Draft Technical Memorandum

TO:	Dennis Pearson, Fluid Motion
FROM:	Eri Ottersburg and Jolaine Johnson
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RE:	**Best Available Control Technology Analysis** **Fluid Motion, LLC Manufacturing Facility** **Monroe, Washington** **LAI Project No. 1787002.010**

Introduction

Fluid Motion, LLC (FML) has proposed changes at its boat manufacturing facility (facility) located in Monroe, Washington that required a Notice of Construction (NOC) application submission to the Puget Sound Clean Air Agency (PSCAA). FML has proposed to increase production. Upon review of the NOC application, PSCAA requested a top-down evaluation of Best Available Control Technology (BACT) for emissions of particulate matter, volatile organic compounds (VOCs), hazardous air pollutants, and odorous compounds, specifically for styrene and methyl methacrylate (MMA).

At the request of FML, Landau Associates, Inc. (LAI) prepared this technical memorandum, which presents the revised emissions inventory for FML's Monroe operations. This memorandum also describes the methods used to conduct the BACT analysis and the findings of the BACT analysis.

Facility Description

FML manufactures fiberglass boats at its facility located at 17341 Tye Street SE in Monroe, Washington. Approval Order No. 10220 was issued by PSCAA in 2010 for the construction and operation of the facility. In September 2018, FML submitted an NOC application (NOC 11660) for its plans to increase production at the facility.

Emission Sources

FML manufactures large fiberglass boats in batch operations at its Monroe facility. VOC emissions are generated by the evaporation of polyester or vinyl ester plastic resins and gel coats during application and curing. The primary VOC from resins and gel coats is styrene. Gel coats also contain MMA. Other pollutants in various products used at the facility include, methyl ethyl ketone, n-hexane, xylene, toluene, cyclohexane, ethylbenzene, benzene, and dimethyl ether.

Revised Emissions Inventory

In the interest of reducing potential emissions of contaminants that are regulated as hazardous air pollutants (HAPs) and toxic air pollutants (TAPs), FML has replaced some of the products used in the manufacturing process. An inventory of potential emissions has been developed based upon the products currently in use and to refine previous estimates of total VOC emissions.

The emissions inventory is based on the maximum amount of products that will be used in each part of the manufacturing process at the facility and the maximum content of VOCs, TAPs, and HAPs in each product type. Emissions of styrene and MMA from process applications of gel coats, resins, and putty are based on emissions factors presented in the Unified Emission Factors for Open Molding of Composites (ANSI/ACMA 2011). For all other operations, maximum potential emissions estimates are based on the conservative assumption that all of the VOCs, TAPs, or HAPs contained in the product will be released during the operation.

When volatile materials are atomized for application in fiberglass manufacturing operations, particulate matter (PM) emissions may be generated. The original emissions inventory for the FML operations assumed that mechanical atomized application techniques would be used to apply these materials. When mechanical non-atomizing catalyzed resin application techniques are used, PM emissions are assumed to be zero.[1] FML's Monroe operations use mechanical non-atomized resin application techniques, so the PM emissions are assumed to be negligible for these operations.

Table 1 below presents a summary of potential emissions of VOCs, TAPs, and HAPs for each process operation.

Table 1: Potential Air Emissions from Fluid Motion's Boat Manufacturing Operations in Monroe, Washington

		Air Contaminant Emissions (tons/year)			
Product Used	**Amount Used (tons/year)**	**Styrene**	**MMA**	**Other HAPs/TAPs**	**Total VOCs**
Gel Coat	32	3.44	0.72	0	4.16
Polyester Resin	133	5.12	0	0	5.12
Vinyl Resin	15	0.58	0	0	0.58
Radius Putty	17	0.65	0	0	0.65
Initiator	4	0	0	0.20	0.20
Mold Release	0.01	0	0	0.012	0.010
Wood Stain	0.2	0	0	0.12	0.11
Spray Adhesive	0.3	0	0	0.12	0.12
Total Emissions (tons/year)		9.78	0.72	0.45	10.9

HAP = hazardous air pollutant
MMA = methyl methacrylate
TAP = toxic air pollutant
VOC = volatile organic compound

A detailed worksheet for potential emissions is provided in Attachment 1.

[1] Clean Air Engineering Project No. 7735: Test Report July 11, 1996. Summary of PM/PM_{10} Emission Testing Conducted at US Marines Pipestone III Facility.

Future actual emissions for facility-wide manufacturing operations will be the same as potential emissions.

General Approach for BACT Assessment

BACT is applied to new or modified stationary sources for each air pollutant subject to regulation under Chapter 70.94 of the Revised Code of Washington. BACT is an emission limitation based on the maximum degree of reduction that can be feasibly achieved for each air pollutant emitted from any new or modified stationary source. This section describes the approach taken for evaluation of BACT for VOCs, HAPs and odorous compounds from FML's Monroe manufacturing facility.

EPA Top-Down BACT Evaluation Approach

PSCAA has requested a full BACT evaluation using a "top-down" approach as described in the US Environmental Protection Agency's (EPA's) draft New Source Review Workshop Manual: Prevention of Significant Deterioration and Non-Attainment Area Permitting (EPA 1990). The following five steps make up the top-down process:

- The first step in the top-down analysis is to identify all available control technologies that can be practicably applied for each emission unit.
- The second step is to determine the technical feasibility of potential control options and to eliminate options that are demonstrated to be technically infeasible.
- The third step is to rank all remaining options based on control effectiveness, with the most effective control alternative at the top.
- The fourth step is to evaluate the remaining control alternatives. If the top-ranked control alternative is considered unacceptable based on disproportionate economic, environmental, and/or energy impacts, it is discarded. Justifications for discarding top-ranked control options must be approved by the permitting authority.
- The fifth and final step is to choose the top-ranked alternative from the list of control options remaining after applying Steps 1 through 4. This option is then established as BACT and the maximum resulting emission rate becomes the emission limitation.

Reference Materials for BACT Evaluation

The following resources were referenced to determine possible control technologies, technical feasibility, and control effectiveness:

- PSCAA's NOC Worksheet for NOC Approval Order No. 10761
- PSCAA's NOC Worksheet for NOC Approval Order No. 10220.
- Control Techniques Guidelines for Fiberglass Boat Manufacturing Materials (EPA 2008)
- EPA's Assessment of Styrene Emission Controls for FRP/C and Boat Building Industries (Kong et al. 1996a, b)

- EPA's Reasonably Available Control Technology (RACT)/BACT/Lowest Achievable Emission Rate (LAER) Clearinghouse (RBLC) (EPA; accessed April 8, 2019)
- State guidance and databases
  - Bay Area Air Quality Management District (AQMD)
  - South Coast AQMD
  - San Diego Air Pollution Control District (APCD)
  - San Joaquin APCD
  - Sacramento Metropolitan AQMD
  - Texas Commission on Environmental Quality (TCEQ).

BACT for Volatile Organic Compounds and Hazardous Air Pollutants

BACT evaluations are largely based on the calculation of annualized cost per ton of pollutant reduced for each technically feasible control option. As presented in the Revised Emissions Inventory section above, total potential VOCs from the facility's manufacturing operations are conservatively estimated at 11.1 tons/year. Total potential HAPs emissions are estimated at 10.9 tons/year. All of the HAPs emitted are also VOCs. It is presumed that controls that are effective for VOC reductions will be similarly effective in the reduction of HAPs emissions.

BACT for Odorous Compounds

Two odorous compounds emitted from the facility are styrene and MMA. Odor threshold values are concentrations at which half of a population of observers would not be able to detect the odor. Half of a population may still perceive the odor at and below the odor thresholds. Perception of odor is considered a logarithmic function, resulting in a need for substantial reductions of styrene and MMA to reduce odor to a point where it is unlikely for anyone to detect the odor.

Odor impacts are not expected due to operations at the Monroe facility. The neighborhood is an industrial area and the closest residential housing is a quarter mile away from the Monroe facility. FML is not aware of any complaints regarding odor from its operations at its Monroe facility.

According to PSCAA's Worksheet for Approval Order No. 10220, previous emissions at the Monroe site from a previous boat manufacturing operation were 17 tons per year of styrene, which is nearly double the current proposed emissions. The PSCAA Worksheet noted that during inspections of the past operations, sometimes styrene odor was detected outside the facility, but the facility did not have a history of odor complaints.

As with the previous operations at the Monroe facilities, odor may be detected for short periods, but there is not expected to be a chronic odor issue as a result of the project. The proposed FML operations will not likely generate odor complaints, impact residential areas, or be an ongoing problem.

Styrene and MMA are also regulated VOCs as well as HAPs and TAPs. Therefore, the BACT evaluations for reduction in emissions of these substances as odorous compounds will be considered in the BACT evaluation for VOCs. Additional technologies focused on odor control from fiberglass operations have also been considered in the odor BACT evaluation as described below.

BACT Evaluation for Volatile Organic Compounds, Hazardous Air Pollutants, and Toxic Air Pollutants

The emission rates and exhaust stream characteristics used for the BACT evaluations are provided in Table 2 below.

Table 2: Emissions and Exhaust Parameters for Facility BACT Evaluation

Variable	Value
Emissions	
VOCs	10.9 tpy
HAPs	10.6 tpy
TAPs	10.9 tpy
Odor Compounds (Styrene and MMA)	10.5 tpy
Exhaust Flow	30,000 acfm
Exhaust Temperature	65°F
Hours of Operation	2,030 hr/yr

°F = degrees Fahrenheit
acfm = actual cubic feet per minute
hr/yr = hours per year
tpy = tons per year

Step 1: Identify Available Control Technologies

General approaches to control of VOC emissions from fiberglass manufacturing and coating operations are substitute materials; alternative application techniques; and add-on controls.

Substitute Materials

Vapor-Suppressed Resins and Gel Coats

Vapor-suppressed resins and gel coats use an additive, typically wax, that suppress vaporization of VOCs. As material cures, the wax additive rises to the surface of the resin or gel coat material and inhibits the vaporization of styrene and MMA. This can reduce emissions from resins by as much as 40 percent. Emission reductions for gel coats are not known, but are expected to be in a similar range. Vapor-suppressed resins or gel coats can be used only in limited applications and are not ideal for large and complex structures or assemblies. Wax film must be removed before parts can be bonded, increasing labor, and the ultimate structural integrity of the bonds is reduced.

Low-Monomer Resins and Gel Coats

Low-monomer resins and gel coats, also known as low-VOC resins and gel coats, contain reduced concentrations of styrene and MMA. The use of low-monomer materials decreases the amount of VOCs available to be emitted (EPA 2008). Therefore, low-monomer resins and gel coats can significantly reduce VOC emissions without other changes in equipment or work practices.

Alternative Application Techniques

Non-Atomizing Resin Application

Non-atomizing resin application techniques include the following:

- Bucket and brush – Individual batches of resin are mixed with catalyst in a bucket or pail and applied by hand using a brush or paint roller. This method is feasible only for low volume production.
- Pressure-fed resin rollers – Similar to bucket and brush application, resin is applied by hand using a roller; however, the roller is fed a continuous supply of resin from a mechanical fluid pump. Resin rollers must operate almost continuously to prevent the resin from hardening between the mixer and roller cover.
- Flow coaters – Similar to spraying, but the resin leaves the flow coater in a stream rather than an atomized spray. Like pressure-fed rollers, flow coaters must be operated continuously to prevent hardening inside the applicator.
- Fabric impregnators – Dry fiberglass fabric is fed through resin-covered rollers. Resins can be manually mixed and added to the machine or fed to the machine by fluid pumps.
- Fluid impingement technology – Similar to spraying and flow coating, a gun dispenses two streams of resin that form a fan of large droplets. The larger droplet size minimizes emissions compared to atomized spray application.

Alternative Atomized Spray Application Techniques

Alternative spray techniques include the following:

- Airless spray – This atomizing spray technique uses high pressures to coat materials. It can be used to coat large areas but requires the use of different nozzles for different spray patterns. With proper operation and nozzle maintenance, it can have a transfer efficiency between 65 and 70 percent (IDNR 1998).
- Air-assisted airless spray – This atomizing spray technique use lower pressures than airless spray. This technique can be used to coat large areas, but has a higher initial capital cost and requires more maintenance and operator training than airless spray. With proper operation and nozzle maintenance, this technique can have a high transfer efficiency.

- High-volume low-pressure spray – This atomizing spray technique uses low pressures and transfers high volumes. With proper operation and nozzle maintenance, this technique has increased transfer efficiency and reduced overspray.

Closed Molding

Closed molding techniques include vacuum bagging, vacuum-assisted resin transfer molding, resin transfer molding, and compression molding. Closed molding involves enclosing the entire part in a multi-part mold, preventing the resin surfaces from having contact with the air, thereby inhibiting evaporation. Closed molding has been successfully used for making small parts, but cannot be used for large surface areas or for gel coat operations, which are the source of MMA emissions.

Add-On Controls

Add-on controls to reduce VOC emissions include thermal and catalytic oxidizers, adsorption, and condensers. In 2008, the EPA did not identify any facilities in the fiberglass boat manufacturing industry using add-on controls to reduce VOC emissions. However, add-on controls have since been applied at several large fiberglass manufacturing facilities in California.

Thermal Oxidizer

A thermal oxidizer (TO), also known as a thermal incinerator, destroys VOCs through incineration. Supplemental fuel and air are added to maintain a flame that heats the waste gas to its ignition temperature. The appropriate reactor temperature and residence time depends on the level of VOC control desired and the composition of the waste gas. Several types of TOs exist: direct flame, recuperative, and regenerative. While direct flame TOs have only a combustion chamber, recuperative and regenerative types have systems to improve energy efficiency and/or energy recovery. TO controls are used most frequently when heat from the manufacturing process can be used to preheat the gases and reduce fuel use. Recuperative or regenerative type TOs are not technically feasible for batch operations.

Catalytic Oxidizer

A catalytic oxidizer, also known as a catalytic incinerator, is similar to a TO. A catalyst is used in the reaction chamber to enable conversion at lower reaction temperatures than a TO. Air streams containing compounds that poison the catalyst (e.g., chlorine, sulfur, lead, arsenic, and phosphorus), have a low heating value, or have a high particulate content are not recommended for catalytic oxidation because they foul the catalyst. In addition, volumetric flow rates and concentrations of combustibles in the waste gas should be relatively constant.

Adsorption

Adsorption systems provide VOC treatment by adsorbing contaminants onto adsorbent media. These systems are well-suited for air streams with low concentrations of VOCs or low volumetric gas flow rates, VOCs with intermediate molecular weights, low temperatures, and low moisture. Activated carbon is the most common adsorbent used, but alumina, zeolites, and polymers can also be used. Adsorption systems are either once-through or regenerative. The activated carbon can be regenerated using steam (generally for product recovery) or hot flue gas followed by a small oxidizer.

Condensers

Vapor condensers involve cooling the VOC-containing gas to condense the contaminants into liquid form. In many cases, very large temperature drops are required to achieve effective condensation, requiring significant energy investment to accomplish cooling. Condensers have a particular advantage if product recovery is desired.

Flare

A flare controls VOC emission through combustion. A waste VOC stream is piped to the flare and burned in an open flame. Flares can accommodate variable VOC concentrations, flows, heating values, and species contents. However, corrosion of the flare tip can occur with waste gas streams containing high concentrations of halogenated or sulfur compounds. Flares are primarily used in chemical plants and refineries to control releases of large volumes of gas during upset conditions.

Biofiltration

Biofiltration involves passing the off-gas through a wet, biologically active filter bed. When the vapor stream passes through the filter, contaminants are retained for degradation by micro-organisms such as bacteria, heterotrophs, oligotrophs, and fungi. Prior to biofiltration, the waste stream would go through a number of pre-treatment processes to remove particulates, equalize the flow, and adjust the humidity and temperature to maintain the optimum conditions for the micro-organisms. The treatment process generally produces end products of carbon dioxide, water, and mineral salts. Biofiltration can treat a variety of VOCs, but are of particular relevance to the treatment of benzene, toluene, ethylbenzene, and xylene compounds, and low concentrations of VOCs (less than 2,000 parts per million [ppm]). However, achieving reliable removal efficiencies can be problematic due to the variable nature of biological systems. Also, hot exhaust streams will require cooling upstream of the biofilter.

Step 2: Identify Feasible Control Technologies

Substitute Materials

Vapor Suppressed Resins and Gel Coats

As described in PSCAA's NOC Worksheet for Approval Order No. 10761, the wax additive in vapor-suppressed resins and gel coats rises to the surface of the curing material, inhibiting the evaporation of styrene and MMA. A wax film forms on top of the resin or gel coat and must be removed to bond different structural pieces together. The use of vapor-suppressed resins and gel coats lengthens the assembly process, increases labor costs, and compromises structural integrity. Thus, the use of vapor-suppressed resins and gel coats is considered technically infeasible for large or numerous boat fabrication operations.

Low-Monomer Resins and Gel Coats

Low-monomer resins and gel coats, due to reformulation, exhibit greater deficiencies and difficulty of use. Despite deficiencies, low-monomer VOC resins and gel coats can reduce VOC emissions without other changes in equipment or work practices. Low-monomer resins and gel coats are considered technically feasible.

Alternative Application Techniques

Non-Atomizing Resin Application

Non-atomizing resin application techniques include the following:

- Bucket and brush – The use of a bucket and brush for application is appropriate only for small surface areas and low volume production. This method is considered technically infeasible for high volume production.
- Pressure-fed resin rollers and flow coaters – Since resin rollers must operate continuously to prevent resin from hardening between the mixer and roller cover, this method is considered technically infeasible for batch operations.
- Flow coaters – Since flow coaters must operate continuously to prevent from hardening inside the applicator, this method is considered technically infeasible for batch operations.
- Fabric impregnators – Dry fiberglass fabric is fed through resin-covered rollers. Resins can be manually mixed and added to the machine or fed to the machine by fluid pumps. Since fabric impregnators have limited surface area application that is not suitable for manufacturing large boat hulls, this method is considered technically infeasible.
- Fluid impingement technology – Similar to spraying and flow coating, a gun dispenses two streams of resin that form a fan of large droplets. The larger droplet size minimizes emissions compared to atomized spray application. This application technique is considered technically feasible.

Non-atomizing technology is feasible for applying production and tooling resins and putty only.

Closed Molding

As described in PSCAA's NOC Worksheet for NOC Approval Order No. 10761, closed molding techniques are feasible only for small fabrication pieces, and cannot be applied to larger fabrication pieces that use gel coat operations. Therefore, closed molding is not considered technically feasible.

Add-On Controls

Thermal or Catalytic Oxidizer

Both a thermal and catalytic oxidizer require spraying operations to be enclosed and vented to the oxidizer. The effectiveness of VOC control is dependent on the efficiency of the ventilation capture system. Thermal and catalytic oxidizers are considered technically feasible for boat manufacturing operations. However, as described in PSCAA's NOC Worksheet for Approval Order No. 10761, regenerative-type oxidizers are not feasible for batch operations because efficiency gains are lost when the recovery refractory is reheated multiple times.

Adsorption

Adsorption systems, typically carbon, require that spraying operations are enclosed and vented to the adsorption system. The effectiveness of VOC control is dependent on the efficiency of the ventilation capture system and adsorption rate of the VOC constituents. Carbon adsorption has been demonstrated in practice for emissions from fiberglass manufacturing and is considered to be technically feasible. All of these systems (and those used at facilities in California) use adsorption in series with product recovery or oxidation equipment. The adsorber is used to concentrate the waste gas stream such that subsequent oxidation is self-sustaining (little or zero supplemental fuel is needed for combustion).

Condensers

Since condensers require very large temperature drops to achieve effective condensation, the system requires significant energy investment to accomplish cooling. Condensers are considered to be technically infeasible because of the large energy requirements of the system.

Flare

Fiberglass boat manufacturing operations emit low concentrations of VOCs. The expected gas streams would have a low flammability and would require the use of auxiliary fuel in a flare system. Due to this, a thermal or catalytic oxidizer is more appropriate for boat manufacturing operations, and the use of a flare is considered technically infeasible.

Biofiltration

Fiberglass boat manufacturing operations emit low concentrations of VOCs and emit pollutants that can be treated by biofiltration. However, it is difficult to apply this technology to the relatively high volumetric flow rates from FML's facility. According to the EPA's "Assessment of Styrene Emission Controls for FRP/C and Boat Building Industries," a boat manufacturer in Europe applied biofiltration. However, the flow rate of the source was 10,000 actual cubic feet per minute (acfm). Furthermore, buildup of acid byproduct could be the cause of decreased efficiency of this technology for treating styrene emissions over time (Kong et al. 1996b). Use of this technology has not been demonstrated in practice for styrene emissions.

Additional Methods and Technologies for Odor Control

To identify control technologies for odorous compounds from fiberglass manufacturing operations, LAI and FML contacted the National Marine Manufacturers Association (NMMA) for any information regarding odor reductions. John McKnight of NMMA reported that he was not aware of any add-on technologies that effectively reduce styrene odors to levels that are not detectable by everyone. He advised that some operations have attempted to add other chemical substances to disguise the styrene odor, but that too has proven ineffective. In an email dated April 30, 2019, Mr. McKnight indicated that, in his experience, the methods and emission limits established as Maximum Achievable Control Technology (MACT) pursuant to 40 CFR 63 Subpart VVVV – National Emission Standards for Hazardous Air Pollutants for Boat Manufacturing are the best available methods (McKnight 2019).

A web search was conducted for odor control technologies for fiberglass manufacturing operations. A company named Perry Fiberglass Products, Inc. specializes in odor control systems (Perry Fiberglass; accessed May 20, 2019). Technologies provided by this company and a brief discussion of technical feasibility are detailed below.

1. **Air Stripper**

   An air stripper, or degasifier, is not meant to control odorous compounds from the air, but to remove odorous contaminants in water. The odorous water is mixed with air to deodorize the water. The process air, then containing odorous compounds and HAPs (most likely), must be vented to an air emission control unit like an adsorption unit or catalyst. This technology is not appropriate for odor control of air emissions from boat manufacturing operations.

2. **Wet Scrubber**

   A wet-scrubber is primarily used to control inorganic gases (EPA 2003) but has been used for nuisance odor control. Wet scrubbers remove air pollutants through absorption into a liquid solvent. The pollutant to be absorbed must be soluble in the liquid. Packed-bed wet scrubbers consist of a chamber containing layers of packing material. In this chamber, scrubbing liquid is introduced above the packing and flows down through the bed while the gas stream flows up the chamber countercurrent to the liquid. Spray scrubbers consist of a chamber in which the gas stream is contacted with liquid droplets generated by spray nozzles. A wet scrubber is not considered feasible for the purposes of controlling low concentrations of VOCs, which requires impractically tall absorption towers, long contact times, and high liquid-gas ratios. Furthermore, styrene and MMA have low water solubility and more readily volatilize rather than being absorbed into a liquid or solvent.

3. **Biofilter**

   See previous discussion of biofilters for VOC control.

Step 2 Summary

Table 3 summarizes the technical feasibility of the control technologies listed in Step 1 above.

Table 3: Technical Feasibility of VOC Controls for Fiberglass Boat Manufacturing

Technology	Technical Feasibility
Vapor-Suppressed Resins and Gel Coats	The use of vapor-suppressed resins and gel coats are considered to be technically infeasible for use on major portions of the vessel due to bonding and structural integrity concerns.
Low-Monomer Resins and Gel Coats	Feasible.
Non-Atomizing Resin Application	Feasible for applying production and tooling resins only.
Closed Molding	Since closed molding is not possible for gel coat operations, this technique is considered to be technically infeasible.
Thermal Oxidizer	Feasible.
Catalytic Oxidizer	Feasible.
Adsorption	Feasible.
Condenser	The use of a condenser is considered to be technically infeasible because of the amount of temperature drop needed to condense emissions.
Flare	The gas stream has a relatively low heat content and this technology has not been demonstrated to be effective for this type of source. This option is technically infeasible.
Biofiltration	This technology has not been demonstrated in practice for treatment of styrene emissions and high flow rates. This option is technically infeasible.
Air Stripper	Not designed for control of odors from air streams. This option is technically infeasible.
Wet Scrubber	Not effective for low concentration and low solubility VOCs such as styrene. This option is technically infeasible.

Step 3: Rank Effectiveness

The commercially available control technologies identified in Step 2 as feasible for use in fiberglass boat manufacturing are ranked in Table 4 based on their effectiveness in controlling VOCs.

Table 4: Control Effectiveness of VOC Controls

Technology	Control Effectiveness
Thermal Oxidizer	61 - 93%
Adsorption	91%
Catalytic Oxidizer	90%
Non-Atomized Resin Application	41%
Low-Monomer Resins and Gel Coats	Case-by-case

Step 4: Evaluate Remaining Controls

The controls listed in Table 4 above were evaluated for economic feasibility starting with the most effective control. Costs presented in this section reflect annualized direct and indirect costs for each control equipment option. Costs were estimated using the EPA's Air Pollution Cost Control Manual (EPA 2002) and the cost spreadsheet provided with the EPA's "Assessment of Styrene Emission Controls for FRP/C and Boat Building Industries" (Kong et al. 1996b). The direct equipment and operating costs were updated to 2019 dollars using the consumer price index from the US Bureau of Labor Statistics. The price for electricity and natural gas was obtained from the US Energy Information Administration. Table 5 presents the calculated cost/ton of pollutant removed for each of the control technologies. Typically, a control technology is considered cost-effective if the annualized cost is less than $10,000 to $12,000 per ton of pollutant removal (Ecology 2016). Cost calculation spreadsheets are provided in Attachment 2.

Table 5: Cost Effectiveness of VOC Controls

Technology	Cost Effectiveness ($/ton of VOC)	Cost Effectiveness ($/ton of Odorous Compounds)
Thermal Oxidizer	$26,855	$28,004
Catalytic Oxidizer	$64,674	$67,452
Adsorption		
MIAB System		
MIAB F	$40,545	$42,230
MIAB C	$38,834	$40,468
Thermatrix PADRE	$57,925	$60,396
Polyad System	$36,781	$38,328
Rotary Concentrator	$33,004	$34,403
C&C Fluidized-Bed Preconcentrator		
Recovery	$37,484	$39,095
Oxidation	$43,820	$45,663

Thermal Oxidizer

Costs associated with TOs were estimated using the EPA's Air Pollution Cost Control Manual (EPA 2002) with site-specific electricity and natural gas prices. Without heat recovery or energy recuperation, a TO is estimated to cost $26,855 per ton for VOCs and $28,004 per ton for odorous compounds (styrene and MMA). TOs are not cost-effective for FML operations.

Adsorption

Costs associated with catalytic oxidizers were estimated using the EPA's Assessment of Styrene Emission Controls for FRP/C and Boat Building Industries (Kong et al. 1996b) with site-specific electricity and natural gas prices. The following adsorption technologies were reviewed by the EPA:

- MIAB – Fixed-bed and continuous duty fluidized-bed carbon adsorption systems to preconcentrate VOC emissions. The VOCs are desorbed for recovery or catalytic oxidation.
- Thermatrix PADRE – self-regenerable adsorbent system that removes and recovers VOCs. A two-stage condenser is used to recover the desorbed VOC as a liquid. In a few cases, waste gas is routed to an oxidizer. This system has been applied to low flow processes (less than 7,000 acfm).
- Polyad – Preconcentration system using fluidized-bed adsorber followed by catalytic oxidation or solvent recovery system.
- Rotary Concentrator – Rotary concentrator system using activated carbon or specialized zeolite adsorbent followed by a thermal or catalytic oxidizer.
- C&C Fluidized Bed Preconcentrator – Fluidized-bed adsorption unit followed by either a fluidized-bed or moving-bed desorption unit and condenser or oxidizer.

As presented in Table 5, above, these technologies are not cost-effective control options.

Catalytic Oxidizer

Costs associated with a catalytic oxidizer were estimated using the EPA's Air Pollution Cost Control Manual (EPA 2002) with site-specific electricity and natural gas prices. Without heat recovery or energy recuperation, a catalytic oxidizer is estimated to cost $64,674 per ton for VOCs and $67,452 per ton for odorous compounds (styrene and MMA). Catalytic oxidizers are not cost-effective for FML operations.

Step 4 Summary

Based upon the cost evaluations presented above, add-on control technologies are not effective for control of emissions from these operations. Emission reductions from these operations will be achieved through product control and application techniques.

Step 5: Select BACT

Based on the information presented in Steps 1 through 4, the use of non-atomizing resin application techniques and low-monomer resins and gel coats is recommended for implementation as BACT for VOC, HAPs/TAPs, and odor control for the facility. Gel coats must still be applied with atomizing spray guns, so control of gel coat operations can be achieved only through the use of low-monomer gel coats.

The BACT level of control must be at least as stringent as emission standards under 40 CFR 60, 61, and 63. There are no Part 60, 61, or 63 emission standards that apply to the facility. However, emission standards for boat manufacturing at major sources are promulgated in 40 CFR 63 Subpart VVVV, National Emission Standards for Hazardous Air Pollutants for Boat Manufacturing. Under Subpart VVVV, the emission limits shown in Table 6 apply.

Table 6: Subpart VVVV Emission Limits

Operation	Application Method	Weighted Average Organic HAP Limit (weight percent)
Production resin operations	Non-atomized	35
Tooling resin operations	Non-atomized	39
Pigmented gel coat operations	Any method	33
Clear gel coat operations	Any method	48
Tooling gel coat operations	Any method	40
Carpet and fabric adhesive	Any method	5

Several states have developed BACT guidance and presumptive BACT limits. This guidance is summarized in Table 7 below. Search results from the EPA's RBLC and California clearinghouse are provided in Attachment 3. Low-VOC materials is the most common control technique found in these clearinghouses. Two facilities in California employ adsorption technology similar to those described in the EPA's styrene guidance document. However, none of these control techniques is cost effective for FML's facility operations.

Table 7: BACT Guidance Summary

Source	BACT Limit
Bay Area AQMD BACT Guideline for Polyester Resin Operation - Molding and Casting	Compliance with BAAQMD Reg.8, Rule 50 and use of aqueous emulsion cleaner instead of acetone for cleanup to maximum extent possible.
San Diego APCD BACT Guideline for Fiberglass Manufacturing Line (<10 tons/yr)	Compliance with Rule 67.12, Polyester Resin Operations.
San Joaquin APCD BACT Guideline for Fiberglass Boat Manufacturing Operation (< 120 gallons/day and < 25 tons VOCs per year)	For gelcoats: Air assisted application (or equivalent) and material VOC content (by weight) less than or equal to: - pigmented gelcoats: 33% - clear gelcoats: 48% - tooling gelcoats: 40% for resins, any of the following application methods: 1) non-atomized spray technique (such as the use of fluid impingement technology (FIT) spray guns), 2) flowcoaters, 3) pressure-fed rollers, 4) resin impregnators, 5) hand lay-up, or 6) any equivalent method as approved by the APCO; and materials with a material VOC content (by weight) less than or equal to: - resins: 35% - tooling resins: 39% and the use of non-VOC containing cleaning solvents
San Joaquin APCD BACT Guideline for Adhesive Application Operation –	Use of adhesives with VOC content of 80 grams/liter or less (less water and exempt compounds)

Source	BACT Limit
Bonding of Fiberglass Boat Hulls and Decks, Non-Atomizing Application	
TCEQ BACT Guideline for Mechanical Coatings/Fiber-Reinforced Plastics	Use of resins and gelcoats that meet the monomer limitations in 40 CFR Part 63, Subparts WWWW or VVVV. Use proper ventilation design to minimize styrene odor. 100% capture of monomer emissions to minimize fugitive emissions. Use high transfer efficiency spray application equipment. Airless, HVLP spray equipment, fluid impingement technology, non-atomized application equipment, brushes, or rollers. Implementation of ACMA controlled spray techniques, including operator training, spray gun calibration and the use of overspray containment flanges on molds may be required to achieve acceptable impacts. Collecting and venting VOC and exempt solvent to an add-on control device may be required for operations with VOC and exempt solvent emissions greater than 60 tpy. Efficiency of thermal control device is 98% or greater. Provide details. Good housekeeping and best management practices. Acetone replacement compounds should have a vapor pressure less than 1.0 mmHg at 40°C. Aqueous cleaners should have a VOC content less than 5.0% by weight. See applicable 40 CFR Part 63 requirements regardless of whether the requirements are directly applicable.

The FML Monroe facility uses gel coats with a maximum of 33 percent styrene and resins with a maximum of 35 percent styrene. Therefore, the current emission limits are proposed as the BACT emission limits. Odor

BACT for odor will match the BACT for VOCs, HAPs, and TAPs, which is reduced styrene and MMA product formulations and the use of non-atomized techniques for styrene resins. Additional odor BACT requirements can be included in proposed conditions in terms of operational practices – building doors, windows, and other openings will be required to be closed (except for incidental personal passage) at all times while applying resin or gel coat. Because there is the potential for ambient odor, a complaint recording and response will be established by FML.

Proposed BACT emission limits are summarized in Table 8.

Table 8: Proposed BACT Emission Limits

Pollutant	BACT Limit
VOCs, HAPs, TAPs and odorous compounds	Gel coats with less than 33% organic HAPs Resins with less than 35% organic HAPs using non-atomizing application Adhesives with less than 5% organic HAPs

Limitations

This technical memorandum has been prepared for the exclusive use of Fluid Motion, LLC and applicable regulatory agencies for specific application to the NOC Application 11660. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of LAI. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by LAI, shall be at the user's sole risk. LAI warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

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Attachments

Attachment 1: Revised Emissions Inventory Tables
Attachment 2: Cost Calculation Spreadsheets
Attachment 3: Search Results from the EPA's RBLC and California Clearinghouses