, roofing asphalt, rubber tire recycling process, machining cooling oils, and plastics.

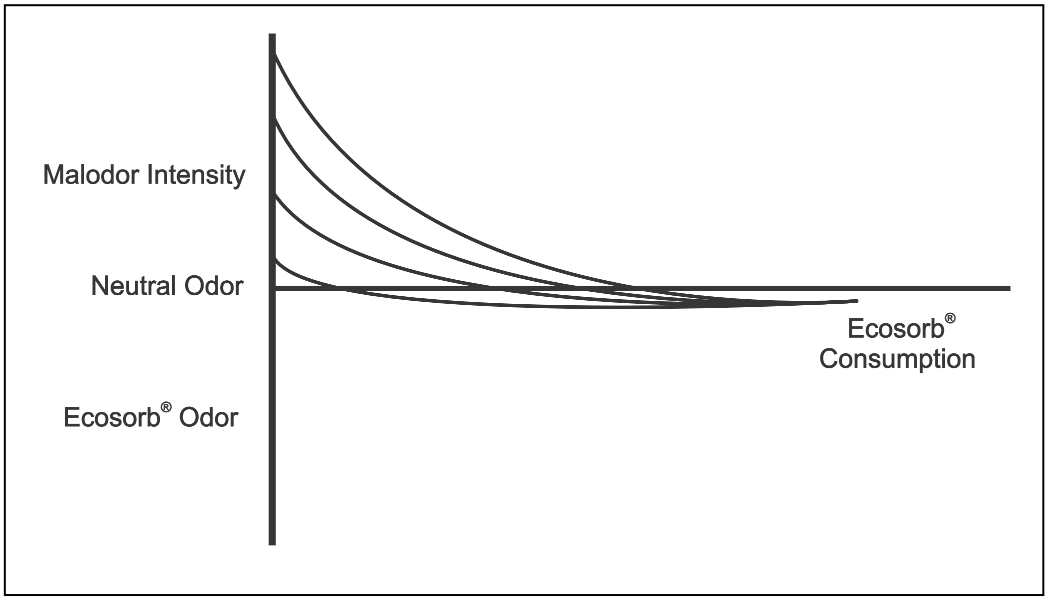
Dosing techniques for the additives vary from the simplest of manual addition to more complicated yet simple automated metering systems.

APPLICATION INFORMATION

The quantity of Ecosorb® required for odor control depends on the volume and intensity of the malodor source. The correct application and dilution rate will create an atmosphere where neither the malodor nor the Ecosorb® scent is noticeable.

The graph below demonstrates that an increase in Ecosorb® consumption directly relates to a reduction of malodor sensitivity. Once the equilibrium point of "neutral odor" is reached, an increase in the Ecosorb® use, results in an Ecosorb® scent within the surrounding atmosphere.

Figure 3.1: Ecosorb® consumption for control of malodors



Once the neutral point is reached, many clients lose the perception that an odor problem exists or that Ecosorb® is working effectively. OMI suggests that you increase the Ecosorb® level slightly beyond the equilibrium point so that a slight hint of the product is noticeable to the operators. This will become their guideline if the unit requires more or less Ecosorb® in the environment.

The most effective addition and dilution rates for Ecosorb® need to be determined on-site. The level of malodor present determines the Ecosorb® level required. The determining factors are odor composition, efficiency of the delivery system, airflow rates, probability of contact between droplets and odor molecules, contact time and reaction time.

ATOMIZATION NOZZLES

Design engineers have two options when specifying nozzles. They can utilize the recommended nozzles in this manual or they can specify their own. If an engineer specifies their own nozzles, they need to pay attention to the nozzle droplet size. OMI recommends a droplet size of less than 25 microns with an optimum of less than 10 microns. Numerous nozzle manufacturers exist who will tell you their nozzles provide such a fine spray. However, their nozzle may not provide the best atomization capabilities. The fact is that all nozzles produce a spectrum of droplet sizes and OMI needs to specify the nozzle that provides the highest volume in the size range needed.

Spraying Systems Company provides "Spray Particle Definitions" below.

> **Drop of Particle Size:** A measure of the droplet size such as diameter, weight, or volume. It can be expressed as the Median Volume Diameter (MVD), Mass Median Diameter (MMD), Sauter Mean Diameter (SMD) Median, or Mean Number Diameter (MND).
>
> **(MVD) Median Volume Diameter:** A means of expressing particle size in terms of the volume of liquid sprayed. The median volume diameter particle size when measured in terms of volume (or mass) is a value where 50% of the total volume of liquid sprayed is made up of drops with diameters larger than the median value and 50% smaller than the median value.
>
> **(SMD) Sauter Mean Diameter:** A means of expressing the fineness of a spray in terms of the surface area produced by the spray. The Sauter Mean Diameter expresses a uniform drop size diameter in terms of the actual total surface area as produced by the totality of drops in a given spray. The Sauter Mean Diameter is obtained by summing all the surface areas of all the drops produced by a given spray and all of the volumes of all of the drops. Then dividing the total volume by the total surface area and finding the diameter of a drop having the same volume to surface area ratio.
>
> **(MND) Median Number Diameter:** A means of expressing particle size in terms of the number of particles in the spray. This means that 50% of the particles by count or number are smaller than the Median and 50% of the particles are larger than the given diameter.
>
> **(MND) Mean Number Diameter:** Or average particle size. A means of expressing particles size in terms of the actual number of particles counted and measured and obtaining a simple arithmetical average by dividing the actual number of particles into the number of size classes and obtaining a mean or average size.

Of all the particle size expressions listed, the most useful terminology for the general description of spray appears to be the Median Volume Diameter. This deals with volume of liquid sprayed and weighs the given diameter in the direction of where the significant portion of the liquid sprayed will be found.

WATER QUALITY

One must pay close attention to supply water quality in all atomization systems, especially when specifying nozzle type systems. Atomization nozzle design usually includes small diameter orifices (0.008” typical) and narrow passages (0.020” common). Untreated potable water will always cause nozzle blockage. Water with Total Dissolved Solids (TDS) counts exceeding roughly 200 ppm or with high calcium should be treated in order to prevent excessive nozzle blockage. If water quality is questionable, it is worthwhile to obtain a water analysis report from a specialist and make treatment or filtering recommendations based on factual information. Should you find it necessary to treat the water, we recommend softening the water or reverse osmosis (RO) filtration. Deionized water is not recommended because it is aggressive and can affect pumps and other components.

SECTION 4

ODOR CONTROL EQUIPMENT

ODOR CONTROL EQUIPMENT

HYDRAULIC HIGH-PRESSURE SYSTEMS

Hydraulic high-pressure systems are the system of choice for most outdoor installations and even some indoor installations. These systems provide good atomization through patented nozzle design, are simple to specify and design, and are simple to install. They should always be specified with an adjustable, automatic Ecosorb® proportioner, which injects full strength Ecosorb® into the low-pressure water stream.

The atomization nozzles are commonly installed in a flexible ¼ inch (6 mm) ID hose, available with a large selection of nozzle spacing's. Stainless steel hose line may also be used. Similarly, a flexible feed/manifold line is used with these systems. The feed/manifold line is typically ¼, 3/8, or ½ inch (6, 10 or 12 mm) in diameter, depending on flow needs and line length versus pressure drop requirements. It is recommended that the flexible hose section terminations be fitted with male, female, and female swivel reusable hose fittings. Standard brass or stainless steel fittings can be used throughout the system. Galvanized fittings are not recommended due to corrosion and subsequent nozzle plugging.

Figure 4.1: High Pressure Feed System

Nozzle plugging is a concern in all atomization systems. Attention to water quality and good water filtration will help with this potential problem. The standard high-pressure systems described are all provided with at least two stages of water filtration: 20 micron and 5 micron. When designing a system, it is important that this level of water filtration be specified.

System Sizing and Selection

To correctly size and specify a Hydraulic High Pressure system, one must first define the area to be covered and the location of the atomizing nozzles in order to cause Ecosorb® to come into contact with the malodor. If the installation is open air, the engineer must consider nozzle location in relation to the odor source, areas to be protected from the odors (neighbors), prevailing and secondary wind conditions. Figure4.2: Paper industry Ecosorb®

Figure 4.2: Paper industry wastewater plant surrounded by nozzle system misting Ecosorb®

Often, we place a nozzle line with controls around the entire perimeter of an odor source, such as a wastewater pond. This allows us to deliver atomized Ecosorb® to about 60% of the perimeter when the prevailing winds are in effect. When the air moves in an unusual direction, it becomes necessary to engage the remainder of the system. Occasionally it makes sense to install atomization nozzles in a straight-line configuration perpendicular to the prevailing wind and between the odor source and the areas being protected. For example, this installation might be along a fence or roofline. Overall, the most effective wastewater plant surrounded by nozzle system misting equipment placement is to place the atomization nozzles as close to the odor source as is possible. In dealing with an exhaust stack or scrubber, the odors are confined to a given space and the airflow volume becomes a variable for us to deal with.

Nozzle spacing is not critical, as long as we consider that Ecosorb® must simply come into contact with the malodor. However, if one takes a conservative approach and locates the nozzles closer together than necessary, it is possible to increase the Ecosorb® dilution rate to prevent excess product usage. If nozzle spacing is set too far apart in order to minimize equipment costs, increasing the Ecosorb® concentration may be inadequate to sufficiently overcome the odor molecules that are bypassing the Ecosorb® molecules. A conservative suggestion is to space the nozzles 3 to 5 feet (1 to 1.5 meters) apart. Consult your Ecosorb® distributor for further advice on a particular application.

Once you have selected a protection pattern and nozzle spacing, you can select the appropriate pump system assembly. The number of nozzles and anticipated operating pressure will determine flow requirements, which then leads to pump selection. Table 4.1 provides operating specifications for some standard systems available from your Ecosorb® distributor. Consult your distributor for larger systems.

Table 4.1: Operating specifications for standard Ecosorb® systems

Model No.	Flow		Motor		Electrical Details 60 HZ	Electrical Details 50 HZ
	GPM	**LPM**	**HP**	**kW**	**1 & 3 Phase**	**1 & 3 Phase**
EC 0.25	0.25	0.9	0.4	0.3	110	N/A
EC 1.0	1	3.7	1.5	1.1	110/220/460	240/380
EC 2.2	2.2	8.3	2	1.5	110/220/460	240/380
EC 3.0	3	11.3	3	2.2	220 – 1 ph only	240
EC 3.9	3.9	14.8	5	3.7	220/460 – 3 ph only	380
EC 5.0	5	18.9	5	3.7	220/460	380
EC 7.3	7.3	27.6	8	6	220/460	380
EC 9.3	9.3	35.2	15	11.25	220/460	380

Systems must operate in the 800 to 1000 psi (55 to 70 bar) range in order to obtain the 10-micron (or less) droplet size that provides the best Ecosorb® efficiency. The pump used for this relatively high-pressure is a plunger type, positive displacement style that is cooled by the liquid flowing through the pump. Therefore, one must consider the expected flow rates of a system to select the appropriate pump so that adequate flow is maintained. If a system is designed that provides inadequate flow for a given pump, such as through over sizing a pump or designing a system with multiple downstream circuit control, the discharge pressure regulator within the system will bypass liquid back into the low-pressure liquid stream. This design feature provides flexibility in the number of nozzles a single pump can support up to its maximum flow capability at the particular operating pressure.

The design engineer has a 30% design margin to work with. For instance, if a particular pump has the capability of supplying 1 gpm (4 LPM), then the system can be designed to operate from 0.7 gpm to 1.0 gpm (2.8 LPM to 4.0 LPM) continuously. However, asking a 1 gpm (4 LPM) pump to operate endlessly at 0.7 gpm (2.8 LPM) will likely degrade the long-term reliability of the pump.

If a pump operates with too low a flow to adequately remove the heat energy normally transferred into the liquid stream, the pump operating temperature will increase. Should the operating temperature exceed 140° F (60° C), a safety dump valve will open releasing liquid (diluted Ecosorb®) into a drain.

High-Pressure Nozzles

Nozzle flow rate is a function of operating pressure. The most common nozzles diameters are the 0.008”, 0.012”, and 0.020” (0.20 mm, 0.30 mm, and 0.50 mm). The flow capacity of these nozzles is shown in Table 4.2.

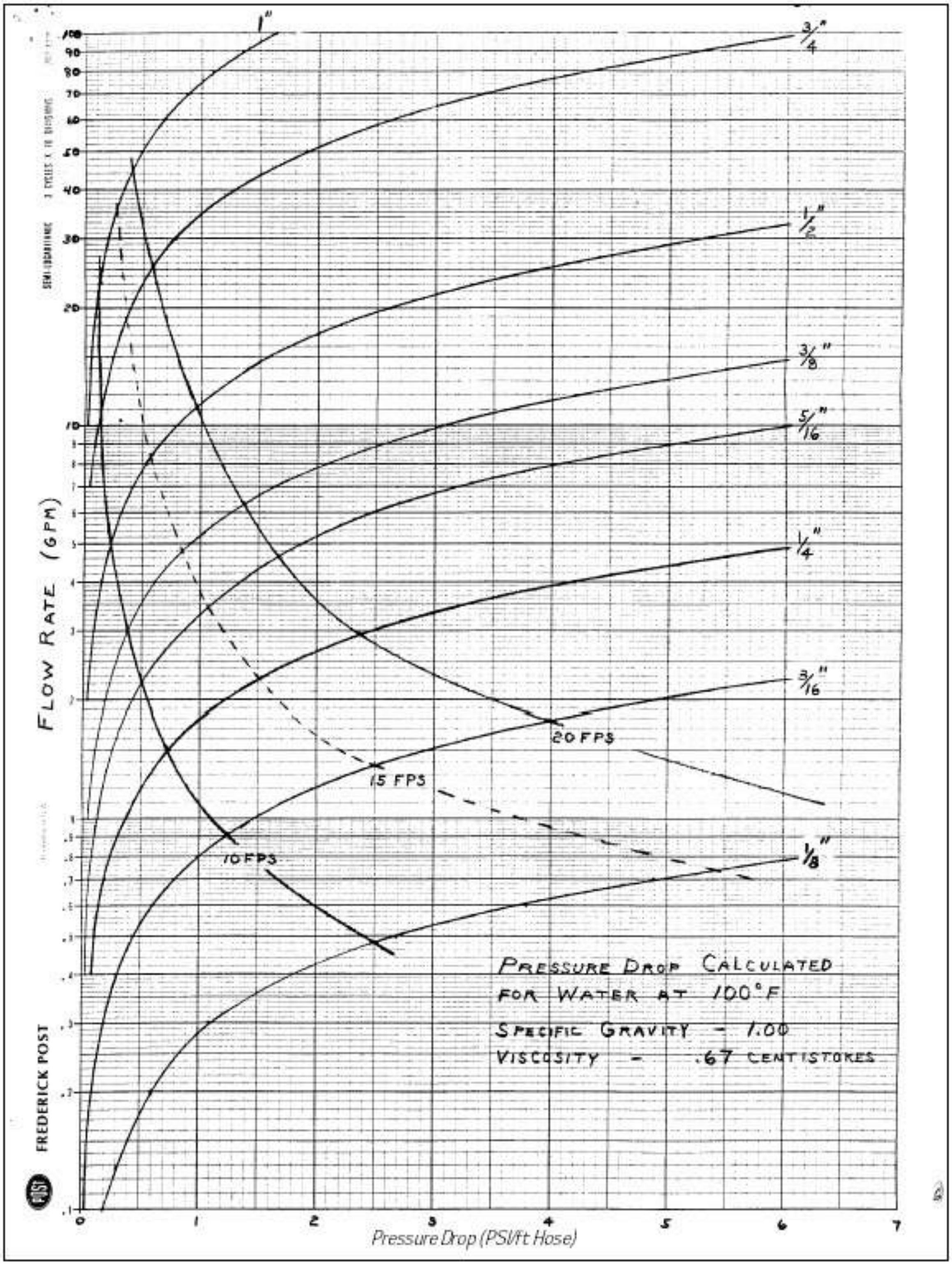
Good engineering practices require the designer to pay attention to pressure drops in the system. We have some latitude here since we can operate within a pressure range without significant impact. However, we should know what type of pressure drop to expect within a given system design. To help with this, the hose manufacturer provides Figure 4.3. The nozzles themselves will cause a minute pressure drop per nozzle (due to turbulence at the nozzle tip), but this will be insignificant when compared to the system pressure drop, provided the designer selects a pump with adequate capacity to supply all the nozzles.

At this point you should be ready to select and specify your system. **Don’t forget the pressure drop across all those fittings!**

Table 4.2: Nozzle Diameter and Flow Capacities

Operating Pressure PSI (bar)	**Flow in US gpm (LPM)**		
	Nozzle Diameter 0.008" (0.20 mm)	Nozzle Diameter 0.012" (0.30 mm)	Nozzle Diameter 0.20" (0.50 mm)
800 (55)	0.0209 (0.079)	0.0344 (0.130)	0.0576 (0.218)
900 (60)	0.0222 (0.084)	0.0365 (0.138)	0.0611 (0.231)
1000 (70)	0.0235 (0.089)	0.0384 (0.145)	0.0644 (0.244)

Figure 4.3: Flexible hose pressure drop



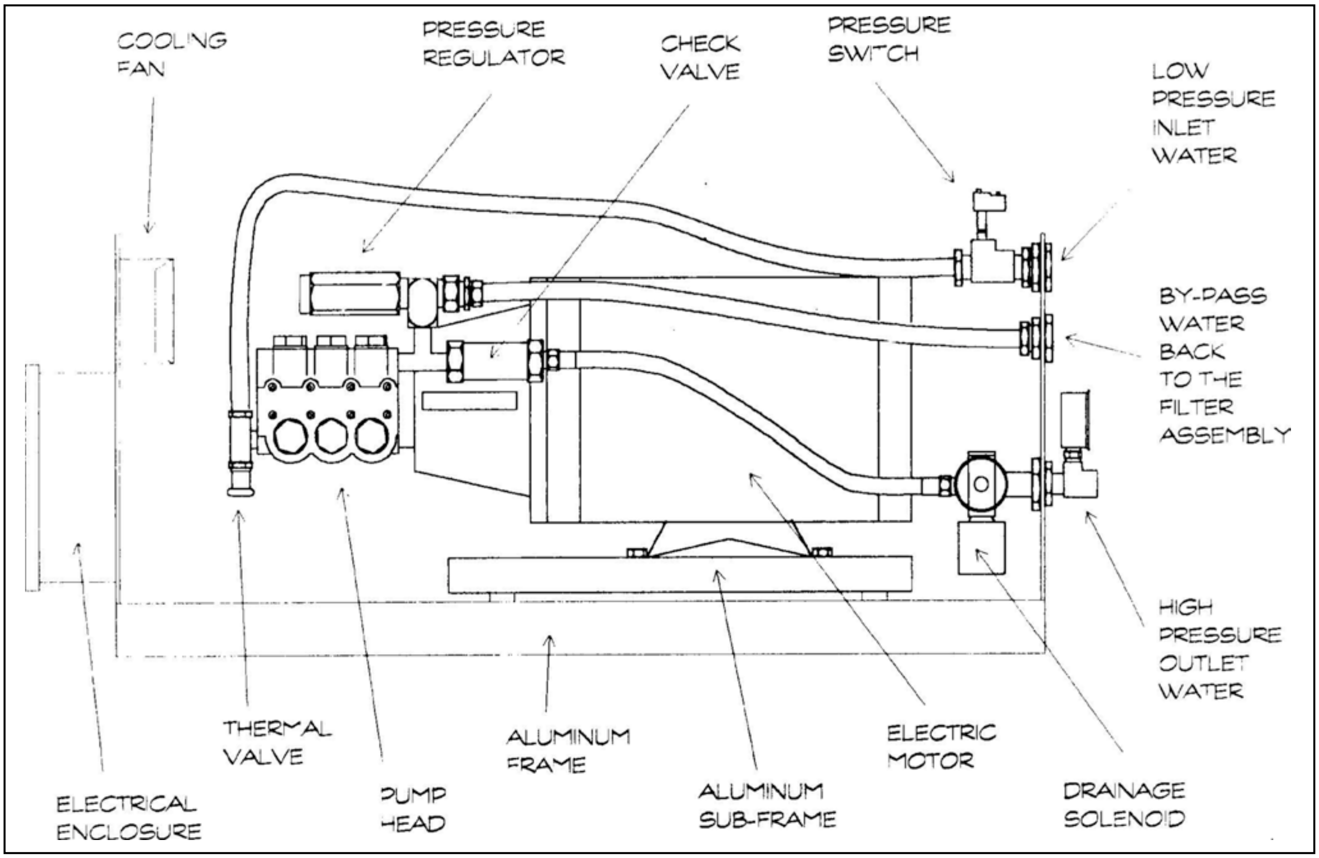
PRESSURE DROP CALCULATED
FOR WATER AT 100°F
SPECIFIC GRAVITY - 1.00
VISCOSITY - .67 CENTISTOKES

Pump Module Equipment Layout[1]

Equipment layout for modules EC1.0 to EC9.3

Figure 4.4 provides a general layout of the equipment found on the smaller direct-driven range of ECS&P pumping equipment. It is important to familiarize yourself with this module's equipment location and function. This will help you better understand the operation of the fog system.

Figure 4.4: Typical high-pressure pump layout



[1] Environmental Control Systems & Products Manual.

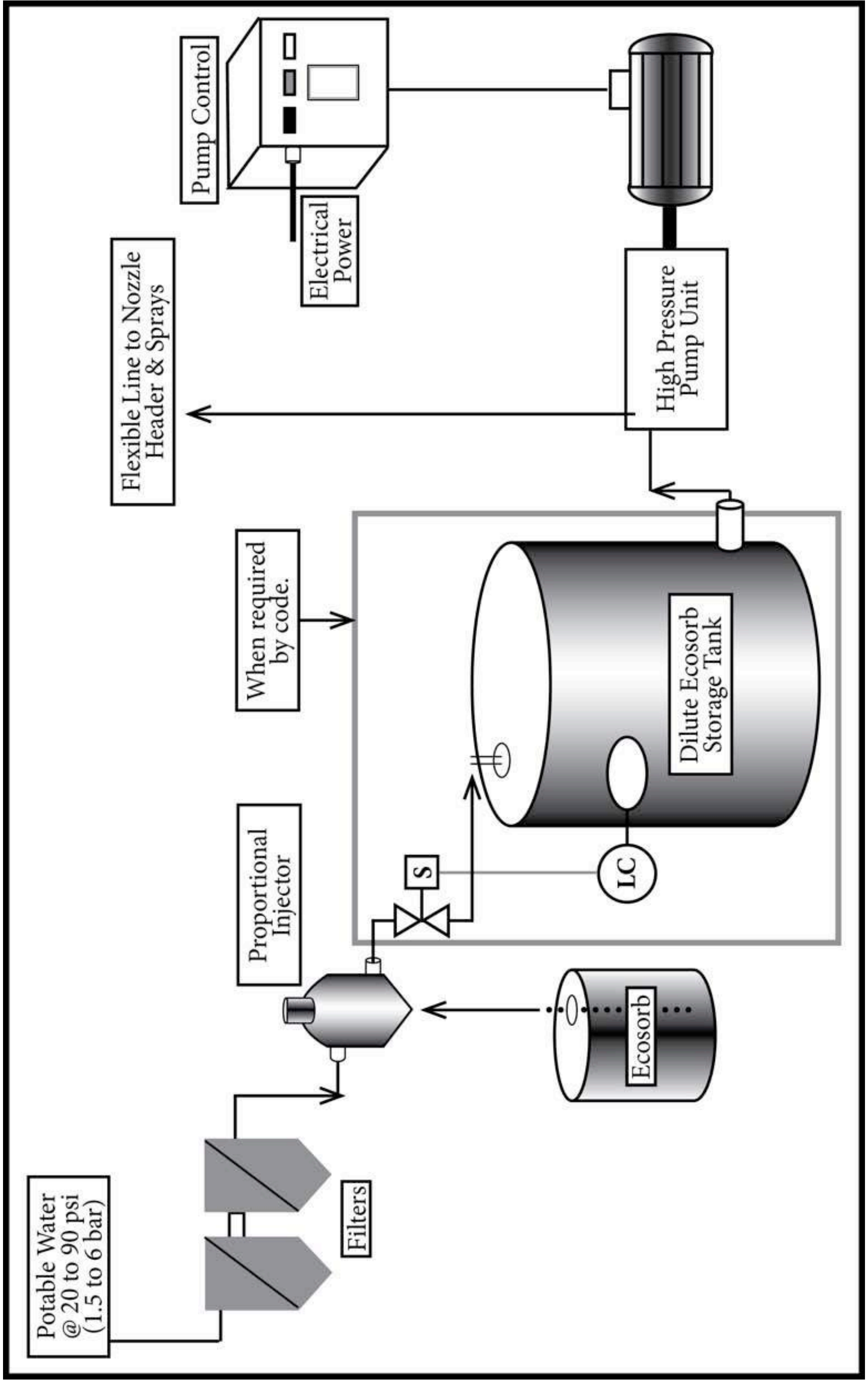


Figure 4.5: High Pressure Odor Control System, designed & supplied by ECS&P

Module Shipping Dimensions and Weights

Table 4.3: ECS&P Pump System Dimensions and Weights

Module		**EC 1.0/2.2/3.0**	**EC 3.9/5.0/7.3/9.3**
Dimensions	Inches	40" x 24" x 34" (L x B x H)	45" x 24" x 39" (L x B x H)
Weight	Pounds	240	260
Complete unit, incl. Pump/Control Box/Injector/Water Filters & 300 ft hose. Additional hose – add 10 lb. / 100ft			

Table 4.4: ECS&P Hydraulic Atomization Units, Nozzle Minimums & Maximums

Model Number	**0.008 Nozzle Capacity**	**0.020 Nozzle Capacity**
EC 0.25 Mini - Pump	1 - 10 Nozzles	1 - 3 Nozzles
EC 1.0	20 - 45 Nozzles	5 - 11 Nozzles
EC 2.2	50 - 100 Nozzles	12 - 24 Nozzles
EC 3.0	70 - 136 Nozzles	16 - 33 Nozzles
EC 3.9	85 - 175 Nozzles	20 - 42 Nozzles
EC 5.0	110 - 227 Nozzles	25 - 55 Nozzles
EC 7.3	150 - 331 Nozzles	40 - 81 Nozzles
EC 9.3	200 - 442 Nozzles	50 - 103 Nozzles

PNEUMATIC (COMPRESSED AIR) ATOMIZATION NOZZLE SYSTEMS

Compressed air atomization nozzle systems provide an excellent method to deliver atomized Ecosorb to an application. The systems are simple in design and easily installed. The largest single advantage of air atomization nozzle systems is their ability for control—the higher the air pressure (the smaller and faster the droplet size and the higher the liquid pressure), the greater the volume of product that can be disbursed offering a system suitable for duel operation. As an added benefit, these systems can be and often are designed to operate without electrical power, making them ideal for potentially explosive environments. The systems require facility compressed air.

Figure 4.6: Pneumatic Atomization Nozzle System

Pneumatic atomization systems utilize "air atomizing" nozzles that are manufactured by companies such as *Spraying Systems, Delevan, Delta and Bete* and are available through your Ecosorb distributor. Compressed air is mixed with the Ecosorb liquid stream within the nozzle, producing a completely atomized spray. System design is typically a pneumatic design where one must deal with pressure regulation, flow control, compressed air quality, and pneumatic plumbing.

General rules regarding nozzle location and spacing are the same as described in the "Hydraulic, High Pressure Systems" section of this manual. The challenge is the same; get the Ecosorb into contact with the malodor molecules.

Figure 4.7: Atomizing Nozzles

When specifying an air atomization system, pay close attention to air consumption since you could be applying a somewhat significant load on the facility system, and with the sizing of the air header. The most common nozzles used in many Ecosorb systems are the Spraying Systems 1/4J SU11, and the BETE 1/4- PR050. Typical operating pressures are in the 20 to 30 psi (1.5 to 2.0 bar) range, for both liquid and air. The nozzle catalogue data sheets in Figure 4.10 and Tables 4.5 and 4.6 provide you with liquid flow rates in GPH so that you can estimate Ecosorb consumption. As always, dilution rates will vary with the application. Deciding which nozzles to specify is a function of application and facility capacities. The nozzle data sheets point out that a selected nozzle can be adjusted to cover a wide range of spray capacities merely by increasing or decreasing the air pressure.

Figure 4.8: Flowmax series nozzles

The Flomax® series of nozzles (Figure 4.8) offers a better solution for applications where there is a larger airflow (i.e. stack application) that requires many nozzles and/or air supply is limited. Contact your Ecosorb distributor for assistance with these applications.

Nozzle spacing is questionable, as it is in high-pressure systems, since it is application dependant. However, too wide a spacing and therefore too few nozzles may be more difficult to correct than too many nozzles spaced conservatively close. Close spacing can be compensated for through higher Ecosorb dilution, but at the expense of increased air consumption.

Since atomization takes place within the delivery nozzle (by mixing compressed air with the Ecosorb solution), it is necessary to plumb both compressed air and liquid to the nozzles. Thus, a manifold system is recommended. Ecosorb needs to be pumped under regulated pressure to the nozzle manifold system. Selecting a pump, electric or pneumatic, is a simple process of considering flow, pressure, and material requirements. Similarly, one needs to specify pressure regulation and flow control. An "ECS&P" package unit—the Air Atomization and Control Box—is available from your Ecosorb distributor. It combines these components into a turnkey unit assembly.

The liquid supply pump, shown in Figure 4.11, is an air driven diaphragm pump that requires no electricity. This is a self-priming pump that may be located several feet from the Ecosorb solution tank, above or below the liquid level. The pump is rated for a maximum head of 200 ft (7.0 meters), but the NPSH must be limited to 6.0 ft (1.8 meters). Additionally, it is recommended that the pump to be set to operate at 1.5 times larger than the actual flow requirements in order to enhance long term reliability. The air supply to the pump should be oil free and dry.

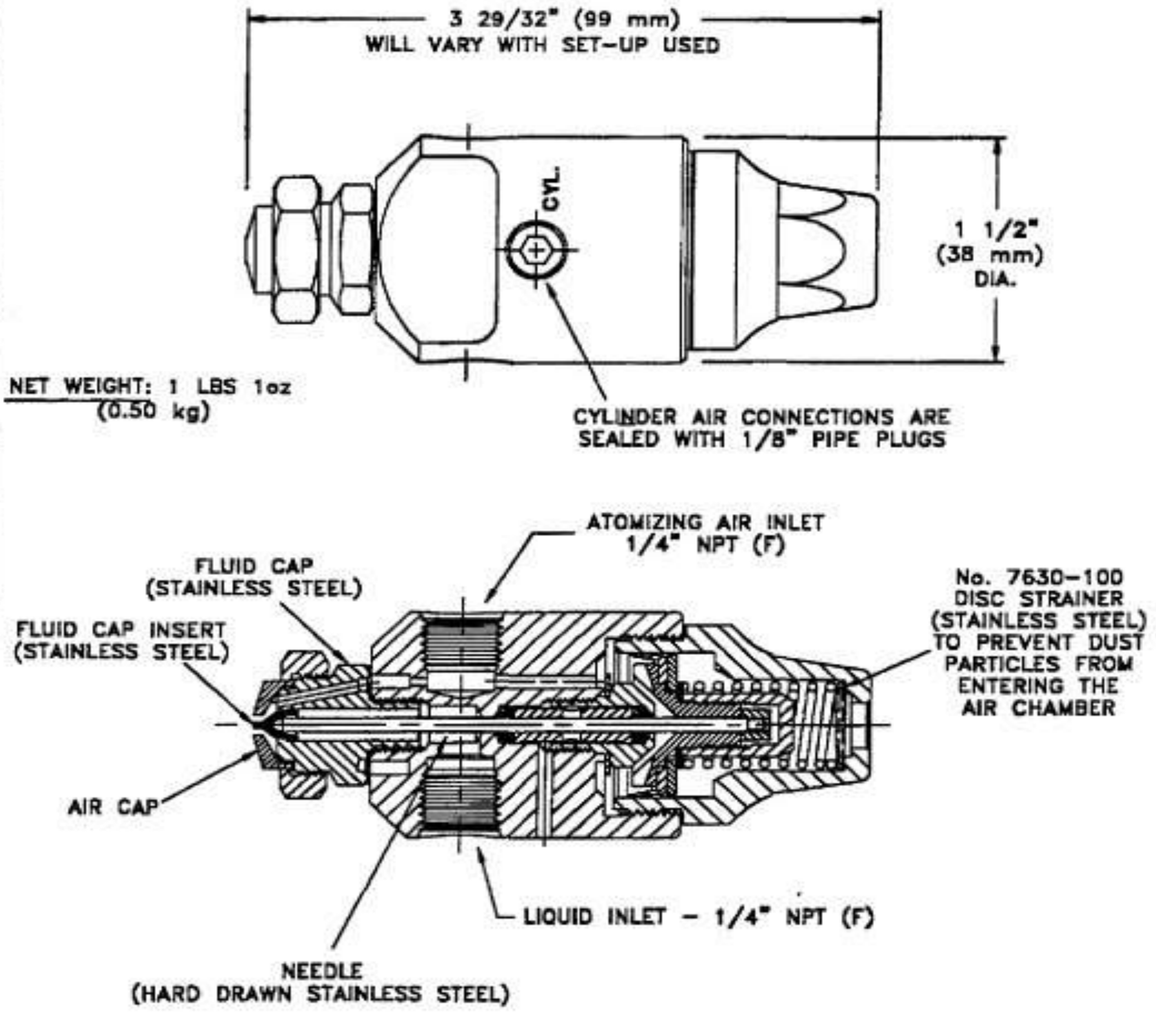
It is recommended that you take its air consumption into consideration when analyzing the load on the facility compressed air system. The pump air consumption is relatively low but does add to the facility load. Additionally, the pump liquid specifications must be compared to total nozzle consumption.

If the design engineer is specifying a relatively large system, inadequate air and liquid supply could be a nasty surprise. The design engineer will need to specify additional pump and control components if greater air or liquid flow is needed. Or, the design engineer can divide the system into multiple circuits.

An air operated mobile (portable) unit is available from ECS&P, Figure 4.9. The Mobile Odor Response (MOR) system is an effective method of meeting or being prepared for a potential odor problem at small or large facilities—from oil refineries to chemical manufacturers or landfill operations.

An air operated mobile (portable) unit is available from ECS&P, Figure 4.9. The Mobile Odor Response (MOR) system is an effective method of meeting or being prepared for a potential odor problem at small or large facilities—from oil refineries to chemical manufacturers or landfill operations.

Figure 4.9: Mobile Odor Response System



SEE INDUSTRIAL CATALOG FOR INFORMATION REGARDING SET-UPS AND CAPACITIES.

DESCRIPTION

No. 6218-1/4JAU AUTOMATIC AIR ATOMIZING NOZZLE - USING SAME INLET FOR ATOMIZING AND CYLINDER AIR

Spraying Systems Co.
Spray Nozzles and Accessories
North Avenue at Schmale Rd. • P.O. Box 7900
Wheaton, Il. 60189-7900

Ref:

Revision No. 3

Data Sheet No.
6218

Figure 4.10: Air Atomizing Nozzle Schematic

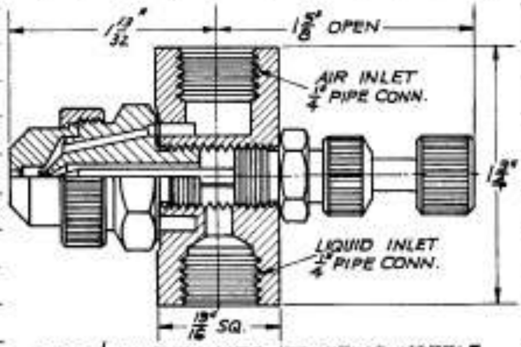
Table 4.5: Air Atomizing Nozzle

AIR PRESSURE IN p.s.i.	WATER PRESSURE IN p.s.i.																				
	6	8	10	12	14	16	18	20	22	24	26	28	30	35	40	45	50	55	60	65	70
6	.24 .45	.48 .47	.96 .37	1.14 .35																	
8	.24 .55	.45 .51	.84 .46	1.02 .45	1.32 .41	1.56 .33	1.68 .32														
10	.06 .66	.36 .62	.66 .55	.90 .54	1.08 .50	1.32 .40	1.50 .39	1.80 .31													
12	.03 .76	.18 .71	.48 .67	.72 .63	.96 .59	1.14 .46	1.32 .45	1.62 .35	1.92 .34	2.10 .33											
14		.06 .82	.36 .78	.54 .75	.84 .70	1.02 .55	1.14 .53	1.50 .40	1.88 .39	1.92 .38	2.10 .38										
16			.18 .87	.39 .85	.66 .80	.84 .63	1.02 .61	1.32 .45	1.68 .42	1.74 .42	1.92 .41	2.10 .41									
18			.03 .97	.24 .96	.54 .90	.69 .72	.90 .67	1.23 .50	1.50 .46	1.62 .46	1.64 .45	1.92 .44									
20				.048 1.04	.36 1.00	.54 .79	.84 .74	1.08 .56	1.32 .53	1.38 .52	1.62 .50	1.68 .49	2.04 .48								
22					.24 1.10	.42 .88	.66 .83	.99 .63	1.20 .58	1.25 .57	1.44 .55	1.62 .53	1.80 .52								
24						.24 .98	.54 .93	.86 .70	1.08 .66	1.14 .65	1.32 .62	1.44 .59	1.68 .56	2.10 .53							
26						.09 1.06	.42 1.00	.72 .76	.90 .72	.96 .71	1.14 .67	1.32 .64	1.56 .60	1.92 .57							
28							.30 1.06	.60 .82	.78 .80	.84 .78	1.02 .74	1.20 .70	1.44 .63	1.80 .62							
30							.12 1.17	.45 .93	.70 .87	.72 .86	.90 .81	1.02 .78	1.26 .74	1.62 .66	2.04 .63						
32								.30 1.02	.54 .97	.60 .93	.78 .86	.90 .84	1.08 .82	1.50 .74	1.86 .68						
34								.12 1.10	.36 1.04	.48 1.02	.67 .97	.78 .93	.96 .88	1.38 .80	1.68 .74	2.16 .68					
36									.06 1.14	.30 1.10	.60 1.02	.66 .99	.84 .96	1.26 .86	1.62 .80	2.10 .73					
38										.18 1.17	.45 1.11	.60 1.08	.72 1.03	1.09 .95	1.50 .85	1.98 .78	2.34 .73				
40											.30 1.19	.42 1.16	.66 1.11	.96 1.01	1.32 .93	1.80 .83	2.22 .78	2.56 .76			
42											.21 1.28	.30 1.26	.54 1.19	.90 1.09	1.20 1.02	1.68 .90	2.04 .85	2.46 .80			
44												.24 1.30	.42 1.28	.78 1.16	1.08 1.07	1.56 .95	1.92 .90	2.34 .85	2.70 .81		
46												.12 1.39	.30 1.35	.66 1.25	.96 1.16	1.44 1.02	1.80 .95	2.22 .88	2.58 .86		
48													.18 1.42	.54 1.34	.85 1.23	1.26 1.10	1.68 1.01	2.10 .94	2.46 .91	2.88 .86	3.18 .84
50														.42 1.42	.72 1.33	1.14 1.20	1.56 1.11	1.92 1.02	2.28 .98	2.70 .96	3.00 .89
52															.66 1.38	1.02 1.29	1.44 1.16	1.80 1.07	2.16 1.01	2.61 .96	2.94 .94
54															.54 1.46	.90 1.35	1.32 1.23	1.68 1.14	2.05 1.07	2.49 1.01	2.82 .97
56																.84 1.42	1.20 1.33	1.56 1.21	1.92 1.14	2.40 1.06	2.70 1.03
58																.74 1.50	1.08 1.39	1.50 1.27	1.80 1.19	2.28 1.12	2.64 1.08
60																.66 1.58	.96 1.48	1.26 1.39	1.68 1.28	2.13 1.19	2.64 1.12
62																.54 1.67	.90 1.56	1.14 1.46	1.56 1.36	2.04 1.24	2.34 1.18
64																	.78 1.64	1.02 1.57	1.44 1.43	1.92 1.32	2.22 1.28
66																	.70 1.71	.93 1.63	1.32 1.52	1.80 1.38	2.10 1.34
68																		.84 1.71	1.23 1.58	1.71 1.46	2.04 1.42
70																		.81 1.76	1.11 1.66	1.65 1.53	1.92 1.47

IN EACH LINE
FIGURES ABOVE INDICATE WATER ATOMIZED IN G.P.H. AT p.s.i. WATER PRESSURE
FIGURES BELOW INDICATE ATOMIZING AIR IN C.F.M. (FREE) AT p.s.i. AIR PRESSURE

RECOMMENDED WORKING RANGE IS INSIDE HEAVY LINES

SET-UP NO.	11
FLUID NOZZLE NO.	2050
AIR NOZZLE NO.	67147
SPRAY PATTERN	ROUND



TYPE ¼JN PNEUMATIC ATOMIZING NOZZLE SHOWN ABOVE. TYPE ¼J IS THE SAME BUT IT DOES NOT HAVE A SHUT-OFF NEEDLE.

DESCRIPTION

¼JP PNEUMATIC ATOMIZING NOZZLE
SET-UP NO. 11

SPRAYING SYSTEMS CO.
Engineers and Manufacturers
3201 RANDOLPH ST. BELLWOOD, ILL.

DR. BY H.J.
DATE 12-21-65
DWG. NO. 2921

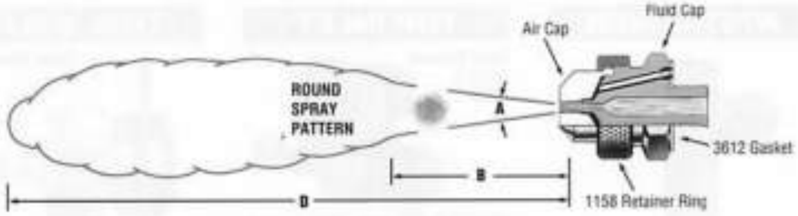
1/8J & 1/4J

Air Atomizing
PRESSURE SPRAY SET-UPS

DESIGN FEATURES

For the Round Spray pattern, angle "A" is maintained throughout distance "B". Beyond "B", the spray becomes turbulent and will project out to distance "D".

When using a Pressure-Fed Liquid System, the liquid is supplied to the nozzle under pressure. The liquid and compressed air or gas are mixed internally to produce a completely atomized spray.



ROUND SPRAY AND DEFLECTED FLAT SPRAY AIR CAPS
Air Caps used in these spray set-ups produce a narrow full cone round spray and deflected flat spray patterns.

Note: The No. 1158 Retainer Ring and 3612 Gasket must be ordered separately from the spray set-up, but are included in the standard nozzle assembly. **SEE PAGE D3 FOR ORDERING INFORMATION.**

ROUND SPRAY

Spray Set-up No.	Spray Set-up Consists of Fluid and Air Cap Combination	LIQUID CAPACITY in gph (gallons per hour) and AIR CAPACITY in scfm (standard cubic feet per minute)															SPRAY DIMENSIONS				
		LIQUID PRESSURE in psi (pounds per square inch)																			
		10 psi			20 psi			30 psi			40 psi			60 psi							
		Air Press. psi	gph	scfm	Air Press. psi	gph	scfm	Air Press. psi	gph	scfm	Air Press. psi	gph	scfm	Air Press. psi	gph	scfm	Air psi	Liquid psi	Spray Angle A Deg.	B in.	D feet
SU11	Fluid Cap 2050 + Air Cap 67147	10	.66	.55	14	1.50	.40	24	1.68	.56	32	1.86	.68	50	2.28	.98	12	10	13°	12"	9'
		12	.48	.67	18	1.23	.50	28	1.44	.63	36	1.62	.80	54	2.05	1.07	24	20	13°	13"	10'
		14	.36	.78	22	.99	.63	32	1.08	.82	40	1.32	.93	58	1.80	1.19	36	30	13°	14"	11'
					24	.86	.70	36	.84	.96	44	1.08	1.07	62	1.56	1.36	44	40	14°	15½"	12½'
					26	.72	.76	38	.72	1.03	48	.85	1.23	66	1.32	1.52	62	60	15°	17½"	14½'
					28	.60	.82	40	.66	1.11	50	.72	1.33	68	1.23	1.58					
					30	.45	.93	42	.54	1.19	52	.66	1.38	70	1.11	1.66					
SU12A	Fluid Cap 2050 + Air Cap 73160	10	.66	.66	18	1.44	.87	24	1.98	1.00	30	2.40	1.14	40	3.30	1.36	12	10	12°	17"	12'
		12	.54	.77	20	1.32	.98	28	1.68	1.17	34	2.16	1.29	46	2.94	1.54	20	20	13°	18"	13'
		14	.42	.90	22	1.20	1.06	32	1.44	1.35	38	1.92	1.47	52	2.58	1.83	34	30	13°	19"	14'
					24	1.08	1.16	34	1.32	1.46	42	1.62	1.68	58	2.28	2.09	42	40	13°	20"	15'
					26	.90	1.26	36	1.20	1.57	44	1.50	1.78	62	2.10	2.26	58	60	15°	22"	17'
								38	1.11	1.66	46	1.38	1.88	66	1.86	2.46					
								40	1.02	1.76	48	1.32	1.98	70	1.68	2.67					
SU12	Fluid Cap 2850 + Air Cap 73160	12	1.26	.73	22	2.16	1.05	30	2.90	1.24	36	4.32	1.26	48	5.82	1.50	22	10	12°	19"	13'
		16	1.08	.94	26	1.74	1.26	34	2.46	1.42	40	3.85	1.36	52	5.28	1.65	34	20	13°	20"	14'
		20	.90	1.15	30	1.44	1.47	38	2.10	1.65	44	3.55	1.56	56	4.92	1.73	42	30	13°	21"	15'
		22	.81	1.25	34	1.26	1.67	42	1.74	1.87	48	2.80	1.78	60	4.56	1.88	48	40	14°	22"	16'
		24	.78	1.36	38	1.08	1.87	46	1.50	2.03	52	2.46	2.01	64	4.08	2.08	60	60	15°	23½"	17½'
		26	.77	1.43	40	1.02	1.96	50	1.24	2.25	56	2.16	2.20	68	3.72	2.25					
		28	.76	1.56	42	.94	2.04	52	1.20	2.36	60	1.86	2.36	70	3.60	2.34					
SU22B	Fluid Cap 40100 + Air Cap 1401110	16	3.44	2.68	28	5.03	3.71	40	6.10	4.72	48	7.75	5.30	65	10.7	6.74	24	10	18°	26"	16'
		20	2.35	3.20	32	3.70	4.17	44	5.03	5.17	55	5.95	6.07	75	8.67	7.73	40	20	20°	30"	20'
		22	1.90	3.46	36	2.64	4.65	48	3.95	5.65	65	3.55	7.28	80	7.65	8.25	55	30	20°	32"	22'
		24	1.54	3.70	40	1.85	5.13	55	2.30	6.50	75	1.95	8.50	85	6.65	8.80	75	40	21°	36"	26'
		26	1.23	3.97	44	1.30	5.63	60	1.56	7.12	80	1.40	9.10	90	5.64	9.40	85	60	21°	38"	30'
		28	.96	4.22	48	.90	6.10	65	1.08	7.75	85	1.00	9.70	95	4.63	10.0					
		30	.72	4.48	50	.76	6.36	70	.73	8.35	90	.72	10.3	100	3.62	10.6					
SU22	Fluid Cap 60100 + Air Cap 1401110	12	8.1	2.00	20	13.6	2.55	30	16.3	3.25	38	19.5	3.74	54	25.7	4.66	14	10	17°	24"	16'
		14	6.6	2.32	22	12.0	2.85	34	13.1	3.75	42	16.5	4.20	60	21.8	5.34	26	20	18°	27"	19'
		16	4.9	2.66	24	10.2	3.15	38	9.9	4.32	46	13.6	4.71	65	18.5	5.98	40	30	20°	30"	22'
		18	3.4	3.00	26	8.6	3.45	40	8.7	4.61	50	10.8	5.30	70	15.2	6.68	50	40	20°	31"	23'
					28	7.2	3.75	42	7.6	4.90	52	9.6	5.58	75	12.2	7.80	70	60	21°	36"	28'
					30	5.9	4.05	44	6.6	5.20	54	8.6	5.85	80	10.0	8.14					
					32	4.6	4.35	46	5.6	5.50	56	7.6	6.14	85	8.0	8.90					
SU42	Fluid Cap 100150 + Air Cap 1891125	14	11.7	3.05	20	27.5	3.04	28	36.6	3.55	32	49.4	3.31	42	70.6	3.17	14	10	19°	35"	20'
		16	8.5	3.60	22	23.0	3.49	30	32.6	3.96	36	42.2	4.10	46	65.0	3.85	24	20	20°	39"	23'
					24	18.0	3.95	32	28.7	4.36	40	35.1	4.90	50	59.0	4.63	34	30	21°	41"	25'
					26	14.4	4.40	34	24.8	4.78	44	28.0	5.66	54	53.2	5.40	44	40	21°	42"	26'
					28	11.3	4.85	36	20.9	5.20	46	24.5	6.05	58	47.4	6.16	54	60	22°	46"	30'
								38	17.5	5.60	48	21.3	6.45	65	37.8	7.54					
								40	14.6	6.03	50	18.4	6.86	70	30.0	8.55					

DEFLECTED FLAT SPRAY

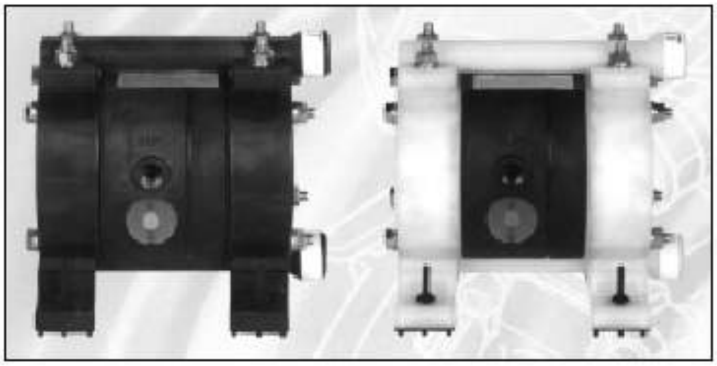
Spray Set-up No.	Spray Set-up Consists of Fluid and Air Cap Combination	LIQUID CAPACITY in gph (gallons per hour) and AIR CAPACITY in scfm (standard cubic feet per minute)														
		LIQUID PRESSURE in psi (pounds per square inch)														
		10 psi			20 psi			30 psi			40 psi			60 psi		
		Air Press. psi	gph	scfm	Air Press. psi	gph	scfm	Air Press. psi	gph	scfm	Air Press. psi	gph	scfm	Air Press. psi	gph	scfm
SU240E	Fluid Cap 28150 + Air Cap 189110-75°	6	2.9	1.6	14	3.9	2.6	22	4.7	3.3	26	5.8	3.6	38	7.4	4.6
		8	2.5	1.9	16	3.5	2.8	24	4.3	3.6	32	4.8	4.4	46	6.4	5.5
		10	2.0	2.3	18	3.1	3.1	26	4.0	3.8	38	3.8	5.3	54	5.3	6.6
		12	1.5	2.7	20	2.8	3.5	30	3.3	4.5	44	2.8	6.2	62	4.2	7.8
					22	2.3	3.8	34	2.3	5.2	46	2.3	6.6	70	2.8	9.4

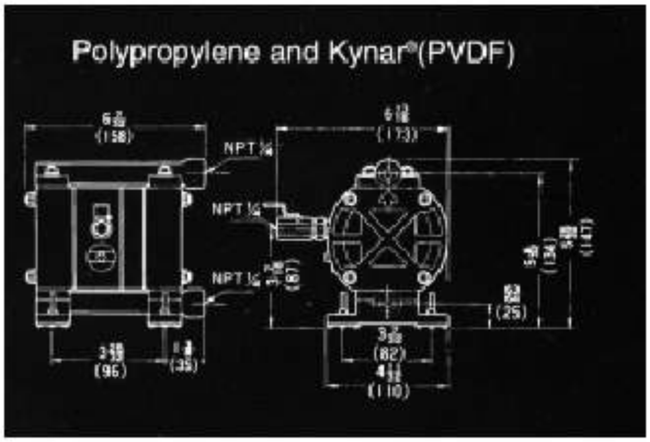
Spray Pattern

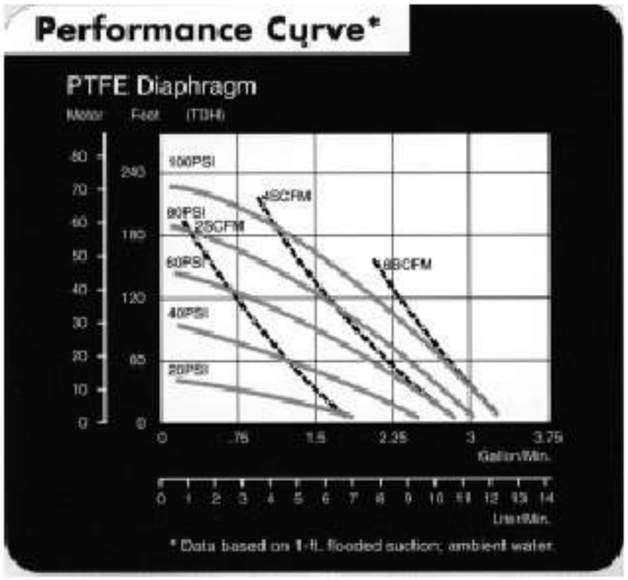
Deflected Flat Spray

Figure 4.11: Yamada Air Drive

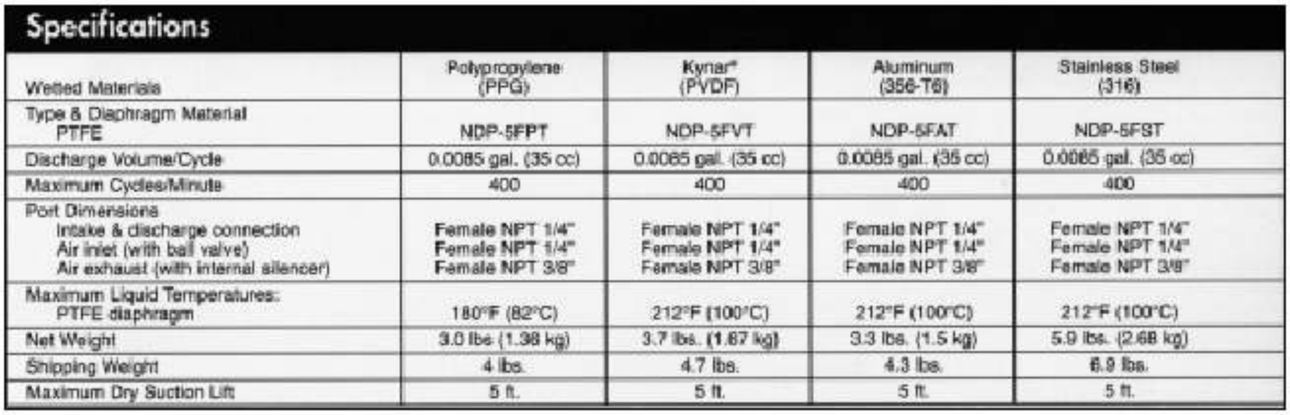
YAMADAAIR DRIVEN PUMP INFORMATION







* Data based on 1-ft. flooded suction; ambient water.



Specifications

Wetted Materials	Polypropylene (PPG)	Kynar® (PVDF)	Aluminum (356-T6)	Stainless Steel (316)
Type & Diaphragm Material PTFE	NDP-5FPT	NDP-5FVT	NDP-5FAT	NDP-5FST
Discharge Volume/Cycle	0.0085 gal. (35 cc)	0.0085 gal. (35 cc)	0.0085 gal. (35 cc)	0.0085 gal. (35 cc)
Maximum Cycles/Minute	400	400	400	400
Port Dimensions Intake & discharge connection Air inlet (with ball valve) Air exhaust (with internal silencer)	Female NPT 1/4" Female NPT 1/4" Female NPT 3/8"	Female NPT 1/4" Female NPT 1/4" Female NPT 3/8"	Female NPT 1/4" Female NPT 1/4" Female NPT 3/8"	Female NPT 1/4" Female NPT 1/4" Female NPT 3/8"
Maximum Liquid Temperatures: PTFE diaphragm	180°F (82°C)	212°F (100°C)	212°F (100°C)	212°F (100°C)
Net Weight	3.0 lbs. (1.38 kg)	3.7 lbs. (1.67 kg)	3.3 lbs. (1.5 kg)	5.9 lbs. (2.68 kg)
Shipping Weight	4 lbs.	4.7 lbs.	4.3 lbs.	6.9 lbs.
Maximum Dry Suction Lift	5 ft.	5 ft.	5 ft.	5 ft.

Figure 4.12: ECS&P Air Control

Figure 4.17: ECS&P Air Control Box

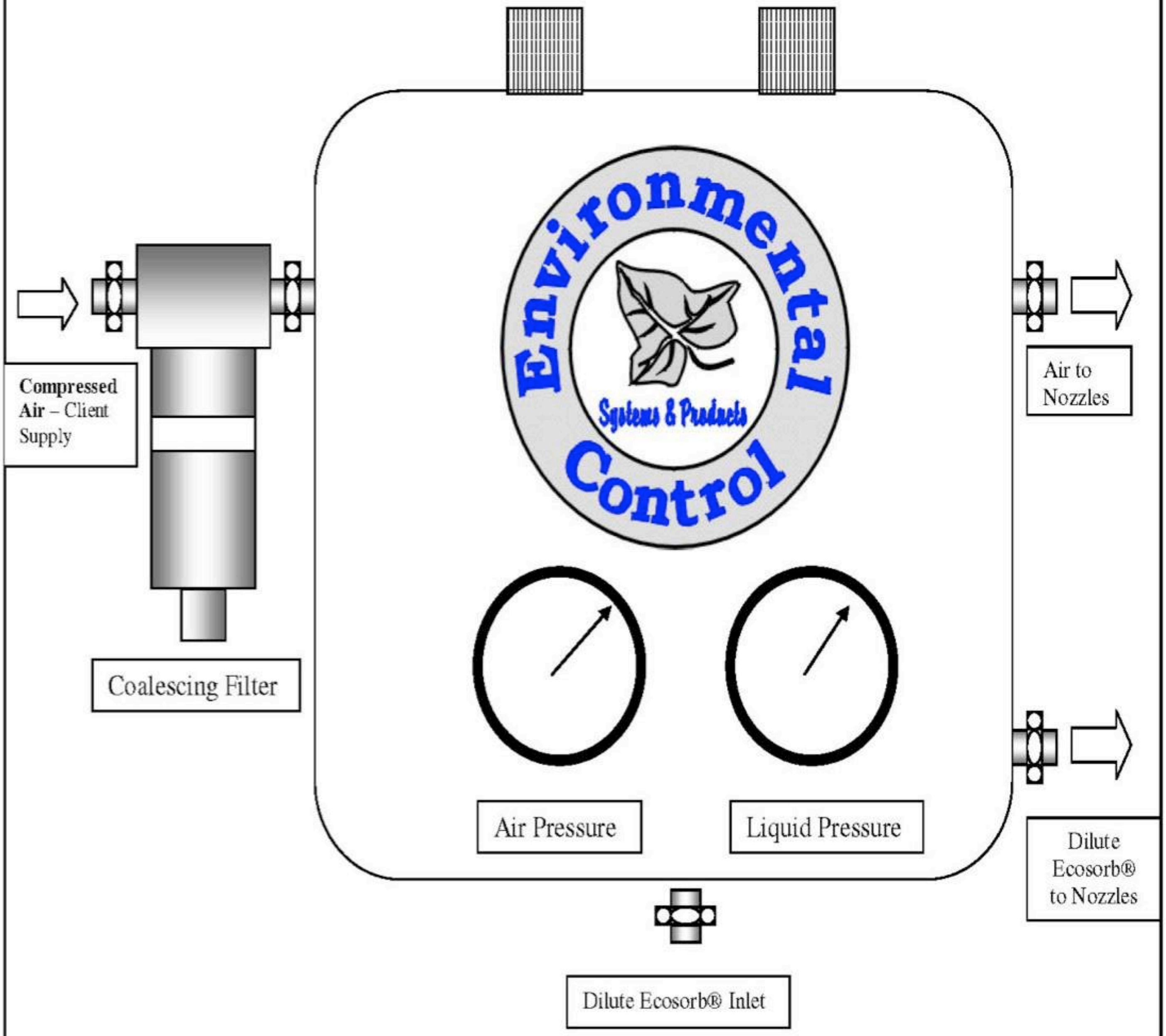


Figure 4.13: ECS&P Air Control Box Schematic

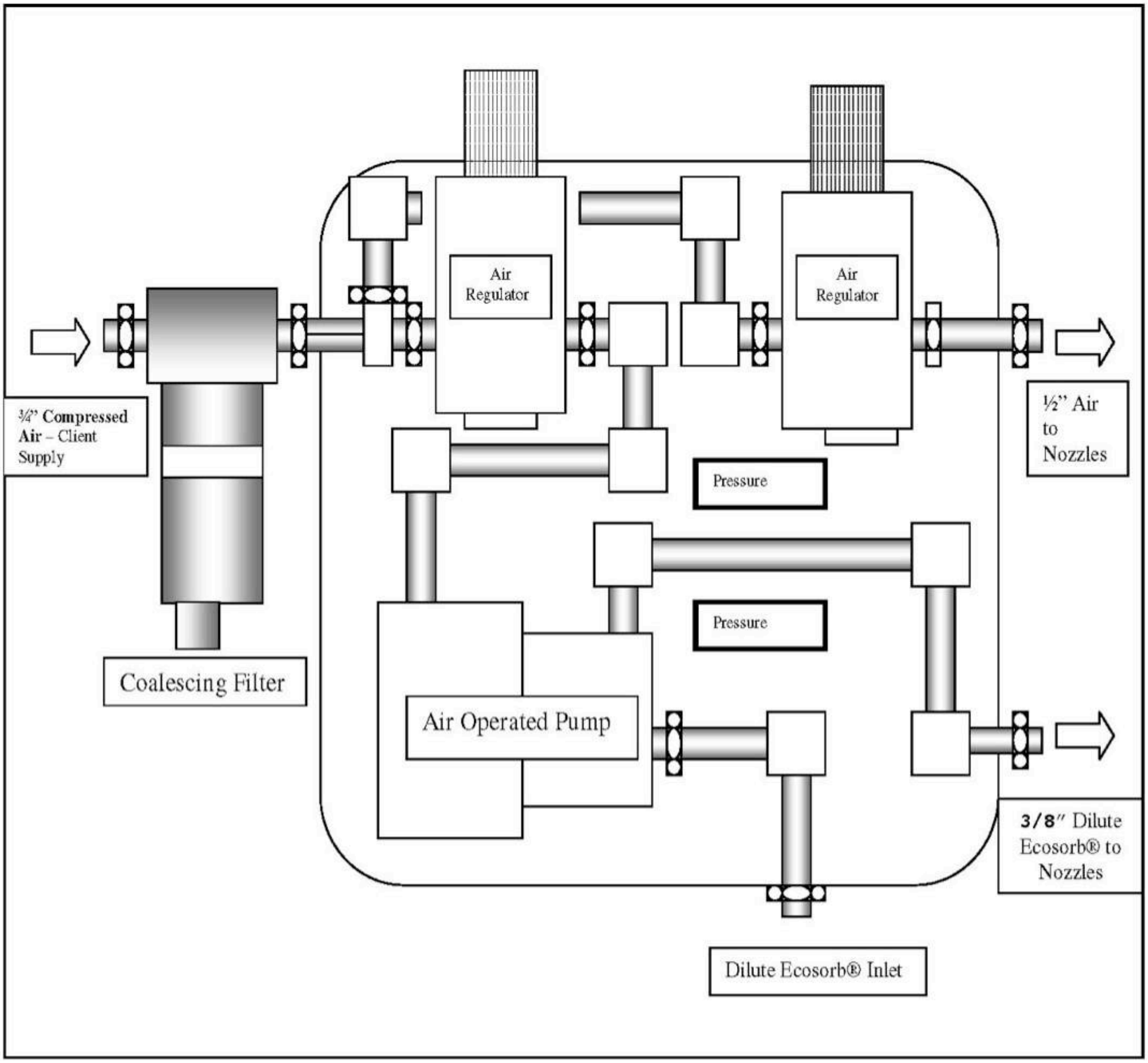
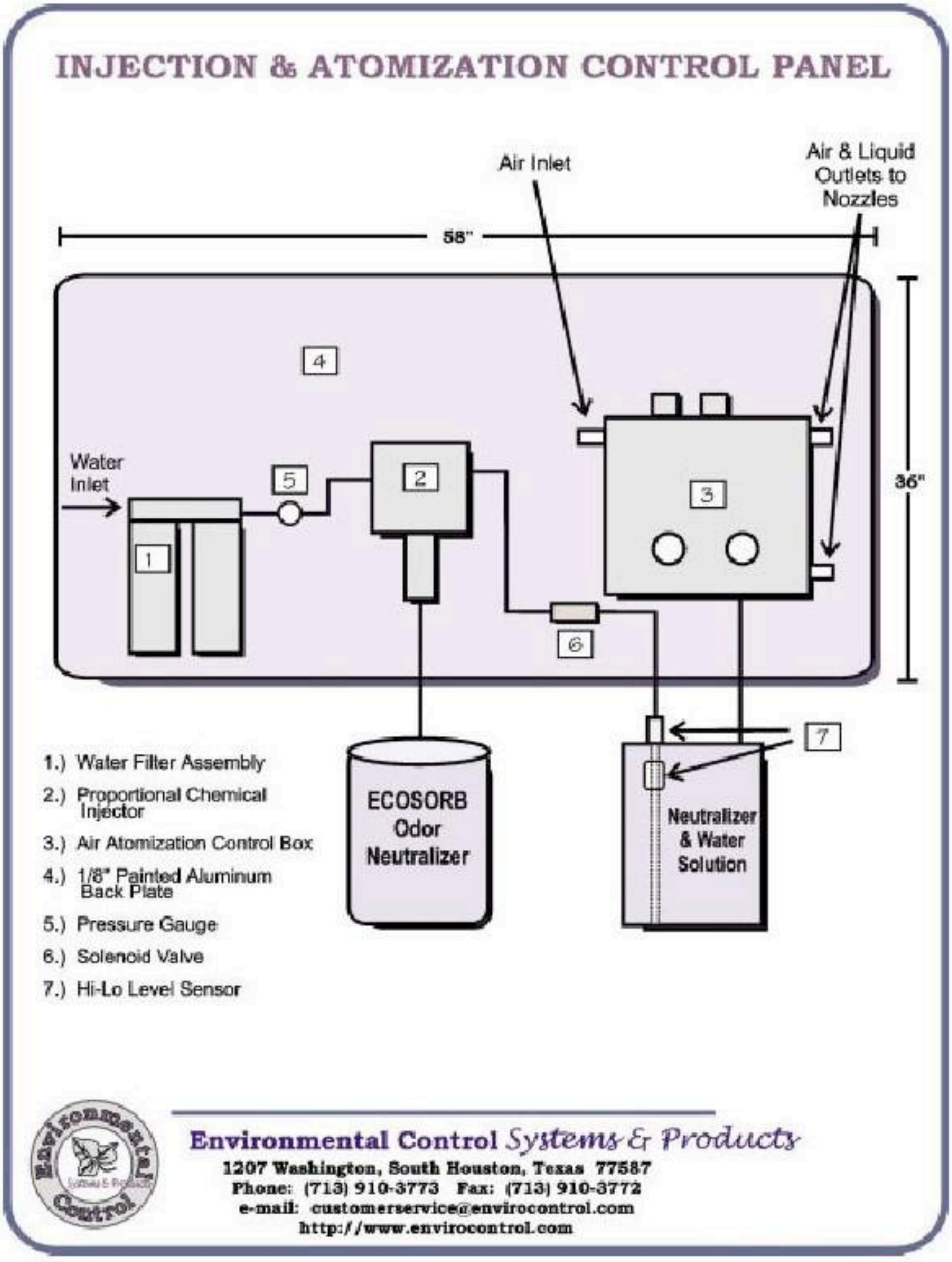


Figure 4.14: Injection and Atomization Control Panel Schematic



HOLLOW BLADED FAN

The hollow bladed fan is an innovative, simple, and effective solution for the delivery of Ecosorb® in relatively still air applications. Usually used indoors, the fan is excellent for applications where one does not want to add high moisture content to the ambient air and where localized delivery is sufficient.

The hollow bladed fan is an electrically driven (explosion proof option is available) four-bladed fan with an orifice passage located in the longitudinal axis of each blade. Ecosorb® is delivered into the fan hub from where it is transmitted into the blades and exits the blade tips where it is well atomized.

The dispersion distance for Ecosorb® is from 30 to 60 feet (10 to 20 meters) depending on the model selected. Attaching the fan to a 360° oscillator, one can realize over 2,800 square feet (240 square meters) of coverage with one fan. The oscillating unit can be adjusted to cover from 3.75° to a full 360° of sweep range. For larger areas, one can specify multiple fans.

Figure 4.15: Hallow bladed fan

Installation of these fans is simple. A wheeled floor stand is available for mobile applications or low level installations. Usually, the fans are installed in elevated wall or ceiling locations above the odor source. Two U-bolts suspend the fan assembly from a horizontal 1.25-inch (32 mm) OD steel pipe. Purpose-made wall and ceiling mount kits are also available. This installation technique is consistent with or without the optional oscillators.

The fan is only a delivery apparatus and requires a metering pump to move the dilute working solution from the container to the fan. Any adequate pump satisfies this need and it is common practice to use a diaphragm electronic metering pump. The fan comes complete with a flow meter for monitoring purposes. However, if one uses a diaphragm electronic metering pump, it is likely the flow meter will become nothing more than an indicator of liquid flow due to the rapid pulsing of the pump. If one does not specify an electronic metering pump, flow control should be included in the system. Simple system schematics are shown in Figures 4.16, 4.17 and Table 4.7.

Figure 4.16: EC&P Odor Fan

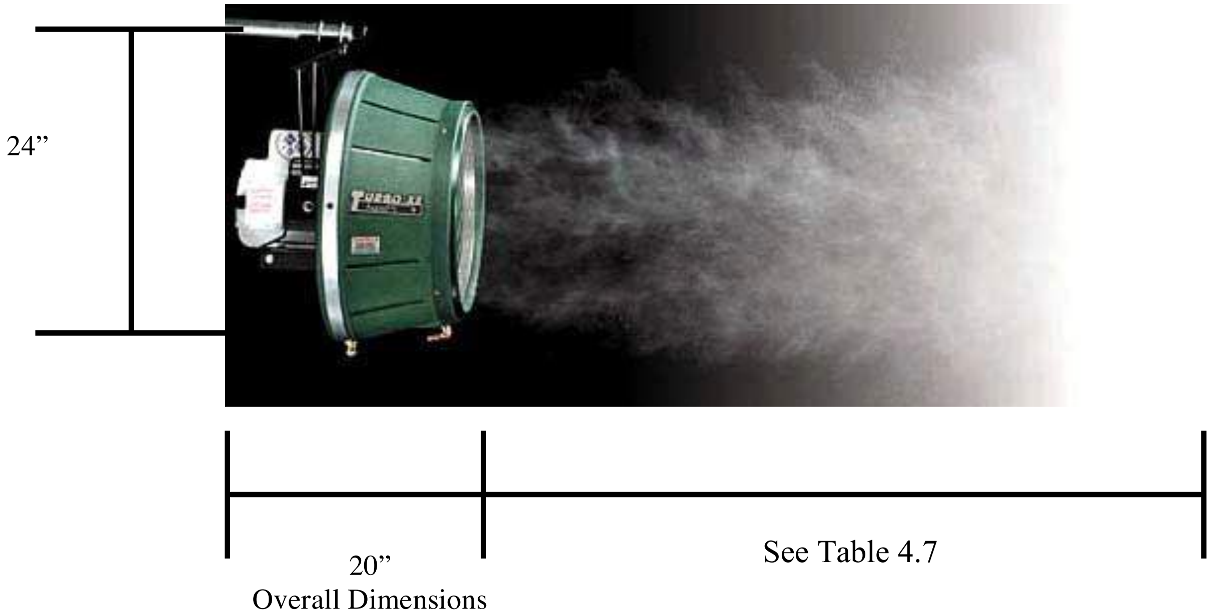
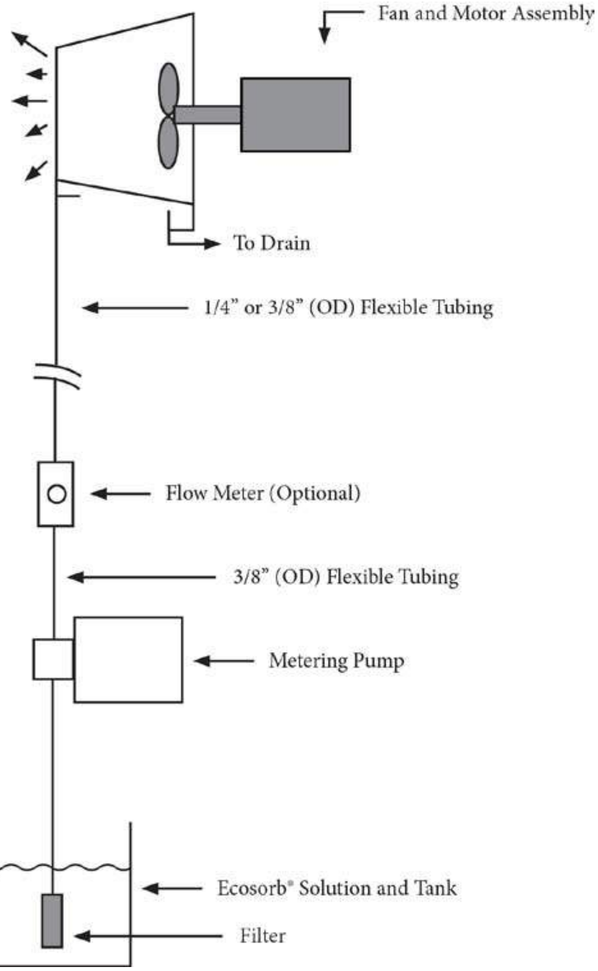


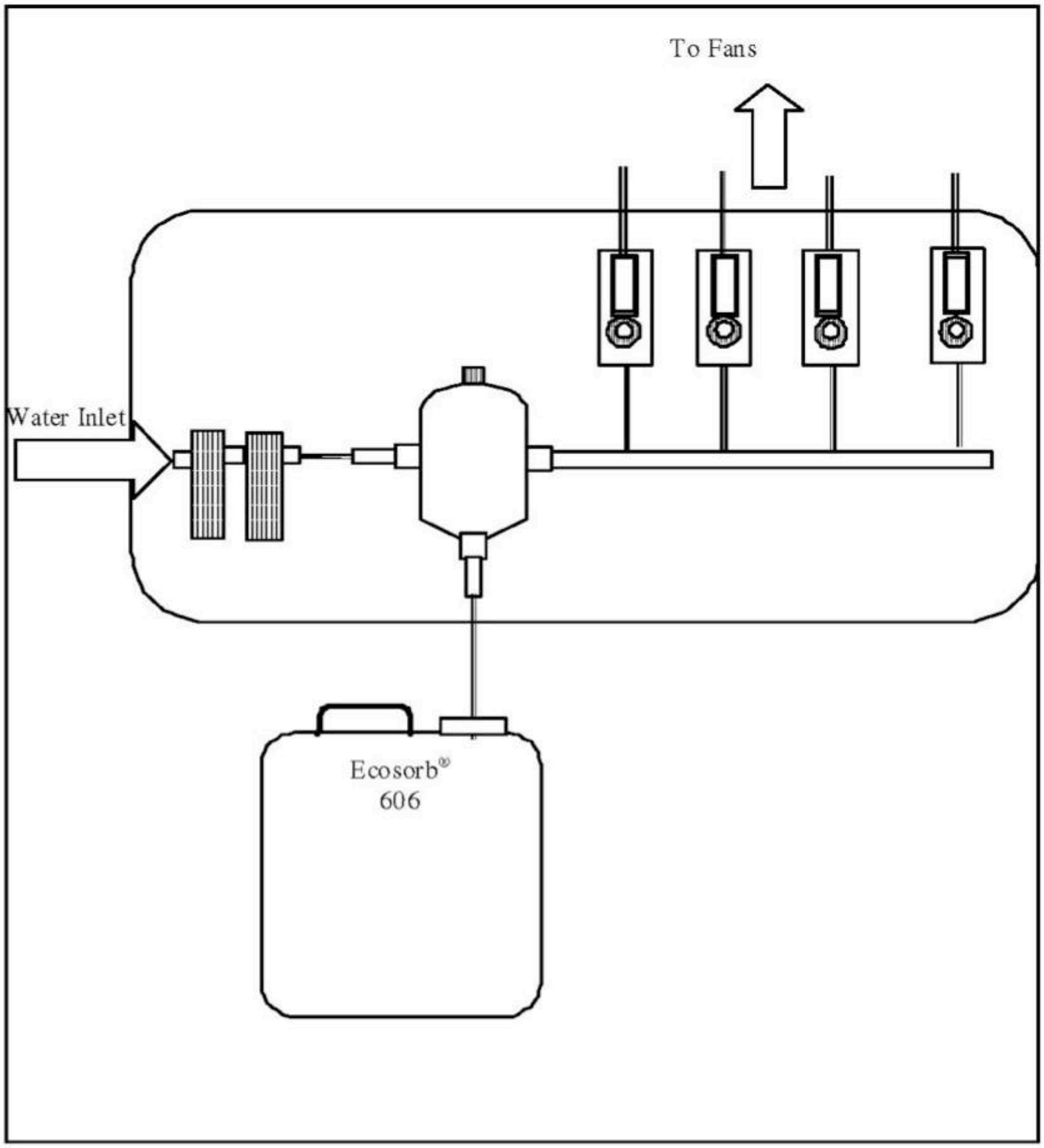
Figure 4.17: Hollow Bladed Fan System Schematic



The installation of multiple fans is possible. These are individually controlled by flow meters mounted on a fan standard control panel. An example is shown in Figure 4.18.

The liquid pump is located at ground level near the premix container of Ecosorb® and the product is pumped up to the fan(s). The engineer needs to pay attention to liquid pressure losses due to fan elevation and line length, especially if specifying a pump other than an electronic chemical metering pump. Each fan assembly has a drain line connection on the guard shroud for return condensate. This low volume of waste should be properly plumbed and disposed.

Figure 4.18: Multi-Fan Control Panel



Pump sizing primarily involves ensuring enough capacity is provided and then relying on flow control to tune the system to optimum, cost effective operation. Maximum fog output capability for the fans is quite high, from 8 to 30 GPH (0.5 to 1.9 LPH) depending on the model, thereby allowing the user to run a high volume of Ecosorb® solution. However, when delivering Ecosorb® with a fan, especially indoors and where one does not want to add significant moisture to the air, it is common to operate in the 0.5 to 1.0 GPH (30 to 130 cc/minute) range and run with higher dosages of Ecosorb®. As always, the flow rate and dosage is application sensitive.

If the pump is oversized, the flow can always be reduced with flow control. A common pump specified is a 24-gallons per day (7.0-litres per hour) electronic metering pump by “Pulsafeeder,” model LPB4SAPTC1XXX.

Fan specifications are provided in Table 4.7.

Table 4.7: Model Specifications

Model Number	Motor Horsepower (kW)	Forced Airflow CFM (M3/H)	Rated Dispersion Distance-Feet (meters)	Maximum Dry Fog Output GPH (LPM)	Explosion Proof Motor Option Available[1]
ECS&P 707	1 (0.75)	3260 (5540)	30 -70 (9 -21)	30 (1.9)	Yes
ECS&P 720	3/4 (.55)	3180 (5400)	30 -65 (9 -19)	24 (1.5)	Yes
ECS&P 701	1/2 (0.37)	2730 (4640)	30 -60 (9 -18)	20 (1.3)	Yes
ECS&P 740	1/4 (0.19)	2160 (3670)	25 -40 (7.6 -12)	12 (0.75)	

Table 4.7 (continued): Model Specifications

Model Number	Available Voltages for Standard Packages							Flow Load Amperage	Weight in Pounds [2]	Noise dB(A) at 10 feet
	60 HZ				50 HZ					
	115/1	230/1	230/3	460/3	240/1	380/1	575/3			
ECS&P 707	X	X	X	X	X	X	X	10.4 at 115 V/1	50	76-79
ECS&P 720					X	X		7.6 at 115 V/1	53	74-77
ECS&P 701	X	X						7.2 at 115 V/1	39	68-72
ECS&P	X	X						3.4 at 115 V/1	40	74-77

---

[1] “Explosion Proof Motors:
Class 1, Group D locations containing volatile gases
Class 2, Group F & G locations containing dust.”

[2] “Add 5 to 10 pounds for explosion proof.”

TRADITIONAL CHEMICAL SCRUBBERS

Odorants can be decomposed either by oxidation, chlorinating, or chemical conversion. There are a variety of scrubbing mediums or substances whose molecules contain surplus oxygen or chlorine atoms that split off easily producing nascent oxygen or chlorine, or which have the affinity to convert the odorous gas into a neutral substance.

The most commonly used oxidizing agents are hydrochloric acid (HCl), sodium hypochlorite (NaOCl), and hydrogen peroxide (H_2O_2). All have advantages and disadvantages. Sodium hypochlorite is cheap but the scrubber effluent can contain chlorine and chloride. Hydrogen peroxide has no residue products, but is more expensive to operate and requires special materials of construction. Other common scrubbing solutions used for odor and emission control are caustic soda, chlorine, and sulfuric acid. It is also common practice to incorporate two or more scrubber units with different reactants in each vessel.

Each of these chemicals is known to be reactive. They are considered hazardous for storage and handling and present the following major drawbacks:

- Each requires special hazardous chemical containment.
- The interface equipment requires high levels of maintenance because the chemical is highly reactive.
- Workers must wear protective clothing and breathing apparatus when servicing the scrubber.
- The spent chemical requires neutralization before disposal.
- Not one of these chemicals works on the full spectrum of odors.
- They have the propensity to develop other odors. For example, sodium hypochlorite releases a chlorine odor.

None of these drawbacks apply to Ecosorb®!
Conventional chemical scrubbers are designed for a large contact area between the gas and liquid phases. However, odor control applications require some dedicated design features. In particular, the air residence time in the scrubber must be sufficient, as must be the contact surface area.

Since most odorous gas streams contain a mixture of different substances (sometimes as many as 100 different chemicals), the majority of odor removal applications require multi-stage scrubber units. Thus, the capacity to absorb both alkaline and acidic components is combined.

Scrubbers provide the traditional mechanical form of odor control where gases can be collected and treated before emitted to the atmosphere. In odor control scrubber applications, Ecosorb® can be used as both the primary scrubbing solution and as a secondary scrubbing medium. Ecosorb® is not formulated to control process emissions in compliance with federal or state regulations. But in many of cases, it is used as a polishing agent to neutralize those gases not cleaned by traditional mediums.

Because Ecosorb® works through molecular bonding, it is most efficient in misting-type scrubber applications and is not recommended for traditional packed bed scrubber applications. Experience shows that in various malodor applications, removing the internal packing media and adding atomization nozzles can easily modify the conventional “packed bed-type” scrubbers. This offers an environmentally safe solution for the operation of traditional scrubbers because hazardous chemicals no longer need to be handled.

When designing a misting scrubber or modifying an existing unit, it is important to pay close attention to the atomized (mist) droplet size. The best droplet size is less than 10 microns. It is not recommended to operate Ecosorb® in a misting scrubber where the droplet size is greater than 10 microns. The smaller droplet size provides higher efficiency rates due to larger surface area and increased velocity. Another advantage as a result of ensuring smaller droplet size is the minimization of liquid waste leaving the scrubber. Finally, droplet velocity plays a large role in the absorption of the malodor into the Ecosorb® droplet. In high-pressure systems, we recommend you operate the nozzles at the highest possible pressure. If you are using air-aspirated nozzles, the highest practical air pressure setting should be used.

Important Points

Ecosorb® is often specified in a retrofit as the primary scrubbing solution and therefore as a replacement to the common but more hazardous chemicals. Whether you are retrofitting existing equipment or fitting new equipment, it is important to pay attention to several points:

1. In a retrofit, regardless of what had or is being used as the current scrubbing solution, the chamber and equipment must be purged with clean water until the pH of any liquid within the system is between 5 and 8. Ecosorb® works outside these pH parameters but with reduced efficiency.

2. Ecosorb® must be delivered in droplet sizes below 10 microns. However, if too much vapor is present, the droplets will join and form larger droplets thereby reducing the efficiency of Ecosorb®. This makes selection of the correct nozzle size and pattern important. The nozzles can be installed in a radial (Christmas tree) pattern, concurrent or in a counter-current configuration. The best pattern is counter-current, as this allows maximum impact with the malodor particles.

3. Media or baffles within the chamber can cause condensation and decrease efficiency. These (if practically possible) should be removed.

4. Since we are dealing with nuisance odor control, success is measured by a reduction in odor level. The reduction of certain gases can be monitored using proper instrumentation. Some modern “hand held” portable units, particularly those that use a “CITY®” sensor, are able to register the changes reasonably accurately.

5. Contact time is important for Ecosorb® to work effectively on some gases. Therefore, one needs to maximize the gas contact time within the system. We recommend a minimum contact time of five seconds. This can easily be accomplished by fitting the discharge duct with a small, slender, secondary vessel of plastic construction before release to the atmosphere.

Design Considerations
Odorous gas streams are usually a combination of numerous gases, making the initial Ecosorb® dilution ratio difficult to select. As in all other applications, it is necessary to establish the precise Ecosorb® dilution ratio through trial and error. Experience shows that scrubbers usually operate in the range of 100:1 to 400:1 dilution. But, some applications may require a higher or lower dilution ratio.

As always, dilution is a function of odor intensity and the chemical characteristics of the odorous gas. However, in a scrubber one must also decide how much diluted Ecosorb® should be injected into the system for maximum efficiency. For example, one needs to determine what liquid flow rate should be specified, which determines how many atomization nozzles to specify. This can be addressed scientifically using basic psychometric techniques (a psychometric chart, figure 4.28, has been included in the back of this section). The objective is to establish how little Ecosorb® solution must be applied to the gas stream inside the scrubber to achieve complete neutralization without saturating the discharge.

Below we recap the important variables when designing a misting scrubber.

1. The first requirement is the **CONTACT TIME** between the odorous gas and Ecosorb® within the system. We recommend a minimum of 5 seconds.

2. The second variable is the **MOISTURE CONTENT** of the air stream into the scrubber (inlet conditions). Here, the designer must determine how much moisture can be added to the air stream to affect complete neutralization without adding too much moisture. Too much moisture results in condensation and reduced Ecosorb® efficiency through droplet size growth.

   a. If the compounds to be neutralized are water soluble, the designer should maximize the moisture addition to the air stream while not causing saturation. Besides carrying the Ecosorb®, it assists in the scrubbing process. It is recommended that you restrict the maximum addition to least 15% relative humidity (RH) away from saturation (100% RH). The farther you stay away from total saturation the better, while still adding a sufficient amount of dilute Ecosorb® to affect the neutralization.

   b. A good starting point for moisture addition is in the range of 10 to 30 grains of moisture per pound of dry air flowing through the scrubber. Inlet air moisture conditions now become important. If the inlet air is 75º F (24º C) and 65% RH, one can easily add 30 grains of moisture per pound of air and be safely within the 85% RH design range. However, if the inlet condition is 75º F (24º C) and 75% RH, adding 30 grains of moisture closely approaches the saturation point.

3. A further design consideration is the **SPRAY NOZZLE SELECTION** and **OPERATING SET POINT(S)**. These play a large role in the efficiency of a scrubbing system.

   a. Air aspirated spray nozzles offer the designer the maximum the amount of control in the form of operating spray volume, droplet size, and impact velocity. Pay attention to the spray pattern, as air will flow from a high-pressure region into a low-pressure region. Thus, the gas prefers to flow through areas in the spray pattern that have "holes" or where there are "less dense" misting conditions.

b. When using high-pressure nozzles, we recommend the designer install the nozzles in a conical configuration since this offers the best contact pattern. It is not important whether the designer chooses a central header pipe with varying radial branch pipe lengths or a header (hose) fitted with nozzles at uniform spacing, formed in a conical pattern. Propriety high-pressure nozzle cluster blocks are another recommended method.

Sample Calculations

The following provides a set of calculations to size a scrubber system for an actual installation:

Scrubber volume: Approximately 754 ft^3 (21.35 cubic meters)

Air flow: 6,000 scfm at 13.5 ft^3/pound = 444 pounds/minute

Contact time: 754 ft3 x 1 minute/6,000 ft^3 = 0.125 minutes = 7.54 seconds

Air inlet conditions: Approximately 75º F (24º C), 60% RH (~78 grains/pound dry air)

Desired moisture addition: ~30 grains/pound dry air (~75º F, ~82% RH)

30 grains/pound x 444 pounds/minute = 13,320 grains/minute needed

13,320 grains/minute x 1 ounce/437.5 grains = 30.4 ounces/minute required (0.24 gpm)

0.24 gpm x 1 nozzle/0.022 gpm = 10.9 nozzles

For the above example, we recommend one use two 6-nozzle clusters that add ~33 grains of moisture per pound of dry air. The suggested starting point for dilute Ecosorb® is 200:1. This dilution can then be decreased until the most economical ratio is achieved.

In actual applications where the addition of ~30 grains of moisture causes saturation of the air, we then recommend the addition of 15 grains per pound of inlet air. This requires half the number of nozzles but an increase in Ecosorb® concentration to achieve the correct neutralization effect.

If you encounter problems with this design procedure, please contact Odor Management Inc. for the name of your local Ecosorb® distributor.

Ecosorb® Misting Scrubbers for Odor Control

Figure 4.19: Ecosorb® Misting Scrubber Unit

Ecosorb® Misting Scrubbers are relatively new on the market although this technology has been available for a while. The introduction of these units allows for neutralization of odorous gas streams using environmentally safe products to chemically convert gases and eliminate odors without creating any hazardous residue or toxic discharge.

The misting scrubber can be powered entirely by compressed air, offering a system that uses low-pressure sprays and is suitable to use in explosive environments. High-pressure systems are also available with a variety of electrical operating options. These units are completely plumbed and include water filters, a high performance proportional feeder, and an adjustable control unit all mounted on a control panel.

The misting scrubber operates by filling the scrubber volume with very fine droplets (<10 μm - Median Volume Diameter). These droplets can be introduced with a wide range of size, velocity, concentration, and flow rate. This offers complete flexibility of operation to suit the reality of process-upset conditions. The tiny droplets are discharged at high velocity and impact by selected spray nozzles into the incoming odorous molecules, where absorption/adsorption and neutralization is affected.

The Ecosorb® misting scrubber unit is designed to operate with either a positive or negative gas pressure, providing installation flexibility and in some cases without a fan requirement.

Units are available for a large range of airflows—from 100 m^3/h (60 CFM) and larger. For more information contact ECS&P at www.envirocontrol.com.

Figure 4.20: Air Aspirated Control Unit

Figure 4.21: Hydraulic Control Unit

VAPOR PHASE SYSTEMS

The selection of the best odor neutralization dispersion technology is not a simple task. The Vapor Phase application has been developed by OMI Industries as a simple, efficient, and most importantly; economical delivery system for the Ecosorb® odor neutralizer.

The newest technology available in Ecosorb® odor neutralizer dispersion is the Vapor Phase Unit. These units perform well under many varied uses such as petrochemical plants, foundries, food processors, wastewater plants, landfills, and even apartment complexes. The reason for this acceptance in these different environments is that the Vapor Phase Units are simple to operate and efficient in getting the results needed to solve the odor problem without high capitalization costs.

INTRODUCTION TO VAPOR PHASE SYSTEMS

As discussed in Section One, Ecosorb® odor neutralizer is a mixture of natural essential oils and water, applied as a minute droplet that takes the form of a sphere. The oil and water partially separate, with a thin film of oil forming on the outside of the sphere, and the water on the inside. On contact, the odor is encapsulated and a noticeable odor difference is apparent immediately. After encapsulation, a chemical reaction takes place, which reduces the odor molecule to its lowest form.

Applied as minute droplets, the effectiveness of Ecosorb® odor neutralizer is a function of the surface area available. The smaller the droplet, the greater the surface area available for attraction given a constant volume of product.

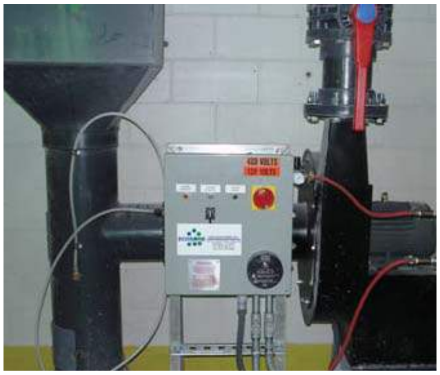


Figure 4.22: Vapor Phase Unit

Traditional dispersion technology is to apply odor control products by atomized spray, producing a very small droplet. The most common droplet produced by atomized spray is under the size of about 25 microns. The inconsistency of the droplet spray is that at least 50% of the droplets produced are larger than the indicated droplet size (25 micron) the nozzle should produce.

OMI Industries has developed the Vapor Phase Unit to decrease the size of the droplets. The smaller and greater number of droplets produced by the same amount of product, the greater the surface area available for attraction, encapsulation, and neutralization. Therefore a more efficient and economical use is the major benefit of the Vapor Phase Unit.

The OMI Industries Vapor Phase Unit produces a sub micron droplet. The smaller droplets can be transported at much higher velocity, increasing the rate of collision with the odor or gas stream. The smaller droplets are dispersed as a "dry spray" – invisible to the naked eye. The system uses a smaller amount of concentrate product, eliminating the requirement of water to dilute the product to make a "wet spray". Due to the increased velocity (engineered outlet design is 5,000 ft/min) the Vapor Phase Unit has a superior discharge dispersion pattern, allowing more efficient coverage. This makes it possible to provide effective odor control to areas that could not be serviced before, as the OMI Industries Vapor Phase Unit needs only electrical power to operate. There are many different combinations of electrical service available so the unit can meet the electrical needs of many countries.

Applied as close to a gas phase as possible, the dispersion stream offers several advantages. The Ecosorb® product is used in a more efficient manner, requires no mixing or dilution, is mechanically simple (requires minimal maintenance), and offers a more natural working atmosphere.

VAPOR PHASE UNITS – GENERAL OPERATION

The Vapor Phase System is designed to very simply produce sub-micron droplets and disperse the droplets to an area, exhaust stack or the atmosphere.

This is accomplished by using a high-pressure blower to intake atmospheric air and vaporize Ecosorb® product within the airstream. The air stream containing the suspended Ecosorb® product is then distributed into the target odorous environment usually through engineered design perforated PVC pipe. Holes drilled at prescribed centers allow the outlet air stream to exit the PVC pipe run at a controlled velocity, which has been determined to provide the most efficient dispersion pattern.

The Ecosorb® product is sprayed into the distribution air stream by using an air-operated nozzle. The product is drawn from the product storage tank or directly from a drum or tote with an electrically operated feed pump. This provides for a steady flow of Ecosorb® odor neutralizer to the liquid side of the spray nozzle. Air to create the spray from the nozzle is provided by a continuous duty compressor and regulator included within the system.

All units have a simple, easy to use and understand controls. The different types of power required by the units is provided through a transformer that provides the power for the air compressor, feed pump, heater, indicator lamps, and additional options.

VAPOR UNITS – SIZING FOR THE SITUATION

To determine the correct size of the OMI Industries Vapor Phase Unit needed to solve the odor situation, several items must be taken into consideration:

What is the odor that needs to be eliminated? Knowing the odor will help determine what size of Vapor Phase Unit is needed. The heavier the odor, the more Ecosorb® will be needed - therefore the feed pump must be sized to meet this need.

What is the size of the area to be treated? By measuring the length of the pipe run (including any “tees”, “elbows”, and “crosses”) the static pressure of the blower can be determined. This will need to be done to be certain that the airflow will be sufficient to reach the end of the pipe run. Also, should the unit be used to treat an exhaust stack air stream, the data from that stack must also be used. Velocity, humidity, and temperature are as important as the height and diameter of the stack.

Not much space is required to install the units, however the units should be placed where there is adequate air available to the inlet side of the unit. Also, on the smaller 450CFM unit the outlet is at the rear of the unit so some room needs to be left to install piping, and connect to the piping run. With all system sizes, the distribution delivery system should incorporate sweeps rather than hard 90 degree fittings and tees, especially near the unit so as to reduce potential vapor removal from the treatment air carrying Ecosorb® product.

NOTE: There are several variables requiring consideration when sizing a system. The selection and engineering of the proper system requires experience in this field and should be referred to OMI Industries directly. A layout of the intended distribution system including dimensions, bends, turns, and sweeps is necessary for OMI Industries to design the system correctly, providing proper piping, fittings and the associated pressure drop calculations. Also identify the intended location of the vapor generator assembly and the available power.

STANDARD VAPOR PHASE UNITS

There are three standard Vapor Phase Units manufactured by OMI Industries. Specifications for each unit are shown.

Specifications for 450 CFM, 12 IWG Vapor Phase System

- 100% powder coated 16 gauge welded steel enclosure
- 100% powder coated 10 gauge steel base
- External dimensions: 42” W x 42” L x 38” H
- 230 /460/380/575 VAC, 50/60 hertz, 3 phase, 3.0 HP electric motor
    - 12 full load amps at 460/3/60
- 450 CFM @ 12 IWG Cast Aluminum Pressure Blower
- Oil-less diaphragm air compressor, complete with:
    - Adjustable air pressure regulator
    - Liquid filled pressure gauge
- NEMA 4X electrical box inside enclosure complete with:
    - Motor starter
    - Adjustable thermal overload
    - 1.5 KVA transformer
    - Fuse block
    - Terminal strips
- 45 gallon odor neutralizer product tank
- 4.5 gallon per day chemical feed pump
- Slip-lock internal tube connections
- Air atomization nozzle with push button clean-out needle
- Hinged door access for easy product refills, nozzle cleaning, and system maintenance checks
- 6” diameter Fernco flexible coupling outlet
- Engineered to 5,000 feet per minute velocity

Figure 4.24: EC 450 Indoors

Figure 4.25: EC 450 Outdoors

Specifications for 600 CFM 20 IWG Vapor Phase System

- Galvanized steel skid
- External dimensions: 36" W x 72" L x 52" H
- 208/230/460/380/575 VAC, 50/60 hertz, 3 phase, 5.0 HP electric motor
  - 15 full load amps at 460/3/60
- 600 CFM @ 20" WG cast aluminum pressure blower
- Oil-less diaphragm air compressor with:
  - Adjustable air pressure regulator
  - Liquid filled pressure gauge
- NEMA 4X electrical box inside enclosure complete with:
  - ° Motor starter
  - ° Adjustable thermal overload
  - ° 1.5 KVA Transformer
  - ° Fuse block
  - ° Terminal strips
- 6 gallon per day chemical feed pump
- Air atomization nozzle with push button clean-out needle
- Hinged Door Access for nozzle cleaning and maintenance checks
- 6" diameter outlet with Fernco flexible fitting
- Engineered to 5,000 feet per minute velocity at vaporization ports

Figure 4.26: EC 600

Specifications for 1200 CFM 20 IWG Vapor Phase System

- Galvanized steel skid
- External dimensions: 36" W x 72" L x 52" H
- 208/230/460/380/575 VAC, 50/60 hertz, 3 phase, 5 HP electric motor
  - 20 full load amps at 460/3/60
- 1200 CFM @ 20" WG cast aluminum Pressure Blower
- Oil-less diaphragm air compressor with:
  - Adjustable air pressure regulator
  - Liquid filled pressure gauge
- NEMA 4X electrical box inside enclosure complete with:
  - Motor starter
  - Adjustable thermal
  - 1.5 KVA Transformer
  - Fuse block
  - Terminal strips
- 12 gallon per day chemical feed pump
- Air atomization nozzle with push button clean-out needle
- Hinged door access for nozzle cleaning and maintenance checks
- 8" diameter outlet with Fernco flexible fitting
- Engineered to 5,000 feet per minute velocity at vaporization ports

Figure 4.27: EC 1200

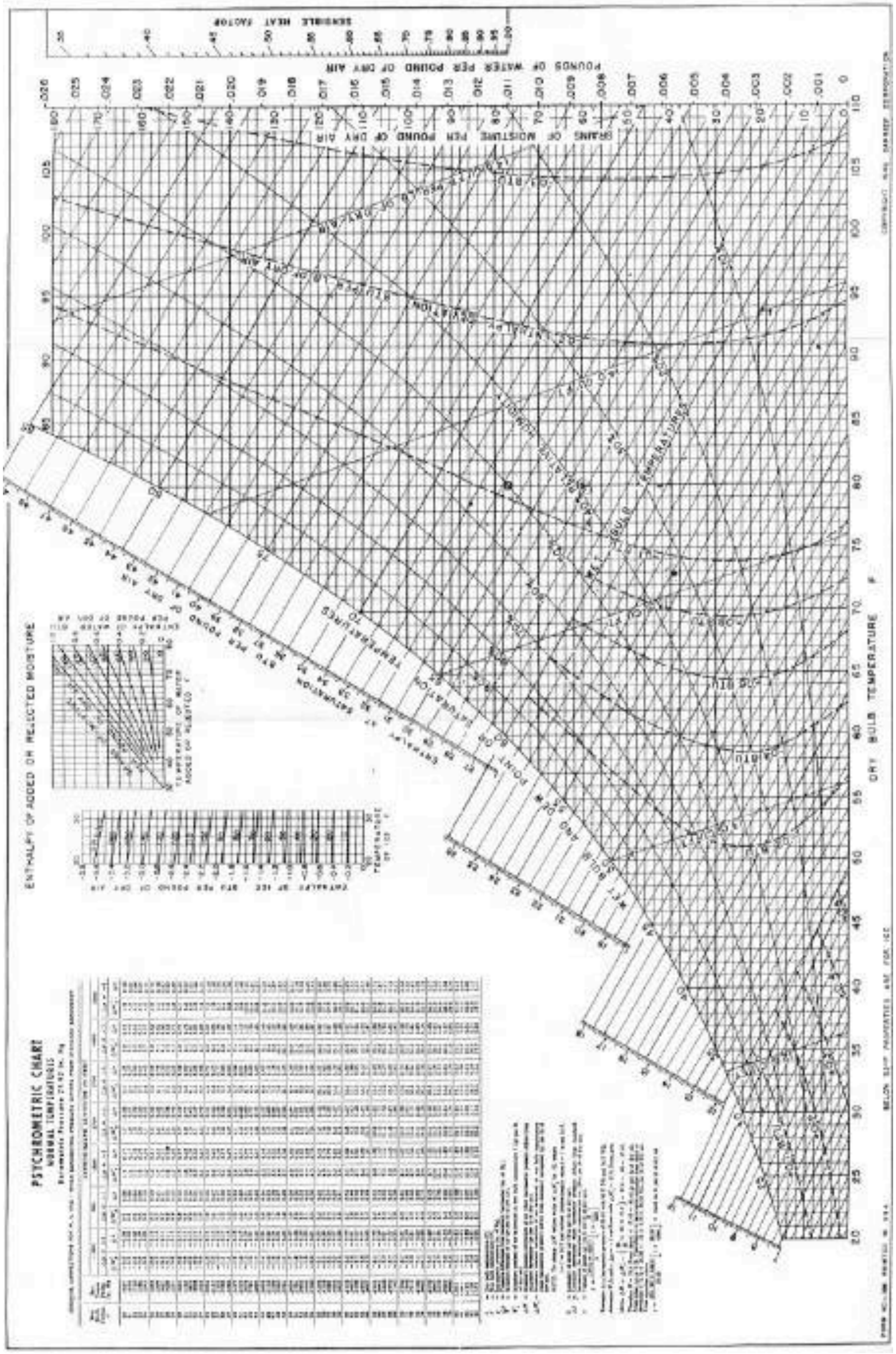
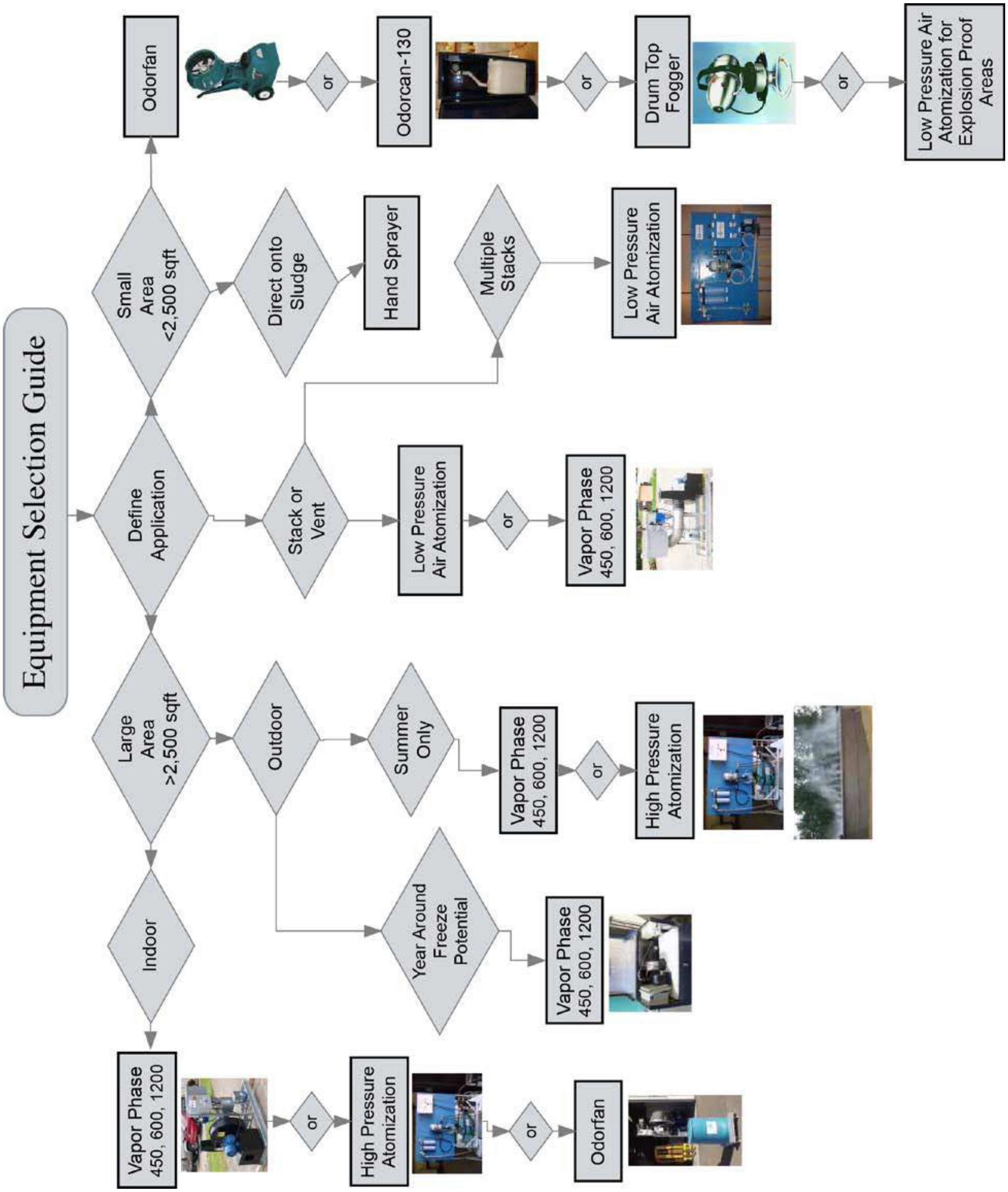


Figure 4.28 Psychrometric Chart

EQUIPMENT SELECTION GUIDE



SECTION 5

REFERENCE MATERIALS

Papers:

Letters:

Lab Reports:

Southern Petroleum Laboratories:

Industry Bulletins

Technical Data Sheets

Control of Malodors using Ecosorb® “A Natural Product”

Sulfur Dioxide, Hydrogen Sulfide, and Ammonia Mechanisms for their removal

Ying Zhang, M.S.
R.W. Hurd, M.S.
Donald R. Wilkinson, Ph.D.

Delaware State University
March 1997

ABSTRACT

Ecosorb removes many malodors, including sulfur dioxide, hydrogen sulfide and ammonia, from the environment. It is made up of a combination of essential oils consisting of an equilibrium of neutral organic compounds and organic buffers. Its pH ranges from 4.0 to 6.8.

Acidic malodors such as hydrogen sulfide and sulfur dioxide are removed by at least four mechanisms including solubility, oxidation/reduction, neutralization and addition across double bonds. Basic malodors such as ammonia and other amines are removed by at least three mechanisms including solubility, addition and neutralization. In all cases the final products consist of organic salts, newly formed organic compounds, very weak natural organic acids (those that were present in the original essential oil mixture), and malodors dissolved in the water/oil mixture. Resulting organic compounds are frequently subjected to oxidation or reduction when in solution. In the case of sulfur dioxide and hydrogen sulfide these reactions result in the formation of free sulfur, or higher oxidation states including SO_2 and SO_3.

The removal efficiency is related to the interaction of the above-mentioned mechanisms, the atomizing efficiency (size and speed of droplets), humidity, temperature and reaction time.

INTRODUCTION

Malodors include acids, bases, and neutral compounds. Several of these are polar compounds and are water-soluble, others are non-polar and are soluble in other non-polar organic solvents. An example of using this solubility would be the scrubbing of ammonia gas from the atmosphere by misting it with water. Although this method can remove ammonia, the reaction is temperature dependent, reversible and not very efficient. The same statement could be made when applied to other soluble bases, soluble acids and even to some neutral compounds.

Some malodors, including sulfur compounds, can be oxidized by air when the compounds are in solution. During this process sulfur compounds can produce sulfur. This procedure is slow, not very efficient, and dependent on moisture content, temperature and mixing with air.

These mechanisms for odor removal can and will take place naturally, although inefficiently. Ecosorb contains a mixture of selected essential oils that can facilitate the efficient removal of many malodors.

Wilkinson and Zhang have broken the malodors down into four main groups which include bases, acids, neutrals and those that will not react with essential oils. A summary of this breakdown of 37 common malodors is shown in Table 1.

MALODORS			
	Group	**Reactions**	**Number of Compounds**
A.	Bases	React by acid/base mechanism 13 compounds plus CH3S, TME, and DMEA	16
B.	Acids	(If they contain relatively small anions) 10 compounds including HCN and phenol, S02, C12 react by addition to a double bond and by neutralization.	10
C.	Neutrals	Includes styrene, CO, CO2, acetaldehyde, ozone.	5
D.	Will not react	Possibly will not react with Ecosorb due to steric hindrance caused by large anion.	6
	Total number of malodors		37

Table 1: Malodor Breakdown

The groups include the following malodors:

Group A: ammonia, butylamine, cadaverine, dibutylamine, diisopropylamine, dimethylethylamine, diphenyl sulfide, ethylamine, indole, methylamine, putrescine, pyridine, skatole, triethylamine, trimethylamine

Group B: ethyl mercaptan, hydrogen sulfide, methylmercaptan, propylmercaptan, hydrogen cyanide, chlorophenol, sulfur dioxide, phenol and sulfurous acid

Group C: acetaldehyde, chlorine, ozone, carbon monoxide, dioxide, and styrene

Group D: allyl mercaptan, amyl mercaptan, crotyl mercaptan, tert-butyl mercaptan, thiophenol (Contain large anions, which cause steric hindrance. These are not as common or as volatile as other compounds in Group A and B.)

Dr. Sylvain Savard, a chemist and Project Leader of the Center of Industrial Research for Quebec, Canada, prepared a report on "The Operating Principles of the Ecosorb System to Neutralize Odors". He pointed out that Ecosorb is a combination of volatile essential oils that are selected for their ability to neutralize odors. The composition of these essential oils can vary because of many factors including:

1. Type of soil in which the plant is cultivated.
2. Time of year of harvest.
3. Part of the plant used.
4. Amount of water in the plant.
5. Amount of exposure to the sun during growth process.
6. Storage conditions before distillation.

The solution contains approximately 30 major chemical compounds, and numerous minor compounds (major and minor in terms of concentration).

Dr. Savard reports that the solution can react through three mechanisms including: Van der Waals Forces, Zwaardemaker pairing and chemical reactions. The solution is mixed with water and sprayed into small droplets, which are in the form of a mist or fog and remain airborne for long periods of time. These small droplets represent a large surface area, which are covered, or partially covered with a film of essential oils. The electrostatic charges on the droplet surface attract gas molecules. When in contact, removal by one of three mechanisms can occur. Sometimes this reaction is slow and other times it is fast. Once captured, the odor is gone. The droplets can cluster, increase in mass and condense.

Wilkinson and Zhang have studied possible chemical reactions between selected essential oils and hydrogen sulfide, sulfur dioxide and ammonia. The essential oils being studied contain three types of substances: weak organic acids, weak organic bases and neutral organic compounds.

---

[1] Dr. Sylvain Savard, a chemist and Project Leader of the Center of Industrial Research for Quebec, Canada, "The Operating Principles of the Ecosorb System to Neutralize Odors".

The acids and bases react and end up as a buffer solution. The oil mixture has a pH of approximately 4.5. When diluted the pH is approximately 6.0. This final buffer like solution is fairly stable, but can change pH with time depending on its environment and how well it is sealed from its environment. We have found the mixture of essential oils to have a pH between 4.0 and 6.0 in the concentrated form.

Based on experimental data already discussed, malodors can be classified into one of three categories: acids, bases and neutrals. Compounds such as hydrogen sulfide, sulfur dioxide, amine, ethyl amine, etc. are bases. Compounds such as styrene are neutral. Acids and bases will react with essential oil buffers in a normal acid/ base reaction forming organic salts and water. Many of these acids and some bases will react with the selected essential oils by addition across conjugated double bonds. This has been shown to be the case with hydrogen sulfide. The question of neutral compounds is still to be studied. Whatever the chemical mechanism or mechanisms involved, the amount of malodor reacting with the essential oils (the bulk kinetic prediction) is much less than the amount of malodor removed (recalculated amount) because of oils.

Previous reports have shown the particular mixture of oils to be very efficient in removing hydrogen sulfide, sulfur dioxide, ammonia, mercaptans, and alkylamines.

Dr. Davidovits of Boston College has studied the effects of pH and Van der Waals' forces on sulfur dioxide.[1] His work is extremely important. He shows how pH greatly affects the amount of sulfur dioxide that remains dissolved in water droplets. He observed as much as a 300% increase in the amount of sulfur dioxide that remained in water if the pH was increased from 3.0 to 6.0. He further concluded that the size and speed of the droplet greatly affected the effectiveness of removing sulfur dioxide from the atmosphere. He also discusses the tremendous effect pH has on the distribution constant of sulfur dioxide in water.

If the work of Dr. Savard, Carter Laboratories, Dr. Davidovits, Boston College and Dr. Wilkinson and Ms. Zhang, Delaware State University are combined, overall mechanisms for the effectiveness of selected essential oils in removing malodors from the environment develops.

Of primary importance in odor removal is the formation of very small droplets with an initial high velocity. This will ensure a large surface area and increased opportunity for collisions with gas molecules. If we are using only water, then the efficiency of removing gas molecules now depends on the solubility of each individual gas in water. The more soluble the gas, the more readily it will dissolve. Once dissolved, the gas will begin to leave the droplet and establish an equilibrium (according to Henry's Law) between its concentration in the gas phase and its concentration in the aqueous phase. The pH of the droplet will greatly affect this solubility by a factor of as much as 300. Some gases are readily soluble, and others only slightly soluble. When selected essential oils are added to the mix the droplets

---

[1] Davidovits, P. and Jayne, J.T., Department of Chemistry, Boston College, Chestnut Hill, Massachusetts and D.R. Worsnop, M.S. Zahniser, and C.E. Kolb of Aerodyne Research, Inc., Billerica, Massachusetts "Uptake of SO2 (gas) by Aqueous Surfaces as a Function of pH: The Effect of Chemical Reaction at the Interface," Journal of Physical Chemistry
1990, 94, 6041-6048.

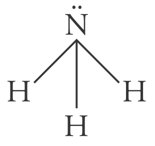
are covered, or partially covered with a thin layer of essential oils. These oils attract most gases to the droplet surface where chemical reactions and pH effects come into play. The oils greatly influence the initial attraction of gas molecules, the pH greatly influences the solubility (gas uptake), and chemical reactions "irreversibly" remove some of the gas molecules by forming new, less volatile compounds. The change in the organic content of the droplet and a resulting change in its polarity all cause a large increase in the distribution constant between gas molecules in the vapor and aqueous phases. This increase indicates that more of the gas remains trapped in the aqueous layer than would normally be trapped at a given temperature.

EXPERIMENTAL RESULTS

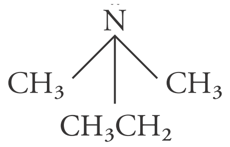
Mechanisms for Basic Malodors:

There are many amines that have been classified as malodors including triethylamine (TEA), and dimethylethylamine (DMEA), ammonia, and trimethylamine. These gaseous amines stimulate nerve endings in the nose and are irritants. They can lead to cell necrosis (cells swell and disintegrate) and increased permeability of the alveolar walls. They can cause flooding of the alveoli and produce a delayed pulmonary edema that may be fatal.

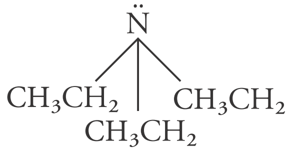
Ammonia is extremely soluble in water and will rapidly dissolve. The oils will have some effect on increasing the attraction of gas molecules to the droplet. A chemical reaction occurs between essential oil buffers and ammonia forming organic ammonium salts. Ammonia, which would normally easily leave the droplet, will now remain to a larger extent in the aqueous layer. This change in the distribution constant will keep the ammonia trapped in the water droplet until condensation occurs, affecting a very efficient removal of this gas from the environment. Since ammonia is a base, the oil mixture should be adjusted to a pH of approximately 4.0 to 6.2 to more effectively remove the gas. This would be true for any basic malodor (alkylamines, etc.). The pH of the essential oil mixture is typically in this range when used.



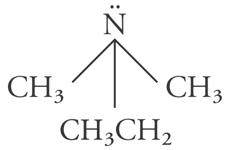
ammonia
Figure 1



trimethylamine
Figure 2



triethylamine
Figure 3



dimethylethylamine
Figure 4

Ammonia (Fig. 1) is the most basic amine. It possesses a nitrogen atom containing a non-bonded electron pair. Its ability to donate this pair to other chemical compounds gives it the characteristic of a base. Notice that this is also true for trimethylamine (Fig. 2), as well as triethylamine (Fig. 3) and dimethylethylamine (Fig. 4).

Amines, being basic, will react with organic acids present in essential oils forming organic salts. The ease and rate of reaction is, in part, a function of the strength of the base. The strength of these bases can be measured by their equilibrium constant (K_b). The larger the value of K_b the more basic is the amine. Ammonia has a K_b of 1.8×10^{-5} (very weak), TME has a K_b of 6×10^{-1} (much stronger), DMEA has a K_b of approximately 2.3^{b} (stronger than TME) and TEA has a K_b of 5.6 (slightly stronger than DMEA). Amines will readily react with the weak organic acids present in the selected essential oils. These weak organic acids are naturally occurring acids, which have proven **not** to be toxic or carcinogenic.[3, 4]

DMEA	+	H^+A^-	=	$DMEAH^+A^-$
Amine	+	Organic acid	=	An organic salt
$(CH_3)_2(CH_2CH_2)N$	+	H^+A^-	=	$(CH_3)_2(CH_2CH_2)N{:}H^+A$
TEA	+	$H+A^-$	=	$TEAH^+A^-$
Amine	+	Organic acid	=	An organic salt
$(CH_3CH_2)_3N{:}$	+	H^+A^-	=	$(CH_3CH_2)_3N{:}H^+A^-$

Figure 5: Chemical Reactions

Ammonium salts formed with essential oils are non-crystalline solids, have a low melting point, are yellow in color, are thermally unstable, are subject to air oxidation, and can undergo rearrangement to form more stable organic amines. The salts are formed by the reaction of the base with the acidic portion of the buffers, e.g. ammonium eugenolate, or ammonium acetate.

Ammonia has been found to be virtually 100% removed within 15 minutes after treatment with the oil mixture both in a laboratory and in actual situations. The oil mixture is more efficient in removing stronger bases such as TEA and DMEA, which may be present as malodors. Their concentration levels may be reduced to less than 0.1 ppm on contact. The essential oil mixture was titrated versus a standard solution of ammonia. It was found that 1 mL of the oil mixture was needed to neutralize 0.00012 g. of NH_3. Because of the solubility and distribution factors mentioned previously, the total amount of NH_3 removed from the environment would be much larger than the amount predicted from chemical reactions alone. The number of g. of NH_3 removed by 1 mL of the oils may be as high as 0.012 g.

In the case of NH_3 we are dealing with a substance that is very soluble in water, and is very reactive at lower pH values. We therefore would expect the difference between the bulk prediction and recalculated

---

[3] Ecosorb was tested for toxicity in accordance with EPA Regulations and was found to have no positive eye irritation reactions, had a zero dermal irritation score, (Toxicity Category IV for skin effects), not to be toxic by 6 oral ingestion at the 5 g/kg level (Toxicity Category IV), not toxic by dermal application (Toxicity IV), had no positive Buehler tests for skin sensitization, tested, not detected, for halogenated hydrocarbons and tested, not detected, for harmful volatile organics (protocol 624).

[4] Results available on request.

values, which would correct for gas-phase diffusion neutralization due to NH_3 uptake, to be more pronounced. The increase in gas uptake would be a much larger factor, possibly as much as 20 or 100 times as great. In an attempt to visually see this effect a theoretical chart of expected values for NH_3 was constructed and is shown in Figure 6.

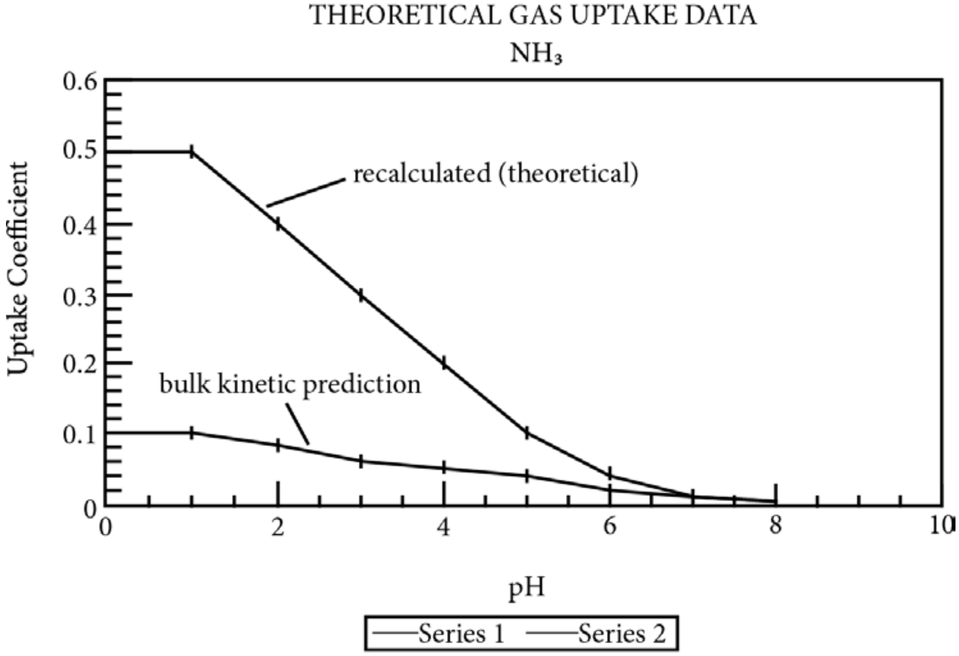


Figure 6: Theoretical Gas Uptake

It would seem that the efficiency of essential oils in holding onto gaseous substances such as SO_2, H_2S, and NH_3 is a function of the misting efficiency (size and speed of the droplet), the solubility of the substance in water (which is facilitated by the organic nature of the essential oils a variable not studied in the above mentioned paper), and the chemical reactions (chemisorption) taking place between active ingredients in the oils and the gas.

Summary: Selected essential oils will effectively remove the basic malodors NH_3, TEA and DMEA by a combination of mechanisms including an acid-base reaction, increased solubility due to pH factors, and changes in distribution constants. A portion of the amine forms a non-crystalline solid ammonium salt, which is readily removed from the air during the scrubbing process. The remaining amine dissolves in the essential oil/water droplet and is strongly held in the droplet due to changes in its solubility and distribution constant. Amines have been shown to be virtually removed within fifteen minutes after contact with the mixture.

Mechanisms for Acidic Malodors:

Acidic malodors include hydrogen sulfide, sulfur dioxide, chlorine, alkyl mercaptans, phenols and other volatile acids. An essential oil mixture will have the same general mechanism for attracting these acids as it does for ammonia. In this case the pH of the mixture should be adjusted to 6.0 - 6.2. The higher the pH will more greatly affect the absorption of hydrogen sulfide, and other acidic gases. The gases will chemically react with the oil buffers forming organic salts, and by adding across double bonds in conjugated components of the oils, forming new, derivitized essential oils. The chemical reactions and pH adjustment will greatly increase the efficiency of removing acidic gases from the atmosphere. The pH of the essential oil mixture is typically at a pH of 6.0 when used.

Sulfur dioxide is an oxidant gas and exposure to it alters pulmonary immunologic responses and increases the host's susceptibility to bacterial infection. The gas reacts readily with water and forms sulfurous acid, which is an irritant.

The above-mentioned compounds are acids, or will form acids when in contact with water. The compound H_2S has been tested and believed to react with Ecosorb by addition across a double bond as well as by a neutralization mechanism. Several compounds in the mixture contain double bonds, which can react with acidic malodors.[1] Compounds containing a conjugated system of double bonds, one of them being an electron-withdrawing group such as a carbonyl (C=O), which facilitates the addition, will more readily react with these acids. A solution of H_2S underwent a pH change from approximately 4.0 to 6.0 when it came in contact with the oils, indicating the elimination of this acid. Infrared studies of the reaction of H_2S with a conjugated aldehyde show loss of one of the aldehyde's double bonds. Experimental data indicates the H_2S is removed by the reaction shown in the following reaction. When the double bonds were removed through the addition of Br_2, the oils proved to be less effective in removing these malodors.

Hydrogen sulfide, when in an aqueous media, can also be air oxidized to form free sulfur. This may also happen to organic sulfides. Mercaptans react using the mechanism illustrated above. Ionization of these compounds is shown below. Malodors, such as hydrogen sulfide, that have not reacted chemically, but have dissolved in water droplets, will oxidize over a period of time. The oxidation products will be less volatile and therefore will no longer produce an odor problem.

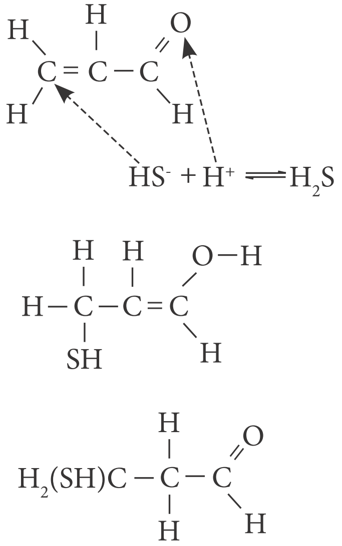


Figure 7

$CH_3CH_2SH \sim CH_3CH_2S^- + H^+$

$CH_3SH \sim CH_3S^- + H^+$

$SO_2 + H_2O \sim H_2SO_3$

$H_2SO_3 \sim H^+HSO_3^-$

Figure 8: Ionization

---

[1] Yet unpublished research by Wilkinson and Zhang.

Molecular models were constructed for Phenol, H_2S, H_2SO_3, C_2H_5SH, and CH_3SH. These models were added on to a double bond in a model of a conjugated aldehyde. No steric hindrance was noted in the case of Phenol, H_2S, H_2SO_3, and CH_3SH, and only slight hindrance in the case of C_2H_5SH. Models of higher molecular weight mercaptans showed considerable steric hindrance indicating difficulty in reacting by the suggested mechanism.

Acidic malodors will also react with the aforementioned buffers forming organic salts. It was found that 1 mL of Ecosorb reacted with 0.000118 g. of SO_2, and as in the case of NH_3 this value could be as high as 0.0118 g. There are three major factors effecting the removal of an acidic gaseous malodor from the environment: (a) uptake as a function of pH, (b) modeling of the gas uptake (Henry's Law), and (c) interaction at the interface. The following chart was used to discuss the uptake of the gas SO_2 by fast moving water droplets.

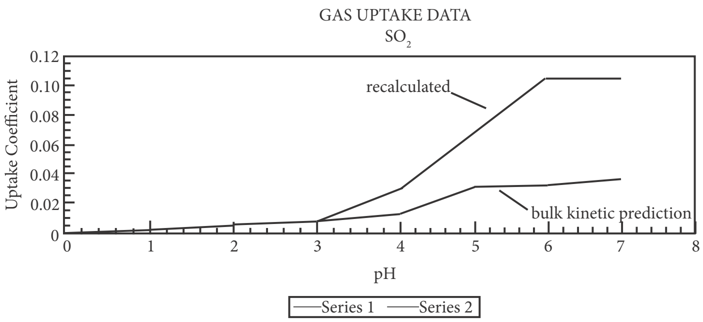


Figure 9: SO_2 Uptake Data

The lower curve represents the bulk kinetics prediction, or the amount of SO_2 we anticipate being removed by liquid water. The Y-axis (uptake coefficient) relates to the relative amount of the gas being removed. Under normal conditions we would anticipate SO_2 dissolving into the droplets of water more efficiently at a pH of 4.0 to 7.0, since the gas is an acid anhydride and will react chemically much better as the pH increases. This lower curve considers primarily the solubility of SO_2 at the pH listed. The upper curve is what we actually find when studying removal of the gas under fast-moving droplet conditions. We observe a 4 fold increase in removal efficiency caused by a combination of the above listed factors:

a) SO_2 is more soluble in water that is less acidic, reaching a maximum at a pH of 5.0. The fact that the droplets are small and fast moving causes more collisions, and increased surface resulting in a more efficient removal of the gas when using a mist.

b) Because of the limited solubility of SO_2 in water, re-evaporation of the gas due to Henry's Law is important. A portion of the gas would be lost due to this equilibrium. However, it is believed that $SO_2(g)$ enters the liquid droplet not as $SO_2(aq)$, but via a surface complex. Under these conditions, since there is increased surface area, surface complex formation would be increased in the presence of a second chemical substance. This leads to:

c) Interactions at the interface. This constitutes a chemisorption process in which, in the present case, $SO_2(g)$ collides with a water molecule at the interface and forms a complex such as HSO_3^-. The effect of fast moving, extremely small droplets combined with the above mentioned three factors make the removal of SO_2 more efficient when the sample is misted with small droplets of water than when we look at reactions of water solutions (H_2SO_3) of the gas. In the article we find that the recalculated gas uptake values are greater than the bulk kinetic prediction by a factor of 4.

Wilkinson and Zhang determined hydrogen sulfide levels in a field test using an MDA Zellweger monitoring device. This instrument produced higher readings at high humidity versus low humidity using identical concentrations of hydrogen sulfide. Hydrogen sulfide levels apparently remained constant when sprayed with a water solution of essential oils when measured with the MDA device. However, when a filter containing silica gel was attached to the instrument's intake line hydrogen sulfide levels decreases from 15.7 ppm to approximately 1 ppm in twelve minutes. It is apparent that if one is interested in determining hydrogen sulfide gas alone and not in hydrogen sulfide dissolved in water, then a water-removing filter must be added to the system. For proper analysis of hydrogen sulfide gas in a gaseous sample an instrument must be used that: (a) does not use heat to vaporize the sample, (b) is specific for the gas only, and/or (c) contains a hydrophobic filter to prevent hydrogen sulfide dissolved in water from being analyzed as hydrogen sulfide gas.

Summary:

Selected essential oils have been shown to be effective in removing the malodors Phenols, H_2S, SO_2, C_2H_5SH, and CH_3SH from a contaminated atmosphere. Sulfur dioxide, methyl mercaptan, and ethyl mercaptan were reduced to less than 0.1 ppm on contact with Ecosorb. Hydrogen sulfide took as long as 15 minutes for removal. Selected phenols were also effectively removed. Acidic compounds capable of ionizing in water, and not having bulky anions which would cause steric hindrance, will react with specific compounds contained in the product. Compounds listed in this section meet these criteria. Acidic malodors will also react with the natural buffers to produce organic salts.

Mechanisms for Neutral Malodors:

Neutral compounds such as benzene and styrene are less soluble in water than acids and bases. They are also less chemically reactive with most essential oils. At the present time little research has been done on these compounds. It would seem that pH would have less of an effect on solubility and on the distribution constant. The electrostatic oil film around droplets would still act to facilitate the removal of these gases, but the overall effectiveness in removing the gases would be much less than with the aforementioned compounds. Styrene can react with itself under basic conditions to form polystyrene. There are compounds in the essential oil mixture that have a conjugated system similar to styrene. It is proposed that the mixture's pH be adjusted to levels of 8.0, 9.0, 10.0 to study the effect of these higher pH's on the removal of styrene. Additional modification of the scrubber and the oils will be made to increase the efficiency of removing styrene from the environment.

CONCLUSIONS

The most universal scrubber for malodors is water. However, water offers some disadvantages including its rapid loss of dissolved gases. The uptake of a gas into water is a function of (a) pH, (b) gas phase diffusion, (c) re-evaporation due to Henry's Law, (d) change in polarity of water due to polarity modifiers and (e) interactions at the interface. Ecosorb facilitates the removal of malodors by chemically reacting with the gas itself, by changing the pH and affecting the solubility of the gas in water, by increasing the organic makeup of droplets of water, and by possibly increasing the distribution constant between the gas and water. The effectiveness of Ecosorb in removing high concentrations of malodors is measured more by its influence in solubility and the distribution constant of malodors in water than in its specific chemical reactions. The effectiveness of the product in removing low concentrations of malodors is related primarily to the chemical reactions involved, and less to pH and atomizing characteristics.

THE USE OF ECOSORB® 206 IN CONTROLLING STYRENE ODORS

Donald R. Wilkinson, Ph.D.
Delaware State University

Darius Agoumba, M.S.
Delaware State University

Charles R. Timcik, M.S.
Odor Management, Inc.

February 25, 2000

INTRODUCTION

Among environmental problems caused by pollution, in general, air pollution is one of our most serious concerns. Air pollution is defined as the presence of solid particles, liquid droplets, or gaseous compounds normally not present in air or which are present in concentrations greater than normal.[1] One of these gaseous pollutants is styrene.

Styrene monomer is a colorless to yellowish oily liquid with an aromatic, almost floral and penetrating odor. Styrene monomer is slightly soluble in water and cannot easily be removed from the environment. An appropriate way by which hazardous waste species may be reduced from the atmosphere is by dissolution in water in the form of a cloud of rain droplets.[2]

Styrene reacts with atomic oxygen or hydroxyl radicals in air.[3] [4] It is non-persistent in water and has a short half-life. As a proof, the concentration of styrene monomer found in fish tissues is somewhat higher than average concentrations of styrene in the water from which the fish were taken.[5]

In spite of its importance and usefulness, OSHA and EPA consider styrene as a hazardous substance. This chemical is also cited on the special Health Hazard Clean Air Act. The Clean Air Act of 1990[6] requires reductions in emissions of toxic VOCs like styrene. Although some urgency exists to develop systems capable of removing such contaminants down to very low levels, it is necessary to develop new means to reduce styrene concentration in different wastes where present. Reduction of styrene concentration in the milieu is not only of benefit for all users of the environment, but also it will financially help industries by transforming these wastes into non-toxic and possibly usable materials.

It is known that solubility depends on the ability of a solvent to interact with a solute more strongly than solute particles interact with each other. Whether water molecules can surround an organic compound is one of the key factors determining its environmental behavior and impact. Multifunctional oxygenated compounds can absorb water over the entire range of relative humidity.[7] An appropriate way by which hazardous wastes species may be removed from the environment is by dissolution in water in form of cloud or rain droplets.[8] Unfortunately, as said previously, styrene is not very soluble in water. As a result, this method may not be applicable for styrene.

---

[1] Zhang, Ying. Mechanism of Odor Control by Essential Oils, Master of Science Thesis, Delaware State University: Dover, April 1997, 1.

[2] Stanley, E. Manahan. Environmental Chemistry, 6th Ed, 1986, 569.

[3] Hoigne, J., Bader, H., Rate Constants of Ozone with Organic and Inorganic Compounds in Water. 1. Non-Dissolving Organic Compounds, Water Res. 1983, 17, 83-173.

[4] Brede, O., Helmstreit, W., Mehnert, R. Nanosekunden-Pulsradiolyse Von Styrol in Waessriger Loesung, J. Prakt. Chem. 1974, 316, 14-302.

[5] AQUIRE Database, ERL-Duluth, U.S.E.P.A.

[6] Amy, Hudson. Taking Control of Styrene Emissions, Composites Technology, Sept / Oct 1996.

[7] Irona, Nongkynrih and Mahendra, K. Quinolinium Dichromate Oxidations. Kinetics and Mechanism of the Oxidative Cleavage of Styrenes, J. Org. Chem. 1993, 58, 4925-49928.

[8] Hurd, C. D., Green, F. O., J. Am. Soc. 1939, 61, 2979.

Work at Delaware State University using Ecosorb (mixture of essential oils) to reduce malodors such as ammonia, hydrogen sulfide, and sulfur dioxide, demonstrated that these oils react through several mechanisms, the most important being solubility.

As demonstrated, original Ecosorb is not as efficient in neutralizing chemicals such as styrene (only 10 - 30% reduction) and benzene because not only are these substances less soluble in water than are acids and bases, but they are also less chemically reactive. Because Ecosorb contains a mixture of both low and high molecular weight oils, as well both water-soluble and water insoluble oils, it was recommended that its composition be Modified to include fewer low molecular weight and fewer water soluble oils. These changes would make the new product, referred to as Ecosorb 206, less soluble in water, but also increase the solubility of styrene in the product. Initial tests were made on two different types of the modified product. One of the two samples was more promising than the other and was selected for further testing.

The main purpose of this research was to use this new product in an attempt to more efficiently reduce environmental styrene levels. This research included kinetic studies on possible styrene degradation once in solution and to isolate and identify degradation products.

EXPERIMENTAL

New product 1 (M69795) and new product 2 (M69794) are modified versions of Ecosorb. They are water suspensions of natural plant oils and are produced by Odor Management, Inc. of Barrington, IL. These experimental products are designed as styrene odor neutralizers and are non-toxic.

To identify product components, a method using a HP 5890 GC/MS, was created to separate components and to analyze data using the Wiley Library. The scan mode was used to detect total mass to charge (m/e) fragments. Chromatograms of the standard product, Ecosorb 606 and the new Ecosorb 206 were obtained and compared. Ecosorb 206 contained greater concentrations of less water soluble, high molecular weight components and lower concentrations of the more water soluble, lower molecular weight components.

Styrene, as a relatively non-polar, hydrophobic organic compound is only slightly soluble in water, having a solubility of 55 +/- 10 ppm (wt/vol.) at 24°C. Therefore, the relative insolubility of styrene in water involves the selection of a solvent (solution), which will increase styrene's solubility (Table 1). Previous studies by Delaware State University's chemistry department researchers demonstrated that styrene's solubility increases to approximately 4,000 ppm in water that was saturated with concentrated Ecosorb.[9] However, this increased solubility was not sufficient to reduce styrene concentrations in a polluted environment. When water containing smaller amounts of Ecosorb 206 (suspended either with constant agitation, or dissolved with the aid of another organic solvent) the same styrene solubility was achieved. The use of smaller amounts of Ecosorb 206 than Ecosorb 606 affected a much larger dissolution of styrene making this new product a much more efficient scrubbing solution.

---

[9] Zhang, Ying. Mechanism of Odor Control by Essential Oils, Master of Science Thesis, Delaware State University: Dover, April 1997, 1.

A Plexiglas/gas chamber, with a volume of approximately 1.12ft^3, was used in this experiment. Air was passed through a bubbling tube containing styrene and a flow-controlled bypass. By clamping the bypass one could control styrene flow and thus total styrene concentration while maintaining a constant total flow rate.

Misting experiments were carried out using 0.33 CFM, 1 CFM, and 5 CFM of air flow with a total styrene concentration of approximately 400 ppm (wt/vol.) and a misting rate of 6.6 mL/min with dilutions of Ecosorb206 in 35% isopropanol. The isopropanol was used to increase solubility of Ecosorb206 in water and had a small affect on the overall solubility of styrene. The solution was diluted to 1/25, again to1/50 and a third time 1/100 with water. The chamber was first sprayed with styrene under different flow rates (those cited before) until a constant concentration of approximately 400-ppm (wt/vol.) was reached. A 1mL sample of styrene vapor was removed from the outlet of the chamber and was injected into the GC/MS as a standard. The chamber was misted separately with the different diluted solutions of Styrosorb using an adjustable pressure pump and nebulizer while maintaining a constant airflow. In each case outlet samples were removed after approximately 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes and 30 minutes. Evaluation of styrene levels at the end of each experiment was made using heights of selected styrene fragments obtained from chromatograms. Average percent reductions of styrene were measured and confidence limits calculated at both 90% and 95% confidence levels. Results of these experiments are summarized in Tables 2-7.

Odor Management, Inc (OMI) in California manufactured a scrubber, similar to Delaware State University's prototype. Field tests at Molded FiberGlass Companies/ West in Adelanto, California and again at Lasco Bathware in Anaheim, California were arranged in an attempt to test the prototype scrubber in removing styrene from a fiberglass fabrication process. A Dyna-FID hydrocarbon gas analyzer with a flame ionization detector (FID), a total hydrocarbon gas analyzer, was used to determine styrene concentrations at MFG West. A similar Rat Fitsch analyzer was used at and provided by Lasco. The aim of these tests was to confirm laboratory findings in an actual field environment while using a greater airflow. The equipment was designed as a prototype model, not operating under realistic process volumetric airflow, but operating under acceptable airflow conditions to prove the concept. The prototype model system operated at approximately 650 CFM.

Air handling systems at MFG West were designed to discharge 75,000 CFM. Exhausts were on the roof and nearly inaccessible from the ground. To simplify the experiment, MFG/West constructed a mock spray booth with two filter elements. The mock booth was attached to the scrubber blower assembly inlet with flexible metal ducting. MFG/West then provided a resin spray assembly and an operator. The scrubber assembly consisted of the blower, a contact/mixing chamber into which the product was atomized, and a filter assembly fixed down stream of the chamber. Liquid flow rates inside the chamber could be varied through the addition or removal of atomization nozzles and by changing nozzle orifice size. The field test at MFG West confirmed the lab findings; styrene can be removed from process air using Ecosorb206 with a coalescing filter design.

The second field test at Lasco was performed to confirm the findings of the experiment at MFG West while using actual process air and experiment with effluent recirculation. Lasco owned and provided the analyzer. Actual process exhaust gas was fed to the inlet of the scrubber blower via 75 feet of flexible ducting attached to a tap on one of the Lasco exhaust stacks.

Ecosorb solutions contain natural hydrocarbons. Therefore, the FID measured styrene and also the presence of these hydrocarbons in exhaust air of both field experiments. To avoid confusion in exhaust readings by the FID, each analysis was preceded with a measurement of background conditions. Given the system design, exhaust background was expected to remain constant and could be subtracted from the total yielding styrene exhaust count. Table 8 summarizes field test results at Lasco Bathware and shows a strong correlation between percent reduction of styrene in field tests with laboratory styrene reductions. The instruments were calibrated with methane and the actual ppm count is 1/8 of those shown (methane contains a single carbon and styrene contains eight).

Condensates from the successful California field tests were collected, shipped to Delaware State University and analyzed for the presence of styrene. This was done to confirm field-test data that styrene was collected. No styrene was found in any of three samples. Liquid condensates were decanted and residues, collected from the bottom of all containers, were analyzed and found to contain the styrene degradation byproducts shown in Figure 6.

The above results led to further laboratory investigations. At completion of laboratory tests involving misting styrene with Ecosorb 206 condensates were collected from the laboratory's experimental chamber for analysis. Then, 1uL of condensate was injected into a GC/MS at predetermined intervals over approximately fifteen minutes (15 min). A plot of log abundance vs. time for the first fifteen minutes showed first order kinetics. The average rate constant for the degradation of styrene in water was 0.270 and in Ecosorb206 solution 0.278, or approximately equal rates of degradation. Figure 1, Figure 2. This is better illustrated in Figure 3 where the straight lines are parallel indicating equal rates of degradation. Over the next twenty-four hours the same test was repeated in order to determine styrene degradation with respect to time. Figure 4 and Figure 5 show this degradation.

DISCUSSION

Ecosorb 206 contains plant extracts consisting of essential oils having functional groups able to react with malodors and a larger concentration of higher molecular weight oils. Therefore, essential oils in Ecosorb 206 are capable of removing styrene vapor once dispersed into the chamber. This dispersion is a major key in the effectiveness of the process involving essential oils. It was necessary to keep solutions agitated during the misting operation.

A general scrubber for the removal of pollutants (malodors) is water. The dissolution of gaseous molecules into liquids is a combination of four processes:

- Diffusion of gas molecules to the liquid surface
- Accommodation of gas molecules on the surface
- Possible chemical conversion to form a soluble product
- Liquid-phase diffusion of dissolved products away from the liquid surface

The connection of processes 2 and 3 with 4 is strongly dependent on solubility of the gas in the liquid (expressed by the Henry's law constant). If mass accommodation is faster than liquid diffusion the surface becomes saturated in the trace gas, leading to re-evaporation of dissolved trace gases, which reduces the net uptake rate. The ability of a gas to diffuse into water is greatly affected by the surface area of the water and the likelihood of collision. A large number of fine water droplets moving at a rapid velocity are major factors in the initial removal of malodors by misting techniques. If the surface of fast moving water droplets is modified by the addition of substances having various polarities (found in Ecosorb), the solubility of gases can be greatly changed, and these modifiers can intensely effect the distribution constant.

Misting chamber tests were made at total airflows of 0.33 CFM, 1 CFM, 5 CFM; styrene concentrations of 400 ppm (wt./vol.) and a misting rate of 6.6 mL/min were made using various Ecosorb concentrations.

It was found when analyzing our data that a 90% confidence level, even though discarding many of the extreme data, produces a more realistic average. Therefore, considering the apparatus utilized, using a 90 % confidence level is more acceptable than using a 95% confidence level. Analysis of obtained data from the chamber test, indicated that a 1/50 solution of Ecosorb 206 is most efficient in removing styrene at any of the three flow rates tested. It is capable of removing styrene concentrations between 70% and 84% with 400-ppm styrene inlet conditions.

Compared to previous similar works, and as mentioned earlier, actual reduction of styrene concentrations observed during these experiments is explained by the following hypothesis: micro droplets of water are covered with a thin layer of the components of Ecosorb. This oil shell creates an electrostatic attraction for gas molecules in the general environment of the droplet. The malodor's molecules are attracted to the droplet surface where some of the molecules chemically react, while others dissolve in the droplet itself. Some of the more water-soluble oils dissolve in the water droplet thereby changing the polarity of the droplet and also changing the solubility of the malodor in the droplet. The overall effect of this change in polarity is to decrease the distribution constant between malodors in the vapor state and dissolved in water. A decrease in the distribution constant, resulting in a decreased loss of the malodor to the atmosphere, will also bring about a more irreversible absorption of the malodor in water, than would be experienced in water alone. In addition, the size and speed of the droplets intensely affected the potency of removing styrene from the chamber. Also, because of neutrality of styrene, pH of the actual mixture has less effect on solubility and on the distribution constant.

Data obtained from degradation of styrene were used to study its kinetics. Results indicated that styrene concentration decreased with time and concentrations of styrene dropped 96% after 24 hours most of this reduction occurring during the first fifteen minutes. These data yield straight lines when they are plotted as logarithms of styrene abundance versus time.

Constants of degradation (rate constant) k were determined. Rate constants are related to the speed of a chemical reaction. $k = 0.278$ when styrene reacted in water after 15 min. $k = 0.270$ when styrene reacted in an Ecosorb206/2-propanol/water solution after 15 min. Because the rate constants are similar the degradation of styrene in water was similar to that in an Ecosorb206 solution.

Equations of straight lines mentioned earlier represent kinetics of a one-compartment model. According to theory relative to compounds that can be described by one-compartment models, styrene elimination occurs through a first-order process. This means that rate of elimination of styrene at any time is proportional to its amount in the environment at that time. As styrene is eliminated by first-order kinetics, time required for 1/50 is approximately 4 times more efficient than Ecosorb 606 and 88 times more efficient than water in removal of styrene.

Condensate formed the next day consisted of a clear liquid. This can be explained by the fact that most molecules with higher molecular weights, that characterize insolubility of essential oils, are removed by falling out of suspension during coalescence. The present liquid contains only dissolved lower molecular weight or water-soluble oils, some higher molecular weight oils and dissolved styrene. Dissolved styrene increases solubility of all oils making the condensate clear. Previous degradation studies proved that styrene, present in the liquid rapidly degraded. Small amounts of this product injected into a GC/MS and then analyzed using a Wiley library permitted confirmation of the presence of benzoic acid, benzene dicarboxylic acid and bicyclo [4.2.0] octa-1, 3, 5-triene. Possible pathways of these products are shown in Figure 6. These compounds fall out of solution and were present at the bottom of the condensate container. Condensate samples did not reveal any of these degradation products when injected into a GC/MS. They were removed by decanting all liquid, then dissolving the residue in methanol from the floor of the chamber and analyzing by GC/MS followed with a library search. Products obtained from the reaction between Ecosorb206/water mixture and styrene have been confirmed when compared to products obtained when styrene was reacted with selected strong oxidants. Their formation is justified by the fact that one of the pathways of styrene alteration consists in catalytic oxidation of the side chain to styrene 7,8-oxide followed by catalyzed conversion by epoxide-hydrolase to phenyl glycol. The latter can be glucoronided directly and oxidized further to mandeleic acid, phenylglyoxylic acid and benzoic acid. The similarity between obtained results and catalytic oxidations demonstrate the efficiency of using carefully blended essential oils such as Ecosorb206 to reduce styrene levels in the environment.

Also, during biotransformation of styrene in humans approximately 90% of absorbed styrene is eliminated as mandelic acid and phenylglyoxylic acid in the urine.

CONCLUSIONS

Once in solution, styrene is rapidly degraded. Because of its poor solubility in water a major difficulty in removing styrene vapor is getting it into solution.

Absorption and chemical reactions help explain reduction of styrene from the environment using essential oils (Ecosorb). The rate-controlling step is adsorption of styrene on the surface of droplets of Ecosorb followed by dissolution. The latter depends on solubility of styrene, pH of the solvent and water–gas interaction.

As water solubility of a gas decreases, concentration of essential oils (Ecosorb) must increase. Styrene, a slightly water-soluble compound, is more readily removed using a new product, Ecosorb206. Efficiency of Ecosorb is improved by adding 2-propanol as an additional solvent. This alcohol facilitates solubility of styrene even though it adds another hydrocarbon that can make the rate of removing difficult to measure when using analytical devices other than a GC/MS. Avoiding this addition will require slightly higher concentrations of Ecosorb with either constant agitation or modification with a surfactant to keep it suspended in water. Since styrene reduction is based on its solubility, it is helpful if a coalescing scrubber is used and condensate collected. In addition, this condensate may be recycled and after being used several times, treated as waste.

GENERAL COMMENTS:

- Ecosorb 206 diluted 1/25 is 4 times more efficient in getting styrene into solution than Ecosorb 606.
- Ecosorb 206 diluted 1/25 is 88 times more efficient in getting styrene into solution than water.
- Once in solution styrene degrades into one of 3 compounds (benzoic acid, benzene dicarboxylic acid and an intermediate bicyclo [4.2.0] octa-1,3,5 triene). This degradation is independent of the solution used to dissolve styrene. The intermediate is unstable and rapidly changes to benzene dicarboxylic acid, also named phthalic acid.
- Between 70% to 100% of styrene can be effectively removed from an environment by:
    A. Forcing the styrene containing air though a scrubber.
    B. Misting with fine droplets of water.
    C. Coating these droplets with a carefully formulated mixture of essential oils.
    D. Forcing the droplets to efficiently coalesce.
    E. Collecting, enriching with new essential oils and recirculating the condensate.
    F. Degrading the styrene to reduce hazardous waste concentrations.

Getting malodors into solution is of primary importance in their removal and subsequent degradation. Ecosorb606 and Ecosorb206 facilitate dissolution of water-soluble and/or water insoluble malodors, through chemical reactions increase degradation of acidic and basic malodors and assists in preventing the malodor's return to the vapor state.

TABLE 1: *Solubility of Styrene in Various Liquids (ppm = g/10^6mL)*

H_20 @ 24°	**35% 2-Propanol @ 24°C**	**Conc. Ecosorb @ 24°C**	**25% Ecosorb 206 @ 24°C**
55 ± 10 ppm	165 ± 30ppm	4000 +/-500ppm	4000± 700ppm

TABLE 2: *Average reduction after measuring reduction every 10 minutes for 50 minutes - Using a Confidence Level of 90% and discarding values outside of the Confidence Limit using standard t table values*
Airflow = 0.33 CFM, Styrene conc. = 400 ppm (wt./vol.), Misting rate = 6.6 mL/min.

Ecosorb 206 Dilution	Average % Reduction of Styrene
1/4	94.4
1/25	83.9
1/50	79.1
1/100	75.3

TABLE 3: *Average reduction after measuring reduction every 10 minutes for 50 minutes - Using a Confidence Level of 95% and discarding values outside of the Confidence Limit using standard t table values*
Airflow = 0.33 CFM, Styrene conc. = 400 ppm (wt./vol.), Misting rate = 6.6 mL/min.

Ecosorb 206 Dilution	Average % Reduction of Styrene
1/4	85.2
1/25	94.4
1/50	79.1
1/100	82.3

TABLE 4: *Average reduction after measuring reduction every 10 minutes for 50 minutes - Using a Confidence Level of 90% and discarding values outside of the Confidence Limit using standard t table values*
Airflow = 1.0 CFM, Styreneconc. = 400 ppm (wt./vol.), Misting rate = 606 mL/min.

Ecosorb 206 Dilution	Average % Reduction of Styrene
1/4	80.6
1/25	64.6
1/50	89.7
1/100	54.4

TABLE 5: *Average reduction after measuring reduction every 10 minutes for 50 minutes - Using a Confidence Level of 95% and discarding values outside of the Confidence Limit using standard t table values*
Airflow = 1.0 CFM, Styrene conc. = 400 ppm (wt./vol.), Misting rate = 6.6 mL/min.

Ecosorb 206 Dilution	Average % Reduction of Styrene
1/4	80.6
1/25	64.5
1/50	83.7
1/100	54.4

TABLE 6: *Average reduction after measuring reduction every 10 minutes for 50 minutes - Using a Confidence Level of 90% and discarding values outside of the Confidence Limit using standard t table values*
Airflow = 5.0 CFM, Styrene conc. = 400 ppm (wt./vol.), Misting rate = 6.6 mL/min.

Ecosorb 206 Dilution	Average % Reduction of Styrene
1/4	75.5
1/25	45.4
1/50	73.5
1/100	43.4

TABLE 7*: Average reduction after measuring reduction every 10 minutes for 50 minutes - Using a Confidence Level of 95% and discarding values outside of the Confidence Limit using standard t table values*
Airflow = 5.0 CFM, Styrene conc. = 400 ppm (wt./vol.), Misting rate = 6.6 mL/min.

Ecosorb 206 Dilution	Average % Reduction of Styrene
1/4	75.8
1/25	44.9
1/50	71.8
1/100	44.0

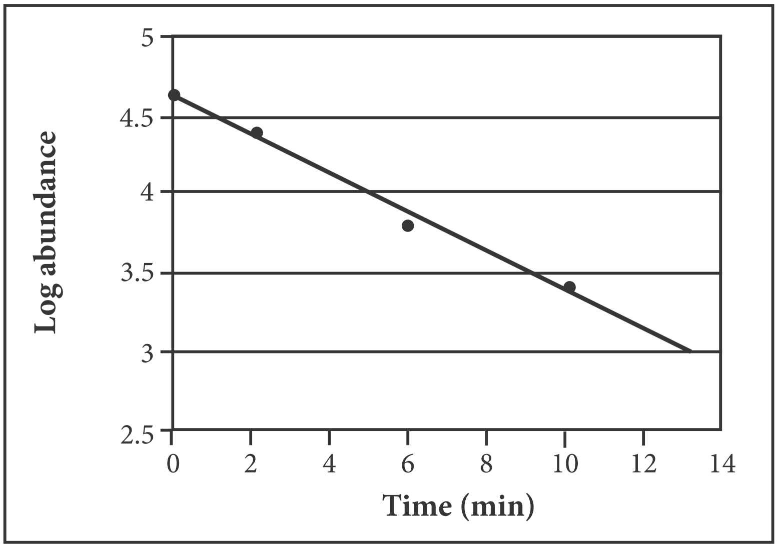
TABLE 8: *Field Test Results - Lasco Bathware, November 4, 1998*

Liquid Flow, gpm	Dilution	Inlet ppm	Outlet ppm Styrene	Ppm Reduction	% Reduction
.234	25:1	600	110	490	81.60%
		600	120	480	80.00%
		700	220	480	68.50%
		740	300	440	59.40%
.198	50:1	600	110	490	81.60%
		600	120	480	80.00%
		700	220	480	68.50%
		740	300	440	59.40%
.292	23:1	580	150	430	74.00%
		580	150	430	95.00%
		660	240	420	89.50%
		460*	240*	220	79.0%*
.422	50:1	400	20	380	95.00%
		380	40	340	89.50%
		440*	90*	350	79.0%*

** Recirculated*

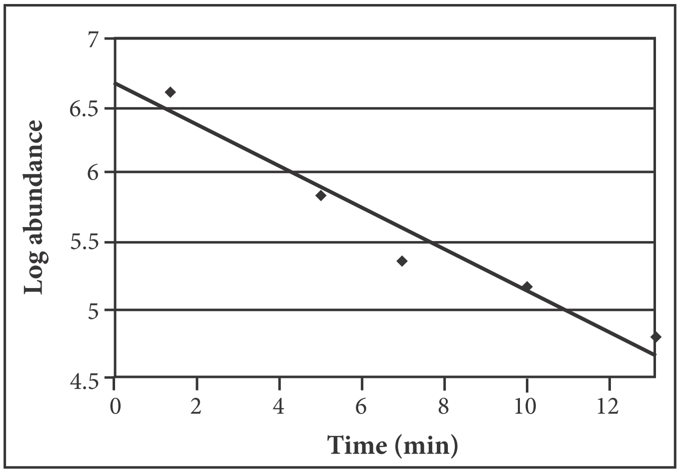
Outlet ppm styrene is outlet total minus outlet background
ppm = wt/vol
Data from Odor Management, Inc.

Figure 1: Degradation of Styrene in Water after 13 minutes – Determination of Initial Rate Constant



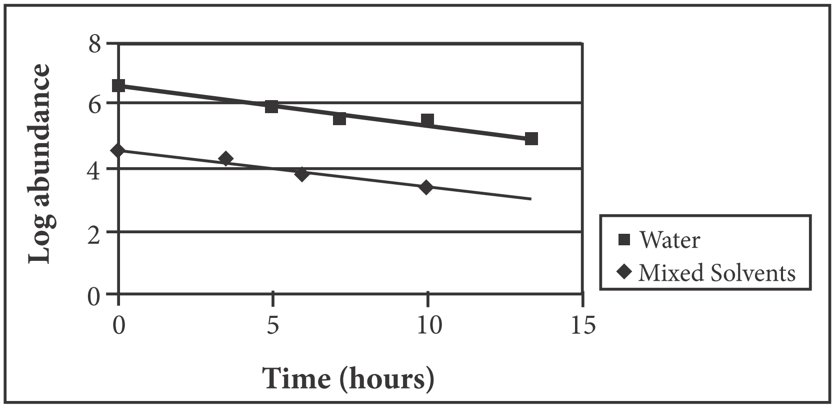
The initial styrene degradation rate is very rapid and follows first order kinetics. The average rate constant (k) for this reaction at 24°C was 0.270. Good linearity was obtained with a coefficient of correlation, R, equal to 0.9887 and R^2 = 0.9993.

Figure 2: Degradation of Styrene in Ecosorb206 / 2-Propanol / Water after 13 Minutes -Determination of Initial Rate Constant



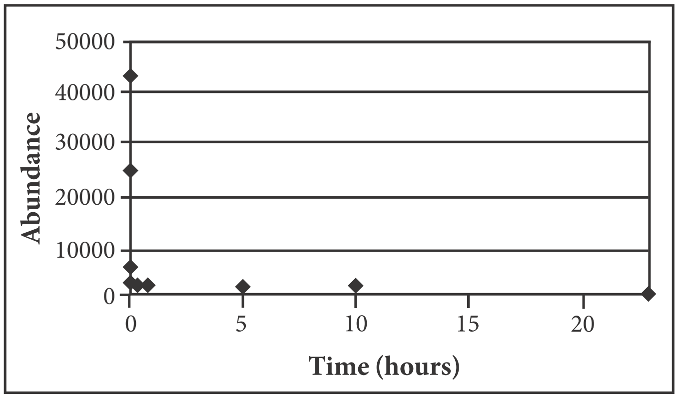
The initial styrene degradation rate is very rapid and follows first order kinetics. The average rate constant (k) for this reaction at 24°C was 0.278. Good linearity was obtained with a coefficient of correlation, R, equal to 0.9708 and $R^2 = 0.9424$.

Figure 3: Degradation of Styrene in Ecosorb206 / 2-Propanol / Water and in Water after 13 Minutes -Determination of Initial Rate Constant



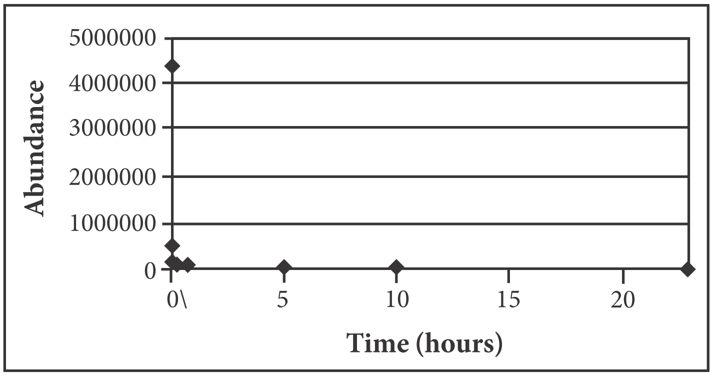
Styrene degrades rapidly when in solution. Rates of degradation are independent of the makeup solutions. The rate constants (k) for degradation of styrene in water and in a mixed solvent containing Styrosorb were 0.278 and 0.270 respectively (experimentally equal). This figure shows almost identical styrene degradation rates in the two solvents.

Figure 4: Degradation of Styrene in Water



There is an initial rapid styrene degradation followed by a slow degradation reaching the instrument's detection limit in 24 hours.

Figure 5: Degradation of Styrene in Ecosorb206 / 2-Propanol / Water after 24 Hours



There is an initial rapid styrene degradation followed by a slow degradation reaching the instrument's detection limit in 24 hours.

Figure 6: Degradation of Styrene

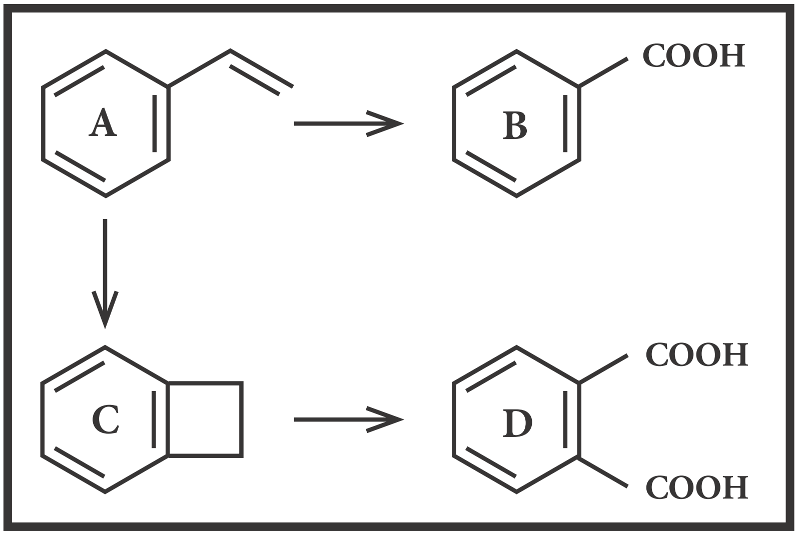
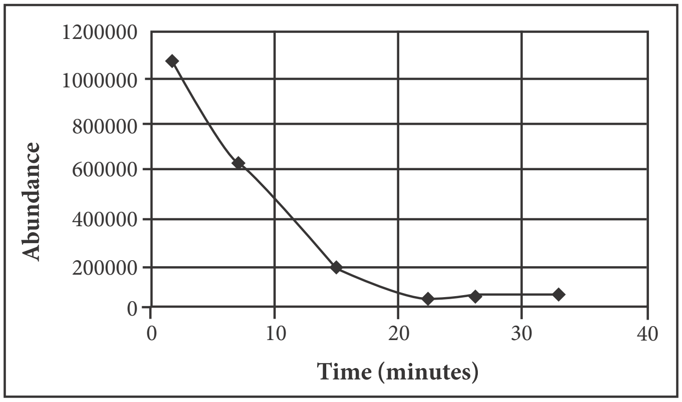


Figure 7: Degradation of Styrene in a Solution of Ecosorb206 - Laboratory Test



Effect of Ecosorb 206 on the Solubility of Benzene

TOXTRAP, Inc.
1059 Horsepond Rd.
Dover, DE 19901
USA

July 11, 2000

TABLE OF CONTENTS

FIGURES

SOLUBILITY OF BENZENE IN WATER AT 23ºC

Three benzene standards prepared using ethanol as a solvent (g benzene/100 mL solution):

1. 0.036 %
2. 0.059 %
3. 0.098%

Each standard was injected into a HP 5890 Gas Chromatograph equipped with dual flame ionization detectors. Each injection was split into two different columns thereby producing four chromatograms per standard. Results are shown in Figure 1. Good linearity was obtained with a coefficient of correlation of 0.9935.

Two 100-mL water samples. At 23ºC, were saturated with benzene and allowed to stand for two hours. The top ¼ layer was removed by aspiration (to remove any undissolved benzene), a 1-uL sample removed from the center of remaining solution and analyzed using the same protocol used with standards. Four chromatograms were obtained with each solution. The following results were obtained:

Benzene concentration in sample #1 = 0.070%
Benzene concentration in sample #2 = 0.082%
Average benzene solubility in water = 0.076% (@ 23ºC)

***Columns: A. 30 m 0.53 mm ID, Restek RTX-BAC-1**
B. 30 m 0.53 mm ID, Restek RTX-BAC-2

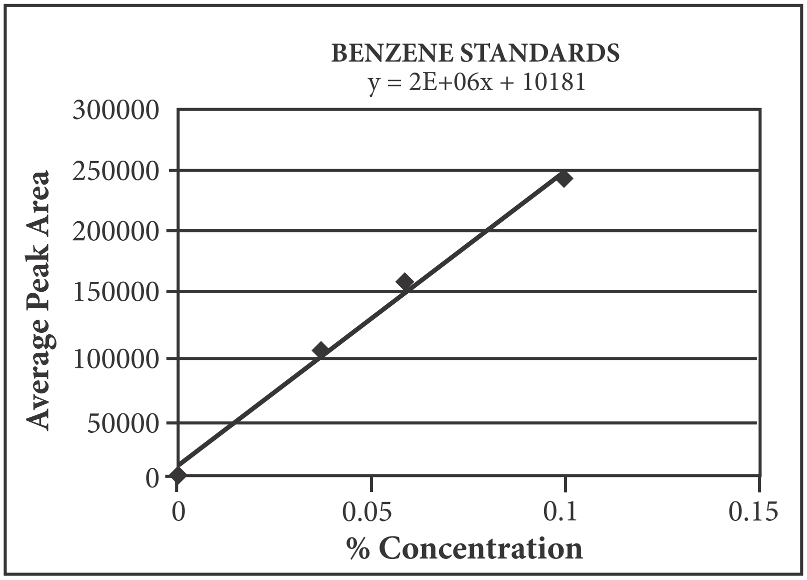


Figure 1 and Table 1: Peak Area vs. Concentration of Benzene in Ethanol

% CONC.	AREA
0	0
.36	108631
.59	167245
.98	243055

SUMMARY:
Table 2-6: Solubility of Benzene in Solution Containing Ecosorb®206

Table 2

6 mL solution + .9 mL benzene			
	1/100	**1/50**	**1/25**
Mean solubility (% g/100 mL)	2.26 +/- 0.17	5.43 +/- 0.56	6.75+/-2.04
Standard Deviation	.15	.48	1.73
Percent standard deviation (CV)	6.43	8.79	25.66
Solution pH	4.3	4.2	3.7

Table 3

6 mL solution + 0.9 mL benzene (BASIC SOLUTION)			
	1/100	**1/50**	**1/25**
Mean solubility (% g/100 mL)	6.17 +/-0.87	5.10 +/-.034	11.47+/-0.84
Standard Deviation	0.74	0.29	0.71
Percent standard deviation (CV)	11.95	7.75	3.21
Solution pH	7.7	7.7	7.7

Table 4

6 mL solution + 3.0 mL benzene			
	1/100	**1/50**	**1/25**
Mean solubility (% g/100 mL)	12.56+/-4.59	16.49+/-3.36	28.83+/-3.97
Standard Deviation	3.9	2.85	3.37
Percent standard deviation (CV)	31.07	17.3	11.69
Solution pH	4.3	4.2	3.7

Table 5

6 mL solution + 3.0 mL benzene (BASIC SOLUTION)			
	1/100	**1/50**	**1/25**
Mean solubility (% g/100 mL)	4.27+/-0.84	11.77+/-5.37	10.03+/-1.68
Standard Deviation	0.71	4.57	1.43
Percent standard deviation (CV)	16.65	38.8	14.24
Solution pH	7.7	7.7	7.7

Table 6

6 mL solution + 3.0 mL benzene in 30% 2-propanol			
	1/100	**1/50**	**1/25**
Mean solubility (% g/100 mL)	7.79+/-2.79	8.60+/-4.52	23.70+/-1.43
Standard Deviation	2.37	3.84	1.22
Percent standard deviation (CV)	30.41	44.63	5.14
Solution pH	4.3	4.2	3.7

DISTRIBUTION CONSTANT (Kd):

- 1/100 causes a 15.54% decrease in benzene release to the atmosphere.
- 1/50 causes a 17.34% decrease in benzene release to the atmosphere.
- 1/25 causes a 22.97% decrease in benzene release to the atmosphere

Figure 2: 6 mL of Solution + 0.9 mL Benzene

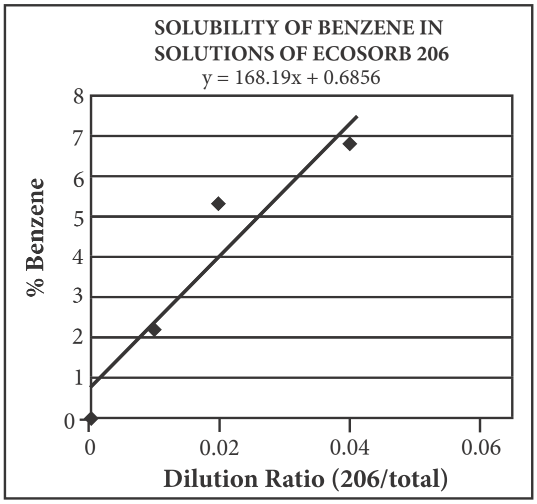


Figure 3: 6 mL of Solution + 0.9 mL Benzene (made Basic with NaOH)

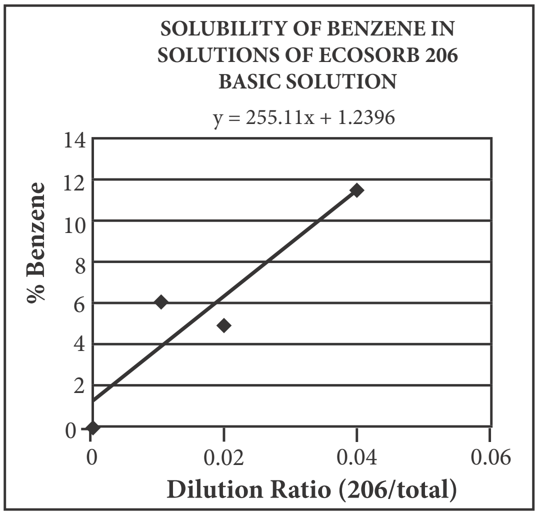


Figure 4: 6 mL of Solution + 3.0 mL Benzene

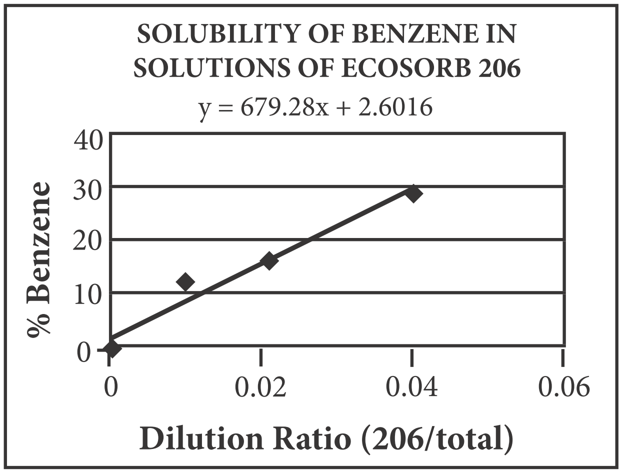


Figure 5: 6 mL of Solution + 3.0 mL Benzene (made Basic with NaOH)

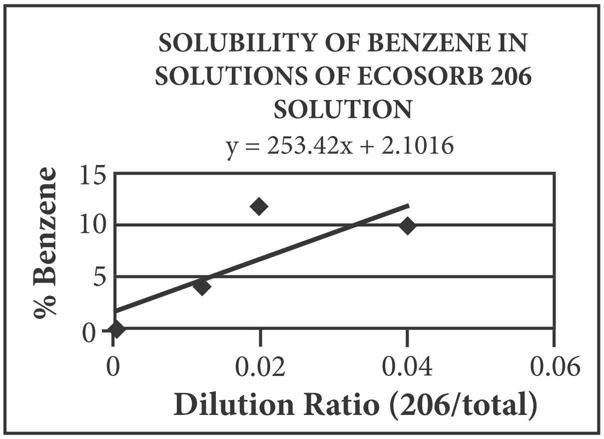


Figure 6: 6 mL of Solution + 3.0 mL Benzene in 30% 2-propanol

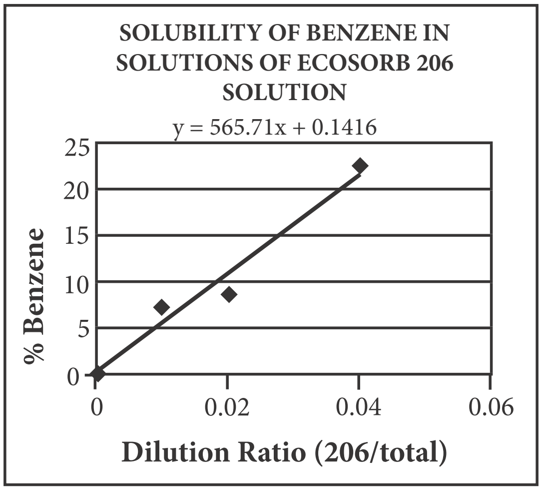
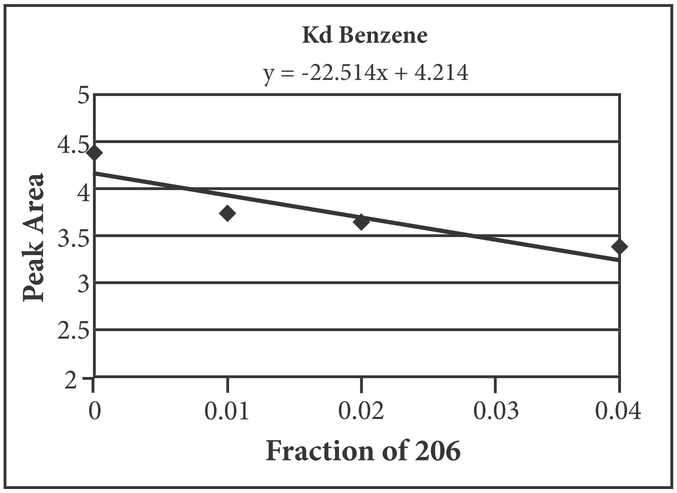


Figure 7: Distribution Constant (Kd) for Benzene Solutions of Ecosorb 206 @ 60°C



DISCUSSION

Solubility Data:

Six studies: 6 mL of various dilutions of Ecosorb206:

1. Added 0.9 mL of benzene (note pH of each solution).
2. Added 0.9 mL of benzene and sufficient dilute NaOH to change pH to 7.7.
3. Added 3.0 mL of benzene
4. Added 3.0 mL of benzene and sufficient dilute NaOH to change pH to 7.7.
5. Added 3.0 mL of benzene to soln. made to equal 30% 2-propanol
6. Determined distribution constant ratios of benzene in various concentrations of Ecosorb206.

The following statistical data were calculated:

· % benzene,
· standard deviation,
· confidence limit at 90% confidence level, and
· coefficient of variation (% relative standard deviation).

When benzene was added, samples were mixed, allowed to stand for 2 hours and the top ¼ to 1/3 removed by aspiration. (to remove un-dissolved benzene from surface).

In all cases % benzene in solution increased with an increase in concentration of Ecosorb206. Graphs contain equation of trend line. The slope is indicative of effect of increasing concentration of 206 as related to total concentration of benzene.

When 0.9 mL of benzene was added a larger increase (> slope & % benzene values) occurred when solution was made basic. Basic solutions also had a tighter range (lower CV). No free benzene was observed and it was assumed that solutions were not yet saturated with benzene.

When 3.0 mL of benzene was added to 6 mL of solutions an obvious two-layer interface occurred, indicating that an excess of benzene was present. After two hours, the upper ¼ to 1/3 was removed by aspiration. In this study acidic solutions had much greater concentrations of benzene, again indicated by % benzene values and a larger slope. CV values were slightly better in acidic solutions.

Solutions containing 30% 2-propanol efficiently dissolved benzene, but with inconsistent results.

As Ecosorb206 concentrations increased, the amount of benzene remaining in solution, compared to benzene released to the environment, increased. Or conversely, as Ecosorb206 concentrations increase, less benzene is released (a negative slope).

As benzene was added to solutions of Ecosorb206, solutions became milky white indicating that benzene was both dissolved and suspended (emulsified). Total efficiency is the sum of these two factors. In high benzene concentrations, increasing pH made little contribution in benzene removal. Dilutions of 1/00 contained 8-16 % benzene, 1/50 dilution contained 23-30% and 1/25 contained 24-32%. Once trapped, benzene will begin to leave the solution and reach equilibrium between benzene in liquid and benzene in vapor (Kd). When this factor is studied with benzene in water and compared to equal amounts of benzene in various solutions of Ecosorb206 we found 1/100 206 caused a 15.54% decrease in benzene release, 1/50 caused a 17.34% decrease and 1/25 caused a 22.97% decrease.

Solutions of 1/100 increase benzene removal by approximately by a factor of 165, 1/50 by a factor of 217 and 1/25 by a factor of 377 or 37.700%.

Based on this study, Ecosorb206 should greatly improve removal of benzene and assist in preventing benzene vapors from returning to the environment. A dilution of 1/100 would appear to be efficient in removing small amounts of benzene, while 1/50 may be required for higher benzene concentrations.

SOLUBILITY OF BENZENE

Tables 7-11: Solubility of Benzene

6 mL of solution + .09 mL benzene						
Standard Average concentration/Area Ratio = 3.72 - 07						
		1/100		**1/50**		**1/25**
pH		4.3		4.2		3.7
	Area	%	**Area**	%	**Area**	%
	6.47E+06	2.41	1.61+07	5.99	1.48E+07	5.51
	5.82E+06	2.17	149E+07	5.54	1.37E+07	5.1
	6.31E+06	2.35	1.44E+07	5.36	2.34E+07	8.7
	5.65E+06	2.1	1.30E_07	4.84	2.07E+07	7.7
Mean %		2.26		5.43		6.75
Standard deviation		.15		.48		1.73
C.L.		.17		.56		2.04
CV		6.43		8.79		25.66

6 mL of solution + .09 mL benzene (BASIC SOLUTION)						
Standard Average concentration/Area Ratio = 3.72 – 07						
		1/100		**1/50**		**1/25**
pH		7.7		7.7		7.7
	Area	%	**Area**	%	**Area**	%
	1.89E+07	7.03	1.42E+07	5.28	3.27E+07	12.16
	1.72E+07	6.4	1.28E+07	4.76	2.88E+07	10.71
	1.60E+07	5.95	1.45E+07	5.39	3.22E+07	11.98
	1.42E+07	5.28	1.33E+07	4.95	2.96E+07	11.01
Mean %		6.17		5.1		11.47
Standard deviation		.74		.29		.71
C.L.		.87		.34		.84
CV		11.95		5.75		6.21

6 mL of solution + 3.0 mL benzene						
Standard Average concentration/Area Ratio = 3.72 - 07						
		1/100		**1/50**		**1/25**
pH		4.3		4.2		3.7
	Area	%	**Area**	%	**Area**	%
	4.39E+07	16.33	3.92E+07	14.58	7.08+07	26.34
	4.17E+07	15.51	3.65E+07	13.58	6.88E+07	25.59
	2.58E+07	9.6	5.24E+07	19.49	8.71E+07	32.4
	2.37E+07	8.82	4.92E+07	18.3	8.33E+07	30.99
Mean %		12.56		16.49		28.83
Standard deviation		3.9		2.85		3.37
C.L.		4.59		3.36		3.97
CV		31.07		17.3		11.69

6 mL of solution + 3.0 mL benzene						
Standard Average concentration/Area Ratio = 3.72 - 07						
		1/100		**1/50**		**1/25**
pH		7.7		7.7		7.7
	Area	%	**Area**	%	**Area**	%
	1.10E+07	4.09	4.38E+07	16.29	3.14E+07	11.68
	9.09E+06	3.38	4.06E+07	15.1	2.88E+07	10.71
	1.36E+07	5.06	2.21E+07	8.22	2.48E+07	9.23
	1.22E+07	4.54	2.01E+07	7.48	2.29E+07	8.52
Mean %		4.27		11.77		10.03
Standard deviation		.71		4.57		1.43
C.L.		.84		5.37		1.68
CV		16.65		38.8		14.24

6 mL of solution + 3.0 mL benzene in 30% 2-propanol						
Standard Average concentration/Area Ratio = 3.72 - 07						
		1/100		**1/50**		**1/25**
pH		4.3		4.2		3.7
	Area	%	**Area**	%	**Area**	%
	1.62E+07	6.03	1.50E+07	5.58	6.72E+07	25
	1.48E+07	5.51	1.35E+07	5.02	6.52E+07	24.25
	2.74E+07	10.19	3.33E+07	12.39	6.28E+07	23.36
	2.54E+07	9.45	3.07E+07	11.42	5.96E+07	22.17
Mean %		7.79		8.6		23.7
Standard deviation		2.37		3.84		1.22
C.L.		2.79		4.52		1.43
CV		30.41		44.63		5.14

Table 12: Distribution Constant

Distribution Constant Study using Headspace Analysis		
	Area	**Mean**
1 mL water + 1 mL std. Benzene solution	4.61	4.44E+06
	4.27E+06	
1 mL 1/100 Ecosorb206 + 1 mL std. Benzene solution	3.92E+06	3.75E+06
	3.57E+06	
1 mL 1/50 Ecosorb206 + 1 mL std. Benzene solution	3.62E+06	3.67E+06
	3.72E+06	
1 mL 1/25 Ecosorb206 + 1 mL std. Benzene solution	3.47E+06	3.42E+06
	3.36E+06	

Odor Control Versus Emission Control

Selecting one technology over the other is a function of individual facility needs and cost effectiveness

By Charles R. Timcik, MS, and Donald R. Wilkinson, PhD

There is considerable interest in odor and emission control. Emission control via add-on controls usually involves capturing or destroying chemical emissions before they are emitted into the atmosphere. Odor control is differentiated from emission control in that the odorous gas does not necessarily need to be removed from the process air; it only needs to be undetectable by olfactory senses. Therefore, expensive emission add-on controls need not be applied if the operator can successfully remove the odor.

Frequently, emission control also results in odor control. If compounds do not enter the atmosphere our olfactory senses will not detect them. However, the technique used to capture an emission can itself emit an odor as a byproduct of the process, such as chlorine gas discharging from a scrubber.

Manufacturing sites are allowed to emit odorous compounds into the air up to a certain level per year. Nonetheless, regulations often disallow the site from emitting nuisance odors that disturb neighbors. Consequently, some manufacturers will turn to emission control when simple odor control suffices.

Emission Control

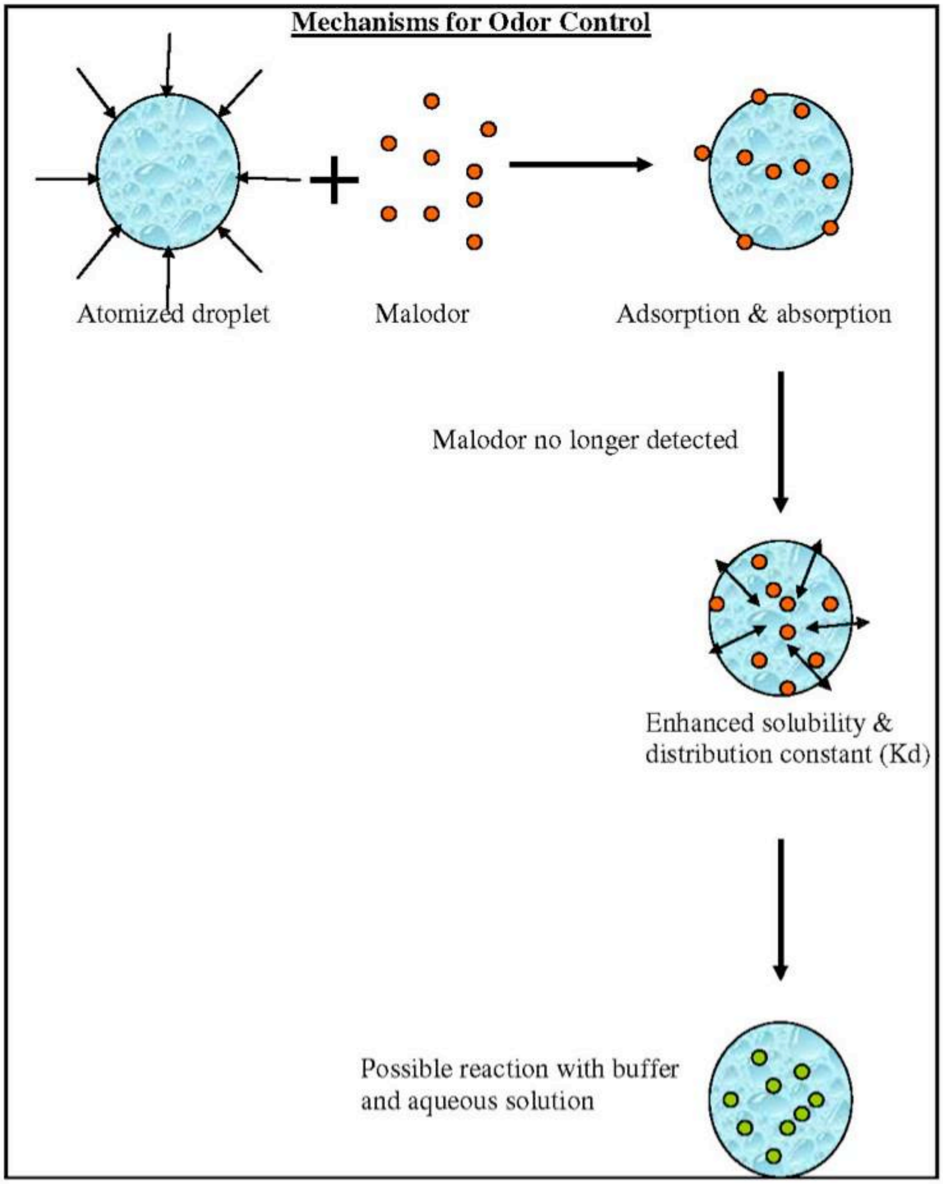
Several popular emission control devices applied are chemical scrubbers, activated carbon adsorption devices, biological filters, thermal and catalytic converters and incinerators. Each has its benefits and shortcomings. Generally speaking, they all effectively treat the specific hazardous gases for which they are designed; however, they cannot control a broad spectrum of odors. Many emission control devices produce an odorous off-gas. Scrubbers often require handling of acids or caustics and all emission control devices are considered costly capital investments with most having high recurring costs. The efficiency of all emission control devices is measured by the ability to remove a specific gas (or gases) from the exhausting air with the removal rate measured in parts per million (ppm) or weight removed per unit time.

Odor Control

Odor control, outside application of the above mentioned emission control systems, typically involves the introduction of a liquid aerosol, or atomized product, into the process air. This occasionally includes the use of masking agents that attempt to overlay a pleasant odor onto the malodor in an effort to “mask” the malodor. It is a stretch to say this technique actually controls odors because they cover them, not remove them.

In addition to masking agents, one can find products that are plant oil based and claim to be odor neutralizers. A closer look shows that many are primarily masking agents combined with surfactants. Still, a safe, efficient, cost-effective odor control solution utilizing essential oil technology is available. With this technology, no effort is made to remove the malodor gas but to treat it so it is undetectable by olfactory senses. Although beyond the scope of this article, it is worth noting that developments in equipment and the understanding of how scientific oil blends function indicate that future application of this technology may well apply itself to emission control.

Mechanisms of Odor Control Using Essential Oils



Essential oils have been used for years to remove organic substances. Pine oils are used to dissolve grease and oil, while lemon oil is often added as an apparent masking agent. When essential oils are carefully selected, unique characteristics of these oils assist in removing a broad range of malodors, and do so by several interesting mechanisms. Because the oil blend has a characteristic pleasant odor, it is sometimes confused with masking agents. But differentiation from masking is obvious given the mechanisms of control. The mechanisms for malodor removal using a scientific and efficient blend of water soluble and insoluble essential oils include solubility, buffer solutions and chemical reactions.

Solubility
When mixed with water and sprayed as a fine mist of atomized droplets into the air, water-soluble oils dissolve in the small droplets and change the droplet's polarity. The droplets become less polar thereby increasing solubility of most malodors. Non-water soluble oils form a thin surface layer on each atomized droplet, which creates a negative electrostatic charge on the droplet's surface. This causes the droplets to repel each other (like charges repel) and stay in an atomized form for longer time periods. The electrostatic charge also facilitates attraction of malodor molecules to the droplet surface whereby they absorb into the droplet. This solubility increases droplet density and brings about coalescence and removal of the malodor from the vapor state.

The odors we smell come from malodors in the vapor state. Once trapped in solution, they have no odor, except for some that return to the vapor state. Polarity changes of water also act to change the distribution constant - for example, the amount of gas that stays in solution versus the amount that returns to the vapor state -and prevent odors from returning. Consider a simple analogy - When standing over an odorous pond and sensing malodor, one does not smell what is in the pond, one senses the gases leaving the pond. When gases are absorbed into the droplets or attached onto the droplet surface, they are not released for the olfactory senses to detect.

Buffer
The essential oil mixture contains both weak organic acids similar to citric acid and salts of these acids that form a buffer solution. Buffer solutions can neutralize both acidic and basic malodors, and more importantly, they greatly increase the solubility of acidic and basic malodors in droplets. Buffers not only facilitate solubility but also can partially neutralize many malodors in a fashion similar to acidic or caustic scrubbers.

Chemical Reactions
Many organic compounds, such as styrene, are stable in the vapor state but degrade rapidly once in solution. Other compounds stable in the vapor state will degrade slowly once in solution. In some cases, degradation of malodors in solution is so slow that for practical purposes it appears non-existent. Getting malodors into solution is the first step in helping nature destroy malodors. Because large amounts of water are used during the misting process, malodors in solution are greatly diluted and their concentrations fall below detectable levels.

University and independent laboratory tests confirm the existence of these odor control mechanisms specific to at least one commercially available odor control product utilizing a specific essential oil blend. Reductions in compounds, such as styrene, hydrogen sulfide, sulfur dioxide, ethyl and methyl mercaptans, ammonia and other amines are documented. Field tests at wastewater plants and industrial sites produce similar results.

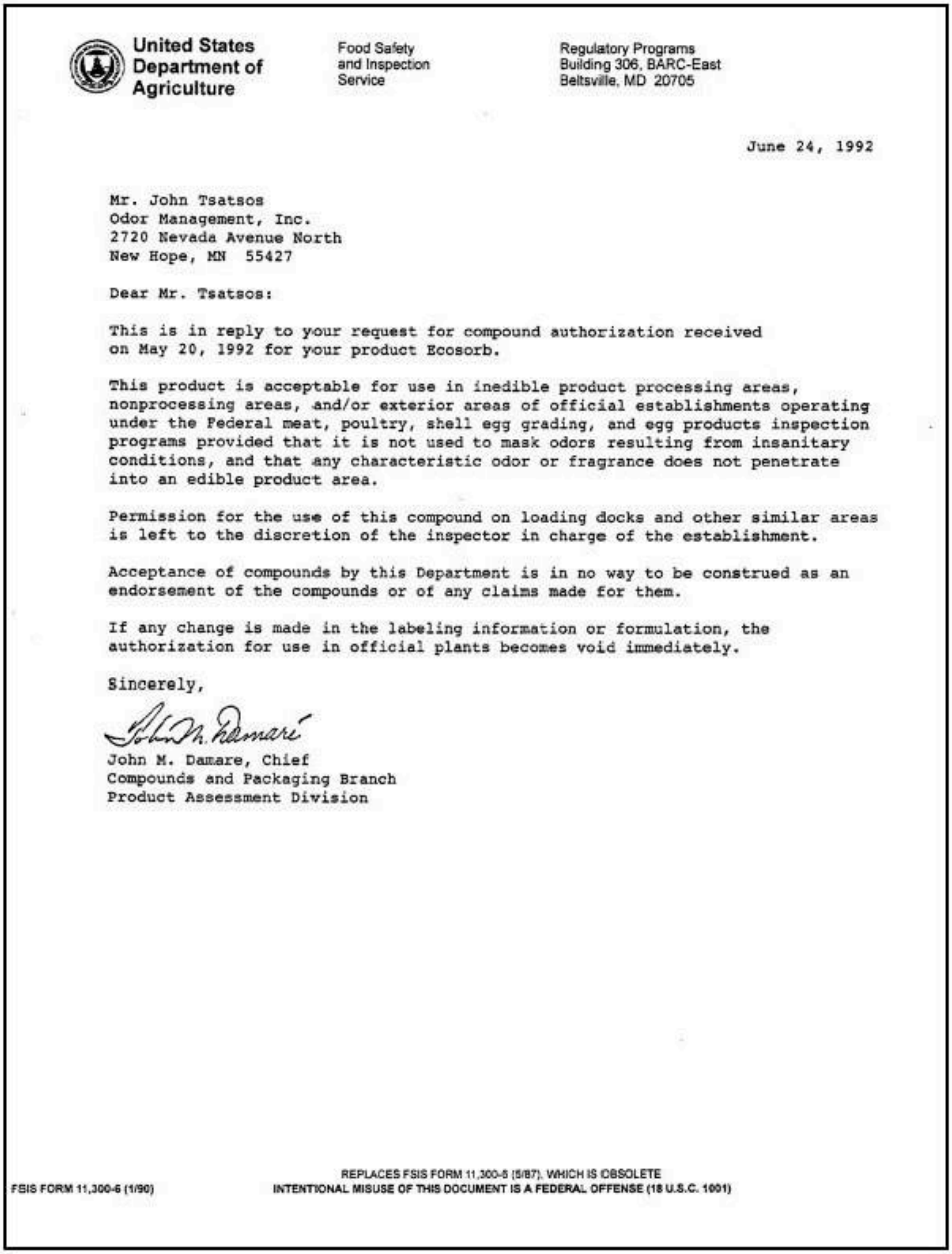
Summary
A carefully selected essential oil mixture can remove malodors from the environment through a combination of mechanisms with solubility being the first and of greatest importance. This mechanism is aided by the use of extremely small water droplets moving at high speeds, changes in water polarity, the effect of electrostatic charges on droplet surfaces, pH and capacity of the mixture's natural buffer and prevention of the dissolved malodor in returning to the atmosphere. Removal is increased by natural malodor degradation and several possible chemical reactions taking place while in solution.
The correct blend of essential oil mixtures is successfully applied by:

- misting dilute solutions;
- bubbling air through a water solution of oils;
- evaporation of an undiluted mixture directly into the air (vapor phase evaporators);
- topical application; and
- directly mixing it with odorous slurries.

Although designed for odor control, under correct conditions essential oils can be applied for emission control of several malodors. Essential oils can be used to control virtually all odors by adjusting their concentration and mixture makeup, their application rates, their forced or no forced coalescence, and their pH. Because essential oil mixtures have characteristic scents they may also exert a masking effect. The masking effect should not be considered a mechanism for odor removal. When a good essential oil mixture is used properly, no odor should be detected - neither the malodor nor the natural fragrance of the oil blend.

A difference does exist between odor control and emission control. Both have their place in the environmental industry. Selecting one technology over the other is a function of individual facility needs and solution cost effectiveness. Should a facility need to reduce or remove hazardous gases emitting from its process for legal or environmental reasons, emission control technology is available. Should a facility need to reduce or remove odors that are irritants to employees or neighbors, a simpler cost-effective odor control technology is available.

This article originally appeared in the March/April 202 issue of Water & Wastewater Products, Volume 2, Number 2, page 28. Charles R. Timcik is the Technical Director of Odor Management Inc. Barrington, IL and Donald R. Wilkinson, PhD, is a Professor of Chemistry (retired).



**United States
Department of
Agriculture**

Food Safety
and Inspection
Service

Regulatory Programs
Building 306, BARC-East
Beltsville, MD 20705

June 24, 1992

Mr. John Tsatsos
Odor Management, Inc.
2720 Nevada Avenue North
New Hope, MN 55427

Dear Mr. Tsatsos:

This is in reply to your request for compound authorization received on May 20, 1992 for your product Ecosorb.

This product is acceptable for use in inedible product processing areas, nonprocessing areas, and/or exterior areas of official establishments operating under the Federal meat, poultry, shell egg grading, and egg products inspection programs provided that it is not used to mask odors resulting from insanitary conditions, and that any characteristic odor or fragrance does not penetrate into an edible product area.

Permission for the use of this compound on loading docks and other similar areas is left to the discretion of the inspector in charge of the establishment.

Acceptance of compounds by this Department is in no way to be construed as an endorsement of the compounds or of any claims made for them.

If any change is made in the labeling information or formulation, the authorization for use in official plants becomes void immediately.

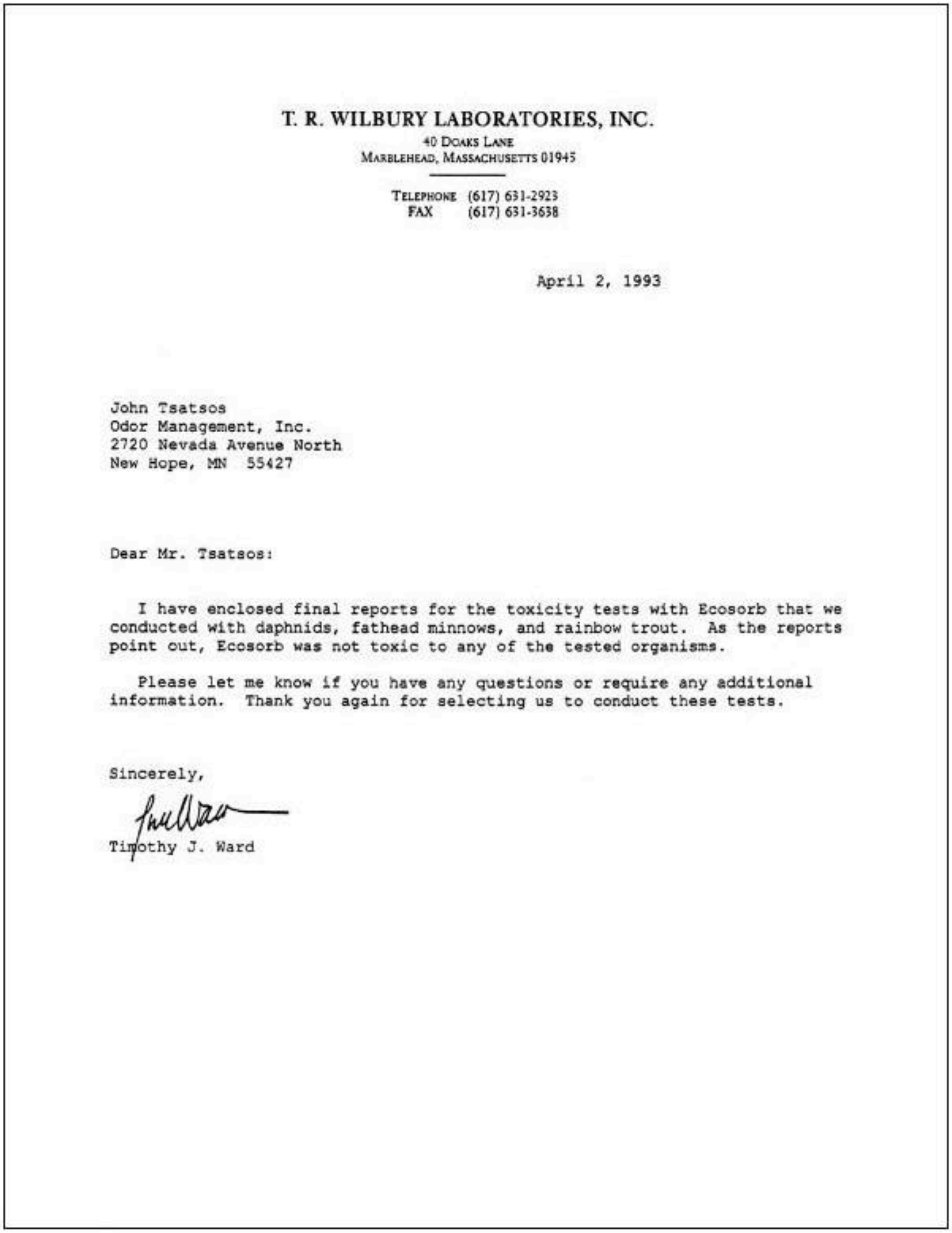
Sincerely,

John M. Damare

John M. Damare, Chief
Compounds and Packaging Branch
Product Assessment Division

FSIS FORM 11,300-6 (1/90)

REPLACES FSIS FORM 11,300-6 (5/87), WHICH IS OBSOLETE
INTENTIONAL MISUSE OF THIS DOCUMENT IS A FEDERAL OFFENSE (18 U.S.C. 1001)



T. R. WILBURY LABORATORIES, INC.
40 DOAKS LANE
MARBLEHEAD, MASSACHUSETTS 01945

TELEPHONE (617) 631-2923
FAX (617) 631-3638

April 2, 1993

John Tsatsos
Odor Management, Inc.
2720 Nevada Avenue North
New Hope, MN 55427

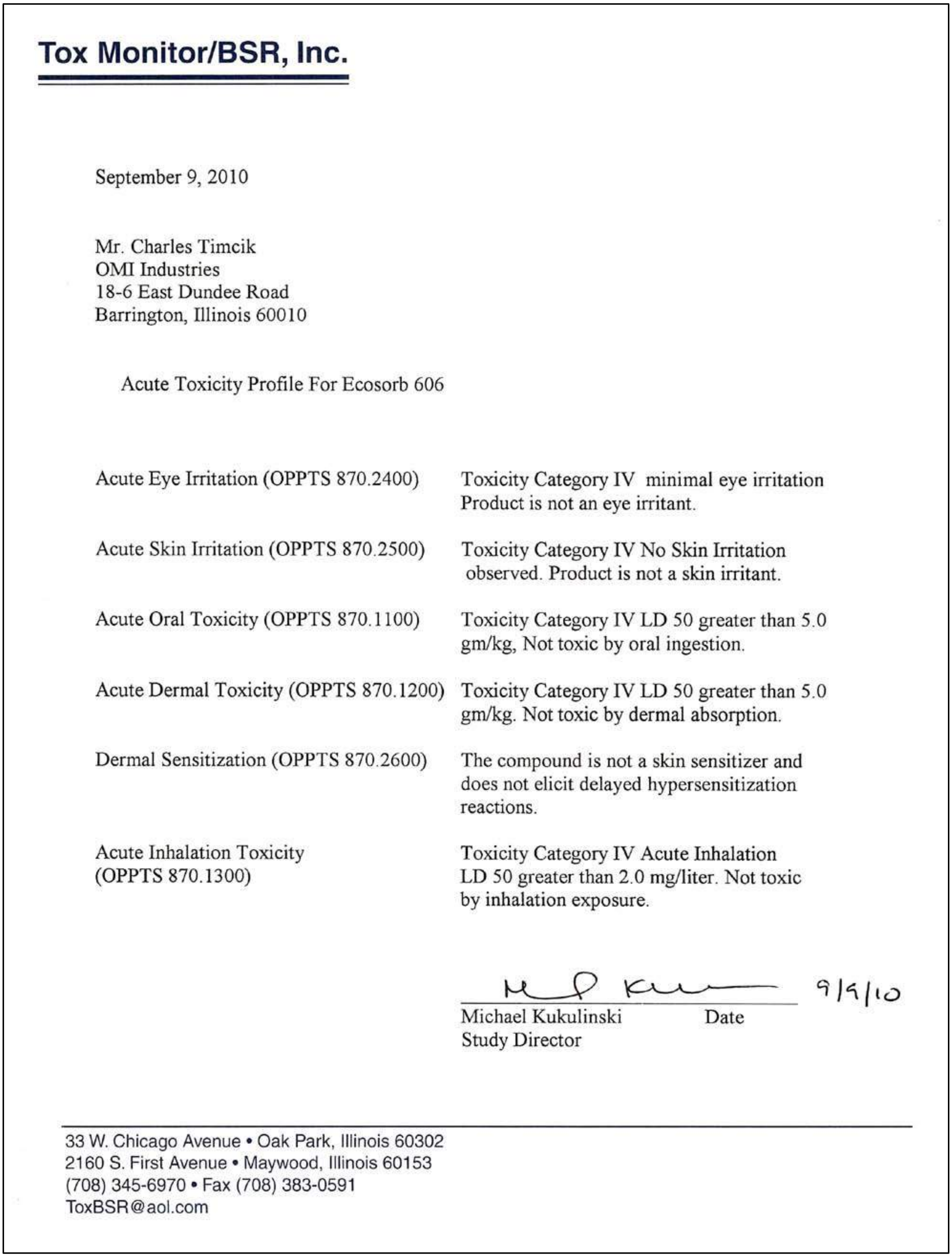
Dear Mr. Tsatsos:

I have enclosed final reports for the toxicity tests with Ecosorb that we conducted with daphnids, fathead minnows, and rainbow trout. As the reports point out, Ecosorb was not toxic to any of the tested organisms.

Please let me know if you have any questions or require any additional information. Thank you again for selecting us to conduct these tests.

Sincerely,

Timothy J. Ward



Tox Monitor/BSR, Inc.

September 9, 2010

Mr. Charles Timcik
OMI Industries
18-6 East Dundee Road
Barrington, Illinois 60010

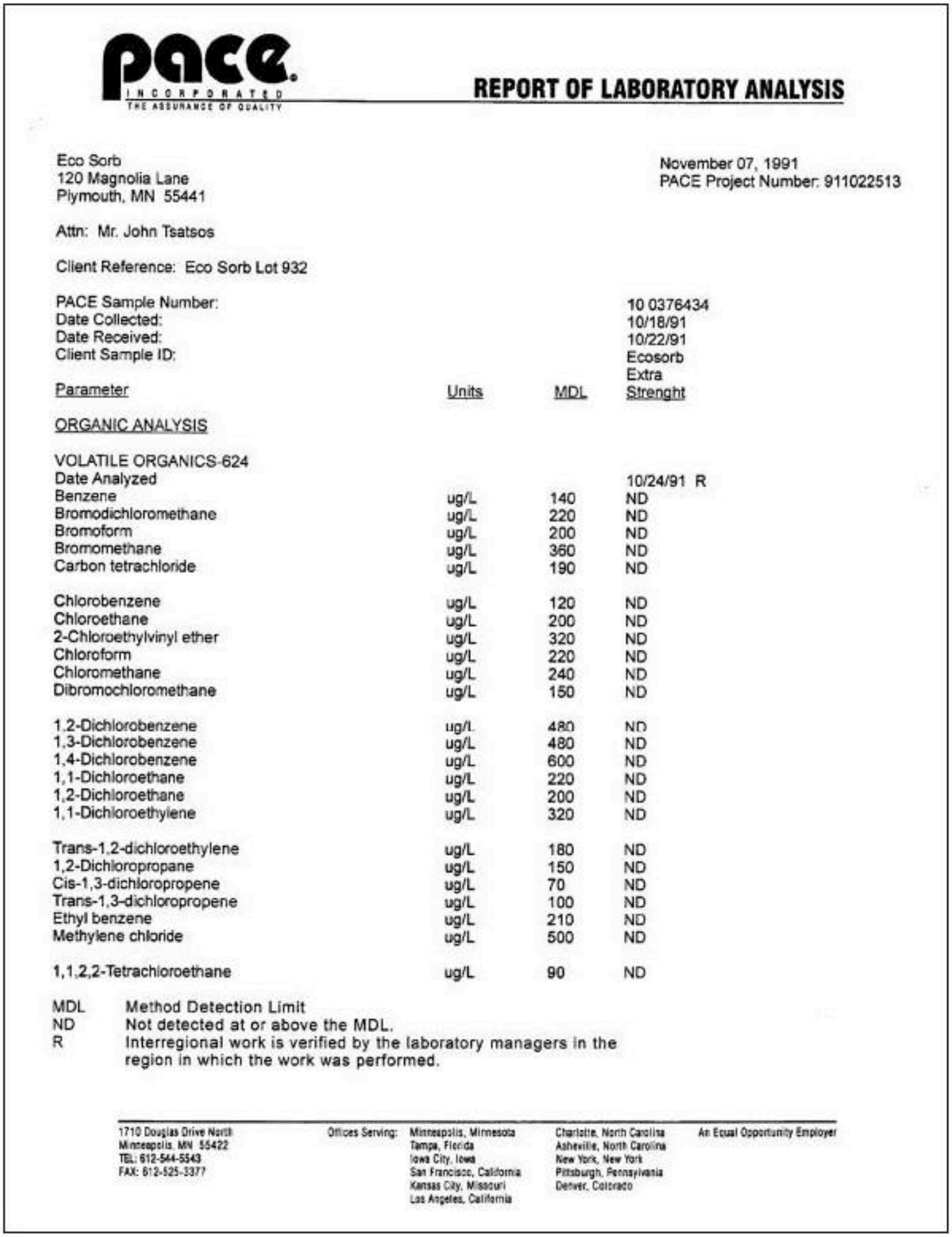
Acute Toxicity Profile For Ecosorb 606

Acute Eye Irritation (OPPTS 870.2400)	Toxicity Category IV minimal eye irritation Product is not an eye irritant.
Acute Skin Irritation (OPPTS 870.2500)	Toxicity Category IV No Skin Irritation observed. Product is not a skin irritant.
Acute Oral Toxicity (OPPTS 870.1100)	Toxicity Category IV LD 50 greater than 5.0 gm/kg, Not toxic by oral ingestion.
Acute Dermal Toxicity (OPPTS 870.1200)	Toxicity Category IV LD 50 greater than 5.0 gm/kg. Not toxic by dermal absorption.
Dermal Sensitization (OPPTS 870.2600)	The compound is not a skin sensitizer and does not elicit delayed hypersensitization reactions.
Acute Inhalation Toxicity (OPPTS 870.1300)	Toxicity Category IV Acute Inhalation LD 50 greater than 2.0 mg/liter. Not toxic by inhalation exposure.

9/9/10

Michael Kukulinski Date
Study Director

33 W. Chicago Avenue • Oak Park, Illinois 60302
2160 S. First Avenue • Maywood, Illinois 60153
(708) 345-6970 • Fax (708) 383-0591
ToxBSR@aol.com



pace.
INCORPORATED
THE ASSURANCE OF QUALITY

REPORT OF LABORATORY ANALYSIS

Eco Sorb
120 Magnolia Lane
Plymouth, MN 55441

November 07, 1991
PACE Project Number: 911022513

Attn: Mr. John Tsatsos

Client Reference: Eco Sorb Lot 932

PACE Sample Number: 10 0376434
Date Collected: 10/18/91
Date Received: 10/22/91
Client Sample ID: Ecosorb Extra Strenght

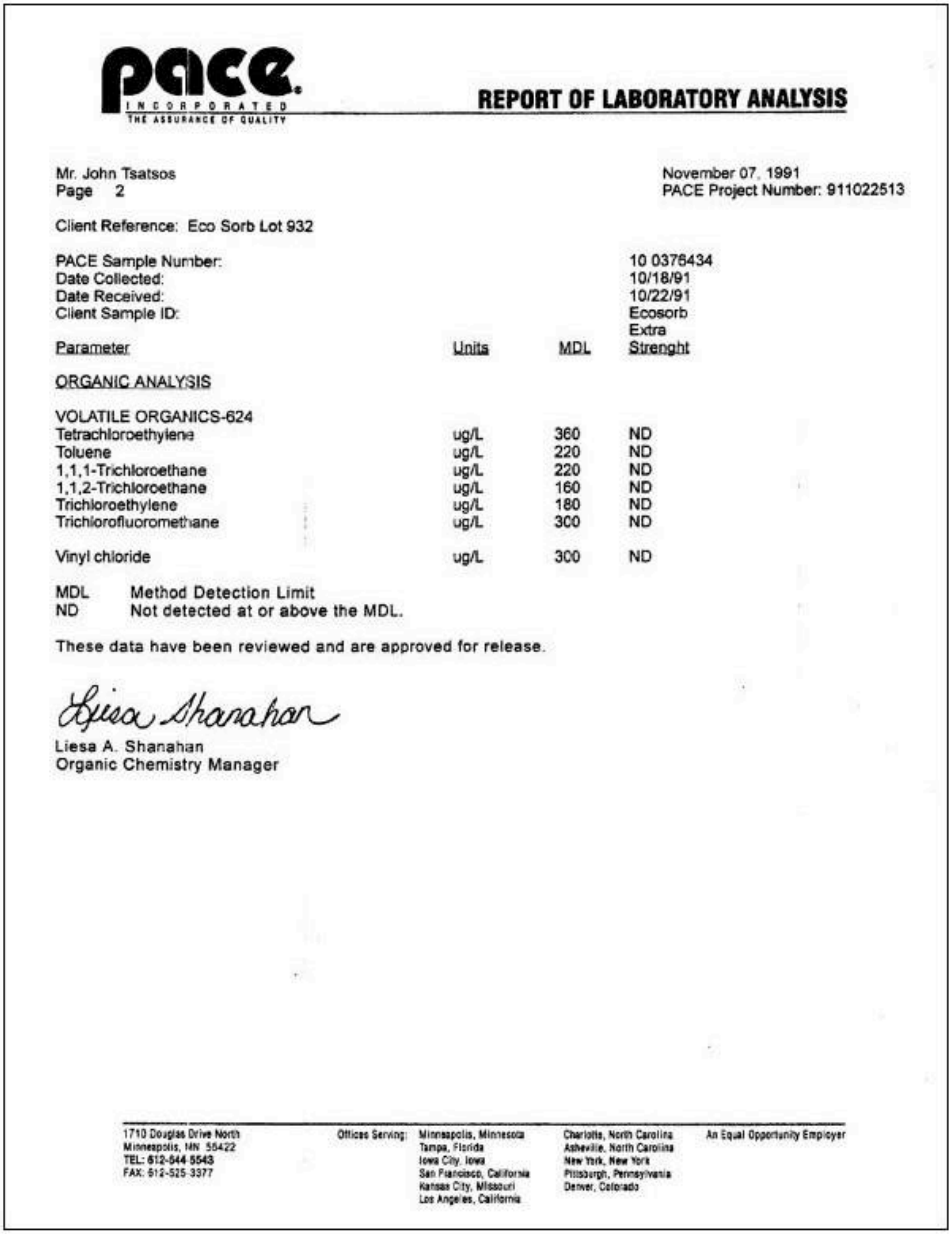
Parameter	Units	MDL	Ecosorb Extra Strenght
ORGANIC ANALYSIS			
VOLATILE ORGANICS-624			
Date Analyzed			10/24/91 R
Benzene	ug/L	140	ND
Bromodichloromethane	ug/L	220	ND
Bromoform	ug/L	200	ND
Bromomethane	ug/L	360	ND
Carbon tetrachloride	ug/L	190	ND
Chlorobenzene	ug/L	120	ND
Chloroethane	ug/L	200	ND
2-Chloroethylvinyl ether	ug/L	320	ND
Chloroform	ug/L	220	ND
Chloromethane	ug/L	240	ND
Dibromochloromethane	ug/L	150	ND
1,2-Dichlorobenzene	ug/L	480	ND
1,3-Dichlorobenzene	ug/L	480	ND
1,4-Dichlorobenzene	ug/L	600	ND
1,1-Dichloroethane	ug/L	220	ND
1,2-Dichloroethane	ug/L	200	ND
1,1-Dichloroethylene	ug/L	320	ND
Trans-1,2-dichloroethylene	ug/L	180	ND
1,2-Dichloropropane	ug/L	150	ND
Cis-1,3-dichloropropene	ug/L	70	ND
Trans-1,3-dichloropropene	ug/L	100	ND
Ethyl benzene	ug/L	210	ND
Methylene chloride	ug/L	500	ND
1,1,2,2-Tetrachloroethane	ug/L	90	ND

MDL	Method Detection Limit
ND	Not detected at or above the MDL.
R	Interregional work is verified by the laboratory managers in the region in which the work was performed.

1710 Douglas Drive North
Minneapolis, MN 55422
TEL: 612-544-5543
FAX: 612-525-3377

Offices Serving:
Minneapolis, Minnesota
Tampa, Florida
Iowa City, Iowa
San Francisco, California
Kansas City, Missouri
Los Angeles, California
Charlotte, North Carolina
Asheville, North Carolina
New York, New York
Pittsburgh, Pennsylvania
Denver, Colorado

An Equal Opportunity Employer



pace. INCORPORATED
THE ASSURANCE OF QUALITY

REPORT OF LABORATORY ANALYSIS

Mr. John Tsatsos
Page 2

November 07, 1991
PACE Project Number: 911022513

Client Reference: Eco Sorb Lot 932

PACE Sample Number:			10 0376434
Date Collected:			10/18/91
Date Received:			10/22/91
Client Sample ID:			Ecosorb Extra
Parameter	Units	MDL	Strenght
ORGANIC ANALYSIS			
VOLATILE ORGANICS-624			
Tetrachloroethylene	ug/L	360	ND
Toluene	ug/L	220	ND
1,1,1-Trichloroethane	ug/L	220	ND
1,1,2-Trichloroethane	ug/L	160	ND
Trichloroethylene	ug/L	180	ND
Trichlorofluoromethane	ug/L	300	ND
Vinyl chloride	ug/L	300	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

These data have been reviewed and are approved for release.

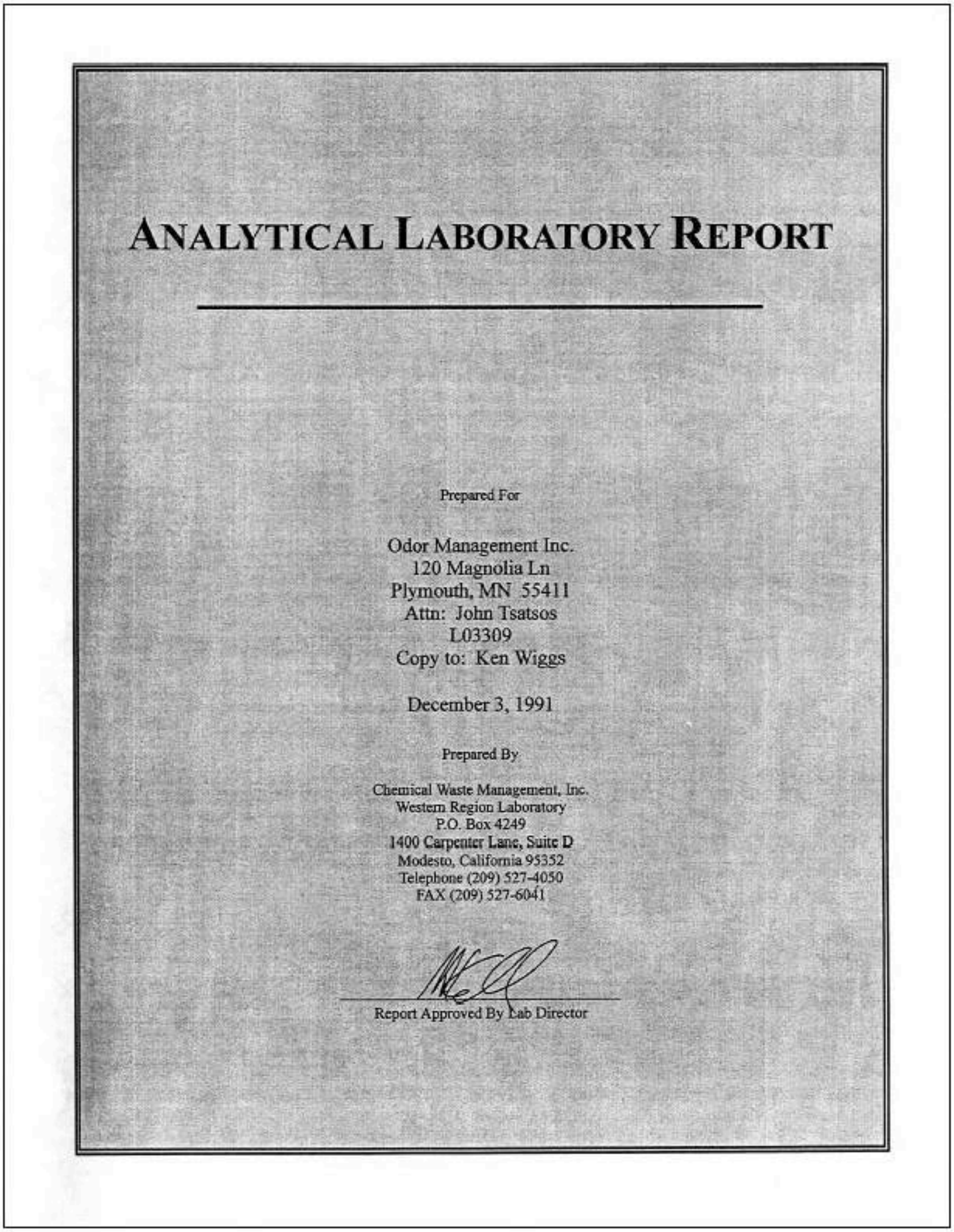
Liesa Shanahan

Liesa A. Shanahan
Organic Chemistry Manager

1710 Douglas Drive North
Minneapolis, MN 55422
TEL: 612-544-5543
FAX: 612-525-3377

Offices Serving:
Minneapolis, Minnesota
Tampa, Florida
Iowa City, Iowa
San Francisco, California
Kansas City, Missouri
Los Angeles, California
Charlotte, North Carolina
Asheville, North Carolina
New York, New York
Pittsburgh, Pennsylvania
Denver, Colorado

An Equal Opportunity Employer



ANALYTICAL LABORATORY REPORT

Prepared For

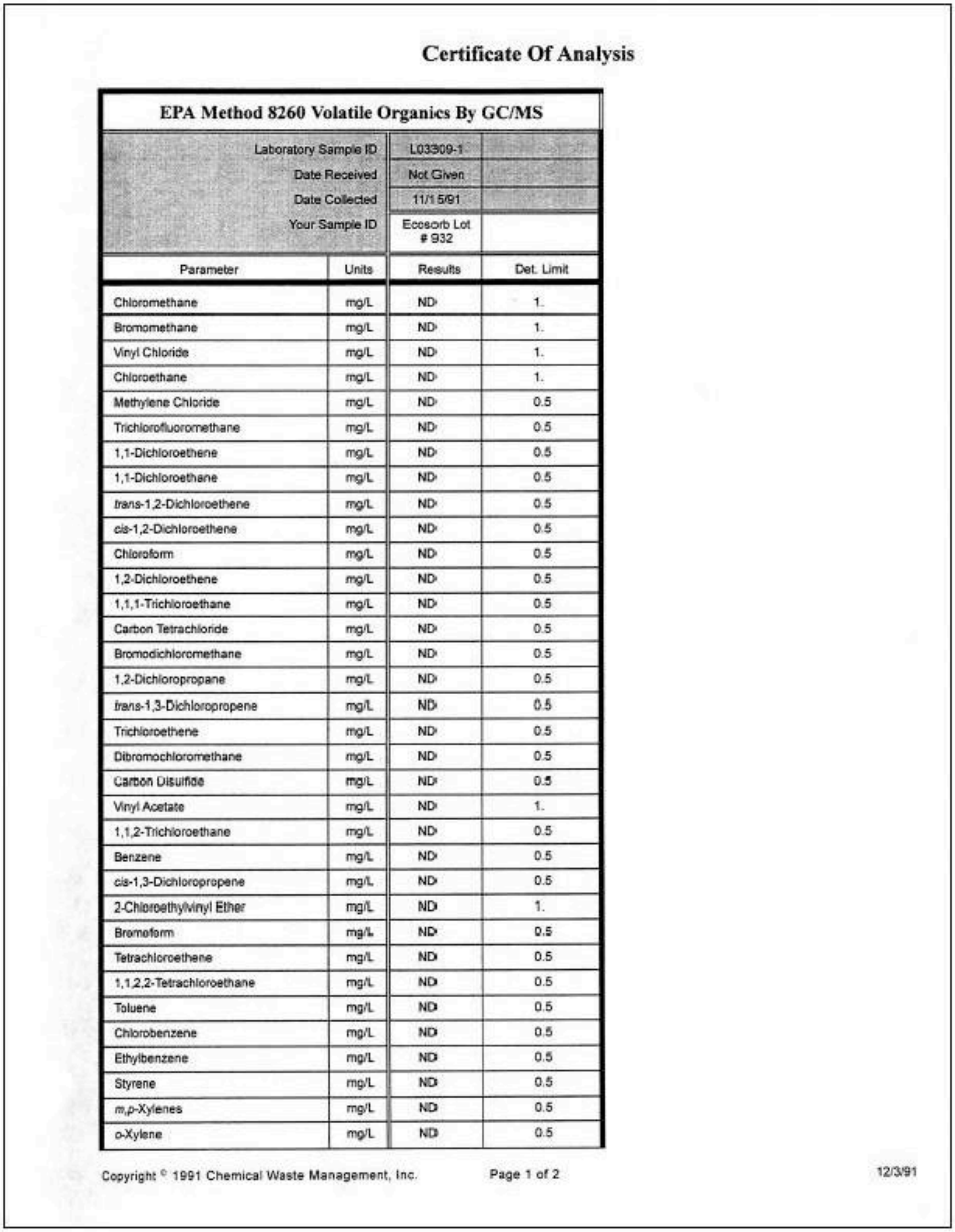
Odor Management Inc.
120 Magnolia Ln
Plymouth, MN 55411
Attn: John Tsatsos
L03309
Copy to: Ken Wiggs

December 3, 1991

Prepared By

Chemical Waste Management, Inc.
Western Region Laboratory
P.O. Box 4249
1400 Carpenter Lane, Suite D
Modesto, California 95352
Telephone (209) 527-4050
FAX (209) 527-6041

Report Approved By Lab Director



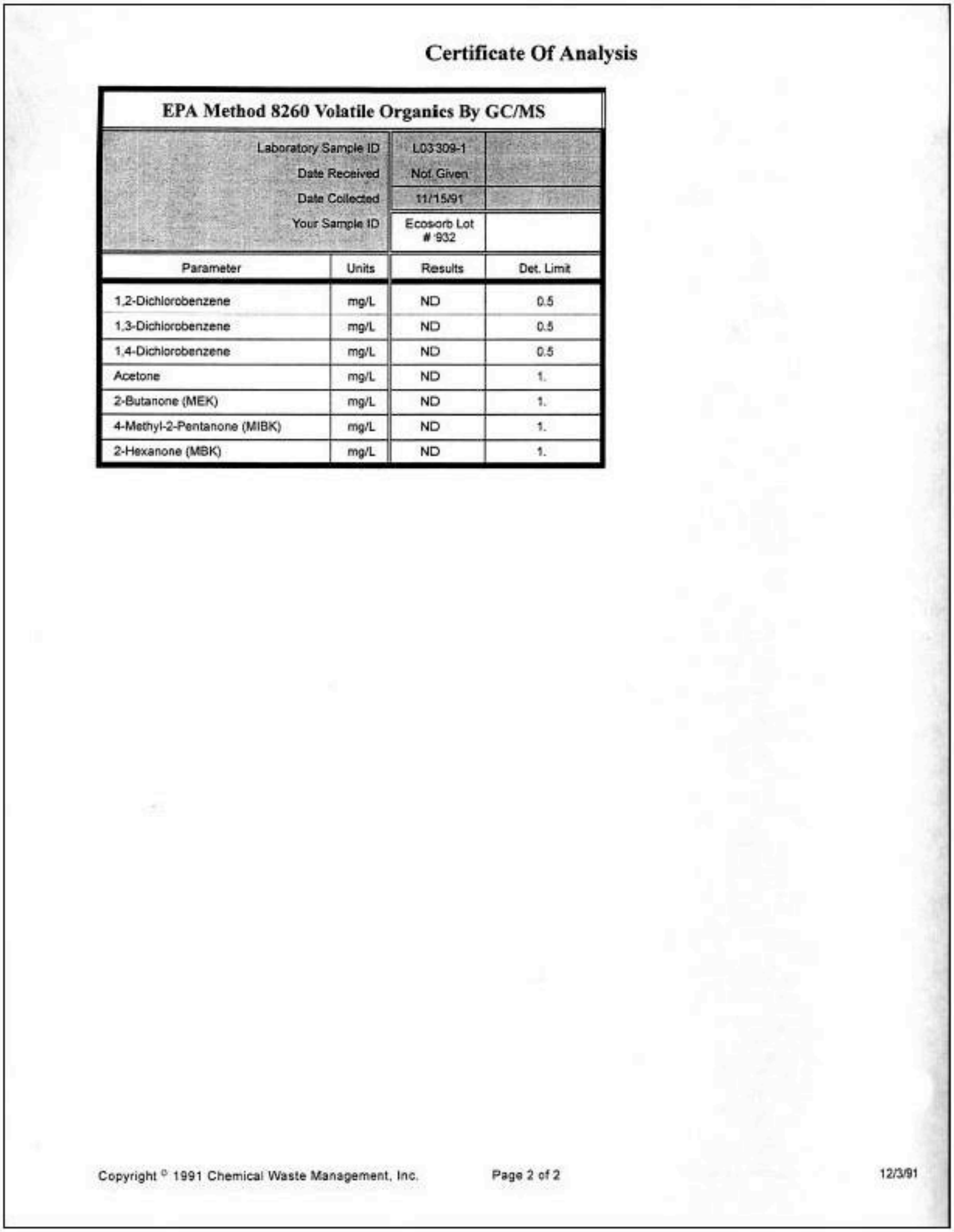
Certificate Of Analysis

EPA Method 8260 Volatile Organics By GC/MS

Laboratory Sample ID	L03309-1	
Date Received	Not Given	
Date Collected	11/15/91	
Your Sample ID	Ecosorb Lot # 932	

Parameter	Units	Results	Det. Limit
Chloromethane	mg/L	ND	1.
Bromomethane	mg/L	ND	1.
Vinyl Chloride	mg/L	ND	1.
Chloroethane	mg/L	ND	1.
Methylene Chloride	mg/L	ND	0.5
Trichlorofluoromethane	mg/L	ND	0.5
1,1-Dichloroethene	mg/L	ND	0.5
1,1-Dichloroethane	mg/L	ND	0.5
trans-1,2-Dichloroethene	mg/L	ND	0.5
cis-1,2-Dichloroethene	mg/L	ND	0.5
Chloroform	mg/L	ND	0.5
1,2-Dichloroethene	mg/L	ND	0.5
1,1,1-Trichloroethane	mg/L	ND	0.5
Carbon Tetrachloride	mg/L	ND	0.5
Bromodichloromethane	mg/L	ND	0.5
1,2-Dichloropropane	mg/L	ND	0.5
trans-1,3-Dichloropropene	mg/L	ND	0.5
Trichloroethene	mg/L	ND	0.5
Dibromochloromethane	mg/L	ND	0.5
Carbon Disulfide	mg/L	ND	0.5
Vinyl Acetate	mg/L	ND	1.
1,1,2-Trichloroethane	mg/L	ND	0.5
Benzene	mg/L	ND	0.5
cis-1,3-Dichloropropene	mg/L	ND	0.5
2-Chloroethylvinyl Ether	mg/L	ND	1.
Bromoform	mg/L	ND	0.5
Tetrachloroethene	mg/L	ND	0.5
1,1,2,2-Tetrachloroethane	mg/L	ND	0.5
Toluene	mg/L	ND	0.5
Chlorobenzene	mg/L	ND	0.5
Ethylbenzene	mg/L	ND	0.5
Styrene	mg/L	ND	0.5
m,p-Xylenes	mg/L	ND	0.5
o-Xylene	mg/L	ND	0.5

Page 1 of 2 12/3/91

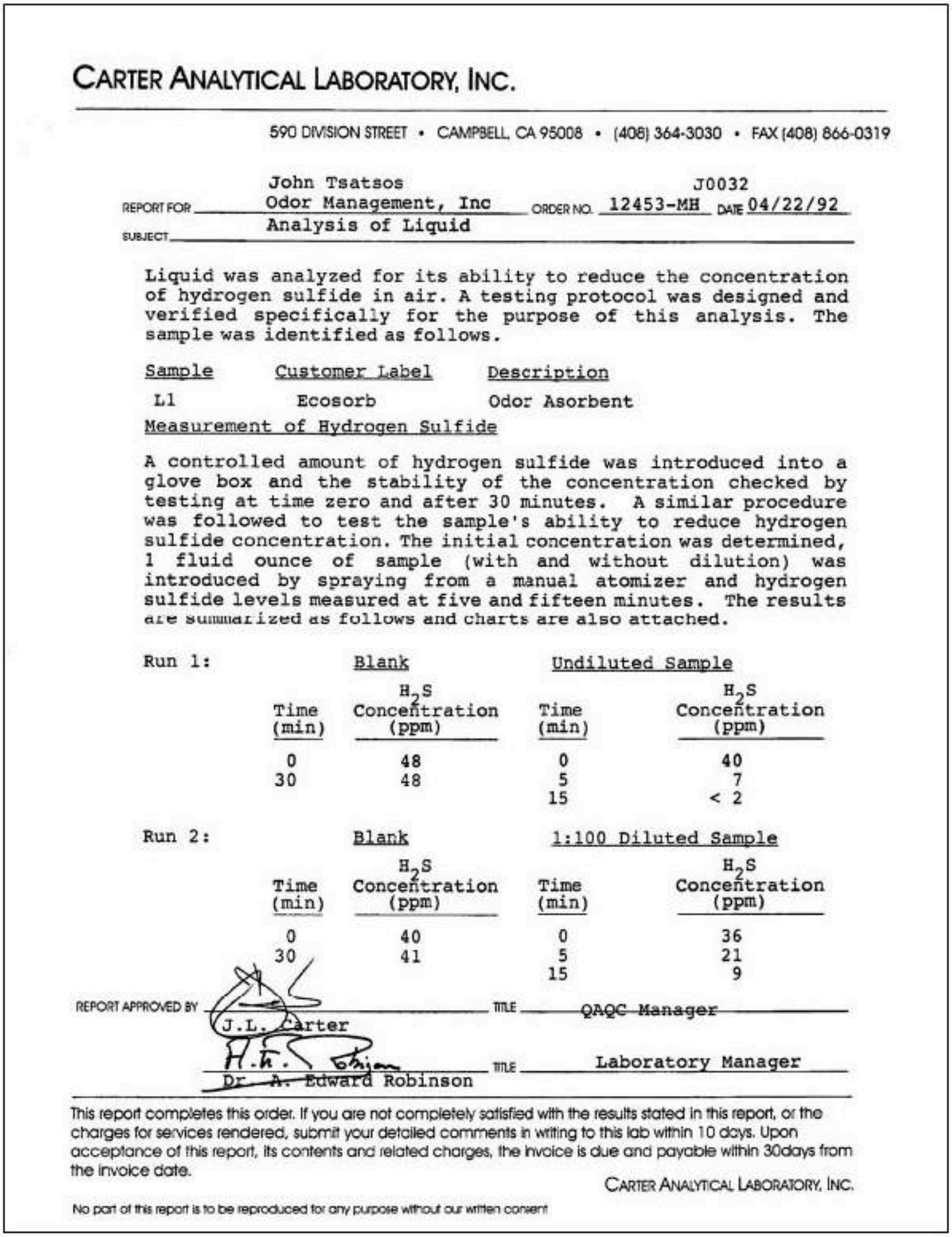


Certificate Of Analysis

EPA Method 8260 Volatile Organics By GC/MS

Laboratory Sample ID		L03309-1	
Date Received		Not Given	
Date Collected		11/15/91	
Your Sample ID		Ecosorb Lot # 932	
Parameter	**Units**	**Results**	**Det. Limit**
1,2-Dichlorobenzene	mg/L	ND	0.5
1,3-Dichlorobenzene	mg/L	ND	0.5
1,4-Dichlorobenzene	mg/L	ND	0.5
Acetone	mg/L	ND	1.
2-Butanone (MEK)	mg/L	ND	1.
4-Methyl-2-Pentanone (MIBK)	mg/L	ND	1.
2-Hexanone (MBK)	mg/L	ND	1.

Page 2 of 2 12/3/91



CARTER ANALYTICAL LABORATORY, INC.

590 DIVISION STREET • CAMPBELL, CA 95008 • (408) 364-3030 • FAX (408) 866-0319

REPORT FOR John Tsatsos
Odor Management, Inc
ORDER NO. J0032
12453-MH DATE 04/22/92
SUBJECT Analysis of Liquid

Liquid was analyzed for its ability to reduce the concentration of hydrogen sulfide in air. A testing protocol was designed and verified specifically for the purpose of this analysis. The sample was identified as follows.

Sample	Customer Label	Description
L1	Ecosorb	Odor Asorbent

Measurement of Hydrogen Sulfide

A controlled amount of hydrogen sulfide was introduced into a glove box and the stability of the concentration checked by testing at time zero and after 30 minutes. A similar procedure was followed to test the sample's ability to reduce hydrogen sulfide concentration. The initial concentration was determined, 1 fluid ounce of sample (with and without dilution) was introduced by spraying from a manual atomizer and hydrogen sulfide levels measured at five and fifteen minutes. The results are summarized as follows and charts are also attached.

Run 1:

Blank Time (min)	Blank H_2S Concentration (ppm)	Undiluted Sample Time (min)	Undiluted Sample H_2S Concentration (ppm)
0	48	0	40
30	48	5	7
		15	< 2

Run 2:

Blank Time (min)	Blank H_2S Concentration (ppm)	1:100 Diluted Sample Time (min)	1:100 Diluted Sample H_2S Concentration (ppm)
0	40	0	36
30	41	5	21
		15	9

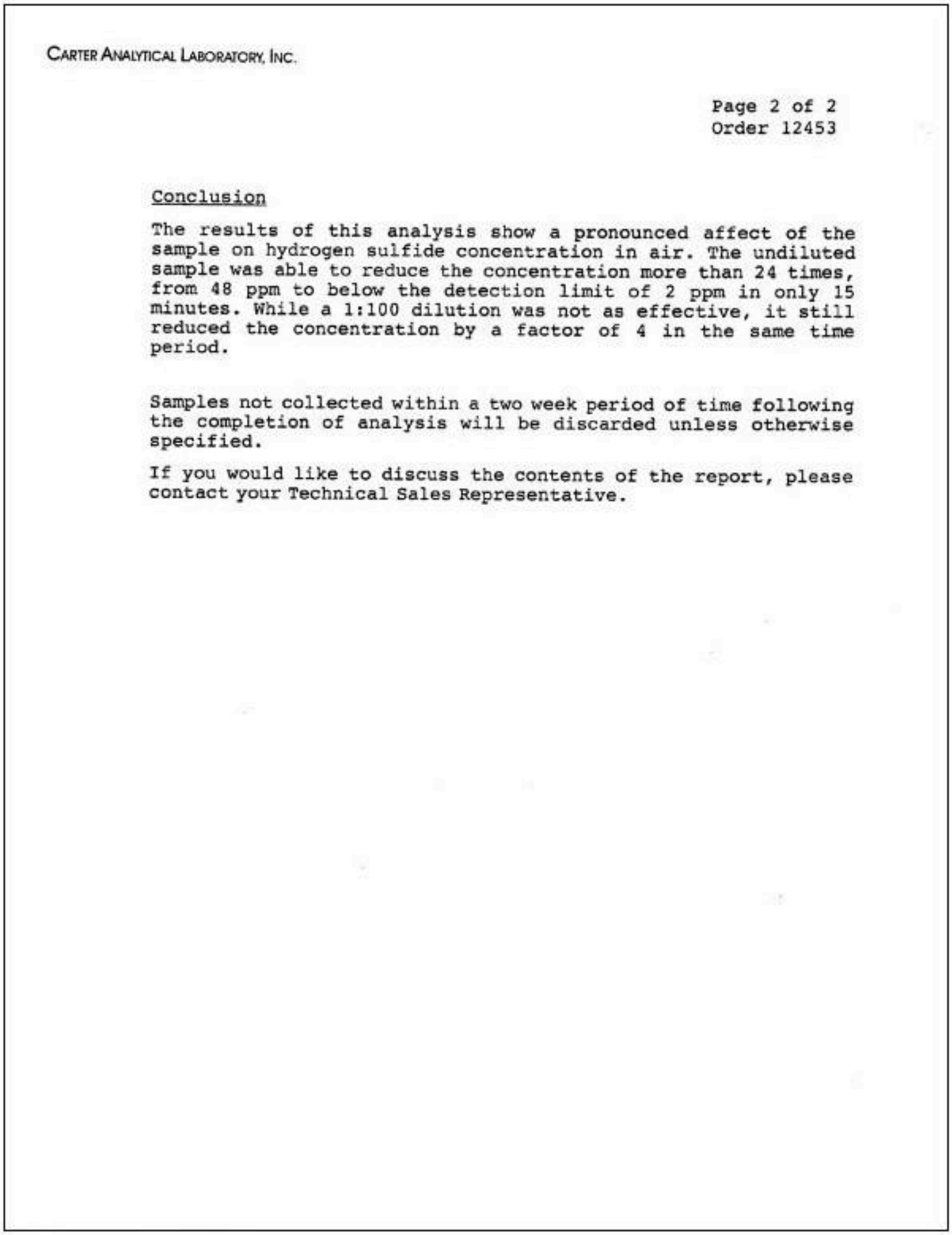
REPORT APPROVED BY J.L. Carter TITLE QAQC Manager

A.E. Robinson
Dr. A. Edward Robinson TITLE Laboratory Manager

This report completes this order. If you are not completely satisfied with the results stated in this report, or the charges for services rendered, submit your detailed comments in writing to this lab within 10 days. Upon acceptance of this report, its contents and related charges, the invoice is due and payable within 30days from the invoice date.

CARTER ANALYTICAL LABORATORY, INC.

No part of this report is to be reproduced for any purpose without our written consent



CARTER ANALYTICAL LABORATORY, INC.

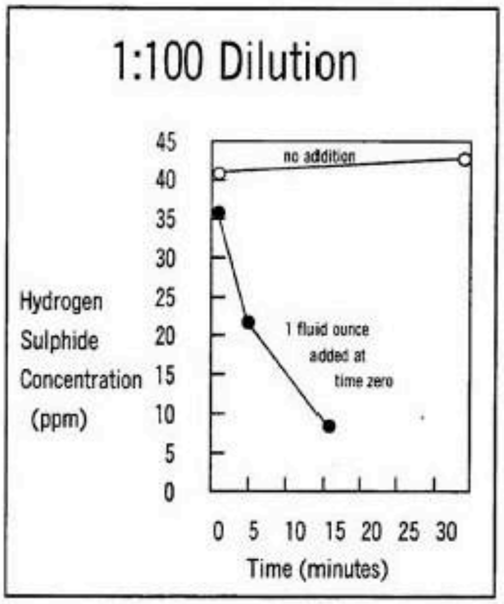
Page 2 of 2
Order 12453

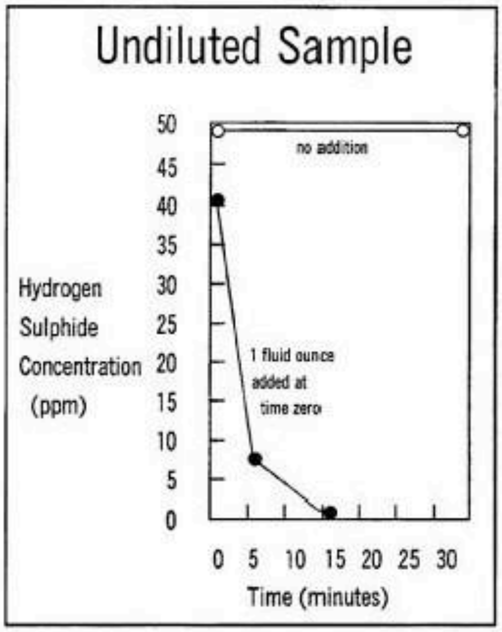
Conclusion

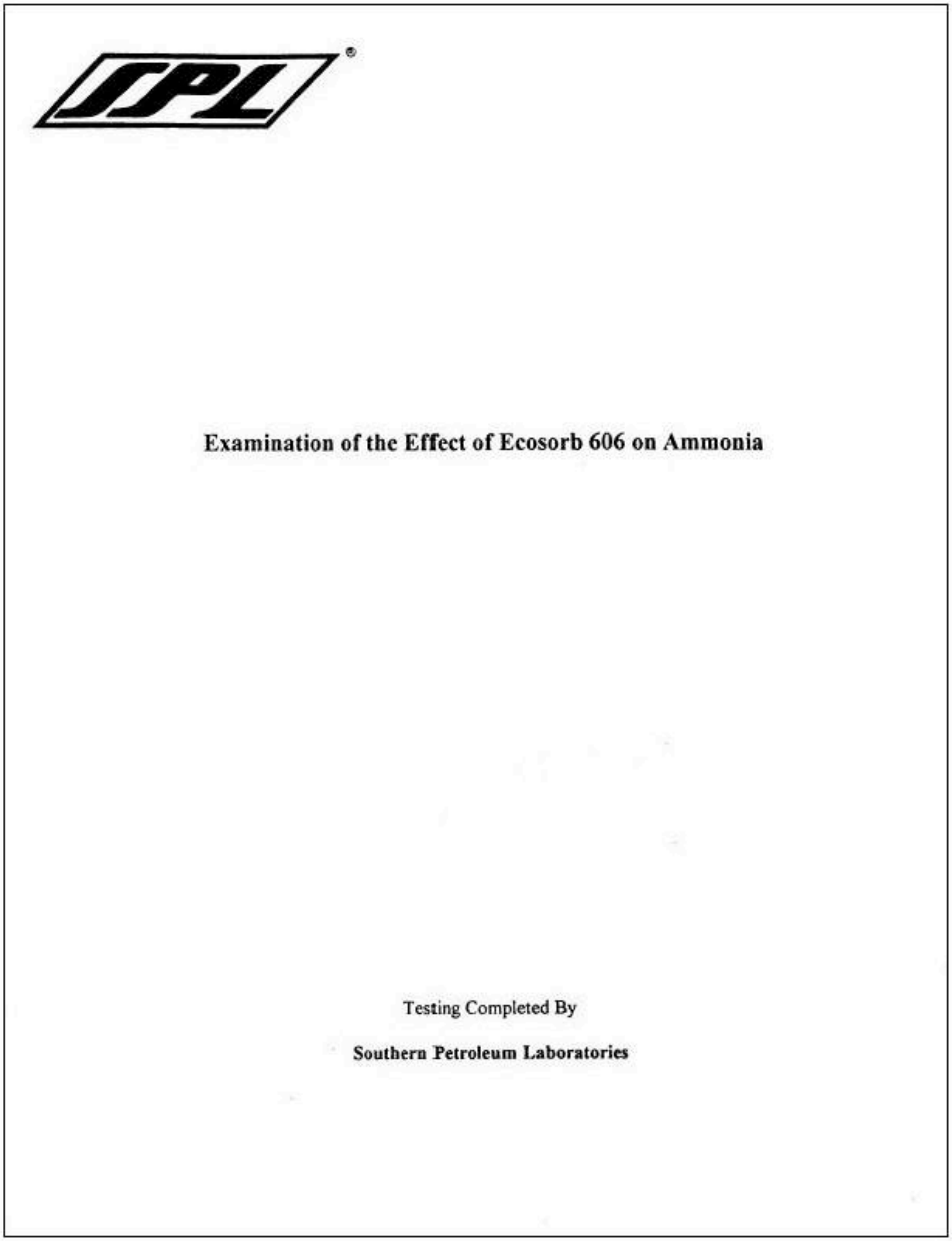
The results of this analysis show a pronounced affect of the sample on hydrogen sulfide concentration in air. The undiluted sample was able to reduce the concentration more than 24 times, from 48 ppm to below the detection limit of 2 ppm in only 15 minutes. While a 1:100 dilution was not as effective, it still reduced the concentration by a factor of 4 in the same time period.

Samples not collected within a two week period of time following the completion of analysis will be discarded unless otherwise specified.

If you would like to discuss the contents of the report, please contact your Technical Sales Representative.


1:100 Dilution
Hydrogen Sulphide Concentration (ppm)
45
40
35
30
25
20
15
10
5
0
no addition
1 fluid ounce added at time zero
0
5
10
15
20
25
30
Time (minutes)

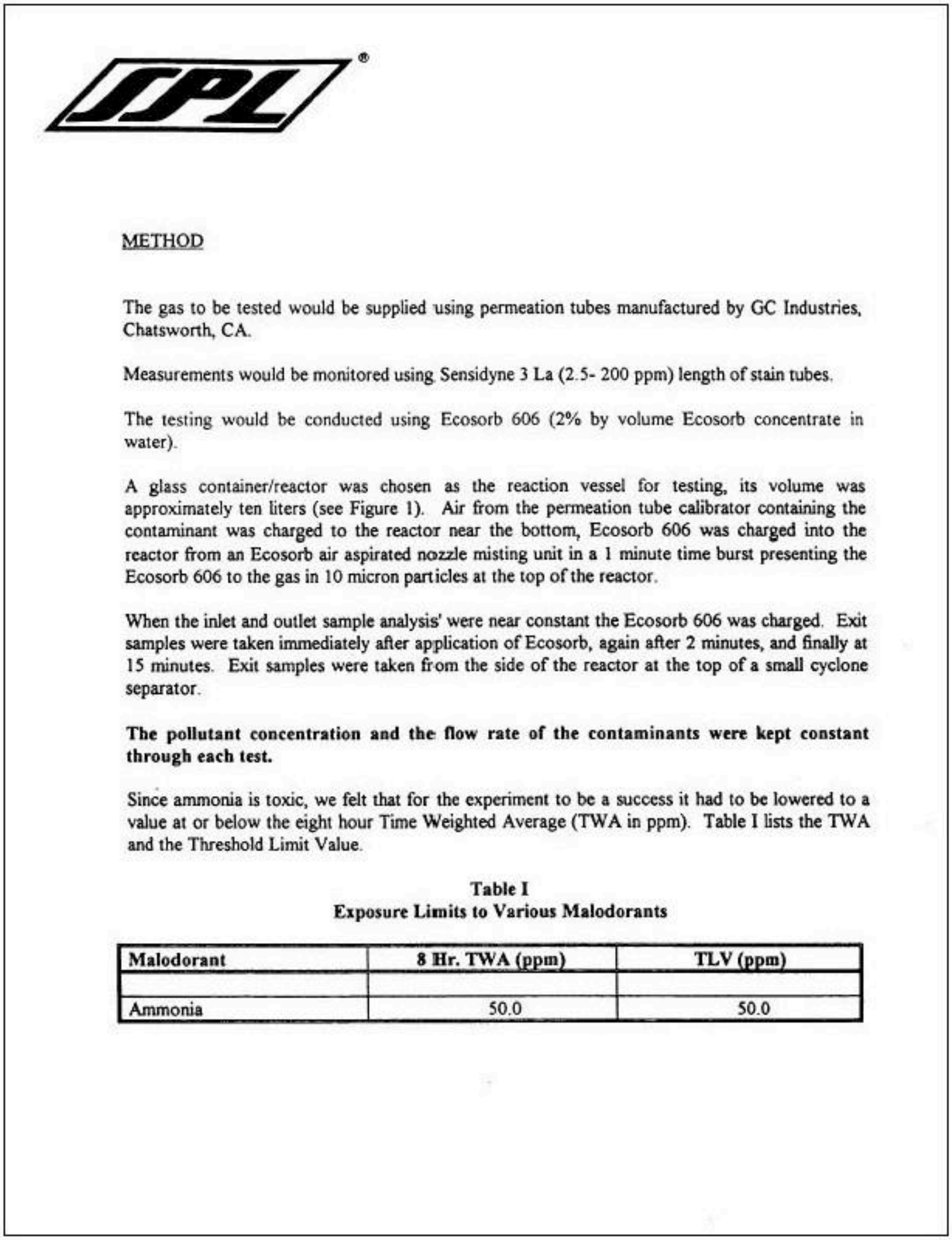

Undiluted Sample
Hydrogen Sulphide Concentration (ppm)
50
45
40
35
30
25
20
15
10
5
0
no addition
1 fluid ounce added at time zero
0
5
10
15
20
25
30
Time (minutes)



Examination of the Effect of Ecosorb 606 on Ammonia

Testing Completed By

Southern Petroleum Laboratories



METHOD

The gas to be tested would be supplied using permeation tubes manufactured by GC Industries, Chatsworth, CA.

Measurements would be monitored using Sensidyne 3 La (2.5- 200 ppm) length of stain tubes.

The testing would be conducted using Ecosorb 606 (2% by volume Ecosorb concentrate in water).

A glass container/reactor was chosen as the reaction vessel for testing, its volume was approximately ten liters (see Figure 1). Air from the permeation tube calibrator containing the contaminant was charged to the reactor near the bottom, Ecosorb 606 was charged into the reactor from an Ecosorb air aspirated nozzle misting unit in a 1 minute time burst presenting the Ecosorb 606 to the gas in 10 micron particles at the top of the reactor.

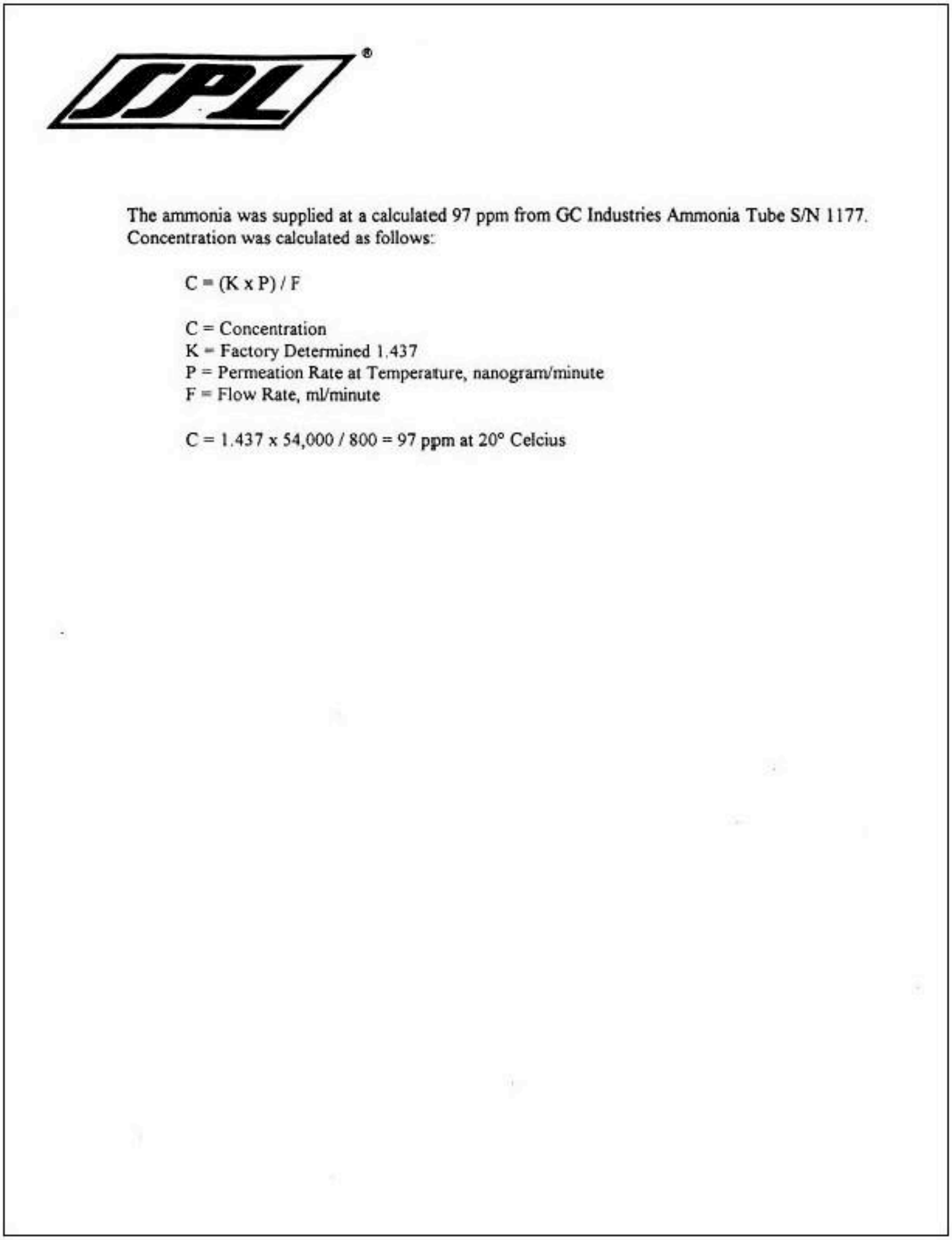
When the inlet and outlet sample analysis' were near constant the Ecosorb 606 was charged. Exit samples were taken immediately after application of Ecosorb, again after 2 minutes, and finally at 15 minutes. Exit samples were taken from the side of the reactor at the top of a small cyclone separator.

The pollutant concentration and the flow rate of the contaminants were kept constant through each test.

Since ammonia is toxic, we felt that for the experiment to be a success it had to be lowered to a value at or below the eight hour Time Weighted Average (TWA in ppm). Table I lists the TWA and the Threshold Limit Value.

Table I
Exposure Limits to Various Malodorants

Malodorant	8 Hr. TWA (ppm)	TLV (ppm)
Ammonia	50.0	50.0



The ammonia was supplied at a calculated 97 ppm from GC Industries Ammonia Tube S/N 1177. Concentration was calculated as follows:

C = (K x P) / F

C = Concentration
K = Factory Determined 1.437
P = Permeation Rate at Temperature, nanogram/minute
F = Flow Rate, ml/minute

C = 1.437 x 54,000 / 800 = 97 ppm at 20° Celcius

ECOSORB CONTACT TESTING PROCESS

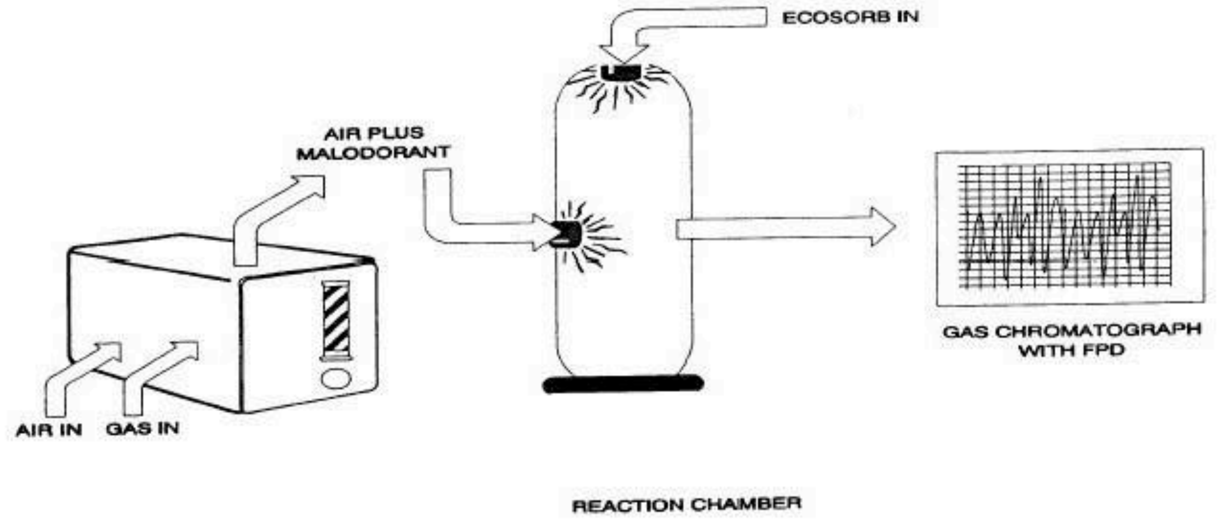


FIGURE 1

Table II
Ammonia Solubility in Water

Malodorant	Solubility in Water
Ammonia	89 grams/100 cc @ Deg. C.

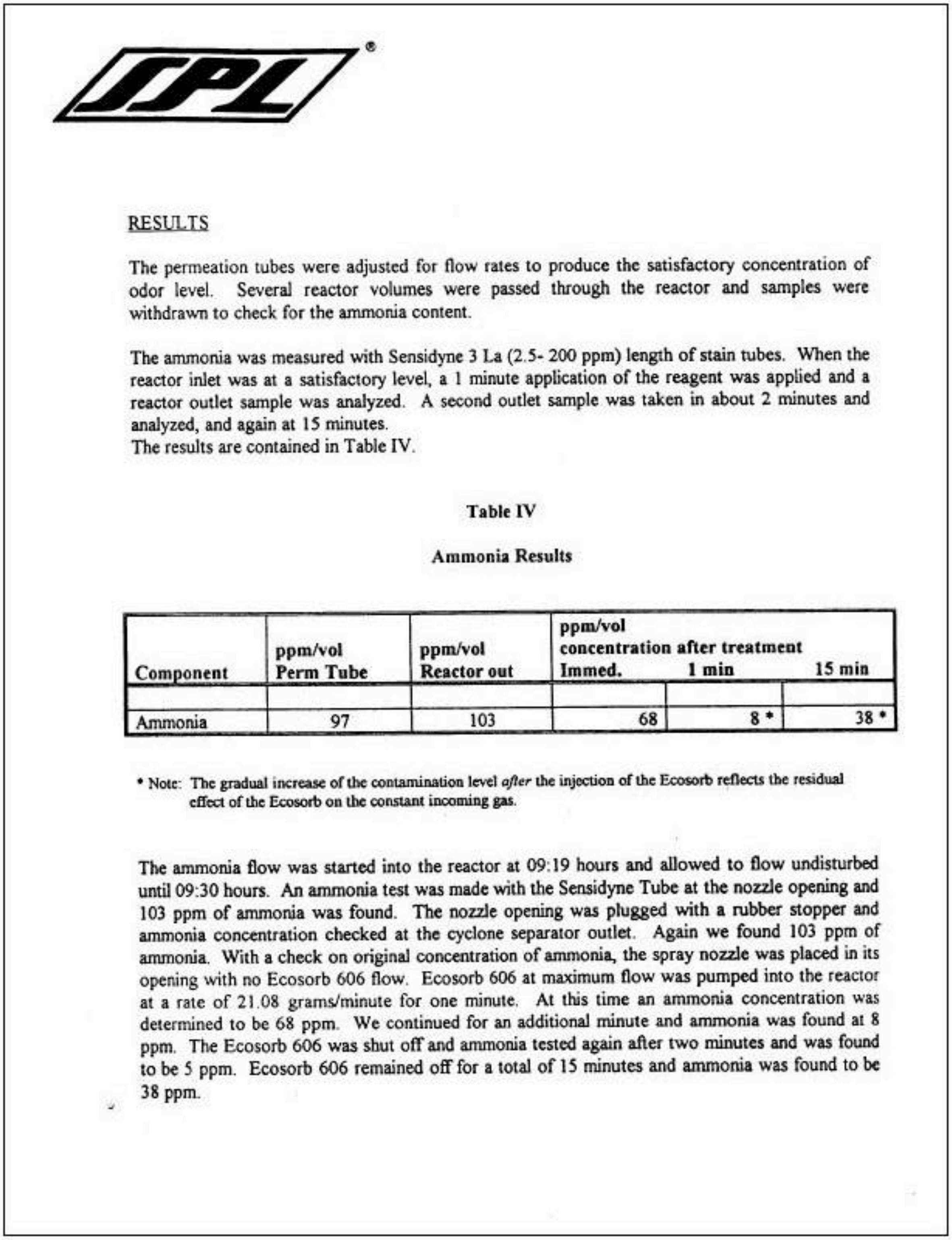
Table III
Permeation Tube Properties

Tube	Serial No.	Shipment Date	Wt. @ Shipment	Empty Weight	Perm Rate @ 25 C. (P)	Wt. @ Run End	Air Flow Rate (F)	K	ppm Mal-odorant
Ammonia	1177	01/18/93	307.93100	275.73	50,700	300.2	800	1.437	90.00

Concentration ppm vol = (K x P) / F

Table III is a list of permeation tubes using in data for their output. All of the permeation tubes were obtained from:

GC Industries
8967 OSO Avenue
Chatsworth, CA 91311
Phone: 510/226-1329



RESULTS

The permeation tubes were adjusted for flow rates to produce the satisfactory concentration of odor level. Several reactor volumes were passed through the reactor and samples were withdrawn to check for the ammonia content.

The ammonia was measured with Sensidyne 3 La (2.5- 200 ppm) length of stain tubes. When the reactor inlet was at a satisfactory level, a 1 minute application of the reagent was applied and a reactor outlet sample was analyzed. A second outlet sample was taken in about 2 minutes and analyzed, and again at 15 minutes.
The results are contained in Table IV.

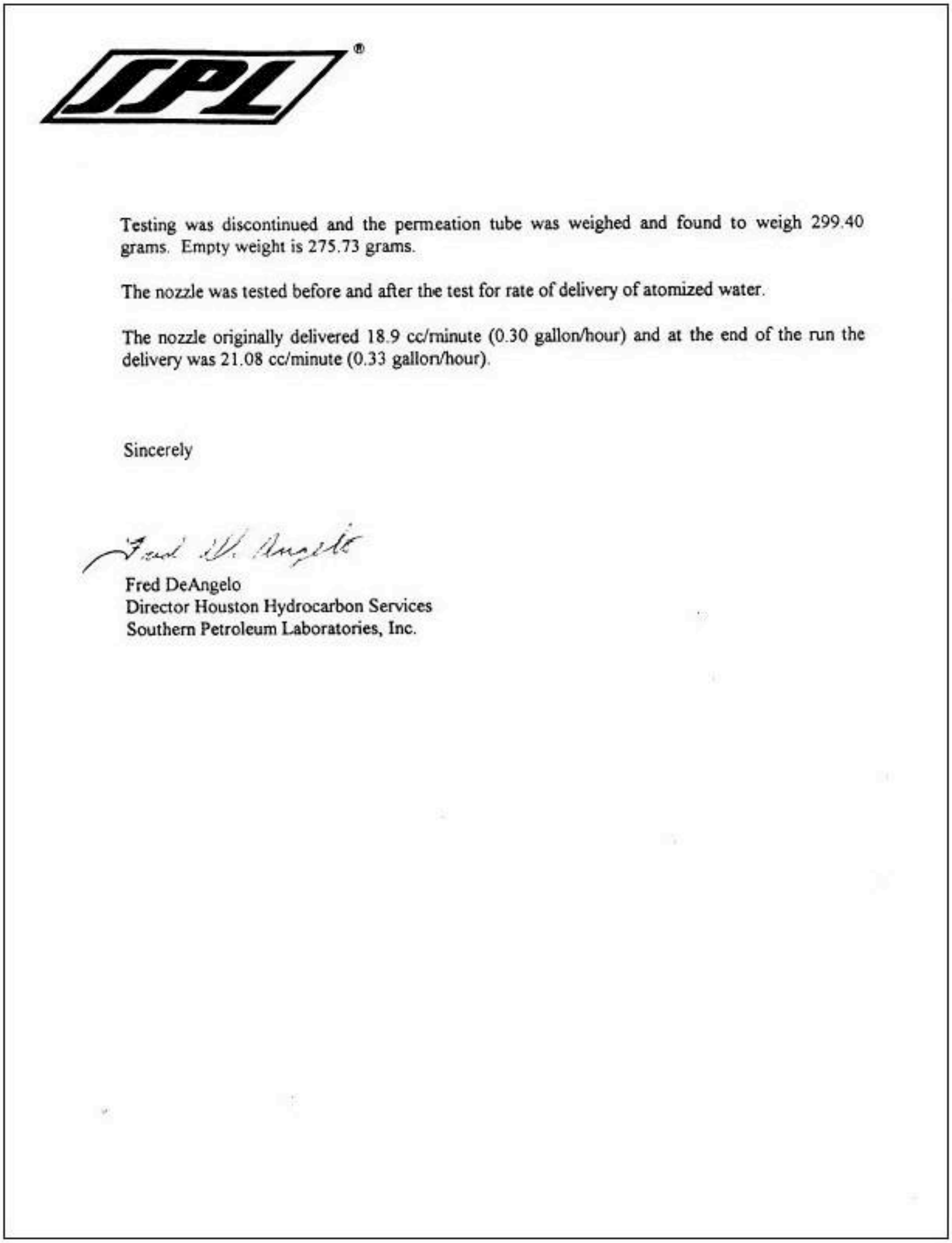
Table IV

Ammonia Results

Component	**ppm/vol Perm Tube**	**ppm/vol Reactor out**	**ppm/vol concentration after treatment Immed.**	**1 min**	**15 min**
Ammonia	97	103	68	8 *	38 *

* Note: The gradual increase of the contamination level *after* the injection of the Ecosorb reflects the residual effect of the Ecosorb on the constant incoming gas.

The ammonia flow was started into the reactor at 09:19 hours and allowed to flow undisturbed until 09:30 hours. An ammonia test was made with the Sensidyne Tube at the nozzle opening and 103 ppm of ammonia was found. The nozzle opening was plugged with a rubber stopper and ammonia concentration checked at the cyclone separator outlet. Again we found 103 ppm of ammonia. With a check on original concentration of ammonia, the spray nozzle was placed in its opening with no Ecosorb 606 flow. Ecosorb 606 at maximum flow was pumped into the reactor at a rate of 21.08 grams/minute for one minute. At this time an ammonia concentration was determined to be 68 ppm. We continued for an additional minute and ammonia was found at 8 ppm. The Ecosorb 606 was shut off and ammonia tested again after two minutes and was found to be 5 ppm. Ecosorb 606 remained off for a total of 15 minutes and ammonia was found to be 38 ppm.



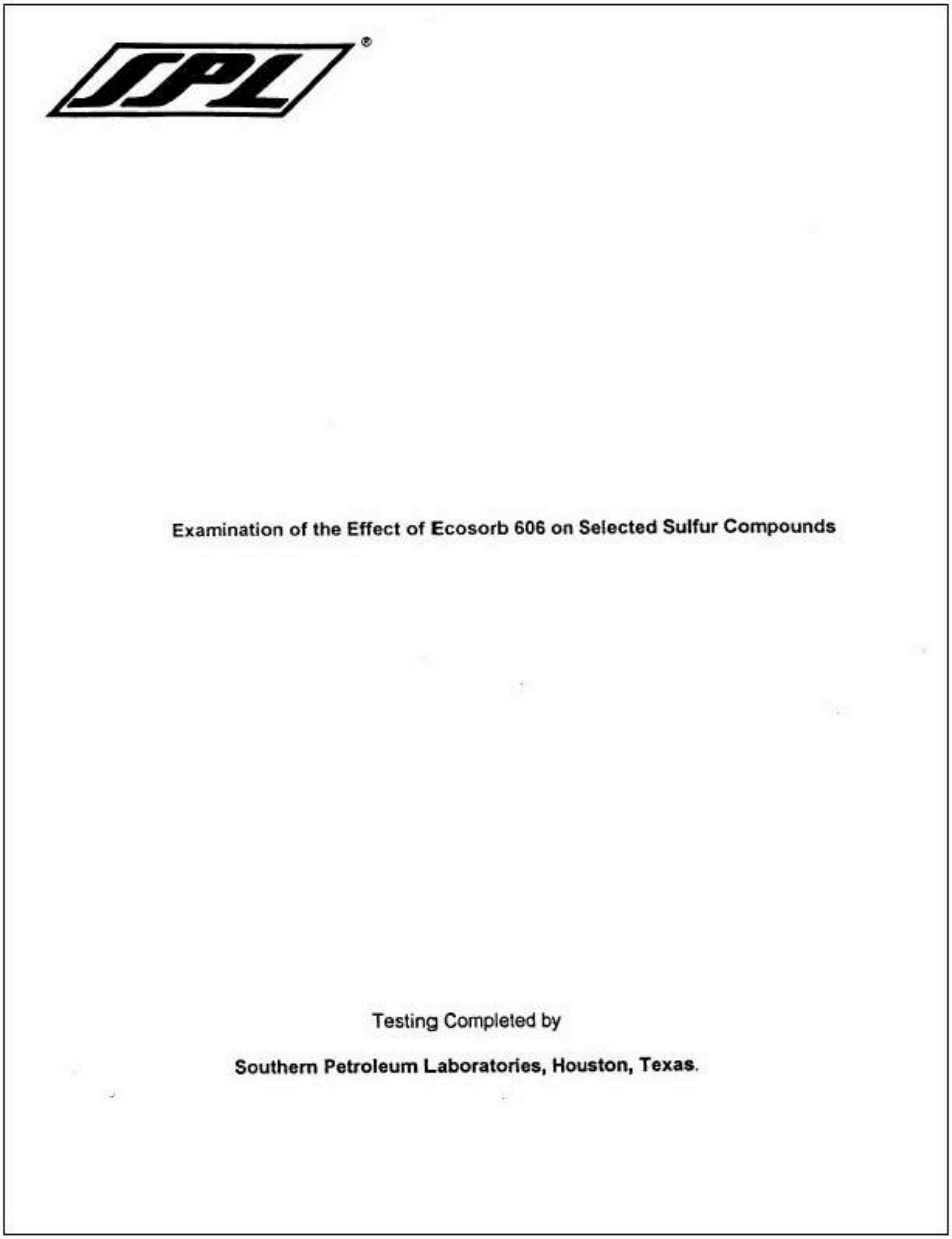
Testing was discontinued and the permeation tube was weighed and found to weigh 299.40 grams. Empty weight is 275.73 grams.

The nozzle was tested before and after the test for rate of delivery of atomized water.

The nozzle originally delivered 18.9 cc/minute (0.30 gallon/hour) and at the end of the run the delivery was 21.08 cc/minute (0.33 gallon/hour).

Sincerely

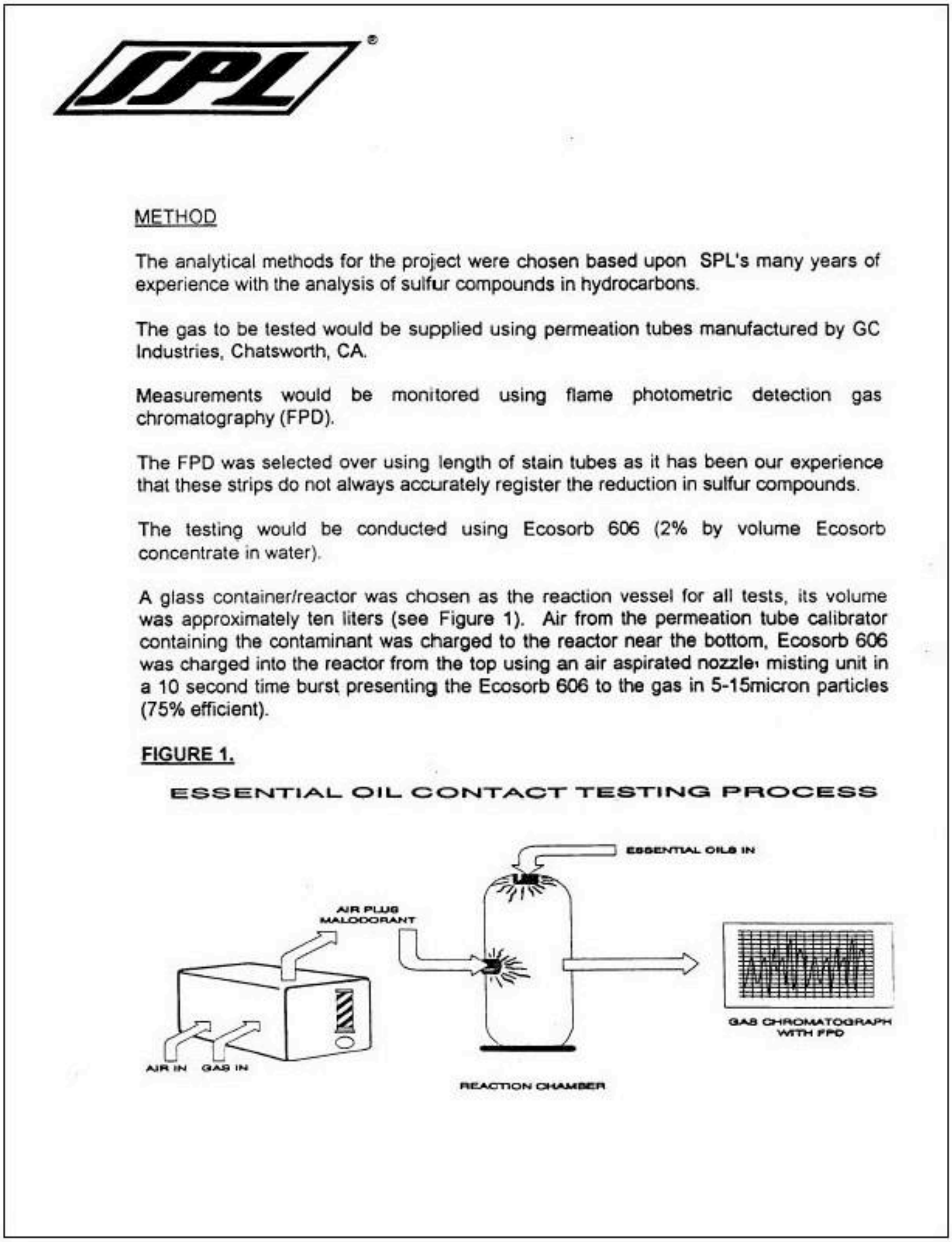
Fred DeAngelo
Director Houston Hydrocarbon Services
Southern Petroleum Laboratories, Inc.



Examination of the Effect of Ecosorb 606 on Selected Sulfur Compounds

Testing Completed by

Southern Petroleum Laboratories, Houston, Texas.



SPL®

METHOD

The analytical methods for the project were chosen based upon SPL's many years of experience with the analysis of sulfur compounds in hydrocarbons.

The gas to be tested would be supplied using permeation tubes manufactured by GC Industries, Chatsworth, CA.

Measurements would be monitored using flame photometric detection gas chromatography (FPD).

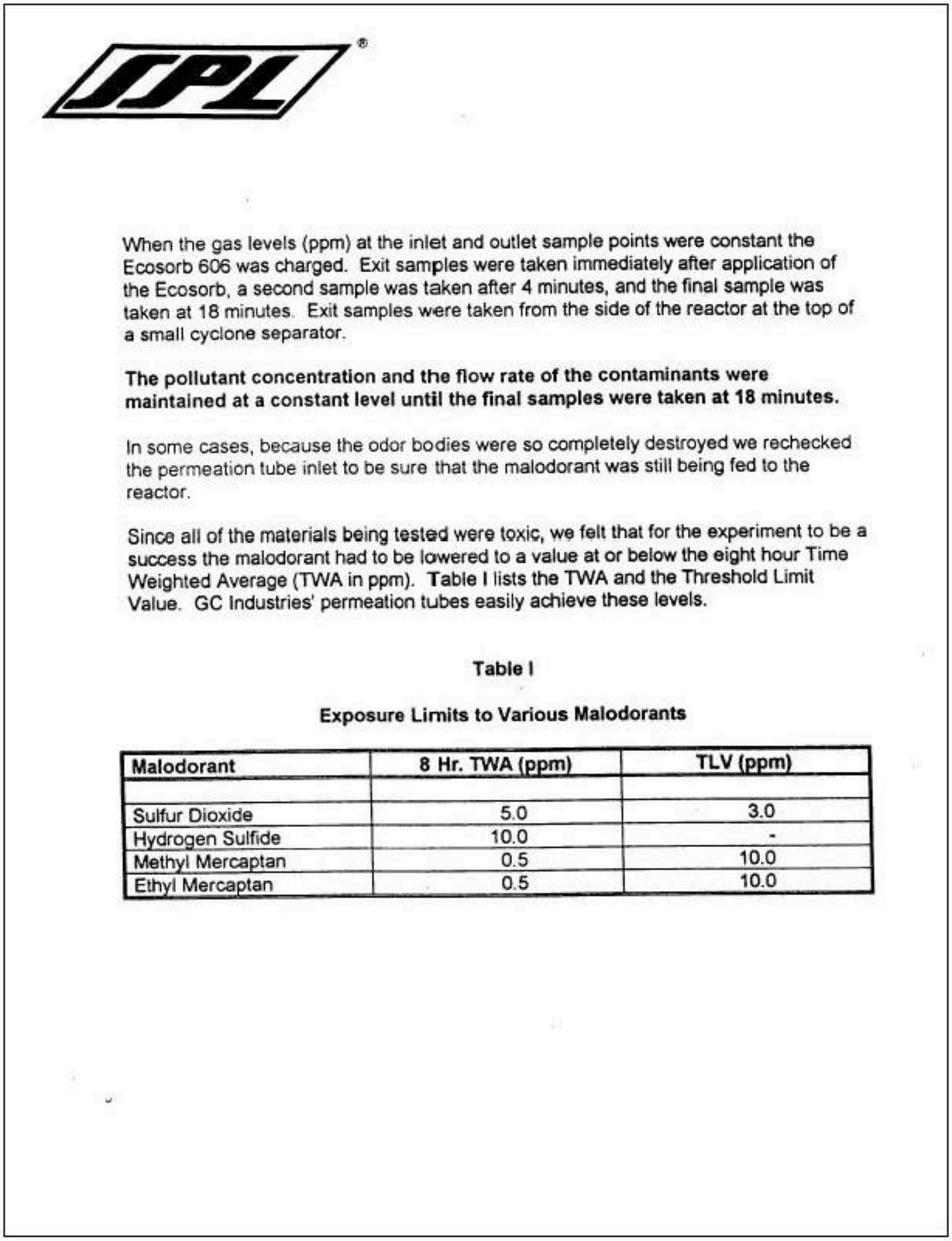
The FPD was selected over using length of stain tubes as it has been our experience that these strips do not always accurately register the reduction in sulfur compounds.

The testing would be conducted using Ecosorb 606 (2% by volume Ecosorb concentrate in water).

A glass container/reactor was chosen as the reaction vessel for all tests, its volume was approximately ten liters (see Figure 1). Air from the permeation tube calibrator containing the contaminant was charged to the reactor near the bottom, Ecosorb 606 was charged into the reactor from the top using an air aspirated nozzle› misting unit in a 10 second time burst presenting the Ecosorb 606 to the gas in 5-15micron particles (75% efficient).

FIGURE 1.

ESSENTIAL OIL CONTACT TESTING PROCESS



When the gas levels (ppm) at the inlet and outlet sample points were constant the Ecosorb 606 was charged. Exit samples were taken immediately after application of the Ecosorb, a second sample was taken after 4 minutes, and the final sample was taken at 18 minutes. Exit samples were taken from the side of the reactor at the top of a small cyclone separator.

The pollutant concentration and the flow rate of the contaminants were maintained at a constant level until the final samples were taken at 18 minutes.

In some cases, because the odor bodies were so completely destroyed we rechecked the permeation tube inlet to be sure that the malodorant was still being fed to the reactor.

Since all of the materials being tested were toxic, we felt that for the experiment to be a success the malodorant had to be lowered to a value at or below the eight hour Time Weighted Average (TWA in ppm). Table I lists the TWA and the Threshold Limit Value. GC Industries' permeation tubes easily achieve these levels.

Table I

Exposure Limits to Various Malodorants

Malodorant	8 Hr. TWA (ppm)	TLV (ppm)
Sulfur Dioxide	5.0	3.0
Hydrogen Sulfide	10.0	-
Methyl Mercaptan	0.5	10.0
Ethyl Mercaptan	0.5	10.0

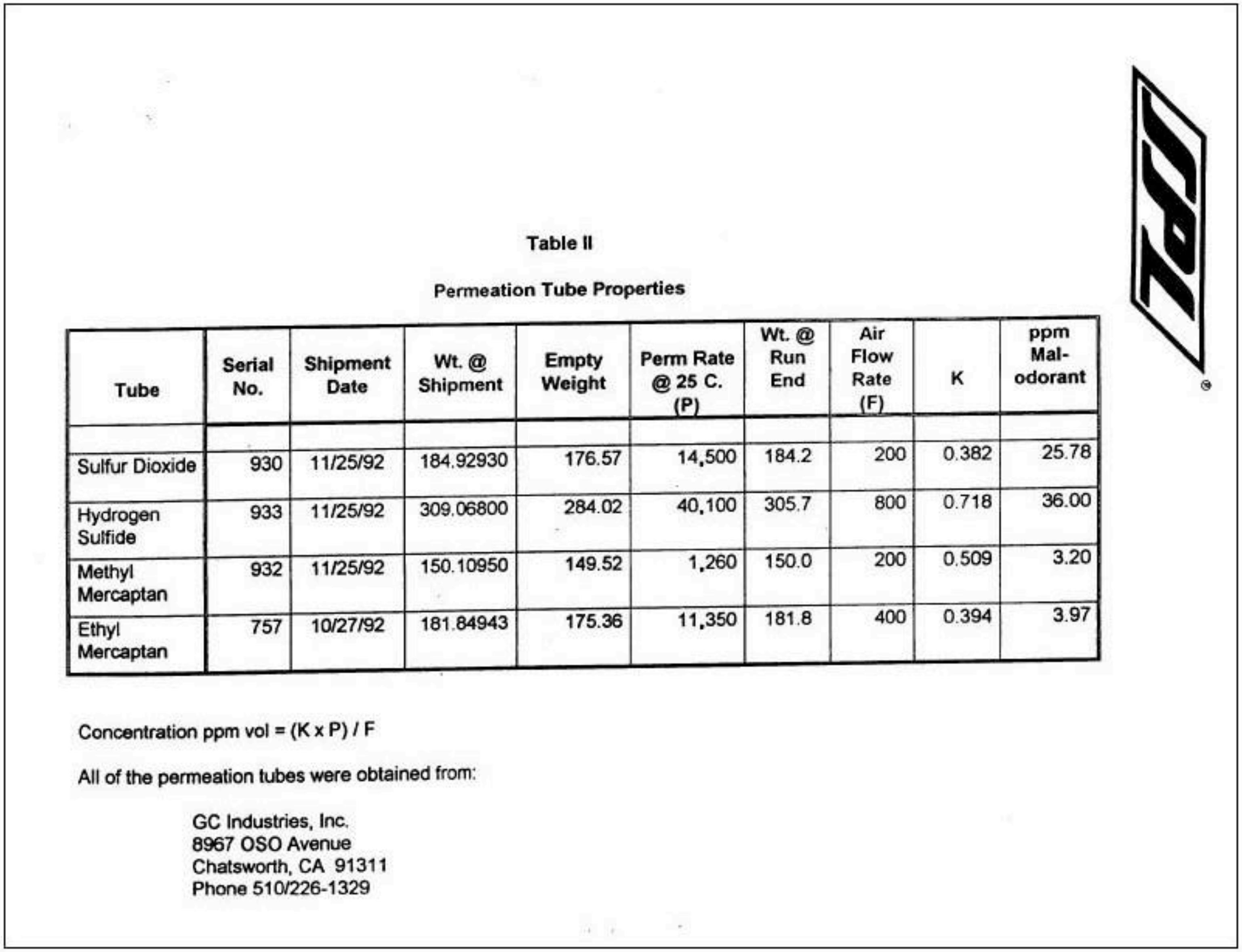


Table II

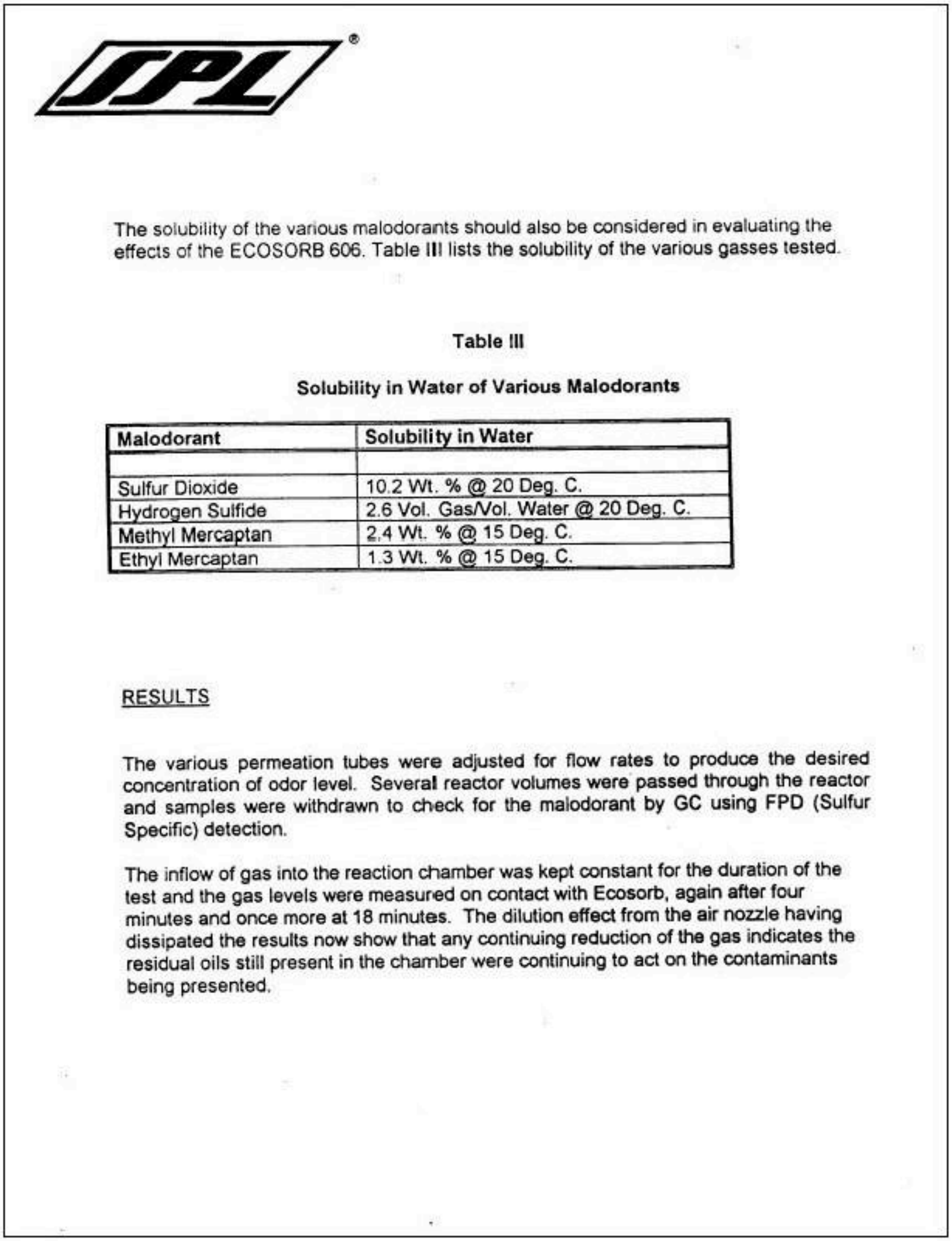
Permeation Tube Properties

Tube	Serial No.	Shipment Date	Wt. @ Shipment	Empty Weight	Perm Rate @ 25 C. (P)	Wt. @ Run End	Air Flow Rate (F)	K	ppm Mal-odorant
Sulfur Dioxide	930	11/25/92	184.92930	176.57	14,500	184.2	200	0.382	25.78
Hydrogen Sulfide	933	11/25/92	309.06800	284.02	40,100	305.7	800	0.718	36.00
Methyl Mercaptan	932	11/25/92	150.10950	149.52	1,260	150.0	200	0.509	3.20
Ethyl Mercaptan	757	10/27/92	181.84943	175.36	11,350	181.8	400	0.394	3.97

Concentration ppm vol = (K x P) / F

All of the permeation tubes were obtained from:

GC Industries, Inc.
8967 OSO Avenue
Chatsworth, CA 91311
Phone 510/226-1329



The solubility of the various malodorants should also be considered in evaluating the effects of the ECOSORB 606. Table III lists the solubility of the various gasses tested.

Table III

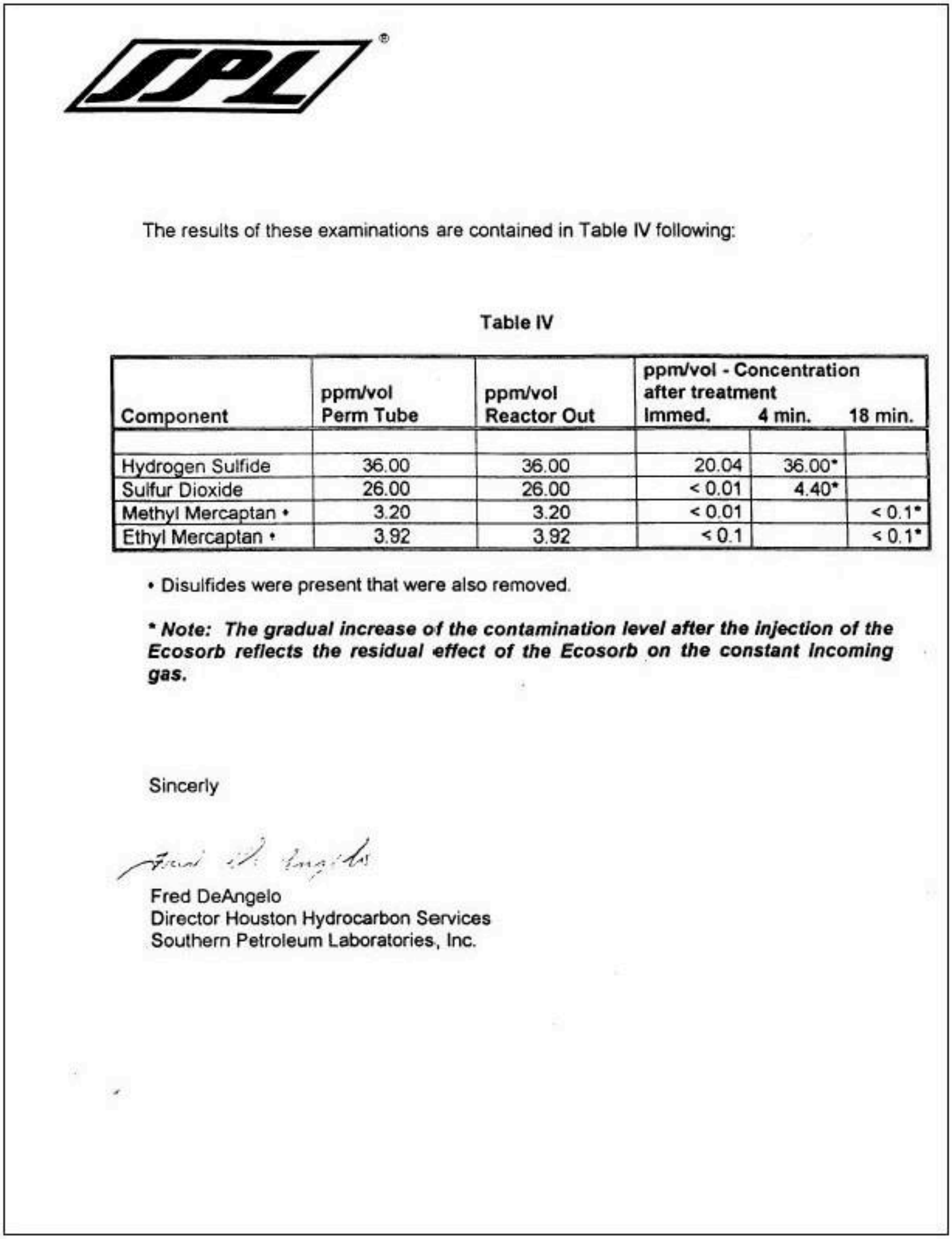
Solubility in Water of Various Malodorants

Malodorant	**Solubility in Water**
Sulfur Dioxide	10.2 Wt. % @ 20 Deg. C.
Hydrogen Sulfide	2.6 Vol. Gas/Vol. Water @ 20 Deg. C.
Methyl Mercaptan	2.4 Wt. % @ 15 Deg. C.
Ethyl Mercaptan	1.3 Wt. % @ 15 Deg. C.

RESULTS

The various permeation tubes were adjusted for flow rates to produce the desired concentration of odor level. Several reactor volumes were passed through the reactor and samples were withdrawn to check for the malodorant by GC using FPD (Sulfur Specific) detection.

The inflow of gas into the reaction chamber was kept constant for the duration of the test and the gas levels were measured on contact with Ecosorb, again after four minutes and once more at 18 minutes. The dilution effect from the air nozzle having dissipated the results now show that any continuing reduction of the gas indicates the residual oils still present in the chamber were continuing to act on the contaminants being presented.



The results of these examinations are contained in Table IV following:

Table IV

Component	ppm/vol Perm Tube	ppm/vol Reactor Out	ppm/vol - Concentration after treatment		
			Immed.	4 min.	18 min.
Hydrogen Sulfide	36.00	36.00	20.04	36.00*	
Sulfur Dioxide	26.00	26.00	< 0.01	4.40*	
Methyl Mercaptan •	3.20	3.20	< 0.01		< 0.1*
Ethyl Mercaptan •	3.92	3.92	< 0.1		< 0.1*

• Disulfides were present that were also removed.

**** Note: The gradual increase of the contamination level after the injection of the Ecosorb reflects the residual effect of the Ecosorb on the constant incoming gas.***

Sincerly

Fred DeAngelo
Director Houston Hydrocarbon Services
Southern Petroleum Laboratories, Inc.

EFFECTS OF ECOSORB 206SG3 & 606SG3 ON VOLATILE COMPONENT REDUCTION IN HEATED ASPHALT SAMPLES

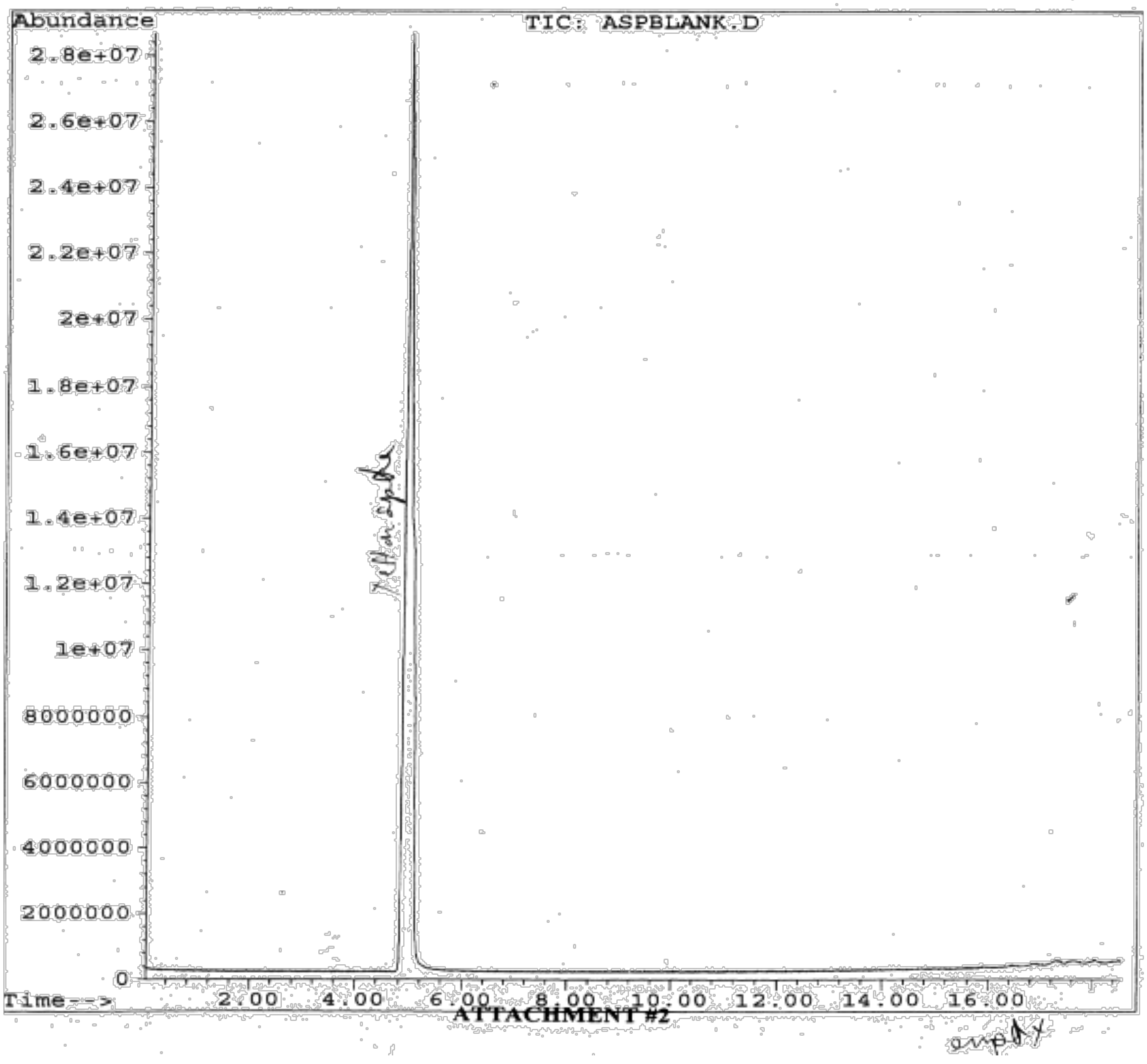
Charles R. Timcik, M.S.
Odor Management, Inc.

Donald R. Wilkinson, Ph.D.
Delaware State University

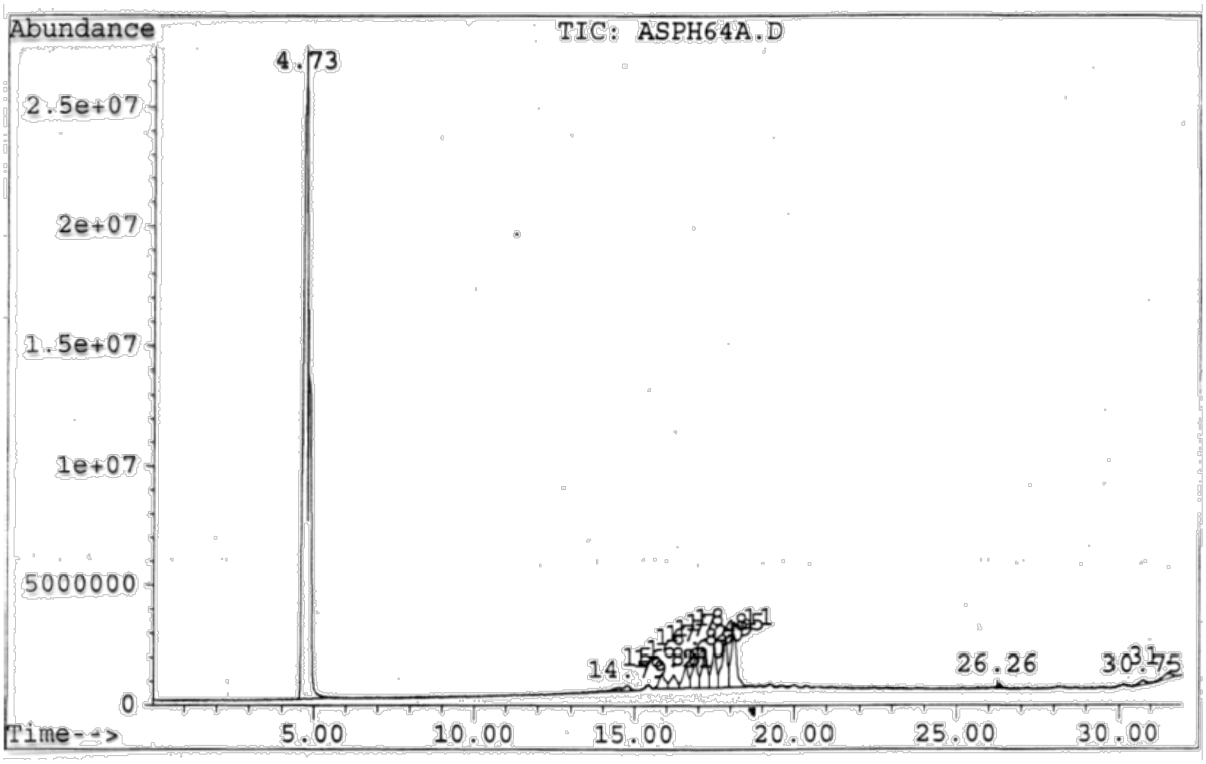
Samples Used in Study

PG70-22 (7022)
PG64-22 (6422)
ECOSORB 206SG
ECOSORB 606SG

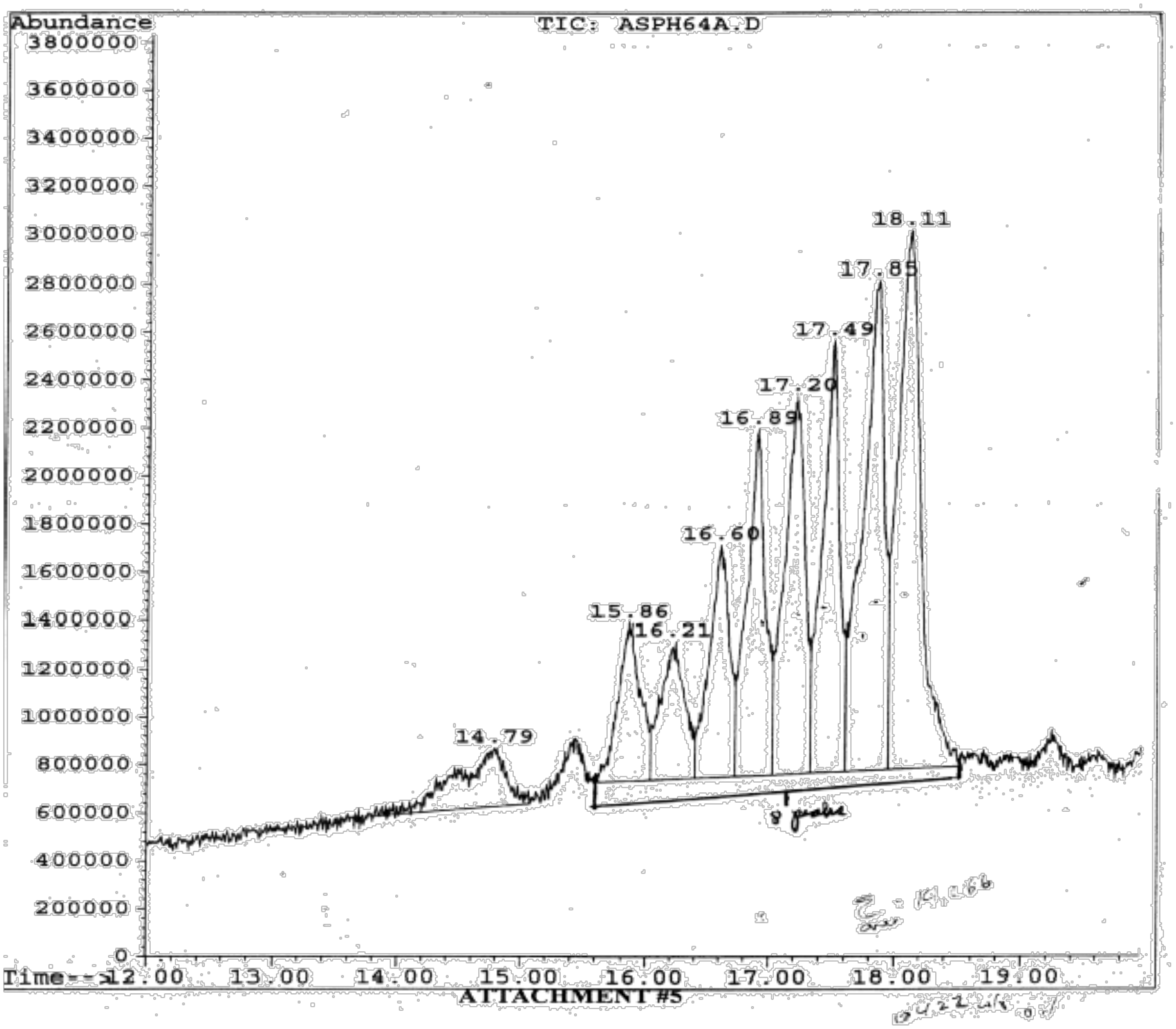
Blank Run/No Asphalt



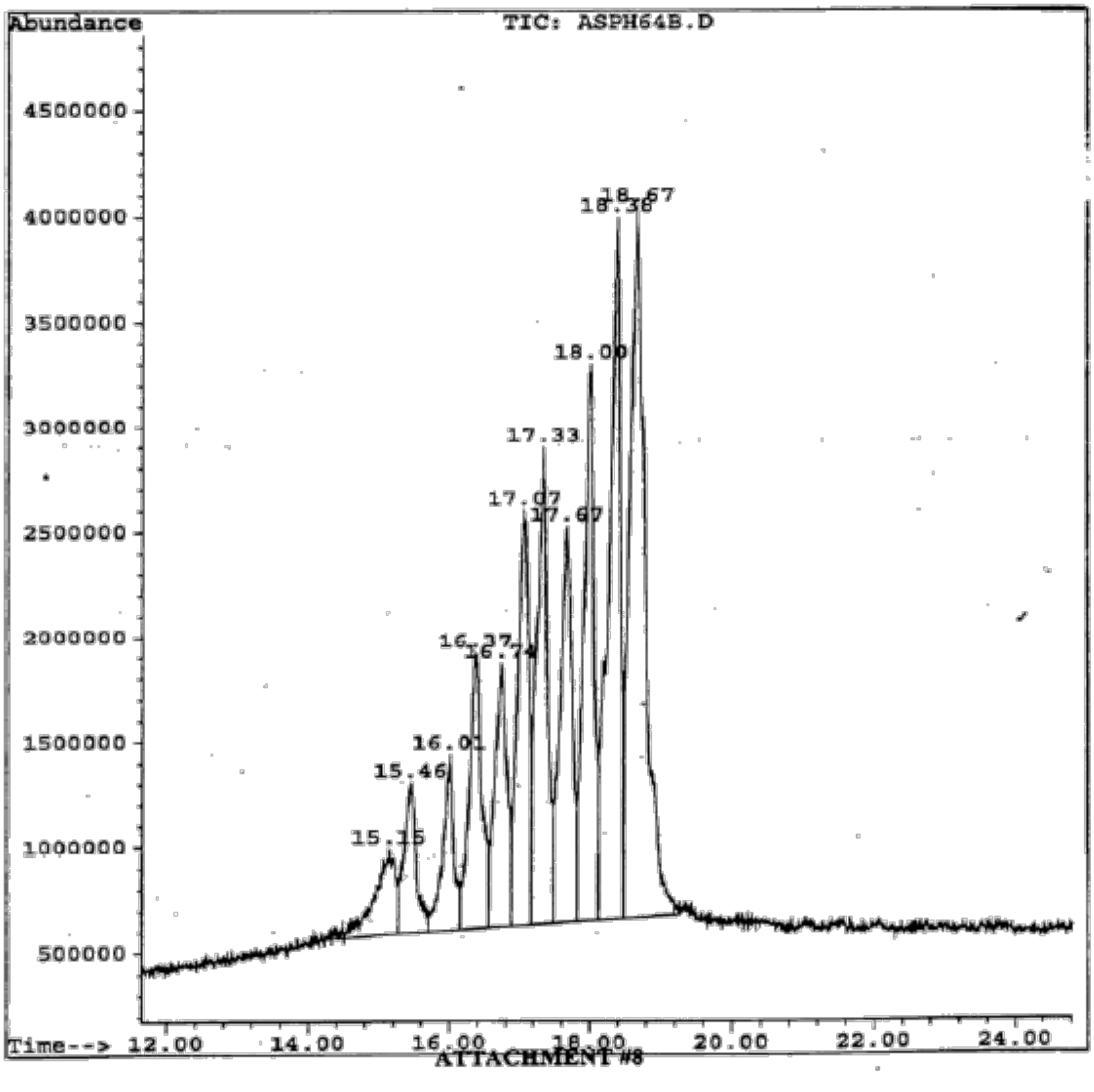
<u>6422 WITHOUT ECOSORB</u>



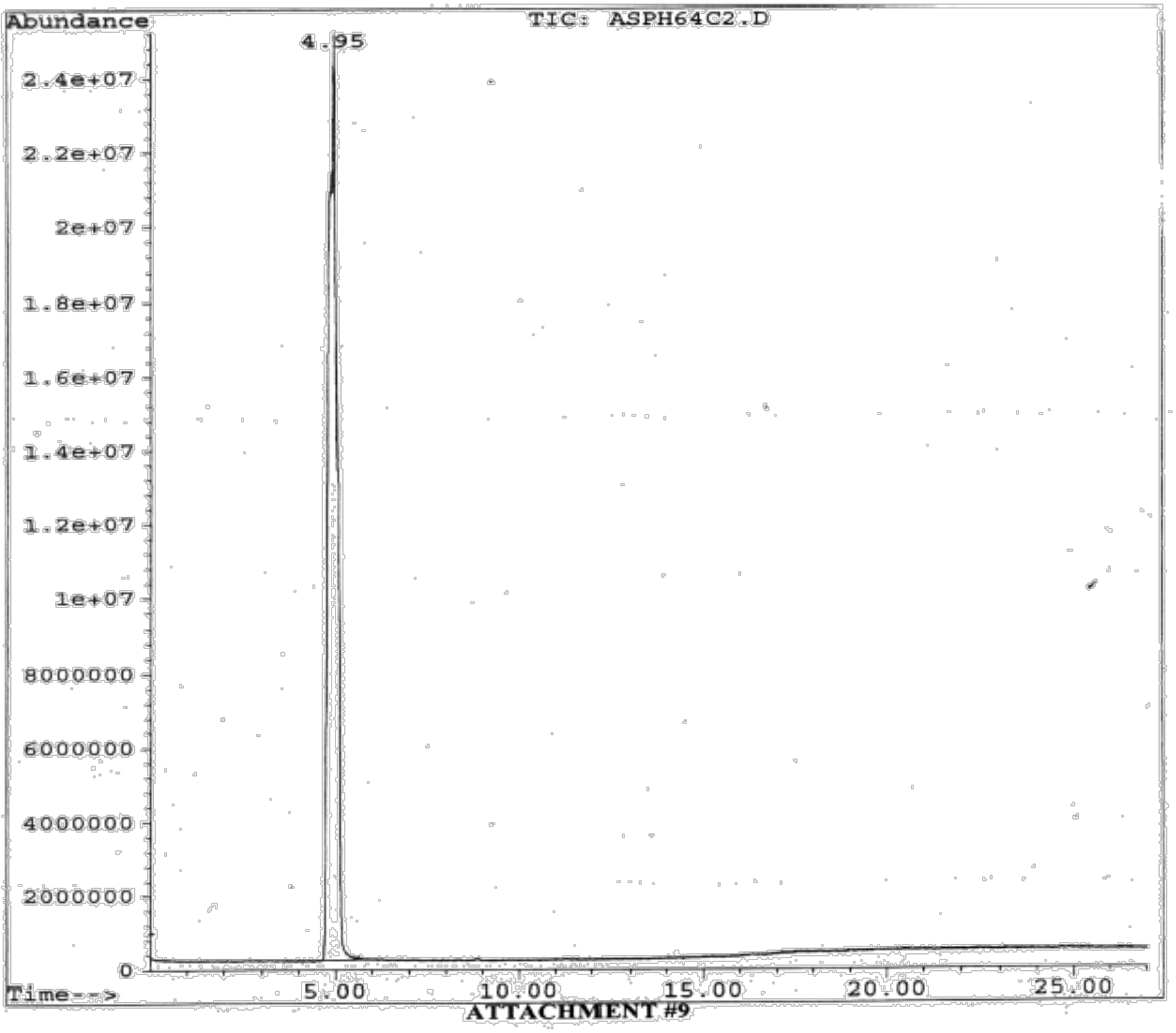
6422 Without Ecosorb (Expanded)



6422 + 206SG (Expanded)



6422 WITH 606SG



ATTACHMENT #9

6422 Results

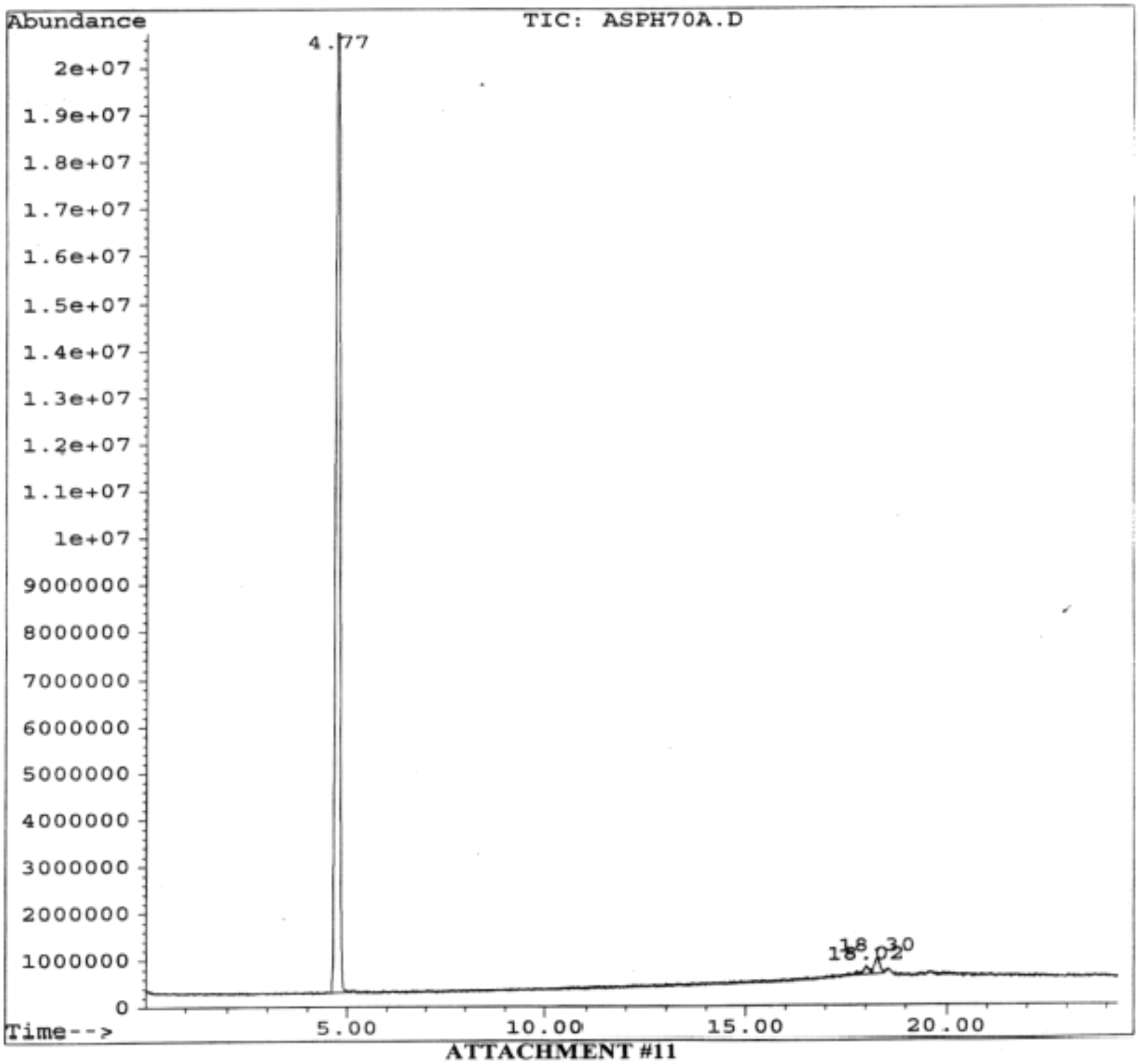
Detection Limit is 500 counts. Less than 500 counts reads “not detected”

6422 without oil
14,266 (+/-5%) counts

6422 with 1 uL of 206SG3 Oil
14,735 (+/-5%) counts

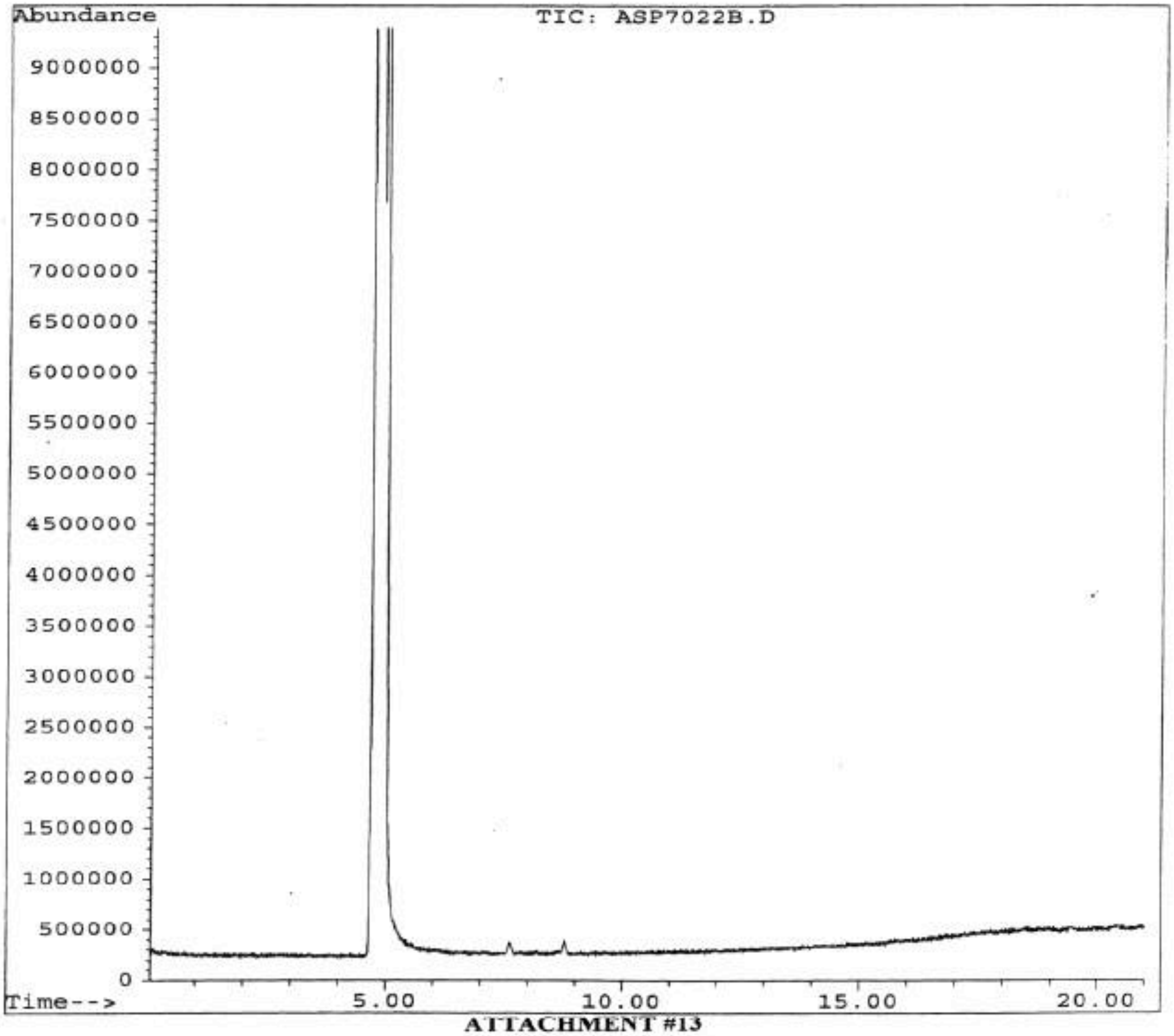
6422 with 1 uL of 606SG3 Oil
<500 (+/-5%) counts

7022 Without Ecosorb



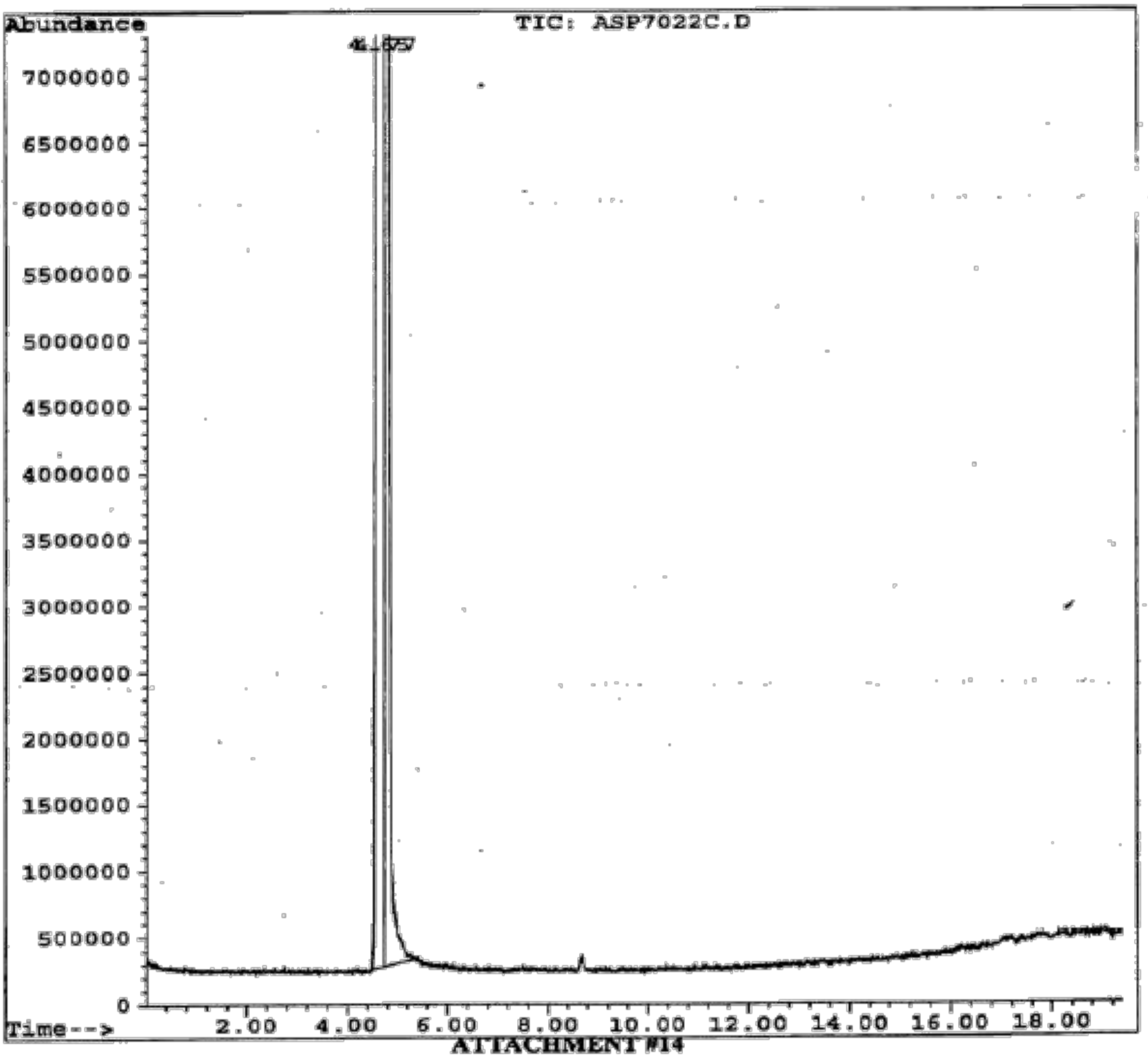
ATTACHMENT #11

7022 + 206SG



ATTACHMENT #13

Asphalt 7022 + 606SG



7022 Results

Detection limit is 500 counts. Less than 500 counts reads “not detected”.

7022 without oil
1,494 (+/-5%) counts

7022 with 1 uL of 206SG3 Oil
<500 (+/-5%) counts

7022 with 1 uL of 606SG3 Oil
<500 (+/-5%) counts

Conclusions

1. The only volatile components detected in the two samples were a series of increasingly higher molecular weight hydrocarbons.

2. Ecosorb 206SG did not have any effect in reducing volatile hydrocarbons in sample 6422. Sample 606SG appeared to greatly reduce the volatile hydrocarbon output when treating 6422.

3. Asphalt sample 7022 produced approximately 1/10 the amount of volatile hydrocarbons when treated under identical conditions as 6422.

4. Both 206 and 606 appeared to reduce volatile hydrocarbon levels of 7022 to the minimum detection limit of the instrument, although the amount of volatile hydrocarbons present were only approximately three times the minimum detection limit.

Asphalt Additive Olfactometric Testing In Japan

Ecosorb® 606A and 206A Additives

A summary report of that provided by
Yoshi Taniguchi and Yuzo Mizuno
of EcoRo Japan Co., Ltd.

In July of 2004 an odor concentration test was run in Japan quantifying the effects of Ecosorb® asphalt additive 606A in a common paving asphalt. The asphalt hot mix plant had received odor complaints from neighbors usually when the liquid binder (a.k.a. bitumen) was transferred from a delivery truck to the plant storage tank. The unique characteristic of this test protocol is that it quantifies the odor concentration in terms of dilution when it is not detectable by a test panel as opposed to US and EU standards that attempt to quantify odor in terms of dilution when it is detectable. The test was run according to the procedure outlined by the Japanese Environment Agency Notification No. 63.

Exhaust samples were collected from the vent of a tank receiving fresh bitumen that was untreated with Ecosorb® additive and a tank vent receiving bitumen treated with Ecosorb® additive at a dosing rate of 0.01% (100 ppm). A panel of six pre-qualified individuals, with one being a certified "odor judgment technician" are tasked with quantifying the odor index of the bagged samples through a dilution and sensory technique. From the odor index, the odor concentration is developed mathematically. The odor concentration, a unitless quantification, represents the perceived intensity of the odor(s). In this case, the odor concentration of the untreated asphalt binder odor emission was quantified to be 4000 while the odor concentration of the treated binder was quantified to be 160; a 96% reduction in odor emission realized through the addition of the Ecosorb® additive. Understanding how this quantification was done is important and enlightening. Please refer to tables 1 and 2 on the following pages.

The six panelists were instructed to smell the collected sample gas at varying dilutions with clean air and identify at what dilution they no longer could smell whatever was in the bag. Obviously, a more intense odor would require a greater dilution with clean air to make it undetectable. To vary the dilution ratio for the test, descending amounts of sample gas were added to 3 liters (3000 ml) of clean air. For the first dilution ("No. of time" column "1" on the tables) 300 ml of sample air was added to 3 liters of clean air presenting a dilution ratio of 10 (3000 ml/300 ml). If the panelist could sense the smell of the diluted air, the next dilution level of test air was presented to the panelist, that being column 2, 100 ml in 3 liter = 3000 ml/100 ml = dilution ratio 30. This continued until the dilution ratio where each panelist could not sense the sample gas was identified.

Through simple qualitative observation of the tables one can see the gas from the untreated asphalt had an odor of much greater intensity than that of the treated sample. Generally speaking, the panelists stopped sensing the untreated sample at dilutions of 3000:1 and 10,000:1 while the treated samples being less intense were around 300:1 and 1000:1.

The science world likes to quantify things. In order to do so, they determined the logarithmic (log) value of the dilution at which each of the panelist could no longer sense the sample odor and the log of the previous dilution at which it was detected. The two log values were averaged with the assumption that the actual non-detection dilution fell somewhere in between and that averaged log value established each panelists "odor threshold value" for the sample gas.

Why complicate this procedure with the use of log values? The relation between odor content and perceived intensity is not linear but rather more exponential. Simply stated, a little increase in odor content results in a much greater increase in perceived intensity. Using log values provides a more linear relationship. Here if the dilution rate quantifies the perceived intensity (later labeled as "odor concentration"), then the log of that number relates to the amount of odor content.

Next the odor threshold values for each panelist were averaged, after dropping the high and low values. The “odor index” for the sample gasses is then determined by multiplying the average by 10. Multiplying times 10 is a common method of taking some of the coarseness out of logarithmic number analysis. For most of us, the odor index is somewhat meaningless and no doubt has statistical value to the analysis procedure.

However, quantification of the “odor concentration” has significant value since it represents the perceived intensity. Since we are using logarithmic numbers to represent the odor as it relates to dilution of the sample air and the points at which it is not detectable by the panelists, and we have identified an average threshold or non-detectable point, the protocol defines the odor concentration as the dilution identified by the average of the threshold values. In this case the average threshold values are 2.2 for the treated asphalt and 3.6 for the untreated asphalt. Therefore, to quantify the odor concentration of the two samples, what numbers have a log value of 2.2 and 3.6? $10^{2.2} = 158$ rounded to 160; $10^{3.6} = 3981$ rounded to 4000.

The odor concentration of gasses coming off the untreated asphalt is 4000!
The odor concentration of gasses coming off the treated asphalt is 160!
A 96% reduction in perceived odor!

This then provides us with our first quantified field test of the asphalt additive and solid, quantified evidence of what we already know. The Ecosorb® asphalt additive is very effective at reducing the odorous emission of asphalt binder (bitumen).

Charles R. Timcik
Technical Director
OMI Industries

Table 1: Untreated Asphalt Binder (*bitumen*)

No. of time	1	2	3	4	5	6	7	8	Each panelist's Odor threshold value	exclude highest and lowest value
Test sample injection quantity	300 ml	100 ml	30 ml	10 ml	3 ml	1 ml	300 µl	100 µl		
Dilution ratio	10	30	10^2	3×10^2	10^3	3×10^3	10^4	3×10^4		
Logarithm value	1.00	1.48	2.00	2.48	3.00	3.48	4.00	4.48		
Panelist A	—	—	—	○	X				2.74	*
Panelist B	—	—	—	○	○	○	X		3.74	*
Panelist C	—	—	—	○	○	X			3.24	
Panelist D	—	—	—	○	○	○	X		3.74	
Panelist E	—	—	—	○	○	○	X		3.74	
Panelist F	—	—	—	○	○	○	X		3.74	
Average value of 4 panelist excluding highest and lowest odor threshold value of Logarithm value X									3.615	
Odor index	Y = 10X = 36.15 ≒−36									
Odor concentration	C = 10(Y /10) = $10^{3.6}$= 3981 ≒ 4000									

Table 2: Asphalt Binder (*bitumen*) Treated with Ecosorb® Additive

No. of time	1	2	3	4	5	6	7	8	Each panelist's Odor threshold value	exclude highest and lowest value
Test sample injection quantity	300 ml	100 ml	30 ml	10 ml	3 ml	1 ml	300 µl	100 µl		
Dilution ratio	10	30	10^2	3×10^2	10^3	3×10^3	10^4	3×10^4		
Logarithm value	1.00	1.48	2.00	2.48	3.00	3.48	4.00	4.48		
Panelist A	—	○	X						1.74	*
Panelist B	—	○	○	X					2.24	
Panelist C	—	○	○	X					2.24	
Panelist D	—	○	○	○	X				2.74	*
Panelist E	—	○	○	○	X				2.74	
Panelist F	—	○	X						1.74	
Average value of 4 panelist excluding highest and lowest odor threshold value of Logarithm value－X									2.24	
Odor index	Y ＝ 10X ＝ 22.4 ≒－22									
Odor concentration	C ＝ 10(Y /10) ＝ $10^{2.2}$ ＝ 158 ≒ 160									

GEOTECHNOLOGY INC
MATERIALS TESTING SERVICES

July 29, 2004

Report No. A-463335
0766301.45IT.7001L

Mr. Tom Minett
Odor Management, Inc.
18-6 E. Dundee Road, Suite 101
Barrington, IL 60010

Re: AASHTO T283 Testing
ECOSORB TSR Series

P. O. No. 5721

Dear Mr. Minett:

In accordance with your request, Geotechnology conducted a comparative investigation of adding a triple dose of adding ECOSORB solution to asphalt binder to determine the effect on the asphalt tensile strength. Our investigation included gyrotory compacting asphalt specimens of SP125 mix batched using a 3:10,000 gallon ratio of ECOSORB and Shell 64-22 binder. Also, a control set of specimens were compacted using plain 64-22 binder from the same tank. You will find below the comparative moisture induced damage (AASHTO T-283) results. Six specimens of each set were compacted with three in each set conditioned and three unconditioned in accordance with AASHTO T-283.

UNCONDITIONED SPECIMENS
(containing ECOSORB at 3:10,000 gallon ratio)

Specimen ID	Tensile Strength	Stripping Condition
A	1,551	Good
B	1,561	Good
C	1,599	Good
Average	1,570	

CONDITIONED SPECIMENS
(containing ECOSORB at 3:10,000 gallon ratio)

Specimen ID	Tensile Strength	Stripping Condition
D	1,303	Good
E	1,530	Good
F	1,483	Good
Average	1,438	

GEOTECHNOLOGY INC
MATERIALS TESTING SERVICES

AASHTO T283 Testing
July 29, 2004
Page No. 2

Report No. A-463335
0766301.45IT.7001L

UNCONDITIONED SPECIMENS
(with no ECOSORB)

Specimen ID	Tensile Strength	Stripping Condition
J	1,580	Good
K	1,585	Good
L	1,608	Good
Average	1,591	

CONDITIONED SPECIMENS
(with no ECOSORB)

Specimen ID	Tensile Strength	Stripping Condition
G	1,439	Good
H	1,515	Good
I	1,523	Good
Average	1,492	

COMPARISION OF TEST RESULTS

Average Conditioned Specimen

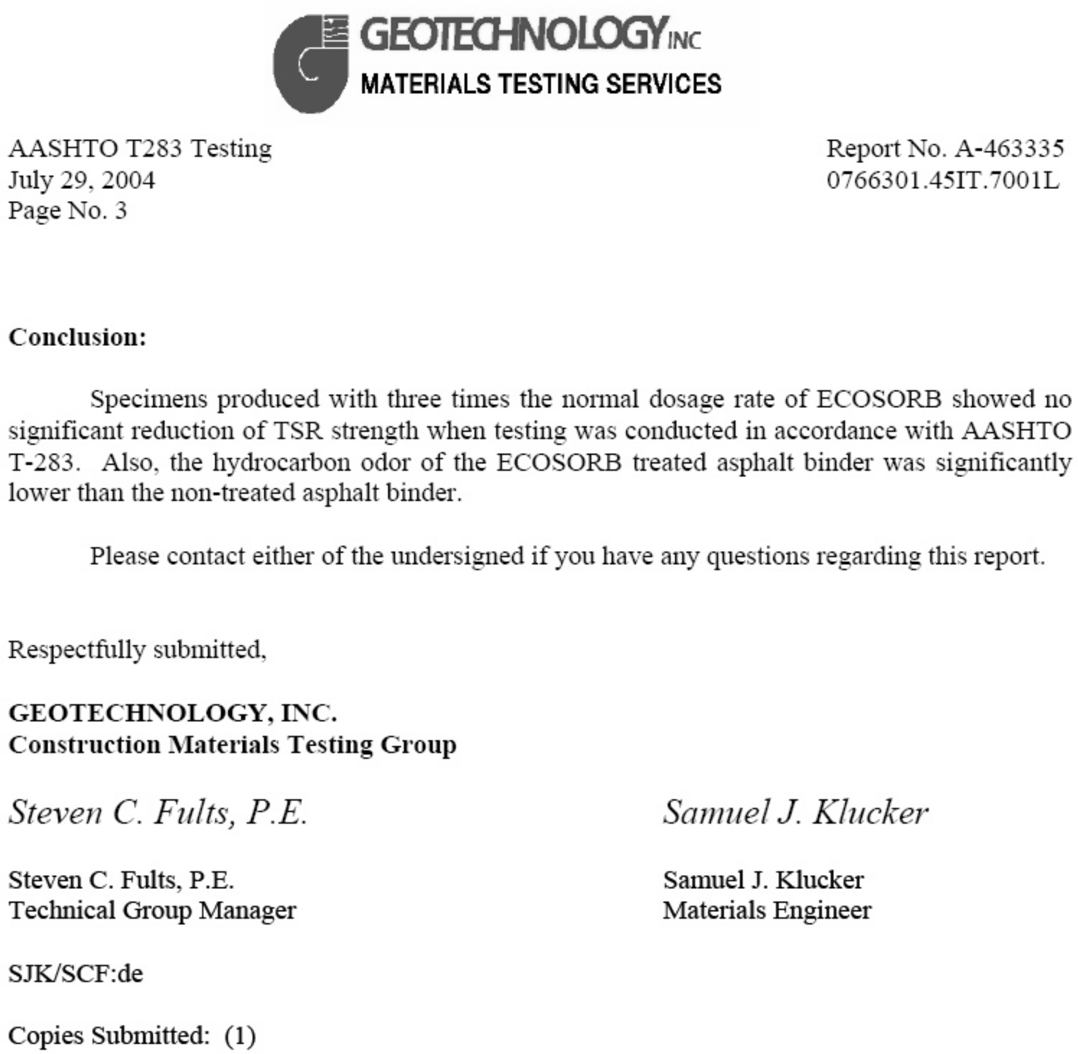
	ECOSORB	Non-ECOSORB	Percent of Non-ECOSORB Strength
Tensile Strength	1,438	1,492	96.4 %

Average Unconditioned Specimen

	ECOSORB	Non-ECOSORB	Percent of Non-ECOSORB Strength
Tensile Strength	1,570	1,591	98.7 %

ECOSORB Tensile Strength Ratio = 91.6

Non-ECOSORB (control) Tensile Strength Ratio = 93.8



GEOTECHNOLOGY INC
MATERIALS TESTING SERVICES

AASHTO T283 Testing
July 29, 2004
Page No. 3

Report No. A-463335
0766301.45IT.7001L

Conclusion:

Specimens produced with three times the normal dosage rate of ECOSORB showed no significant reduction of TSR strength when testing was conducted in accordance with AASHTO T-283. Also, the hydrocarbon odor of the ECOSORB treated asphalt binder was significantly lower than the non-treated asphalt binder.

Please contact either of the undersigned if you have any questions regarding this report.

Respectfully submitted,

GEOTECHNOLOGY, INC.
Construction Materials Testing Group

Steven C. Fults, P.E.

Steven C. Fults, P.E.
Technical Group Manager

Samuel J. Klucker

Samuel J. Klucker
Materials Engineer

SJK/SCF:de

Copies Submitted: (1)

SAFETY DATA SHEETS

- Ecosorb® 206
- Ecosorb® 505
- Ecosorb® 606
- Ecosorb® 806
- Ecosorb® 206A
- Ecosorb® 303A
- Ecosorb® 606A
- Ecosorb® 806A
- Ecosorb® 1200A
- Ecosorb® Gel
- Ecosorb® SprayGel

SAFETY DATA SHEET
ECOSORB® 206

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**ECOSORB® 206**
APPLICATIONS:	**ODOR NEUTRALIZER CONCENTRATE**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, Illinois 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards

ENVIRONMENTAL: Acute Aquatic Toxicity – No acute toxicity
Bioaccumulation Potential – Not expected to bioaccumulate
Rapid Degradability – Rapidly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

ADDITIONAL INFORMATION:

Product is a proprietary blend of essential oils, surfactant, and water. Product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200). Product has been tested for toxicity according to the USEPA Guidelines.
Acute Oral Toxicity per EPA OPPTS 870.1100: Not toxic by oral ingestion
Acute Dermal Toxicity per EPA OPPTS 870.1200: Not toxic by dermal absorption
Acute Inhalation Toxicity per EPA OPPTS 870.1300: Not toxic by inhalation exposure
Primary Eye Irritation Study per EPA OPPTS 870.2400: Product is not an eye irritant
Primal Skin Irritation Study per EPA OPPTS 870.2500: Product is not a skin irritant
Dermal Sensitization Study per EPA OPPTS 870.2600: Product is not a skin sensitizing agent

All Ingredients are on the TSCA Chemical Substance Inventory, Australian AICS, Canadian DSL, Japanese ENCS, and Korean ECL.

European Inventory Status:
EINECS: Existing components according to the definition in the 7th Amendment to Directive 67/548/EEC. All starting materials (ingredients) and final components and additives of product Ecosorb® 206 are listed in EINECS.

WHMIS – Compound is not classified as controlled. Ecosorb® 206 is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	CAS No.:	Weight %:
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		1-20%

4. FIRST AID MEASURES:

INHALATION:	None
INGESTION:	Do not induce vomiting. Position to avoid aspiration should vomiting occur. Drink several glasses of water. Call a physician or poison control center if symptoms persist.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: None

SUITABLE EXTINGUISHING MEDIA: This material is not flammable. Use extinguishing media for surrounding fire.

SPECIAL FIRE FIGHTING PROCEDURES: None

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat or drink while cleaning up. Wearing eye protection and protective gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Flush to drain with large quantities of water. Always follow state, local and federal regulations.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area between 40˚F (4˚C) and 85˚F (29˚C). Allowing product to freeze is likely to cause layering. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: None required

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Milky white / opaque white.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	~5.9-6.8
FREEZE POINT:	~32°F
INITIAL BOILING POINT:	~209°F
FLASH POINT:	None
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	0.99
SOLUBILITY:	Soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Greater than 5000 mg/kg acute oral
TOXIC CONC. - LC50:	Unknown
INHALATION:	No effects on acute inhalation.
INGESTION:	No effects on acute ingestion at 5000 mg/kg bodyweight.
SKIN:	No effects on acute dermal at 5000 mg/kg bodyweight.
EYES:	Contact with eyes may result in mild irritation.

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Being organic the material should be able to biodegrade.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Non-toxic to marine life.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices. Drain with excess amounts of water.

14. TRANSPORT INFORMATION:

UN NUMBER:	Not applicable; not hazardous
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY:	N/A
RISK PHRASES:	N/A
SAFETY PHRASES:	N/A
EU DIRECTIVES:	None known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB® 505

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**ECOSORB® 505**
APPLICATIONS:	**ODOR NEUTRALIZER**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, Illinois 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not Classified by GHS standards

ENVIRONMENTAL: Acute Aquatic Toxicity – No acute toxicity
Bioaccumulation Potential – Not expected to bioaccumulate
Rapid Degradability – Rapidly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: No physical hazards by GHS standards.

ADDITIONAL INFORMATION:

Product is a proprietary blend of essential oils, surfactant, and water. Product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200). Product has been tested for toxicity according to the USEPA Guidelines.
Acute Oral Toxicity per EPA OPPTS 870.1100: Not toxic by oral ingestion
Acute Dermal Toxicity per EPA OPPTS 870.1200: Not toxic by dermal absorption
Acute Inhalation Toxicity per EPA OPPTS 870.1300: Not toxic by inhalation exposure
Primary Eye Irritation Study per EPA OPPTS 870.2400: Product is not an eye irritant
Primal Skin Irritation Study per EPA OPPTS 870.2500: Product is not a skin irritant
Dermal Sensitization Study per EPA OPPTS 870.2600: Product is not a skin sensitizing agent

All Ingredients are on the TSCA Chemical Substance Inventory, Australian AICS, Canadian DSL, Japanese ENCS, and Korean ECL.

European Inventory Status:
EINECS: Existing components according to the definition in the 7th Amendment to Directive 67/548/EEC. All starting materials (ingredients) and final components and additives of product Ecosorb 505 are listed in EINECS.

WHMIS – Compound is not classified as controlled. Ecosorb® 505 is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		0.1-15%

4. FIRST AID MEASURES:

INHALATION: None

INGESTION: Do not induce vomiting. Position to avoid aspiration should vomiting occur. Drink several glasses of water. Call a physician or poison control center if symptoms persist.

SKIN: Remove contaminated clothing and flush the skin with plenty of water and soap.

EYES: Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: None

SUITABLE EXTINGUISHING MEDIA: This material is not flammable. Use extinguishing media for surrounding fire.

SPECIAL FIRE FIGHTING PROCEDURES: None

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat or drink while cleaning up. Wearing eye protection and protective gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Flush to drain with large quantities of water. Always follow state, local and federal regulations.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area between 40˚F (4˚C) and 85˚F (29˚C). Allowing product to freeze is likely to cause layering. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: None required

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Milky white / opaque white.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	~5.9-6.8
FREEZE POINT:	~32°F
INITIAL BOILING POINT:	~209°F
FLASH POINT:	None
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	0.99
SOLUBILITY:	Soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Greater than 5000 mg/kg acute oral
TOXIC CONC. - LC50:	Unknown
INHALATION:	No effects on acute inhalation.
INGESTION:	No effects on acute ingestion at 5000 mg/kg bodyweight.
SKIN:	No effects on acute dermal at 5000 mg/kg bodyweight.
EYES:	Contact with eyes may result in mild irritation.

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: This product is biodegradable by GHS standards.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Non-toxic to marine life.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices. Drain with excess amounts of water.

14. TRANSPORT INFORMATION:

UN NUMBER:	Not applicable; not hazardous
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY:	N/A
RISK PHRASES:	N/A
SAFETY PHRASES:	N/A
EU DIRECTIVES:	None known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB® 606

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**ECOSORB® 606**
APPLICATIONS:	**ODOR NEUTRALIZER**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, Illinois 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards

ENVIRONMENTAL: Acute Aquatic Toxicity – No acute toxicity
Bioaccumulation Potential – Not expected to bioaccumulate
Rapid Degradability – Rapidly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

ADDITIONAL INFORMATION:

Product is a proprietary blend of essential oils, surfactant, and water. Product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200). Product has been tested for toxicity according to the USEPA Guidelines.
Acute Oral Toxicity per EPA OPPTS 870.1100: Not toxic by oral ingestion
Acute Dermal Toxicity per EPA OPPTS 870.1200: Not toxic by dermal absorption
Acute Inhalation Toxicity per EPA OPPTS 870.1300: Not toxic by inhalation exposure
Primary Eye Irritation Study per EPA OPPTS 870.2400: Product is not an eye irritant
Primal Skin Irritation Study per EPA OPPTS 870.2500: Product is not a skin irritant
Dermal Sensitization Study per EPA OPPTS 870.2600: Product is not a skin sensitizing agent

All Ingredients are on the TSCA Chemical Substance Inventory, Australian AICS, Canadian DSL, Japanese ENCS, and Korean ECL.

European Inventory Status:
EINECS: Existing components according to the definition in the 7th Amendment to Directive 67/548/EEC. All starting materials (ingredients) and final components and additives of product Ecosorb 606 are listed in EINECS.

WHMIS – Compound is not classified as controlled. Ecosorb® 606 is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		1-20%

4. FIRST AID MEASURES:

INHALATION:	None
INGESTION:	Do not induce vomiting. Position to avoid aspiration should vomiting occur. Drink several glasses of water. Call a physician or poison control center if symptoms persist.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: None

SUITABLE EXTINGUISHING MEDIA: This material is not flammable. Use extinguishing media for surrounding fire.

SPECIAL FIRE FIGHTING PROCEDURES: None

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat or drink while cleaning up. Wearing eye protection and protective gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Flush to drain with large quantities of water. Always follow state, local and federal regulations.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area between 40˚F (4˚C) and 85˚F (29˚C). Allowing product to freeze is likely to cause layering. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: None required

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Milky white / opaque white.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	~5.9-6.8
FREEZE POINT:	~32°F
INITIAL BOILING POINT:	~209°F
FLASH POINT:	None
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	0.99
SOLUBILITY:	Soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Greater than 5000 mg/kg acute oral
TOXIC CONC. - LC50:	Unknown
INHALATION:	No effects on acute inhalation.
INGESTION:	No effects on acute ingestion at 5000 mg/kg bodyweight.
SKIN:	No effects on acute dermal at 5000 mg/kg bodyweight.
EYES:	Contact with eyes may result in mild irritation.

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: This product is biodegradable by GHS standards.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Non-toxic to marine life.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices. Drain with excess amounts of water.

14. TRANSPORT INFORMATION:

UN NUMBER:	Not applicable; not hazardous
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY:	N/A
RISK PHRASES:	N/A
SAFETY PHRASES:	N/A
EU DIRECTIVES:	None known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB® 806

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**ECOSORB® 806**
APPLICATIONS:	**ODOR NEUTRALIZER**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, Illinois 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards

ENVIRONMENTAL: Acute Aquatic Toxicity – No acute toxicity
Bioaccumulation Potential – Not expected to bioaccumulate
Rapid Degradability – Rapidly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

ADDITIONAL INFORMATION:

Product is a proprietary blend of essential oils, surfactant, and water. Product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200). Ecosorb® 806 is a blend of two Ecosorb products. The two Ecosorb products have been tested for toxicity according to the USEPA Guidelines.
Acute Oral Toxicity per EPA OPPTS 870.1100: Not toxic by oral ingestion
Acute Dermal Toxicity per EPA OPPTS 870.1200: Not toxic by dermal absorption
Acute Inhalation Toxicity per EPA OPPTS 870.1300: Not toxic by inhalation exposure
Primary Eye Irritation Study per EPA OPPTS 870.2400: Product is not an eye irritant
Primal Skin Irritation Study per EPA OPPTS 870.2500: Product is not a skin irritant
Dermal Sensitization Study per EPA OPPTS 870.2600: Product is not a skin sensitizing agent

All Ingredients are on the TSCA Chemical Substance Inventory, Australian AICS, Canadian DSL, Japanese ENCS, and Korean ECL.

European Inventory Status:
EINECS: Existing components according to the definition in the 7th Amendment to Directive 67/548/EEC. All starting materials (ingredients) and final components and additives of product Ecosorb 806 are listed in EINECS.

WHMIS – Compound is not classified as controlled. Ecosorb® 806 is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		1-20%

4. FIRST AID MEASURES:

INHALATION: None

INGESTION: Do not induce vomiting. Position to avoid aspiration should vomiting occur. Drink several glasses of water. Call a physician or poison control center if symptoms persist.

SKIN: Remove contaminated clothing and flush the skin with plenty of water and soap.

EYES: Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: None

SUITABLE EXTINGUISHING MEDIA: This material is not flammable. Use extinguishing media for surrounding fire.

SPECIAL FIRE FIGHTING PROCEDURES: None

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat or drink while cleaning up. Wearing eye protection and protective gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Flush to drain with large quantities of water. Always follow state, local and federal regulations.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area between 40˚F (4˚C) and 85˚F (29˚C). Allowing product to freeze is likely to cause layering. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: None required

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Milky white / opaque white.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	~6.0-6.8
FREEZE POINT:	~32°F
INITIAL BOILING POINT:	~212°F
FLASH POINT:	None
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	0.99
SOLUBILITY:	Soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Greater than 5000 mg/kg acute oral
TOXIC CONC. - LC50:	Unknown
INHALATION:	No effects on acute inhalation at 5.30 mg/L of air for 4 hours.
INGESTION:	No effects
SKIN:	No effects on acute dermal at 2000 mg/kg bodyweight.
EYES:	Contact with eyes may result in mild irritation.

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: This product is biodegradable by GHS standards.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Non-toxic to marine life.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices. Drain with excess amounts of water.

14. TRANSPORT INFORMATION:

UN NUMBER:	Not applicable; not hazardous
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY:	N/A
RISK PHRASES:	N/A
SAFETY PHRASES:	N/A
EU DIRECTIVES:	None known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB 206A

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**ECOSORB® 206A**
APPLICATIONS:	**Non-aqueous Compound Additive**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards.

ENVIRONMENTAL: Acute Aquatic Toxicity – Classification not possible
Bioaccumulation Potential – Should not bioaccumulate
Rapid Degradability – Slightly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

ADDITIONAL INFORMATION:

Keep away from flames and hot surfaces. – No smoking. Keep container tightly closed. Use foam, dry chemical or carbon dioxide for extinction. Store in a well-ventilated place. Dispose of contents in accordance with local/regional/national/international regulations. Do not eat, drink or use tobacco when using this product.

The product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200)

HMIS Classification: Health 0; Flammability 1, Reactivity 0, Protective Equipment B

All ingredients can be found listed on the following chemical substance inventories:
European EINECS, United States TSCA, Canadian DSL, and Australian AICS

WHMIS – Compound is not classified as controlled. Ecosorb® 206A is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		1-30%
PROPRIETARY PLANT ORIGIN DILUTANT		50-99%

4. FIRST AID MEASURES:

INHALATION:	If symptoms are experienced, remove source of contamination and move to fresh air. See physician if symptoms persist.
INGESTION:	Drink several glasses of water. Do not induce vomiting. See physician if symptoms persist.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Approximately 330˚F (166˚C) (Open Cup)

SUITABLE EXTINGUISHING MEDIA: Treat as oil fire. Use foam, dry chemicals, carbon dioxide

SPECIAL FIRE FIGHTING PROCEDURES: None, use standard fire fighting procedures.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None known

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat, drink or smoke while cleaning up. Wearing eye protection and gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Collect all material for proper disposal. Where necessary, collect using absorbent media.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area. Store at temperatures between 4˚C and 35˚C. Avoid sparks and flame in storage. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: Recommended with organic cartridges if fumes become irritating

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Clear yellow liquid.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	Not applicable
FREEZE POINT:	Gels at ~3˚C
INITIAL BOILING POINT:	~172°C
FLASH POINT:	166˚C (Open Cup)
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	**~**0.87
SOLUBILITY:	Not soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Unknown
TOXIC CONC. - LC50:	Unknown
INHALATION:	No known effects
INGESTION:	No known effects
SKIN:	No known effects
EYES:	Contact with eyes may result in irritation

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Being organic the material should be able to biodegrade.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Unknown

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices.

14. TRANSPORT INFORMATION:

UN NUMBER:	Unknown
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous
US DOT CLASSIFICATION:	Class 55

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY: N/A

RISK PHRASES: N/A

SAFETY PHRASES: N/A

EU DIRECTIVES: Non known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB® 303A

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**Ecosorb® 303A**
APPLICATIONS:	**Non-aqueous Compound Additive**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards

ENVIRONMENTAL: Acute Aquatic Toxicity – Classification not possible
Bioaccumulation Potential – Not expected to bioaccumulate
Rapid Degradability – Biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Flammable Liquid – Category 4

GHS LABEL:
SYMBOL: No symbol
SIGNAL WORD: WARNING
HAZARD STATEMENTS: Combustible liquid
PRECAUTIONARY STATEMENTS: Keep away from flames and hot surfaces. – No smoking. Keep container tightly closed. Keep cool. Wear protective gloves/eye protection. Use foam, dry chemical or carbon dioxide for extinction. Store in a well-ventilated place. Dispose of contents in accordance with local/regional/national/international regulations. Do not eat, drink or use tobacco when using this product.

ADDITIONAL INFORMATION:

The product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200)

HMIS Classification: Health 1; Flammability 2, Reactivity 0, Protective Equipment B

All ingredients can be found listed on the following chemical substance inventories:
European EINECS, United States TSCA, Canadian DSL, and Australian AICS

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	CAS No.:	Weight %:
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (Essential Oils)		10-50%
PROPRIETARY PLANT ORIGIN DILUTANT		40-90%

4. FIRST AID MEASURES:

INHALATION: None

INGESTION: Do not induce vomiting. Position to avoid aspiration should vomiting occur. Call a physician or poison control center immediately.

SKIN: Remove contaminated clothing and flush the skin with plenty of water and soap.

EYES: Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Approximately 169 F (76˚C) (Closed Cup)

SUITABLE EXTINGUISHING MEDIA: Treat as oil fire. Use foam, dry chemicals, carbon dioxide

SPECIAL FIRE FIGHTING PROCEDURES: None, use standard fire fighting procedures

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None known

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat, drink or smoke while cleaning up. Wearing eye protection and gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Collect all material for proper disposal. Where necessary, collect using absorbent media.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area. Store at temperatures between 4˚C and 30˚C. Avoid sparks and flame in storage. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	**CAS No.:**	**STD:**	**LT EXP. 8HRS:**	**ST EXP. 15 MIN:**
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: Recommended with organic cartridges if fumes become irritating

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Clear yellow liquid.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	Not applicable
FREEZE POINT:	Gels at ~3˚C
INITIAL BOILING POINT:	~175°C
FLASH POINT:	76˚C (Closed Cup)
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	0.88
SOLUBILITY:	Not soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Unknown
TOXIC CONC. - LC50:	Unknown
INHALATION:	No effects
INGESTION:	No effects
SKIN:	No effects
EYES:	Contact with eyes may result in irritation

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Being organic the material should be able to biodegrade.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Unknown

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices.

14. TRANSPORT INFORMATION:

UN NUMBER: NA1993

GENERAL: This material is classified by DOT as a Class 3 – combustible liquid, N.O.S. (Contains hydrocarbons and terpenes). Packing group 3. Not classified hazardous by IATA and IMO regulations

MARINE POLLUTANT: No

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY: N/A

RISK PHRASES: N/A

SAFETY PHRASES: N/A

EU DIRECTIVES: Non known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB 606A

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**Ecosorb® 606A**
APPLICATIONS:	**Non-aqueous Compound Additive**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards.

ENVIRONMENTAL: Acute Aquatic Toxicity – Classification not possible
Bioaccumulation Potential – Should not bioaccumulate
Rapid Degradability – Slightly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

ADDITIONAL INFORMATION:

Keep away from flames and hot surfaces. – No smoking. Keep container tightly closed. Use foam, dry chemical or carbon dioxide for extinction. Store in a well-ventilated place. Dispose of contents in accordance with local/regional/national/international regulations. Do not eat, drink or use tobacco when using this product.

The product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200)

HMIS Classification: Health 0; Flammability 1, Reactivity 0, Protective Equipment B

All ingredients can be found listed on the following chemical substance inventories:
European EINECS, United States TSCA, Canadian DSL, and Australian AICS

WHMIS – Compound is not classified as controlled. Ecosorb® 606A is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		1-30%
PROPRIETARY PLANT ORIGIN DILUTANT		50-99%

4. FIRST AID MEASURES:

INHALATION:	If symptoms are experienced, remove source of contamination and move to fresh air. See physician if symptoms persist.
INGESTION:	Drink several glasses of water. Do not induce vomiting. See physician if symptoms persist.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Approximately 266˚F (130˚C) (Closed Cup)

SUITABLE EXTINGUISHING MEDIA: Treat as oil fire. Use foam, dry chemicals, carbon dioxide

SPECIAL FIRE FIGHTING PROCEDURES: None, use standard fire fighting procedures.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None known

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat, drink or smoke while cleaning up. Wearing eye protection and gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Collect all material for proper disposal. Where necessary, collect using absorbent media.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area. Store at temperatures between 4˚C and 35˚C. Avoid sparks and flame in storage. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: Recommended with organic cartridges if fumes become irritating

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Clear yellow liquid.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	Not applicable
FREEZE POINT:	Gels at ~3˚C
INITIAL BOILING POINT:	~175°C
FLASH POINT:	130˚C (Closed Cup)
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	~0.88
SOLUBILITY:	Not soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Unknown
TOXIC CONC. - LC50:	Unknown
INHALATION:	No known effects
INGESTION:	No known effects
SKIN:	No known effects
EYES:	Contact with eyes may result in irritation

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Being organic the material should be able to biodegrade.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Unknown

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices.

14. TRANSPORT INFORMATION:

UN NUMBER:	Unknown
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous
US DOT CLASSIFICATION:	Class 55

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY: N/A

RISK PHRASES: N/A

SAFETY PHRASES: N/A

EU DIRECTIVES: Non known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB® 806A

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**Ecosorb® 806A**
APPLICATIONS:	**Non-aqueous Compound Additive**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards.

ENVIRONMENTAL: Acute Aquatic Toxicity – Classification not possible
Bioaccumulation Potential – Should not bioaccumulate
Rapid Degradability – Slightly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

ADDITIONAL INFORMATION:

Keep away from flames and hot surfaces. – No smoking. Keep container tightly closed. Use foam, dry chemical or carbon dioxide for extinction. Store in a well-ventilated place. Dispose of contents in accordance with local/regional/national/international regulations. Do not eat, drink or use tobacco when using this product.

The product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200)

HMIS Classification: Health 0; Flammability 1, Reactivity 0, Protective Equipment B

All ingredients can be found listed on the following chemical substance inventories:
European EINECS, United States TSCA, Canadian DSL, and Australian AICS

WHMIS – Compound is not classified as controlled. Ecosorb® 806A is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		1-30%
PROPRIETARY PLANT ORIGIN DILUTANT		50-99%

4. FIRST AID MEASURES:

INHALATION:	If symptoms are experienced, remove source of contamination and move to fresh air. See physician if symptoms persist.
INGESTION:	Drink several glasses of water. Do not induce vomiting. See physician if symptoms persist.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Approximately 239˚F (115˚C) (Closed Cup)

SUITABLE EXTINGUISHING MEDIA: Treat as oil fire. Use foam, dry chemicals, carbon dioxide

SPECIAL FIRE FIGHTING PROCEDURES: None, use standard fire fighting procedures.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None known

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat, drink or smoke while cleaning up. Wearing eye protection and gloves is recommended.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Collect all material for proper disposal. Where necessary, collect using absorbent media.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area. Store at temperatures between 4˚C and 35˚C. Avoid sparks and flame in storage. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: Recommended with organic cartridges if fumes become irritating

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Clear yellow liquid.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	Not applicable
FREEZE POINT:	Gels at ~3˚C
INITIAL BOILING POINT:	~177°C
FLASH POINT:	115˚C (Closed Cup)
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	~0.88
SOLUBILITY:	Not soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Unknown
TOXIC CONC. - LC50:	Unknown
INHALATION:	No known effects
INGESTION:	No known effects
SKIN:	No known effects
EYES:	Contact with eyes may result in irritation

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Being organic the material should be able to biodegrade.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Unknown

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices.

14. TRANSPORT INFORMATION:

UN NUMBER:	Unknown
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous
US DOT CLASSIFICATION:	Class 55

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY: N/A

RISK PHRASES: N/A

SAFETY PHRASES: N/A

EU DIRECTIVES: Non known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB 1200A

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**Ecosorb® 1200A**
APPLICATIONS:	**Non-aqueous Compound Additive**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:
HEALTH: Not Classified.
ENVIRONMENTAL: Classification not possible.
PHYSICAL: Not Classified.

ADDITIONAL INFORMATION:

Wear protective gloves/eye protection. Use foam, dry chemical or carbon dioxide for extinction. Dispose of contents in accordance with local/regional/national/international regulations. Do not eat, drink or use tobacco when using this product.

The product is not considered hazardous according to the Federal Hazard Communication Standard (29 CFR 1910.1200)

HMIS Classification: Health 1; Flammability 1, Reactivity 0, Protective Equipment B

All ingredients can be found listed on the following chemical substance inventories:
European EINECS, United States TSCA, Canadian DSL, and Australian AICS

WHMIS – Compound is not classified as controlled. ECOSORB® 1200A is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS		1-30%
PROPRIETARY BLEND (Trade Secret) MINERAL SALTS AND PLANT ORIGIN DILUTANT		Balance

4. FIRST AID MEASURES:

INHALATION:	None
INGESTION:	If swallowed, induce vomiting immediately. Position to avoid aspiration. Call a physician or poison control center immediately.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Approximately 316˚F (158˚C) (Open Cup)

SUITABLE EXTINGUISHING MEDIA: Treat as oil fire. Use foam, dry chemicals, carbon dioxide.

SPECIAL FIRE FIGHTING PROCEDURES: None, use standard fire fighting procedures.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None known

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat, drink or smoke while cleaning up. Wearing eye protection and impervious gloves.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: Contain any spills with absorbents to prevent migration and entry into sewers and streams.

SPILL CLEANUP METHODS: Collect all material for proper disposal according to local regulations. Take up small spills with dry chemical absorbent. Large spills may be taken up with pump or vacuum.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wear eye protection and protective gloves. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Store in a tightly closed container in a cool and dry area. Store at temperatures between 4˚C and 30˚C. Avoid sparks and flame in storage. Not compatible with oxidizing agents.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: None required, use NIOSH/MSHA approved respirators if necessary

PROTECTIVE GLOVES: Use impervious gloves

EYE PROTECTION: Use safety glasses or goggles.

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Liquid.
COLOR:	Clear yellow liquid.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	Not applicable
FREEZE POINT:	Gels at ~3˚C
INITIAL BOILING POINT:	~220°C
FLASH POINT:	158˚C (Open Cup)
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	0.95
SOLUBILITY:	Not soluble in water.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Unknown
TOXIC CONC. - LC50:	Unknown
INHALATION:	No effects
INGESTION:	Not expected to be a primary route of exposure
SKIN:	Contact with skin may result in irritation
EYES:	Contact with eyes may result in irritation

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Being organic the material should be able to biodegrade.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Unknown

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices.

14. TRANSPORT INFORMATION:

UN NUMBER: Not applicable; not hazardous

GENERAL: Non-hazardous

MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous
US DOT CLASSIFICATION:	Class 55

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY: N/A

RISK PHRASES: N/A

SAFETY PHRASES: N/A

EU DIRECTIVES: Non known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB® GEL

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**ECOSORB® GEL**
APPLICATIONS:	**ODOR NEUTRALIZER**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, Illinois 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards

ENVIRONMENTAL: Acute Aquatic Toxicity – Classification not possible
Bioaccumulation Potential – Unknown
Rapid Degradability – Not rapidly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

ADDITIONAL INFORMATION:

Product is a proprietary blend of copolymer, essential oils, surfactant and water. Product is not considered hazardous according to Federal Hazard Communication Standard (29 CFR 1910.1200). Do not eat, drink or use tobacco when using this product.

All Ingredients are on the TSCA Chemical Substance Inventory, Australian AICS, Canadian DSL, Japanese ENCS, and Korean ECL.

European Inventory Status:
EINECS: Existing components according to the definition in the 7th Amendment to Directive 67/548/EEC. All starting materials (ingredients) and final components and additives of product Ecosorb® Gel are listed in EINECS.

HMIS Classification: Health 0; Flammability 0; Reactivity 0; Protective Equipment B.

WHMIS – Compound is not classified as controlled. Ecosorb® Gel is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	CAS No.:	Weight %:
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		0.1-10%
Acrylamide/Potassium Acrylate Copolymer, Crosslinked	CAS 31212-13-2	0.1-10%

4. FIRST AID MEASURES:

INHALATION:	None
INGESTION:	Drink several glasses of water, see physician if symptoms persist. May cause discomfort and diarrhea.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: None

SUITABLE EXTINGUISHING MEDIA: This material is not flammable. Use extinguishing media for surrounding fire.

SPECIAL FIRE FIGHTING PROCEDURES: None

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat or drink while cleaning up.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Collect with absorbent materials and dispose of according to local regulations.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Allowing product to freeze is likely to cause layering. Recommended to store between 40˚F (4˚C) and 85˚F (29˚C).

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: None required

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Semi-liquid/semi-solid slurry.
COLOR:	Milky white / opaque white.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	~5.9-6.8 (liquid component)
FREEZE POINT:	~32°F
INITIAL BOILING POINT:	~209°F(liquid component)
FLASH POINT:	None
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	0.96
SOLUBILITY:	Not readily soluble.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Unknown
TOXIC CONC. - LC50:	Unknown
INHALATION:	No known effects
INGESTION:	Large amounts may cause diarrhea. Gel is not digestible.
SKIN:	No known effects
EYES:	Contact with eyes may result in mild irritation.

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Material is able to biodegrade or otherwise decompose environmentally.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Non-toxic to marine life.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose of according to federal, state, and/or local requirements. Product is not known to be classified as a hazardous waste or material. It may be disposed of as an industrial waste in a manner acceptable to good waste management practices

14. TRANSPORT INFORMATION:

UN NUMBER:	Not applicable; not hazardous
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY:	N/A
RISK PHRASES:	N/A
SAFETY PHRASES:	N/A
EU DIRECTIVES:	None known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.

ECOSORB® is a registered trademark of OMI Industries

SAFETY DATA SHEET
ECOSORB® SPRAY GEL

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY:

PRODUCT NAME:	**ECOSORB® SPRAY GEL**
APPLICATIONS:	**ODOR NEUTRALIZER**
SUPPLIER:	**OMI Industries** **One Corporate Drive, Suite 100** **Long Grove, Illinois 60047** **USA**
TELEPHONE No.:	**(847) 304 9111**
EMERGENCY TELEPHONE No.:	**(800) 662 6367**

2. HAZARDS IDENTIFICATION:

GHS CLASSIFICATIONS:

HEALTH: Not classified by GHS standards

ENVIRONMENTAL: Acute Aquatic Toxicity – Classification not possible
Bioaccumulation Potential – Unknown
Rapid Degradability – Not rapidly biodegradable
Chronic Aquatic Toxicity – Classification not possible

PHYSICAL: Not classified by GHS standards.

GHS LABEL:

PRECAUTIONARY STATEMENTS: Do not eat, drink or use tobacco when using this product.

ADDITIONAL INFORMATION:

Product is a proprietary blend of copolymer, essential oils, surfactant and water. Product is not considered hazardous according to Federal Hazard Communication Standard (29 CFR 1910.1200).

All Ingredients are on the TSCA Chemical Substance Inventory, Australian AICS, Canadian DSL, Japanese ENCS, and Korean ECL.

European Inventory Status:
EINECS: Existing components according to the definition in the 7th Amendment to Directive 67/548/EEC. All starting materials (ingredients) and final components and additives of product ECOSORB® SPRAY GEL are listed in EINECS.

HMIS Classification: Health 0; Flammability 0; Reactivity 0; Protective Equipment B.

WHMIS – Compound is not classified as controlled. ECOSORB® SPRAY GEL is not a controlled product in Canada.

3. COMPOSITION/INFORMATION ON INGREDIENTS:

INGREDIENT NAME:	**CAS No.:**	**Weight %:**
PROPRIETARY BLEND (Trade Secret) OF PLANT EXTRACTS (ESSENTIAL OILS)		0.1-10%
Acrylamide/Potassium Acrylate Copolymer, Crosslinked	CAS 31212-13-2	0.1-10%

4. FIRST AID MEASURES:

INHALATION:	None
INGESTION:	Drink several glasses of water, see physician if symptoms persist. May cause discomfort and diarrhea.
SKIN:	Remove contaminated clothing and flush the skin with plenty of water and soap.
EYES:	Flush eyes immediately with plenty of water for 15 minutes.

5. FIRE FIGHTING MEASURES:

FLASH POINT: None

SUITABLE EXTINGUISHING MEDIA: This material is not flammable. Use extinguishing media for surrounding fire.

SPECIAL FIRE FIGHTING PROCEDURES: None

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

HAZARDOUS DECOMP. PRODUCTS: None

6. ACCIDENTAL RELEASE MEASURES:

PERSONAL PRECAUTION IN SPILL: Do not eat or drink while cleaning up.

PRECAUTIONS TO PROTECT THE ENVIRONMENT: None required.

SPILL CLEANUP METHODS: Collect with absorbent materials and dispose of according to local regulations.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Wearing eye protection and protective gloves is recommended. Use good personal hygiene practices. Wash hands before eating, drinking or smoking.

CONDITIONS FOR SAFE STORAGE, INCLUDING INCOMPATIBILITIES: Allowing product to freeze is likely to cause layering. Recommended to store between 40˚F (4˚C) and 85˚F (29˚C).

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION:

INGREDIENT NAME:	CAS No.:	STD:	LT EXP. 8HRS:	ST EXP. 15 MIN:
ESSENTIAL OIL BLENDS			Not Established	Not Established

INGREDIENT COMMENTS: Essential oils are naturally occurring.

PROTECTIVE EQUIPMENT: None required

PROCESS CONDITIONS: None

VENTILATION: Adequate ventilation

RESPIRATORS: None required

PROTECTIVE GLOVES: Recommended

EYE PROTECTION: Recommended

OTHER PROTECTION: None required

HYGIENIC WORK ROUTINES: Wash with soap and water before eating, drinking and smoking.

9. PHYSICAL AND CHEMICAL PROPERTIES:

PHYSICAL STATE:	Semi-liquid/semi-solid slurry.
COLOR:	Milky white / opaque white.
ODOR:	Slight citrus or floral odour.
pH-VALUE:	~5.9-6.8 (liquid component)
FREEZE POINT:	~32°F
INITIAL BOILING POINT:	~209°F (liquid component)
FLASH POINT:	None
EVAPORATION RATE:	Not available.
RELATIVE DENSITY:	~0.99
SOLUBILITY:	Not readily soluble.

10. STABILITY AND REACTIVITY:

STABILITY/INCOMPATIBILITY: Incompatible with strong oxidizing agents.

HAZARDOUS REACTIONS/DECOMPSITION PRODUCTS: None known

11. TOXICOLOGICAL INFORMATION:

TOXIC DOSE - LD 50:	Unknown
TOXIC CONC. - LC50:	Unknown
INHALATION:	No effects
INGESTION:	Large amounts may cause diarrhea. Gel is not digestible.
SKIN:	No effects
EYES:	Contact with eyes may result in mild irritation.

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Unknown

PRESISTENCE AND DEGRADABILITY: Material is able to biodegrade or otherwise decompose environmentally.

BIOACCUMULATION POTENTIAL: Unknown

ACUTE FISH TOXICITY: Non-toxic to marine life.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHODS: Dispose to landfill according to Local, State and Federal regulations.

14. TRANSPORT INFORMATION:

UN NUMBER:	Not applicable; not hazardous
GENERAL:	NMFC Code 48580-3
MARINE POLLUTANT:	No
AIR TRANSPORT:	Non-hazardous

15. REGULATORY INFORMATION:

LABEL FOR SUPPLY: N/A

RISK PHRASES: N/A

SAFETY PHRASES: N/A

EU DIRECTIVES: None known

16. OTHER INFORMATION:

DISCLAIMER: The information contained herein is accurate to the best of our knowledge. OMI Industries makes no warranty of any kind, express or implied, concerning the safe use of this material in your process or in combination with other substances.