P2: Region 5 Hazardous Substance Reduction On the Path to Greener Chemistry

Module 3: Proven Approaches to Performing Hazardous Substance P2 Assessment
Green Industrial Performance Through Waste Minimization
Waste and Pollution

1. Over-Production
2. Waiting
3. Transport
4. Processing
5. Inventory
6. Motion
7. Repair/Rejects
8. Natural Capital
Green Management Thought

- Productivity and Quality
- Environmental Performance

Time
Options for Addressing Wastes

- Source Reduction
- In-process Recycling
- Clean Technology
- Raw Material Substitution
- Preventative Maintenance
- Energy Efficiency
- Out-of-process waste recycling
- Off-site waste recycling
- Last resorts:
  - End-of-pipe technologies
  - Pollution control
Waste Management Hierarchy

- **Source Reduction, Waste Elimination, and Reuse**
- **Recycling and Composting**
- **Treatment or Energy Recovery**
- **Disposal**

Most Preferred

Least Preferred
Waste Management Options

Effects on Economics and Liability

Economic Benefit

Liability

Disposal  Treatment  Off-Site Recycling  Pollution Prevention
Waste Management: Descriptive Approach

• Use quality improvement tools to solve problems associated with inefficient operations
• Utilized by cross-functional teams as opposed to individuals
• “Explore” processes to identify opportunities
Process Analysis and Mapping

• Why should we map a process?
• Focused Process Analysis
• Three Questions Used in Process Mapping
Case Study: Oily Wastewater at Automotive Plant

Process Mapping:

• Perceived problem: waste water treatment system is inadequate with respect to oil and grease discharges

• Perceived Solution: Need a bigger/better wastewater treatment system
How does oil get into the wastewater?

Materials Receiving

- Steel Coils
- Packaging
- Pallets
- Landfill

Blanking & Drawing

- Press Oil
- Hydraulic Oil
- Draw Compound
- Pyrogard D
- Gear Lube

Shipping

- WWTP
- Press Oil
- Pyrogard D
- Gear Lube
- Draw Compound

 WWTP

 WWTP

 WWTP

 WWTP
Short-Term: Segregate and Sell Wasted Oil

• Keep about 225,000 ga of oil out of wastewater
• Cost savings = about $240,000 annually
  – sale of waste oil
  – reduced off-site wastewater treatment*
How does die get into the wastewater?

General Process Flow Diagram: Die

Materials Receiving → Blanking & Drawing → Shipping

Deaths → Degreaser → Wash Bay

Dieds → Spent Degreaser → WWTP
Perceived Problems

System unable to handle volumes
- Not big enough
- Too much oil discharged

Waste oil dumped to WWTP

Unable to remove oil from water
- Wastewater treatment system ineffective
- Inadequate capacity
- Spent degreaser dumped continuously

Too much oil discharged

Degreaser solution contaminated
Parts cleaning process contaminates solution
Problem Quantification

Sources of Data:
• Purchasing records
• Warehouse records
• Material Safety Data Sheets (MSDS)
• Flow meters
• Time studies
• Waste manifests
• Laboratory analysis
Identifying Pollution Prevention Opportunities

• Solicit cooperation from *key personnel*

• Conduct *thorough* assessments

• Ask *open ended* questions
Waste Reduction Techniques

- Machine or technology modifications
- Method modifications
- Material substitutions or modifications
- Personnel changes and training
- Management changes
- Business environment conditions
Production Processes and Operating Practices:

- Spill/leak prevention
- By-product segregation
- Improved raw material handling
- Preventive and predictive maintenance
- Employee training
- Effective supervision
- Employee participation programs
- Production planning and scheduling
- Cost allocation and accounting
Total Cost Accounting and Economic Justification

- Traditional Views of Environmental Costs
- Problems with Traditional Views
- Three Levels of Financial Information
Cost Considerations for Promoting P2

• Usual (Direct) Costs
• Hidden Costs
• Future Liability
• Less Tangible Costs
Typical Cost Considerations

- Raw Materials
- Record Keeping
- Waste Disposal
- Energy
- Labor
Developing Economic Justification for P2 Projects

• Corporate projects require *economic justification*.
• Focus on *direct costs* first.
Water is *important* vs. water is *cheap*

What is the true cost of water?

$2.25 per 1,000 gallons?

Water usage in processes drives chemical usage.
Perception Changes at Ford

Before Project
- Cost = $200,000/year
- 90 million gallon/year
- Difficult to justify changes

After Project
- Water was costing $7 million per year
- Reduced to 60 million gallons per year
- Multiple projects implemented
- *Saving over $2 million per year*
Additional Resources

• Illinois Sustainable Technology Center
• Great Lakes Regional Pollution Prevention Roundtable
• National Pollution Prevention Roundtable
• EPA Green Purchasing
• Waste to Profit Network
Best Management Practices to Reduce Hazardous Chemical Usage
Composites Industry in MN

**Styrene Use**

- 2009 Toxics Release Inventory (TRI) data for Styrene
  - 810,000 pounds managed
  - 272,500 pounds air release reported
- MN Industry Operations
  - Process open lay-up with controlled spraying
  - 50% of survey respondents utilized reduced emissions processes
Fiber Reinforced Plastic Industry

- Developed over 50+ years
- Established performance
- Structured on commodity chemical cost/volume
- Regulated emissions and worker exposure
Fiber Reinforced Plastic Industry

Manage styrene to limit exposure and release

• Process options
  – Operator training
  – Non-atomizing spray equipment
  – Closed molding

• Material options
  – Lower styrene resins
  – No styrene resins
Case Study: Process Equipment

Goal: Increase open mold operation material efficiency and product quality

• Non-atomized application
  – Low pressure application stream
  – Reduced overspray

• Resin metering equipment
  – Operator feedback on material utilization
  – Improved part consistency

• Decrease in styrene emissions
  – 35% gel coat, 65% chop fiber
Case Study: Process and Material

**Goal:** Meet air permit requirements for open mold, gel coat and resin operations

- Non-atomized application
  - Low pressure application stream
  - Reduced overspray
- Low styrene general purpose polyester resin
  - 43% to 38% styrene
  - Performance criteria met
- **43% decrease in styrene emissions**
Emission Reduction Modeling

Impact potential for combined process and resin change

<table>
<thead>
<tr>
<th>Styrene Content</th>
<th>43%</th>
<th>38%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atomized</td>
<td>254*</td>
<td>183</td>
</tr>
<tr>
<td>Non-atomized</td>
<td>102</td>
<td>86</td>
</tr>
</tbody>
</table>

*Styrene emission rate lb-styrene/ton resin processed

Styrene Emissions Potential 168 pounds per ton resin processed
Yield Savings 8.4 percent
Material Cost Savings (at $0.75/lb) $126 per ton resin processed
Case Study: Closed Molding

Vacuum assisted injection molded process, good for low to moderate complexity parts

Resin Transfer Molding (RTM) – Higher vacuum, robust molds, molding technology expertise
Light Resin Transfer Molding (LRTM) – Moderate vacuum, lower investment, faster implementation

• Opportunities
  – Consistent parts
  – Two sided parts
  – Emission reduction

• Challenges
  – New operations
  – Investment
  – Limits on part complexity
Case Study: Closed Molding

**Goal:** Decrease styrene emissions to meet worker exposure and air permitting requirements

- Phase I - Non-atomized spray and low styrene resin
- Phase II - Convert 60% of production closed mold operation
- Save 80,000 lb styrene emission per year

http://www.mntap.umn.edu/fiber/resources/41-Phoenix.pdf
### Emission Reduction Modeling

Impact potential for combined process and resin change

<table>
<thead>
<tr>
<th>Styrene Content</th>
<th>43%</th>
<th>38%</th>
<th>Release Fraction</th>
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</thead>
<tbody>
<tr>
<td><strong>Non-atomized</strong>(^1)</td>
<td>102</td>
<td>86</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Closed Mold</strong>(^2)</td>
<td>8</td>
<td>-</td>
<td>1%</td>
</tr>
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</table>

*Styrene emission rate lb-styrene/ton resin processed

\(^1\) Estimates based on Unified Emissions Factors, Open Molding of Composites, ACMA UEF-1-2011a

\(^2\) EPA Compilation of Air Emission Factors, AP-42

Styrene Emissions Difference  78 pounds per ton resin processed
Yield Savings  4 percent
Material Cost Savings(at $0.75/lb)  $59 per ton resin processed
# Styrene Free Resin Evaluation

<table>
<thead>
<tr>
<th>Product Name</th>
<th>NOVOC 8124</th>
<th>Aropol 67301</th>
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</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>NOVOC Performance Resins LLC</td>
<td>Ashland Chemical</td>
</tr>
<tr>
<td>Description</td>
<td>Styrene free general purpose polyester resin</td>
<td>General purpose polyester styrene resin</td>
</tr>
<tr>
<td>Crosslinking</td>
<td>Acrylates</td>
<td>Styrene</td>
</tr>
<tr>
<td>Structures</td>
<td><img src="image1.png" alt="Structure" /></td>
<td><img src="image2.png" alt="Structure" /></td>
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</tbody>
</table>
Case Study: Salo Resin Project

• Salo Manufacturing, Inc.
  – Open mold fiberglass bath and shower manufacturer
  – Demonstration project 2011
• Goal:
  – Define non-styrene compositions
    • deliver performance
    • acceptable cost
## Case Study: Non-Styrene Resin

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize formulation</td>
<td>- Gel coat compositions not available</td>
</tr>
<tr>
<td></td>
<td>- Laminate composition developed using NOVOC® 8124 with high filler load</td>
</tr>
<tr>
<td>Produce parts</td>
<td>- Resin workability required optimization</td>
</tr>
<tr>
<td></td>
<td>- Test units failed ANSI Z124.1.2 deflection test, missed key industry standard</td>
</tr>
<tr>
<td></td>
<td>- Composition options for improved performance possible</td>
</tr>
<tr>
<td>Meet cost objective</td>
<td>- Cost structure outside application target</td>
</tr>
</tbody>
</table>
Case Study: MnTAP FRP Project

Partnership Project
• Sunrise Fiberglas LLC
• MnTAP
• Composite Materials Technology Center (COMTEC), Winona State University

Goal
• Define operating conditions for part layup operations with non-styrene resins
• Measure physical properties of parts
• Share results of study
Trial Details

- **Resin Comparison**
  - NOVOC® 8124, NOVOC Performance Resins, LLC
  - Aropol 67301, Ashland Chemical
  - Resins had comparable shear and gel times

- **Sprayed Parts**
  - 65/35 to 80/20 glass/resin loading
  - E-glass roving with silane sizing

- **Hand Layup**
  - 2 layer construction
  - E-glass CSM with powder binder

- **Observations**
  - Parts had good open work time
  - Glass did not wet easily with resin
Non-styrene resin properties 15-25% lower performance than base resin

Analysis conducted at Composite Materials Technology Center (COMTEC) at Winona State University
### Composite Density/Void Volume

<table>
<thead>
<tr>
<th></th>
<th>Non-Styrene Resin</th>
<th>Base Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculated Composite Density</td>
<td>1.660</td>
<td>1.662</td>
</tr>
<tr>
<td>(g/cm³)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured Composite Density</td>
<td>1.280</td>
<td>1.581</td>
</tr>
<tr>
<td>(g/cm³)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Void Volume (%)</td>
<td>23</td>
<td>5</td>
</tr>
</tbody>
</table>

Extremely high void volume calculated for the non-styrene resin

Analysis conducted at Composite Materials Technology Center (COMTEC) at Winona State University
Scanning Electron Microscopy (SEM)

Aropol

NOVOC

Analysis conducted at Composite Materials Technology Center (COMTEC) at Winona State University

Minnesota Technical Assistance Program
http://www.mntap.umn.edu
Observations Summary

Non-styrene resin composites

• **15-25%** lower physical properties
• **19%** lower density composition
• **23%** void volume calculated

Microscopy

• Poor resin glass adhesion
• Non-homogeneous composition

Resin and glass used in trial did *not* have optimal compatibility to maximize composite performance.
**Goal:** Define use and performance ranges for non-styrene resins using a design of experiment approach

- Collaborate - University, Industry, Supplier Partners
  - Generate performance results for alternate resin/composite compositions
  - Identify optimal performance from lab data
- Transferrable outcomes
  - Test best compositions in FRP shop process
  - Compare performance with incumbent resins
Acknowledgements

• FRP Process Optimization and Alternative Resins
  – US EPA R5 and MPCA, 1999-2001
  – US EPA R5 and MPCA, P2 Grant 2011

• Partners
  – Salo Manufacturing, Inc.
  – Sunrise Fiberglas
  – Phoenix Industries

• Contributors
  – COMTEC, Winona State University
  – American Composite Manufacturers Association (ACMA)
  – Interplastic Corporation
  – NOVOC Performance Resins, LLC