Metal Finishing Workshop

February 9, 2011

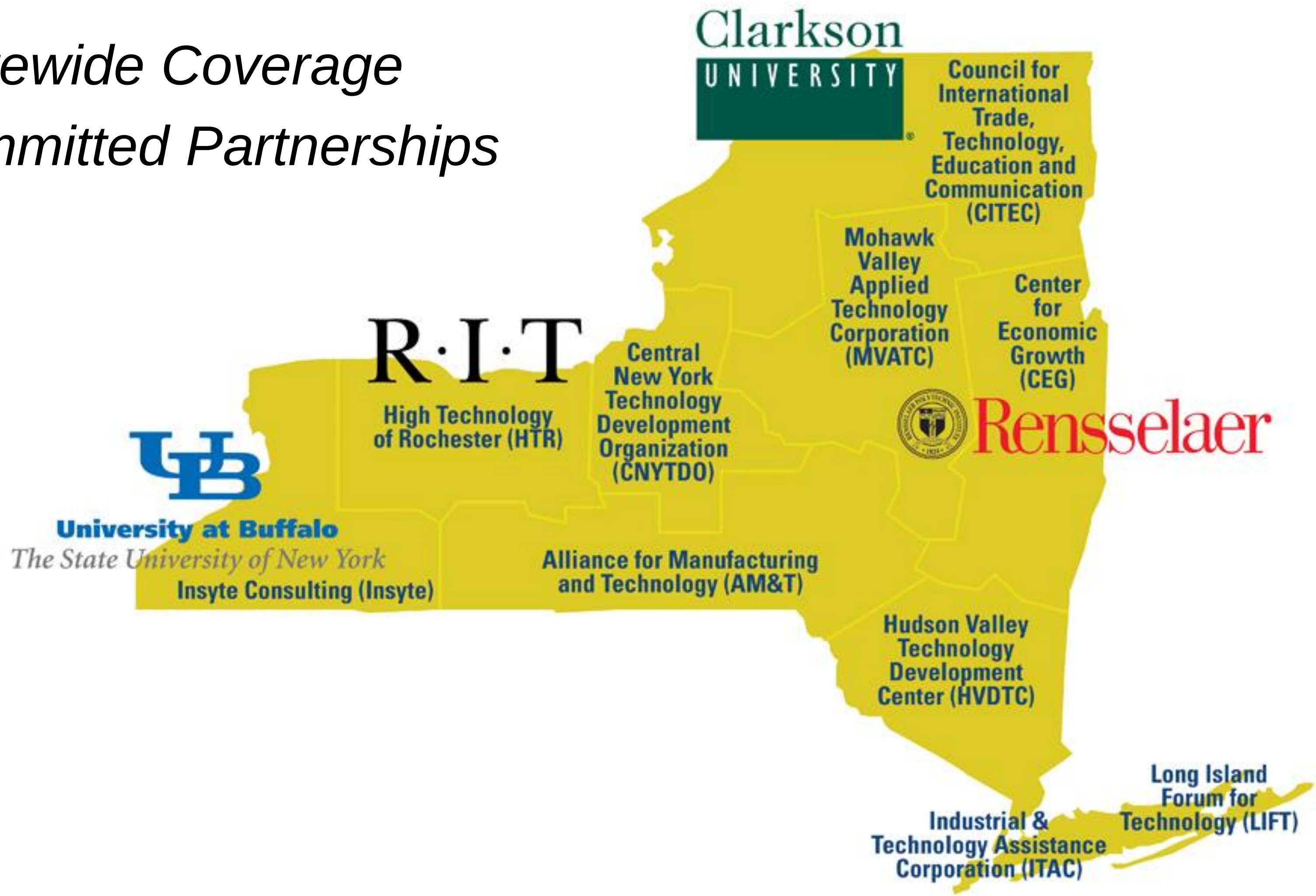
Hosted by:

New York State Pollution Prevention Institute at

Rochester Institute of Technology

NYS Pollution Prevention Institute

- *Statewide Coverage*
- *Committed Partnerships*



New York State Pollution Prevention Institute (NYS/P2I)

Vision & Mission

Vision:

The vision of the NYS P2I is to foster the transformation and development of sustainable businesses and organizations in New York State in a collaborative program committed to making the State a leader in environmental stewardship.

Mission:

The mission of the Institute is to provide a high-impact, comprehensive and integrated program of technology research development and diffusion, outreach, training and education aimed at making New York State more sustainable for workers, the public, the environment and the economy through:

- reductions in toxic chemical use
- reductions in emissions to the environment and waste generation
- the efficient use of raw materials, energy, and water

Cleaning Steps: Control and Chemical Life Extension

Dave Fister
Senior Staff Engineer
NYSP2I

Overview

- Alkaline Cleaners and Acid Etching:
  - use, management, and life extension methods

Common Cleaning Steps

- First step: Alkaline cleaners
  - Removal of greases, oils, waxes, dirt from the metal parts
  - Typically heated to accelerate the cleaning process
  - May include ultrasonics or agitation to accelerate the cleaning process
- Second step: Acid cleaning/etching
  - Removal of metal oxides (rust, smut, etc.)
  - Makes the metal surface chemically active for the next step (plating, conversion coating, etc.)

Alkaline Cleaner Bath Life

- The cleaner chemical components are lost by:
  - Dragout to the rinse by parts
  - Reaction with the organics (emulsification, chelation, etc.)
- The cleaner effectiveness degrades as the oil and dirt loading goes up with potential redeposition of contaminants

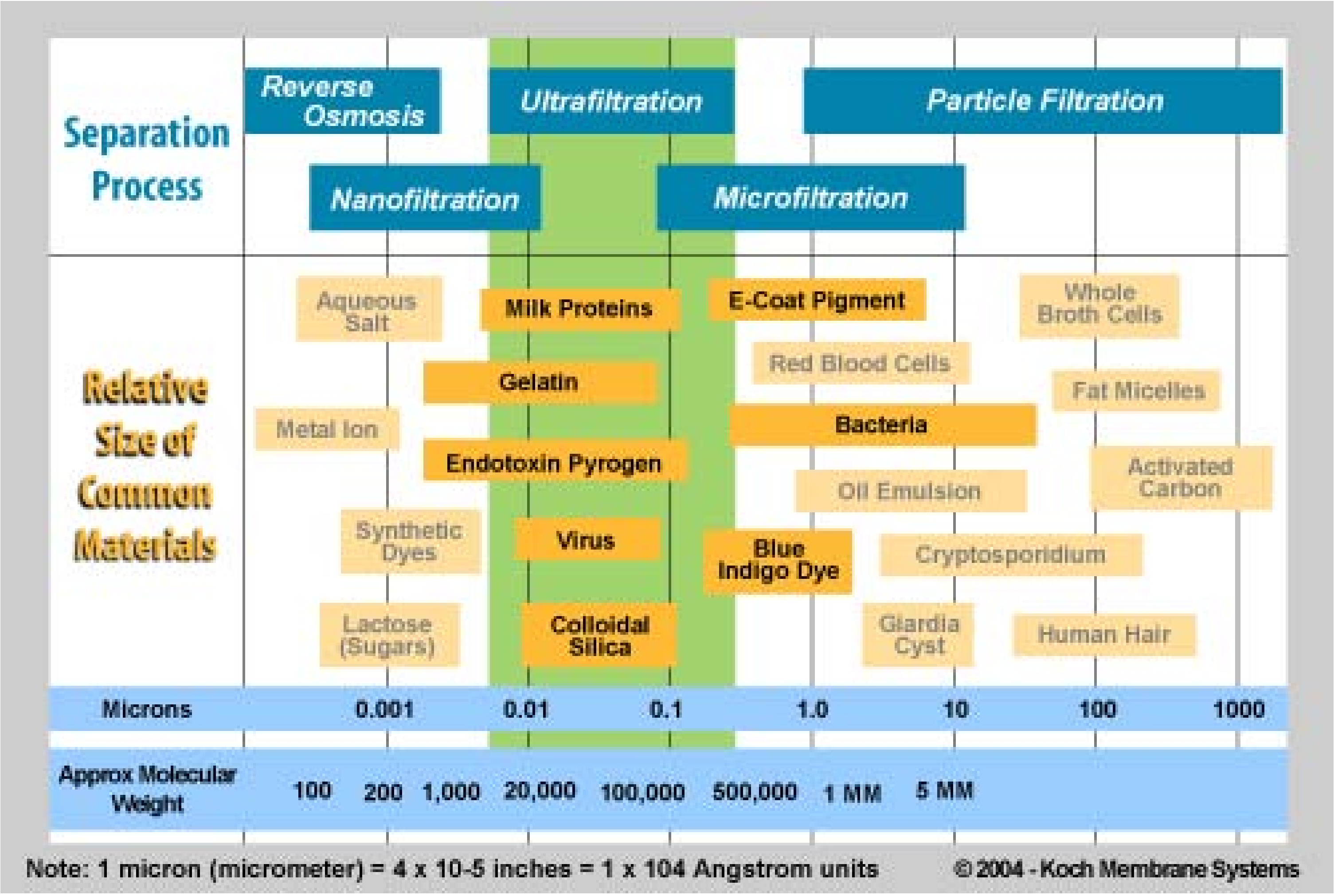
Cleaner Monitoring

- The chemical supplier should be able to provide test kits or test methods to monitor the cleaner chemistry
- Make cleaner chemistry additions based on the test results

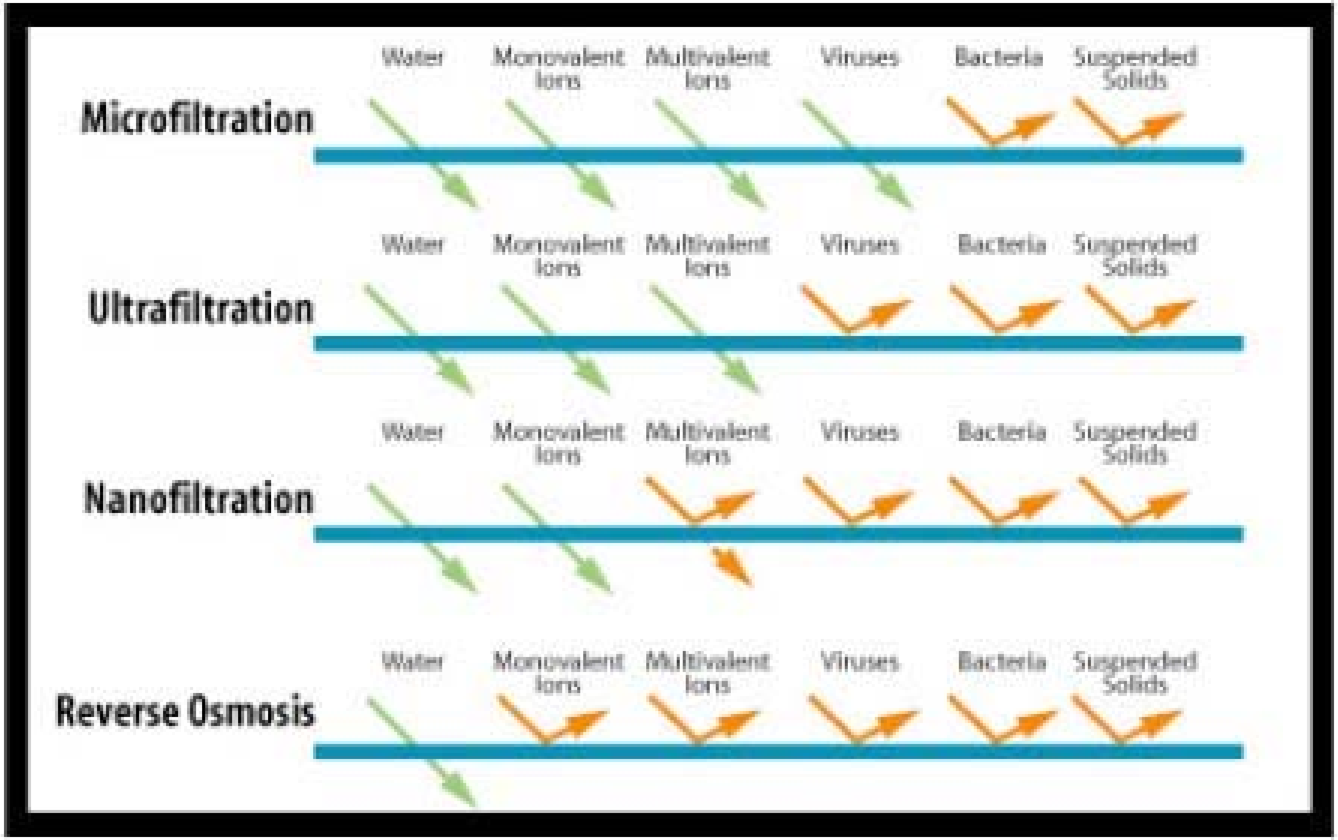
Cleaning the Cleaner

- Cooling a cleaning bath sometimes causes the oils to come out of emulsion and can then be skimmed off (weekend shutdowns)
- Continuous in-tank filtration can usually remove suspended solids (typical polymer filters cannot tolerate solution temperatures >120º F)
- In-tank spargers and weirs can help remove surface oils
- High temperature, high pH tolerant metal or ceramic ultrafiltration can remove colloidal solids and emulsified oils, in most cases without removing any of the cleaning chemistry

Filtration Levels Overview



http://www.kochmembrane.com/sep_uf.html



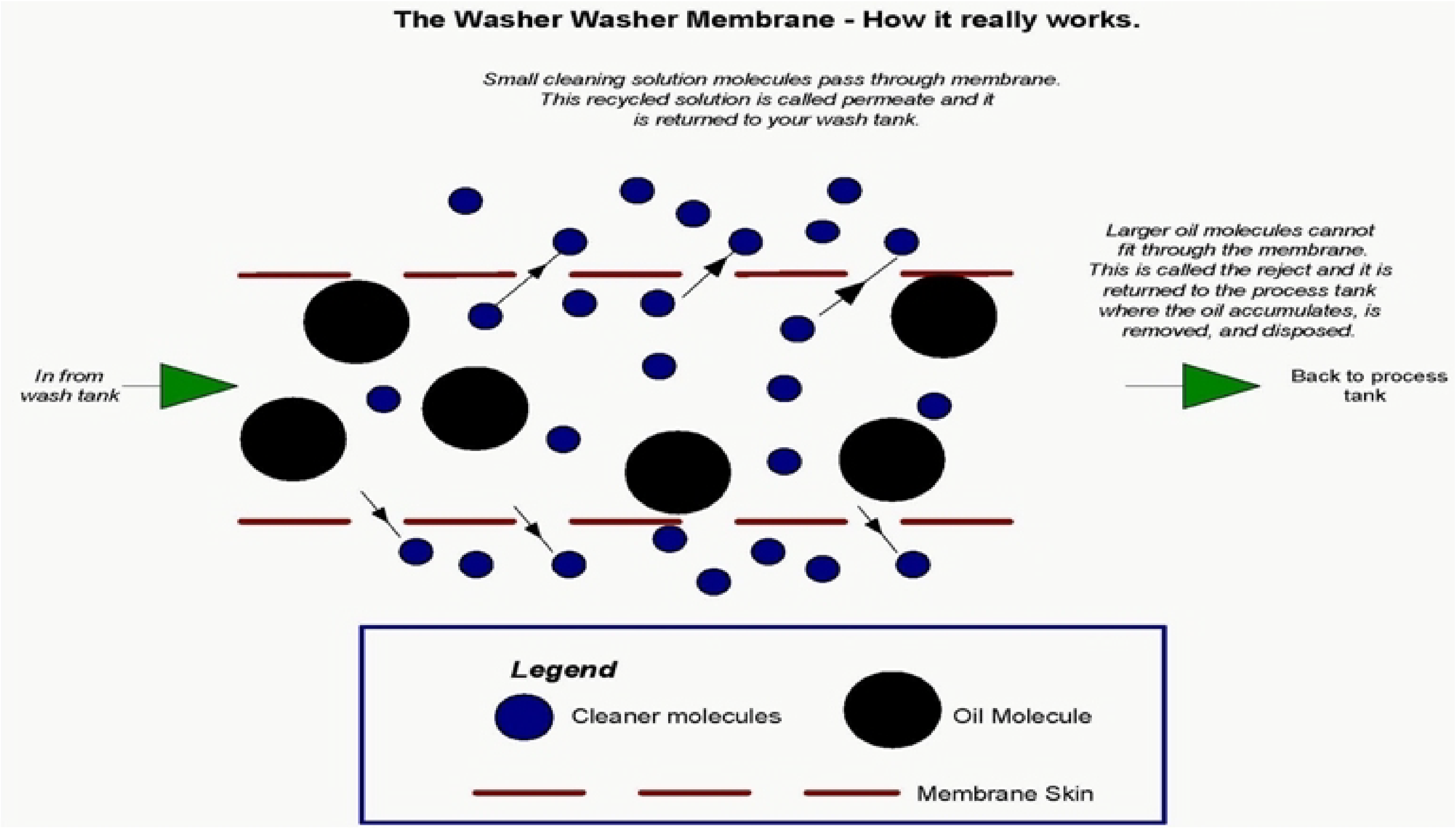
Membrane Process Characteristics

http://www.kochmembrane.com/sep_uf.html

TiO_2/SS Material Micro-Ultrafiltration

- Arbortech equipment (benchtop demonstration)
- Filter able to remove solids and oil emulsions from a cleaner at 200º F and pH of 1-14

Image provided by Arbortech



Schematic provided by Arbortech

Case Study

Chromate/E-Coat Paint Line - Midwest Engine Manufacturer

2005 Costs

• Washer Washer	$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

Data provided by Arbortech

Acid Applications

- Acid Pickling
- Stripping baths
- Activation baths
- Deoxidizer Passivation baths
- Anodizing
- Electropolishing
- Etching

Acid Bath Life

- Acid is consumed (expended) as it dissolves metal in the cleaning process
- Acid is consumed by alkali dragged into the bath from previous cleaning tanks
- Therefore, active acid goes down and dissolved metal goes up as the bath is used
- Metal (solid) + Acid (H+, anion -) ⟶ Metal ion (+, dissolved) + nitrate ion or chloride ion or phosphate, etc.(-)
- Acid dragout into acid rinse

Acid Control

- Monitor acid levels, dissolved metal levels
  - Titration
  - Specific gravity
  - Other methods such as spectroscopy, near infrared, viscosity, etc.
  - Automated systems such as the Scanacon Analyzer*
- Make acid additions based on remaining acid in the bath
- Dissolved metal may interfere with the acid reactions (example, sulfuric acid anodizing bath)

*Scanacon.com

Cost of Dumping an Acid Bath

- Cost of neutralizing the remaining acid in the bath
- Cost of replacing all the acid in the new bath
- Cost of rework due to end-of-life poor cleaning of parts
- Cost of metal sludge filtration and disposal in waste treatment
- Labor costs of waste treatment and making up a new bath
- Labor cost of reporting for hazardous material use and disposal

Acid Bath Maintenance

- Maintaining the acid concentration produces more consistent metal etching and cleaning
- Filtration of the solution will remove any suspended solids
- Surface sparging to a weir will remove floating oils and floating dirt

Acid Life Extension

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.

Various Technologies

- Purpose of each technology is to reduce the dissolved metal while recovering the unreacted acid
  - Chemical additives such as PRO-pHx
  - Diffusion Dialysis
  - Acid Sorption (resin column adsorption and flushing of acid)

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.

PRO-pHx Equipment

← In-tank Filtration

Overflow Filtration →

PRO-pHx Study: Coating Technologies, Inc. and Anoplate

- 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
- Current status: Some tanks were run for 3 years without dumping (tanks were dumped for other reasons such as maintenance issues, etc.)

Unexpected outcomes

- Metal concentration in many baths increased beyond typical operating ranges

- No effect on work-piece processing time or cleaning ability (bath activity stayed constant)

Metal Concentrations

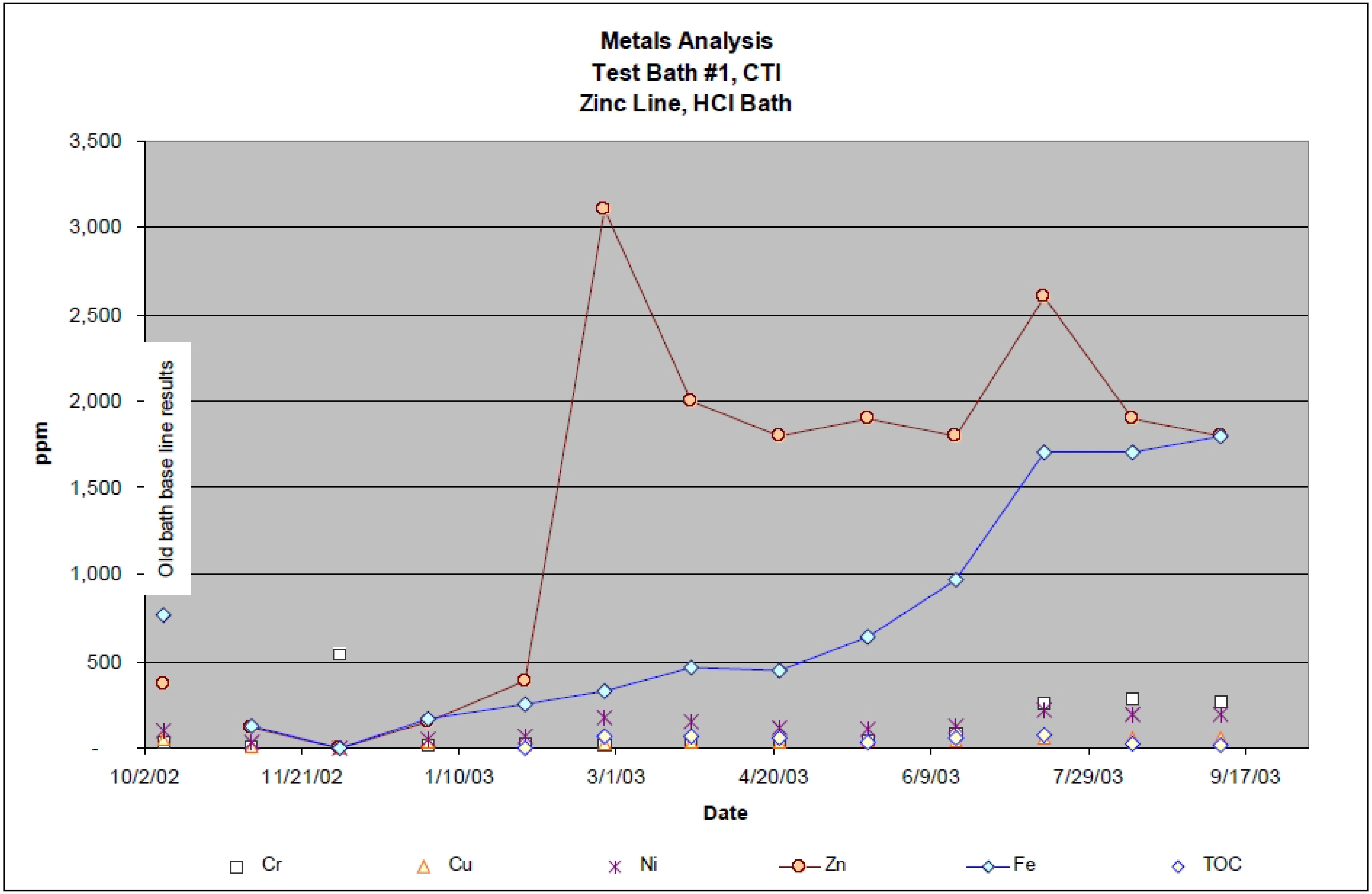


Figure 1

Metal Concentrations

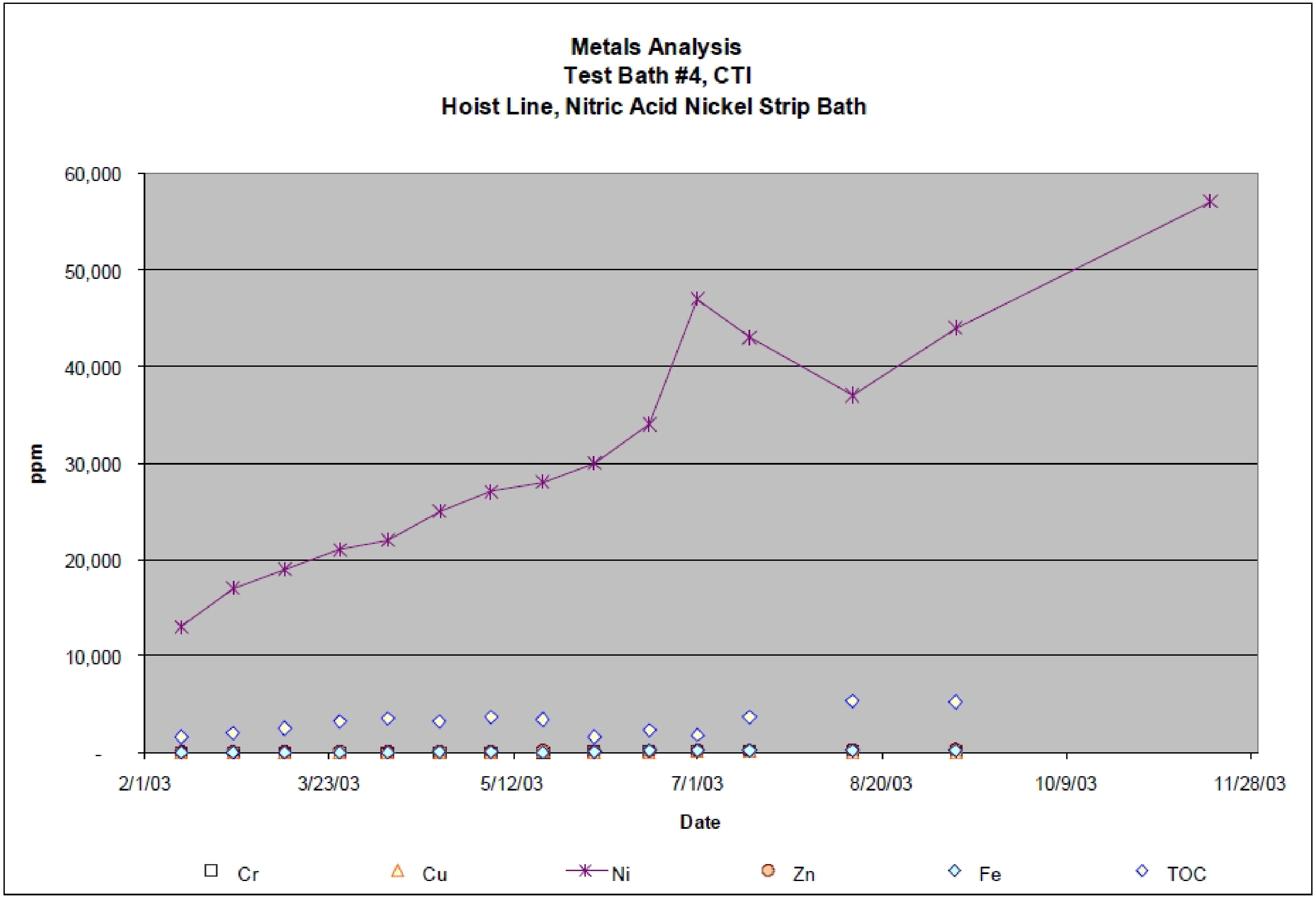


Figure 4

Economic Analysis

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

Annualized Data

	quantity	$/per	Total	
Before PRO-pHx:				
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%**

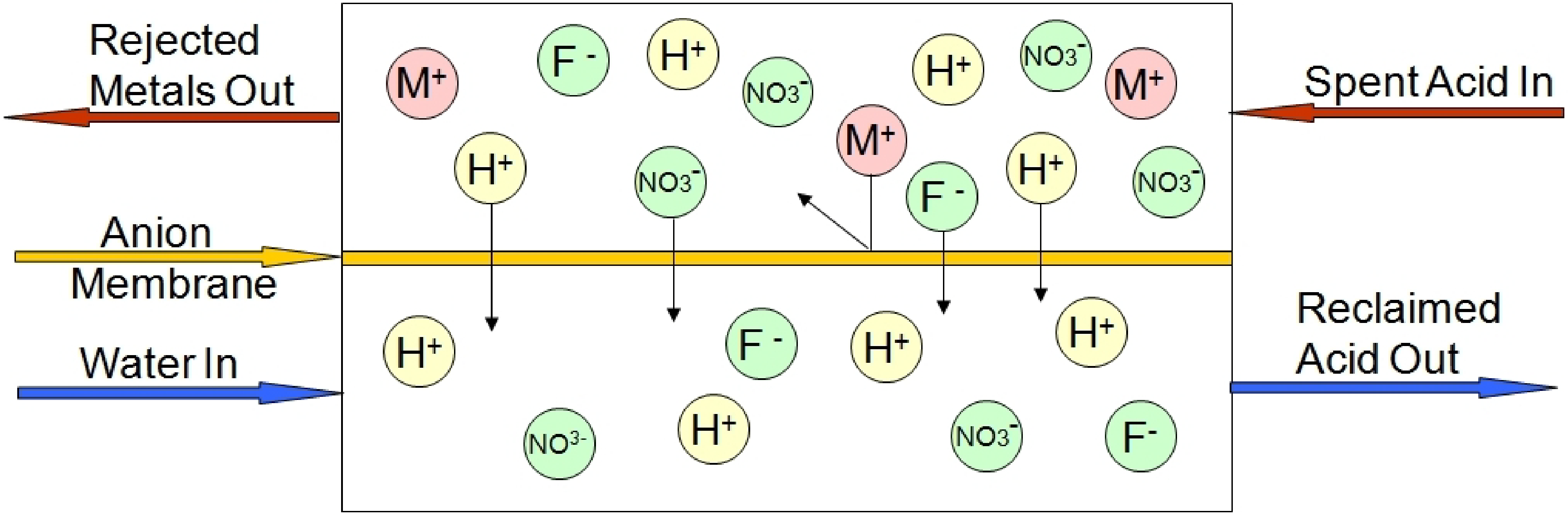
Tank	Caustic Gallons, estimated			Savings		Percents	
	With out PRO-pHx	With PRO-pHx		With PRO-pHx		With PRO-pHx	
		First Year	Subsequent Years	First Year	Subsequent Years	First Year	Subsequent Years
Test Bath 1	2860	1586	1366	1274	1494	44.5%	52.2%
Test Bath 2	3813	1012	792	2801	3021	73.5%	79.2%
Test 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%**

Diffusion Dialysis

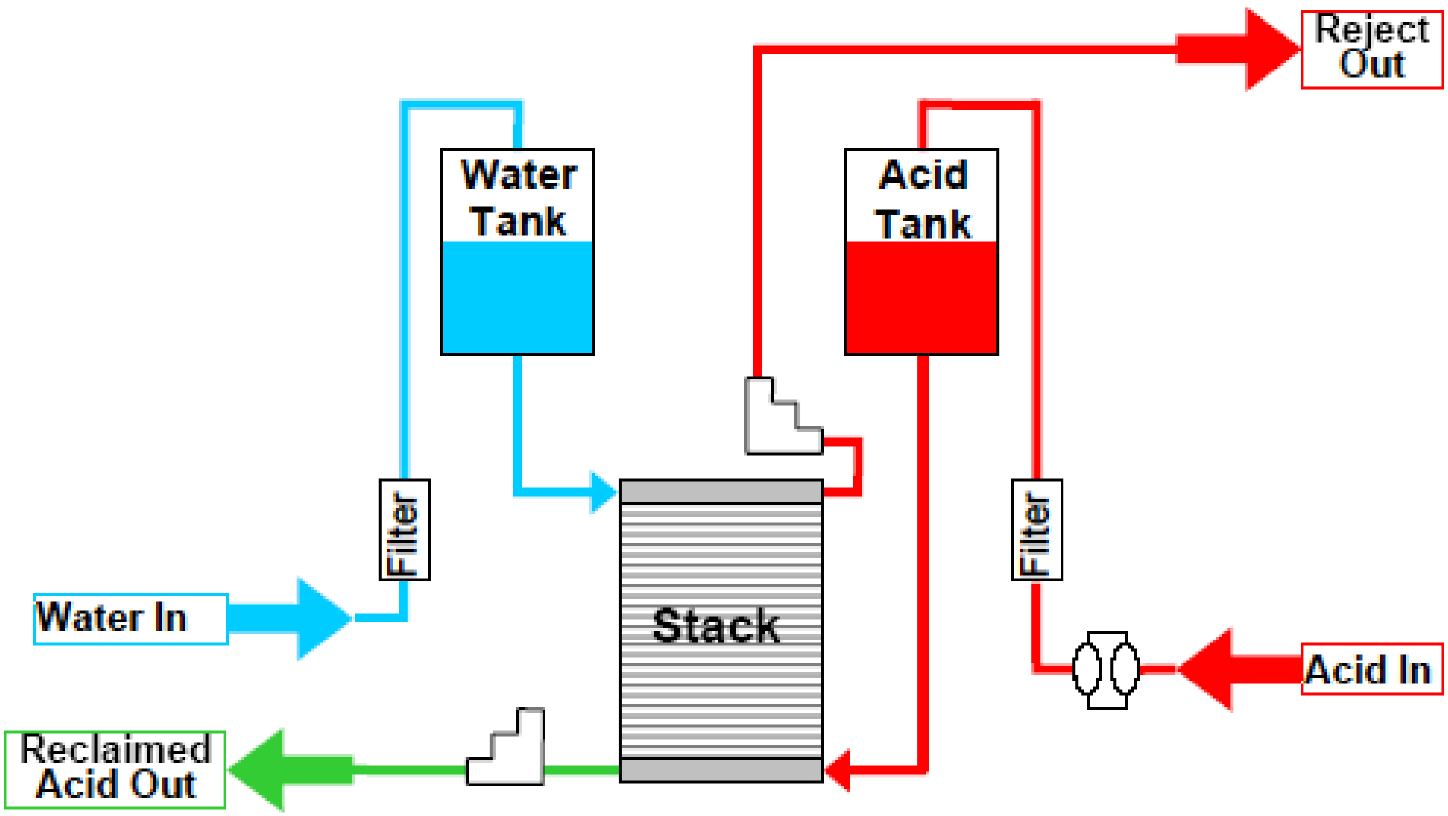
- Diffusion: material movement along a concentration gradient (material moves from high concentration to low concentration)
- Dialysis: Material separation across a membrane based on molecule size and molecule charge. Human kidneys are expert systems at dialysis.

Diffusion Dialysis Process

- Want to separate the dissolved metal from the acid
- Want to have a relatively high acid concentration at least close to that of the original acid, i.e. don't want a dilute acid stream



System Schematic



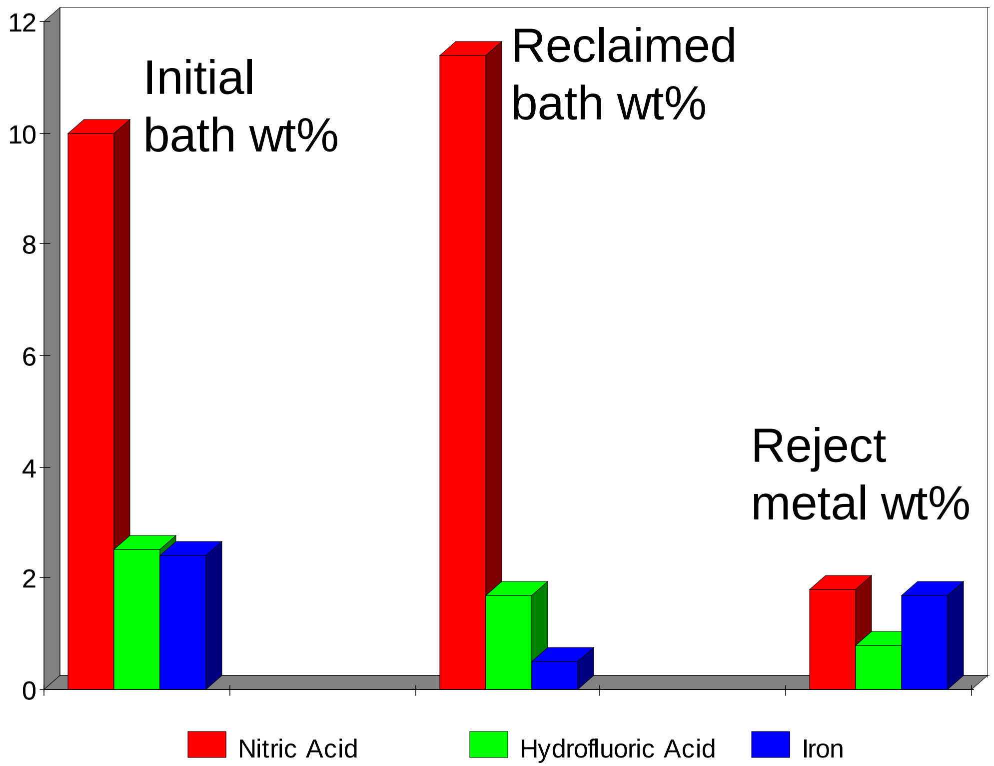
Schematic provided by Mech-Chem Associates, Inc.

Case Study: Nitric-Hydrofluoric Acid, A Common Stainless Steel Pickling Solution:

Expected System Performance:

- 80 – 90% Nitric Acid Recovery,
- 65 – 75% Hydrofluoric Acid Recovery,
- 70 – 90% Metals Removal.

Actual System Performance



Sources

1. PRO-pHx Acid Life Extender: Zero Acid Disposal
   Providing Environmentally Sustainable Technology
   Eliminating Acid Disposal (Presentation)
   www.pro-phx.com

2. Research, Development & Demonstration Project Report:
   Acid Life Extender Test Application At Coating Technology & Anoplate
   (Final Report)

3. Presentation for NYSP2I
   Arbortech Corporation
   www.arbortech.com

4. Steel Acid Presentation
   Mech-Chem Associates, Inc.
   www.mech-chem.com

LEV Integrated with Mechanical Covers to Achieve Energy Savings

Exhaust Systems for Open Surface Tanks

Jim Hankinson - KCH Engineered Systems

KCH Engineered Systems

Pollution Control Exhaust Systems

144 Industrial Drive

Forest City, NC 28043

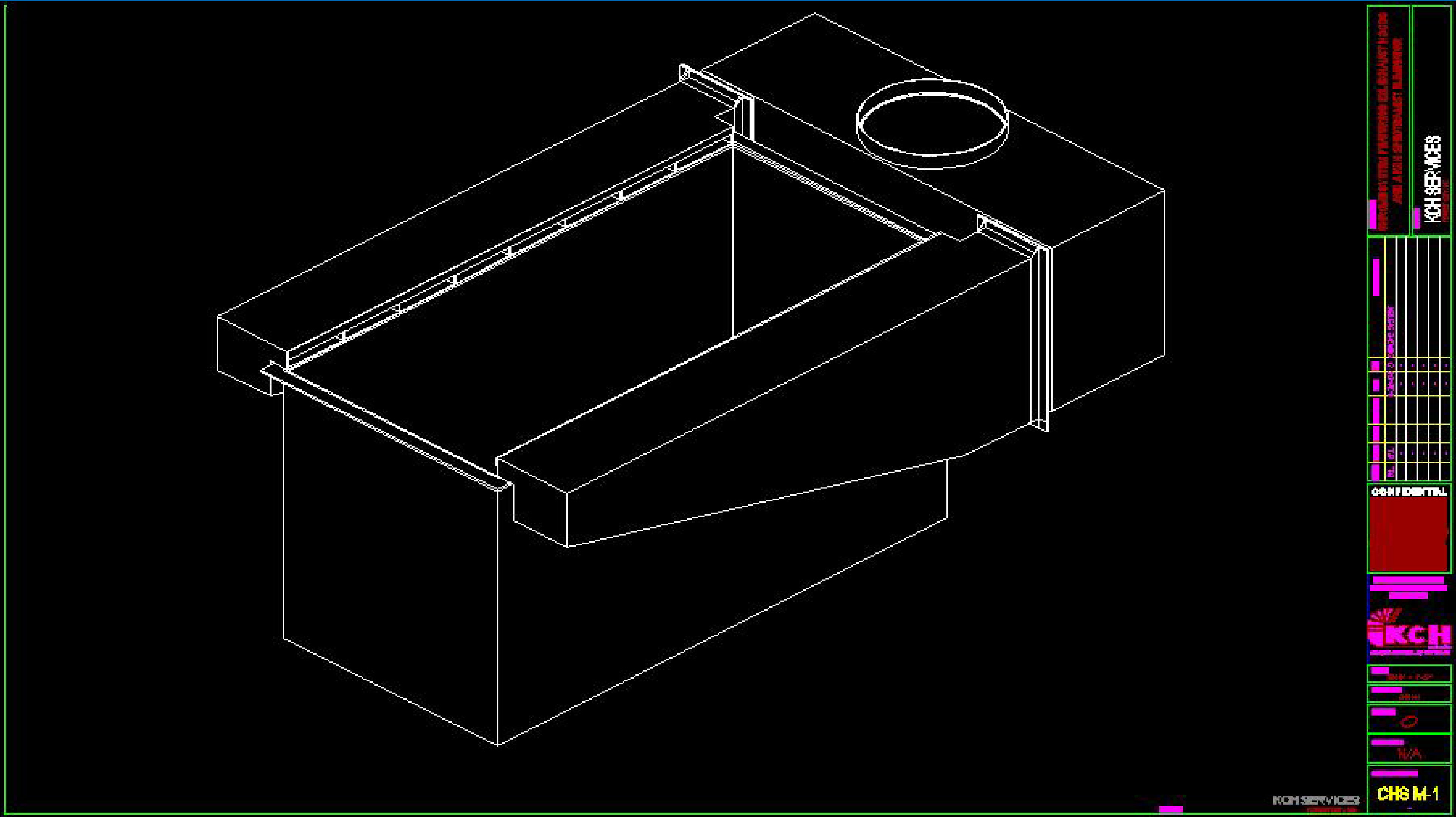
828-245-9836

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 Per ACGIH Guidance 50 CFM/ft2 -- 250 CFM/ft2



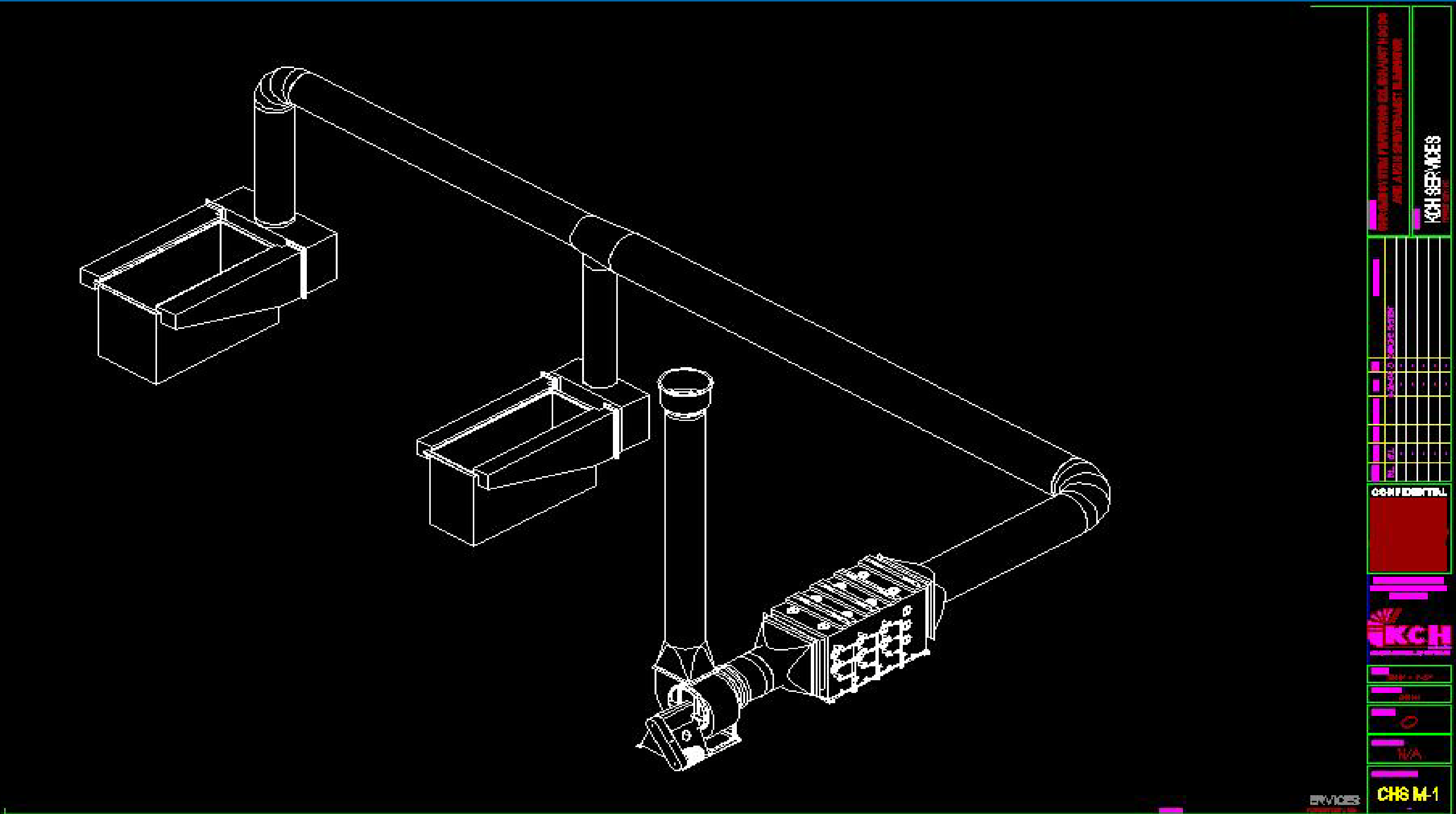
Factors affecting chemical emissions in process tanks.

- 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)


Hard Chrome Plating
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


MAGNAFLUX
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

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

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

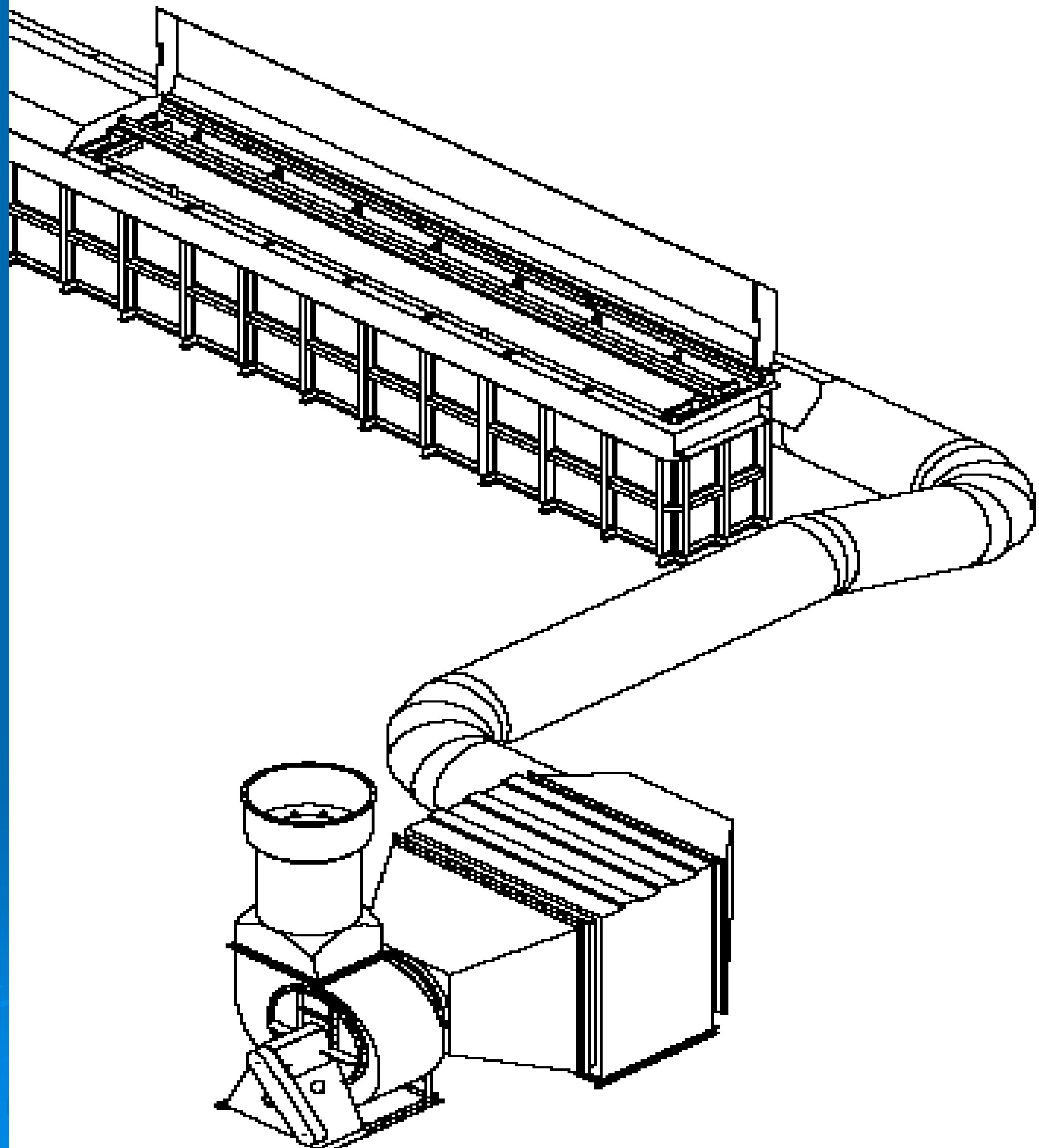
Best Method to adjust exhaust rate

- 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



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 $CS_{fan} = ES_{fan}$ x 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

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

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:

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

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

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

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:

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

The ES_{temper} is 716,068 kWh.

GLOBAL POLLUTION

- Coal fired electrical production is 35% - 40% efficient
- Reduced fan and pump HP = 419,870 kWh/Year
- 852,644 lbs. of CO_2 would be produced
- 1,075 lbs. of particulate matter would escape
- 1,969 lbs. SO_2 would be produced

ANNUAL TOTAL IMPACT

- Electricity Saved ……….. 419,870 kWH
- Natural Gas Saved …… 8,810 mm BTU
- Total Dollar Savings ……………. $66,096
- Total CO_2 Not Emitted……… 1,121 Tons

Calculation for Determination of Energy Cost Savings for Company X

WITH USE OF SEMI-AUTOMATIC COVER SYSTEMS ON THE FOLLOWING TANKS:

- **13 T-17 ETCHANT 33**
- Tank size: 28x6
- Exhaust Fan Size: KCH NH # 60 with 75 HP Motor
- Existing Exhaust Rate: 52,000 CFM
- New Exhaust Rate with cover system closed: 14,200 CFM
- Actual Brake Horsepower Utilized: Approx. 60 BHP
- Actual Brake Horsepower Utilized with cover closed : Approx. 10 BHP
- BHP Savings utilizing Simi-Automatic cover system : 50 BHP
- This reduced BHP achieved by using a variable frequency drive on the existing 75 HP motor

CALCULATION

- 50 BHP x .746 = 37.3 KWH
- 37.3 KWH x 24 = 895.2 KWH/Day
- X 300 Days / Year = 268,560 KWH/ Year
- X .1 (10 cents) per KWH = ***$ 26,856.00*** Energy Dollars Saved per year
- By utilizing the Simi-Automatic Cover System and Variable Frequency Drive

Calculation for Determination of Energy Cost Savings for Company X

WITH USE OF SEMI-AUTOMATIC COVER SYSTEMS ON THE FOLLOWING TANKS

- 13 T-4 CHEM MILL TANK SIZE = 28 X 6
- 13 T-5 CHEM MILL TANK SIZE = 28X6
- Fan Motor Size: 50 HP
- Existing Exhaust Rate (BOTH TANKS): 30,000 CFM
- New Exhaust Rate with cover system closed : 3000 CFM
- Actual Brake Horsepower Utilized: Approx. 50 BHP
- Actual Brake Horsepower Utilized with cover closed: Approx. 15 BHP
- BHP Savings utilizing Simi-Automatic cover system: 35 BHP
- This reduced BHP achieved by using a variable frequency drive on the existing 50 HP motor

CALCULATION

- 35 BHP x .746 = 26.11 KWH
- 26.11 KWH x 24 = 626.64 KWH/Day
- X 300 Days / Year = 187,992 KWH/ Year
- X .1 (10 cents) per KWH ***= $ 18,799 .00*** Energy Dollars Saved per year
- By utilizing the Simi-Automatic Cover System and Variable Frequency Drive

ESTIMATES ON AIR MAKE UP ENERGY COST SAVINGS USING THE AUTOMATIC COVER SYSTEM AND VARIABLE FREQUENCY DRIVE BY KCH

- CS = Annual Cost Savings
- Q = Airflow rate 52,000 CFM
- dg = Annual degree days 3895
- t = Operating time 168/ hrs/wk
- c = Cost of fuel $/unit .00978 cu. ft
- q = Available heat/unit of fuel 10000 BTU/ Cu, Ft.
- CS $= \dfrac{.0154\ Q\ (dg)(t)\ (c)}{Q}$

Cost Savings using the KCH covered tank system reducing the exhaust CFM from 52000 to 14200 CFM on 13 T- 17 Etchant 33

- *0.154 x 52000 x 3895 x 168 x .00978 / 1000 = $51,248.00 spent on tempered make up air exhausting 52,000 CFM*

- *0.154 x 14,200 x 3895 x 168 x .00978 / 1000 = $13,994 spent on tempered make up air exhausting 14,200 CFM utilizing new KCH Tank Cover System*

- *$51,248.00 - 13,994.00 =* ***$37,254 energy cost savings on air make up using the KCH Covered Tank System***

Cost Savings using the KCH covered tank system reducing the exhaust CFM from 30000 to 3000 CFM on 13 T-3 and 13 T-4

- *0.154 x 30000 x 3895 x 168 x .00978 / 1000 = $29,566.00 spent on tempered make up air exhausting 30,000 CFM*

- *0.154 x 3000 x 3895 x 168 x .00978 / 1000 = $13,994 spent on tempered make up air exhausting 3000 CFM utilizing new KCH Tank Cover System*

$29,566.00

- *- 2956.00 =* ***<u>$26,610 energy cost savings on air make up using the KCH Covered Tank System</u>***

Metal Finishing Workshop for Captive and Job Shop Metal Finishers

Session 3: Water Use and Recovery

10:45am – 11:15am

February 09, 2011

Rajiv Ramchandra

NYSP2I

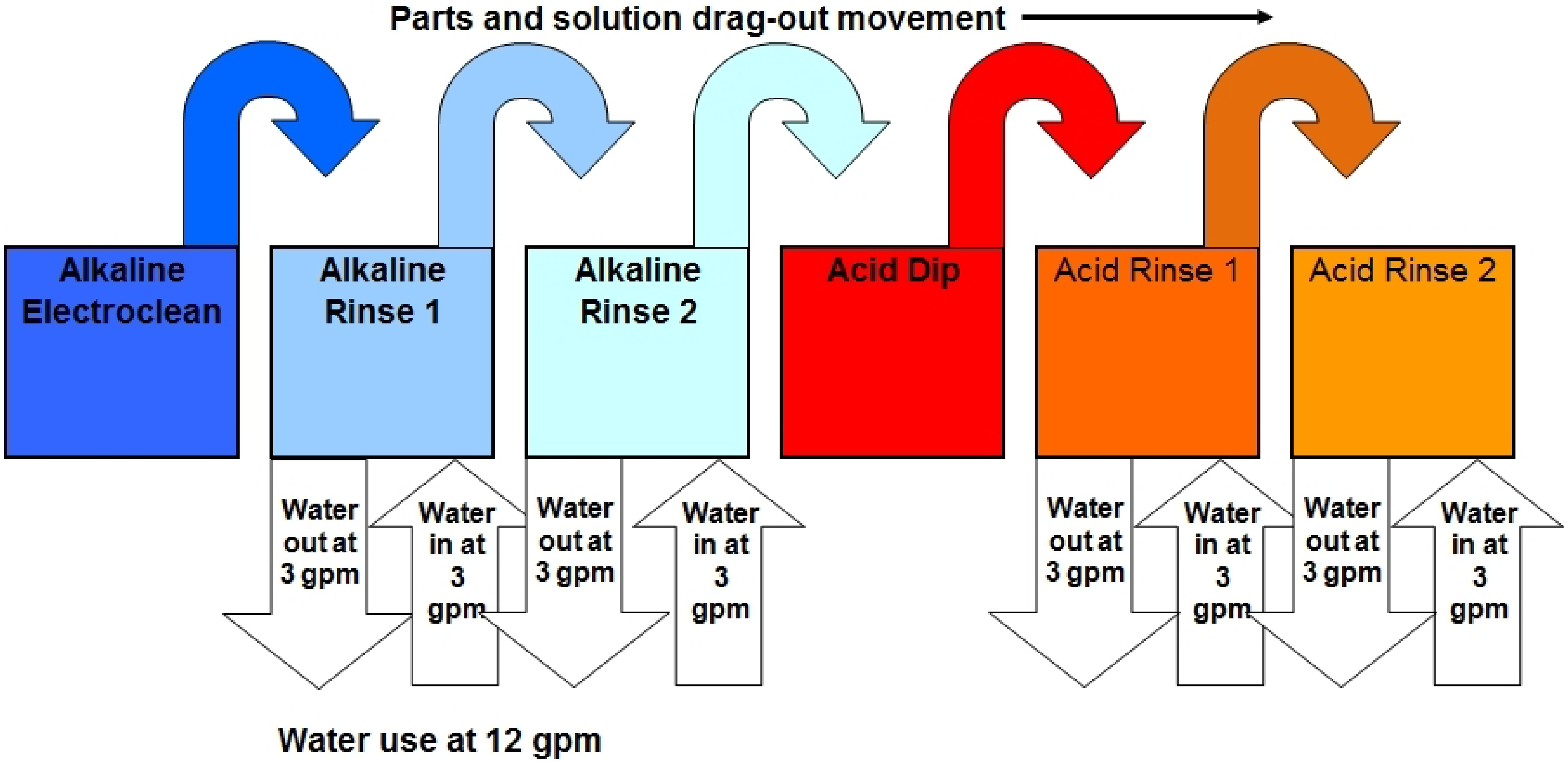
Overview

- Optimizing Rinse Water Use
- Water Recovery
  - Technologies
  - Rinse Water Requirements
  - Which Technologies make sense
  - Cost and Payback considerations

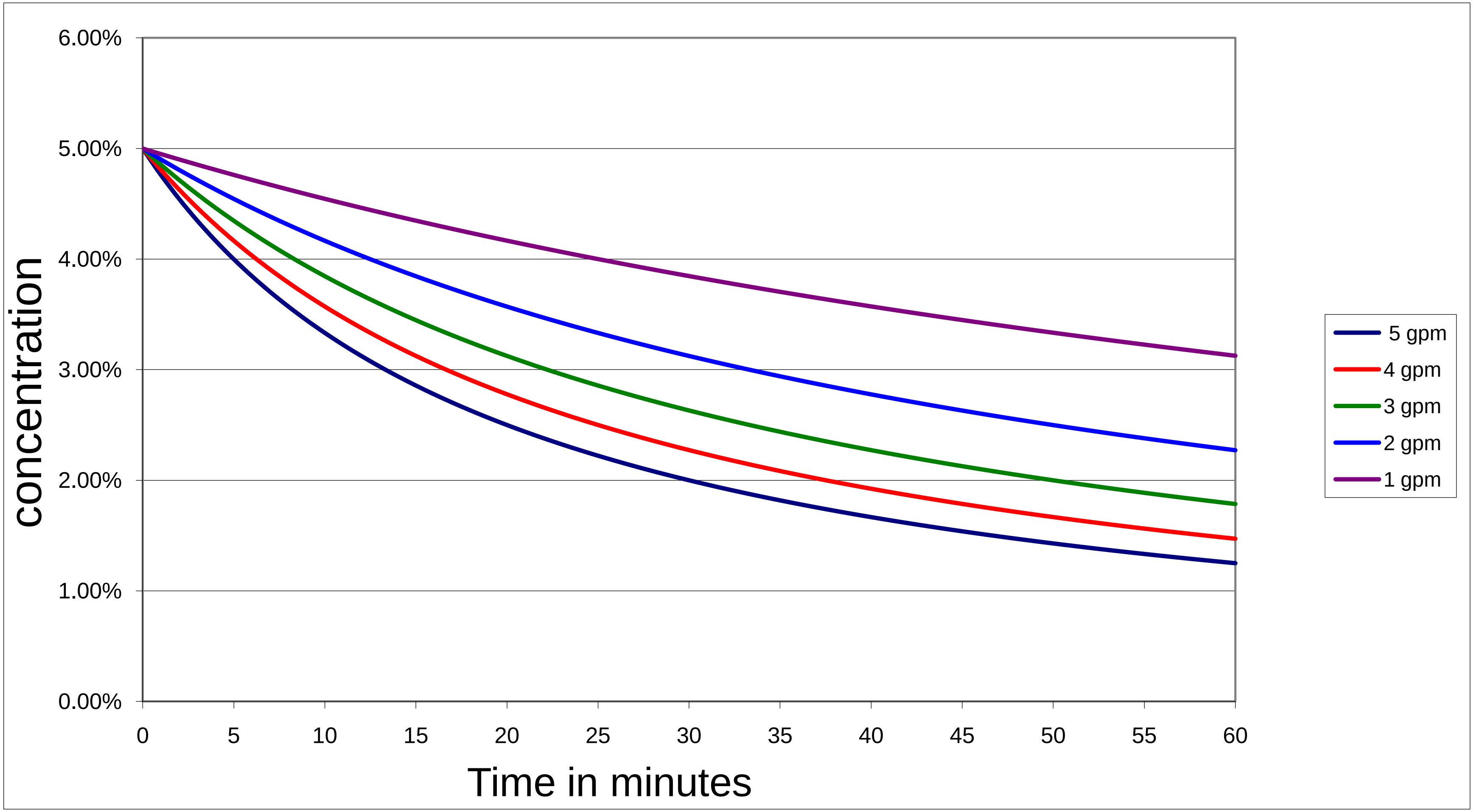
Typical Cleaning Steps

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

Typical Cleaning and Rinsing Layout

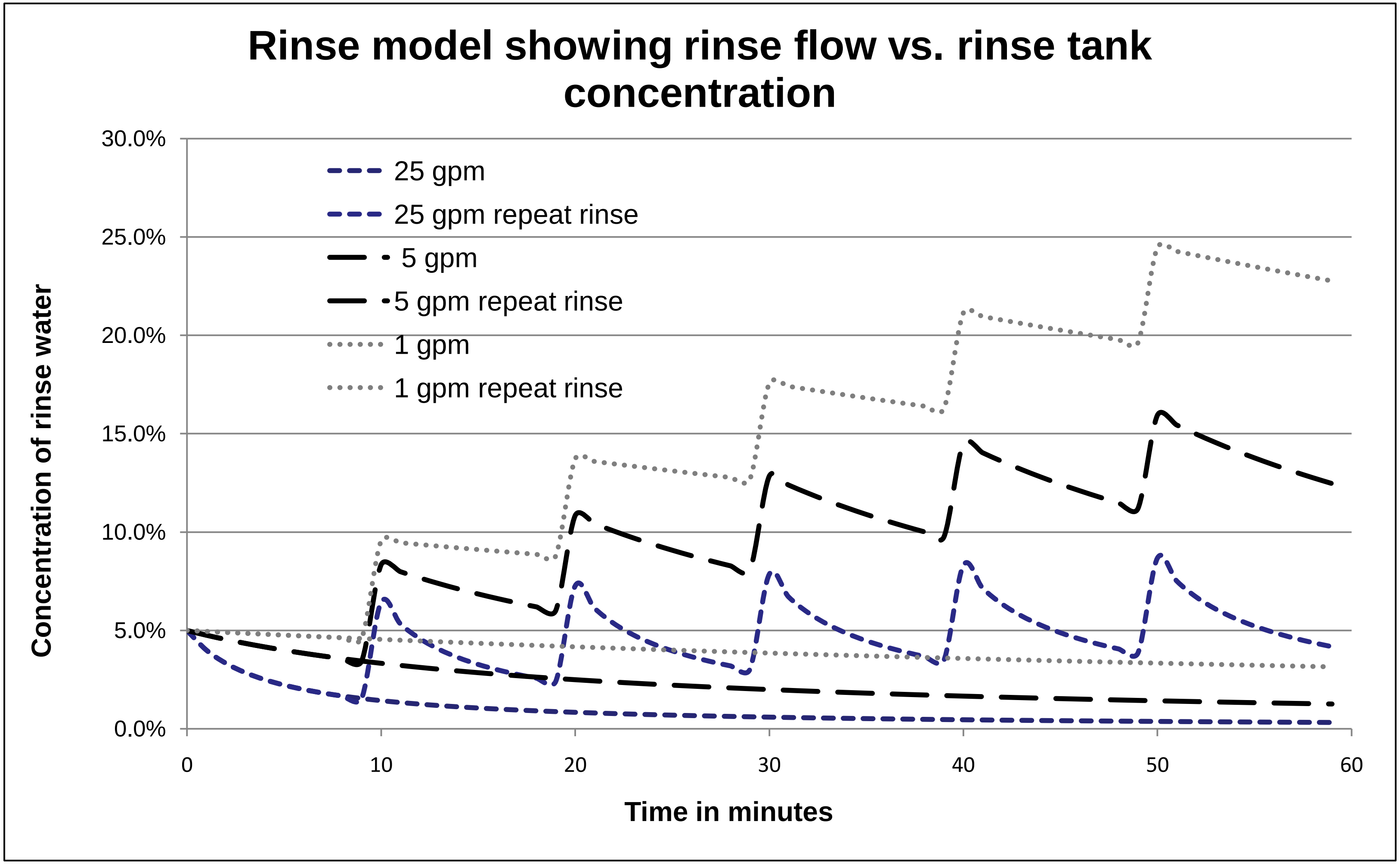


Single Rinse Dilution Model



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

Single Rinse Dilution Model



Single Rinse

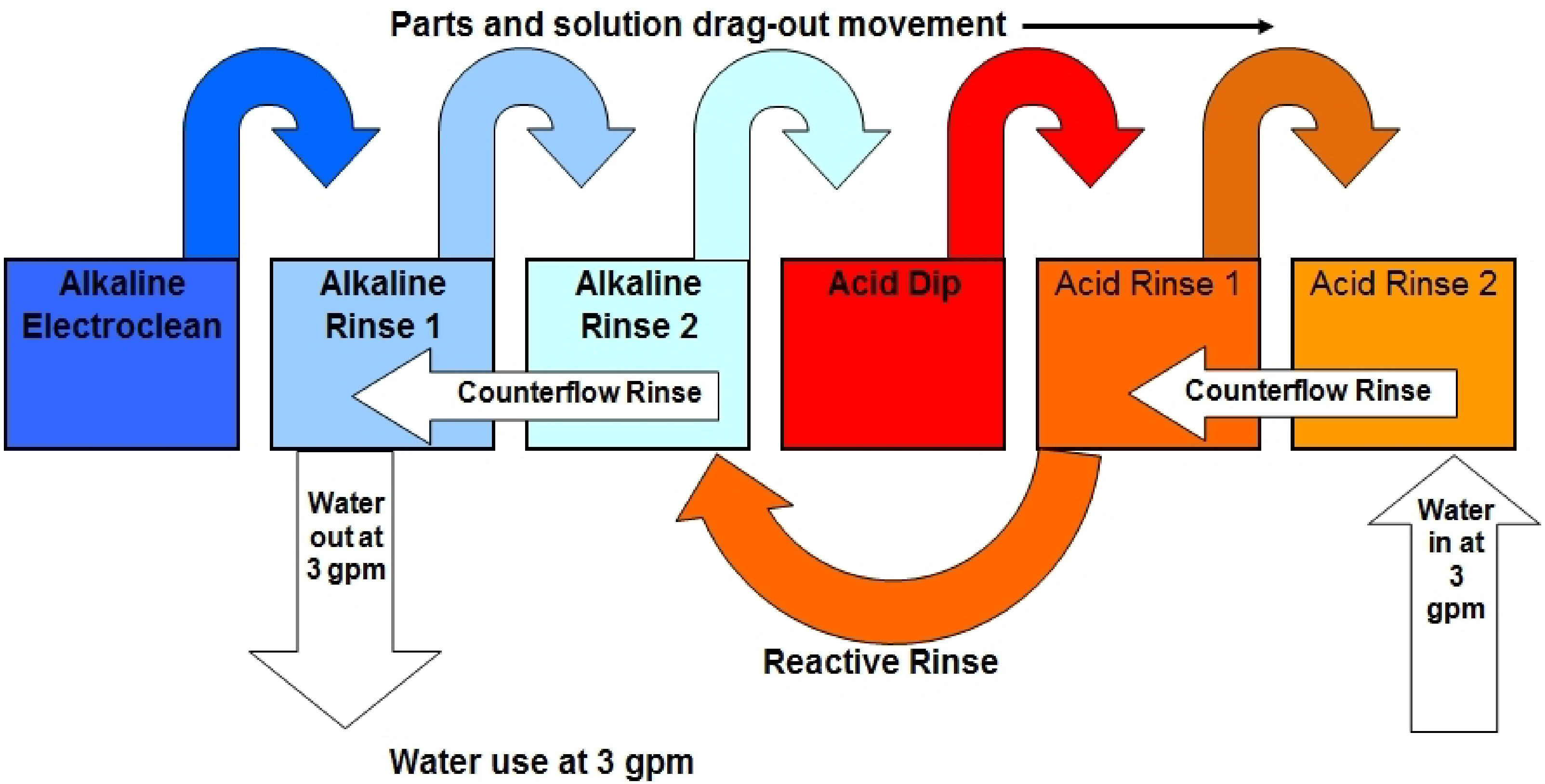
- Conclusion: Based on the rate of dilution in even a small tank (100 gallons), it is very difficult to obtain good rinsing with a single rinse tank. Even relatively high flow rates of 5 gpm cannot keep up with the contamination loading from parts dragout.
- Therefore, there really needs to be a second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

Purpose of Rinsing

- First rinse tank
  - remove most of the previous tank’s chemicals from the part
  - Stop the chemical reaction from the previous tank
- Second rinse tank
  - Final rinse to remove additional chemicals and maximize part cleanliness
  - Minimize contamination of next chemical tank

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

Optimized Cleaning and Rinsing Layout



Water Use in Finishing: 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

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 (create a curve), end with on-line rinse tank measurements

Conductivity/TDS meters cost from $140-$900

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

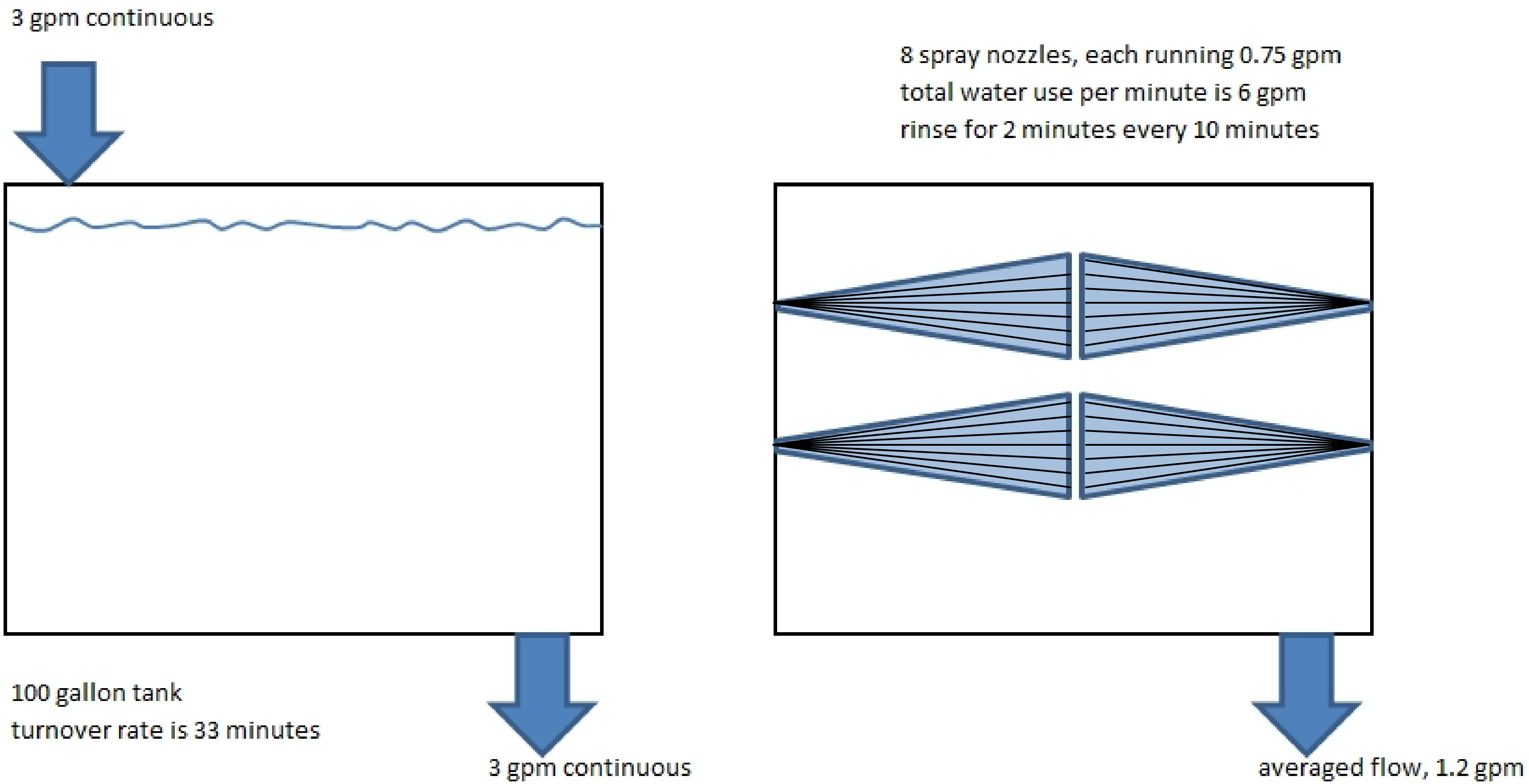
From:
www.freshwatersystems.com

From: Myron L Company, Controlstik Systems

Conductivity/TDS Controls

- Finding the best TDS set points (valve opens when water reaches maximum TDS set point, valve closes when water reaches minimum TDS set point)
- Measure the TDS with a meter in the critical rinse tanks. Knowing the existing flow rate also helps.

Immersion vs. Spray Rinsing



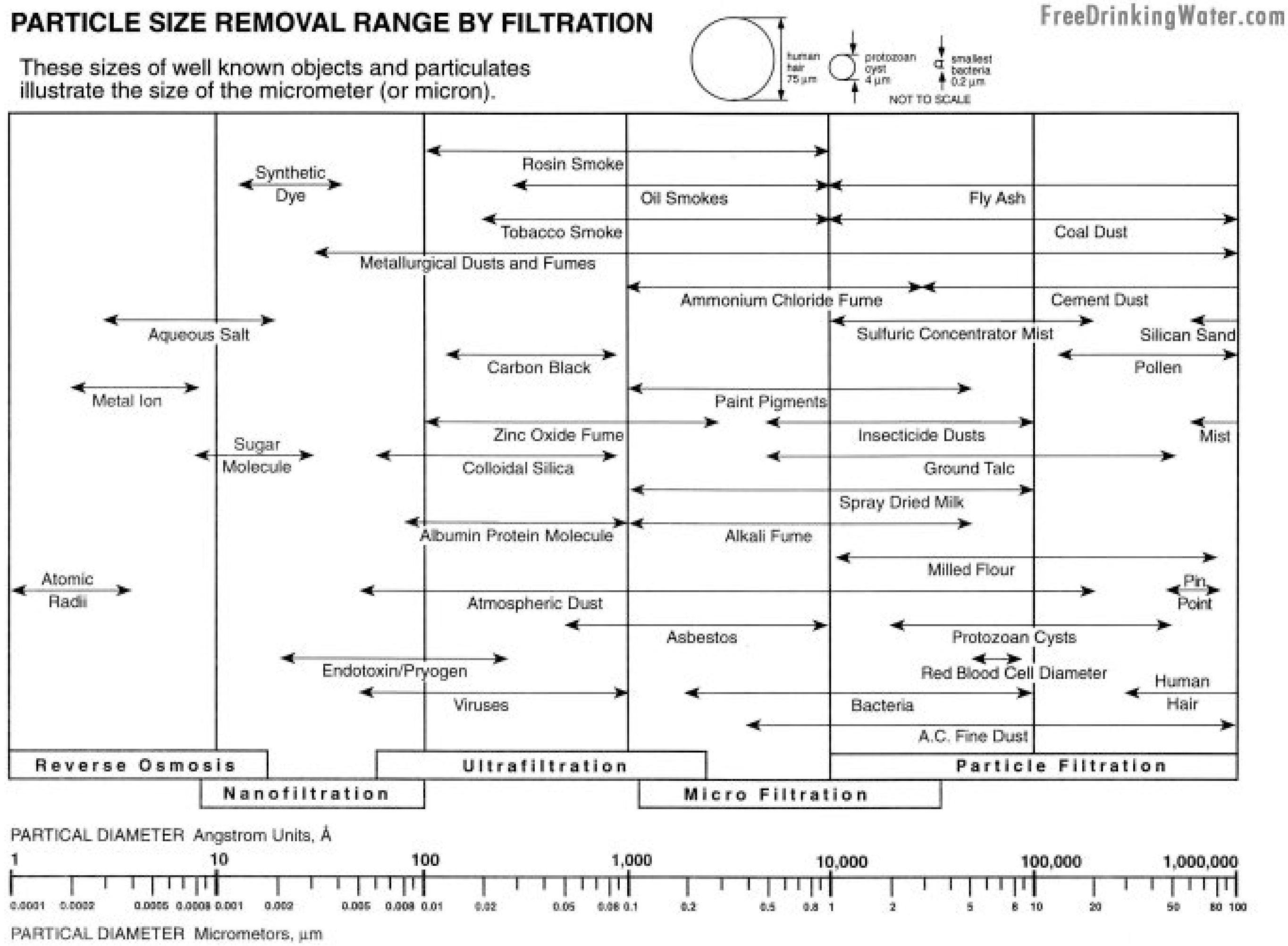
Other options for spray rinsing

- 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

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

Water Recovery Technologies



Source: http://www.freedrinkingwater.com/water-education/quality-water-filtration-method.htm

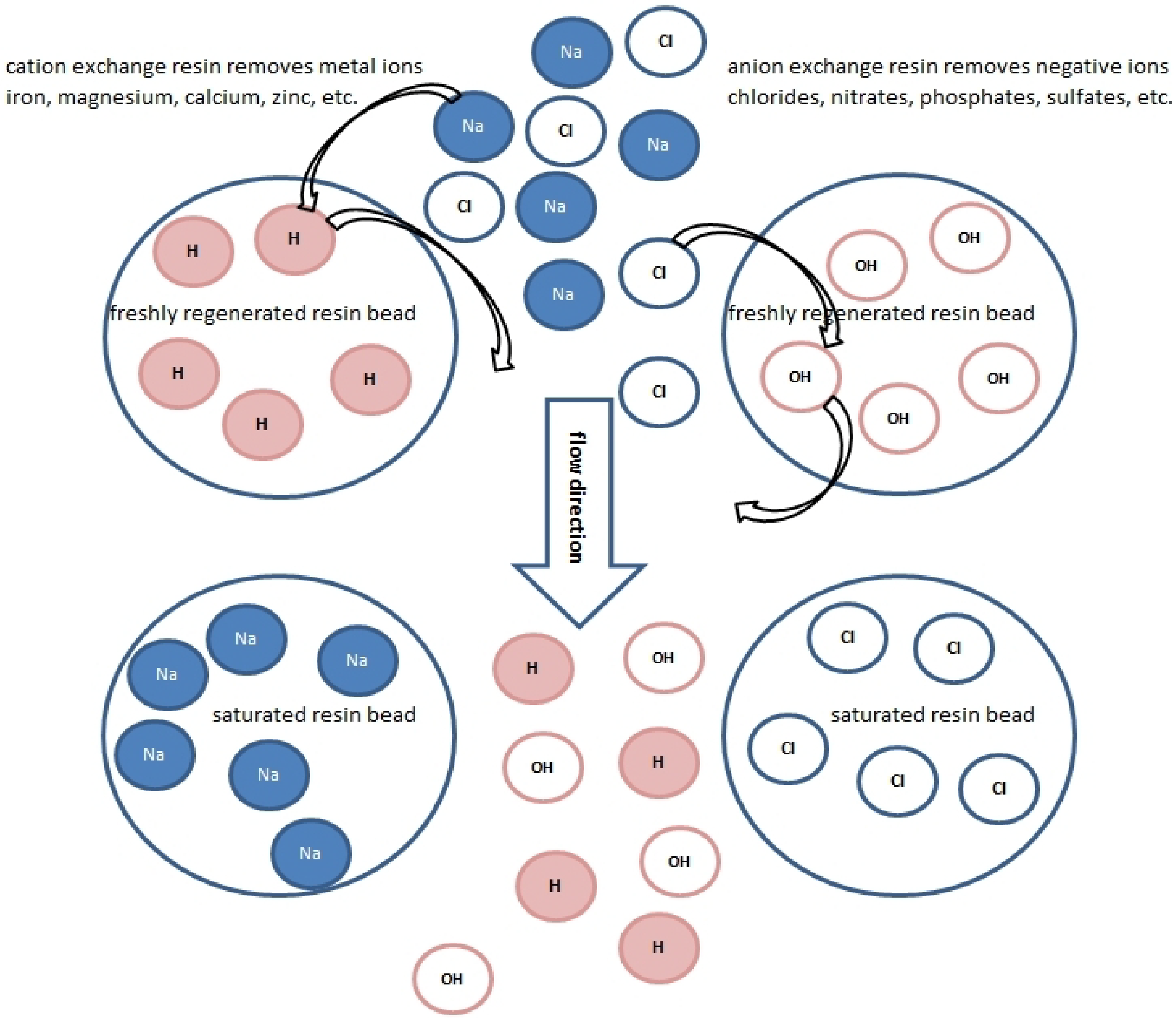
Rinse Water Requirements

- 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
  - Free of oils, soaps, etc.
  - RO/DI, if necessary

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

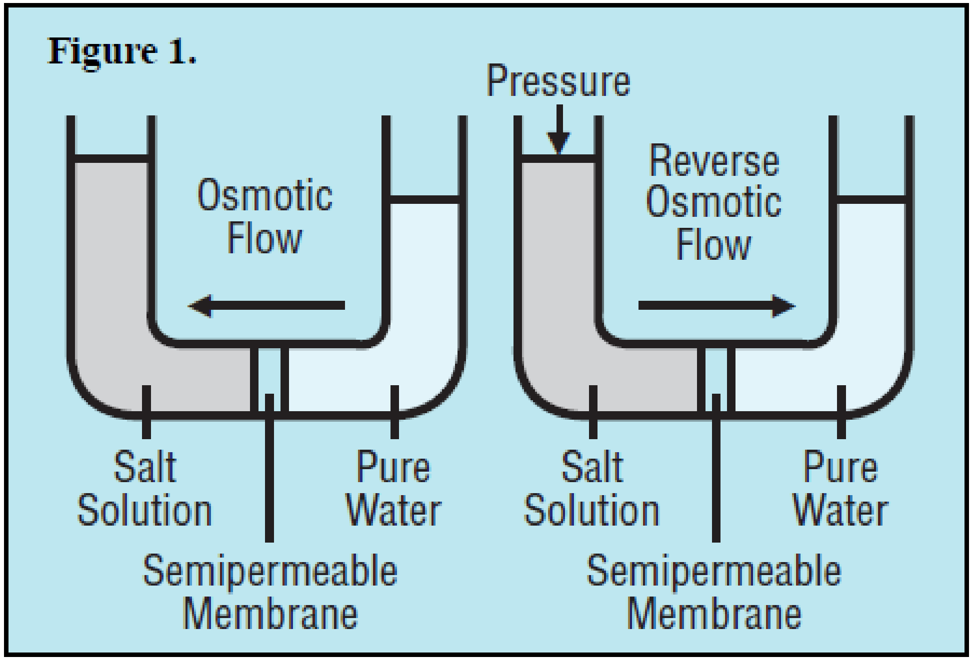
Advantages

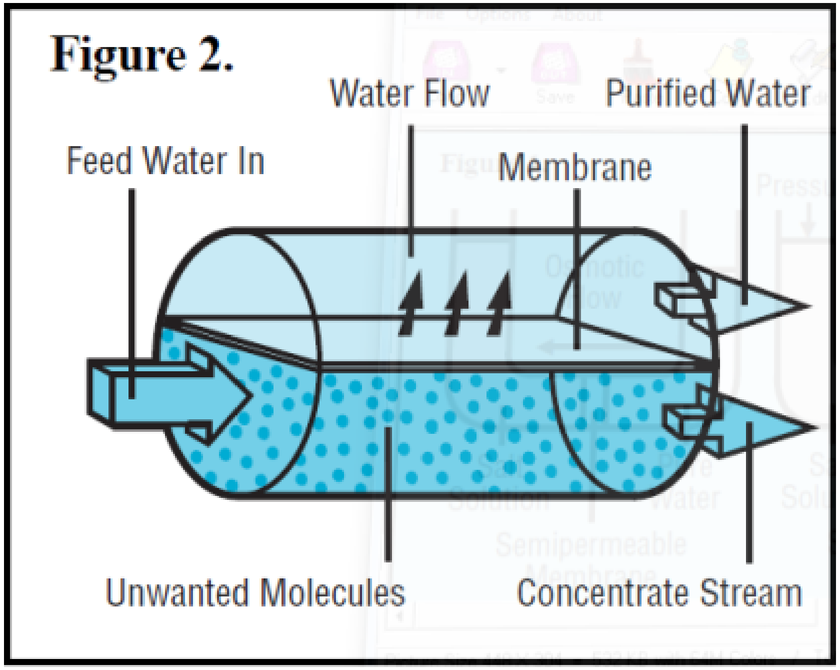
- Excellent ion removal
- Flow rate can be increased with a larger diameter column

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:

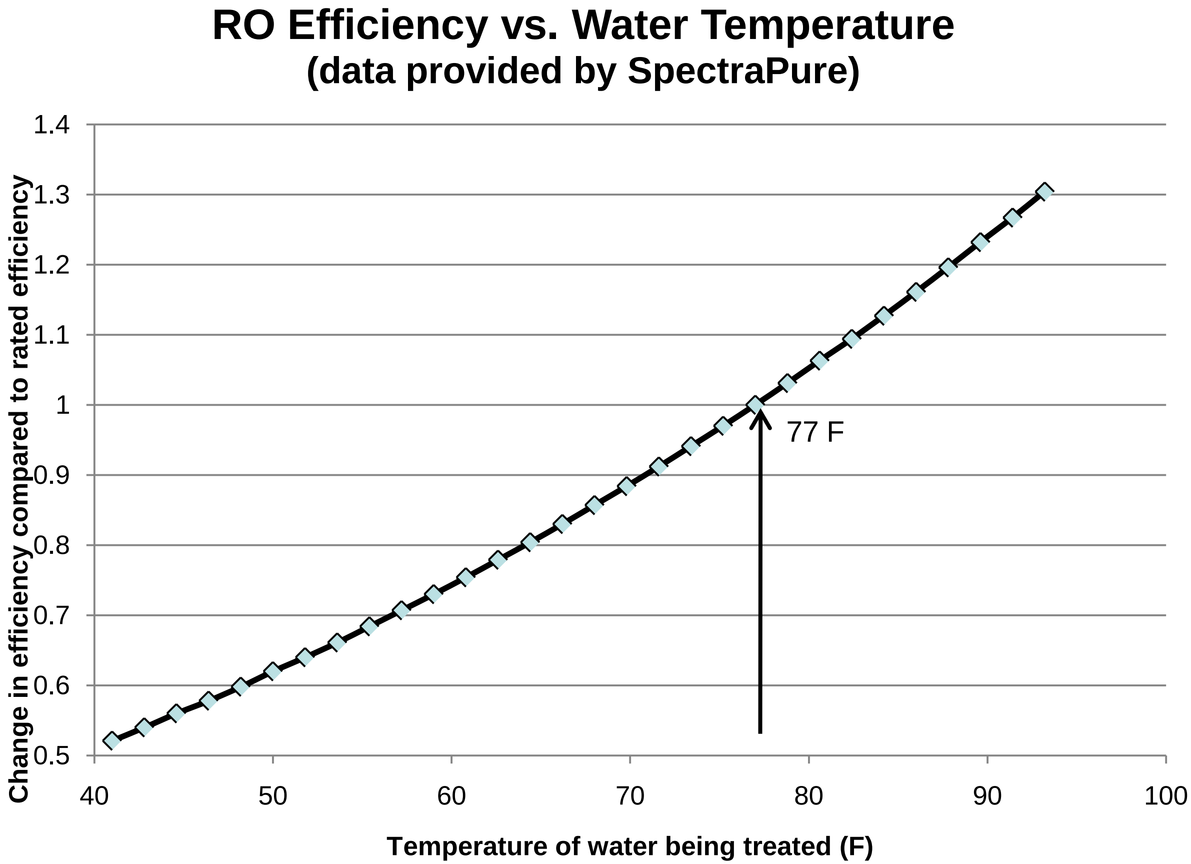
- Removes everything: ions*, bacteria, viruses, solids
- Relatively simple, low maintenance system

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

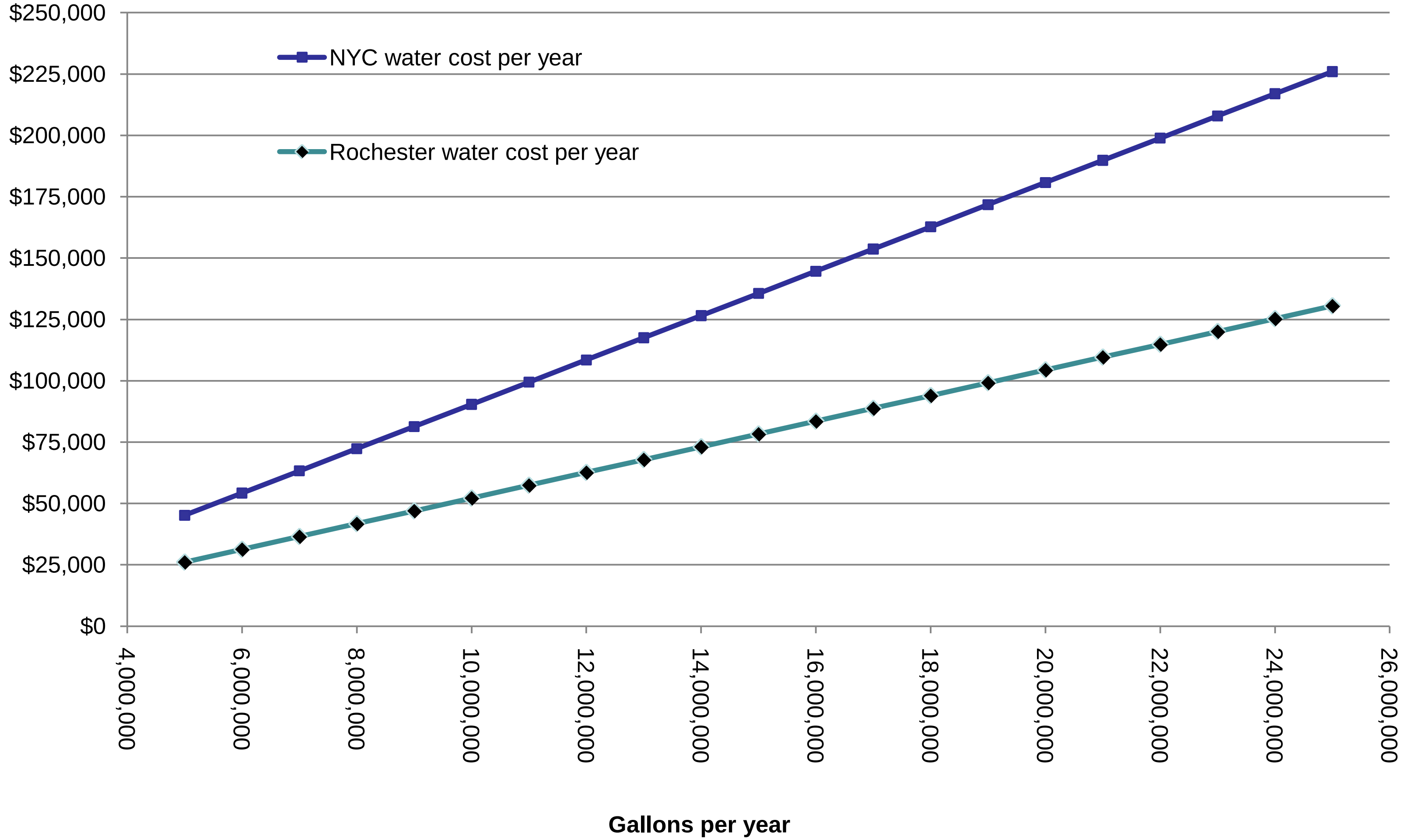
Cellulose Acetate	**Low cost**	**Medium water flow**	**pH range 4-8**	**Max. temp. 95 F**	**Oxidation resistant**
Composite (thin film composite, TFC)	**High cost**	**High water flow**	**pH range 2-11,**	**Max. temp. 113 F**	**Vulnerable to oxidizers (chlorine)**
Aromatic Polyamide	**Medium cost**	**Low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

In short, no perfect membrane material

Water Cost vs. RO Equipment Cost

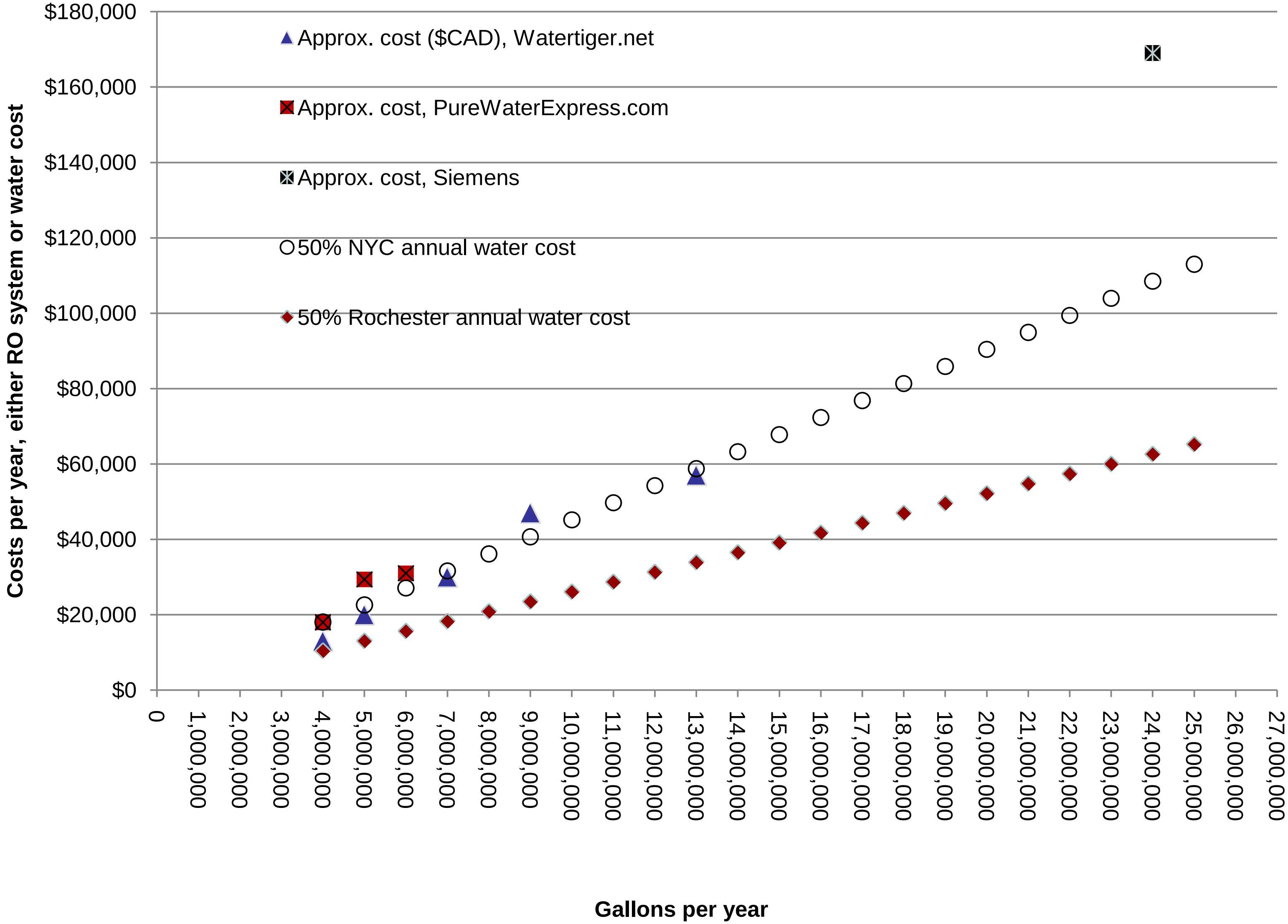
- Some cost comparisons from on-line prices (Watertiger, PureWaterExpress, Siemens)
- Rochester city water charges $5.22/1000 gallons ($2.67 water bill, $2.55 water treatment tax)
- New York City, $9.04/1000 gallons with sewer charges included

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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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.