# Metal Finishing Workshop

## March 4, 2010

Hosted by:

New York State Pollution Prevention Institute at

Rochester Institute of Technology

# Workshop Agenda:

**8:30am -9:00am Registration, Coffee & Bagels**
**9:00am - 9:55am Dave Fister: Plating line overview, Rinse water reduction techniques**

**9:55am - 10:05am Short Break**

**10:05am -11:00am Jim Hankinson: Energy use in the exhaust system**
**11:00am -11:55am Ray Graffia, Jr.: How to save money, improve parts' cleanliness, reduce waste hauling, & lower chemical usage – by extending the life of your aqueous cleaners**

**12:00pm - 1:00pm Lunch**

**1:00pm - 2:00pm Facility Tour and Filtration Demonstration (Arbortech )**
**2:00pm - 2:55pm Dave Fister: Water use reduction & recovery methods**
**Dave Fister: Energy savings in paint & powder coat curing**

**2:55 pm -3:05pm Short Break**

**3:05pm -4:00pm Newton Green and Rajiv Ramchandra: Acid bath management and acid life extension**
**4:00pm -4:30pm Questions and Answers**

# First Morning Session

9:00pm - 9:55pm

Dave Fister:

## Metal Finishing 101,

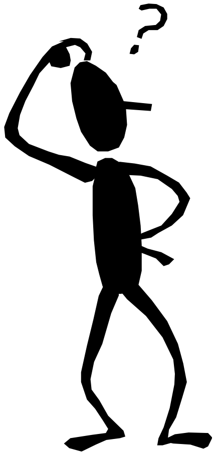
## Stepping away from the process

# Who Can Benefit

- Powder coaters: parts preparation
- Painters: parts preparation
- Platers
- Chemical conversion, phosphating
- Anodizers

- All have similar process steps: cleaning and rinsing

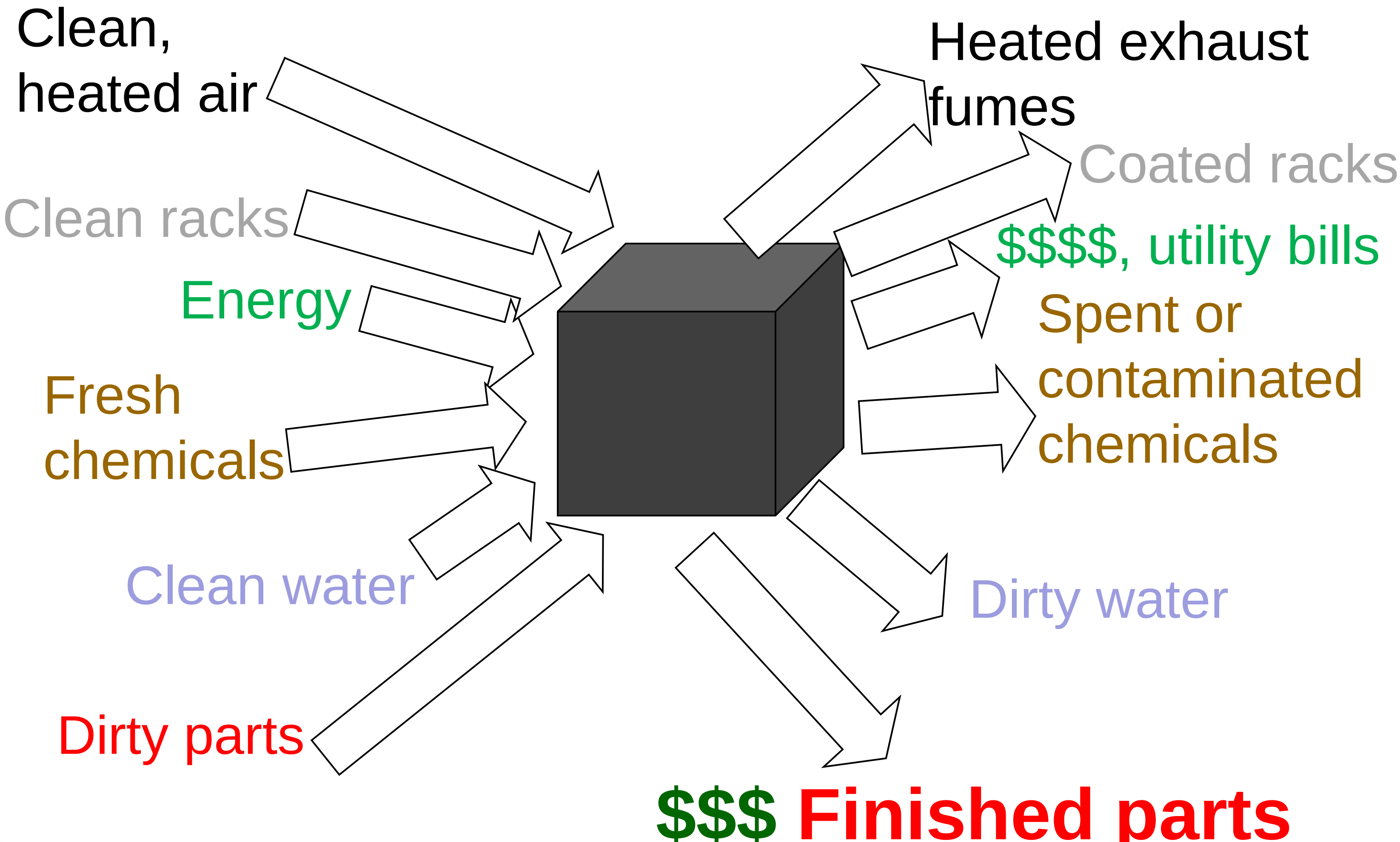
# The Really High Level



- What are we really trying to accomplish?

- Answer: Add some value to parts with some sort of quality coating for the least amount of money.

# The Process


Clean, heated air
Clean racks
Energy
Fresh chemicals
Clean water
Dirty parts
Heated exhaust fumes
Coated racks
$$$$, utility bills
Spent or contaminated chemicals
Dirty water
$$$ Finished parts

# Next, Treatment

- Waste chemicals need to be treated, $$
- Exhaust fumes may need to be scrubbed (scrubbing water needs to be treated), $$
- Fresh make-up air needs to be heated, $$
- Paint fumes, VOC's, may need thermal oxidation, $$
- Dirty water may need to be treated, $$
- Treatment sludge needs to be hauled, $$
- Racks need to be stripped, $$

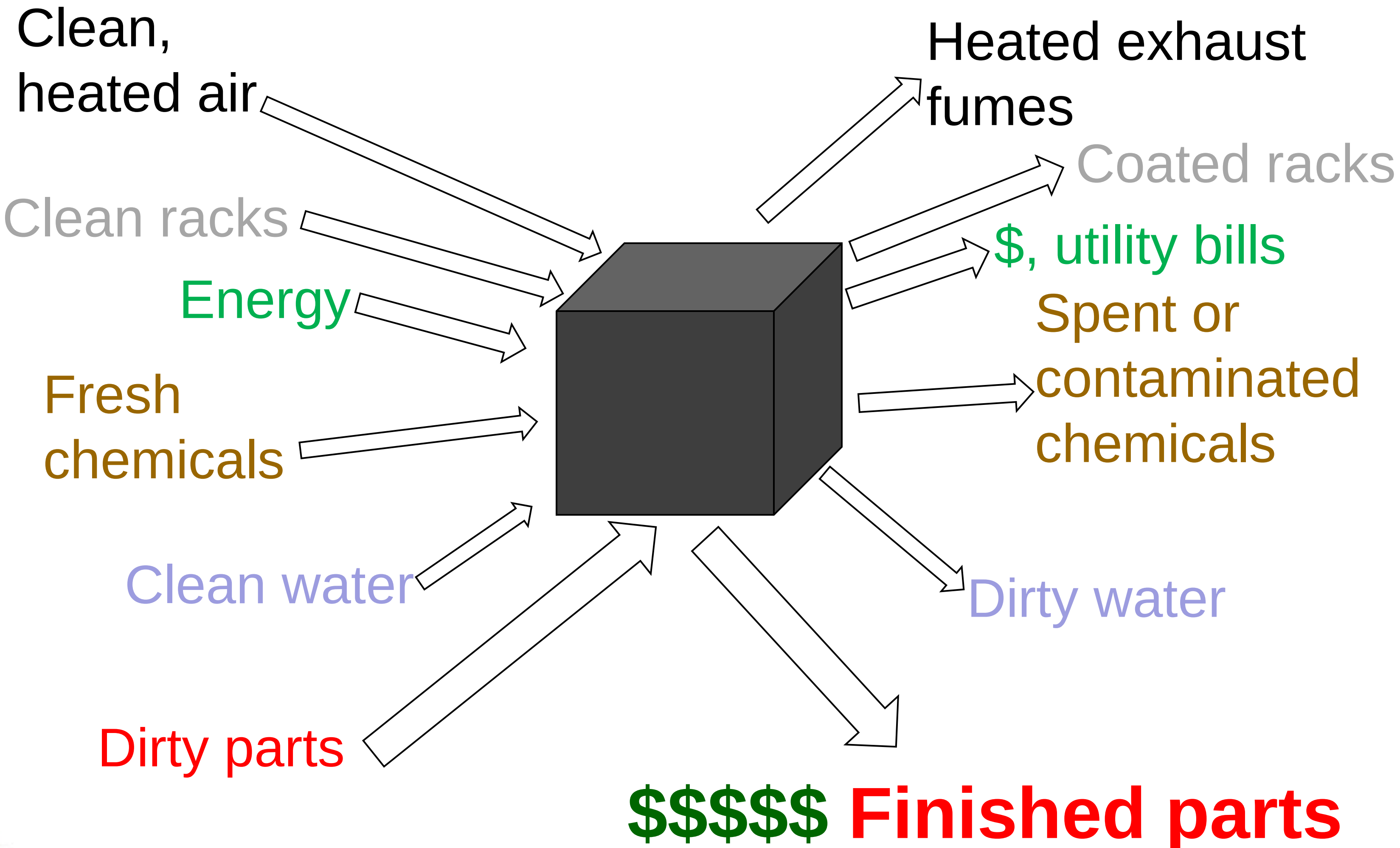
# Develop a Baseline

- Water costs: include water purchase cost and water sewer cost (sometimes a tax item)
- Chemical costs: cleaners, acids, plating salts, etc.
- Waste treatment costs: chemicals, labor, sludge disposal, resin regeneration chemicals, etc.
- Ventilation system: blower motor size, natural gas cost or other heating fuel cost
- Electricity cost: pumps, blowers, compressors, hot air dryers, etc.

# Rochester Example

- Water use = 6,310,000 gpy = $32,900/yr. ($5.22/1000 gallons)
- Exhaust blower = 10,000 cfm = $7,899/yr. for 40 hours per week ($.09/kwh)
- Make-up air heating = 431 decatherms = $2,154 /yr. ($5/decatherm)
- Acid purchases (HCl) = $19,700 ($1.25 /gallon, 15,760 gallons)
- Caustic purchases (NaOH) = $6,400 ($2.10/lb, 3,048 lbs.)
- Sludge disposal = $15,600
- Total cost per year = $66,923/year

# The Improved Process



# Water Use Reduction: Rinse Water

- Measure the flow rate on each rinse tank to determine the rinse water use
  - Needed: ruler, tape measure, stop watch, small pump and hose
  - Pump the tank down 1-2” inches
  - Measure the time it takes for the water level to move some convenient amount (1/2”, 1”, etc.)
  - Measure the surface area of the tank (length, width)
  - Length x width x change in water level = volume in cubic inches (231 cubic inches =1 gallon)
  - Gallons/measured time gives the flow rate

# Typical Cleaning Steps

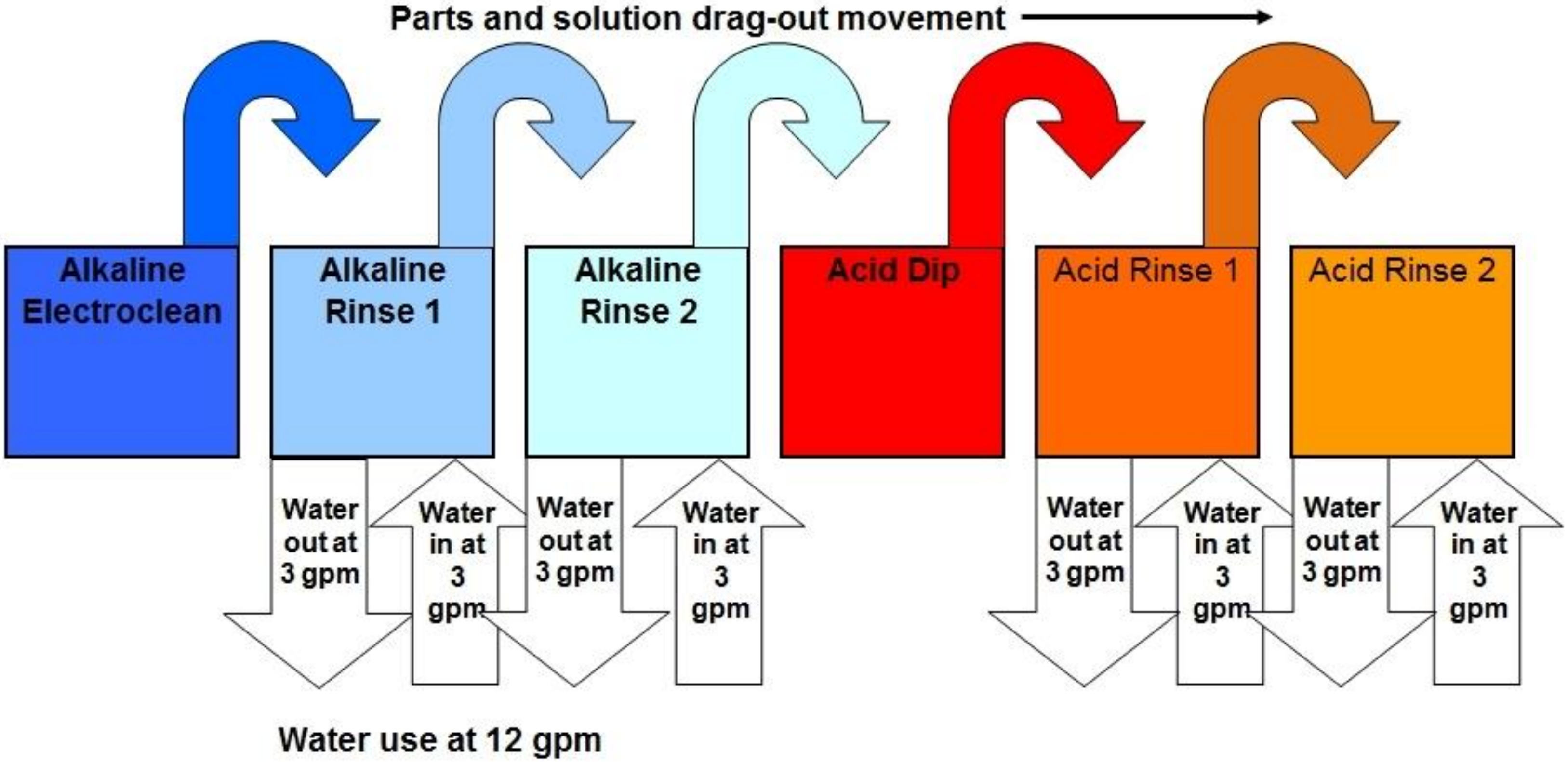
1. Alkaline cleaner, could include ultrasonics, agitation, or electrocleaning to assist the cleaning chemistry in contaminant removal. Contaminants are typically oil, dirt, buffing compound, fingerprints, etc.
2. Rinses (parts drag alkali into rinse water)
3. Acid etch, to remove light rust or oxides
4. Rinses (parts drag acid into rinse water)
5. Sometimes a repeat of the alkaline and acid steps including rinses

# Purpose of Rinsing

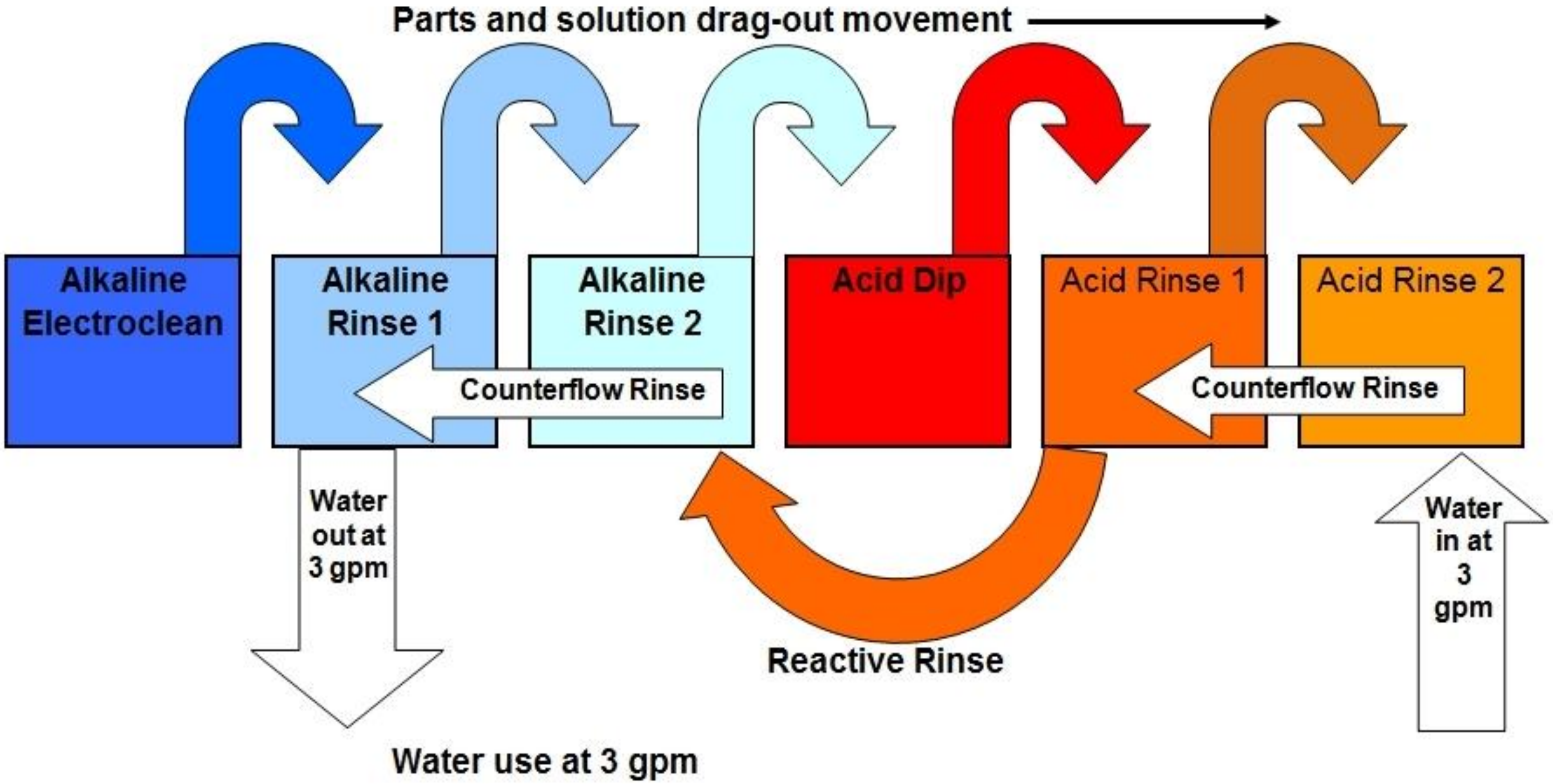
- First rinse tank
  - remove most of the previous tank's chemicals
  - Stop the chemical reaction from the previous tank
- Second rinse tank
  - Final rinse to remove additional chemicals
  - Minimize contamination of next chemical tank

If there was zero dragout of chemicals then there would be no need to rinse!!!

# Typical Cleaning and Rinsing Layout



# Optimized Cleaning and Rinsing Layout



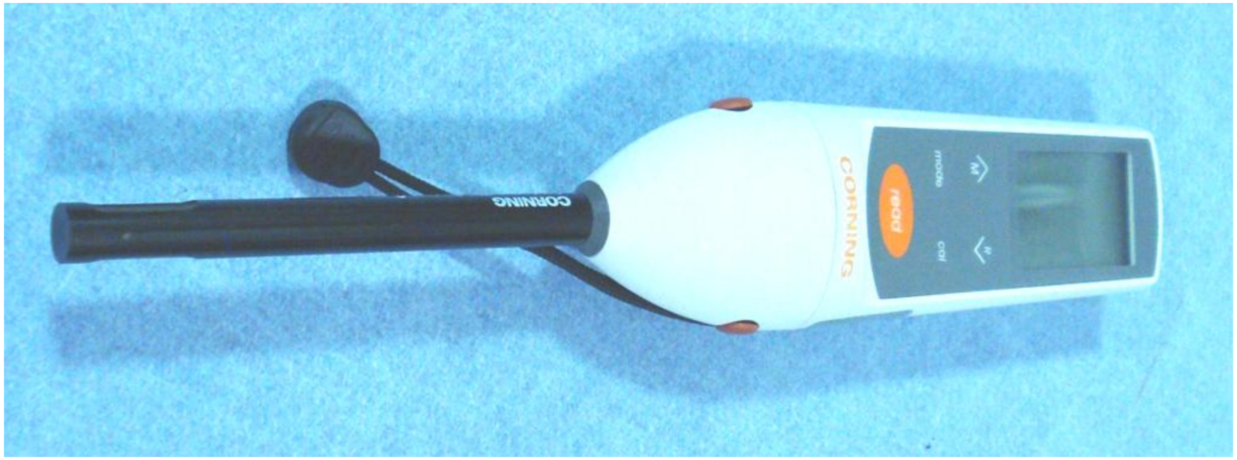
# Monitoring the Rinse

- Rinse water contaminants (chemical solution dragout) are typically electrically conductive in solutions.
- As more solution gets dragged into a rinse tank the rinse conductivity goes up.
- As the rinse flow is increased the contamination level drops more rapidly due to dilution (and vice versa)

Note: Conductivity is directly related to total dissolved solids or TDS

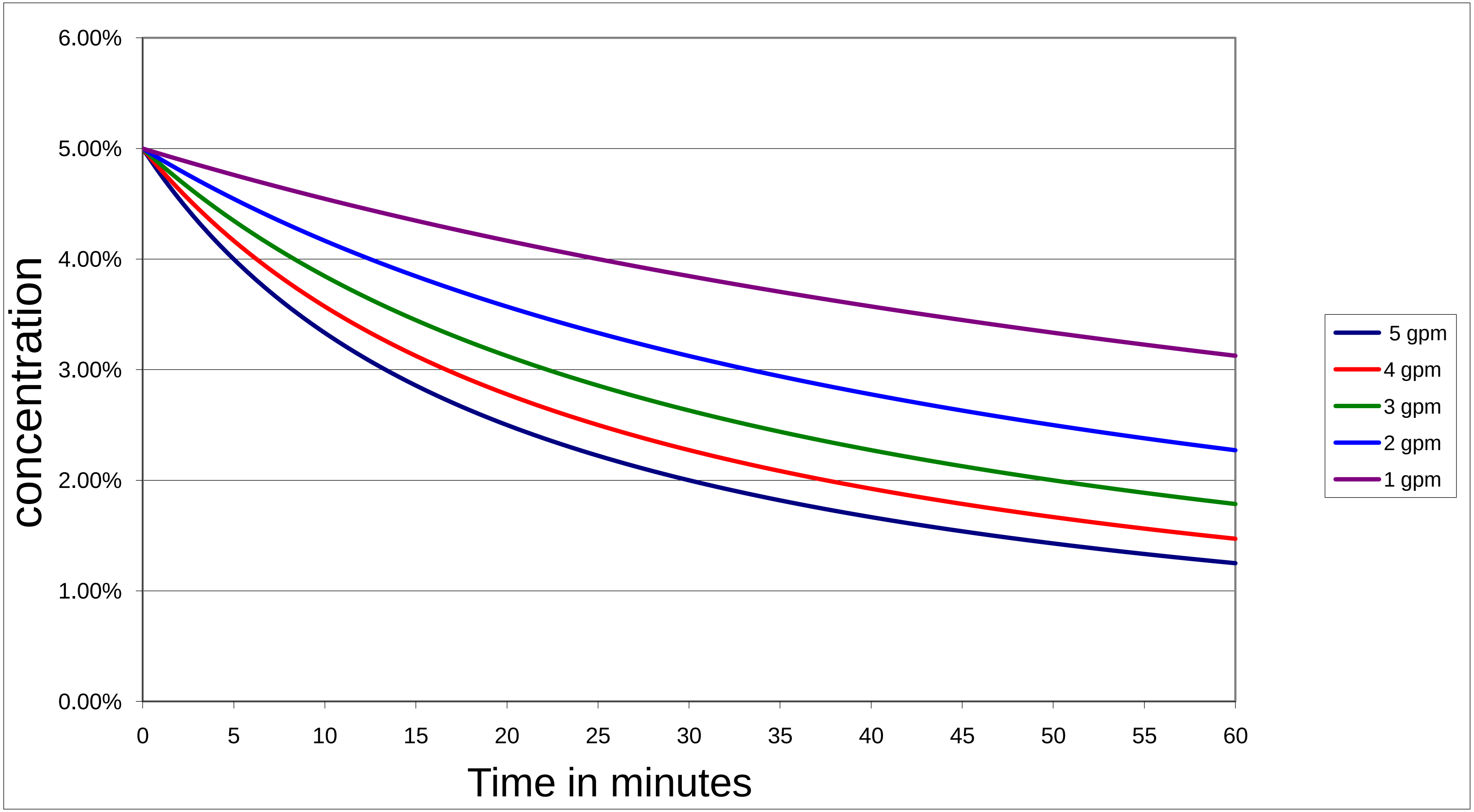
# Flow vs. Concentration

- Measuring contamination in rinse water
  - Chemical analysis (slow and expensive)
  - Solution conductivity: start with a beaker, end with on-line rinse tank measurements



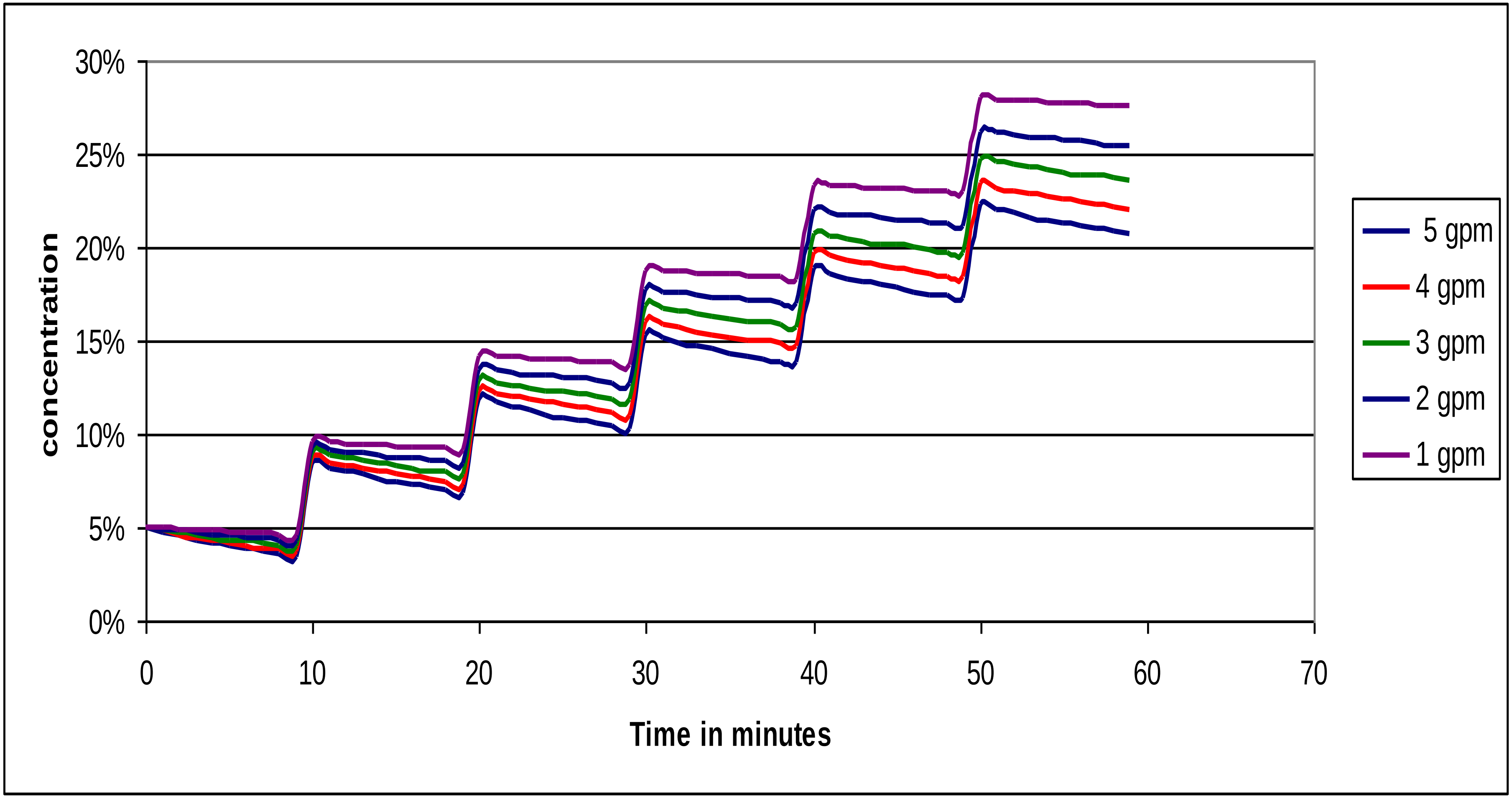

Conductivity/TDS meters cost from $140-$900

# Simple Rinse Dilution Model




100 gallon tank, .05 gal. dragout, 100 gm/gallon in dragout

# Real World Rinse Dilution Model



# Immersion Rinse

- Conclusion: Based on the rate of dilution in even a small tank (100 gallons), it is very difficult to obtain good rinsing with a single rinse tank. Even relatively high flow rates of 5 gpm cannot keep up with the contamination loading from parts dragout.
- Therefore, there really needs to be a second rinse tank for critical rinsing.
- And……it becomes very important to determine your real rinse tank dynamics by measuring flow and conductivity/TDS

# Flow Controls in Immersion Rinsing

- In-line flow restrictors: the hand operated valve has an aperture to restrict the flow to some maximum value at maximum valve opening.
- Conductivity controls: rinse valve opens and closes based on TDS value of rinse tank


From: www.freshwatersystems.com

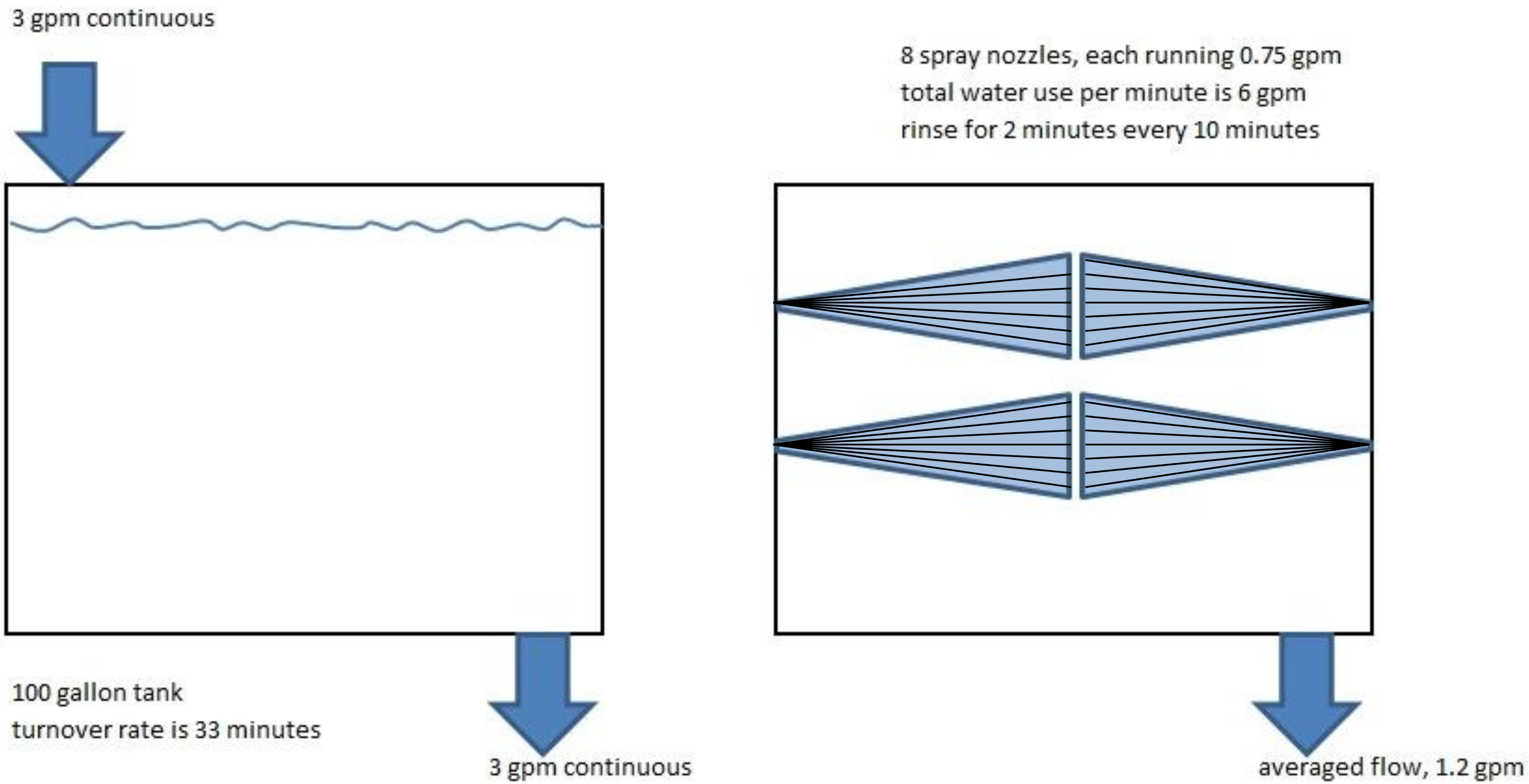

From: Myron L Company, Controlstik Systems

# Conductivity/TDS Controls

Finding the best TDS setpoints (valve opens when water reaches maximum TDS setpoint, valve closes when water reaches minimum TDS setpoint)

- Measure the TDS with a meter in the critical rinse tanks. Knowing the existing flow rate also helps.

# Immersion vs. Spray Rinsing



# Other tricks with spray rinsing

- If part geometry is difficult to rinse with fixed spray, if the line is a manual line then the operator can use a manual spray rinse to reach the hard-to-rinse areas of the parts
- If the chemistry is difficult to rinse with cold water, set up an in-line heater for the spray water supply or have a pre-heated supply tank

# Metal Finishing Workshop

## Rochester Institute of Technology
## March 4, 2010

# Acid Etching of Titanium Alloy Case Study

# Overview

- Introduce TECT Power Corporation
- Define Problem
- Understand the chemical reactions
  - Conduct research
  - Propose stoichiometric solution
  - Test proposed solution on bench scale
  - Confirm veracity of proposed solution
- Develop process alternative consistent with proposed stoichiometric solution
- Implement process alternative
- Measure results

# Introduction to TECT Power Corp.

- Based in Utica, New York
- Manufactures turbine blades to stringent specifications
- Incurred large expenses in disposing of hazardous waste
  - Generated 502 tons of hazardous waste in 2007 from chemical etching operations
  - Spent $395K on purchase and disposal of etching acids
- Contacted local RTDC (MVATC) to find a P2 solution
- MVATC contacted NYSP2I, and a collaborative effort between TECT, MVATC, and NYSP2I was initiated

# Define Problem

- Uses corrosive acids to mill blades to specifications
- Turbine blades are very expensive - $40K per blade
- TECT changes out acid baths frequently (once per week) so as to maintain reasonably constant acid etching rates; doesn't want to overetch (and ruin) turbine blades
- TECT wanted to identify a means of reducing etching costs and waste, but did not replace process due to customer specification requirements

# Understand Stoichiometry

Conduct Research

- Conduct literature search
- Determine chemical reactions of hydrofluoric acid (HF) and nitric acid ($HNO_3$) on titanium

Combine above reactions to obtain overall chemical reaction

$$\mathbf{Ti + 6HF + HNO_3 \rightarrow 2H^+ + TiF_6^{-2} + ½N_2O + 2½H_2O}$$

Note that molar ratio of HF to $HNO_3$ is 6:1!

# Propose Solution

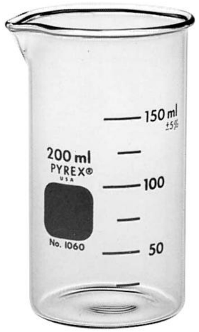
- Next, determine composition of alloy by weight
  - 90% titanium
  - 6% aluminum
  - 4% vanadium
- Determine chemical reactions of hydrofluoric acid (HF) and nitric acid ($HNO_3$) on vanadium and aluminum
- Combine above reactions using molar composition of alloy to obtain overall chemical reaction

$$\mathbf{Ti + 0.12Al + 0.05V + 6.5HF + 1.1HNO_3 \rightarrow}$$

$$\mathbf{2H^+ + TiF_6^{-2} + 0.12AlF_3 + 0.05VF_3 + 0.6N_2O + 2.8H_2O}$$

Note that molar ratio of HF to $HNO_3$ is still about 6:1!

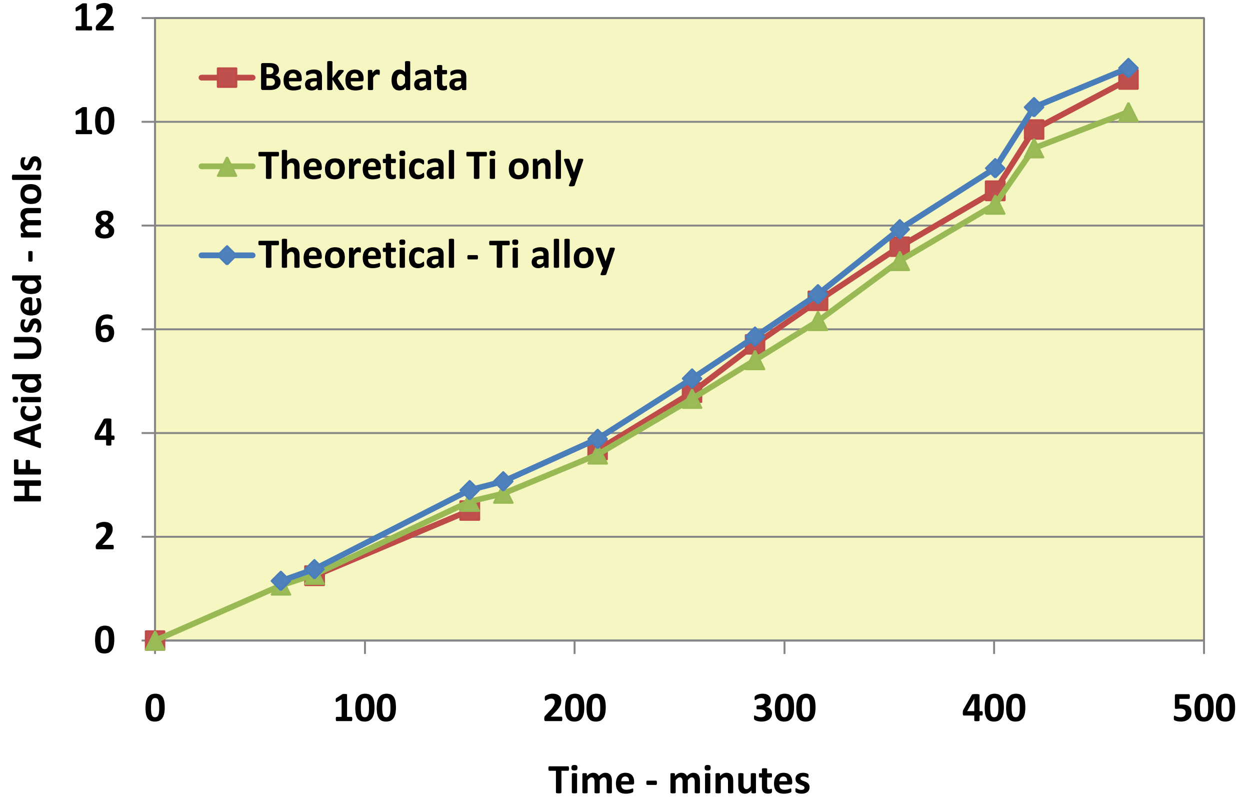
# Conduct Bench-Scale Testing




Test Conditions:

- 500 ml test volume in 1-liter beaker
- Initial acid concentrations at 9% HF and 12% $HNO_3$ as per customer specifications
- Etch titanium coupon for prescribed time period and boost to return acid concentrations to 9% and 12%
- Control temperature with ice bath at 80 deg F
- Run each etch cycle to nearly deplete HF
- Dissolved metal mass determined by weighing coupon on analytical balance

# Confirm Veracity of Proposed Solution



# Application of Beaker Test Results

**An understanding of the stoichiometry allows us to:**

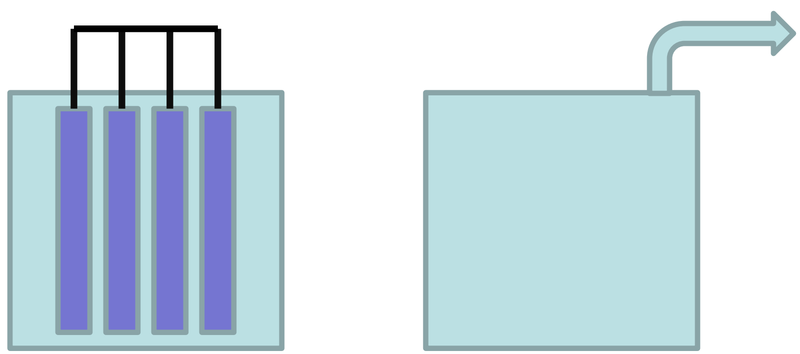
- Determine maximum waste generation
- Determine maximum total metal concentration
- Identify and avoid potentially unacceptable operating conditions

# Determine Maximum Dissolved Metal Concentration

1. Titanium is added during etching
2. Dissolved titanium is removed with liquid to prepare for boosting

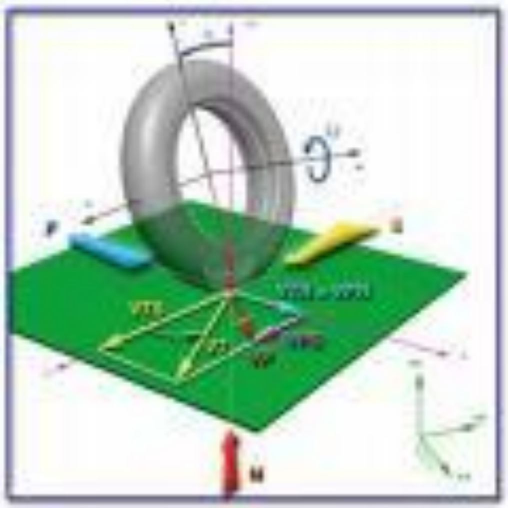
**Mass Balance**

| Metal IN [etch] | Metal OUT [boost preparation] |
|---|---|



➔ **At Steady State: Metal In = Metal Out**

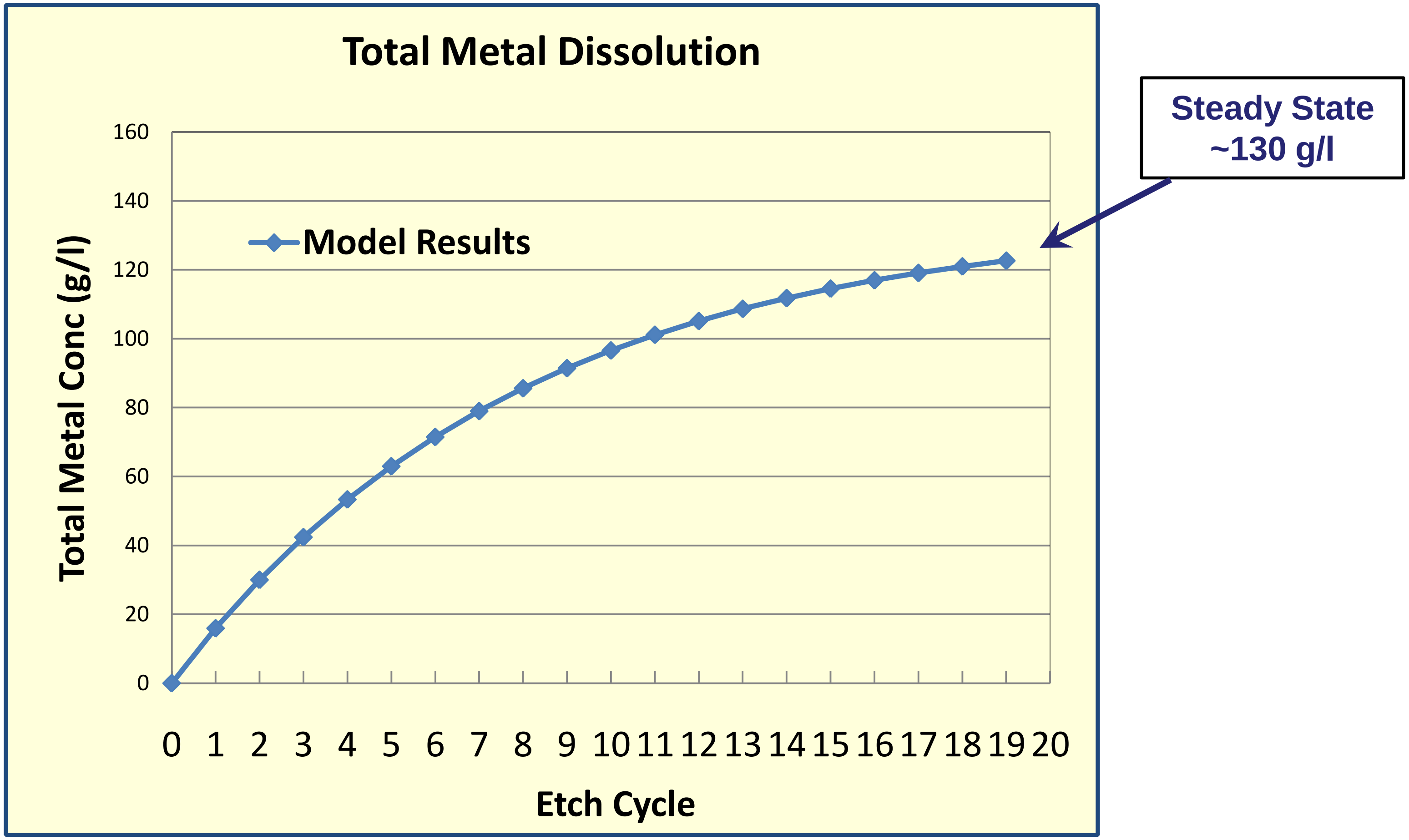
# Develop Mathematical Model



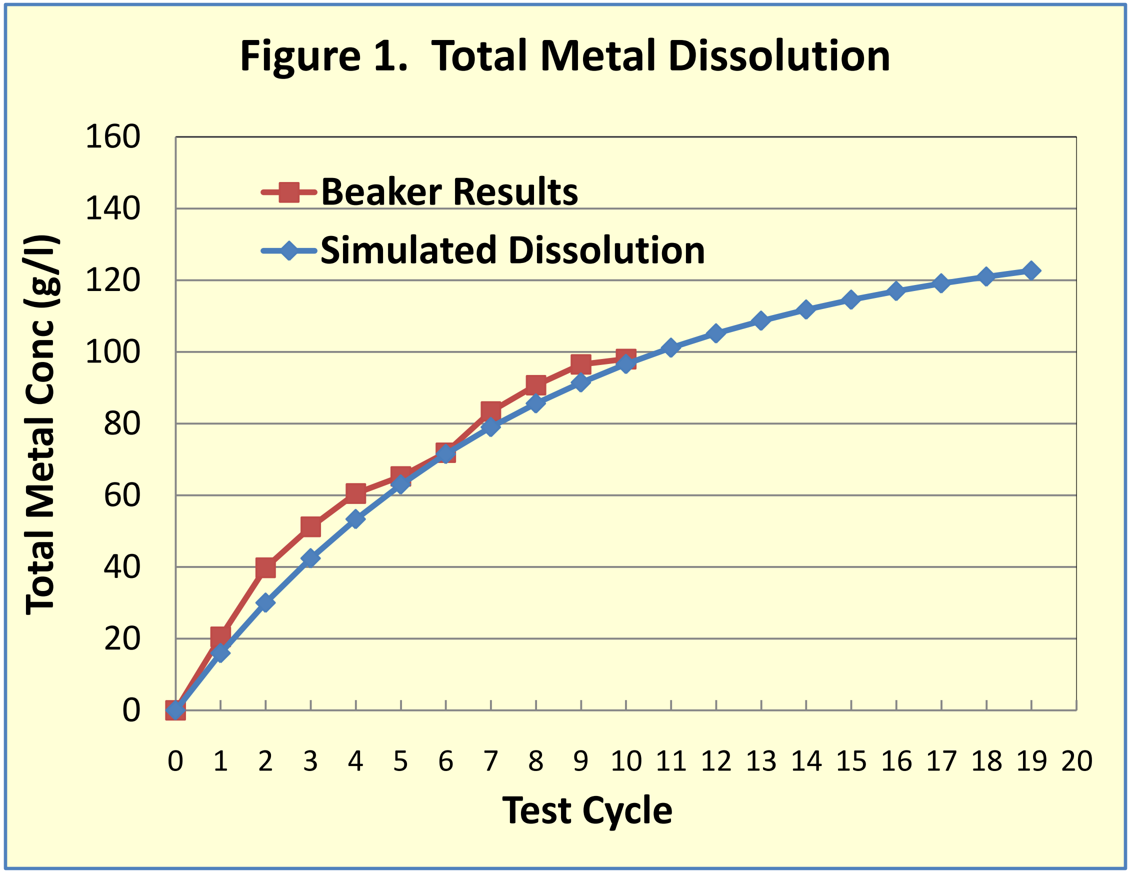
Mathematical Model Formulated to Simulate Beaker Test:

- Titanium dissolution – 6.5 moles HF per mole of Ti
- HF and $HNO_3$ acid concentrations initially set at 9% and 12%, respectively
- HF and $HNO_3$ acid concentrations are boosted at the end of each etch cycle to return to 9% and 12%, respectively

# Model Predictions of Etch Process



# Comparison of Model with Beaker Test Results



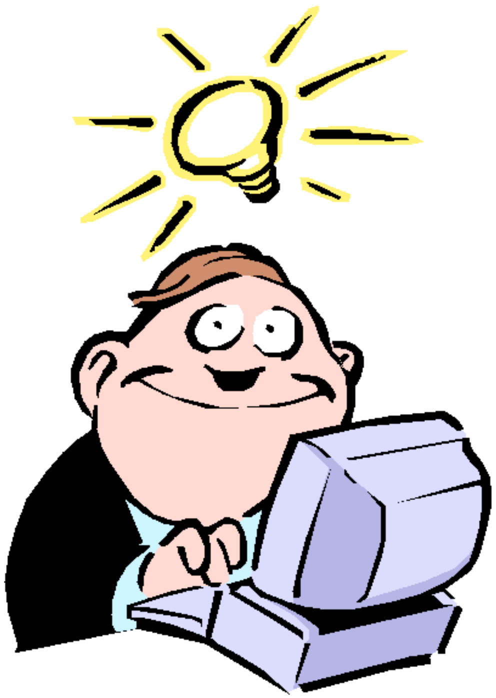

**Math model and beaker data show good correlation**

# Outcome of Steady State Evaluation

- Total metal concentration reached approximately 110 grams/liter at the end of the last beaker etch cycle
- If the saturation concentration of dissolved titanium is greater than 130 grams/liter, then the etch bath could operate indefinitely without dumping (other than for maintenance needs), provided acid boosts were performed correctly
- Operating in this mode reduces the quantity of hazardous waste generated to its minimum level because all tank dumping is eliminated

# Key Learnings from Lab Testing

- Proposed stoichiometric solution is correct
- No precipitation occurred up to 110 grams/liter of dissolved metal
- Etch rates remain constant over multiple boosts
- Multiple etch batches can be run without dumping when the acid boosts are properly conducted, so there is no need to dump acid baths so frequently!



# Actual Results for 2009

- Proposed solution was partially implemented at TECT during the latter half of 2009
- Actual reductions in hazardous waste from chemical etching operations amounted to 292 tons per year in 2009 when compared to the baseline year of 2007
- This 58% reduction represents savings of $178,000 per year, and reflects both implemented P2 process improvements as well as decreased production.

# Potential Results for 2010

- If TECT fully implements NYSP2I's recommendations for all of 2010, hazardous waste from chemical etching operations can be potentially reduced by 431 tons (86%) if production volume returns to 2007 levels
- This represents annual savings of $290,000 for the purchase and disposal of etching acids, due to the longer acid bath lives

# Acid Life Extension

## New York State Pollution Prevention Institute

## Rochester, NY
## March 04, 2010

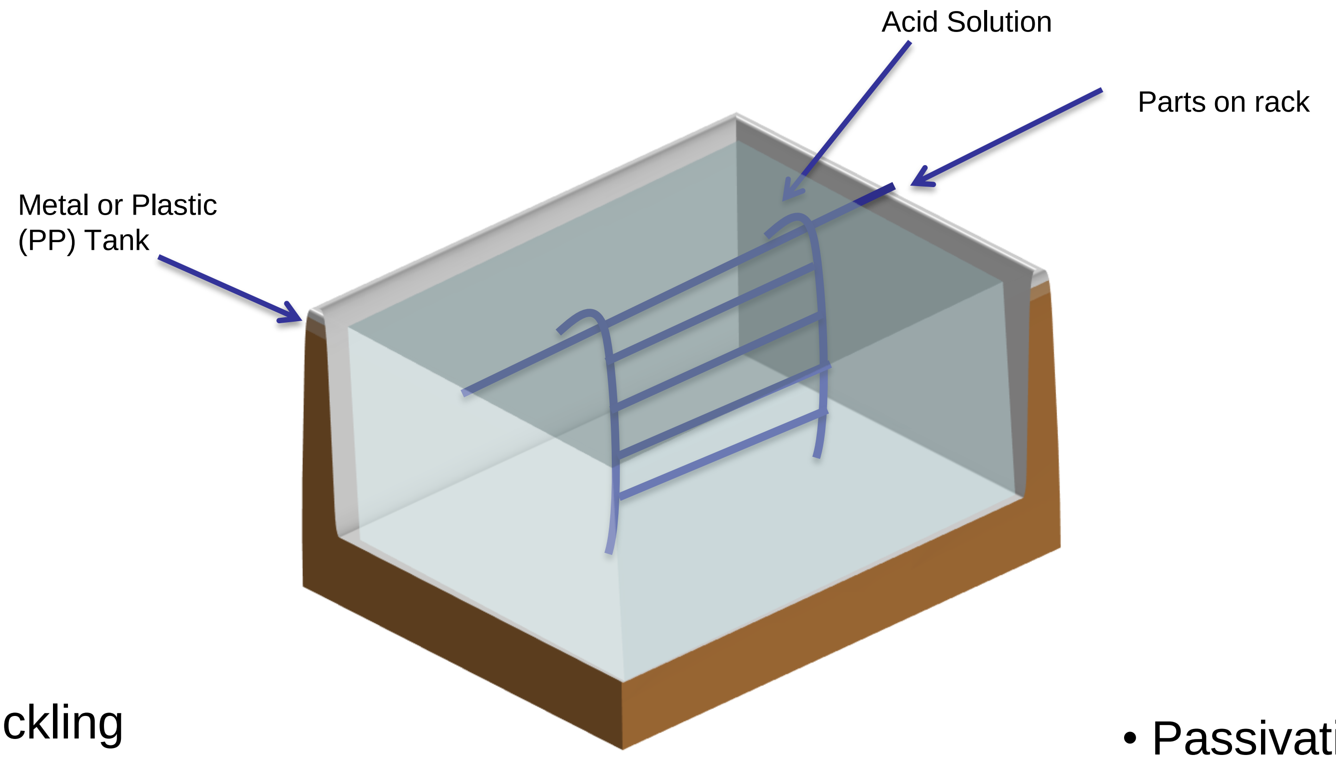
Rajiv Ramchandra

# Acid Life Extension

- What is it?

  *Acid Life Extension* involves increasing the usable life of an acid bath while reducing the amount of acid consumed, consequently reducing the number of times the acid bath is dumped and making the process more consistent, over a given time period.

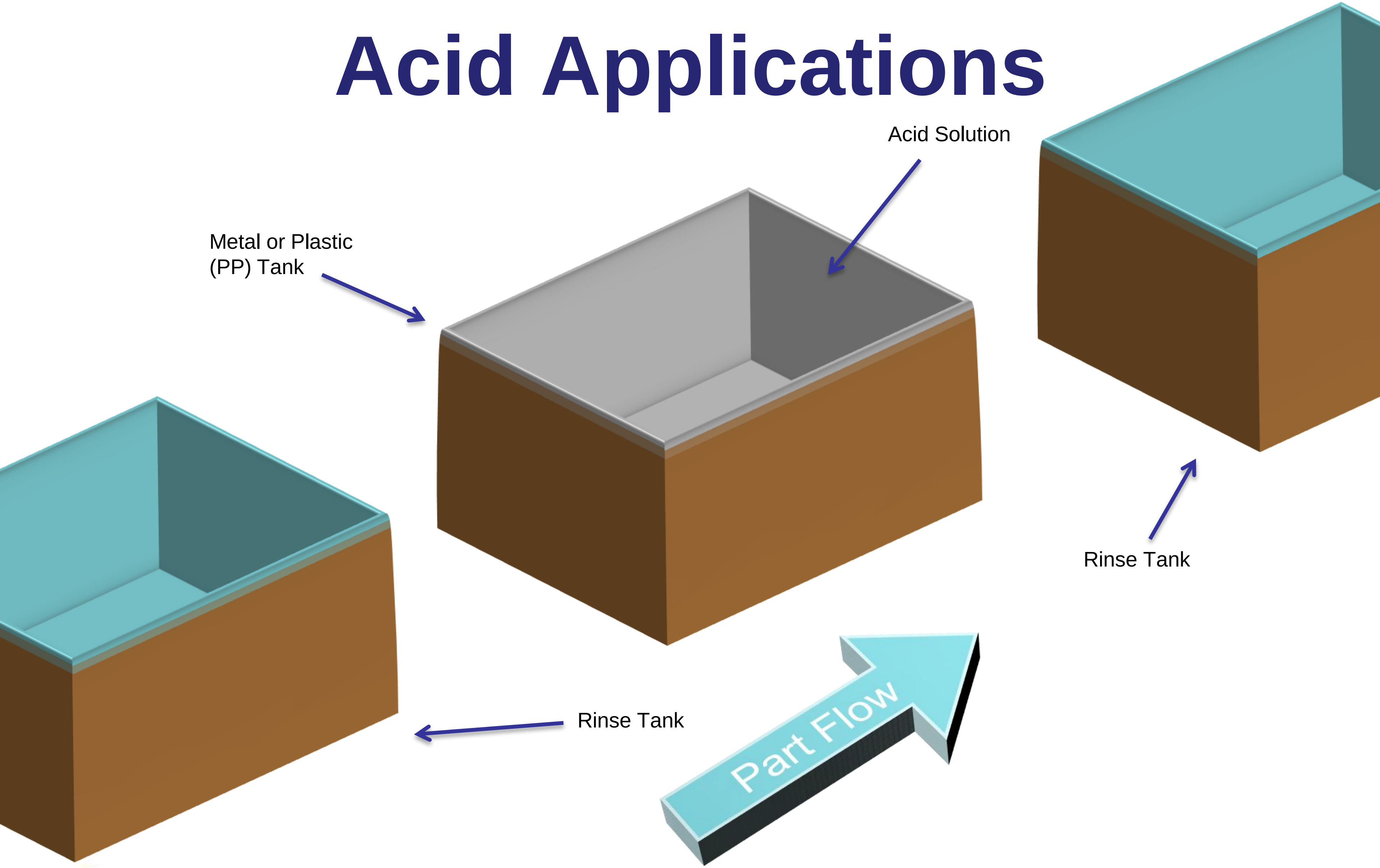
# Acid Applications




- Acid Pickling
- Stripping baths
- Activation baths
- Deoxidizer

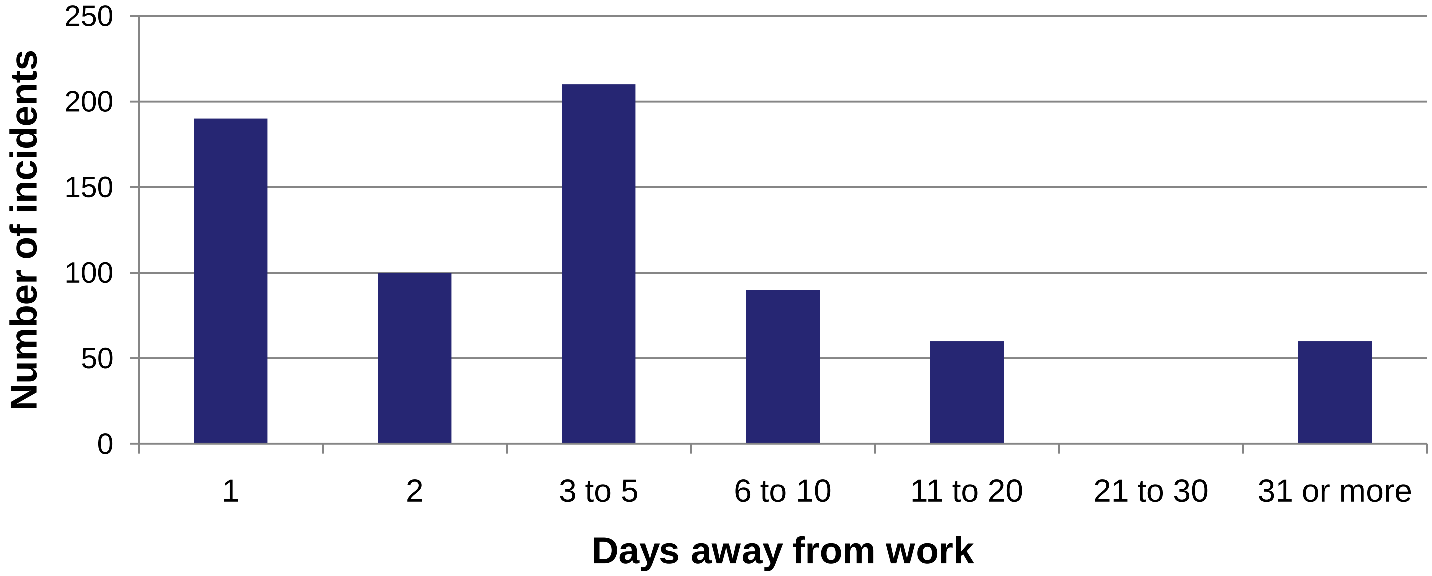
- Passivation baths
- Anodizing
- Electropolishing
- Etching

# Acid Applications



# Acid Use

1. Handling: It is a Hazardous Material
   – In 2008, 710 incidents reported nationwide of nonfatal occupational injuries and illnesses involving days away from work related to acids




Source: Bureau of Labor Statistics, U.S. Department of Labor: http://www.bls.gov/iif/oshwc/osh/case/ostb2151.pdf

# Acid Use

2. Disposal:
   - Waste Management Services
   - Reporting requirements to TRI, RCRA

3. Costs:
   - Purchase cost
   - Disposal cost
   - Cost of rework
   - Labor costs

# Acid Life Extension

**PRO-pHx:**

"PRO-pHx is a catalyzed formulation carried by a proprietary blend of soluble silicates. It effectively immobilizes soluble metals by reacting with them to form insoluble metal silicates.

[It] will also react with volatile and non-volatile organic compounds to produce a non-volatile, non-toxic, non-hazardous waste. The precipitate is then easily filtered."

Information provided by PRO-pHx, Inc.

# Application Guidelines

## Application

- Add PRO-pHx at 1% to total tank volume
- Filter to produce 1 to 2 turnovers per hour
- 1-100 micron filtration

## Measurement

- Track acid titration results & add (spike) acid to strength

## Maintenance

- Filter  as required (filtration may require *fine tuning*)
- Additions of acid and PRO-pHx are required
- Include PRO-pHx at 1% of required acid additions

# Illustrations

← In-tank Filtration

Overflow Filtration →

# Acid Life Extension

| *Name* | *Concentration* | *Temperature* |
|---|---|---|
| **Hydrochloric / Muratic** | **5% to 95% By Volume** | **55 to 160 F** |
| **Nitric** | **10% to 80% By Volume** | **60 to 120 F** |
| **Sulfuric** | **10% to 95% By Volume** | **34 to 190 F** |
| **Citric** | **7% to 15% By Volume** | **60 to 125 F** |
| **Phosphoric** | **7% to 15% By Volume** | **60 to 115 F** |
| **Nitric & Ammonium Bifluoride** | **40% to 70% By Volume** | **70 to 80 F** |
| **Acid Salts** | **7% to 15% By Volume** | **70 to 90 F** |
| **Nitric & Phosphoric** | **15% to 20% By Volume** | **105 to 115 F** |
| **Sulfuric & Oxalic** | **18% By Volume** | **Proprietary** |
| **Sulfuric & Phosphoric** | **18% By Volume** | **105 to 115 F** |
| **Hydrochloric & Acid Salts** | **15% to 20% By Weight** | **70 to 95 F** |
| **Nitric & Hydrofluoric** | **15% to 20% By Volume** | **70 to 115 F** |
| **Sulfuric & Hydrofluoric** | **20% By Volume** | **115 to 130 F** |

– Hydrochloric, Sulfuric, Nitric, Citric, Phosphoric, Nitric / Hydrofluoric, Sulfuric Peroxide and Other Exotic Blends of Acid

**Effective Metals Reduction Include**

Iron, Zinc, Nickel, Copper, Aluminum, Cadmium, Trivalent and Hexavalent Chrome

**Organics Are Eliminated**

# Acid life extension

- Benefits
  - Reduced acid use and reduced costs
  - Reduced disposal quantities and disposal cost
  - Lower material handling, reducing risk to human health
- Things to consider before implementation
  - Installation of filter pump and filter
  - Cost of PRO-pHx
  - Does not work with certain combinations of acids and metals (Ex: Ti, HF-$HNO_3$)

# Ex: Coating Technologies, Inc.

- Metal finishing job-shop in Rochester, NY
- Conducted a 11-month study to assess the performance of PRO-pHx on Muriatic and Nitric acid tanks
- Parameters monitored:
  - Dissolved metals
  - Volume of acid added
  - # of manufacturing defects

# Findings

- All baths remained functional through the course of the study
- All baths experienced an increase in life by at least 2x (with some going up to 20x)
- No defects were traceable to poor acid quality

# Unexpected outcomes

- Metal concentration in many baths increased beyond typical operating ranges
- No effect on work-piece processing time or cleaning ability
- Hypothesis is that PRO-pHx material is acting the way a chelator works in an aqueous solution by tying up the metal and organic compounds making them ‘invisible’ to the acid

# Metal Concentrations

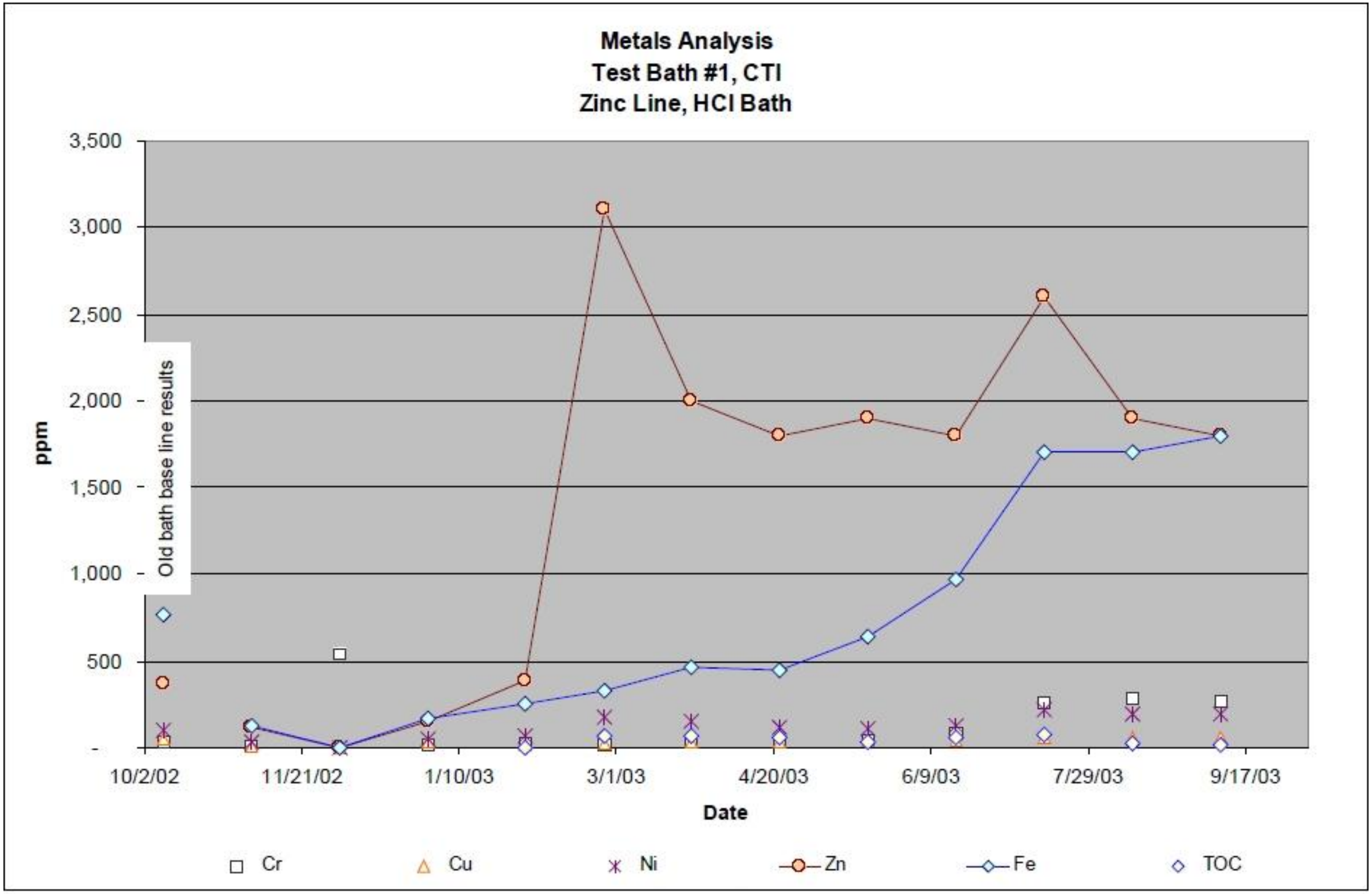



Figure 1

# Metal Concentrations

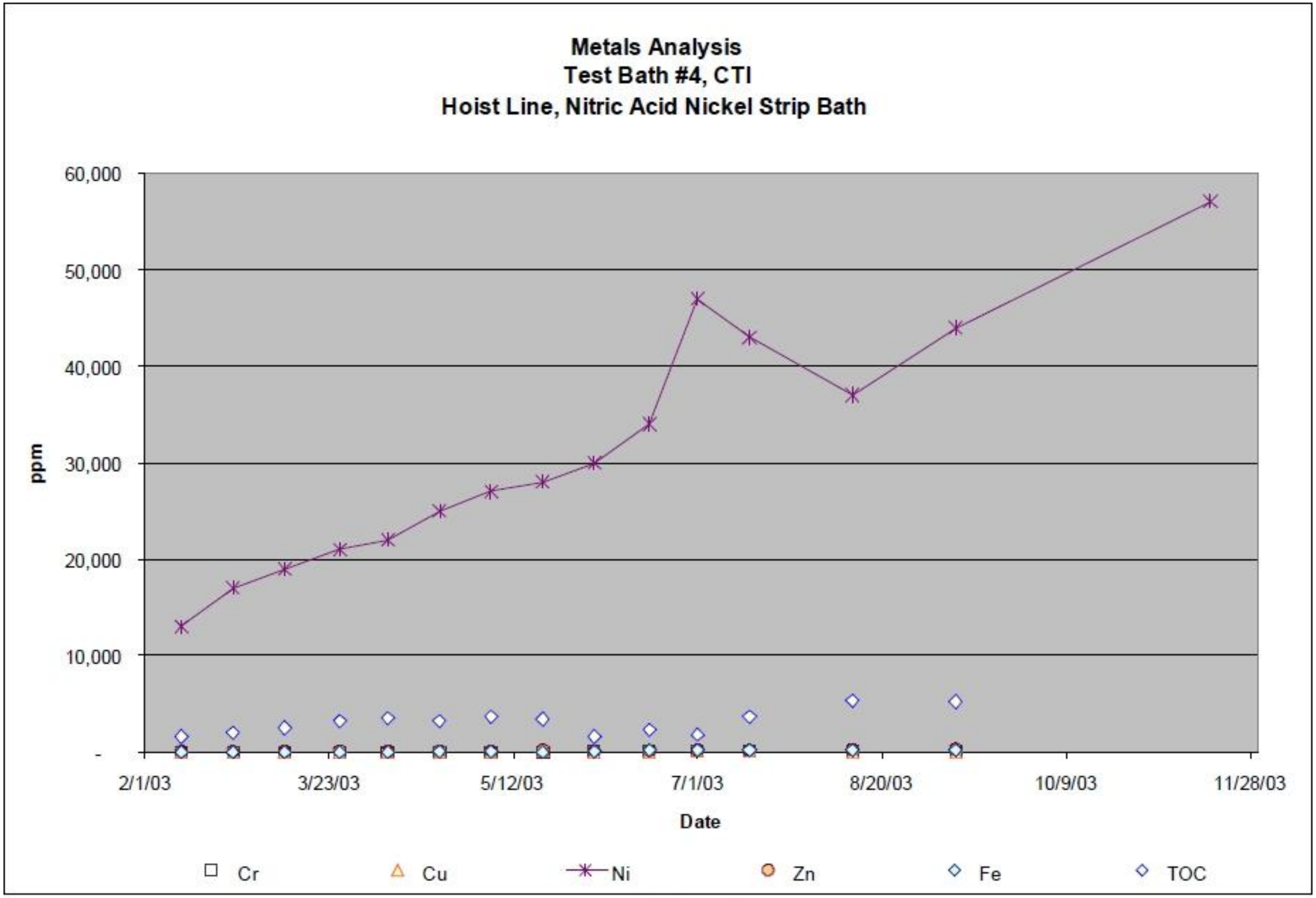



Figure 4

# Economic Analysis

For Test Bath1; HCl tank; Dumped every 4 weeks; 250 gallons at 40%

**Annualized Data**

**Before PRO-pHx:**

| | quantity | $/per | Total |
|---|---|---|---|
| Acid used (gallons) | 1430 | $ 1.44 | $ 2,059.20 |
| Waste treatment ($1.25 for every $1) | | | $ 2,574.00 |
| **Total** | | | $ 4,633.20 |

**With PRO-pHx (first year)**

| | | | | |
|---|---|---|---|---|
| Acid Used (make up) | 110 | $ 1.44 | $ 158.40 | |
| PRO-pHx Used (make up) | 2.5 | $ 60.00 | $ 150.00 | |
| Acid Used (replenishment) | 683 | $ 1.44 | $ 983.52 | |
| PRO-pHx Used (replenishment) | 23.89 | $ 60.00 | $ 1,433.40 | |
| Waste treatment (none required) | | | $ - | |
| Filters (2/week @ $2.5 each) | 104 | $ 2.50 | $ 260.00 | |
| Equipment: Filter Pump | 1 | $ 370.00 | $ 370.00 | |
| **Total** | | | $ 3,355.32 | |
| ***First Year Savings*** | | | ***$ 1,277.88*** | 28% |

# Environmental Results

***Environmental Summary, CTI***

| Tank | Acid Gallons | | | Savings | | Percents | |
|---|---|---|---|---|---|---|---|
| | With out PRO-pHx | With PRO-pHx | | With PRO-pHx | | With PRO-pHx | |
| | | First Year | Subsequent Years | First Year | Subsequent Years | First Year | Subsequent Years |
| Test Bath 1 | 1430 | 793 | 683 | 637 | 747 | 44.5% | 52.2% |
| Test Bath 2 | 1907 | 506 | 396 | 1401 | 1511 | 73.5% | 79.2% |
| Test Bath 3 | 480 | 166 | 126 | 314 | 354 | 65.4% | 73.8% |
| Test Bath 4 | 240 | 234 | 194 | 6 | 46 | 2.5% | 19.2% |
| **Totals** | **4057** | **1699** | **1399** | **2358** | **2658** | **58.1%** | **65.5%** |

| Tank | Caustic Gallons, estimated | | | Savings | | Percents | |
|---|---|---|---|---|---|---|---|
| | With out PRO-pHx | With PRO-pHx | | With PRO-pHx | | With PRO-pHx | |
| | | First Year | Subsequent Years | First Year | Subsequent Years | First Year | Subsequent Years |
| Test Bath 1 | 2860 | 1586 | 1366 | 1274 | 1494 | 44.5% | 52.2% |
| Test Bath 2 | 3813 | 1012 | 792 | 2801 | 3021 | 73.5% | 79.2% |
| Test Bath 3 | 960 | 332 | 252 | 628 | 708 | 65.4% | 73.8% |
| Test Bath 4 | 480 | 468 | 388 | 12 | 92 | 2.5% | 19.2% |
| **Totals** | 8113 | 3398 | 2798 | 4715 | 5315 | **58.1%** | **65.5%** |

# Sources

1.

PRO-pHx Acid Life Extender

Zero Acid Disposal

*Providing Environmentally Sustainable Technology*

*Eliminating Acid Disposal*

(Presentation)

2.

Research, Development & Demonstration Project Report:

Acid Life Extender Test Application At Coating Technology & Anoplate

(Final Report)

# First Afternoon Session

2:00pm - 2:55pm

Dave Fister:

- Water use reduction & recovery methods
- Energy savings in paint & powder coat curing

# Available Water for Reuse

- Rinse water
  - Primary rinse water  (high in TDS, variable pH)
  - Secondary rinse water (low in TDS, variable pH)
- Treated waste water
  - Very low in dissolved metals
  - Very high in TDS from neutralization and treatment
  - Consistent pH, typically slightly alkaline from metal precipitation process
  - Typically room temperature
  - May have some other residuals such as oils, soaps, or emulsifiers

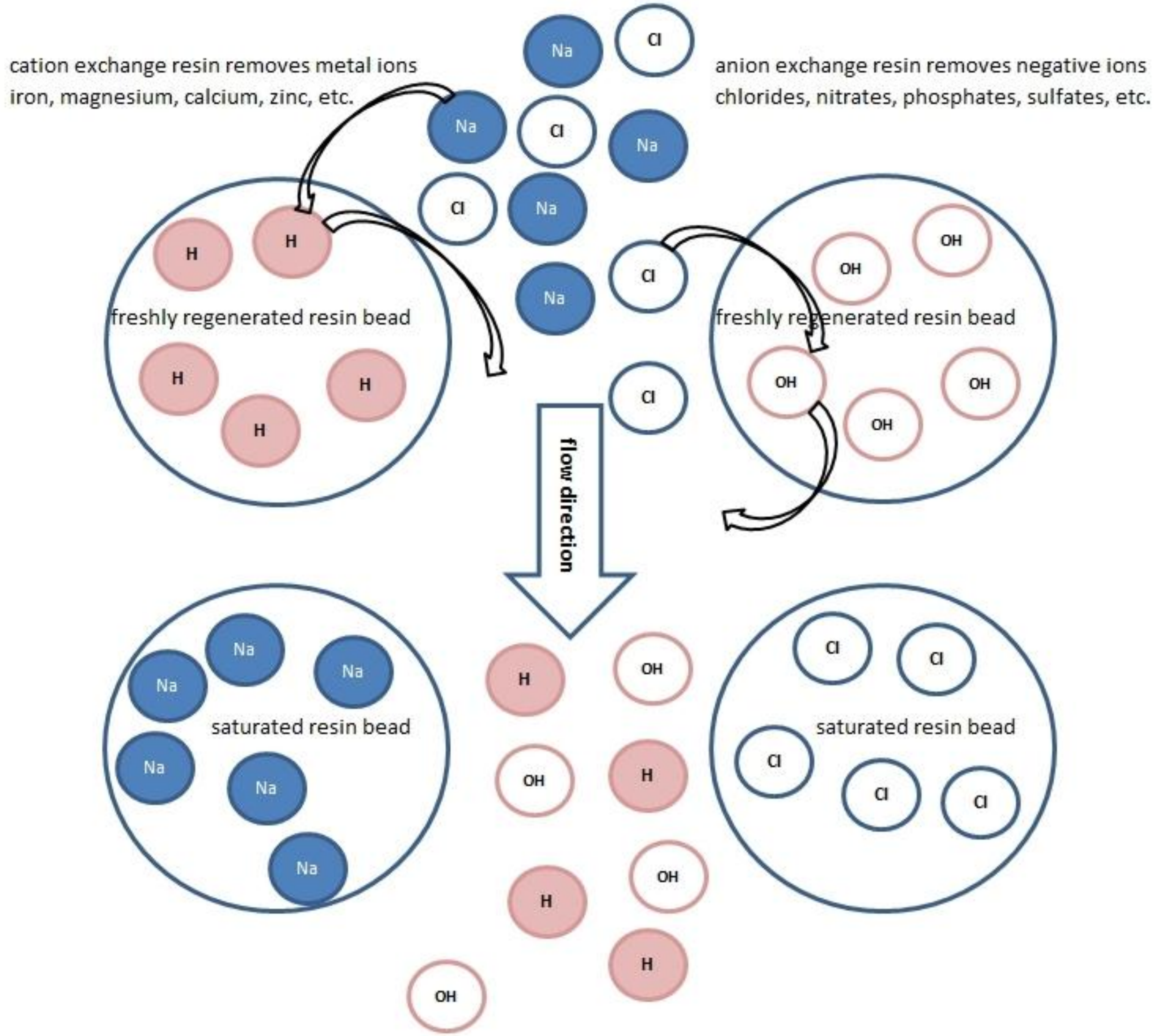
# Rinse Water Requirements

- For reuse as rinse water, water needs to be:
  - low in TDS
  - near neutral in pH to avoid possible contamination of the chemical tanks by rinse dragout into those tanks
  - Free of oils, soaps, etc.

# Methods of Removing TDS

- Mixed bed resin columns (ion exchange) to remove both cations and anions (will not remove dissolved organics such as sacharin)
- Reverse Osmosis to remove all solids and solubles except for small amounts of NaCl (0.5 to 3% of the initial concentration)

# Resin Columns (ion exchange)



# Advantages/disadvantages of Ion Exchange

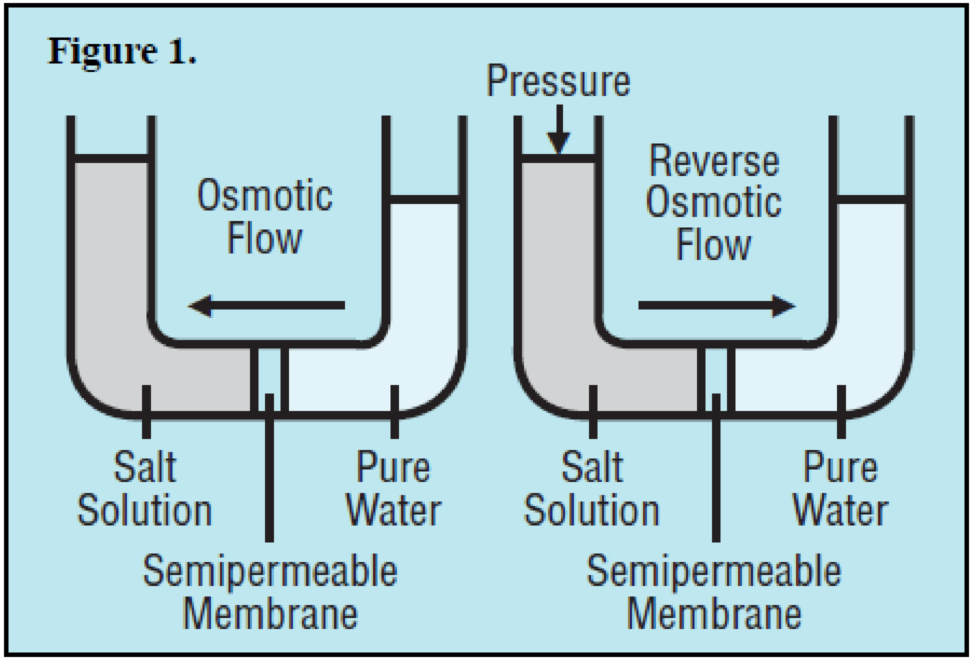
**Advantages**

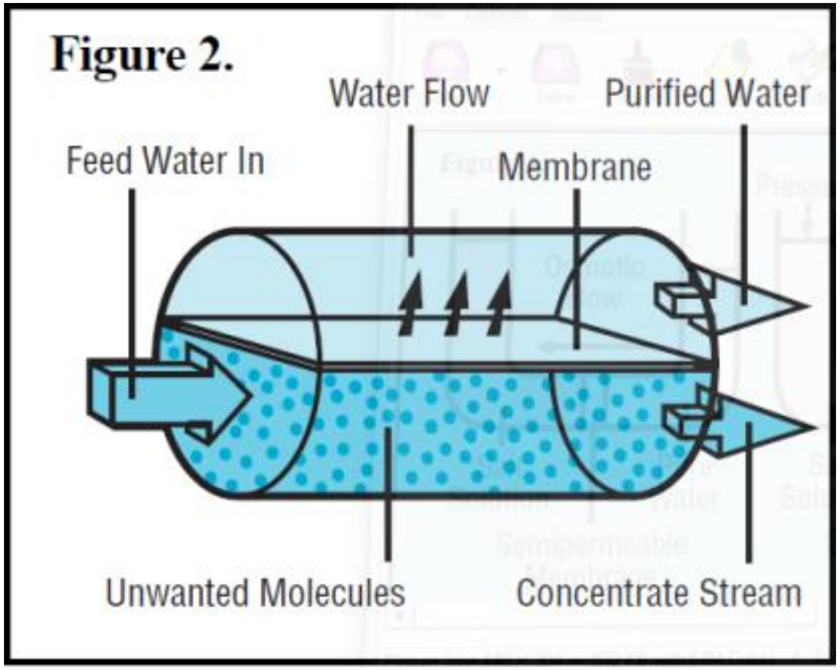
- Excellent ion removal
- Flow rate can be increased with a larger diameter column

**Disadvantages**

- Requires a carbon filter to remove organics
- Requires additional filtration to remove particulate and any resin bead particles
- Requires regular cylinder exchange or regular regeneration to maintain ion removal rate

# Reverse Osmosis



# Advantages/disadvantages of RO

Advantages:

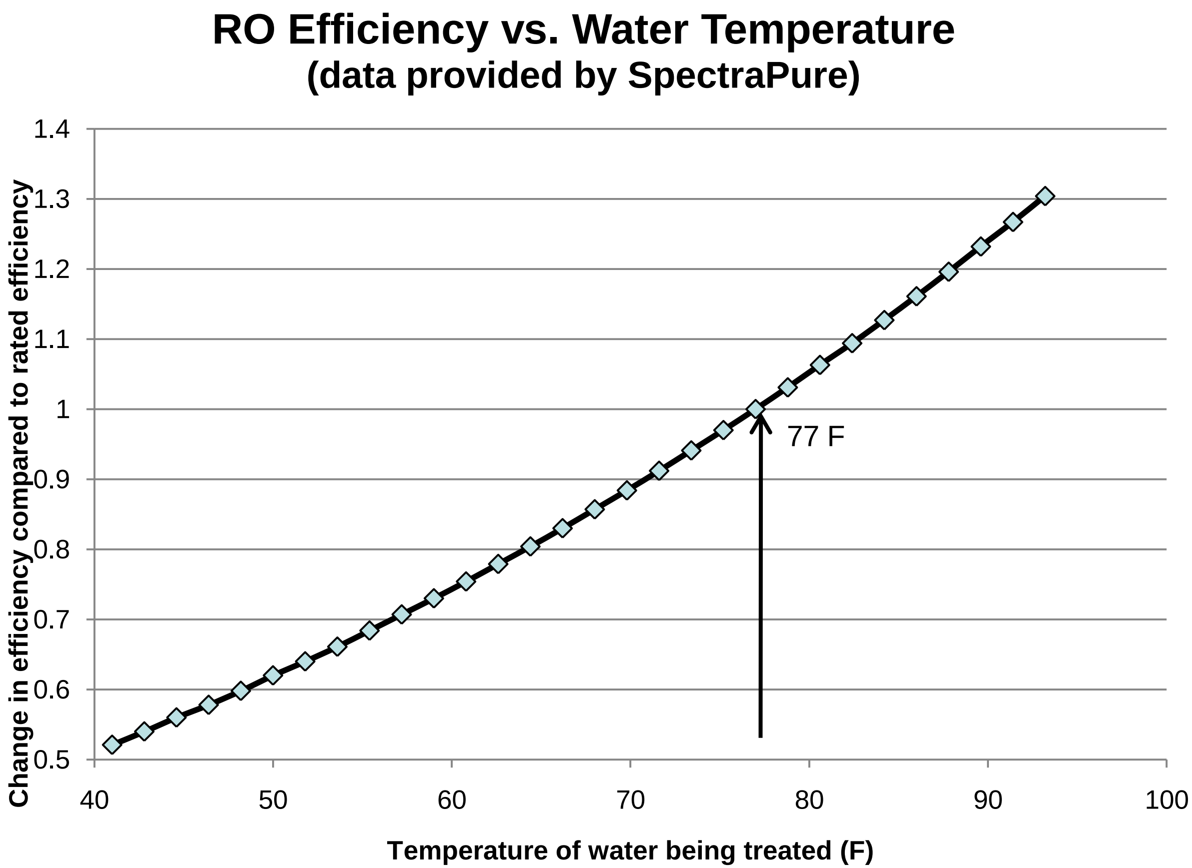
- Removes everything: ions*, bacteria, viruses, solids
- Relatively simple, low maintenance system

Disadvantages:

- Low temperature water produces lower pure water yields
- Higher TDS water produces lower pure water yields
- *Tend to leak small amounts of single charge ions ($Na^+$, $K^+$)
- Membrane can foul rapidly if suspended solids are high (may require pre-filtration with ultrafilter)
- Current technologies allow up to about 75% fresh water yields (typical yields ~50%)

# RO-Temperature Relationship

- Higher water temperatures, over 77º F but no higher than 100F, will have water recovery yields greater than the rated yields.



# Different RO Membrane Types

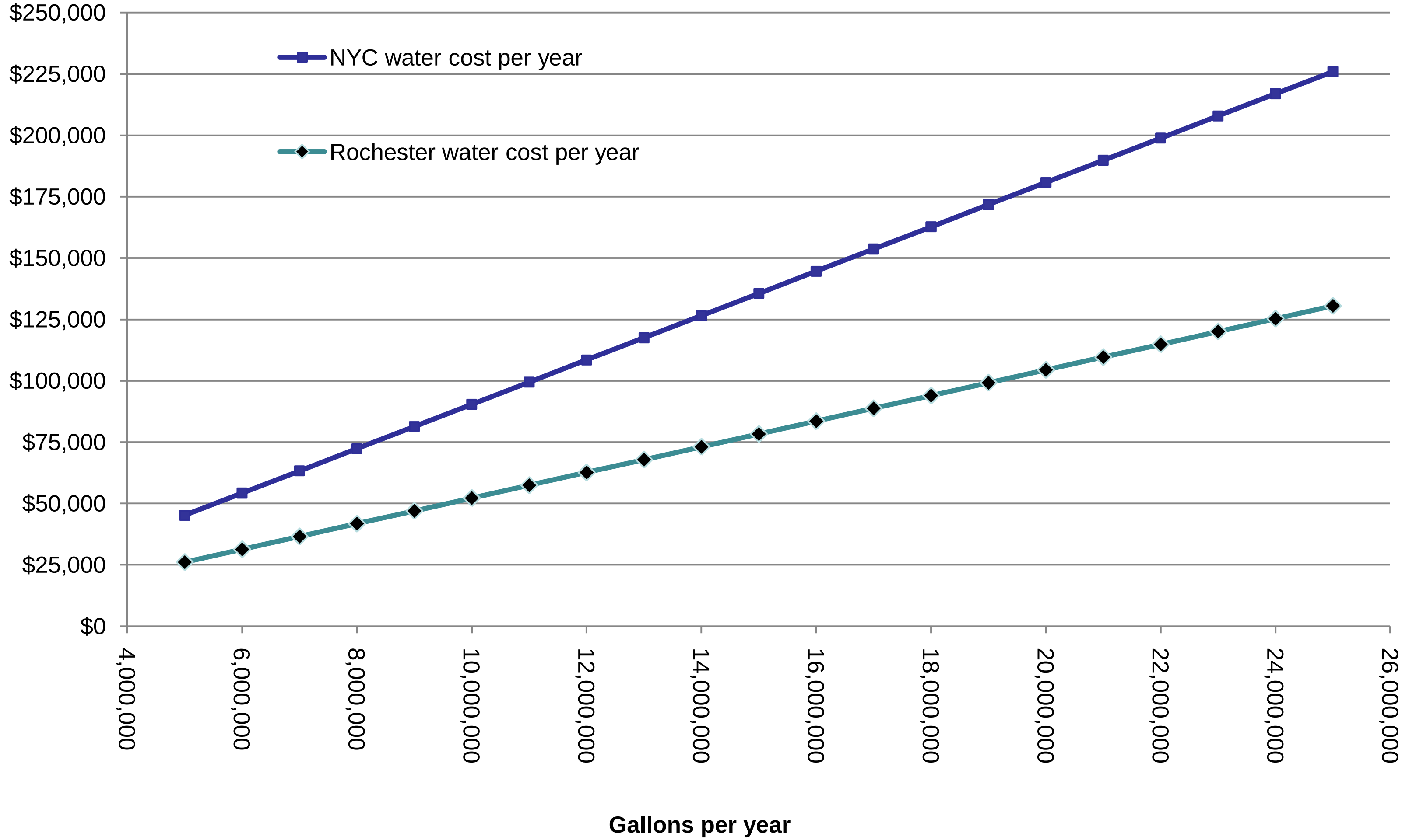
| | | | | | |
|---|---|---|---|---|---|
| **Cellulose Acetate** | **Low cost** | **Medium water flow** | **pH range 4-8** | **Max. temp. 95 F** | **Oxidation resistant** |
| **Composite (thin film composite, TFC)** | **High cost** | **High water flow** | **pH range 2-11,** | **Max. temp. 113 F** | **Vulnerable to oxidizers (chlorine)** |
| **Aromatic Polyamide** | **Medium cost** | **Low water flow** | **pH range 4-11** | **Max. temp, 95 F** | **Oxidation resistant** |

In short, no perfect membrane material

# Water Cost vs. RO Equipment Cost

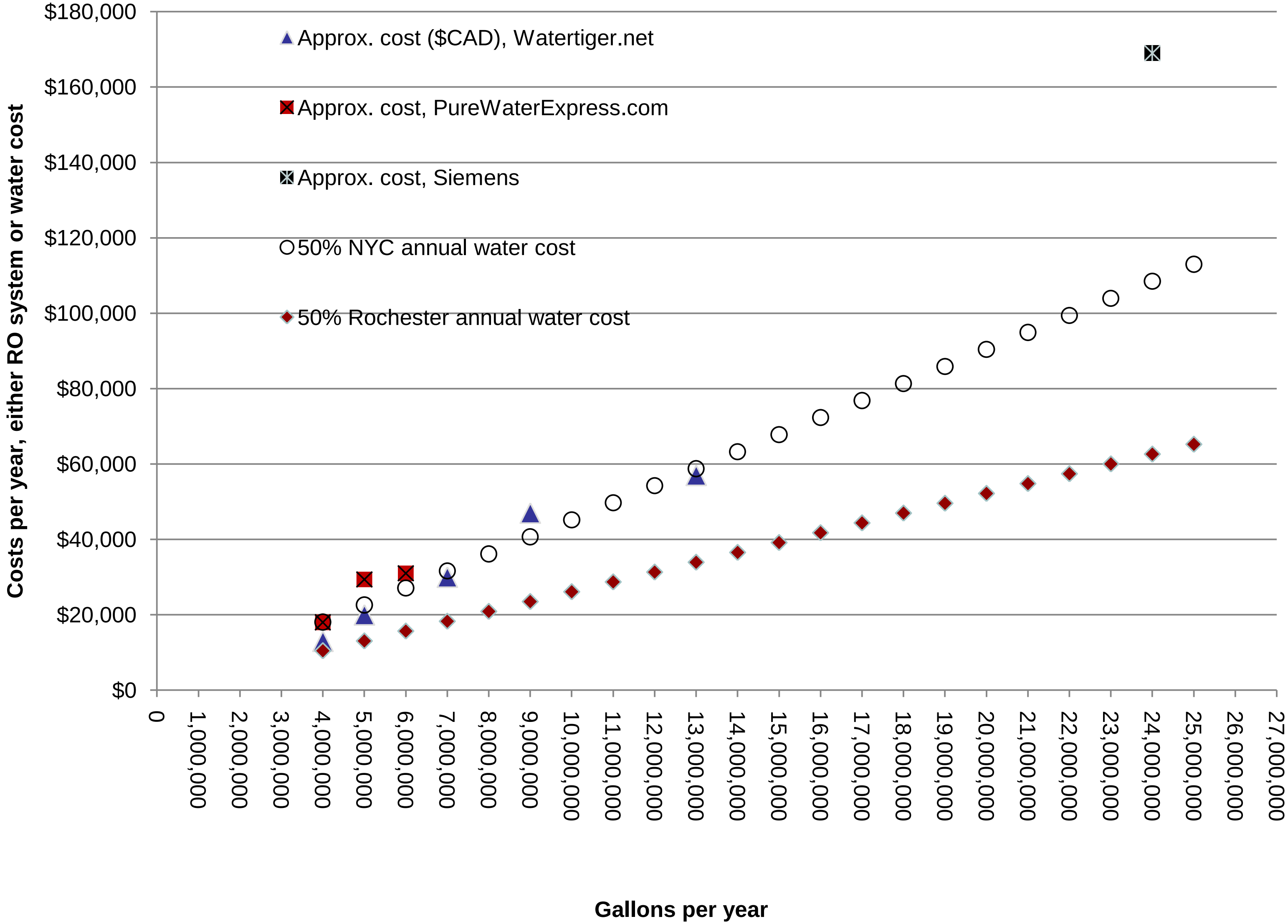
- Some cost comparisons from on-line prices (Watertiger, PureWaterExpress, Siemens)
- Rochester city water charges \$5.22/1000 gallons (\$2.67 water bill, \$2.55 water treatment tax)
- New York City, \$9.04/1000 gallons with sewer charges included

# Water Cost Curves



# Water Recovery Cost

- For an 8 hour operation, pure water storage and waste water storage is needed to obtain the best use of RO equipment (16 hours of off-shift filtration available).
- An RO system should be sized for less than the lows of daily water use.
- Be sure that the concentrate from the RO is still below the metals concentration limit for disposal.


Approx. cost ($CAD), Watertiger.net
Approx. cost, PureWaterExpress.com
Approx. cost, Siemens
50% NYC annual water cost
50% Rochester annual water cost
Costs per year, either RO system or water cost
$180,000
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
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15,000,000
16,000,000
17,000,000
18,000,000
19,000,000
20,000,000
21,000,000
22,000,000
23,000,000
24,000,000
25,000,000
26,000,000
27,000,000
Gallons per year

# Payback Considerations

- At the right place, both DI and RO systems can help recover water for either rinsing or makeup water.
- As water prices continue to rise, the payback for these systems gets better.
- In the previous RO example, NYC costs make an RO system pay for itself in approximately one year.

# LEV Integrated with Mechanical Covers to Achieve Energy Savings

## Exhaust Systems for Open Surface Tanks

**Art Brooks - KCH Engineered Systems**


**KCH Engineered Systems**

**Pollution Control Exhaust Systems**

**144 Industrial Drive**

**Forest City, NC 28043**

**828-245-9836**

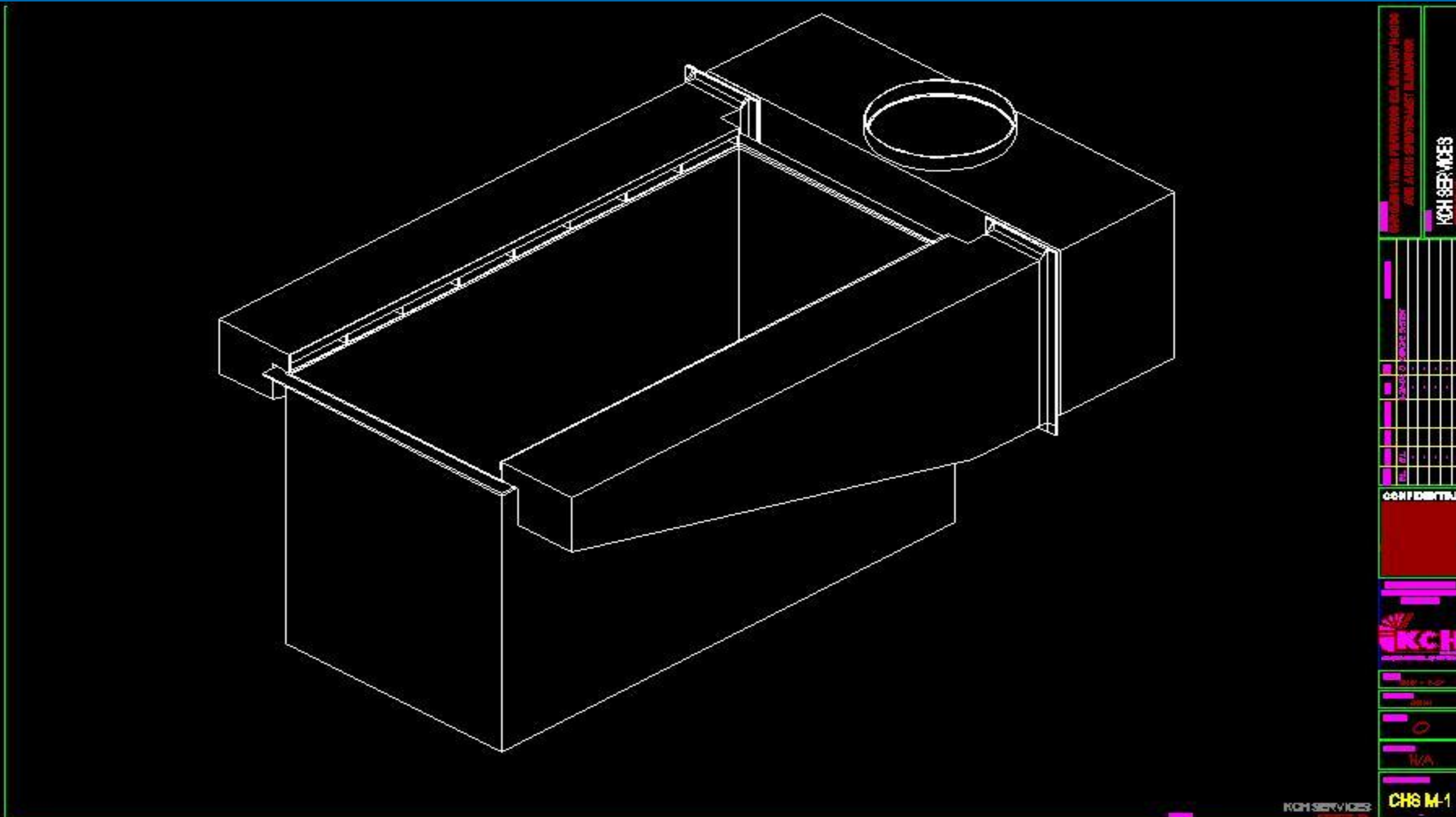
**www.kchservices.com**

# Chemical Process Tanks

- Anodizing  (Sulfuric Acid)
- Electropolishing  (Sulfuric/Phosphoric)
- Electrocleaning  (Sodium Hydroxide)
- Brightening  (Nitric/Phosphoric)
- Precleaning (Sodium Hydroxide)
- Etching  (Nitric/HF)
- Electroplating (Copper, Nickel, Chrome, etc.

# Proper exhaust rates for Open Surface Tanks can vary

## 50 CFM/ft2 -- 250 CFM/ft2



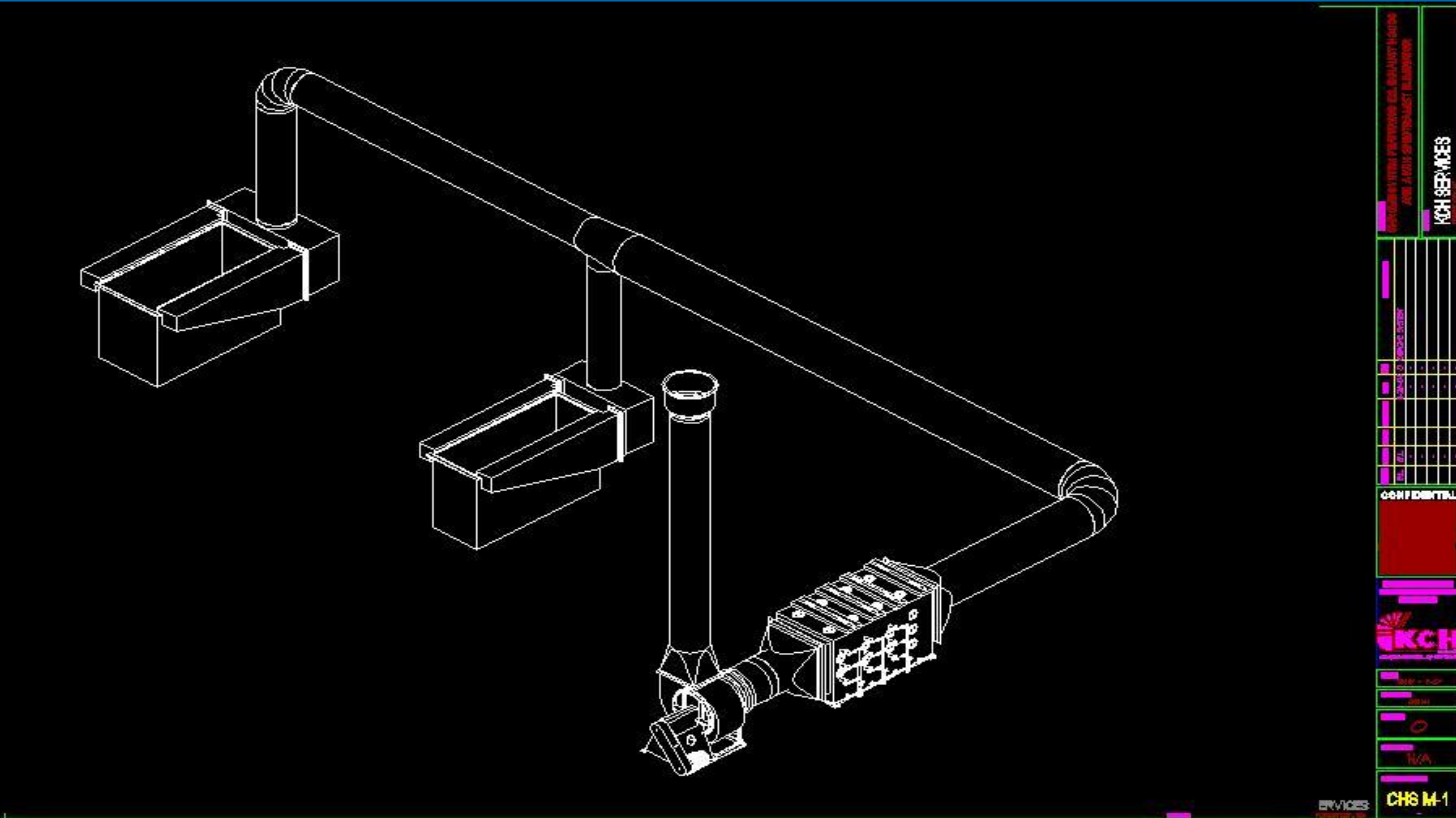
# Factors affecting chemical emissions in process tanks.

- Type of process solution.
- Concentration of chemicals in the tank.
- Amount of exposed surface area to open air.
- Electrification of the solution in the tank.
- Operating temperature
- Vapor Pressure of the liquid
- Part agitation (air v/s eductor)


20,000 AMPS
DIRECT CURRENT

# Method for control:

# LOCAL EXHAUST VENTILATION



# Mechanical Tank covers

- Trash Can Covers and Coffee Cup Lids.
- The substances evaporate from the surface of the tank, then condense on the inside of the cover, and eventually drip back into the tank.

# Advantages of a Covered Tank

- Reduce overall exhaust requirements
- Reduces fugitive emissions
- Reduces heat loss and evaporation rates
- Reduces energy consumption
- Reduces calculated surface area for exhaust rates.

# Tank Cover Design

- Must NOT be removable.
  - Employees will permanently leave them off.
- Mechanical Operation
  - Single Hinged, Double Hinged or Double Covers
  - Actuators for movement
- Movement Control
  - Manual Push Button
  - Automatic
- Material Selection
  - Stainless Steel
  - Polypropylene


LATERAL EXHAUST HOODS
DESIGNED TO BE LOW PROFILE

Utilities routed below rim of tank

# Integrating covers with the exhaust system

- Limit switches are installed to indicate whether the covers are in the complete up or down position.
- PLC control to direct operation and interlock with fan or damper controls.
- Exhaust rate adjustment based on position of the covers.


Principle of automatic covered tank ventilation

# Local Exhaust Ventilation

- Reduces Fugitive Emissions.
- Must be properly designed per the ACGIH Industrial Ventilation manual (25th Edition)
- Lateral hoods v/s Upright Hoods.
- Push – Pull, Pull – Pull
- Slot Velocities

# Methods to adjust exhaust rate

- Relief Dampers
  - Ensure Proper Velocity in control device
  - Can suck in dirt
  - Make up air requirement remains the same
- Internal Volume Dampers
  - Reduces potential for dust.
  - Increases load on the fan

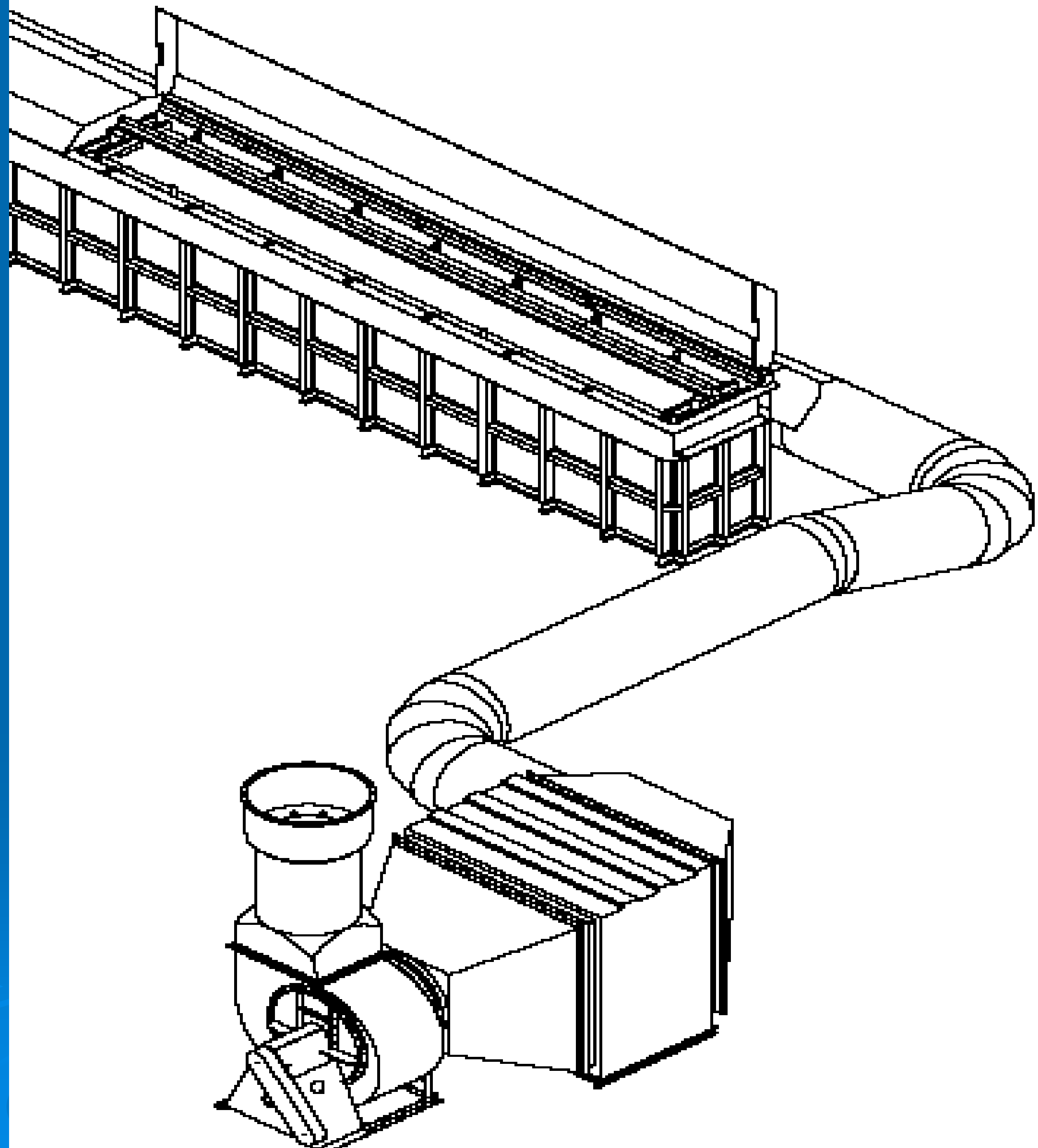
# Best Method to adjust exhaust rate

- Using a VFD controlled Exhaust Fan.
  - VFD adjusts RPM
  - Directed by PLC and cover position.
  - Minimizes tempered Make up air requirements.
  - Reduces energy consumption
  - Optimum for automatic lines.

# Variable Frequency Drives to achieve Energy Savings

- VFDs used with a PLC to ramp the system up and down, based on cover position.
- Adjust the Hertz and RPM of the motor.
- More affordable due to maturing technology
- Many tanks are only accessed a few times daily.
- Exhaust Requirements for cover tanks are much lower.

# Covers integrated with LEV



# Case Study of Energy Savings

- EPA – Environmental Technology Verification Program (ETV)
- Evaluated a Chemical Etch Line utilizing mechanical covers
- Compared operational cost to traditional line without covered tanks
- $62,978 annual operational cost savings

- http://www.epa.gov/etv/verifications/vcenter6-12.htm

# Standard Design bhp:

50,120 CFM = 62 hp (all six tank covers open)

Ventilation fan motor is not available in 62hp. The next size up is a 75 –hp motor.

The 75 hp is used as the baseline for the calculations.

# KCH Design:

17,612 CFM = 26 hp (one tank cover open, five closed)

Ventilation fan motor is not available in 26 hp. The next size up, 30 hp, is used in the calculations for the system verified.

# KCH Design:

The design yields a reduction of 45 hp for the fan, based on the 75-hp motor and 30 hp- motor.

To estimate the amount of energy saved, it is necessary to estimate the amount of time the fan runs. The fan is kept running 24 hrs a day/7 days per week.

The amount of energy savings (ES) for the fan is calculated by using the equation ES = power x time.

## Annual Energy Savings Calculation for Fan:

$$ES_{fan} = \frac{45\text{ hp}}{} \left| \frac{0.746\text{ kW}}{\text{hp}} \right| \frac{24\text{ hr}}{\text{day}} \left| \frac{365\text{ days}}{\text{year}} \right. = 294{,}073\text{ kWh/year}$$

## Annual Cost Savings Calculation for Fan:

The amount of annual cost savings (CS) for the fan is calculated by using the equation $CS^{fan} = ES^{fan}$ x electricity cost.

$$CS^{fan} = \frac{294{,}073\text{ kWh}}{\text{year}} \left| \frac{\$0.044}{\text{kWh}} \right. = \$12{,}939/\text{year}$$

Therefore, the estimated energy savings associated with use of the smaller fan is 294,073 kWh/year and estimated cost savings is $12,939/year.

# Reduction in Scrubber Size

As the scrubber decreases in size, due to lower ventilation throughput, the amount of water recirculated over the scrubber packing surface decreases as well. A 50,000 CFM scrubber would require a 10-hp pump motor; a reduction of 5-hp is anticipated based on a reduced ventilation throughout anticipated.  This water rate can be achieved with a 5-hp motor used to drive the scrubber pump.

If traditional processing is installed containing no lids, the ventilation flow rate is increase to just over 50,000 CFM.  At a flow of 300 gpm, a 10-hp motor is required for the pump to maintain this flow rate.

# Annual Energy Savings Calculation for Scrubber Pump Motor:

$$ES_{scrubber} = \frac{5\ hp}{} \cdot \frac{0.746\ kW}{hp} \cdot \frac{24\ hr}{day} \cdot \frac{365\ days}{year} = 32{,}675\ kWh/year$$

# Annual Cost Savings Calculation for Scrubber Pump Motor:

The amount of annual CS for the scrubber pump motor is calculated by using the equation $CS_{fan} = ES_{fan} \times$ electricity cost.

$$CS_{scrubber} = \frac{32{,}675\ kWh}{year} \cdot \frac{\$0.044}{kWh} = \$\ 1{,}438/year$$

**The estimated energy savings associated with the use of a smaller pump motor is 32,675 kWh/year and the estimated cost savings is $1,438/year**

# Heating and Ventilation (HV) Cost Savings

The facility is climate-controlled to maintain uniform process conditions and uniform working conditions for employees.  This requires that any air drawn in for makeup air must be tempered during the year.

One way to estimate annual cost data for tempering of air is shown in the following formula:

$$CS_{HV} = \frac{0.154\,(Q)\,(dg)\,(T)\,(c)}{q}$$

Where:

| | | | |
|---|---|---|---|
| $CS_{HV}$ | = | Annual Cost Savings | \$/year |
| Q | = | Airflow Rate | 18,150 CFM |
| dg | = | Annual Degree Days | 3,895 days |
| T | = | Operating Time | 168 hr/wk |
| c | = | Cost of Fuel, \$/unit | \$0.00978/$ft^3$ |
| q | = | Available Heat/Unit of Fuel | 1,000 BTU/$ft^3$ |

**For a process system with the lid-closing capability that the KCH ACTSWC technology provides, the cost for tempering air would be:**

$$CS_{HV} = \frac{0.154\ (18{,}150)\ (3{,}895)\ (168)\ (\$0.00978)}{1{,}000\ \text{BTU/ft}^3} = \$17{,}888/\text{year}$$

**For a process system without the lid closing capability that the KCH ACTSEC technology provides, the cost for tempering air would be:**

$$CS_{HV} = \frac{0.154\ (50{,}120)\ (3895)\ (168)\ (\$0.11978)}{1{,}000\ \text{BTU / ft}^3} = \$49{,}396/\text{year}$$

**The yearly cost savings associated with tempering of the air of the KCH ACTSEC technology is $49,3995 - $17,888 = $31,507**.

Annual Energy Savings $ES_{temper}$ can be calcualated, using a unit cost to produce one kWh of electricity:

$$ES_{temper} = \frac{\$31{,}507}{\$0.044/\text{kWh}}$$

The $ES_{temper}$ is 716,068 kWh.

| Table I: Cost Comparisons of Covered and Uncovered Tanks | | | |
|---|---|---|---|
| *Items* | *Operational Cost (with Covers)* | *Operational Cost (without Covers)* | *Operational Cost Savings Per Year* |
| Exhaust fan motor | $8,626 | $21,565 | $12,939 |
| Scrubber pump motor | $1,438 | $2,875 | $1,438 |
| Tempered makeup maintenance | $17,888 | $49,395 | $31,507 |
| Operational and maintenance | $8,547 | $25,641 | $17,094 |
| Totals | $36,499 | $99,476 | $62,978 |

# GLOBAL POLLUTION

- Coal fired electrical production is 35% - 40% efficient
- Reduced fan and pump HP = 326,748 kWh/Year
- 663,298 lbs. of $CO_2$ would be produced
- Total $CO_2$ Not Emitted =869 Tons

ARBORTECH
CORPORATION

## Products For a Better Environment

## Manufacturers of Recycling Equipment & Industrial Wastewater Treatment Systems

# The Washer Washer

**… a simple and green approach to recycling water-based cleaning solutions! How to save money, improve parts' cleanliness, minimize rejects, increase salt spray, reduce waste hauling, cut utility bills & lower chemical usage – by extending the life of your aqueous cleaners.**

# But First:

**Let's start by defining your oils/ soils,**
**so we know how to attack those contaminants!**

## Beginning with your oils, are they:

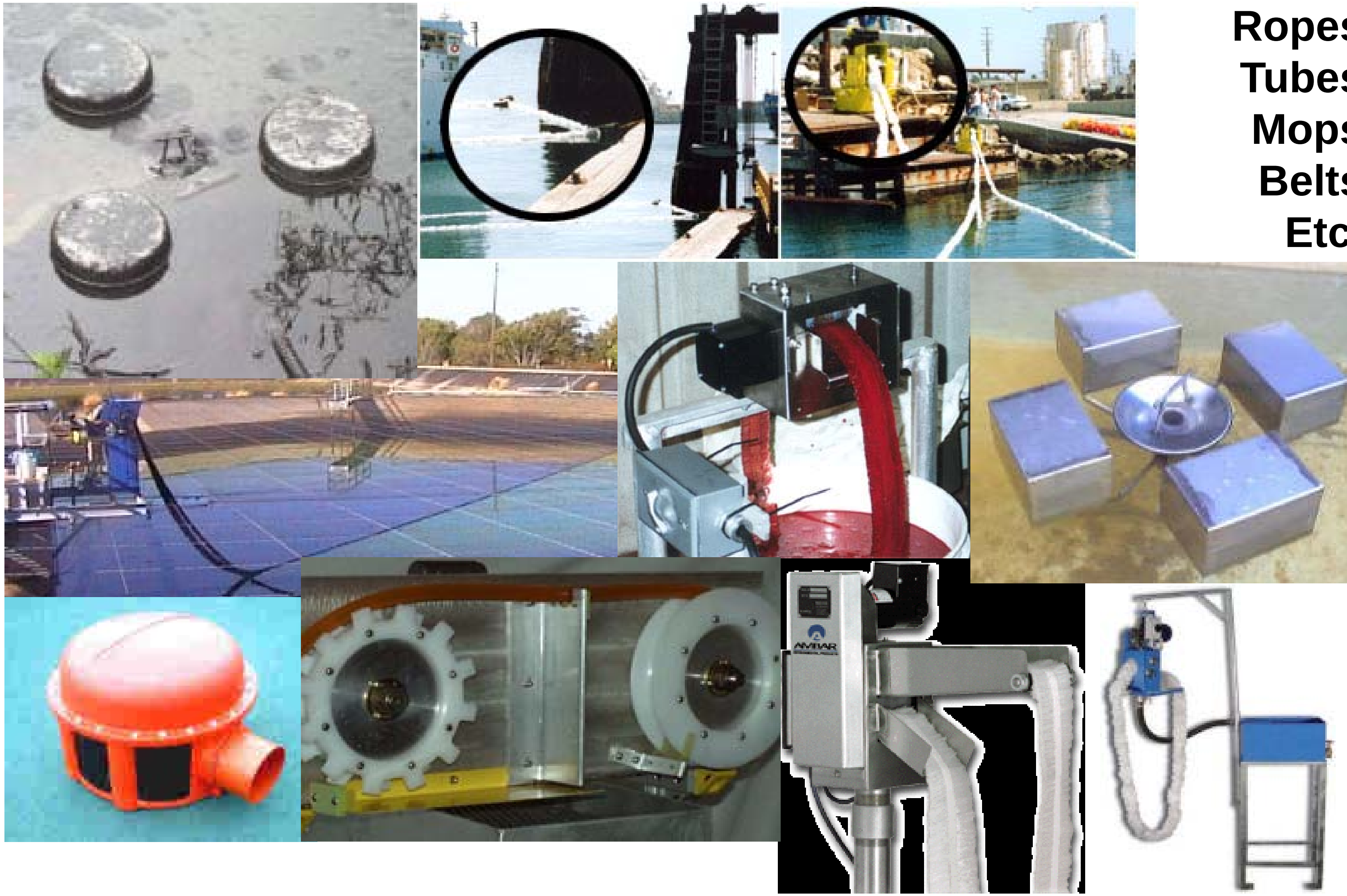
- **All/Part free oil? Skimmers / Shop Vac.**
- **All/Part dispersed? Coalescers / Other O/W Separators.**
- **All/Most/Any emulsified? Chemicals / Membranes.**

## And how about your soils, are they:

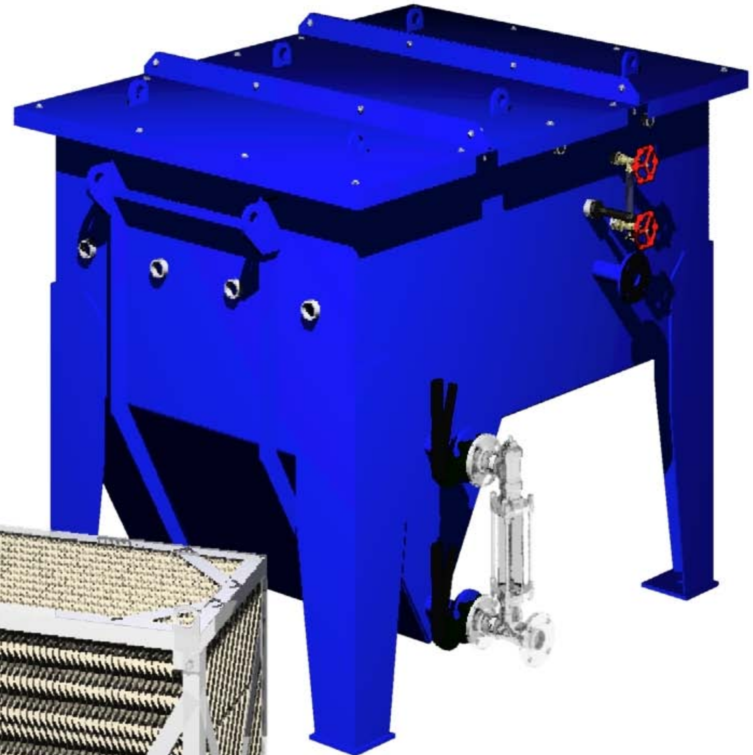
- **Large or small? Conventional Filtration – Bags, Cartridges, etc.**
- **Primarily/exclusively ferrous or magnetic? Magnetic Filters.**
- **Abundant or few? Clarifier / Settling Tank / Side-Stream Filters.**
- **Dissolved or particulate? Chemicals / Membranes.**

# Oil Skimmers

Floating Suctions
Ropes
Tubes
Mops
Belts
Etc.

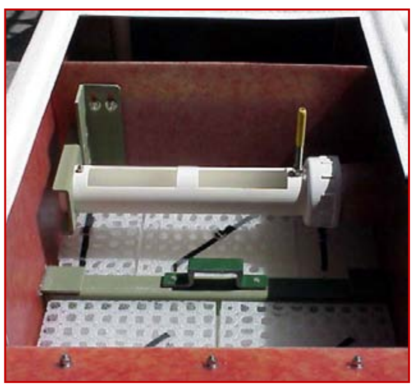


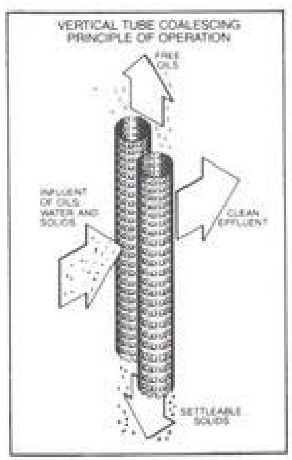
# Coalescing Oil/Water Separators

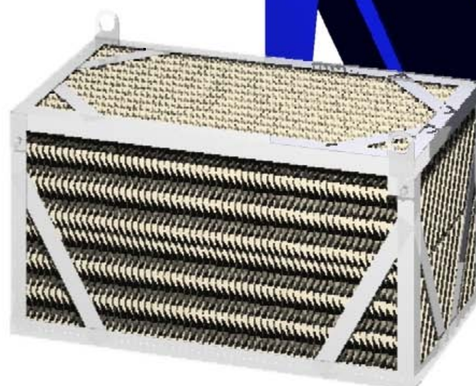


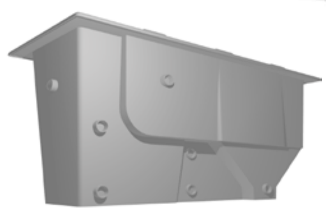
## Offered In A Variety Of:

- Tank Configurations
- Tank materials of construction
- Media spacing
- Media materials of construction



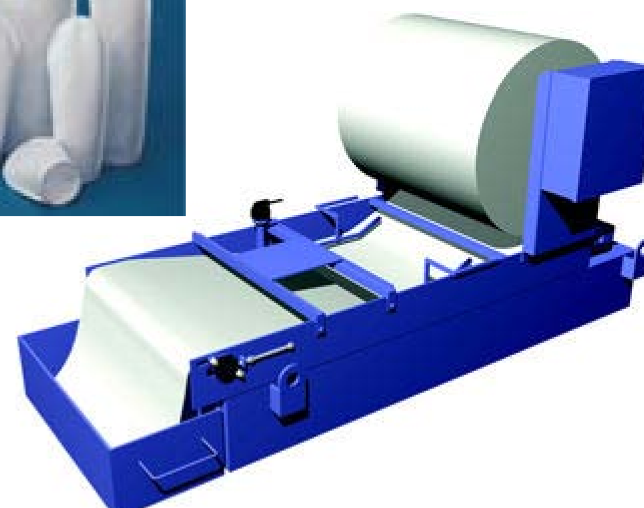




# Liquid/Solids Filters

**Indexing Roll Media**
**Magnetic**
**Cartridge**
**Screen**
**Basket**
**Bag**



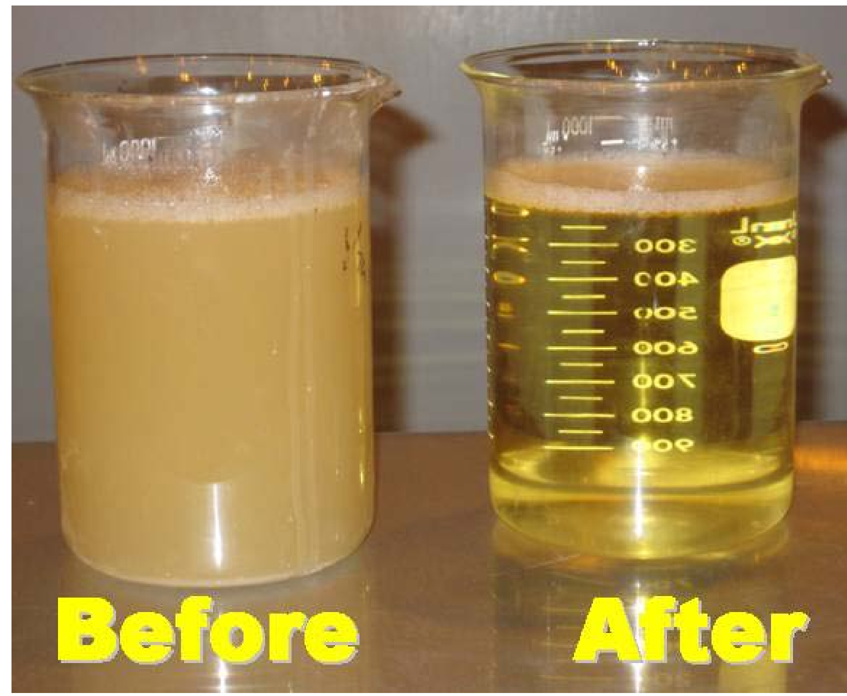
# And Now… Star Of This Show The Washer Washer

- What  Arbortech does
- How the technology works
- Typical cleaning process – do we understand <u>your</u> needs?
- How Arbortech can help you
- Reference equipment in coating applications
- Results / Benefits
- Key facts
- Questions / Answers

# What Does Arbortech Do?

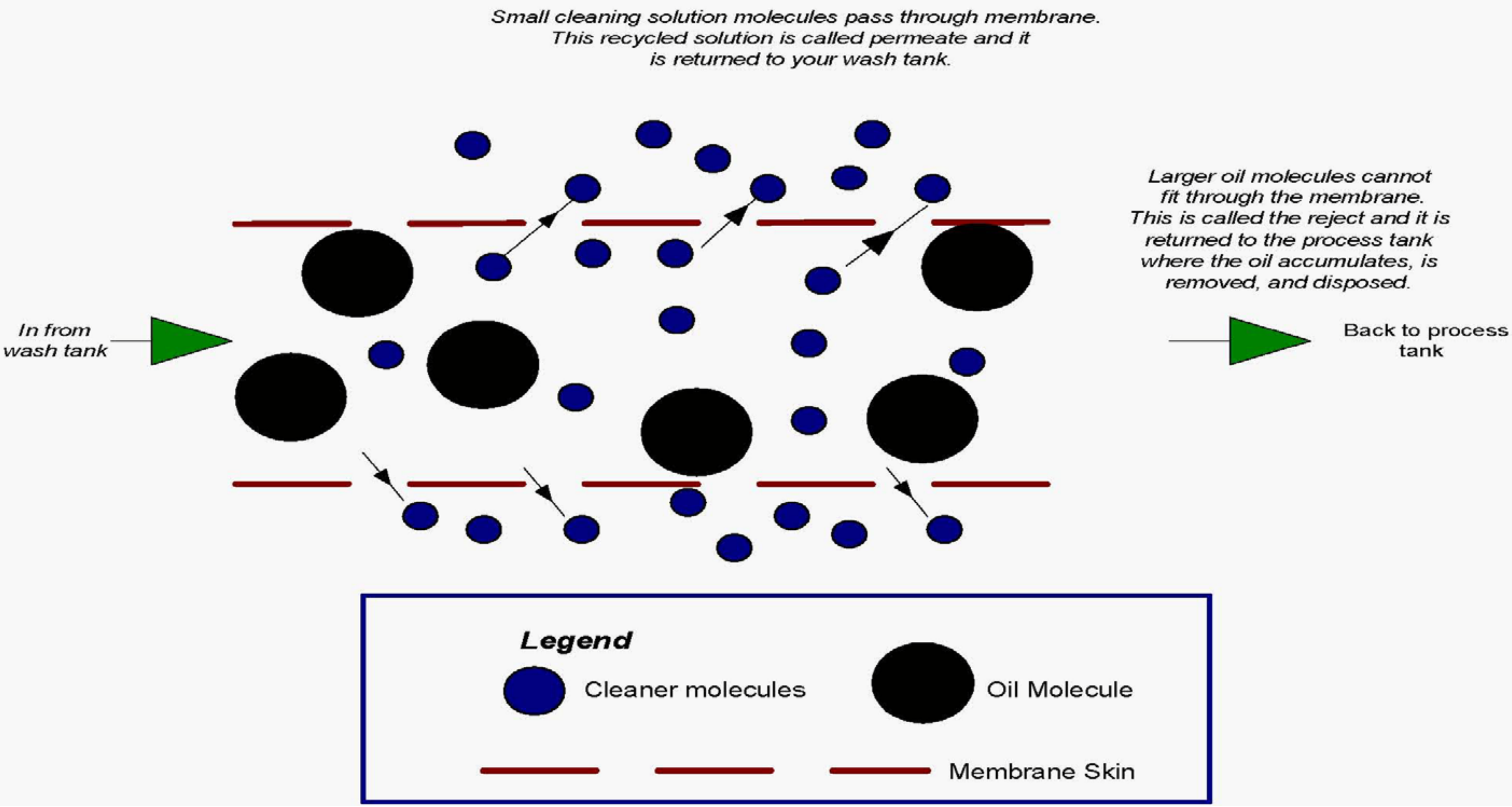
**We design, manufacture and service equipment & systems to recycle aqueous cleaning solutions, with benefits like:**

- **Help meet local regulatory & federal EPA compliance standards**
- **Concentrate waste for easy, efficient, inexpensive haul away**
- **Improve process control by washing your parts in consistently high quality, continuously filtered cleaning solution**
- **Save money – Payback ~1 year**
  - **less labor, water, energy**
  - **slash cleaning chemistry usage**

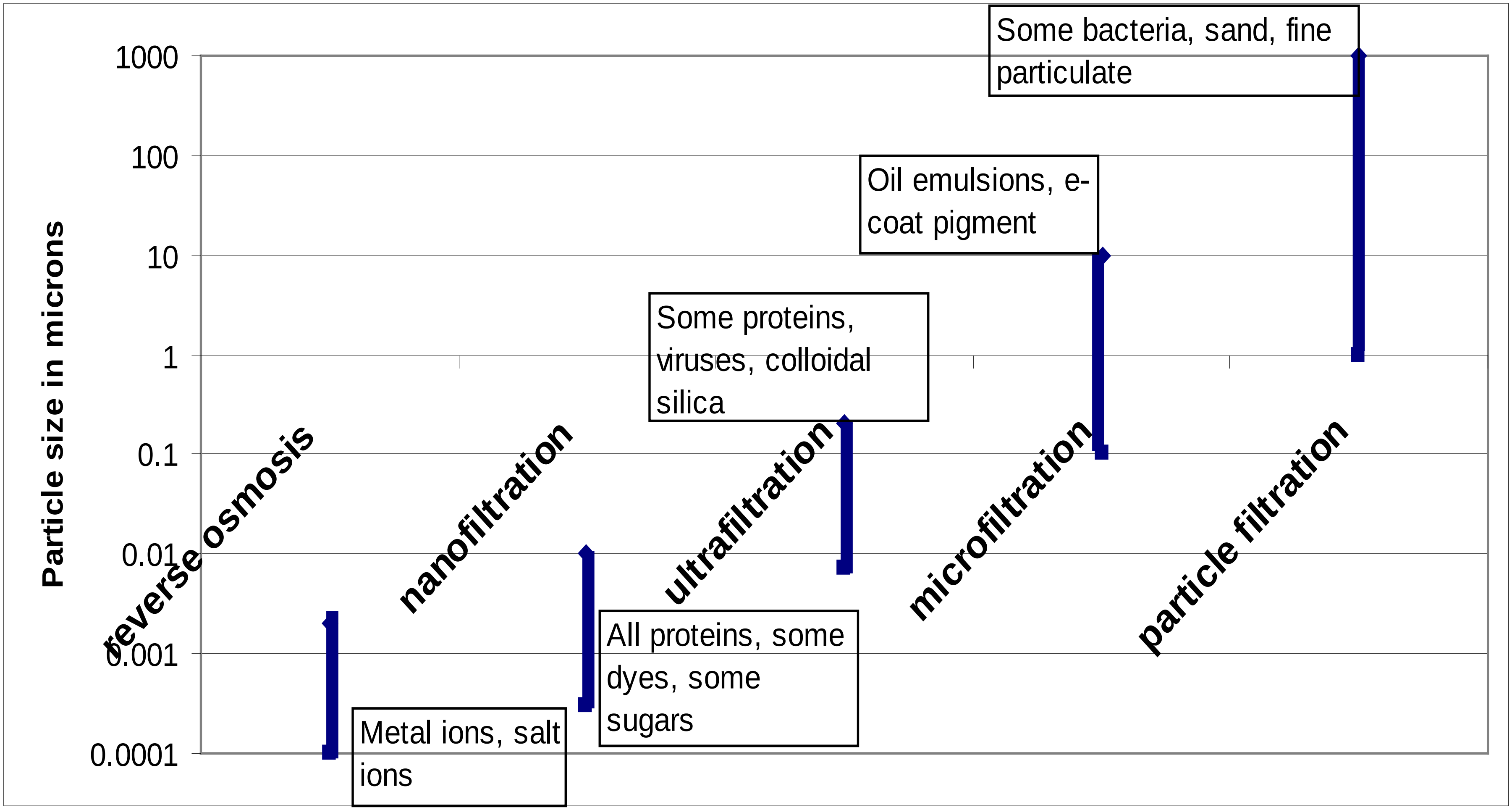


# How Does It Work? MAGIC!

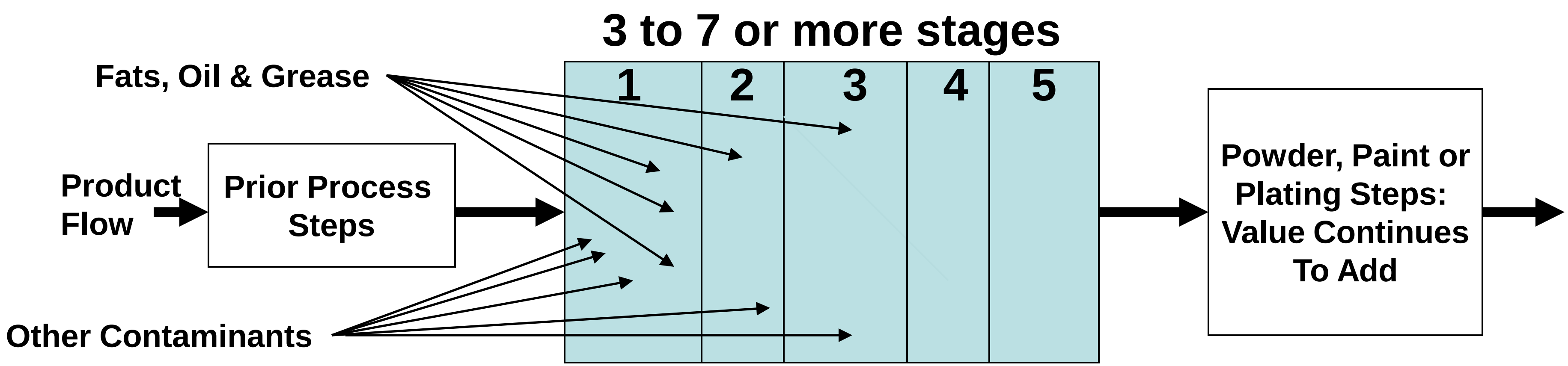
**The Washer Washer Membrane - How it really works.**



# Filtration Scale



# Multi-Stage Cleaning Process

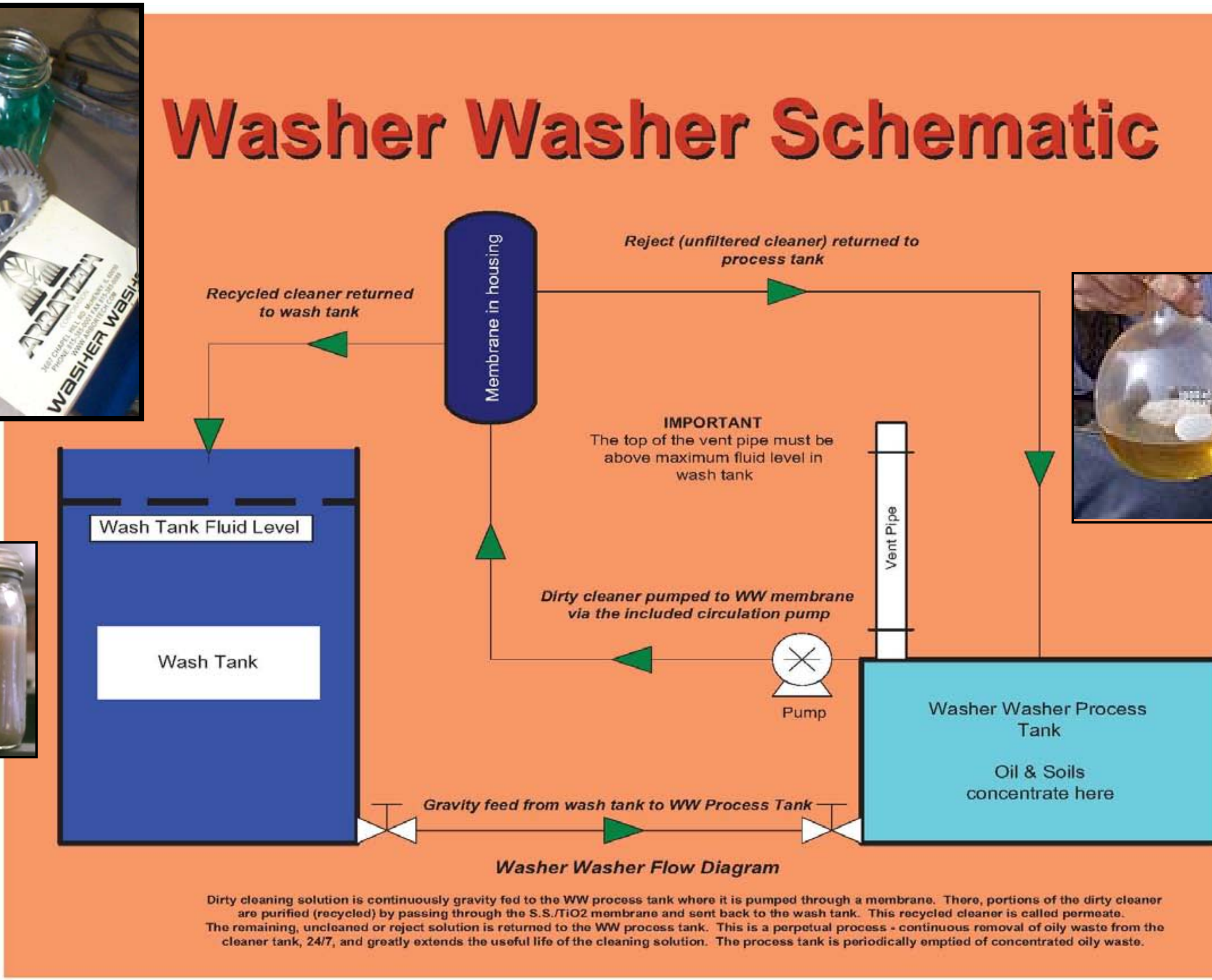



1 = Wash
2 = Rinse
3 = Phos/Degrease
4 = Rinse
5 = Sealer

## Cleaning Process Issues:

1. Cleaning solution dump & recharge frequency?
2. Line down?
3. Costs associated with change out?
4. Quality issues associated with cleaning process?

# Solving Your Cleaning Issues


# Problem? No Problem…

A Midwest engine manufacturer suffered paint defects in its chromate / e-coat paint line in 2005. The symptom was a series of pin-hole dots, all the way down to the surface of the substrate, raising concerns over corrosion protection. Daily testing eventually led to the discovery that cleaning chemistry additions necessary to maintain sufficient free alkalinity to clean the parts raised total alkalinity so high that a white residue was deposited on the parts from the increasing level of spent chemistry. As a result, these cleaning tanks had to be dumped and recharged bi-weekly.

Washer Washer technology removed the spent fractions, oils and soils, without disturbing the solution's cleaning effectiveness; in fact, it improved! With two WW1MOs in place, first year benefits included:

- Wash tank life nearly tripled
- Cleaning chemistry purchases dropped significantly
- Waste treatment costs fell from less frequent tank dumps
- Savings experienced in water usage, energy and labor
- Payback was essentially 12 months – specifically…

# Recycling Results
## (verified & published…)

**Chromate/E-Coat Paint Line - Midwest Engine Manufacturer**

**2005 Costs**

| | |
|---|---|
| • Washer Washer (model WW1MO) | $39,512 |
| • Stands | $2,080 |
| • Miscellaneous (Install Parts & Labor) | $4,000 |
| • Total | $45,592 |

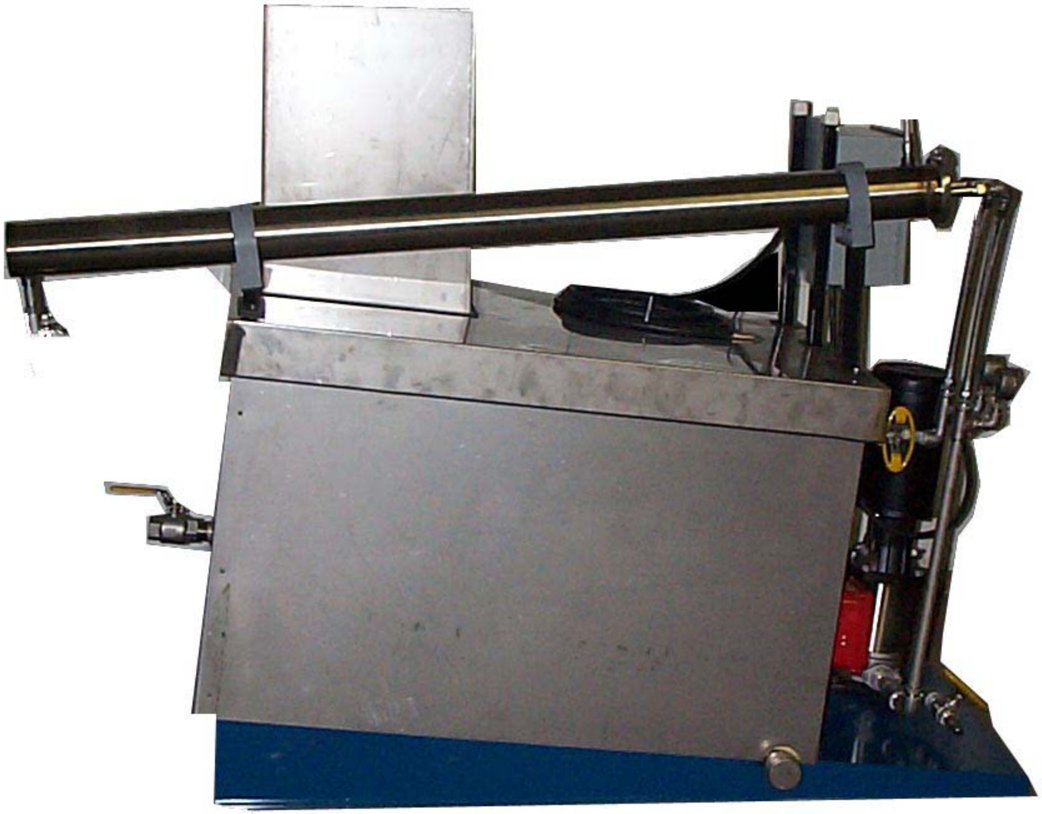
**Client Documented Savings**

| | |
|---|---|
| • Cleaner | $37,901.74 |
| • Waste Treatment | $ 7,108.92 |
| • Total | $45,010.66 |

**R.O.I.**

**R.O.I. = Costs of Implementation/Benefits**
**R.O.I. = $45,592/$45,010.66**
**R.O.I. = 1.01 years**

# WW1MO with pump-to lid design & center panel mount position



# Washer Washer Systems




# Floor Scrubber Recycler: Compatible With Virtually All Floor Wash Solutions

**Temperature from ambient to 200ºF**

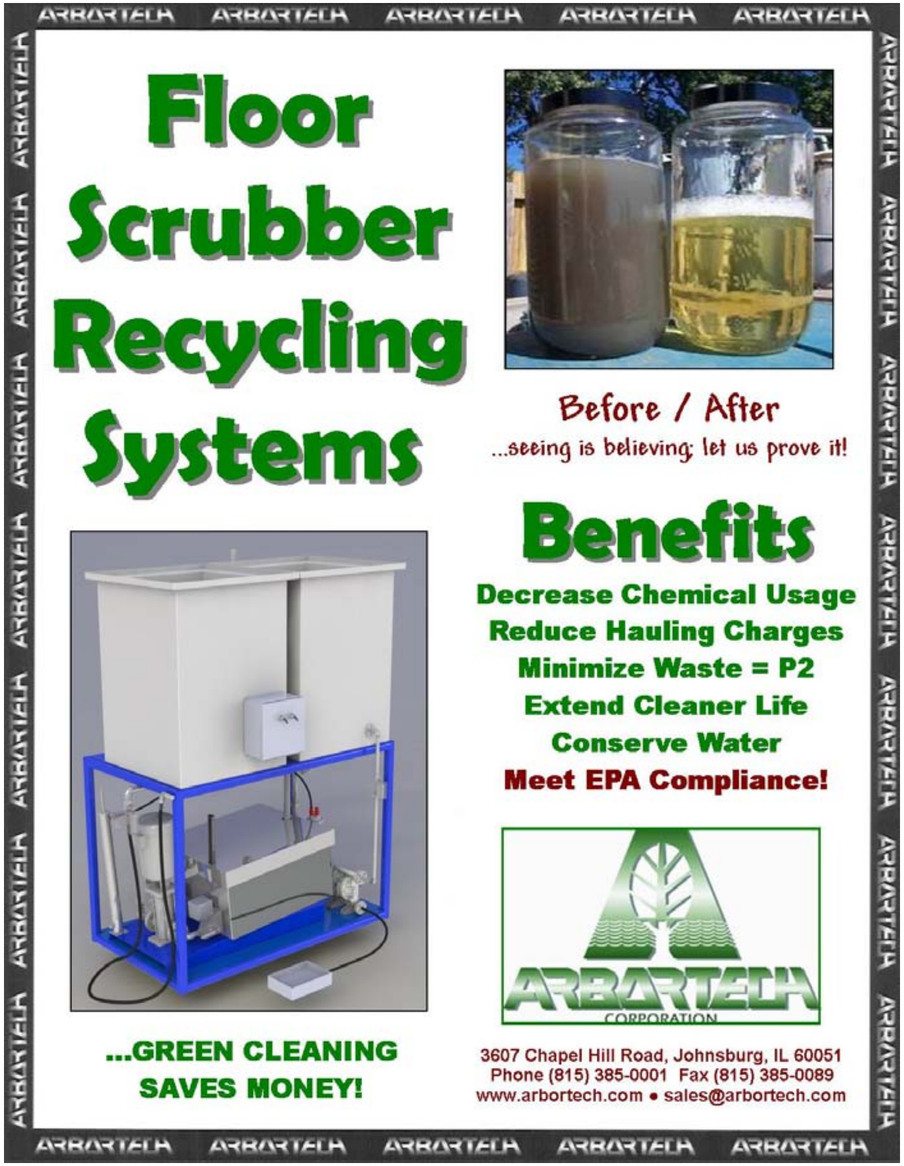
**Entire pH range @ 0-14**

## Tiny Footprint, Fits Anywhere

**88” x 41” x 90”H**

## Plug It In; Start Saving Money

**3/60/230-460 power**

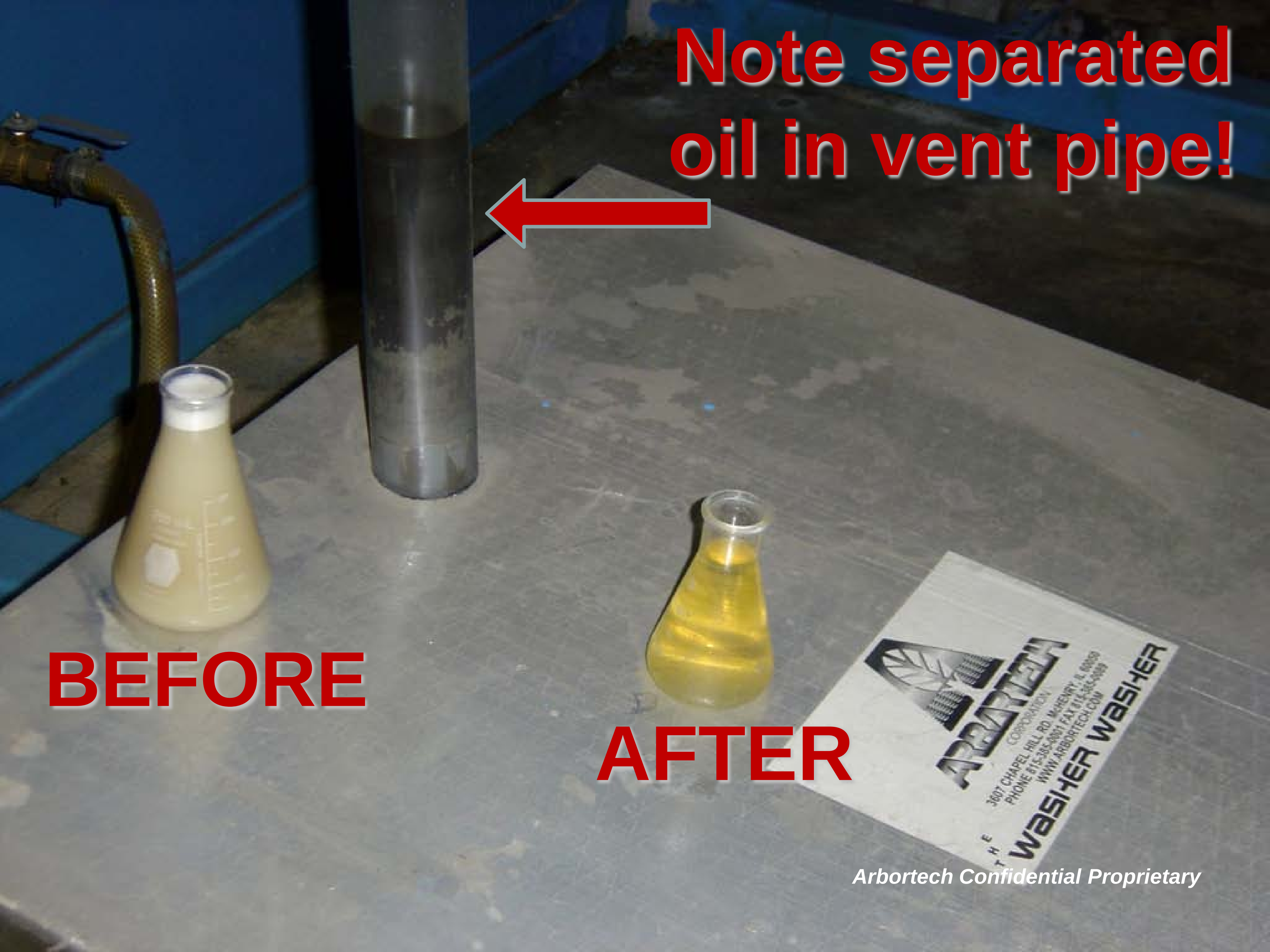


BLUE LINE

# Nu-Way Industries, Inc.
# Des Plaines, IL

GREEN LINE


480 VOLTS
WASHER W


Note separated oil in vent pipe!
BEFORE
AFTER
ARBORTECH
CORPORATION
WWW.ARBORTECH.COM
THE WASHER WASHER
Arbortech Confidential Proprietary

# Results & Benefits

- Extended cleaning solution life, often 4-6X or more
- Fewer washer-related rejects – 50%+ reduction in reworked parts = higher yields
- Substantial savings in cleaning chemistry purchases – as much as >80% reported
- Concentrated waste, therefore disposal fees drop
- Lower dump/recharge labor costs – threefold+ reduction in hours
- Cut manufacturing line down situations
- **Short payback time – usually ~1 year**

# Pilot Project Results

Technology
Evaluation
Highlights

**January 2003 to June 2003**

**Oil & Grease**
**= 88% Removal Rate**

**Suspended Solids**
**= 93% Removal Rate**

**Cleaner Chemical Usage**
**= 64% Reduction**

**Wastewater Generation**
**= 94.5% Reduction**

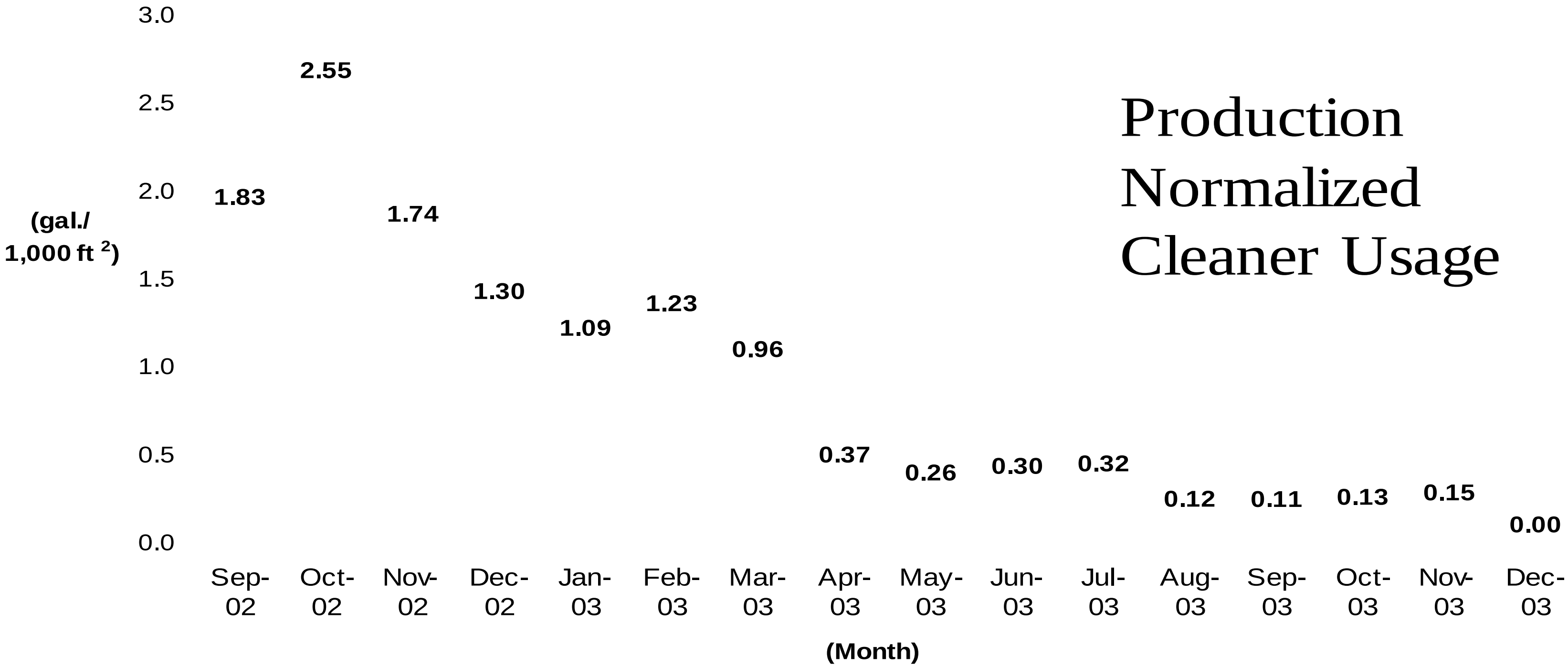
**W.W. & Cleaner Costs**
**= 78% Reduction**

**Washer-Related Rejects**
**= 51% Reduction**

CleanTech 2004
International Cleaning Technology Exposition
Chicago, IL

# Long-Term Results

**Before Project** **During Piloting** **After WW Purchase**




CleanTech 2004
International Cleaning Technology Exposition
Chicago, IL

# Key Arbortech Facts

- **Washer Washers in operation since 2000**

  **--- <u>NO field failures of filters!</u>**

- **Awards**
  - **Illinois Governor's Pollution Prevention Award**
  - **CMC Manufacturer That Counts**
  - **Export Achievement Certificate**



- **Over 100 systems in the field, including several Fortune 500 companies**