Caterpillar finishes have to be tough to withstand harsh working conditions.

Recovery, Reclamation & Recycling Of Water-washed Overspray Paint

By George M. Mitchell and John M. Spangler

Responding to a need for reducing wastes and becoming more efficient with spray paint applications, Caterpillar's East Peoria, IL, plant has developed a proprietary process for recovering and recycling overspray paint. Here, the authors discuss events and studies that led them to the process, current uses of the reclaimed paint products, and the potential for such systems and products in the future.

If your finishing operation is like most others, you've experienced the environmental concerns that have come to the forefront over the past several years. As a result, you've probably had to re-evaluate your coating processes, considering both the environment and the regulations intended for its protection.

The current law and the prospect of new environmental regulations unquestionably have had the effect of stimulating technological innovations in the coatings industry. Evidence of this is easily recognizable when you consider the expansion of applications for powder, waterborne, and electrodeposition coatings.

All of these more "eco-friendly," lower-VOC technologies have certain endemic advantages and limitations. Where a powder might be the coating of choice for the manufacturing of office furniture, it's not a reasonable option for painting most components fabricated in the heavy equipment industry. As might be expected, it is impractical to heat parts weighing several thousand pounds to more than 300 °F.

With these kinds of trade-offs in mind, Caterpillar's East Peoria plant chose a unique way to manage a specific environmental dilemma inherent in some of its operations.

Some History Of Spray Paint Systems

With regard to liquid spray booth coatings—the most common and traditional application method—a major environmental weakness is readily evident. Hand-spray operations generate a large amount of overspray waste. Not very long ago, the transfer efficiency for spray systems (the percentage of paint particles sprayed actually reaching and adhering to a piece being painted) was about 30 to 50 percent. With the widespread introduction of modern electrostatic spray technology in the 1980s, efficiency was improved significantly by 10 to 30 percent. While certainly an advance in the minimization of overspray waste, this new equipment left even the most efficiency-conscious operations wasting about half of all the paint they purchased for their products. The practice of paying someone to dispose of a costly product required for production is neither a good nor long-term solution to the problem.

Overspray paint byproduct generated in paint spraying operations usually takes the form of either a liquid sludge or semi-cured product embedded on dry filter media. Articles in trade journals routinely compare the current cases for and against each of these methods. Should your company plan to install a new paint system, these publications should be reviewed, because proposed and existing environmental regulations are destined to be of even more concern in the coming years.

Variations of two booth designs are used to collect overspray from spray

The spray application of paint has certain endemic advantages and disadvantages. The prospect of disposing of byproduct overspray paint prompted Caterpillar Inc.'s East Peoria, IL plant to develop ways to recover and recycle this material into useful paint products, including coatings for new Cat products that they produce.

application operations, and they are generically referred to as either a water-wash or dry filter design.

Paint booths that incorporate dry filter media to catch paint overspray are usually favored for lower paint consumption lines. This scheme requires a low capital investment relative to water-wash systems, and is quite simple in design. The filters act to remove airborne paint particles by capturing them as they are forced through a dry filter media. Ease of replacing a relatively low number of loaded filters produced by smaller operations makes such an approach a sensible alternative in these instances. As spray volume increases to higher levels, however, more frequent filter replacements are required.

For higher volume operations, very frequent dry filter changes that can be required may cause resulting labor and material costs to become a much more significant factor in the cost/ benefit equation. The intuitive alternative of heavily loading dry filters before replacing them isn't realistic, because among other reasons, inefficient dry filters allow paint particles to escape, and ventilate up the stack into the outside air. As various businesses have discovered, unconstrained, airborne droplets of live paint can find their way to many undesirable outdoor surfaces (*e.g.*, cars sitting in the plant parking lot).

With higher maintenance expenses factored into system design decisions, high-volume applicators are more apt to consider the benefits of the water-wash paint booth. Water-wash systems capture oversprayed paint by using positive air pressure to force the particles into a cascading curtain of water. As a result of being captured in a water curtain, uncured particles of paint accumulate and form a sticky, uncured agglomeration of overspray material in the bottom of the water-wash pit, usually located beneath a grating on which painters stand.

The water-wash design is significantly more efficient than dry filter systems, because it captures a higher percentage of oversprayed particles. Although water-wash installations are more capital intensive than the dry filter technology, for the above reasons they remain the design of choice for many large-volume users of sprayed paint coatings.

Regulatory Changes

The water-wash design, because of its high efficiency and wet byproduct characteristics, has faced substantial challenges with the promulgation of more restrictive landfill regulations in 1993 (commonly referred to as the "Landban" regulations). Prior to that, liquid non-hazardous special wastes, such as water-wash paint sludge, could be disposed of in approved landfills with little, if any, preparation. With the new protocol, a definition is stipulated for "liquid" wastes that classifies any material as liquid that will exude droplets of liquid through a standard conical paper paint filter within a prescribed period of time. All material not passing this test is deemed liquid and, as such, is banned from landfill disposal. This regulatory evolution presented a new and significant challenge to generators of water-wash paint sludge.

Some manufacturers have opted for different disposal methods, such as incineration or fuel blending, of water-wash sludge. Most, however, still favor landfill disposal of this non-hazardous material, even with the newly added processing costs.

Caterpillar's Case Study

Caterpillar's East Peoria facility faced its own environmental manufacturing dilemma in 1990, when the plant's environmental coordinator took notice of imminent regulatory changes in landfill restrictions for liquid wastes. Water-wash paint sludge was quickly identified by the facility's environmental team as one of the plant's largest volume waste streams and, as such, was targeted for reduction.

The initial strategy for dealing with this problem was one seen throughout industry—to reduce the generation of byproduct at the source. To accomplish this, electrostatic spray equipment was installed in all plant spray booths in an effort to increase spray transfer efficiency, and decrease the quantity of overspray produced.

Unfortunately, in Caterpillar's situation, a variety of difficult part geometries limited the overall efficiency improvement to a meager 10 percent, and as with all source reductions, increasing process efficiency still means that material is being wasted, just at a lower rate.

The next step involved efforts to "dewater" paint sludge material on a continuous process basis. The goal was to remove water from the sludge to the point where material collected would pass the required paint filter test. If successful, this could have reduced or eliminated the current practice of occasional batch cleanouts that required stopping production on the paint line for 10-12 hours. Though numerous dewatering devices were tested to concentrate the sludge on-site in the spray booth, none produced significant yields of dewatered sludge material, so this approach was abandoned.

The main impediment to the success of this effort was that spray booths were not designed to channel accumulated paint sludge to any specific location. No reliable method of underwater material collection could be designed to overcome the existing booth's lack of suitability for continuous sludge collection.

Semi-annual, manual batch collections of paint sludge would clearly have to continue as long as this style of booth was in production.

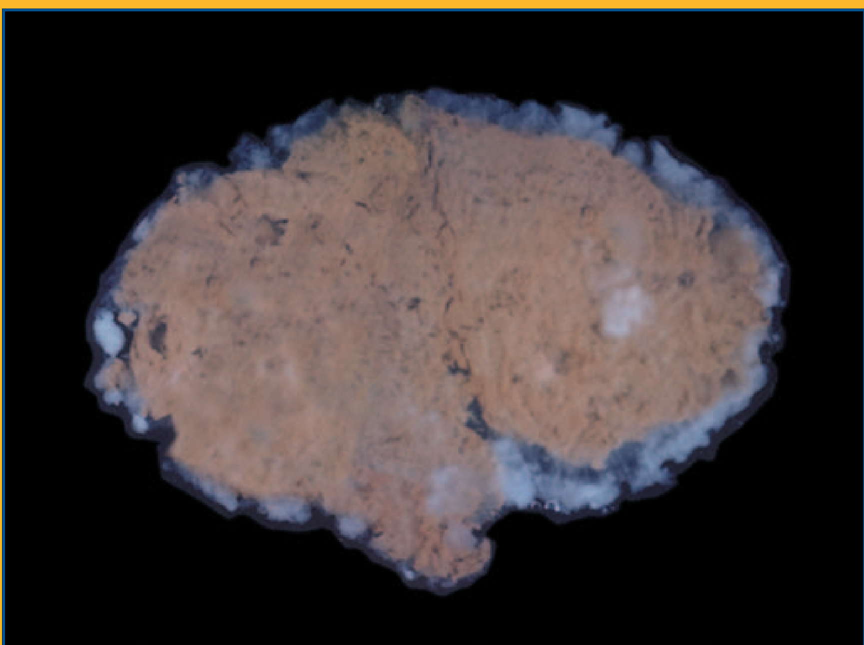
The Recycling Effort (Phase I)

In 1990, with an understanding that the current booth design would not be modified for some time, Caterpillar's East Peoria plant began to focus on the possibility of recycling the overspray material into useful paint products.

Given the dirty, sticky physical state of the water-wash paint sludge—the feedstock of this effort—it became clear that something would have to be done to make the overspray material easier to work with. Several polymeric detackifiers were tested in hopes of solving the problem, but the use of such products was later discontinued because of limited detackification success, and a costly price tag.

Recognizing that polymer-detackified sludge, whatever the cost, was less than chemically ideal for recycling, Cat laboratory personnel sought new and different approaches to the detackification problem. Time spent in the pursuit of this goal was well worth the effort, because a new method was found that was capable of fulfilling Caterpillar's detackification requirements. In fact, Caterpillar subsequently was issued a U.S. patent for the use of hydrophobic fumed silica in detackification of overspray paint particles.

The unique particle encapsulation phenomenon of hydrophobic fumed silica is shown in the accompanying light microscopy photograph. Encapsulating paint particles with an inert, extremely thin layer of a hydrophobic product that is routinely used in other paint formulations offered the remarkable prospect of detackifying overspray sludge, without detrimentally altering its chemistry as a recyclable feedstock. Clearing this obstacle presented the opportunity for Caterpillar to break into an area where others have had little success—the true recycling of *paint.*



Light microscopy photograph illustrates the encapsulating surface phenomena involved in Caterpillar's water-wash paint detackification process. Unlike the polymeric detackification approach, application of hydrophobic fumed silica (the white substance) reduces tackiness of paint particles without detrimentally altering the chemistry.

The Recycling Effort (Phase II)

By late 1990, the East Peoria plant's chemical engineering laboratory began efforts to blend simple paint formulas using their detackified raw material. An alkyd enamel was completed a short time later which, from a durability and performance perspective, met Caterpillar engineering specifications. But, much work had to be done before marketable products could be reliably produced.

While efforts to decrease the variation of the detackified sludge material continued in-house, the Moline Paint Manufacturing Company (Cat's product paint supplier for the plant), began its long-term paint recycling research relationship with Caterpillar, dedicating considerable lab time to product development.

In the early years (and to a lesser extent today), a cloud of skepticism has existed around the entire notion of Caterpillar recycling its paint. This effect has been seen before with recycled products as evidenced in the initially slow, but now common place practice of using recycled paper and plastic products. Using similar rationale, it was decided that for the project to be successful, support for recycled paint products had to be built upon repeated demonstrated successes, ideally with Caterpillar as the customer.

The overall product and market development strategy decided upon was to simultaneously:

(1) Continually improve product-reclaimed raw material quality through material conditioning and processing; while

(2) Accomplishing a methodical series of short-term successes with the technology directed at the appropriate level.

The first of these involved developing a workable series of processing steps that could transform raw, detackified paint sludge into a quality paint raw material. The specifics of this process cannot be discussed in further detail at this time, but may be the subject of discussion in future publications.

The second strategy would be accomplished through pressing new product introductions only as far as the processing improvements toward the first goal would allow. Accomplishing this, it was thought, would help solidify support for the concept of paint recycling by creating an internal and external network of satisfied customers.

The dual approach to developing products and markets has, to date, worked even better than anticipated. By 1991, the first recycled coating was brought into the plant as a safety yellow-line-marking paint used for factory aisles and walkways. For example, the plant's new materials technology laboratory, completed in May, is coated on its interior walls and the exterior with quality paints made using Caterpillar process recycled material. The Sherwin-Williams Company, Moline Paint/ Guardsman, and The Valspar Corporation have developed these and other products that target appropriate applications. Each company concentrates on the types of goods it already sells to Caterpillar. In this case, they are maintenance, sprayed product, and electrodeposition coatings, respectively.

The development of different products utilizing reclaimed material as a partial replacement for pigment has led to a number of interesting discoveries. Maybe the most unique and significant of these is that the presence of reclaimed pigment not only has no negative effect on the products in which it is used, but in some products (as can be seen in the accompanying data table from The Valspar Corporation), the presence of reclaimed materials can significantly *increase* performance characteristics.

240-hr Salt Fog Corrosion Test
The Valspar Corporation

Product	% Reclaim	Metal	Pretreatment	Pretreat Sealer	Creep (in.)
Cathodic	0	Lab (EP10P95)	Iron Phosphate	Chrome-free	3/16
Thermoset	0	Lab (EP2P95)	Zinc Phosphate	Chrome-free	0
Acrylic	5	Lab (EP10P95)	Iron Phosphate	Chrome-free	0–l/4
E-Coat	5	Lab (EP2P95)	Zinc Phosphate	Chrome-free	0
	10	Lab (EP10P95)	Iron Phosphate	Chrome-free	1/32–l/8
	10	Lab (EP2P95)	Zinc Phosphate	Chrome-free	0

Tests conducted at The Valspar Corporation show that the addition of reclaimed pigment additive significantly increases the performance of acrylic E-coat (shown), and other electrodeposition finishes in every instance.

Outlook for the Future

In the coming months, Caterpillar's East Peoria plant will take the series of successes with its paint recycling project and build upon that in a substantial way. By the close of 1995, all track-type tractors produced in East Peoria will be manufactured using a Moline Paint/Guardsman two-component polyurethane coating made, in part, from the company's reclaimed pigment material. This is possible because, within that same period of time, a production-scale processing center will be completed on-site with more than enough capacity to process all of the plant's water-wash overspray paint sludge for use in new paint products. The U.S. Department of Energy and the Environmental Protection Agency awarded Caterpillar a $285,000 matching grant for the installation of equipment and other expenses, for the project.

Any remaining capacity at the processing center can used to perform studies for different Caterpillar facilities, and others who may be interested in the prospect of recycling their material.

The cooperation Caterpillar has enjoyed with its suppliers—Moline Paint/Guardsman, The Sherwin-Williams Company, and The Valspar Corporation—will make it possible for Caterpillar to prove on a large, industrial scale that paint recycling is a viable alternative for the current practice of simply disposing of what can be a valuable material. o

About the Authors

George Mitchell has worked for Caterpillar at East Peoria, IL, as a chemist since 1988. He has held a number of laboratory positions supporting manufacturing operations, including processes utilizing a variety of cutting oils, hydraulic oils, quench oils, water-based machine coolants, rust preventatives, phosphate coatings, and primer and topcoat paints. In 1994, he authored Caterpillar's grant proposal to the Department of Energy's NICE^3 program, which resulted in a $285,000 award for the full-scale implementation of a recovery, reclamation and recycling study of overspray paint. Mitchell is a 1987 graduate of Illinois State University with a BS in chemistry, and is currently completing an MBA at Bradley University.

John Spangler worked for an industrial water treatment firm until 1988, when he accepted a laboratory position as a chemist for Caterpillar at their Mossville, IL, engine plant. Following a promotion in 1989, he moved to the East Peoria facility, where he has worked with manufacturing in such areas as metal working fluids, washer products, and paint and conversion coatings. He was awarded U.S. patent 5092928, titled "Process for Recovering Paint Overspray Particles," which is the first step in a paint recycling program. He also has several additional patents pending for a variety of pollution prevention innovations and improvements, most of which are related to painting processes. Spangler is a 1986 graduate of St. Mary's College of Minnesota, with a BA in chemistry.