Lake Erie  |  EASTER 2017

PFCs

- MERCURY
- DDT
- DIOXINS
- PCBs
- CHLORDANE
Satisfying the Triple Bottom Line

• PROFIT
• PEOPLE
• PLANET
In what year did 3M first begin production of PFCs?

1. 1947
2. 1957
3. 1967
4. 1977
In what year did 3M first begin production of PFCs?

1. 1947
In what year did the production of Teflon begin?

1. 1948
2. 1954
3. 1969
4. 1975
In what year did the production of Teflon begin?

2. 1954
In what year did 3M ‘voluntarily’ cease production of PFOS?

1. 1985
2. 1995
3. 2000
4. 2012
In what year did 3M ‘voluntarily’ cease production of PFOS?

3. 2000
True or False?

Does the Average American have PFOS or PFOA in their body?
True or False?

PFOS (and PFOA) has a half life in humans of 1-2 years?
True or False?

PFCs with shorter Carbon chains are safe (ie, C6)?
What Drives Technology?

Environmental Protection Agency

2015 – On July 21, 2015 the U.S. Court of Appeals for the DC Circuit denied NASF’s objection, claiming that the EPA has misapplied the requirements of the Clean Air Act, and upheld the final rule.

What does this mean for Decorative Chromium Plating?

Hexavalent Chromium

• Maintain lower surface tension
• Maintain lower emission limits
• Eliminate the use of PFOS fume suppressants
REQUIREMENTS OF FINAL RULING

LOWER EMISSION LIMITS

<table>
<thead>
<tr>
<th>Plating Process</th>
<th>New Limits</th>
<th>Previous Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decorative Chromium</td>
<td>0.007 mg/dscm</td>
<td>0.010 mg/dscm</td>
</tr>
<tr>
<td>Chromic acid Anodizing</td>
<td>0.007 mg/dscm</td>
<td>0.010 mg/dscm</td>
</tr>
<tr>
<td>Small Hard Chrome</td>
<td>0.015 mg/dscm</td>
<td>0.030 mg/dscm</td>
</tr>
<tr>
<td>Large hard Chrome</td>
<td>0.011 mg/dscm</td>
<td>0.015 mg/dscm</td>
</tr>
<tr>
<td>New Sources (All)</td>
<td>0.006 mg/dscm</td>
<td>0.015 mg/dscm</td>
</tr>
</tbody>
</table>
REALITY of REGULATIONS

Even though the EPA stated that non-PFOS-based fume suppressants demonstrated they could lower the surface tension, they have not demonstrated the ability to reduce chromium emissions.

Lower Emission Limits combined with non-PFOS-based fume suppressants may cause many installations to use HEPA filters.
WHAT'S IN THE FUTURE?

THE BEST ALARM CLOCK IS SUNSHINE ON CHROME.
HISTORY OF TRIVALENT CHROMIUM

Chromium plating
T.H. Weberstein
US Bureau of Mines
Union Carbide

1932
1939
1920s

Albright Wilson
Harshaw
Plating Process Systems

1970
1976
1985

Black Trivalent Chromium, CASS and TVC
Columbia Chemical
DECOR and BLACKJACK

2004
2006
2012
2015

2018

DINOSAURS

AUTONOMOUS VEHICLES
White Trivalent Chromium Color Evolution

Initial Trivalent Chromium L = 76

Leading Competitor L = 79.08

TriCOL Décor L = 79.43

Hexavalent Chromium L = 82.3
Precision Color Control

Décor

Formulation

BlackJack
## Operational Advantages

<table>
<thead>
<tr>
<th>Trivalent Chromium</th>
<th>Hexavalent Chromium</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Burning / Whitewash</td>
<td>Lower cost per amp-hr</td>
</tr>
<tr>
<td>Improved Thickness Distribution</td>
<td>Tolerant to Impurities</td>
</tr>
<tr>
<td>Tolerant to Current Interruption</td>
<td>Self Passivation</td>
</tr>
<tr>
<td>Microporous as plated</td>
<td></td>
</tr>
<tr>
<td>Improved Covering Power</td>
<td></td>
</tr>
<tr>
<td>Filming of anodes not necessary</td>
<td></td>
</tr>
<tr>
<td>No Pb in plating system</td>
<td></td>
</tr>
</tbody>
</table>
Comparison of Thickness

Hexavalent

Trivalent
# Waste Treatment Requirements

1 gallon (3.785 Liters) of Solution

<table>
<thead>
<tr>
<th>Trivalent Chromium</th>
<th>Hexavalent Chromium</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 g/L chrome metal</td>
<td>120 g/L chromium</td>
</tr>
<tr>
<td>0.17 kg calcium hydroxide</td>
<td>1.36 kg sodium bisulfite</td>
</tr>
<tr>
<td><strong>0.43 kg solids</strong></td>
<td><strong>0.73 kg sulfuric acid</strong></td>
</tr>
<tr>
<td></td>
<td><strong>1.0 kg calcium hydroxide</strong></td>
</tr>
<tr>
<td></td>
<td><strong>2.8 kg solids</strong></td>
</tr>
</tbody>
</table>

| 1 Step Processing        | 3 Step Processing          |

[Image]
# EHS - Environmental, Health and Safety Advantages

<table>
<thead>
<tr>
<th>Trivalent Chromium</th>
<th>Hexavalent Chromium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non- carcinogenic</td>
<td></td>
</tr>
<tr>
<td>Anodes last indefinitely</td>
<td></td>
</tr>
<tr>
<td>No Lead compounds for disposal</td>
<td></td>
</tr>
<tr>
<td>Easy air pollution requirements</td>
<td></td>
</tr>
<tr>
<td>No Sludge (Barium Sulfate)</td>
<td></td>
</tr>
</tbody>
</table>
Benefits by converting to Trivalent Chromium

- New Opportunities, including Automotive
- Reduction in Waste Water Treatment Chemistries
- Reduction in Hazardous Waste Generation
- Increased Production
- Reduced Scrap rates
- Enhanced worker safety
- Green Marketing
THANK YOU