Conducting A Cleaning Assessment

Presented by:
Newton B. Green II, P.E., DEE, PMP
Business Manager
New York State Pollution Prevention Institute

© 2010 New York State Pollution Prevention Institute. All rights reserved
Overview

- The Problem
- How clean is clean?
- What’s new in cleaning technology for automotive rebuilders?
- How do I determine what’s important in a cleaning process?
- Which cleaning technology is right for me?
The Problem

- Cleaning is a critical, bottleneck operation for many maintenance activities
- Many popular cleaning chemicals have been banned or pose a risk to workers and the environment
- Assessing alternative methods can be challenging and time-consuming
Partial MSDS for Mineral Spirits

Product Name: Mineral Spirits 146 HT (Aliphatic Hydrocarbon)

Hazards Identification: May cause mild eye and skin irritation. Prolonged contact may dry the skin and cause burning, redness, and cracking of the skin. Repeated exposure may cause depression of the central nervous system, dizziness, nausea and unconsciousness.

Accidental Release Measures: Eliminate all ignition sources. Notify proper authorities if a runoff has occurred.

Handling and Storage: Containers of this material may be hazardous when emptied. Release of hot vapors from process equipment may result in ignition without obvious ignition sources being present.

RCRA Information: Disposal of used or unused product subject to hazardous waste regulations due to flammability (flash point < 140 F).
Partial MSDS for Sodium Bicarbonate

Product Name: Sodium Bicarbonate (Baking Soda)

Hazards Identification: HMIS Rating is 0-0-0-X. Odorless white crystalline powder. May generate sparks during dry blasting with improperly grounded equipment. Nuisance dusts. No other significant health or environmental effects associated with these products.

Subchronic Effects/Carcinogenicity: None known. Contains no ingredients that are listed as carcinogens or potential carcinogens by IARC, NTP, OSHA, or ACGIH.

Flammable Properties: Non-flammable, non-combustible.

Regulatory Information: OSHA - Not hazardous under 29 CFR 1910.1200. CERCLA Reportable Quantity - none. RCRA - not a hazardous waste by listing or characteristic. SARA Title III - not regulated. DOT - no hazardous substance RQ.
So How Do We Proceed?
Cleaning Assessment Objectives

- Assess current cleaning processes
- Identify potential alternative technologies
- Evaluate technical and economic feasibility of potential alternative technologies
- Develop recommendations
- Provide support for implementation
Assess Current Cleaning Process

- Identify Problem
- Set up Site Visit
- Collect Data (see next slide)
- Evaluate Data
- Revise Problem Statement as Needed
- Prepare Baseline
Collect Data (1 of 2)

- Current Cleaning Process (e.g. equipment, chemistries)
- Parts to be Cleaned (e.g. substrate, geometric complexity, sturdiness, throughput rates, size)
- Contaminants of Concern (e.g. grease, oil, paint, rust)
- Equipment Information (e.g. cycle times, temperatures, chemistries used & concentration)
# Part Data Collection Sheet

## Part Evaluation Sheet

**Part Name:** Carrier Bearing Support  
**Subassembly:**  
**Item #:** 149  
**Material/Surface Finish:** Pearlitic cast iron grade 30  
**Material/Finish Code:** Cast Machined surfaces  
**Model #:** 645  
**Part Number:** 635C8541  
**Length:** 14  
**Width:** 10  
**Height:** 3.3  
**Weight:** 18  
**Contaminants:**  
<table>
<thead>
<tr>
<th>Contaminant Description</th>
<th>Properties</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>Thick film</td>
<td>H</td>
</tr>
<tr>
<td>Carbon</td>
<td>Suspended in oil</td>
<td>M</td>
</tr>
</tbody>
</table>

## Cleaning Method

### Cleaning Process and/or Agent

<table>
<thead>
<tr>
<th>Cleaning Process and/or Agent</th>
<th>Effectiveness</th>
<th>Manual/ Time</th>
<th>Auto/Est. (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Proceco</td>
<td>Removes most oil, and some loose particles</td>
<td>A</td>
<td>20-30</td>
</tr>
<tr>
<td>2) Zep Tanks (If necessary)</td>
<td>Effectively degreases and softens carbon</td>
<td>M</td>
<td>2-3</td>
</tr>
<tr>
<td>3) Small Water Blaster</td>
<td>Imparts a “like new” finish</td>
<td>M</td>
<td>2-3</td>
</tr>
</tbody>
</table>

**Total Cycle time (Range):** 24-36

**Total Manual Cleaning Time (Range):** 4-6

## Requalification Considerations

**Cleanliness:**

1) Some rust is ok
2) No grease, oil, carbon
3) 
4) Insignificant

**Surface:**

1) Surface will not be painted
2) 
3) 
4) 

**Tolerance:**

1) Look for cracks
2) Check height of snap ring groove
3) Bore Size
4)
# Cleaning Process Data Collection Sheet

## Turbocharger Remanufacturer Cleaning Process Sheet

**Process Name**: Aqueous Cleaning System  
**Bldg./Dept/Area**: Teardown

### Equipment

<table>
<thead>
<tr>
<th>Number</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Process Description

- **Load entire turbo onto system (Few exceptions)**
- **Main degreasing operation**
- **Two shifts 10 hr/shift (second shift is new)**
- **140-220 degree operating temp**
- **20-30 minute cycle**

### Soaps, Chemicals, Media

- **DuBois MC-726**
- **Sodium hydroxide solution**

### Electrical Requirements

<table>
<thead>
<tr>
<th>110 A.C.</th>
<th>208 A.C.</th>
<th>230 A.C.</th>
<th>460 A.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Physical Data

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Width (ft)</th>
<th>Height (ft)</th>
<th>Footprint Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>11</td>
<td>10</td>
<td>132</td>
</tr>
</tbody>
</table>

### Other Utilities:

<table>
<thead>
<tr>
<th>Cold Ventilation</th>
<th>Hot Water</th>
<th>Air Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Loading Requirements:

- **Operator area (ft²)**: 45
- **Staging area (ft²)**: 40
- **Number of stations required (ft²)**: 1
- **Total area (ft²)**: 217

### Comments:

- **Comments**:
  - Palet jack used to transport large parts and a crane is used to lift them onto the machine.
  - Loading time: 11 min. Loading of all parts (Manual and with crane).
  - Wash time: 20-30 min. Timer set and allowed to run.
  - Unload time: 9 min. Unload of all parts (Manual and with crane).

### Disposal:

- **Disposal**:
  - C
  - 4 months between cleaning
  - Bath is hauled away by disposal company (May go to 3 months).
Collect Data (2 of 2)

- **Financial Information** (e.g. cost of power, labor, waste disposal; required payback period)
- **Other Information** (e.g. desired production rate, location of bottlenecks, rework rates, strengths and weaknesses of current cleaning processes)
- **Cleanliness Criteria** (“how clean is clean?”)
How Clean is Clean?

- Determine need for monitoring cleanliness
- Identify contaminants of concern (COCs)
- Identify cleanliness measurement method
- Determine cost of cleaning
- Determine criteria for selecting a cleanliness measurement method
- Define limits of acceptable cleanliness
How Clean is Clean?

COCs for Automotive Parts Rebuilders:

- Dirt
- Grease
- Oil
- Baked-on carbon
- Rust
- Gasket residue
How Clean is Clean?

Types of Measurement Methods:

- **Direct** - techniques that take a measurement from the actual surface to be cleaned, e.g. water break test
- **Indirect** - techniques that do not take measurements from the actual surface to be cleaned, e.g. gravimetric analysis
How Clean is Clean?

Direct Measurement Methods:
- Visual inspection (most rebuilders use this)
- Magnified visual inspection
- Touch and/or smell
- Black light
- Water break test
- Contact angle (goniometry)
- Gravimetric measurement
- Optically stimulated electron emission (OSEE)
- Direct oxidation carbon coulometry (DOCC)
- X-ray photoelectron spectroscopy (XPS)
How Clean is Clean?

Indirect Methods:

- Gravimetric analysis of wipe sample
- Ultraviolet spectroscopy
- Optical particle counter
- Visual inspection of wipe sample
- Photoreflectivity of wipe sample using spectrodensitometer
How Clean is Clean?

![Graph showing total cost of cleaning]

- **Cost of Cleaning**
- **Cost of Non-conformance**
- **Total Costs Associated with Cleaning**
Identify Potential Alternative Cleaning Technologies

- Expert Judgment
- Preliminary Testing
- Expert Systems and Software Tools
- Vendor Inquiries
- Industry Association Resources
- Trade Publications
- Internet Research
Evaluate Technical and Economic Feasibility of Alternative Technologies

- Develop Test Plan
- Conduct Cleaning Test Trials
- Evaluate Technical Feasibility
- Evaluate Economic Feasibility
# Master Schedule for Cleaning Trials

## MASTER SCHEDULE - NYSERDA Testing

### PRIMARY Processes

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clam</td>
<td>X</td>
<td>D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>D</td>
</tr>
<tr>
<td>Roch Midland Excel 3%</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>8/25</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
</tr>
<tr>
<td>Clam Cleaning Compound</td>
<td>X</td>
<td>X</td>
<td>D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>D</td>
<td>X</td>
<td>X</td>
<td>D</td>
</tr>
<tr>
<td>CJ's Enzyme</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Intercont</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>8/9</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
</tr>
<tr>
<td>Armakleen M100</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>8/10</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
</tr>
<tr>
<td>Armakleen M400</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>8/9</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
</tr>
<tr>
<td>Armakleen Multi-metal</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>8/9</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
</tr>
</tbody>
</table>

### MART Washer

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarksol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8/28</td>
<td></td>
</tr>
<tr>
<td>Brulín 224</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
<td>8/30</td>
</tr>
<tr>
<td>Armakleen</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>9/1</td>
<td>X</td>
</tr>
</tbody>
</table>

### Tabletop Ultrasonic

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CJ's Enzymatic Chemistry</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
<td>D</td>
</tr>
<tr>
<td>100% Soysolv II</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>X</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>
# Technical Feasibility – Cleaning Test Trials for CV Joints

<table>
<thead>
<tr>
<th>current first steps</th>
<th>alternative first steps</th>
<th>advantages</th>
<th>disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>agitating aqueous washer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high pressure spray</td>
<td>high pressure spray</td>
<td>removes heavy grease efficiently</td>
<td>external thread damage if parts free to move</td>
</tr>
<tr>
<td>medium pressure spray</td>
<td></td>
<td>eliminates mineral spirits (improved EH&amp;S)</td>
<td></td>
</tr>
<tr>
<td>wipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>thermal oven</td>
<td>thermal oven</td>
<td>non-manual</td>
<td>potential damage to substrate(?)</td>
</tr>
<tr>
<td>vibratory degreaser (aqueous)</td>
<td>vibratory degreaser (aqueous)</td>
<td>non-manual</td>
<td>does not work on bell housing (outer race)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>eliminates mineral spirits (improved EH&amp;S)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>removes some rust</td>
<td></td>
</tr>
</tbody>
</table>
## Intake Valves: Glass Bead vs. Baking Soda

<table>
<thead>
<tr>
<th></th>
<th>Masking and Glass Bead Blasting&lt;sup&gt;1&lt;/sup&gt; ($/part)</th>
<th>Baking Soda&lt;sup&gt;2&lt;/sup&gt; ($/part)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>$0.05</td>
<td>$0.03</td>
</tr>
<tr>
<td>Labor&lt;sup&gt;3&lt;/sup&gt;</td>
<td>$0.95</td>
<td>$0.18</td>
</tr>
<tr>
<td>Media</td>
<td>$0.38</td>
<td>$0.44</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1.38</strong></td>
<td><strong>$0.65</strong></td>
</tr>
</tbody>
</table>

**Notes:**
1. Based on glass bead cost of $0.47/lb, 3 passes
2. Based on baking soda cost of $0.50/lb
3. Based on fully-loaded labor rate of $12/hr
# Technical and Economic Feasibility – Baking Soda Blasting

<table>
<thead>
<tr>
<th>Part Information</th>
<th>Cleaning Data</th>
<th>Cost ($/part)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part</strong></td>
<td><strong>Component</strong></td>
<td><strong>Materials of Construction</strong></td>
</tr>
<tr>
<td>Intake Valve</td>
<td>Engine, Cylinder Head</td>
<td>Steel</td>
</tr>
<tr>
<td>Housing</td>
<td>Heavy Duty Fuel Injector (12&quot;x10&quot;x5&quot;)</td>
<td>Aluminum, Brass</td>
</tr>
<tr>
<td>Pump Housing</td>
<td>Fuel Pump, Heavy Duty (5&quot;x3&quot;x1.8&quot;)</td>
<td>Aluminum, Copper</td>
</tr>
<tr>
<td>Throttle Body</td>
<td>Carburetor</td>
<td>Aluminum, Zinc</td>
</tr>
</tbody>
</table>

**Notes:**
1. Based on media consumption rate of 1lb/min and cost of $0.5/lb
2. Assume 90% efficiency of compressor and average electricity cost of $0.10/kwh
3. Based on fully loaded wage rate of $12/hr.
4. Total cost represents baking soda only—does not include pre-cleaning cost of enzymatic cleaning.
Develop Recommendations

- Select Optimal Process
- Formulate Recommendations
- Prepare Future State Analysis
- Present Findings to Client
Criteria for Selection of Technologies – Optical Tool Manufacturing Company

● Musts
  – No severe degradation of the tool surface
  – Removal of contaminants to permit effective transfer of impressions

● Wants
  – Superior removal of contaminants from tool surface
  – Low capital cost of cleaning equipment
  – In situ cleaning process (i.e. no disassembly of machine)
  – Short cleaning cycle time
  – Environmentally friendly cleaning process
  – Minimal health and safety risks
## Criteria for Selection of Technologies

### Scoring System for Cleaning Effectiveness

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria for Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>% Contrast &gt;20</td>
</tr>
<tr>
<td>4</td>
<td>15 &lt; % Contrast &lt;= 20</td>
</tr>
<tr>
<td>3</td>
<td>10 &lt; % Contrast &lt;= 15</td>
</tr>
<tr>
<td>2</td>
<td>5 &lt; % Contrast &lt;= 10</td>
</tr>
<tr>
<td>1</td>
<td>% Contrast &lt;= 5</td>
</tr>
</tbody>
</table>
### Criteria for Selection of Technologies

#### Scoring System for Capital Costs

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria for Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Capital Cost $\leq$ $,$10,000</td>
</tr>
<tr>
<td>4</td>
<td>$10,000 &lt; $\text{Capital Cost} \leq$ $,$25,000</td>
</tr>
<tr>
<td>3</td>
<td>$25,000 &lt; $\text{Capital Cost} \leq$ $,$50,000</td>
</tr>
<tr>
<td>2</td>
<td>$50,000 &lt; $\text{Capital Cost} \leq$ $,$100,000</td>
</tr>
<tr>
<td>1</td>
<td>$\text{Capital Cost} &gt; $,$100,000</td>
</tr>
</tbody>
</table>
# Criteria for Selection of Technologies

## Scoring System for In Situ Process

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria for Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>In situ</td>
</tr>
<tr>
<td>4</td>
<td>[not assigned]</td>
</tr>
<tr>
<td>3</td>
<td>[not assigned]</td>
</tr>
<tr>
<td>2</td>
<td>[not assigned]</td>
</tr>
<tr>
<td>1</td>
<td>Machine disassembly required</td>
</tr>
</tbody>
</table>
Criteria for Selection of Technologies

Scoring System for Cleaning Cycle Time

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria for Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Cycle Time &lt;= 30 minutes</td>
</tr>
<tr>
<td>4</td>
<td>30 minutes &lt; Cycle Time &lt;= 1 hour</td>
</tr>
<tr>
<td>3</td>
<td>1 hour &lt; Cycle Time &lt;= 2 hours</td>
</tr>
<tr>
<td>2</td>
<td>2 hours &lt; Cycle Time &lt;= 4 hours</td>
</tr>
<tr>
<td>1</td>
<td>Cycle Time &gt; 4 hours</td>
</tr>
</tbody>
</table>
## Criteria for Selection of Technologies

### Scoring System for Environmental Impacts

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria for Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Generates no solid waste, wastewater, or air emissions</td>
</tr>
<tr>
<td>4</td>
<td>Generates solid waste, wastewater, or air emissions</td>
</tr>
<tr>
<td>3</td>
<td>Generates solid waste and (wastewater emissions or air emissions)</td>
</tr>
<tr>
<td>2</td>
<td>Generates hazardous waste only</td>
</tr>
<tr>
<td>1</td>
<td>Generates hazardous waste and (wastewater or air emissions)</td>
</tr>
</tbody>
</table>
## Criteria for Selection of Technologies

### Scoring System for Health & Safety

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria for Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>No special personal protective equipment (PPE) required</td>
</tr>
<tr>
<td>4</td>
<td>Special PPE required and/or potential asphyxiation hazard</td>
</tr>
<tr>
<td>3</td>
<td>Toxic chemicals used in process</td>
</tr>
<tr>
<td>2</td>
<td>Suspected carcinogens, teratogens, and/or mutagens used in process</td>
</tr>
<tr>
<td>1</td>
<td>Confirmed carcinogens, teratogens, and/or mutagens used in process</td>
</tr>
</tbody>
</table>
## Results of Technology Evaluation

<table>
<thead>
<tr>
<th>Technology</th>
<th>Weight</th>
<th>Capital Cost</th>
<th>Cleaning Effectiveness</th>
<th>In Situ</th>
<th>Cycle Time</th>
<th>Environmental Impact</th>
<th>Health &amp; Safety</th>
<th>Removes Contaminant</th>
<th>Final Score (Max.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal System</td>
<td>4 5 3 3 2.5</td>
<td>5 5 5 5 5</td>
<td>1 1</td>
<td>1 1</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ granule blasting</td>
<td>4 5 3 3 2.5</td>
<td>3 3 5 5 5</td>
<td>4 1 1</td>
<td>1 1</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Snow blasting</td>
<td>4 5 3 3 2.5</td>
<td>5 1 5 5 5</td>
<td>4 1 1</td>
<td>1 1</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baking Soda blasting</td>
<td>4 5 3 3 2.5</td>
<td>5 3 5 3 3</td>
<td>4 1 1</td>
<td>1 1</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser ablation</td>
<td>4 5 3 3 2.5</td>
<td>1 4 5 5 4</td>
<td>4 1 1</td>
<td>1 1</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biosoy-60</td>
<td>4 5 3 3 2.5</td>
<td>4 4 1 1 1</td>
<td>3 1 1</td>
<td>1 1</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iso Paraffinic/Naphthenic Hydrocarbon blend</td>
<td>4 5 3 3 2.5</td>
<td>4 NA 1 1 1</td>
<td>3 1 1</td>
<td>1 1</td>
<td>43</td>
<td></td>
<td></td>
<td></td>
<td>(adjusted value)</td>
</tr>
<tr>
<td>Armakleen</td>
<td>4 5 3 3 2.5</td>
<td>4 2 1 1 1</td>
<td>3 1 1</td>
<td>1 1</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-Limonene</td>
<td>4 5 3 3 2.5</td>
<td>4 2 1 1 1</td>
<td>3 1 1</td>
<td>1 1</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HTF-85B</td>
<td>4 5 3 3 2.5</td>
<td>4 1 1 1 1</td>
<td>3 1 1</td>
<td>1 1</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Super Electrosafe</td>
<td>4 5 3 3 2.5</td>
<td>4 1 1 1 1</td>
<td>3 1 1</td>
<td>1 1</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrared (or thermal)</td>
<td>4 5 3 3 2.5</td>
<td>5 4 5 4 4</td>
<td>4 1 0</td>
<td>1 0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>4 5 3 3 2.5</td>
<td>5 1 5 5 4</td>
<td>4 0 1</td>
<td>1 0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supersonic Gas/Liquid</td>
<td>4 5 3 3 2.5</td>
<td>3 1 5 5 4</td>
<td>4 0 1</td>
<td>1 0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Final Weighted Score Equation

\[ S_i = \{ \prod M_{ij} \} \sum [B_k W_{ik}] \]
Results of Technology Evaluation (cont’d)

- Best Cleaning Alternatives
  - CO₂ Granules Abrasive Blasting
  - CO₂ Snow Abrasive Blasting
  - Sodium Bicarbonate Abrasive Blasting
  - Laser Ablation
Results of Technology Evaluation (cont’d)

- Cleaning Alternatives Creating Surface Damage
  - Laser Ablation (experimental phase)
  - Infrared (or Thermal) Treatment
Results of Technology Evaluation (cont’d)

- Ineffective Cleaning Alternatives
  - Superheated Steam Cleaning
  - Supersonic Gas/Liquid
Recommendations

- Verify findings using vision system test
- Conduct additional experimental testing
  - CO2 granule abrasive blasting
  - CO2 snow abrasive blasting
  - sodium bicarbonate abrasive blasting
  - laser ablation
- Consider additional alternative technologies
  - thermal oven
  - combinations of alternative cleaning methods
- Conduct long-term studies
  - posterior/anterior tool cleaning cycle differences
  - refinement of % contrast method for polypropylene molds
Flow Charts for Current and Future States – Automotive Reman Project

CURRENT PROCESS
- Receive Parts
- Initial cleaning in kerosene
- Second solvent cleaning to aid disassembly
- Disassemble and evaluate
- Store until needed

Housings
- Wire wheel to remove paint
- Buff surfaces to be sealed
- Solvent clean housing
- Assemble Pump
- Test Pump
  - NO
    - Dissassemble Pump
    - Repair Pump
    - Reassemble Pump
  - YES
    - Good?
      - NO
        - Dissassemble Pump
        - Repair Pump
        - Reassemble Pump
      - YES
        - Solvent Clean Pump

Internal Parts
- Clean in satellite solvent stations
- Assemble Pump
- Test Pump
  - NO
    - Dissassemble Pump
    - Repair Pump
    - Reassemble Pump
  - YES
    - Good?
      - NO
        - Dissassemble Pump
        - Repair Pump
        - Reassemble Pump
      - YES
        - Paint Pump

PROPOSED PROCESS
- Receive Parts
- Clean pump in mid-pressure spray washer
- Dissassemble and evaluate
- Store until needed

Housings
- Bead Blast to remove paint
- Buff surfaces to be sealed
- Clean in Cuda parts washer
- Clean housing in mid-pressure spray washer
- Assemble Pump
- Test Pump
  - NO
    - Dissassemble Pump
    - Repair Pump
    - Reassemble Pump
  - YES
    - Good?
      - NO
        - Dissassemble Pump
        - Repair Pump
        - Reassemble Pump
      - YES
        - Paint Pump
        - Deliver Pump

FLOW CHART OF CURRENT AND PROPOSED CLEANING PROCESSES
# Economics of Future State – Aerospace Parts Manufacturer

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>DESCRIPTION</th>
<th>Annual Cost</th>
<th>Annual Savings</th>
<th>Capital Investment</th>
<th>Payback Period</th>
<th>10-year IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$/year</td>
<td>$/year</td>
<td>$</td>
<td>years</td>
<td>%/year</td>
</tr>
<tr>
<td><strong>Cold Cleaning in Cans</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Case</td>
<td>Methylene Chloride at Workstations (net of labor)</td>
<td>$2,190</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Option 1</td>
<td>Premium Gold at Workstations (net of labor)</td>
<td>$230</td>
<td>$1,960</td>
<td>$0</td>
<td>0.00</td>
<td>INFINITE</td>
</tr>
<tr>
<td>Option 2</td>
<td>NZD-Ultra at Workstations (net of labor)</td>
<td>$1,400</td>
<td>$790</td>
<td>$0</td>
<td>0.00</td>
<td>INFINITE</td>
</tr>
<tr>
<td><strong>Complex Degreaser</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Case</td>
<td>Methylene Chloride in Degreaser</td>
<td>$38,700</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Option 1</td>
<td>Aqueous Cleaning with Vertrel XDA/XF</td>
<td>$22,000</td>
<td>$16,700</td>
<td>$29,000</td>
<td>1.74</td>
<td>56.95%</td>
</tr>
<tr>
<td>Option 2</td>
<td>Aqueous Cleaning with IPA Dip Tank</td>
<td>$26,400</td>
<td>$12,300</td>
<td>$6,500</td>
<td>0.53</td>
<td>189.23%</td>
</tr>
<tr>
<td>Option 3</td>
<td>Replace Methylene Chloride with Vertrel CMS</td>
<td>$82,100</td>
<td>$(43,400)</td>
<td>$0</td>
<td>INFEASIBLE</td>
<td>INFEASIBLE</td>
</tr>
<tr>
<td><strong>Simple Degreaser #1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Case</td>
<td>Methylene Chloride in Degreaser</td>
<td>$62,500</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Option 1</td>
<td>Aqueous Cleaning with Vertrel XDA</td>
<td>$16,000</td>
<td>$46,500</td>
<td>$50,000</td>
<td>1.08</td>
<td>92.87%</td>
</tr>
<tr>
<td>Option 2a</td>
<td>Aqueous Cleaning with Segregated IPA Dip Tank</td>
<td>$22,600</td>
<td>$39,900</td>
<td>$27,500</td>
<td>0.69</td>
<td>145.07%</td>
</tr>
<tr>
<td>Option 2b</td>
<td>Aqueous Cleaning with Integrated IPA Dip Tank</td>
<td>$22,600</td>
<td>$39,900</td>
<td>$50,000</td>
<td>1.25</td>
<td>79.57%</td>
</tr>
<tr>
<td>Option 3</td>
<td>Replace Methylene Chloride with Premium Gold</td>
<td>$58,100</td>
<td>$4,400</td>
<td>$0</td>
<td>0.00</td>
<td>INFINITE</td>
</tr>
<tr>
<td>Option 4</td>
<td>Replace Methylene Chloride with NZD-Ultra</td>
<td>$59,900</td>
<td>$2,600</td>
<td>$0</td>
<td>0.00</td>
<td>INFINITE</td>
</tr>
<tr>
<td>Option 5</td>
<td>Replace Methylene Chloride with Vertrel CMS</td>
<td>$105,900</td>
<td>$(43,400)</td>
<td>$0</td>
<td>INFEASIBLE</td>
<td>INFEASIBLE</td>
</tr>
<tr>
<td><strong>Simple Degreaser #2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Case</td>
<td>Methylene Chloride in Degreaser</td>
<td>$62,500</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Option 1</td>
<td>Replace Methylene Chloride with Premium Gold</td>
<td>$29,100</td>
<td>$33,400</td>
<td>$0</td>
<td>0.00</td>
<td>INFINITE</td>
</tr>
<tr>
<td>Option 2</td>
<td>Replace Methylene Chloride with NZD-Ultra</td>
<td>$30,800</td>
<td>$31,700</td>
<td>$0</td>
<td>0.00</td>
<td>INFINITE</td>
</tr>
<tr>
<td><strong>Total for Option 1, All Cases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Case</td>
<td>Methylene Chloride</td>
<td>$165,890</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Option 1</td>
<td>Various</td>
<td>$67,330</td>
<td>$98,560</td>
<td>$79,000</td>
<td>0.80</td>
<td>124.72%</td>
</tr>
</tbody>
</table>
Provide Support for Implementation

- Assist Client in Equipment Selection and Installation
- Modify Operating Parameters as Needed
- Collect Metrics
Implementation
Results from Engine Systems

From work on a cleaning assessment for a major rebuilder of turbochargers where cleaning of parts was a major bottleneck in production.

- Identified applicable technology
- Company purchased new equipment
- Doubled capacity

Results:

- Economic Growth: $3 million/year
- Job Retention: 12 employees
- Worker Safety: Ergonomic improvements
- Waste Reduction: 1,700 gallons of cleaning solution
- Energy Conservation: Lower electricity consumption by optimizing cleaning process
Results from Dial Transmission

- Action – replace solvents parts washer with ultrasonic cleaning systems
  - $44,000 of annual savings obtained from capital investment of $10,240 - payback period is 12 weeks!
  - 67% reduction in use of compressed air
  - 80% reduction in use of solvents
  - 80% reduction in generation of solvent waste
  - Elimination of solvent droplets in shop air, improving indoor air quality and worker safety
  - Improvements in ergonomics of cleaning processes
  - Reduced energy costs and higher product quality
Results from Arc Remanufacturing

- Action – mid-pressure spray washer with high-pressure spray washer and washwater filtration system
  - Eliminate precleaning operations in vibratory degreaser and rework in primary cleaning process
  - Longer bath lives save on soap costs, water costs, and waste disposal expenses
  - Shorter cycle times result in decreased operating expenses and reduced energy consumption
  - Annual savings of $105,000 are obtained from installed equipment cost of $67,000, or a payback of less than 8 months!
  - Washwater contaminants are separated and encapsulated, and can be disposed of as non-hazardous waste, eliminating a hazardous waste stream
Results from D&W Diesel

- Action – replace two-step cleaning process with one-step ultrasonic cleaning operation and washwater filtration system
  - Eliminate solvent tank cleaning operations at facility
  - Reduced energy costs from elimination of energy-intensive cleaning process; rework eliminated in secondary cleaning process
  - Higher product quality from superior cleaning results
  - Annual savings of $10,000 are obtained from installed equipment cost of $21,300, or a payback of about two years!
  - Washwater contaminants are separated and encapsulated, and can be disposed of as non-hazardous waste, eliminating a hazardous waste stream
  - Longer bath lives save on soap costs, water costs, and waste disposal expenses
Implementation of High-Performance Cleaning Technologies in NY State

Conducted under a grant from the New York State Energy Research and Development Authority (NYSERDA).

Problem:
- Many automotive remanufacturing companies use inefficient or antiquated cleaning systems.
- Old systems are expensive, inefficient, and environmentally costly.
- Small companies often do not have resources to improve systems.

Objective:
- Implement improved cleaning systems in selected NY companies and conduct technology transfer events.

Results:
- Installed alternative systems in 5 NY companies, resulting in $250K of annual savings from a $159K investment.
- Reductions in hazardous and non-hazardous waste of 99% and 61%, respectively; substantial energy savings as well.
- Conducted numerous technology transfer events (demonstrations, published articles, seminars); created 4 new jobs for NY State!
Potential Results in New York State (1)

- Action - replace solvents parts washers with ultrasonic systems, and upgrade aqueous spray washers at 150 transmission rebuilding firms in New York State:
  - Annual savings in cleaning costs are $9,750,000
  - Annual savings in natural gas/propane are 1.64 million cubic feet
  - Reduction in disposal of mineral spirits by over 50,000 gallons per year
  - Elimination of over 150,000 pounds of brakewash per year, and its toxic constituents, including methanol, toluene, and ethylbenzene
  - Significant improvements in indoor air quality and worker safety
Potential Results in New York State (2)

- Action – install washwater recycling systems at 945 automotive parts rebuilding firms in New York State:
  - Reduction in annual natural gas consumption by 27.6 million cubic feet
  - Reduction in annual electricity consumption by 4.39 million KWH
  - Reduction in annual disposal of hazardous waste by over 125,000 gallons; annual reduction in disposal of non-hazardous waste by over 560,000 gallons per year
  - Ergonomic improvements in cleaning processes through elimination of manual rework processes
Questions?