# Volatile Organic Compounds and the Paint Industry

## Introduction: The History of Paint and Paint Manufacturing

Since the dawn of time, humans have looked to leave their mark. In fact, archeologists have found that early humans have mixed ochre-based paint-like substances dating as far back as 100,000 years ago and the first officially dated cave paintings using red or yellow ochre, hematite, manganese oxide, and charcoal can be traced back 30,000-65,000 years.

Over the past few millennia, paint has continued to evolve, using new pigments, new binders, and new solvents to create the paint that we know today. From the earliest examples of paint, which relied on natural earth pigments, charcoal, berry juice, lard, blood, and milkweed sap to the slightly more advanced techniques employed by the ancient Chinese, Egyptians, Hebrews, Greeks, and Romans, paint played many of the same roles that it does today—decoration, wall covering, protective coating, and more.

For the majority of history, paints were simple—using pigments obtained from the earth, fast drying binders, and water, ultimately used for artwork rather than for residential or industrial coatings. This all changed around 13$^{th}$ Century AD. Around this time, those who could afford it began to enlist the help of house painters to cover up or spruce up the inside or outside of buildings, leading to the formation of the first painters' guilds to guide standards and practices regarding paint mixing and application.

Initially organized into two groups—The Painter's Company and The Stainer's Company—these guilds each possessed and maintained the profession of mixing and applying paint, feuding for centuries before merging to form the Worshipful Company of Painters and Stainers in the 1500s.

Unfortunately, paint was prohibitively expensive. Pigment was costly and hard to acquire; paint needed to be mixed using a mortar and pestle; and the application of paint presented a spate of challenges due to the fast drying times and thicker texture of this product. Even with these high cost, challenges, and even laws prohibiting paint in Colonial America, the people demanded paint.

### The Industrialization of Paint

This all changed in the early 1700s, when American inventor Thomas Child invented an early paint mill in Boston and English inventor Marshall Smith invented a "Machine or Engine for the Grinding of Colours," setting forth a wave of innovation and industrialization in paint. By 1741, the paint-making company Emerton and Manby touted its ability to produce paint in a "horse-mill," allowing the business to sell its product at unusually low prices, advertising,

> "One Pound of Colour ground in a Horse-Mill will paint twelve Yards of Work, whereas Colour ground any other Way, will not do half that Quantity."

Entering the 1800s, horses gave way to steam-powered paint mills for grinding pigment, which painters mixed on site, often with linseed oil manufacturers due to its affordability, uniformity, and availability. By 1867, D.R. Averill of Ohio patented the first prepared or "ready mixed" paints in the United States, a year after Sherwin-Williams (then Sherwin, Dunham, and Griswold) opened for business, releasing its first ready-to-use paint (raw umber in oil) in 1873. Sherwin split with Dunham and Griswold, who didn't back the idea of pre-mixed paint and partnered with Edward Williams to form the Sherwin-Williams Paint Company, which received a patent for the re-sealable tin can in 1877 and in 1880, released Painter's Prepared/SWP®, the first successful ready-mixed paint.

### The 20th Century

This was the dawn of the modern paint industry. Until this point, any homeowner or business that needed their walls painted had to hire a professional painter, pay someone to make the paint for them, or mix the pigment, linseed oil, and resin themselves. So began the proliferation of the paint industry.

Alongside the rising demand for coatings for residential, commercial, and industrial buildings came another key need: Transportation. Wagons and coaches moved from wood to metal, while trains and automobiles began to proliferate, resulting in a new need for coating. Initially, automobiles were dipped or brushed using oil-based enamels before spray coatings and nitrocellulose lacquers and primers became the standard for the automotive industry during the 1920s.

Time passed and the coatings industry continued to evolve, introducing new methods and materials to address changing needs. World War II created a shortage in linseed oil, and chemists mixed alcohols and acids to make alkyds (artificial resins). Cheap and easy to make, these gave rise to a new era of paint and coatings (and competition). The 50s saw the rise of latex paints in architectural coatings and acrylic enamels in the automotive industry, while new chemicals and processes made paint production cheaper and more efficient.

### The Beginning of Regulatory Oversight

However, by the 1960s, consumers, manufacturers, and regulators began taking note of their environmental impact, and the paint and coatings industry was an early regulatory target. The Environmental Protection Agency and Clean Air Act came into play throughout the 1960s and 70s, creating a new playing field for all businesses—especially paint and coatings. The early CAA brought to light the dangers of six “criteria” pollutants—airborne particulates, sulfur oxide, nitrogen oxide, ozone, and lead—and developed a framework for increased regulations. By 1978, Consumer Product Safety Commission banned the use of lead in consumer paint and in 1990, new Clean Air Act Amendments sought to minimize Hazardous Air Pollutants and Volatile Organic Compounds. These new standards set forward a new world of complexity for paint manufacturers, who needed to reformulate products, implement administrative changes, and take steps to destroy VOCs.

At The CMM Group, we are experts in VOC abatement for paint manufacturers and more, and we have written this guide to explore the regulations and best practices for destroying VOCs. In this whitepaper, we will discuss the basics of VOCs, the concerns that paint manufacturers have, the regulations set forth by the Environmental Protection Agency, the environmental goals designed by coatings industry groups, and the best practices for reducing your environmental impact as a paint manufacturer.

## Pollution in the Paint Industry: VOCs, HAPs, Particulate Matter

The paint industry has long been known for its impact on the environment. Solvents and resins naturally release VOCs during manufacturing, application, and degassing, whether the paint is being used to coat an automobile, mark a road, or cover a wall. But let’s take a step back to look at the basics of VOCs and HAPs—what they are, what impacts they have on health and the environment, and why it’s so important that paint manufacturers continue to lead the way in VOC abatement.

## VOCs: Volatile Organic Compounds

VOCs are short for Volatile Organic Compounds, which in turn can be summarized as nearly any compound containing carbon that is gas at normal atmospheric temperature and pressure—excluding certain compounds like carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

### What Are VOCs?

#### *Volatile*

The designation of “volatile” occurs when the chemical compound has an initial boiling point less than or equal to 250° C measured at a standard atmospheric pressure of 101.3 kPa. In turn, these compounds are broken down into three categories:

- **Very volatile organic compounds (VVOC)**: Considered volatile at a temperature ranging from <0° C to 50-100° C.
- **Volatile organic compounds (VOC)**: Become gaseous at temperatures ranging from 50-100° C to 240–260° C
- **Semi Volatile Organic Compounds (SVOCs)**: Become gaseous/volatile at temperatures ranging from 240–260° C to 380–400° C

#### *Organic*

Organic is a relatively simple term that means “containing carbon.” Carbon is a natural building block of the world, as it is small enough to form bonds with nearly every element. For example, carbon can bond with itself in stable rings to form diamonds, can form chains, or can form compounds of varying stability.

#### *Compound*

Carbon binds with many different elements to form compounds. At present, there have been over 10 million organic compounds discovered and documented. Of these, more than 12,000 are considered volatile, in that vapor degrades into the air from a liquid or that the compound exists in the form of a gas at room temperature and pressure.

### VOC Impact on Health and the Environment

Volatile Organic Compounds are a major talking point for a variety of reasons, but primarily for the risks they pose for the health of people exposed to the chemicals and the environment at large. From indoor VOCs—responsible for negative health effects on your employees (and in the case of some architectural paint, your customers) to outdoor VOCs, these compounds pose health, environmental, and economic risks when they escape your facility.

#### *Health Impacts of VOCs*

With tens of thousands of different combinations that fit the criteria used to define a VOC, and different impacts depending on the amount of time and exposure, it’s impossible to nail down a list of the exact consequences that VOC exposure has on the human body. Symptoms of acute VOC exposure include irritation of the eyes, nose, and throat, headaches, difficulty breathing, dizziness, and more. Additionally, chronic exposure to VOCs presents another set of health risks that includes cancer, liver and kidney damage, and central nervous system damage.

### *Environmental and Economic Impact of VOCs*

While health impacts are one part of the equation, the environmental impacts are the other. As they are small enough to be carried by air, these compounds can travel with weather patterns or wind to new locations, or end up in waterways and drinking wells. This in turn has its own health and economic impact, causing damage to crops and commercial forest yields, reduced growth and survivability of tree seedlings, and increased susceptibility to diseases, pests and other stresses such as harsh weather.

## HAPs: Hazardous Air Pollutants

VOCs are one part of the challenge that paint manufacturers face, but some of the VOCs also fall into the category of Hazardous Air Pollutants. Hazardous Air Pollutants were defined in the Clean Air Act as "any air pollutant listed [in 42 U.S.C. 7412 (b)]," which includes specific chemicals (e.g. arsenic), compounds that include chemicals listed (For example, Arsenic compounds would mean Arsenite, etc.), and other notable toxins. These 187 chemicals listed by the EPA are recognized as chemicals that cause or may cause cancer or other serious health effects such as reproductive effects or birth defects, or adverse environmental and ecological effects.

Examples of HAPs include: xylenes, toluene, benzene, phenol, glycol ethers, styrene, methyl isobutyl ketone, ethyl benzene, and methylene chloride.

## Particulate Matter

While less of a concern than some other industries, the paint industry still has to deal with dust. Whether that's in the form of titanium dioxide, zinc, calcium, potassium, or any form of pigment added, the use of such products produces dust. If not properly treated, this could be inhaled by your employees, vented into a pollution control system, or emitted into the environment. Particulate matter, when inhaled, can cause respiratory inflammation or if small enough could reach the blood vessels through the lungs.

# Reputation and Regulation on the Paint and Coatings Industry

A lot has changed since the introduction of the Clean Air Act. Lead has been eradicated from paint manufacturing, alkyds have been replaced with latex-based paints, and heavy metal use has reduced.

## Paint and Coatings Still Has Work to Do

Simply put, the industry has made huge strides in the past three decades to not only comply with new standards but go above and beyond. According to the American Coatings Association, VOCs have dramatically decreased despite an increase in the use of architectural coatings, and The U.S. Environmental Protection Agency's (EPA) Toxic Release Inventory (TRI) indicates releases by the paint and coatings sector decreased by 81% between 1990 and 2014.

However, there is still work to be done. With an expected consolidation between giants in the paint industry (in the past 50 years, the United States has seen the number of paint manufacturers drop from 1,100 to a few more than 10), many in the media may turn their attention to those in the paint industry.

There's money to be made in breaking a story, and a relatively innocuous violation of an EPA regulation could go from "EPA Press Release" to the front page of every newspaper, environmental blog, and class action lawyer's website. Additionally, in today's hyperpartisan environmental reporting world, EPA/CAA noncompliance by an industry giant could easily be spun into a PR nightmare on par with the DuPont chemical leak.

## Background: The Environmental Protection Agency

The EPA was established on December 2, 1970, signed into existence by Executive Order by President Nixon. This EO, paired with the National Environmental Policy Act, gave the EPA the ability to enforce regulations—with the most prevalent cause being to enforce another law enacted at that time, the Clean Air Act of 1970. Throughout the years, the EPA has expanded in size and scope, now employing 15,408 people and operating on just over $8 Billion in FY2017.

The EPA uses this money to lead a variety of programs focused on education, enforcement, and more, drafting rules, assisting companies with compliance, and ultimately enforcing regulations. This starts with rulemaking, in which Congress passes a law and gives the EPA authority to write regulations. The EPA then educates the community, helps businesses understand what it means to be compliant, and then begins enforcing the regulations. From here begins enforcement which include civil actions and in rare cases criminal actions.

## The 1990 Clean Air Act Amendments and National Emission Standards for Hazardous Air Pollutants

Additionally, the 1990 Clean Air Act Amendments set forth unique industry standards pertaining to the specific emission amounts for different practices. For paint and coatings manufacturers, who fall under the CAA Standards for Chemical Production and Distribution, regulations are guided by 40 CFR 63 Subpart CCCCCCC (7C).

As a result of the Clean Air Act (CAA), the Environmental Protection Agency, or EPA, is in charge of regulating VOC emissions. Known as the National Ambient Air Quality Standards (NAAQS), they set an acceptable volatile organic compound emission and pollution control standards for paint manufacturers across the country.

Moreover, states have the responsibility of developing a general blueprint to reach and maintain the NAAQS in all parts of the country.

The latest version of this rule was finalized on November 16, 2009, and applies to paints and allied products manufacturing facilities that process, use, or generate materials containing the following toxic air pollutants: benzene, methylene chloride, and compounds of cadmium, chromium, lead, and nickel.

## Additional Considerations: The Paint and Coatings Industry Fighting for Cleaner Air

In addition to the regulatory environment, the industry itself has been working to increase the sustainability and reduce pollution from its own members. The American Coatings Association, the leading voice of companies in the paint and coatings industry, has made clear its stance on pollution control among its members, touting its successes while noting that there is still more work to be done.

From the promotion of environmentally-friendly paint and coatings products to the launch and management of PaintCare®, a not-for-profit 501(c)(3) organization whose sole purpose is to ensure effective operation, the governing body of paint continues to fight for greener products and environmentally friendly operation from its member organizations.

# Minimizing Pollution: A Paint Manufacturer's Guide to Pollution Control

With regulations becoming stricter, an increased focus on the paint and coatings industry from media organizations and environmental advocates, and continued increases in the cost of noncompliance, paint manufacturers need to put increased focus on their emissions. Too often, manufacturers in all industries fall into the following trap: A regulation gets passed, companies scramble to make changes to their operations to become compliant, time passes, and the manufacturer continues to operate at status quo—until new regulations are written and the cycle starts all over again.

Unfortunately, this set it and forget it approach is either too reactive or fails to consider that aging equipment becomes less effective or more breakdown-prone over time. For paint manufacturers, falling into non-compliance or facing a breakdown could derail an entire day or more of operations while you wait for repairs or improvements to your current equipment. Paired with this, a fair amount of time has passed since the last regulatory update. Since then, the technology has improved and better pollution control systems have entered the market, designed to operate with more cost efficiency and possibly even destruction efficiency.

This said, now is the best time to take a look at your operations and consider if you should look for a more efficient, cost effective solution that can save your organization money and help you avoid scrambling for new equipment when regulations change again.

## Pollution Control Options for the Paint and Coatings Industry

For paint and coatings manufacturers, the technology may have improved, but the practice remains the same: collect and destroy emissions using extreme temperatures. Often, this is achieved through a regenerative thermal oxidizer (RTO), often paired with a rotary concentrator system to condense the pollution to increase efficiency. Additionally, forward-thinking paint and coatings manufacturers are taking the heat generated from an RTO and finding ways to reuse this heat with an energy recovery system.

### Rotary Concentrator Systems

For paint and coatings, emissions are usually steady, often featuring high volumes of exhaust air with lower concentration. Due to the high volume and low concentration, destroying pollutants is often inefficient and manufacturers see diminishing returns on their investment.

Knowing this, more paint and coatings manufacturers are using rotary concentrator systems to increase the efficiency of their pollution control. These systems ultimately concentrate the polluted air, resulting not only in increased destruction and cost efficiency, but also reductions to the size of the thermal oxidizer.

#### *How It Works*

Rotary Concentrator Systems from The CMM Group, LLC are hybrid VOC abatement systems designed to efficiently remove and destroy volatile organic compound emissions from a process exhaust air stream. The polluted air passes through a rotating wheel where the air pollutants are adsorbed onto a hydrophobic Zeolite media and then removed and destroyed by use of an oxidizer.

During operation, air pollutants, captured from the process via a ductwork collection system, are passed through a high-efficiency filter as particulate can damage the concentrator wheel media. The concentrator wheel rotates at an approximate speed of 2-8 revolutions per hour, continuously passing a sector of the wheel with adsorbed air pollutant through a desorption plenum for removal by a heated air stream; thus continuously returning a regenerated (or clean) sector back into the main housing for further adsorption.

Desorption is automated as the slipstream of air that was routed through the cooling plenum is sent through a supplemental desorption heater were it is elevated to desorption temperature of 175°C (350°F) and returned to the concentrator housing. This heated desorption air is directed back through the wheel via the desorption plenum were the concentrated pollutants are removed. The highly concentrated air stream is then routed to the Regenerative Thermal Oxidizer (RTO) for thermal destruction. Overall air pollutant destruction efficiencies of 96% can typically be guaranteed.

## Regenerative Thermal Oxidizer

Regardless of whether you choose to use a rotary concentrator to decrease operating costs, the primary choice for paint and coatings companies looking to destroy pollutants is the regenerative thermal oxidizer. Promising high destruction efficiencies and top of the line cost efficiency, these options are designed to destroy greater than 99% of VOCs. Using a heat transferring medium in the form of ceramic surfaces to heat up the polluted air, the heat is stored and transferred through the ceramic surfaces, and they are capable of achieving a thermal efficiency of up to 97%.

Relatively simple, Regenerative Thermal Oxidizers from The CMM Group are designed to destroy air pollutants emitted from process exhaust streams at temperatures ranging from 815°C (1,500 F) to 980°C (1,800 F).

### *How It Works*

In operation, the process exhaust fumes are forced into the Regenerative Thermal Oxidizer inlet manifold (with a high pressure supply fan) and directed into one of the energy recovery canisters by use of inlet (switch) valves. The pollutant laden air passes from the valve assembly vertically upward through the first of the heat exchanger canisters where it adsorbs heat from the ceramic media (thus eventually cooling the media). This preheated air then enters the combustion chamber (typically at a temperature very close to that required for oxidation), is thoroughly mixed for temperature uniformity (turbulence) and held in the combustion chamber at the elevated set-point temperature (temperature) for a residence time of ~0.5 seconds (time). Air pollutant destruction takes place within the combustion chamber where auxiliary fuel is introduced if necessary.

After passing through the combustion chamber, the clean (hot) air is routed vertically downward through a second energy recovery canister where the heat generated during thermal oxidation is adsorbed by the ceramic media (thus preheating the media for the next cycle).

The clean (cooled) air is routed to atmosphere through outlet (switch) valves, the exhaust manifold and ultimately through the exhaust stack. To maximize the heat exchange, the switching valves alternate the airflow path between canisters to continuously regenerate the heat stored within the ceramic media. Thermal energy efficiencies (TER) range from 85% to 97%. To maintain low external shell temperatures and minimize radiant heat loss, the combustion chamber is insulated with long-life ceramic fiber modules. The external shell is typically fabricated of carbon steel. Air pollutant destruction efficiencies of 99% can typically be guaranteed.

# Conclusion

Paint has been part of society since prehistoric times, evolving with societal needs, providing protection to surfaces, improving the aesthetics of our homes, automobiles, and buildings, and keeping us in our lanes on the road. In the last two centuries, paint has continued to evolve to meet the needs of people, businesses, other manufacturers, and in the last 50 years, the environment.

Even though the paint and coatings industry continues to develop innovative products and reduce pollutants, there is still work to be done, as the regulatory environment continues to change as well. For many paint and coating manufacturers, especially those with aging pollution control systems and processes, continuing to operate along the lines of the status quo is dangerous and could result in breakdowns or noncompliance. We hope you enjoyed this guide and invite you to learn more about our pollution control equipment—including Regenerative Thermal Oxidizers and Rotary Concentrator Systems—read more about our success stories below, and contact us for a free consultation.

## Further Reading: Case Studies and Resources

### *Case Study: Leading Paint Manufacturer Selects CMM for Rotary Concentrator System*

To sufficiently capture both VOCs and dust particulates to meet national chemical and coating standards, The CMM Group designed an emission control system for the country's largest paint manufacturer that was custom fitted to the majority of the facility's paint making operation.

To meet capture requirements of 90%, CMM installed a dust particulate and VOC/HAP point source collection system consisting of approximately 70 custom designed dust/ambient emission collection hoods. The system also included three dust collectors and a CMM Rotary Concentrator/Regenerative Thermal Oxidizer capable of an exhaust flow rate of 50,000 scfm and an overall destruction efficiency of 90%+.

The concentrator/oxidizer was installed on an outdoor concrete pad at least 50 feet beyond any future building expansion with access to the unit and emergency access to the facility provided by a service road built by CMM.

### *Case Study: Coatings Manufacturer Installs Regenerative Thermal Oxidizer*

To provide the 98% VOC/HAP destruction efficiency needed to meet national chemical and coating manufacturing standards, The CMM Group installed a 12,500 scfm Regenerative Thermal Oxidizer equipped with an integrated, 95% thermally efficient primary heat exchanger with 2-beds of ceramic media and an insulated hot-side bypass damper.

In addition to a dust collector to provide high speed dispensers (HSD) and low speed mixer (LSM) ventilation, the system also provided point source collection of evaporative emissions from seventeen (17) HSD vents, three (3) LSM vents, one hundred twenty six (126) thin and shade process vessel vents, seven (7) resin storage tanks vents and the resin plant "burp" tank.

Read more: http://www.madehow.com/Volume-1/Paint.html#ixzz5N2H34Xib

http://digitalpub.sherwinpreferredcustomer.com/spring-2016/april/150-anniversary

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http://ec.europa.eu/environment/archives/air/stationary/solvents/activities/pdf/d022_voc_emission_from_manufacturing.pdf

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http://www.thecmmgroup.com/regenerative-thermal-oxidizer/

Resources

http://www.paintcenter.org/newvoccalc.php