# On-line Pollution Prevention Training for Coating Facilities

**Section 1 Coating Alternatives**

I would like to begin this section by addressing the objectives of covering alternative coating types and opportunities for pollution prevention.

First: What are coatings? What are paints? How are paints different than coatings in general.

Second: What are the most effective questions and techniques for initiating P2 improvement for a coating facility?

Third: What direction is the coating industry headed in at this time, what techniques are being proven as P2 performers?

# Why P2?

- Reduce: Hazardous and Solid Waste, Wastewater, Air Emissions
- Help the company save money by lowering production costs
- Reduce the regulatory burden
- Provide a cleaner, healthier, safer work environment for employees
- Produce a more effective/efficient employee

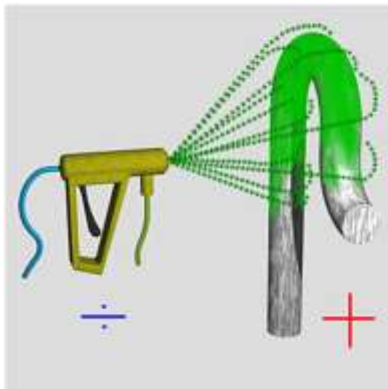
**Paint:** A mixture or dispersion of opaque pigments or powders in a liquid or vehicle. Now used in the general sense which includes all organic and inorganic coatings such as enamels, varnishes, emulsions, bituminous coatings, etc.

Lets start by talking about what a paint is. A paint is basically any opaque colored coating added to a substrate. SO essentially a paint is a subset of all possible coatings which could include a lot of clear or uncolored protective substances. A lot of references to coatings also place adhesives in this general class and I would agree that many adhesives would have similar P2 opportunities to those applicable to coatings.

**Paint System:** The procedures required to apply a coating. This generally includes the preparation, types of coatings, number of coats, film thickness and application methods.

It is also important to address the fact that a coating choice is also related to the cleaning, application and curing methods used. Therefore coatings are addressed as coating systems. Even a simple coating such as common latex house paint can be utilized in various ways ie. Brushed, sprayed, rolled etc. so this practice versus some other coating would be evaluated as a coating system.

# Coatings



Uses

Types

Alternatives

I want to begin by covering why coatings are used. By examining their function in different environments and on different materials we can begin to understand the basis for minimizing the toxicity and amount of coating needed. I then want to briefly address the broad range of coatings available and the basis for being able to substitute coatings based upon the material to which it is being applied and the environment in which it must function.

# Coatings are like clothing for materials?

To begin our discussion I would like for you to imagine coatings as clothing for materials. For instance a primer is kind of like underwear for the outer layers of a coating. Imagine a wool suit without underwear! Or if a coating is for cosmetic purposes only, it might be equivalent to a swim suit. In other words the coating needs to match the environment for which it is intended. If it is used in a wet environment it needs to be waterproof.

# Uses

- Coating Systems for Corrosion Protection of Large Steel Constructions (Heavy-Duty Coatings)
- Automotive Coatings
- Marine Coatings
- Coil Coating
- Coatings for Domestic Appliances
- Coatings for Packaging (Can Coatings)
- Furniture Coatings
- Coatings for Buildings

This is only a brief list of the many uses that you may encounter for coatings. Often coating is simply one step in an overall fabrication and manufacturing process. Therefore the coating system must comply with the other manufacturing and end use requirements of the product. For instance can coatings for food containers must meet FDA requirements for food packaging. A coating may have to be dry quickly for an additional assembly process, or tolerant of heat etc.

# Types of Paints and Coatings

- Oil-Based Coatings
- Cellulose-Based Coatings
- Chlorinated Rubber Coatings
- Vinyl Coatings
- Acrylic Coatings
- Alkyd Coatings
- Saturated Polyester Coatings
- Unsaturated Polyester Coatings
- Polyurethane Coatings
- Epoxy Coatings
- Silicone Coatings
- Urea, Benzoguanamine, and Melamine Resins for Coatings
- Phenolic Resins for Coatings
- Asphalt, Bitumen, and Pitch Coatings
- Silicate Coatings

I know that this list is rather long, but I wanted to stress that here are a lot of coatings and coating types. The purpose of addressing this is not for you to become intimately familiar with the many types, chemistries, and possible uses of coatings (because very few people have a wide, thorough and un-biased, knowledge of all coatings) The purpose of covering and listing these types is to point out that there are a lot of opportunities to change coatings or modify a coating based on it’s performance requirements. Indeed the coatings manufacturers are constantly modifying and testing various chemistries to capture market share from other manufacturers.

# Basic Components of a Paint/Coating

- **Resin (Binders or Polymers)**
  . Constitute the majority of the film or solids
  . The molecules that actually bond to form the protective film on a substrate
- **Pigments**
  . Usually the most expensive component of the coating
  . Either hide or enhance the appearance of the substrate

**Additives**
  . Enhance or impart physical properties of the coating (flow, wetting, durability..)

- **Vehicle (Solvent or Water) for liquid coatings**
  . Used to dissolve and carry resins and additives
  . Significant in application and finish but not film performance

**The finished coating is all about the solids…………!!**

Probably the most important concept that I would like for you to remember from this section is that for any coating that is intended to be dry in it's final state. Any liquid or vapor component that is not part of the final dry film, is a waste!!!!! Therefore, any component Resin, Pigment, Additive or Vehicle that does not become a solid on the intended substrate is a waste. Even if a coating is applied with 100% efficiency to the substrate, the difference between the wet and dry coating represents a waste.

We will get into this in much greater depth later, but I want you to think about this as we discuss coating types and application methods further.

## Physical Categories of Coatings

- **Liquid**

  **1. Solvent borne coatings**
  - a) conventional or low solids
  - b) high solids
- **2. Water borne coatings**
  - a) water emulsion
  - b) water soluble
  - c) water reducible
- **3. Two component coatings**
  - a) solvent borne
  - b) water borne
- **4. Ultraviolet & Electron Beam Cured Coatings**

I will briefly cover the physical categories of various coatings, once again, not for the purpose of creating a comprehensive knowledge of all coating types, but to introduce the concept that basic P2 principles can be applied to any chosen coating and that trade off's need to be evaluated based on the coating selected.

A prime example are water reducible coatings, the performance of the coating may be nearly identical to a solvent borne coating, but the cleaning requirements, drying time or drying energy requirements may be different.

The last category here can be either liquid **or** powder, but they are significant because they can be nearly 100% solids. Essentially the UV or Electron beam acts as a catalyst causing the chemical reaction to cure the coating. In a 100% solids situation the wet and dry coating thickness would be equal.

## Physical Categories of Coatings

- **Solid**

**1. Thermoplastic Powders-**

Polyethylene
Polypropylene
Nylon
Polyvinyl Chloride
Polyesters
Polyamides
Polyvinyledene fluoride/fluorocarbons

**2. Thermoset Powders-**

Epoxy
Polyester
Acrylic

**3. Film-** Polyurethane (3M aerospace), Fluoropolymers,

Thermoplastic powders are usually applied to a heated part and essentially melt onto the substrate, this takes place at temperatures of around 250 to 275 F. Thermoplastic powders usually require a primer to promote adhesion.

Thermoset powders can be applied to a part at ambient temperature but then must be heated to first melt on the part and then to activate a heat sensitive catalyst to cure the coating. This requires a temperature of 360 to 380 F. Thermoset powders do not require a primer, but the substrate must be tolerant of the higher curing temperature.

Film coatings are a rapidly growing category of coatings at this time especially in automotive, aeronautic and aerospace applications. These films can also be applied as either thermoformed to the part or as part of the injection molding process for plastics. One general area where they are also effective is in the replacement of stenciling.

# Pigments

- Inorganic Pigments
  inorganic pigments are usually combinations of a mineral element with oxygen and other elements (most often sulfur, silicon or carbon) that fall in the chemical classes known as oxides, hydroxides, sulfides, sulfates, silicates and carbonates.

- Organic Pigments
  are based on several different chemical families, including: azo compounds, phthalo compounds, quinacridones, condensation acids, and perylenes. Generally speaking, organic pigments are more subject to deterioration (particularly by ultraviolet radiation from sunshine) than inorganic pigments. Still, there are significant differences among organic pigments.

Pigments are important to discuss from a hazardous waste perspective. Pigments give the desired color to the coated substrate. They represent the smallest component by volume yet are often the most expensive ingredient. Generally speaking inorganic pigments are more durable and fade resistant than organic pigments. However both types **<u>may</u>** contain hazardous materials.

## Inorganic Pigments

| COMMON NAME | CHEMICAL NAME | FORMULA | COLOR |
|---|---|---|---|
| Cinnabar | Mercury(II) Sulfide | $HgS$ | Vermilion |
| Cobalt Blue | Cobalt(II) Oxide<br>Aluminum Oxide | $CoO\text{-}Al_2O_3$ | Bright Blue |
| Prussian Blue | Potassium Iron(III) Ferrocyanide | $KFe(Fe(CN)_6)$ | Deep Blue |
| Verdigris | Copper(II) Acetate | $Cu(CH_3CO_2)_2$ | Green |
| Chrome Yellow | Lead(II) Chromate | $PbCrO_4$ | Yellow |
| Burnt Sienna | Iron(III) Oxide<br>in clay | $Fe_2O_3$ | Reddish Brown |
| Malachite | Copper(II) Carbonate<br>Copper(II) Hydroxide | $CuCO_3Cu(OH)_2$ | Green |
| Cadmium Yellow | Cadmium(II) Sulfide<br>Zinc(II) Sulfide | $CdS\text{-}ZnS$ | Lemon Yellow |
| Rutile | Titanium(IV) Oxide | $TiO_2$ | White |
| Chinese White | Zinc Oxide | $ZnO$ | White |
| Lead White | Lead(IV) oxide | $PbO_2$ | White |
| Vine Black | Carbon | $C$ | Black |

As you can see many of the commonly used inorganic pigments may contain hazardous metals such as mercury, lead, chromium and cadmium. Even though the pigment content may be very low and the pigment may be encapsulated in the coating, these metals may cause the paint waste to be considered hazardous. An important P2 consideration is the substitution or elimination of various colors. This issue is frequently addressed in green building criteria for architectural coatings.

## Organic Pigments

| SELECTED ORGANIC PIGMENTS AND PROPERTIES | | | | | |
|---|---|---|---|---|---|
| | PHTHALOCYANINE<br>blues, greens<br>*(e.g., phthalo blue,phthalo green)* | QUINACRODONE<br>reds, oranges, violets<br>*(e.g., Violet 19)* | CONDENSATION ACID<br>*(e.g., alkali blue)* | PERYLENE<br>*(e.g., perylene red)* | AZO<br>yellows, reds<br>*(e.g., Hansa yellow, nickel azo yellow, toluidine red)* |

Organic coatings can also contain hazardous metals such as nickel, barium,…….

# Resins

- epoxies
- polyesters
- alkyds
- urethanes
- acrylics
- vinyls
- phenolics
- silicones
- halogenated types

The resin is the real functional component of a coating. It provides the protective properties, the finish properties and is critical for matching the characteristics of the substrate and the environment in which the substrate will be introduced. The coating itself is commonly named by the resin type ie. Latex paint polyurethane coating, PVC coating etc.

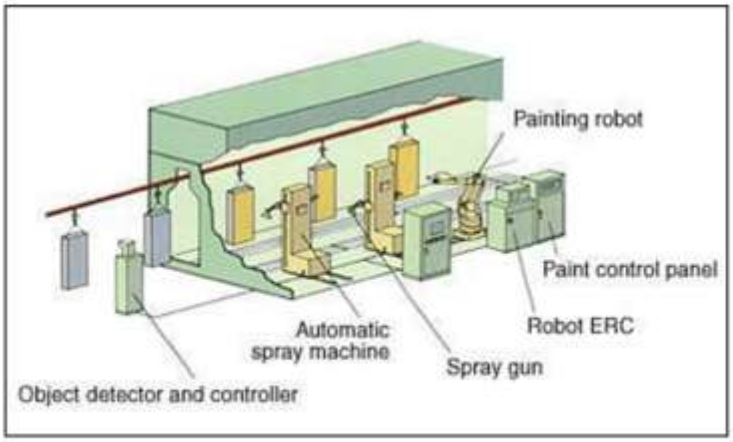
# Paint Additives

- Defoamers
- Wetting and Dispersing Additives
- Surface Additives
- Driers and Catalyst
- Preservatives
- Rheology Additives
- Light Stablilizers
- Corrosion Inhibitors

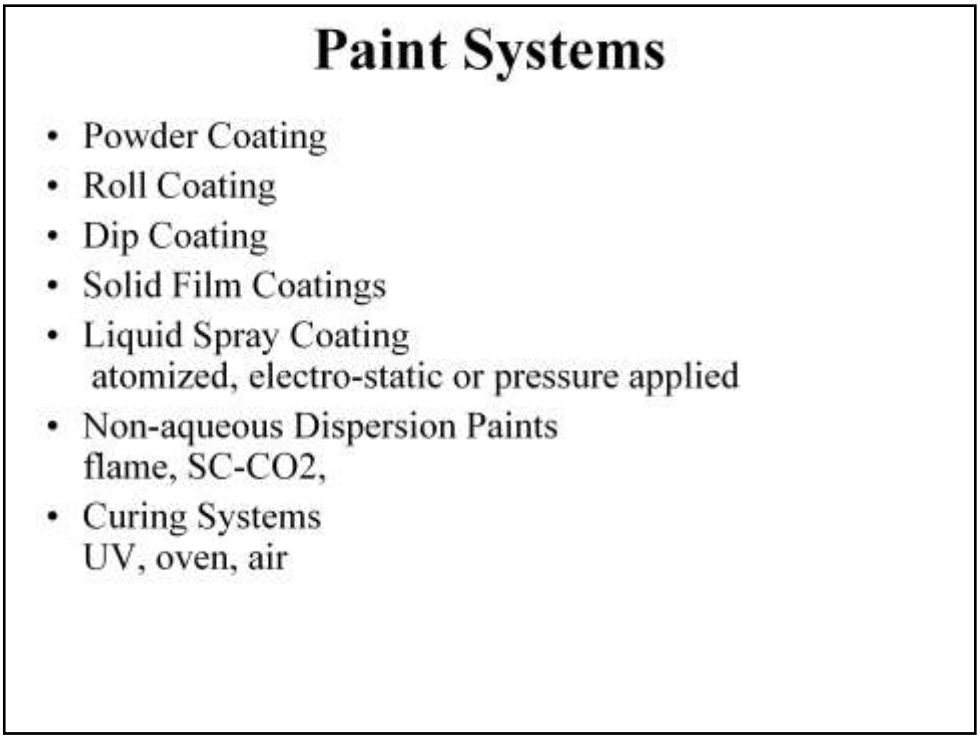
The purpose of this list is not to further complicate the chemistry or general understanding of coatings, but to open the concept of the amount of possible substitution opportunities for coating components. Paint additives can be used to adapt viscosity, performance, curing, and finish characteristics.

# Coating Systems

- Coatings are applied and used as a system
- Use can dictate the universe of alternatives




As I stated earlier coatings are not considered independent of the process in which they are going to be applied. Preparation, application and curing are all important components of a system and they have to bee matched to both the substrate and the coating.




You may encounter a wide range of paint systems when visiting or evaluating coating facilities. Since we have extensive coverage of liquid spray and powder coating in the other parts of the program today. I will address some of the other types of systems.

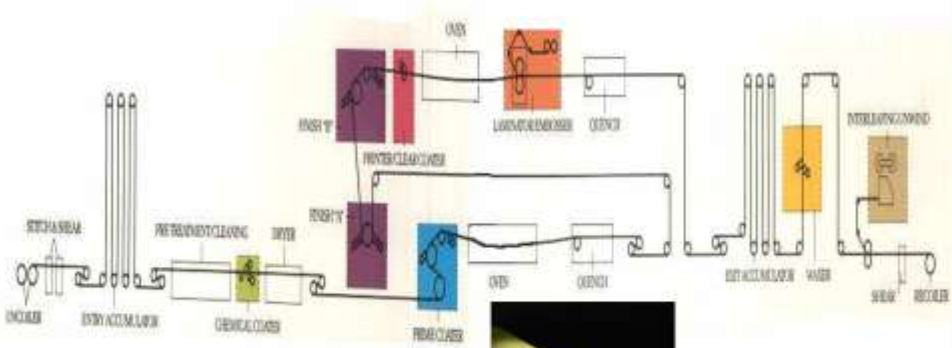
Plastisol dip coating

For a lot of thick protective coatings you will still find a good deal of dip coating. Tool handles, gloves, or other high wear substrates often will utilize this type of system.

**Thermal Spray Coating of Paper Making Roll**

This is a more rare type of system which is also referred to as a flame coating system, the coating is melted and adheres to the substrate as a plasma. This type of coating is used in very high abrasion and heat resistant environments. This photo is a coating on a paper making roll, but it is also used on equipment such as internal components of jet engines or turbochargers.

## Coil Coating using the Roll Coat Method



This system is responsible for a very high volume of metal painting/coating. It is a very rapid and continuous system for applying coating to rolled steel or aluminum.

**Dry Film Coating System**

http://www.3m.com/us/mfg_industrial/adhesives/aerospace/prf.jhtml

This type of system is relatively new but has some real potential. A dry paint film is directly applied to the substrate by either adhesive, thermoforming or placed in a mold prior to injection molding. This technique is being widely used on aircraft and is being adapted to automotive components.

**Ultraviolet light curing systems**

Although this is a curing system and not a coating system per se, it is significant to mention because of the benefits of the high solids and high production output capabilities.

# Overview of basic paint types advantages/problems

I will try to preface this section as only a very general overview of some of the perceived advantages or disadvantages of various coating types. Coatings utility are relative to the substrate to be coated and the environment in which they must function.

## Waterborne Coating Advantages

Reduction of VOC emissions

Finish quality equivalent to organic solvent based

Water clean-up of equipment and area

## Waterborne Coating Disadvantages

- Humidity levels can adversely affect some formulations
- Paint storage area should be heated
- Coatings are highly susceptible to dirt
- Changeover may require new atomizers and components that are not susceptible to corrosion
- Disposal of water/paint mixture resulting from cleanup

Waterborne coating offer a wide range of resin types available while reducing the levels of VOC emissions for transfer and clean-up. They do have draw backs which must be overcome. The automotive industry has been responsible for pushing the envelope of improving the durability and application systems for utilizing the benefits of waterborne coatings. Even the U.S. Army has recently switched their basic camouflage coating for equipment, ground vehicles and aircraft from a solvent based system to a waterborne system which is superior in durability to the previous solvent based system. This change represents a 4 million pound VOC reduction per year.

## High Solids Coating Advantages

Reduce VOC emissions

Raw material cost savings- solvent

Increased production speed

Durability

## High Solids Coating Disadvantages

•Initially more difficult to achieve finish quality
•May need to heat paint to increase viscosity – (not newer paints)
•Overspray cleanup is difficult
•May need to pump coating due to viscosity

Regardless of the base formulation of the coating, I would like to stress the importance of the solids content of the coating applied. The portion of coating that is not solids will be lost as part of the application and curing process, therefore it is essentially a waste. The higher the solids content the less passes or time over the part that is needed to achieve the desired coating thickness. As solids approach 100% the wet and dry thickness become essentially the same.

High solids coatings are not as tolerant as low solids for poor consistency of operation or poor application technique. Parts may also need to be some what cleaner. Newer formulations have less of the initial viscosity problems stated above. I wouldn't be too concerned with the overspray clean-up difficulty, this represents an additional incentive to keep the paint on the part. Poor application technique from low solids coatings can also be difficult to clean-up.

## Two Component Coating Advantages

Chemical and heat resistance

Energy savings – some curing occurs chemically

Durability

## Two Component Coating Disadvantages

- If hand mixed, pot life can be short
- Proper blending with a proportioning gun can solve the pot life problem, but achieving blends may be difficult
- Pumping and transport of the two component systems
- Overspray cleanup is difficult
- Toxicity of the isocyanates and amines used
- Cost

Two component coatings offer a very tough finish, and can have some advantages over other coatings. One main benefit is the chemical curing of the coating itself. Most will air dry along with the chemical "hardening" component. Often the finishes are still baked to finish drying due to time constraints although lower temperatures and times make them attractive for substrates that are not heat tolerant.

The system in the graphic can handle high solids two component coatings. It is a heated, pumped, air-less application system.

## Powder Coating Advantages

Can reduce VOC emissions to near zero

Material utilization can also approach 100% due to product recovery and re-use

Durability

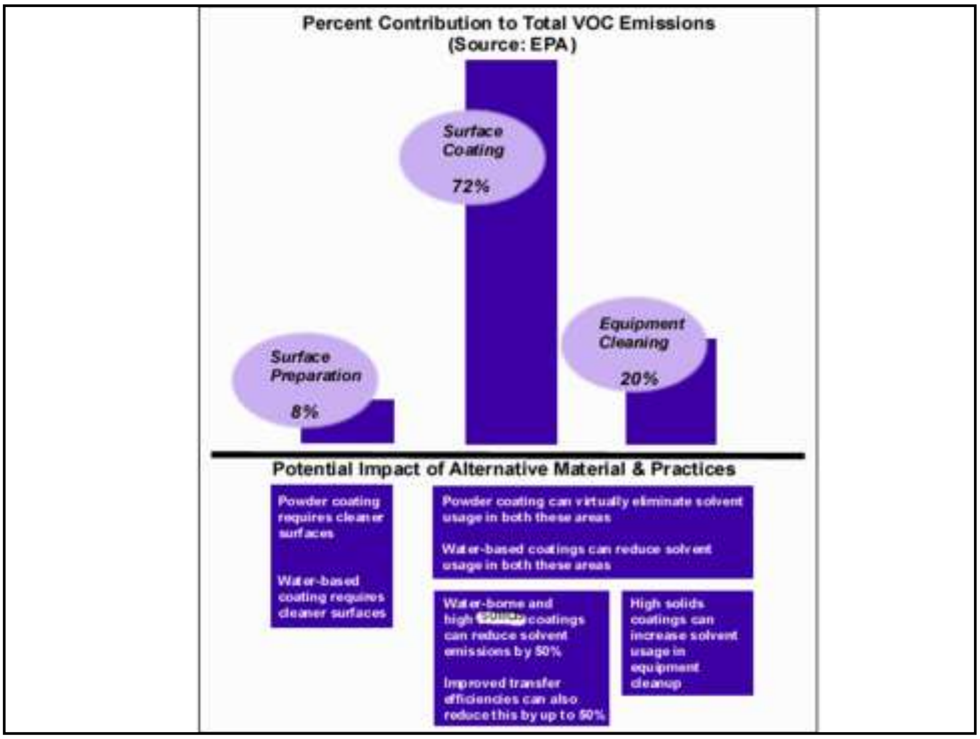
## Powder Coating Disadvantages

- Limited ability for color change
- More difficult to produce blended colors
- Coatings ususually greater than 1 mil thickness
- Parts must be heated

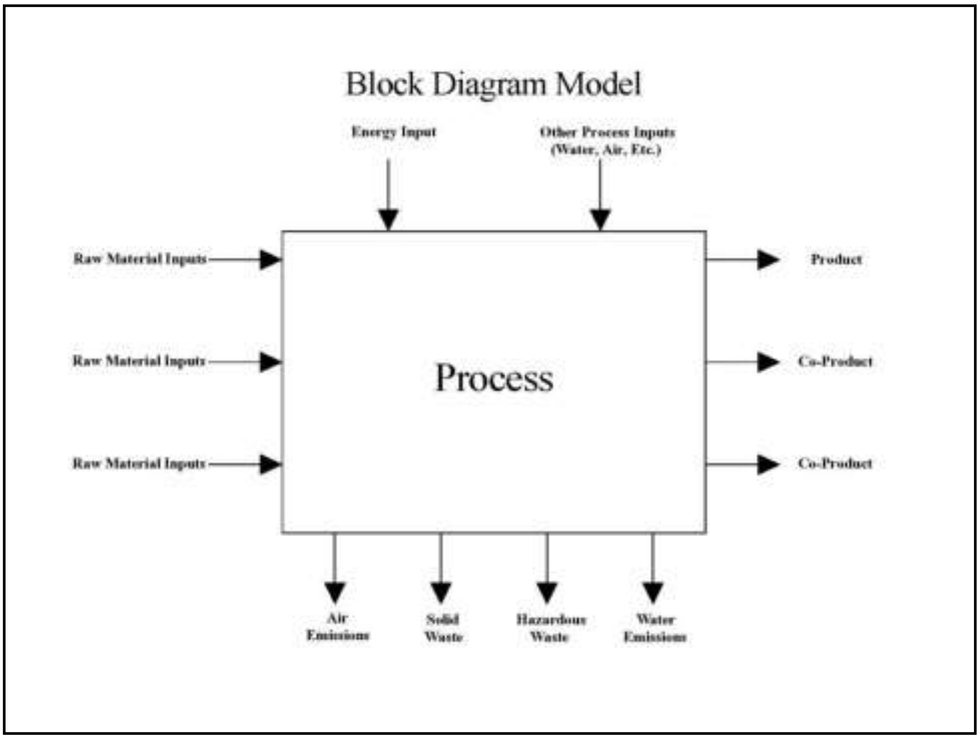
Powder coating can be a very effective method for maximizing efficiency in a coating system. With optimal conditions it is essentially a 100% solids coating with transfer efficiencies that can approach 90 to 100%.

If efficiency is operated at this high level, the small percentage that does not make it onto the part on the first pass can be collected and reused. There are a limited number of times that powder can be recharged electrically before it would have to be recycled. From a waste stand point this system has excellent potential and case studies are very impressive in VOC and paint waste reductions. The key is operating the system in the manner of the graphic above. By precisely controlling the application rate and optimizing the coating transfer nearly 100% of the coating is applied to the work piece.


Often the selection of a coating is a very complex combination of factors for the facility. Versatility in changing colors or speed of production can often be driving factors for shops still using low-solids solvent based coatings. The largest obstacle to P2 in painting and coating is no different than other industries, it is human nature. People resist change!




This slide very demonstrates the various process contributions of VOC emissions for the painting and coating industry. These numbers were compiled from data from the Painting 2000 project with the Iowa Energy Center.




Pollution Prevention for a coating process is the same as any other manufacturing process. It is all about maximizing the utilization of raw materials and other inputs into the final product. As the efficiency of the process increases wastes and per unit costs decrease. This relationship is the fundamental building block for improving any manufacturing system. An even better system would utilize renewable raw materials, or at least allow for recapture of non-renewable components back to the manufacturing process. An example of a Co-product from this system may to reclaim the clean powder coating to coat other work pieces.

# Pollution Prevention Opportunity Hierarchy

- Tier 1 opportunities
  Raw material substitution
  Process efficiency/process control
- Tier 2 opportunities
  Recovery and reuse
- Tier 3 opportunities
  Recycling

Tier 1 represents the basic and truest P2 options, such as why is the coating needed, how much is needed, is there a better substitute.

Tier 2 options should be derived only after exhausting viable Tier 1 options. Tier 2 opportunities may alsor be short term steps on the way to implementing a Tier 1 option in the future.

Tier 3 options are again subordinate to Tier 2 opportunities.

## Tier 1 options

- Reduce or eliminate coating
- Substitute raw materials to minimize adverse health and environmental affects
- Process changes to reduce batch or line wastes

GOLD

Product design is often not as difficult or costly as perceived within an industry or industry sector. An example of this is colored concrete products. Coating architectural concrete can be difficult at best.  A simple product redesign of introducing different colored aggregate components can be used to produce colored concrete that requires no coating at all.

Secondly by analyzing the minimum requirements for the coating may yield opportunities to change either the entire coating or at least one or more of the hazardous components.

For example a coating system might use mercury as a fungicide for example, this can be substituted with other other options without affecting the coating quality.

Process change options can range from narrowing the different colors or types used to things like dedicating lines to certain types to reduce line flushing or mixing coatings in the largest possible batches to reduce clean-up wastes

## Tier 2 options

- In-process capture and reuse of raw material
- Recovery of components for introduction into other products
- Reduction of secondary inputs (water, energy, filters, cleaners,……)

SILVER

Tier 2 options are opportunities that are pursued after maximizing the efficiency of the process. Once this has been accomplished, any resultant waste streams should be analyzed for reintroduction into the intended product. After that reintroduction into products made by the facility. The reduction of secondary inputs could be considered a Tier 1 option if they are major impacts for a facility. It would be hard to argue that energy use is not a major factor for a lot of coating facilities, but it would not usually be the deciding factor in choosing one coating over another. Tier 2 options may need to be assessed after analysis for a change in coating. Most dramatic savings in emissions and costs are achieved by changing the coating or greatly increasing efficiency, after that change, the effect on secondary inputs such as filters, or clean-up or energy may be very different.

# Tier 3 options

- Minimizing packaging and container waste
- Recycling components for alternative products or industries

BRONZE

Tier 3 options should not be forgotten and are almost always areas where any facility will still have opportunities for improvement. They may also be effected by making more major changes in the way a process is operated.

Case studies
Saturn: waterborne paint
General Extrusions: powder coating
Daimler Chrysler: high solids
John Deere: chromate elim.
Centria: high solids coating, chromate

These are just a few case studies that I would like to discuss following our brief introduction to coatings P2. There are numerous case studies available but I wanted to highlight where industry is making strides in reducing coating related wastes.

# Case Study Centria Coatings

High solids coating

Dry in-place chromate coating

Elimination of chromate baths and rinses

Large reduction in waste water generation

This was a P2 assessment of an Ohio facility completed with the assistance of Jim Sferra of SEDO. Centria will have some opportunities to increase the solids content of its present roll applied coatings. Centria has already implemented an elimination of chromate conversion baths and gone to a dry in-place chromate coating utilizing a UV flash lamp process.

# Saturn Waterborne Paint

**Paint ingredients**

Saturn was the first automotive plant to start-up with "waterborne" basecoat paints, the paint layer which gives color to the vehicle exterior.

Previously, paints contained 7-11% HAPs and 9-14% Toxic Chemical ingredients. Five recently-adopted environmentally preferable base coat paints contain less than 1.5% HAPs and less than 2% Toxic Chemicals.

Changes have resulted in significant benefits, including:

1. Improved productivity, first-time quality and uptime (fewer parts to re-paint)
2. Improved safety due to decreased use of hazardous chemicals
3. Cleaner paint booth environment
4. Reduced use of booth clean up materials
5. Reduced costs for paint, clean-up, and waste management

**The Pollution Prevented:** Improvements included approximate reductions of **146 tons** per year of air emissions, **167 tons** per year of solid waste,and **455 tons** per year of hazardous materials. Saturn waterborne paint p2 award

Saturn has been an a forerunner of modifications at existing automotive facilities. Saturn started up with water borne coatings but have made excellent strides in reducing the hazardous air pollutants in their coating.

# John Deere

**John Deere Engine Works** (Waterloo, Iowa)
used computer simulation software to evaluate and improve paint adhesion to aluminum components.

Tests narrowed the variables to three: chromate conversion, paint type, and surface treatment.

The results identified paint type as the major problem.

As a result, John Deere solved its paint adhesion problem and eliminated the chromate-conversion pretreatment process from aluminum parts—a change that has saved the company nearly $500,000 annually.

Mills, Wayne. DOE Software Saves John Deere Money & Time, **PCI**, September 1995

Even though John Deere has been less than forthcoming with the type of paint that they switched to. This case study is significant for 2 other reasons. First they evaluated their process without interrupting production, which some facilities may not see as an option.

Secondly, by testing various scenarios, they were able to eliminate an entire coating from the process and realize a significant cost savings.

# General Extrusions

General Extrusions, Incorporated (GEI) , Youngstown,

aluminum extruding facility with more than 300 employees. GEI extrudes, fabricates and finishes parts for communications equipment,office furniture, heavy duty equipment, computers, appliances, medical equipment, and more.

GEI met the goal for a 90 percent reduction in solvent waste generation in mid 1995 with the installation of the powder coating line and removal of the wet spray line.

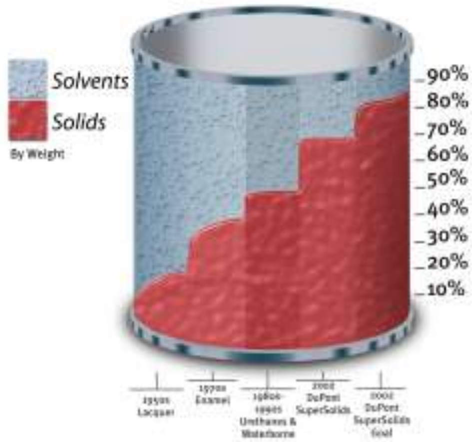
By converting to a powder coating line, GEI reduced VOC emissions from a baseline of 4,100 pounds in 1992 to 0 pounds in 1998.

**http://www.epa.state.oh.us/opp/gov/genextrusion.pdf**

General Extrusions was a 1999 Governors Award winner for pollution prevention. It is an excellent example of a medium sized coating facility that replaced their wet spray lines with powder coating and virtually eliminated all VOC emissions for the facility. Their case study is attached in your handouts.


High solids coating offer P2 benefits regardless of the vehicle base. Du Pont and Chrysler are pushing the solids envelope from the current standard of 50% solids into the 65 to 80% range. This could be significant for a lot of facilities to be able to make massive VOC reductions without initially changing their equipment. This also was achieved by reducing the viscosity of the coating without additional energy inputs such as heating or additional pumping.

# Increasing Solids Content
## *Toward Ultra-Low Emissions*




A breakthrough in Automotive Coatings

DuPont SuperSolids Technology

25% reduction in V.O.C. emissions.
Also reduces scratch & mar
as much as 50%

DUPONT
*The miracles of science*

# Available Ohio Case Study materials

Technical Assistance involving coatings recommendations

**Ansell Edmont**- solvent substitution, CO2 cleaning

**Glidden**- filtration, product re-use

**Aerolite**- application efficiency - electrostatic application

**Kenworth**- cleaning, water reduction

**Premier Coatings**- dip coatings, water based coatings

**Seneca Wire**- cleaning, phosphate elimination

**Midwest Express**- application efficiency, product recovery

**Centria Coatings**- high solids coatings

# Calculating the true cost of a coating

- Cost is not a per gallon or pound slam dunk!
- Cost is variable based on the system used for preparation, application, curing and clean-up.
- Total costs involve all variables, including energy costs, health and safety costs, liability, waste treatment…….

For our exercise portion of this presentation I want you to refer to the PPRC handout in the back of the book. The main point I want to stress from this exercise is that the cost of a coating is not simply it's cost per gallon or pound from a supplier. It is a function of the amount of surface that the coating can cover to the desired finish and thickness. Also costs are often not accurately measured by facilities and this exercise has become integral to many other types of assessments that we do all the time. There is also a stand alone presentation on the **true costs of wastes on the OPP Home Page**.

# Cost calculation exercise/handout

**Determine Costs Per Volume of Paint Solids NOT Price Per Gallon**

**Step 1: Figure Cost of Paint Solids**

***Example:*** **If a paint product costs $15 per gallon and contains 33 percent solids then you**

**would divide 15 by .33. 15 divided by .33 = $45.45, the cost per gallon of the paint solids.**

**Step 2: Figure Ideal Paint Cost Per Square Foot**

***Example:*** **($45.45 per gallon of solids) x (2 mils finished film thickness) x (0.0006233 conversion factor) = 5.7 cents per square foot, assuming an ideal 100 percent transfer efficiency.**

The preliminary steps are to calculate the cost per unit area (in this case per square foot). This is found by calculating the solids x the cost per gallon to find the coating capability. Remember the finished coating is a solid!

## Cost calculation exercise/handout

**Step 3: Figure Actual Paint Cost Per Square Foot**

***Example:*** **A paint operation has an estimated transfer efficiency of 50%. Take the 5.7 cents**

**calculated for 100% transfer efficiency and divide by .50 to determine actual coating cost.**

**(5.7 cents per square foot) divided by (.50 transfer efficiency) = 11.4 cents per square foot.**

**Step 4: Figure Total Cost of Painting Manufactured Product**

***Example:*** **A flat panel part has an area of 10 square feet. Multiply your cost per square foot**

**times the square footage of the part. (11.4 cents per square foot) x (10 square feet) = $1.14 per**

**part. (Note: For parts that are oddly configured, estimate square footage.)**

Secondly you take the cost per unit area and calculate the surface area of the part to be coated. This procedure would be key for a facility to make correct informed decisions about the cost savings of making a coating change.

## Case Study: Coating Change Cuts Production, Regulatory Costs

A Seattle-based company investigated low-solvent coatings to avoid the Title V Air Operating Permit process. Avoiding the permit and its costs was the primary motivator, but the company did not want increased painting costs either.

The company was using a **$13 per gallon** paint with **35% solids** content and had identified an adequate replacement paint that cost **$20 per gallon** and had **60% solids** content.

The company applied the formula detailed on this fact sheet to compare the cost of paint as it is applied to parts rather than compare the cost per gallon. Calculations showed the low-solids paint cost **$2.31 per square foot**, while the high-solids paint would cost only $**2.08 per square foot**. The company paints **50 square feet** of surface area per part. Switching coatings saved the company **$11.50 per part**.

This case study demonstrates the savings that are not obvious by any other method. A 13$ per gallon paint is not necessarily cheaper than a 20$ per gallon paint. This exercise could also be used easily for comparing solvent borne vs water borne. The important thing to remember is to be inclusive of all associated costs when comparing alternatives.

On-line Pollution Prevention Training for Coating Facilities

***Section 2 Coating Operations Efficiency***

Once the proper pretreatment occurs and the best coating material is selected, the paint or coating still must be placed on a part effectively and efficiently

## Does Application Efficiency Matter??

Only if a company is interested in finish quality and keeping production costs, including material and waste costs, low.

## Why is it important?

- Low application efficiency =
  - Wasted raw material
  - Increased material costs
  - high waste generation
- High application efficiency =
  - Waste reduction
  - Lower production costs
  - Better work environment
  - Reduce regulatory burden

Coating application effects raw material usage, waste generation and production costs.

Low application efficiency means less coating is getting on the part and more is going elsewhere, like as hazardous waste or air emissions.

This means wasted coating, increased costs and higher waste generation

Increasing application efficiency will in turn lower production and waste costs, create a better work environment and reduce regulatory oversight.

## Terms & Concepts

- Viscosity
  - Coatings resistance to flow, affected by temp. and composition
- Overspray
  - Any coating that misses the part
- Atomization
  - The breaking up of coating into fine particles or droplets

Viscosity is a coating resistance to flow, affected by temp. and composition…viscosity can effect paint gun selection and application efficiency

Overspray is basically any coating or paint that misses the part

Atomization is the breaking up of coating into fine particles or droplets to be applied to the part…atomization requires energy to break into particles

# Terms & Concepts

- Mil thickness
  - Is the common measurement of a coating
  - 1 mil=1/1000 of an inch (1/4″=250 mils)
  - Measure mil with gauges
    - Wet Film Thickness Gauges or dry film electronic gauges (more accurate but more $$$)

Mil or mil thickness is the common measurement of a coating. One mil equals 1/1000 of an inch.

A 1/4" equals 250 mils. Coatings when applied before drying are measured in wet mils.

To determine the dry mil of actual remaining product, the solids content and rate of coverage must be known to estimate the dry mils.

A mil gauge is commonly used on the job site to measure wet mils during application to adjust the spread rate for proper film build. Wet mils are always measured at 100% solids on the chart.

## Terms & Concepts

- Transfer efficiency (TE)
  - Is the measure of how much paint/coating actually *goes on the product*, compared to *how much is sprayed*
- Film build efficiency (FBE or BE)
  - Measure how close mil build applied meets targeted dry-film thickness

In plain terms, TE is a measure of how much coating is deposited on the part compared with the total amount sprayed, and is an indicator of the amount of wasted material in a coating operation

BE is the measure of how close and consistent the actual film applied to a part is to the desired dry film thickness.

# Application Efficiency

- 4 Components
  - Finish Quality
  - Film Build Efficiency
  - Transfer Efficiency
  - Waste Coating Material

(Iowa Waste Reduction Center, 2003)

# Finish Quality

- Critical aspect of application efficiency
  - Difficult to quantify
  - TE & BE mean nothing w/o good finish quality

Finish quality is evaluated by its acceptability to the customer and is the most important consideration in application efficiency.

The amount of care used to optimize TE and BE will not matter if an unacceptable finish is produced. Part rework causes excessive VOC emissions from stripping and refinishing and generates waste in discarded materials and parts.

Poor finish quality costs companies money because of the waste of time, materials, and energy, as well as costs for waste disposal, maintenance, and the potential increased regulatory burden.

Using good coating technique can decrease the reject rate of parts

(see Section 4.1.3). Chapter 4-Spray Guns and Application Efficiency, CDPHE

# Excess mil build costs

- Desired mil thickness = 2.0
- Cost per gallon = $40
- 3.5 lbs VOCs per gallon

| Build (mils) | % of Target Build | Gallons Required | Coating Cost | VOC Emissions (lbs) |
|---|---|---|---|---|
| **2.0** | **100%** | **50** | **$2,000** | **175** |
| **3.0** | **150%** | **75** | **$3,000** | **263** |
| **4.0** | **200%** | **100** | **$4,000** | **350** |
| **5.0** | **250%** | **125** | **$5,000** | **438** |
| **6.0** | **300%** | **150** | **$6,000** | **525** |

(Iowa Waste Reduction Center, 2001)

As mentioned earlier, Film Build Efficiency is a measure of how close dry mil thickness applied meets the targeted dry film build.

This chart indicates how excess mil build can effect coating costs and waste generation.

# What is TE?

The ratio of the mass of solid coating deposited on a substrate to the mass of solid coating used during application. It can be defined in terms of volume.

$$TE = \frac{\text{Volume of solids coating deposited on Part}}{\text{Volume of solids coating used/sprayed}} \times 100\%$$

This is a more specific definition of Transfer Efficiency. It is measured in % like Film Build Efficiency.

It can be measured using a weight or volume method.

But,

# Cost of Inefficiency

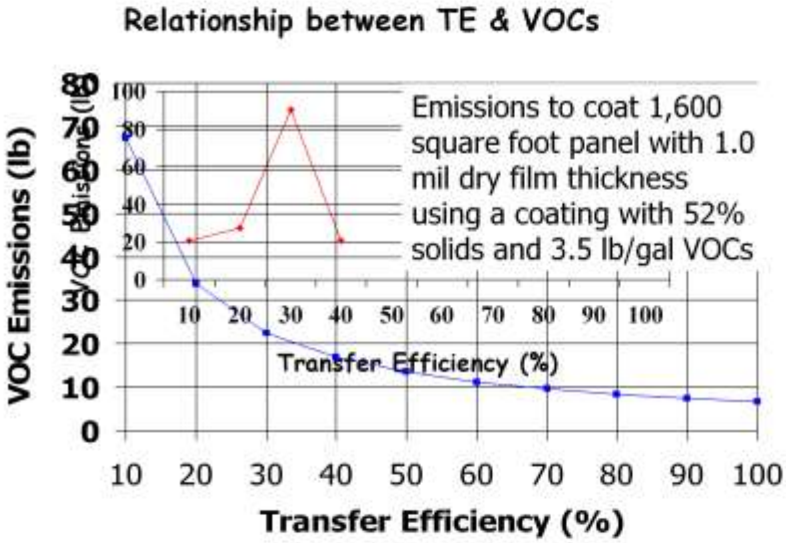
- At $30/gallon
  - A 55-gallon drum of material cost $1,650
- At 30% transfer efficiency
  - 39 of the 55 gallons are waste
  - Overspray and excessive air emission
  - $1,115 of each drum is wasted

(Iowa Waste Reduction Center, 2003)

# Cost of Inefficiency

- Ideal coating process
  - 100% efficient spray process
  - 100% solids
  - 1 weight unit require to paint part
    - All paint on part
    - No Waste!!
- Typical process
  - 50% efficient spray process
  - 50% solids
  - 4x more paint needed for same part
  - 3x amount of paint on part is waste
    - 10 oz. of paint on part
    - 40 oz will be sprayed
    - 30 oz of emissions & overspray

# Relationship between TE & VOCs



# TE in Ohio

- The Airolite Company
  - Manufactures aluminum and steel architectural louvers
  - 8 paint booths
- Equipment change
  - Change paint guns to increase TE
  - HVLP to electrostatic HVLP guns

# TE in Ohio

- Increasing Transfer Efficiency from 20% to 65% (estimated)
  - **$333,000 -** This is more than a 50% reduction raw material (painting) losses
  - **50% less paint would be purchased and used** (7,400 gallons x .50) = 3,700 gallons/year
  - 3,700 gallons x $100 per gallon = **$370,000** annual paint savings
  - *Education & Training must be included

# Transfer and Build Efficiencies

- Paint consumption=100 gallons at 100% TE and BE
- Coating cost=$40/gallon

**Film Build Efficiency %**

| Transfer Efficiency % | 300 | 250 | 200 | 150 | 100 |
|---|---|---|---|---|---|
| 10 | $120,000 | $100,000 | $80,000 | $60,000 | $40,000 |
| 20 | $60,000 | $50,000 | $40,000 | $30,000 | $20,000 |
| 30 | $40,000 | $33,333 | $26,667 | $20,000 | $13,000 |
| 40 | $30,000 | $25,000 | $20,000 | $15,000 | $10,000 |
| 50 | $24,000 | $20,000 | $16,000 | $12,000 | $8,000 |
| 60 | $20,000 | $16,667 | $13,333 | $10,000 | $6,667 |
| 70 | $17,143 | $14,286 | $11,429 | $8,571 | $5,714 |
| 80 | $15,000 | $12,500 | $10,000 | $7,500 | $5,000 |
| 90 | $13,333 | $11,111 | $8,889 | $6,667 | $4,444 |
| 100 | $12,000 | $10,000 | $8,000 | $6,000 | $4,000 |

(Iowa Waste Reduction Center, 2003)

# Factors affecting Efficiency

- Spray Gun & Booth Design
  - Spray gun design & atomization method
  - Nozzle size
  - Air velocity
  - Lighting & space constraints
- Operation conditions
  - Coating composition
  - Part size & geometry
  - Spray pattern
  - maintenance
- Spray Technique
  - Gun-to-part distance
  - Overlapping gun passes
  - Lead & lag triggering times
  - Speed of spray gun travel
- Operator conditions
  - Worker fatigue
  - Worker attitude & training

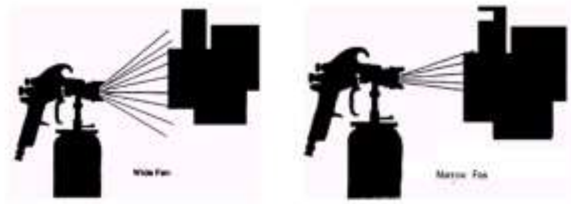



Figure 9-3. Effect of fan width.

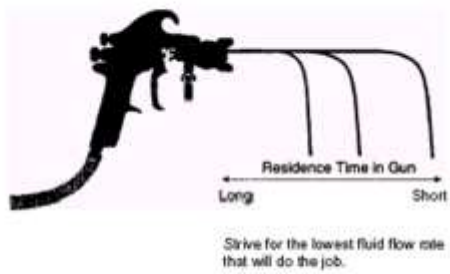



Figure 9-2. Effect of fluid flow rate on residence time in gun.

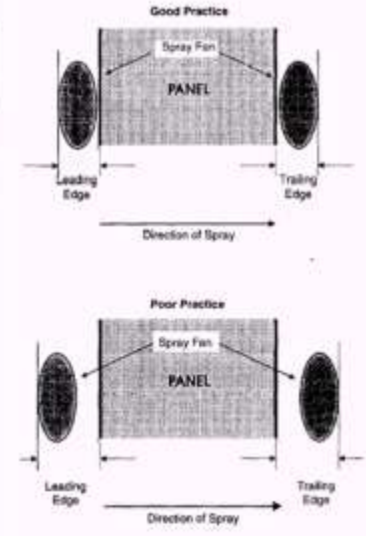



Figure 9-4. Effect of leading and trailing edges on transfer efficiency.

Pollution Prevention in the Paints and Coatings Industry, EPA/625/R-96/003

## Operator Technique

- Inspect size & shape of spray pattern
- Keep pattern on the part
  - Spray pattern should fit part (don't spray the air)
  - Trigger the gun
- Maintain good gun-to-target distance

(Iowa Waste Reduction Center, 2003)

## Operator Technique

- Keep gun square to part surface
- Maintain proper overlap
- Develop consistent plan of attack
  - Documentation
  - Measurement
  - Maintain process control

(Iowa Waste Reduction Center, 2003)

## Training Really Works!!

- Ethan Allen Furniture, North Carolina
  - Developed 3-stage training program
    - Operators were video taped
    - Review tapes to ID improvements
    - Taped again to compare & observe improvements
- Projected savings $50,000-70,000 due to 8-10% less materials used

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center

**Ethan Allen Furniture Case Study**

Old Fort, North Carolina

Ethan Allen has a training program for spray operators that utilizes videotaping as a operator training tool. The training consists of three stages:

1- Operators are videotaped while performing their job (It is important to communicate the purpose of the taping to the operators before video taping starts so that there are no misunderstandings.)

2- The operators in groups of three, along with their supervisors and technical personnel, review the tapes in one-hour sessions in order to identify ways to improve. Instruction on spray techniques is provided during the session

# Table 1 (Pre-Training Results)

| Operator | Material Consumption (lbs) | TE (%) | FBE (%) | Finish Quality #Visible Defects (major/minor) |
| --- | --- | --- | --- | --- |
| #1 | 0.913 | 41.5 | 138 | 6 major-excessive dry spray on all panels |
| #2 | 0.749 | 44.4 | 119 | 3 major (dry spray), 7 minor |
| #3 | 0.633 | 49.5 | 116 | 0 major, 9 minor |
| #4 | 0.719 | 51.7 | 136 | 3 major, 3 minor |

Industrial Paint & Powder, July 2000

# Table 2 (Post-Training Results)

| Operator | Material Consumption (lbs) | TE (%) | FBE (%) | Finish Quality #Visible Defects (major/minor) |
|---|---|---|---|---|
| #1 | 0.404 | 60.7 | 74 | 6 minor |
| #2 | 0.454 | 62.4 | 82 | 6 minor |
| #3 | 0.433 | 61.6 | 86 | 4 minor |
| #4 | 0.446 | 77.5 | 98 | 5 minor |

Industrial Paint & Powder, July 2000

## Table 3 (Comparison Summary)

| Operator | Reduction in Material Consumption | Increase in TE Points | % Increase in TE | % Points from 100% FBE Pre-training/Post-training |
|---|---|---|---|---|
| #1 | 56% | 19.2 | 32% | 38/26 |
| #2 | 39% | 18.0 | 29% | 19/18 |
| #3 | 32% | 21.1 | 20% | 16/14 |
| #4 | 38% | 25.8 | 33% | 36/2 |

Industrial Paint & Powder, July 2000

# Coating P2 Resources

- Sector based resources
- General resources
- P2 organizations
- Manufacturers/ vendors
- Search strategies

On-line Pollution Prevention Training for Coating Facilities- Section 3

There is often no set way of finding where the most valuable pollution prevention resources for a given sector or topic area will come from. To be honest, often the best resources for a given situation may  come from unexpected places. For paintings and coatings good sources of information are everywhere. There is more of a problem of finding current P2 projects, because technology is changing rapidly in a number of areas. Let's just look at a short list of resource areas.

## Source Category: Auto-Refinishing

Note: Reported VOC Ranges are in lbs/gal for liquid coatings and % weight for powder coatings.

| Process Step (*) | Possible Low-VOC Coating Options | Reported typical VOC Ranges |
|---|---|---|
| Pretreatment Wash Primer | Specialty [9] | 6 to 6.3 [9] |
| Primer | Epoxy Ester (SB) [9] | 4.5 [9] |
| Primer | Two-Component Epoxy (SB) [9] | 4.2 to 4.8 [9] |
| Primer | Two-Component Epoxy (WB) [9] | 1.2 [9] |
| Primer Sealer | Two-Component Urethane (SB) [9] | 4.38 to 5.3 [9] |
| Primer Surfacer | Specialty [9] | 4.5 [9] |
| Primer Surfacer | Two-Component Urethane (SB) [9] | 4.75 to 5.3 [9] |
| Primer Surfacer | Urethane Dispersions (WB) [9] | 1.2 [9] |
| Topcoat | Acrylic (SB) [9] | 4.6 to 5.0 [9] |
| Topcoat | Specialty [9] | 5.82 to 6.92 [9] |
| Topcoat | Two-Component Urethane (SB) [9] | 3.5 to 5.0 [9] |
| Topcoat | Urethane Dispersions (WB) [9] | 3.42 to 4.41 [9] |
| Clearcoat | Two-Component Urethane (SB) [9] | 4 to 4.2 [9] |

(*) "Not Specified" indicates no listed process steps for which this coating is typically used in this source category.

**CAGE**

This is one of the sector pages from the coating alternative guide CAGE.

As you can see there are straight forward recommendations for minimizing VOC emissions by changing to available coatings.

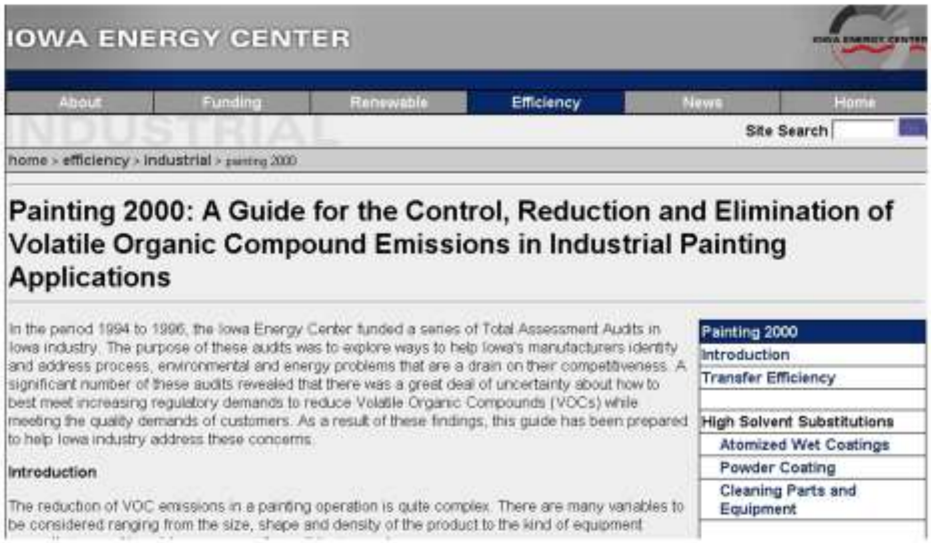

www.paintcenter.org

Another good source are trade association sites where vendors and coating facilities share information and expertise. It is good to check out more than one of these areas, because each individual “expert” has their own biases or “Silver Bullet” as to what a best practice really is. There are quite a number of these and more are listed in your handouts.


www.coatingstech.org

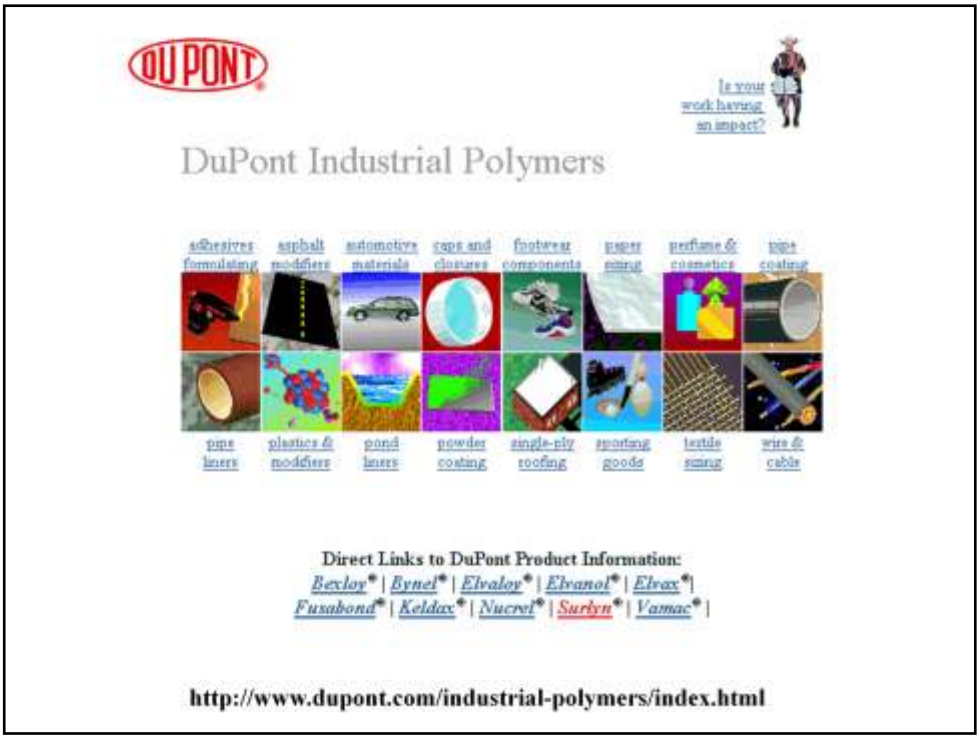
This is a nice research oriented site which might be a little complicated for some facilities but gives some good research based direction for the industry.


There are a number of our P2 organizations which have good sector information. One that is sometimes overlooked are also the military P2 sites like DENIX.

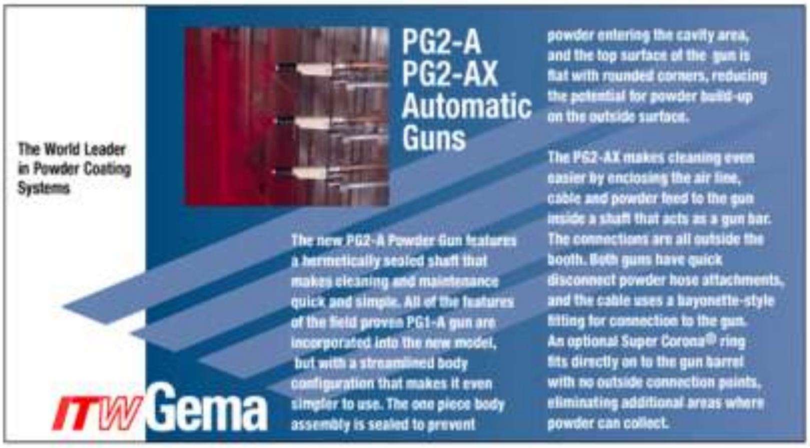



http://www.energy.iastate.edu/efficiency/industrial/p2k-index.html

A good example of a good resource that was found while looking for other information. While looking for energy efficiency information. I found a three year comprehensive P2/E2 study of painting facilities. They had good site visit/survey based information from real coating facilities.




Manufacturers and Vendors are also excellent sources of information. Even though they are obviously biased toward their products, by looking at several there are clearly trends that become evident by looking at their case studies and new products.

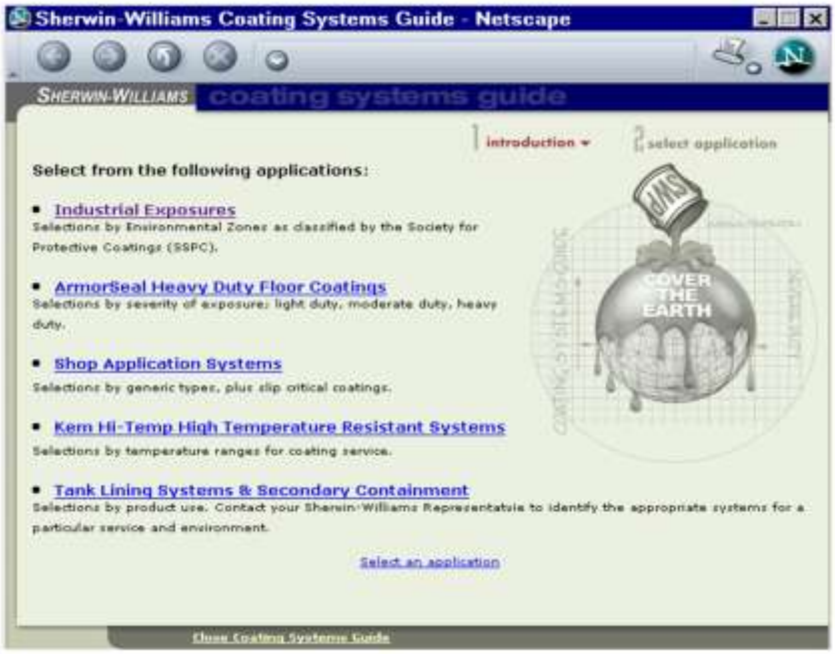



http://www.itwgema.com/

This is true for equipment vendors as well.


http://corporate.ppg.com/ppg/corporate/default.htm

Each site poses it’s own challenges for finding a particular sector or application.




http://www.sherwin-williams.com/industrial-marine/default.asp#

This was a nice tool that selected coating choices by defining the environment in which the coating would be used.


Another important angle for this sector or any other is to research waste reductions for the associated waste. In this case by looking for VOC reductions it led to tools for specific industries like painting and coating.

## Zero VOC Paint Manufacturers

| | Type of Coatings | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Manufacturer | Flat | Non-Flat, Satin | Non-Flat, Eggshell | Non-Flat, Semi-Gloss | Primer, Sealer, Undercoater | Interior | Exterior | Phone Number |
| American Formulators Manufacturers | X | | X | X | | YES | | 619-239-0321 |
| Benjamin Moore & Co. | X | X | X | X | X | YES | | 213-722-3484 |
| Browning Paints | X | X | X | | | YES | | 800-872-3636 |
| Devoe Paint | X | | X | X | X | YES | | 800-654-2616 |
| Dunn Edwards | X | | X | X | X | | | 213-771-3330 |
| Frazee Industries | X | X | X | X | X | YES | | 619-276-9500 |
| Galaxy-2010 | X | X | X | | | YES | YES | 973-790-7641 |
| Griggs Paint & Silkscreen | X | X | X | X | X | YES | YES | 602-243-3295 |
| ICI Paints | X | X | X | X* | X | YES | YES | 213-888-8888 |
| Miller Paint | X | X | X | | X | YES | | 503-255-0190 |
| NonToxiCA | X | X | | | | YES | YES | 800-751-3087 |
| Richards Paints | X | X | X | | | YES | | 800-432-0983 |
| Rodda Paints | X | X | X | | X | YES | | 503-244-7512 |
| Sampson Coatings | X | X | X | X | X | YES | YES | 804-233-8325 |
| Sherwin Williams | X | | X | X | X | YES | | 800-336-1110 |
| Spectra-Tone Paint | X | | X | X | | YES | | 800-272-4607 |

* : Not Available for Exterior Use

Which leads to vendors of low VOC coatings


Another resource particularly for staff at a facility is to attend a formal training in advanced manufacturing/waste reduction. Helen mentioned PACE, but there are others such as this institute at Eastern Michigan University.

Short Course Schedule

| | | | |
|---|---|---|---|
| Coatings and Paint Technology | March 18-20, 2003 | $1,050 | Halle Library, EMU Campus |
| Additives in Coatings | March 25-27, 2003 | $1,050 | Halle Library, EMU Campus |
| Mixing for Uniform Batches | April 1-2, 2003 | $850 | Halle Library, EMU Campus |
| Waterborne Coatings | April 8-10, 2003 | $1,050 | Halle Library, EMU Campus |
| Color Design and Technology | April 29-May 1, 2003 | $890 | EMU Livonia Campus |
| Improving Durability and Performance of Coatings | April 29-May 1, 2003 | $1,050 | Halle Library, EMU Campus |
| Patents and Patenting Workshop | May 8-9, 2003 | $990 | Halle Library, EMU Campus |
| Small Particle Formation | May 15, 2003 | $650 | Halle Library, EMU Campus |
| Polymers for Coating Technogists | May 20-22, 2003 | $1,050 | Halle Library, EMU Campus |
| Rheology of Coatings and Dispersions | September 29-October 1, 2003 | $1,090 | Halle Library, EMU Campus |
| Coatings and Paint Technology | September 30-October 2, 2003 | $1,050 | Halle Library, EMU Campus |
| Waterborne Coatings | October 6-8, 2003 | $1,050 | Halle Library, EMU Campus |
| Particle Based Materials Synthesis | October 16, 2003 | $650 | Halle Library, EMU Campus |
| Nanoparticle Synthesis | October 17, 2003 | $650 | Halle Library, EMU Campus |
| Dispersion of Pigments and Resin in Fluid Media | October 20-22, 2003 | $1,090 | Halle Library, EMU Campus |

Facilities can really learn what the capabilities are for coating technology and strategically plan for modification of their process in the future.

# Painting and Coatings Industry P2 checklist:

www.sbeap.org/ppi/publications/paintings_and_coating_industry_p2_checklist.PDF

*Kansas Small Business Assistance Program June 2001 1-800-578-8898*

Finally I would like for you to briefly take a look at the P2 checklist from Kansas Small Business Environmental Assistance Program. They have what we felt was a concise list of possible P2 opportunity areas. I would think this would be a good starting point for identifying suggestions for a facility.

http://www.sbeap.org/ppi/publications/paintings_and_coating_industry_p2_checklist.PDF

*Kansas Small Business Assistance Program June 2001 1-800-578-8898*

**Painting and Coatings Industry P2 checklist:**

***Surface Preparation***

•Utilize "just-in-time" ordering practices to minimize need to use oils on parts while in storage.

• Reduce solvent evaporation by installing tank lids, increasing freeboard space, and installing freeboard chillers in conventional solvent vapor degreasing units.

• Use aqueous solutions or mechanical methods.

• Maximize mechanical or aqueous cleaning processes.

• Use less toxic solvents.

• Use countercurrent washes.

• Use non-caustic paint removers.

***Coating Application***

• Substitute waterborne, powder, or high-solids paints for solvent-borne paint .