CUNO Application Brief
High Quality Paint Filtration
Point of Application - Automotive Base Coat
Reducing Product Rework through Appropriate Filtration

Introduction
One of the most demanding facets of manufacturing an automobile is the proper application of the exterior finish. The coating is applied for appearance and customer satisfaction. However, the coating also provides protection by reducing corrosion, which in turn improves the appearance and increases the life of the automobile body. To maximize both appearance and corrosion resistance, contaminants must be eliminated from the paint prior to application. An optimized paint filtration system will remove contaminants from the paint thus reducing rework (repainting), improving the finish quality and significantly reducing manufacturing costs. This CUNO Application Brief (CAB) presents the benefit of using an effective base coat filtration system.

Description of the Application
The process begins with a thorough washing of the vehicle body followed by a multiple layer painting process consisting of an electrodeposition (ED) protective dip coating, a primer or anti-chip layer, a base coat (metallic or solid color), and the final clear protective coat. Contaminants present in any of the layers compromise finish quality and often result in costly rework of the defective area. Figure 1 below is a schematic of a typical base coat filtration process.

Figure 1. -Typical Filtration System Schematic
Potential Problems
Defects resulting from particulate are one of the most common and costly problems associated with the application of the base coat in automotive assembly plants. These defects are defined as anything that creates an imperfection in the coating, changing the way light is reflected or refracted, thereby harming the appearance of the surface finish. This is especially noticeable for glossy surfaces which then becomes magnified with the applications of the topical clear coat. Since today’s automotive films can be as thin as 20 microns, small particles less than 20 microns are significant and have a considerable impact on the quality of, and customer satisfaction with, the automobile’s finish. The two main types of particle caused defects are often classified as dirt and craters.

Types of Defects

- **Dirt**: Often includes weld spatter, metal fines, sanding dust, fibers, oven “dirt”, gel particles, pigment flocculation, floor dust, etc.

- **Crater**: A crater (Figure 2) is a depression in the surface finish and includes defects, commonly known as fish eyes. Craters can be caused by resin gel particles, dirt, filter material and poorly dissolved or dispersed additives.

Source of Defects
Dirt or particulate can come from a variety of sources. Despite efforts at the paint manufacturing to properly filter the paints, many contaminants originate in the production of the paint. Contaminants are also present in the assembly plant and the sources include sanding dust, fibers from wipes, clothing, air borne dirt, and overhead conveyers. An additional source of dirt is that brought into the work area by employees from the pollen on their cloths to the personal hygiene products they use.

Paint Contamination
Dirt and particulate can be introduced during the application of the automotive paint at a variety of locations. These include the tote, the transfer line from the tote to the paint re-circulation tank, re-circulation tank, old paint released from the inside of the supply and return piping (Figure 3). Ineffective contamination control at any of these points results in defects and necessary product re-work.
Cost of Defects/Rework
Automotive assembly plants deal with dirt caused defects in several ways. These include:

- **Accept Them (Poor Quality Product)** - This can result in peeling, blistering paint and poor film appearance. In today’s competitive market coupled with the customers demand for quality this is no longer an acceptable option.

- **Minor Rework (Buffing)** - This is where the defects in the film can be removed or made less visible by simply buffing the surface. The process may compromise the finish and also delay the shipment of the automobile.

- **Major Rework (Sand & Repaint)** - This can be limited to sanding and repainting a small area or it may require sanding and repainting of the entire automobile. This adds significant cost to the vehicle, due to lost production time, increased inventory, added material costs and non-value added processing steps, quality and, therefore, customer satisfaction, are also affected as the repair will never match the finish of an automobile which does not require rework.

Reworking adds significant cost to the manufacture of an automobile. An average assembly plant can spend $5,000,000 per year because of lost production time and scrap caused by dirt and craters. Base coat rework compromises the quality of the final finish, as the refinished surface is difficult to match after sanding. This in turn, changes the film appearance making proper color matching difficult to obtain since different lots of paint are often used. The typical result is inferior appearance and protection compared to an original paint finish.

**Filtration**
It is essential to eliminate contaminant from the base coat before it is applied to the automobile. Filtration is a key manufacturing stop in providing a defect free film. Paint filtration is complicated since the filter must allow small particles in the dispersion such as pigment, metal flakes, micas, and fillers to pass through the filter but trap the larger unwanted particles. This filtration method is referred to as classification. The typical removal efficiency of a classifying filter is shown in Figure 4. This compares to clarifying filtration where all particulate and a broad particle size distribution are removed (Figure 5).

Commonly used bag and melt blown filters remove a high percentage of the particles below the filter rating. In coating applications these clarifying characteristics are highly undesirable since they typically strip desired pigments, metallics, micas, and fillers from the paint. The result is a poor coating along with short filter life, (i.e., increased filter change-out, increased disposal costs and higher filter inventories).

**Figure 4. - Classifier**
Removed nearly all 20 micron and larger particles, while allowing nearly all particles smaller than 20 micron to pass.

**Figure 5. - Clarifier**
Removed nearly all 20 micron and larger particles, but also removed a large amount of particles smaller than 20 micron.
Betapure Filter Cartridges
A true, absolute-rated classifying filter is CUNO’s Betapure, which is ideal for base coat applications (Figure 6). It removes undesirable contaminants while allowing pigments, metallic flakes, micas, and fillers to pass through. Betapure is available in a wide range of filter grades, tightly and accurately rated for narrowly differentiated filtration needs.

The rigid structure eliminates pore size changes, unloading, and bypass that are common with other filters. Betapure is supplied in polyolefin or polyester based materials – both compatible with automotive paints.

Betapure Product Advantages
- Maintains paint quality by selectively passing desired pigments, metal flakes, and mica while removing larger contaminants; superior classification characteristics of Betapure.
- Contaminants will not unload or bypass into the paint; rigid non-deformable filter structure.
- Removes oversized particles that would require rework of the automobile; absolute rated.
- Removes gels and deformables that cause craters and fish eyes.
- Eliminates fibers from paint; free of media migration.
- Eliminates filter change-outs during the batch; increased filter service life.

Filtration Location
The proper use of Betapure filters at the locations identified as the supply and return filters in Figure 7 will significantly reduce the incidents of particulate and dirt caused defects in the application of the base coat. These locations include:

- **Tote transfer** - filtration of the paint as it is being transferred from the shipping tote to the re-circulation tank in the paint kitchen
- **Paint Kitchen** - filtration of the paint being supplied to the spray booth and again as it is being returned into the re-circulation tank
Case Study

The use of CUNO’s Betapure, a rigid classifying filter, has provided significant operational savings when compared to commonly used products referred to as melt blown and bag filters. One such application is as follows:

A Year Long Filter Study Cuno versus Nylon Mono-filament (NMO) bags

A major US automotive assembly plant was using nylon NMO bags as the primary filter in the paint re-circulation loop. The NMO bag, a non-rigid, surface filter, has various features that are often detrimental to the effective filtration of the paint. They are:

**Poor Contaminant Removal**
- The bag is capable of removing solid cylindrical contaminants but will easily pass contaminants such as deformable particles or gels (causing craters, fish eyes & seeds) and small diameter long contaminants like fibers

**Short Service Life**
- Bags must be changed at low differential pressure (less than 15 psid) to avoid rupture and paint contamination
- Bags have a very low dirt holding capacity thus requiring frequent change-outs resulting in additional paint loss, increased labor, and increased filter disposal and purchase costs

**Construction**
- NMO bags utilize a thread to sew the seams of the filter. During the thread manufacturing process a lubricant, typically silicone, is required. If the thread is inadvertently produced with silicone lubricant severe paint surface defects will occur.

The selection of the proper filtration system must take into account the process parameters and the quality demands of the application. If this is done correctly, the contaminant will be removed from the paint, the vehicle quality will be met and the overall process costs will be reduced.

The information in Table 1 describes the operating conditions of a year long study at a U.S. Assembly plant. The study evaluated two waterborne base coats (a solid and a metallic paint) under the following conditions.

<table>
<thead>
<tr>
<th>Table 1 - Process Conditions</th>
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<tbody>
<tr>
<td><strong>Solid Paint</strong></td>
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<tr>
<td><strong>Process Conditions</strong></td>
</tr>
<tr>
<td>Flow Rate</td>
</tr>
<tr>
<td>System Pressure</td>
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<tr>
<td>Viscosity</td>
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<tr>
<td>Temperature</td>
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<tr>
<td>Filter</td>
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<tr>
<td>Change-out criteria</td>
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<tr>
<td>Service Life</td>
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High Quality Paint Filtration  Point of Application - Automotive Base Coat
Actual Savings

The cost savings obtained by reducing rework is listed in table 2. The data illustrates that Betapure, when used to filter a solid paint, instead of a bag filter reduced rework from 10 automobiles per 100 to 5 automobiles per 100 (a 50% reduction in rework). Similarly, when filtering a metallic paint, Betapure reduced rework from 20 automobiles per 100 to 14 automobiles per 100 (a 27% reduction in rework).

<table>
<thead>
<tr>
<th>Process Conditions</th>
<th>Solid Paint</th>
<th>Metallic Paint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Betapure Filters</td>
<td>NMO Bag</td>
</tr>
<tr>
<td>Automobile Acceptance (cars per 100)</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Automobiles Requiring Rework (cars per 100)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Rework Reduction (cars per 100)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Improvement in Compliance</td>
<td>50%</td>
<td>--</td>
</tr>
</tbody>
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From the data in table 2 an average improvement in rework was 5.5% yielding an overall annual rework savings of $1,650,687.

(350 vehicles/day x 5.5 vehicles/100 improvement in rework x $350 average cost of rework per vehicle x 245 work days per year = $ 1,650,687)

The process cost savings obtained by converting to the CUNO Betapure and CT filter housing are listed in table 3. The data is based on a paint kitchen with 20 paint lines and related annual expenses with flow rates to 15 gpm and provides the details on how the costs are calculated.

Table 3 - Process Costs

<table>
<thead>
<tr>
<th>Process Issue</th>
<th>CUNO Filtration System</th>
<th>Bags</th>
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</thead>
<tbody>
<tr>
<td>Capital Cost for a 15 GPM System</td>
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<tr>
<td>20 Housings</td>
<td>$12,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>Installation for 20 Systems</td>
<td>$5,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td>$17,000</td>
<td>$22,000</td>
</tr>
<tr>
<td><strong>One time capital savings using CUNO CT filter housings</strong></td>
<td><strong>$5,000</strong></td>
<td></td>
</tr>
<tr>
<td>Annual Expense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Media Expense (A/B x C x D)</td>
<td>$4,000</td>
<td>$19,200</td>
</tr>
<tr>
<td>Labor to change-out filters (A/B x C x E x F)</td>
<td>$865</td>
<td>$15,600</td>
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<tr>
<td>Lost paint during filter change-out (A/B x C x G x H)</td>
<td>$4,500</td>
<td>$45,000</td>
</tr>
<tr>
<td>Disposal Cost – [(A/B x C x G/I) + (A/B x C/J)]K</td>
<td>$2,175</td>
<td>$7,450</td>
</tr>
<tr>
<td>Total Annual Expense</td>
<td>$11,540</td>
<td>$87,250</td>
</tr>
<tr>
<td><strong>Annual Savings using CUNO Betapure Filters</strong></td>
<td><strong>$75,710</strong></td>
<td></td>
</tr>
</tbody>
</table>

A = 48 work weeks per year
B = Filter Life: Betapure 6 weeks, Bags 1 week
C = 20 paint lines
D = Cost of media: Betapure $25, Bags $20
E = Time to change-out filters (hours): Betapure 0.083 hrs, Bags 0.25 hrs
F = $ 65 hourly rate
G = Lost paint during filter change-out (gallons): Betapure 3/8, Bags 5/8
H = $75 per gallon paint cost
I = 55 gallon disposal drum
J = Filters per 55 gallon drum: Betapure 49, Bags 240
K = $500 per 55 gallon drum disposal cost
Conclusion
The one-year study conducted at a U. S. assembly plant clearly demonstrates the cost savings potential achieved by simply improving the filtration of the automotive base coating. The combined Rework Reduction (table 2) and Process Costs (table 3) provided the plant that produced 350 vehicles per day annual savings of $1,726,397.

Recommendations
To optimize paint quality, the key filtration locations in the automotive assembly plant that should convert to CUNO Betapure filter cartridges are:

- the filter from the shipping tote to the paint re-circulation tank,
- the supply filter from the paint re-circulation tank to the spray booth, and
- the return filter from the spray booth to the paint re-circulation tank

The use of Betapure filters will improved paint appearance, reduced rework and provide significant profit improvements.

Please contact your local Cuno distributor for information on how to conduct a test and obtain similar savings.

Scientific Applications Support Services
The cornerstone of CUNO’s philosophy is service to customers, not only in product quality and prompt delivery, but also in validation, application support and in the sharing of scientific information.

CUNO’s Scientific Applications Support Services works closely with customers to solve difficult filtration challenges and to recommend the most efficient, economical filter systems. SASS specialists can perform on-site testing and utilize filtration applications expertise to partner with customers. CUNO resolves filtration problems promptly and efficiently in a cost-effective, confidential manner. CUNO’s broad distributor base and sales offices provide worldwide customer service, local inventory, and field support in virtually every major center of manufacturing.
CUNO ... A World Leader in Fluid Purification
CUNO’s manufacturing sites have ISO 9001 registered quality systems. Global manufacturing together with trained stocking distributors and state-of-the-art laboratory support bring quality solutions to existing and challenging filtration applications.