BEST PRACTICES FOR METAL FINISHING LINE OPERATORS

MARCH 12, 1998

OPERATOR TRAINING WORKSHOP AT GOLD SEAL PLATING

SPONSORED BY:

U.S. EPA

SURFACE TECHNOLOGY ASSOCIATION

PRESENTED BY: TETRA TECH EM INC.

Best Practices for Metal Finishing Line Operators

August 19, 1998

Unit 1

Introduction and Course Overview

EPA/STA Pollution Prevention Technical Assistance Project

- **Training**
  - ➢ **P2 and Compliance Workshop Series (series of 6 now completed)**
  - ➢ **Operator Training (given multiple times)**
- **Mini-Assessments**
  - ➢ **Working with 4 facilities**
  - ➢ **May be more opportunities next year**

Operator Training Workshops

A "hands on" workshop for platers and anodizers:

***Looking for host sites for next workshop in Central Valley or South Bay**

***Next workshop will be in Spanish**

Operator Training Workshop Objectives

- **Understand how your actions impact process operations, efficiency, and waste generation**
- **Learn rack and parts handling techniques that minimize dragout loss and rinse water use**
- **Be able to convey proper operation techniques to other staff and line supervisors**

Agenda

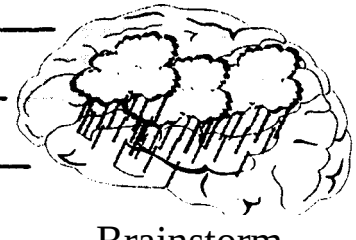
- **Production Quality, Cost, and Environmental Impacts**
- **Common Production Pressures and Issues**
- **Operating Techniques Demonstrations**
- **Impacts of Operating Techniques on Process Efficiency**

Unit 2

Production Quality, Costs, and Environmental Impacts

What Is Waste?

Write down your definition

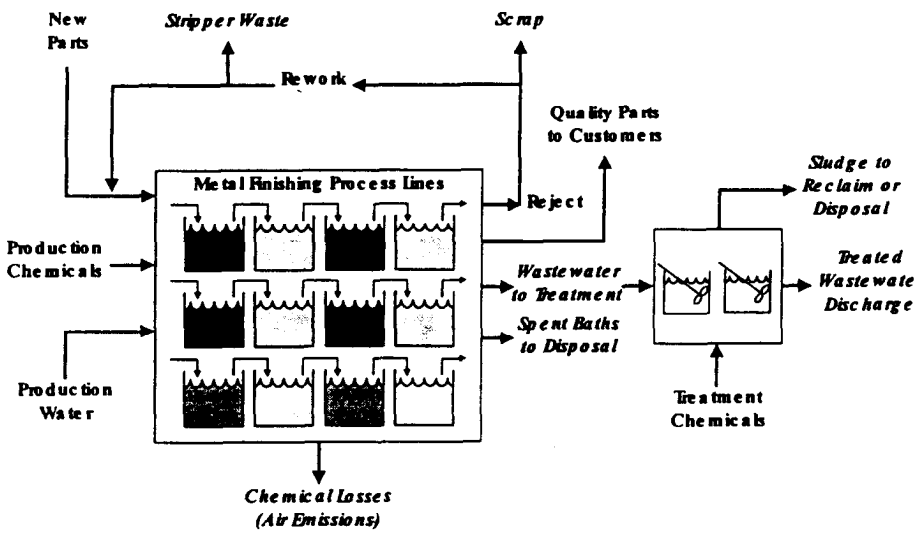


Brainstorm

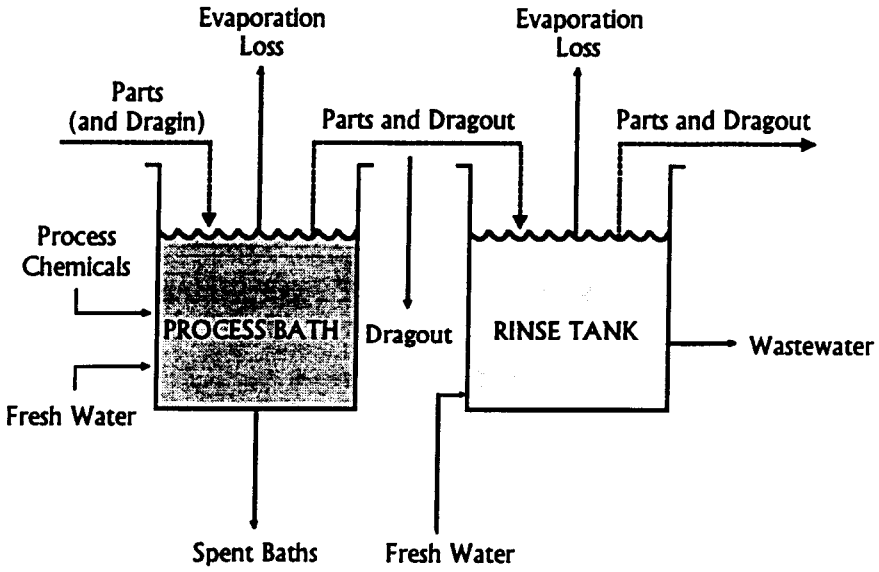
Definitions of Waste

- Inefficient use of equipment, space, labor, time, or energy
- Unusable residual materials generated from processes
- Mismanagement of resources

Facility-Wide Material Flows



Material Flows for Metal Finishing



Dragout Impacts

- Increased plating chemical use
- Increased rinse water use or decreased rinse quality
- Increased dragin into next bath
- Decreased product quality

Dragout Impacts

- Increased wastewater generation
- Increased WWTS treatment chemicals use
- Increased WWTS filter cake generation
- Increased metal concentration in the WWTS discharge

Monthly Cost Savings - Dragout Reduction

	Cost	Savings (Due to 20% Reduction)
Dragout at 0.1 gallon per hour		
Chrome	$100	$20
Nickel	$200	$40
Cadmium	$65	$13
Water use at 10 gpm		
Fresh water:	$130-$500	$26-$100
Sewer fee:	$70-$800	$14-$160
WWTS chemicals:	$400	$80
WWTS sludge:	$100	$20
		Total = $140-$360

Monthly Cost Savings - Water Use Reduction

Before: 400,000 gal/mo After: 300,000 gal/mo

	Monthly Cost		Monthly
	Before	After	Savings
Water purchase	$600	$450	$150
Sewer fee	$300	$230	$70
WWTS O&M	$4,800	$3,600	$1,200
Sludge disposal	$1,900	$1,700	$200

Total Savings = $1,620/mo

Rework and Rejects

- **Processing a rejected part generates three *times* the waste of a successfully plated part**
  - **Raw materials and waste for initial plating**
  - **Initial plating stripped and discarded**
  - **Raw materials and waste to replate**

P2 is Source Reduction

- Alternative raw materials
- Process changes
- Equipment installation
- Operating Practices
  - ➢Most Impact!
  - ➢ Requires new perspectives and habits

What Are Your Job Priorities?

- Speed - get parts out
- Quality - low rejects and rework
- Costs - save money
- Finish - get to end of day

Production and Quality Considerations

- Production rate (i.e., throughput)
- Chemical balance and process bath purity
- Drying and oxidation concerns
- Rinse quality and effectiveness
- Other Considerations

Process Efficiency Considerations

- Throughput.
- Rejects and rework
- Bath maintenance and dragin control
- Dragout loss

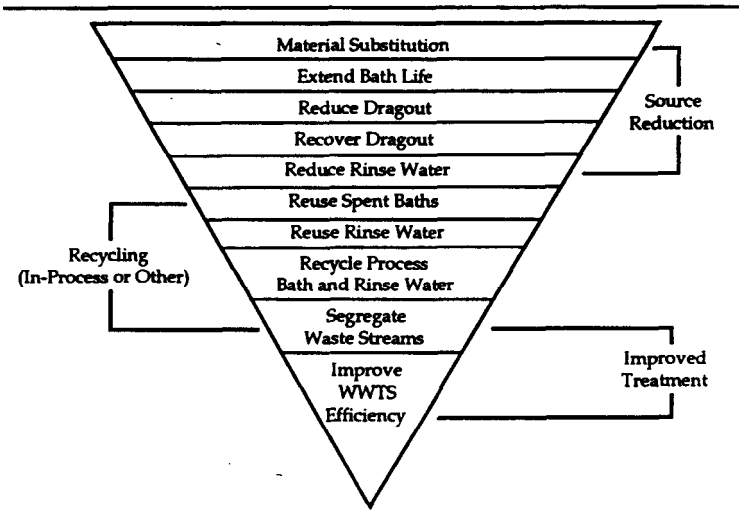
Rinse water quantity and quality

Emphasis only on throughput can negatively impact other parameters!!

P2 Principles for Metal Finishing

+ **Extract the most life (use) out of process chemistries**
+ **Keep process chemistry solutions where they belong: in the tanks**
+ **Return as much escaping solution (dragout) as possible to the tanks**
+ **Use the least amount of rinse water required for good rinsing**

Hierarchy of P2 Strategies for Metal Finishing



Unit 3

Techniques for Improved Process Operations

Video Exercise

VIDEO REVIEW OBSERVATIONS

Find the good and bad operator practices!!

Segment No.	Good Practices	Bad Practices
1		
2a and 2b		
3a and 3b		
4a and 4b		
5		
6a and 6b		
7		
8a and 8b		
9a and 9b		

Dragout Reduction: Bath Conditions

+ Operating concentration

+ Temperature

+ Wetting agents (viscosity effects)

Dragout Reduction: Rack and Barrel

+ Rack design

+ Rack maintenance

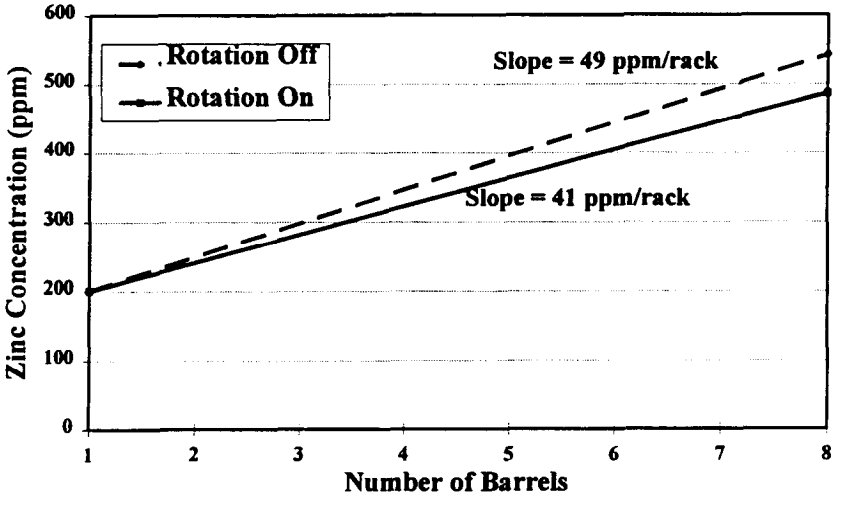
+ Part geometry

+ Part overlap and angle

+ Barrel rotation

+ Barrel hole peening

Using Conductivity to Measure Impact of Barrel Rotation



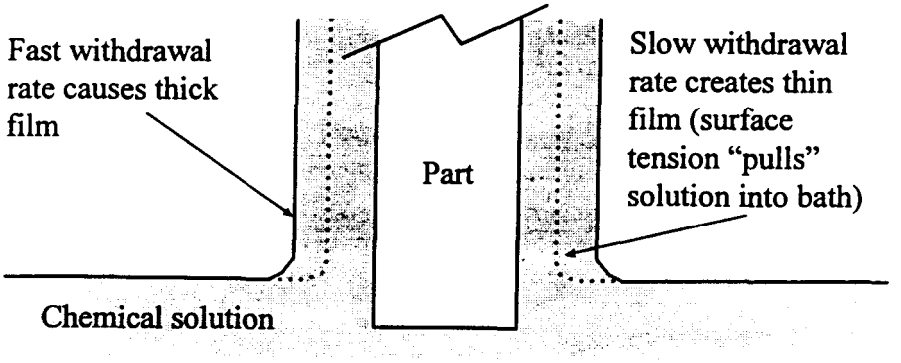
Dragout Reduction: Worker Practices/Operations

+ Withdrawal rate

+ Drainage time (↑ by 5 seconds will ↓ dragout by 30%)

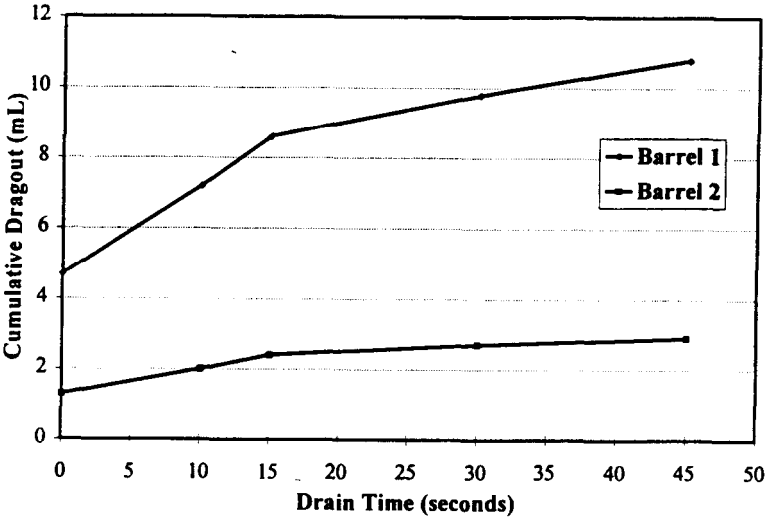
+ Production cycle times must be considered

Impacts of Withdrawal Rate on Dragout



*Other conditions that impact thickness of solution are temperature and bath concentration.

Dragout Volume vs. Drain Time



Dragout Reduction: Process Layout

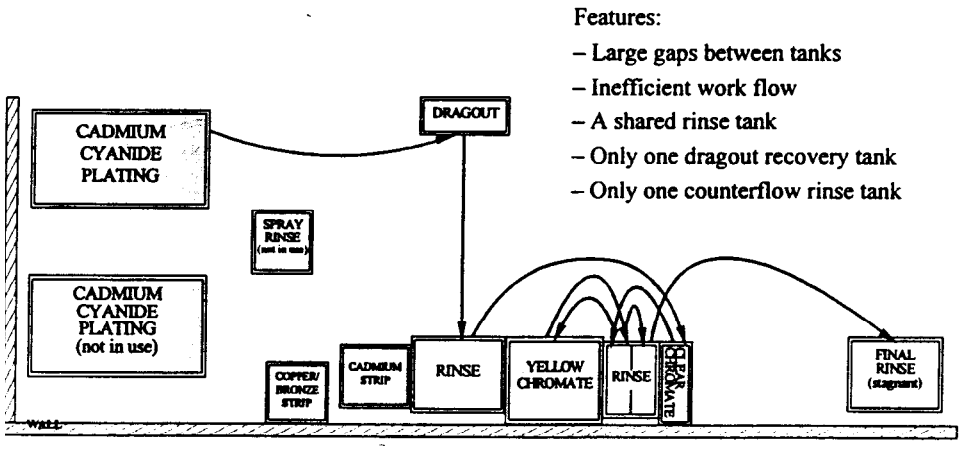
+ Tank spacing and drain boards

+ Tank sequence

+ Dragout tanks (with or without sprays)

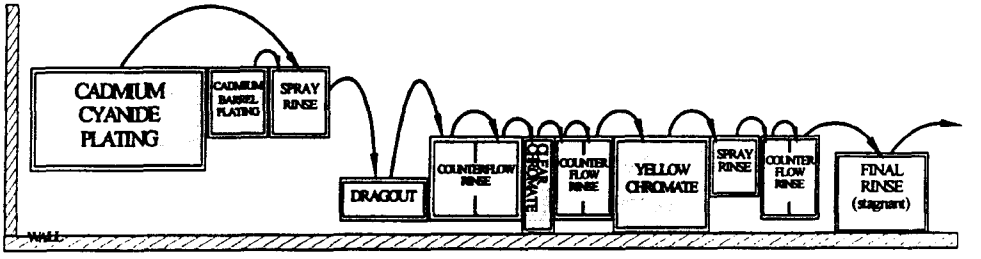
+ Spray rinses

Tank Layout - Before



Tank Layout - After

Features:
(1) spray rinses
(2) dragout tanks,
(3) counter-current rinses
(4) straight process flow



Impacts of Poor Rinse Quality

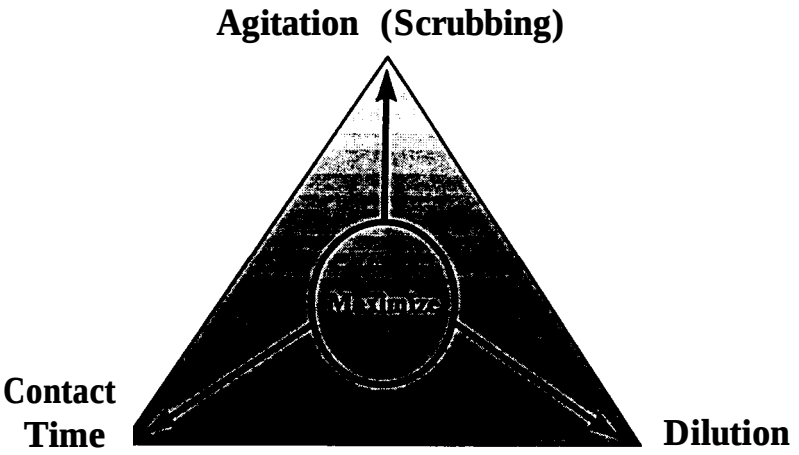
+ Increase dragin of contaminants into next bath

+ Create impurities on parts surface

+ Reduce visual appearance

+ Increase reject/rework

Maximizing Rinse Efficiency



Rinsing Concepts

+ **Turbulent. flow around part (scrubbing)**

+ **Adequate contact time between the part and the rinse water**

+ **Adequate dilution so that dragout from rinse tank does not affect subsequent operation**

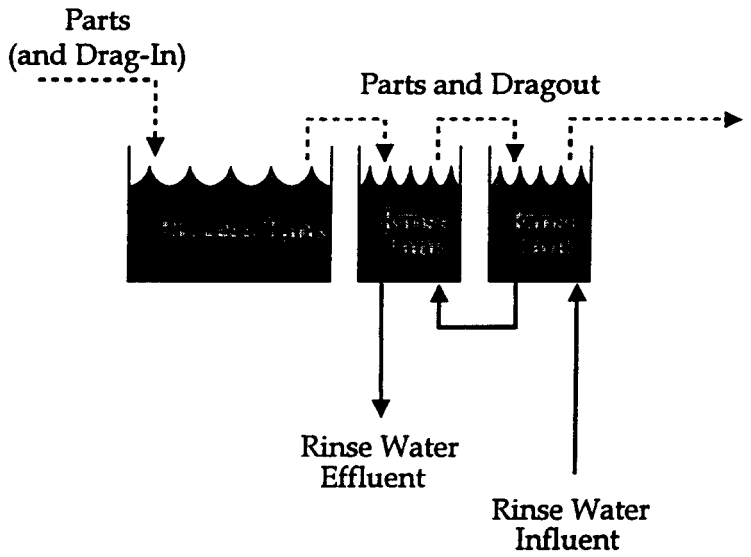
Techniques that Improve Rinse Efficiency

+ **Agitation**
  - **Rack motion**
  - *** Forced air and/or forced water**
  - *** Sprays**
  - **Double dipping**
  - **Addition of vigorous agitation can allow 1 gpm flow reduction in many applications**
+ **Flow Controls and Water Quality**
  - **Flow restricters**
  - *** Conductivity control systems**
  - **Use warm or hot water, if possible**
  - **Tap water vs. deionized water**

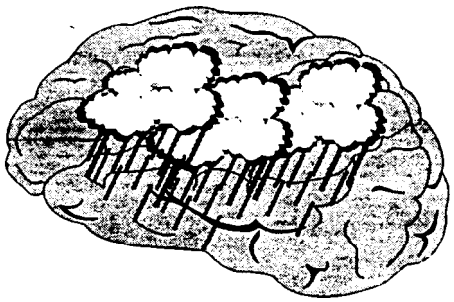
Techniques That Improve Rinse Efficiency (continued)

+ **Tank Design-**
  - *** Size (not bigger than necessary)**
  - *** Locate inlets and outlets to maximize mixing and eliminate short-circuiting**
+ **Tank Layout**
  - *** Multiple tanks better than single rinse tank**
  - *** Countercurrent rinses are extremely efficient (90% reduction compared to a single flowing rinse) but most shops do not accommodate the larger "footprint"**

2-Stage Counter Current Rinse System



Brainstorm



What techniques can you use to improve process efficiency?

Unit 4

Demonstrations of Various Process Operating Techniques

Operator Demonstrations

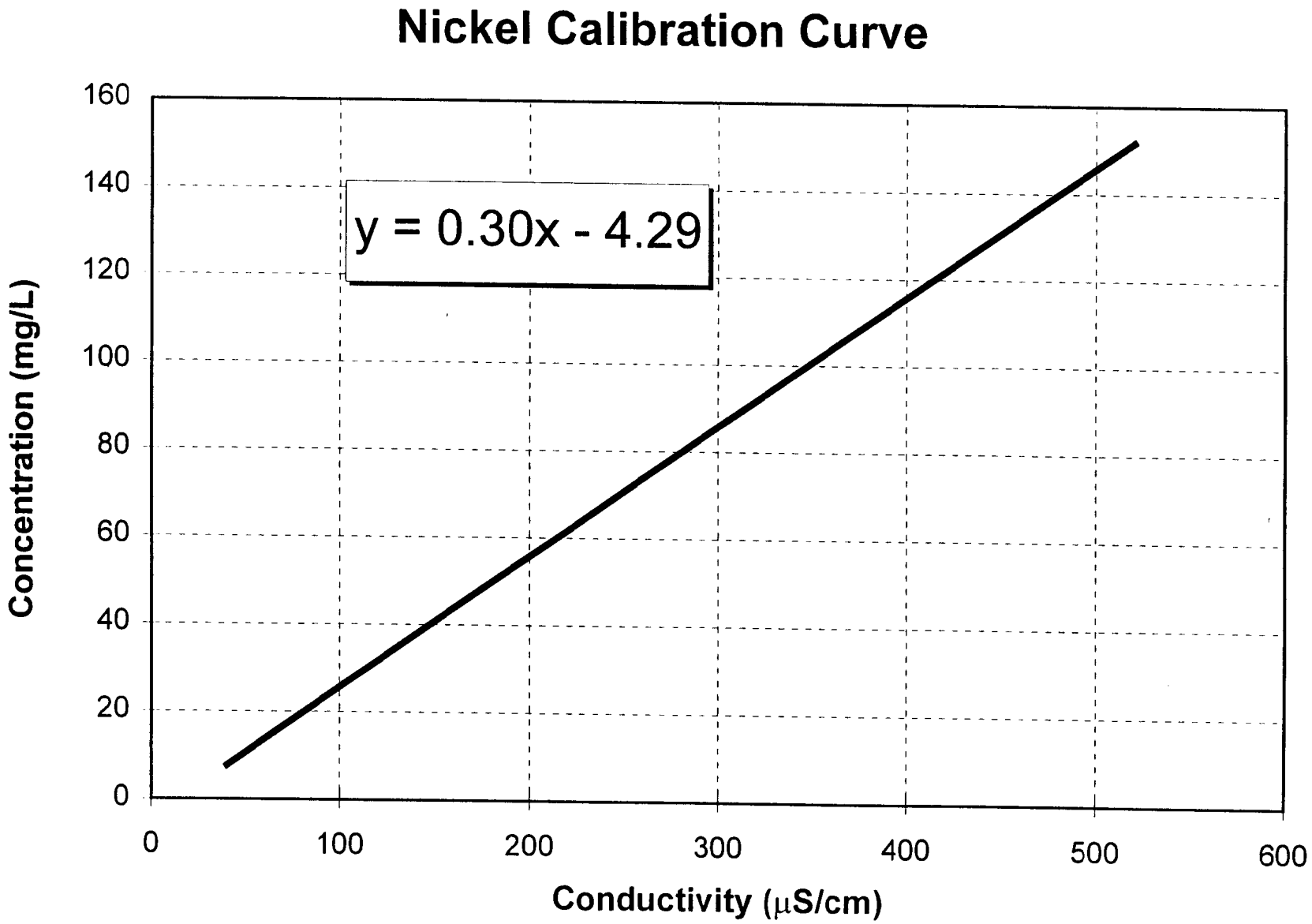
+ **Impacts of parts racking**
+ **Impacts of drainage time**
+ **Impacts of spray rinses**
+ **Impacts of tilting and draining**
+ **Overall impacts of dragout on rinse quality**

Demonstration Team: Roles

+ **Rack Operator - process racks through nickel bath and rinse tanks**
+ **Dragout "Sheriff' - measure conductivity in first and second rinse**
+ **Quality Control Chief - record and plot data**
+ **Rack Cleaner - clean racks for reuse**

Operator Practices Demonstration Plan

Exercise No.	Operating Practice	"Runs"	Process Monitoring	No. of Racks	Student Roles
1	Parts Racking	**Run 1a:** 5 racks with parts racked horizontally (no hang time) **Run 1b:** 5 racks with parts racked vertically (no hang time)	Conductivity measured in the first and second static rinse; the conductivity results in the first rinse used to plot drag out; the conductivity in the second rinse used to plot data on final rinse quality and drag in to next bath.	5 racks with parts racked horizontally; 5 racks with parts racked vertically Each set of racks must have identical parts	There will be five active roles for each exercise: • Processing racks • Timing withdrawal rates • Collecting finished racks • Operating meter and taking measurements • Recording measurements in log and on poster board
2	Drain Time	**Run 2a:** 5 racks without hang time - no drain time **Run 2b:** 5 racks with 5-second hang time (5 seconds removal and 5 seconds drainage)	Conductivity measured in the first and second static rinse; the conductivity results in the first rinse used to plot drag out; the conductivity in the second rinse used to plot data on final rinse quality and drag in to next bath.	10 racks with parts racked vertically	There will be five active roles for each exercise: • Processing racks • Timing withdrawal rates • Collecting finished racks • Operating meter and taking measurements • Recording measurements in log and on poster board
3	Spray Systems	**Run 3a:** 5 racks with no spraying **Run 3b:** 5 racks with spraying above plating tank	Conductivity measured in the first and second static rinse; the conductivity results in the first rinse used to plot drag out; the conductivity in the second rinse used to plot data on final rinse quality and drag in to next bath.	10 racks with parts racked vertically	There will be five active roles for each exercise: • Processing racks • Timing withdrawal rates • Collecting finished racks • Operating meter and taking measurements • Recording measurements in log and on poster board
4	Tilting and Draining	**Run 4a:** 5 racks without tilting and draining **Run 4b:** 5 racks with tilting and draining	Conductivity measured in the first and second static rinse; the conductivity results in the first rinse used to plot drag out; the conductivity in the second rinse used to plot data on final rinse quality and drag in to next bath.	10 racks with parts racked horizontally - need parts with angular shape and areas where solution is "cupped"	There will be five active roles for each exercise: • Processing racks • Timing withdrawal rates • Collecting finished racks • Operating meter and taking measurements • Recording measurements in log and on poster board


Nickel Calibration Curve
y = 0.30x - 4.29
Concentration (mg/L)
160
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
Conductivity (µS/cm)

Exercise No. 1

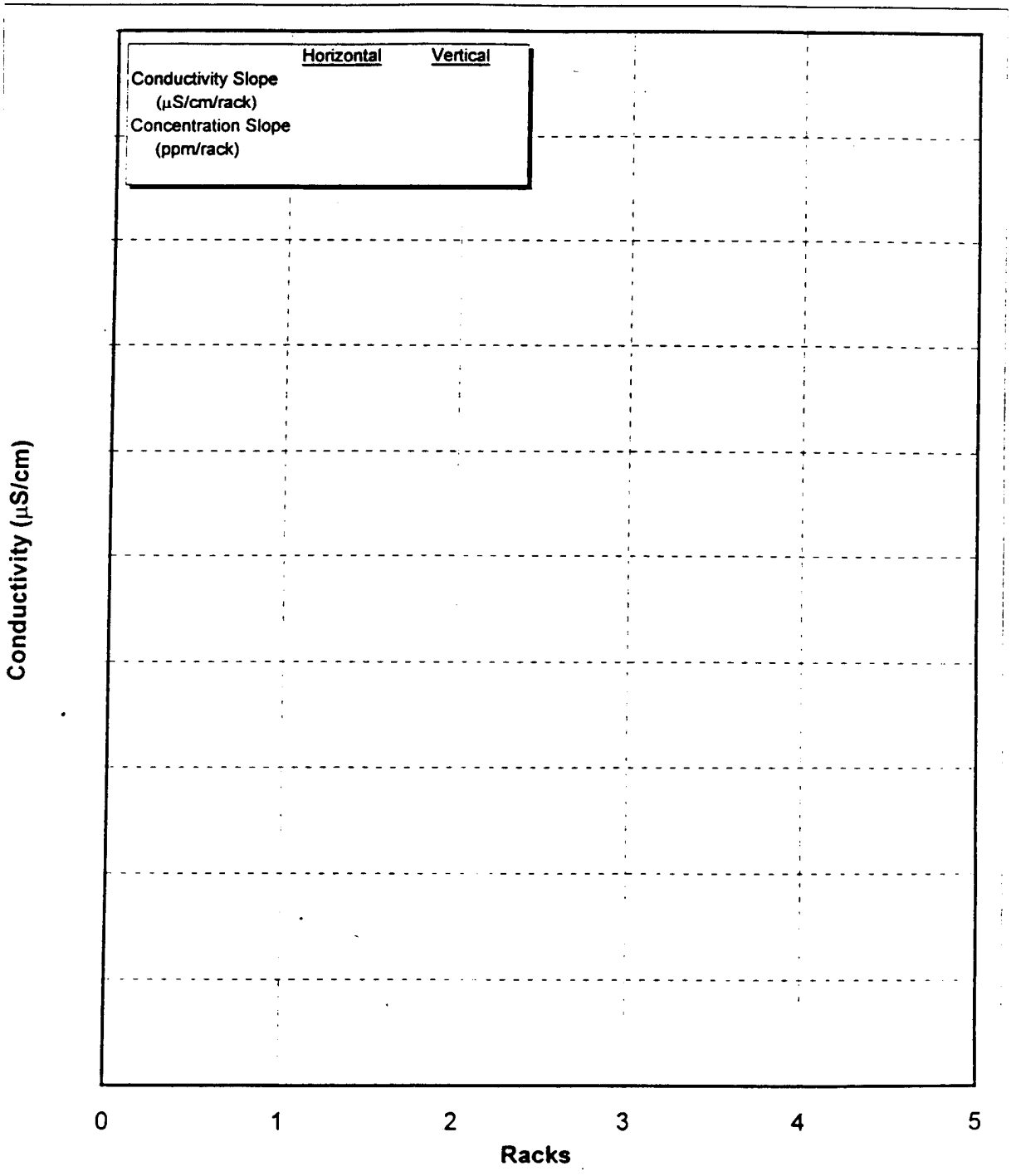
Parts Racking

PARTS RACKING

Conductivity Measurements Log (μS/cm)

	Parts Racked Horizontally		Parts Racked Vertically	
	Measurement	**Increase from Start**	**Measurement**	**Increase from Start**
First Rinse Tank				
Start		-------		-------
Rack 1				
Rack 2				
Rack 3				
Rack 4				
Rack 5				
Second Rinse Tank				
Start		-------		-------
Finish				

PARTS RACKING



Exercise No. 2

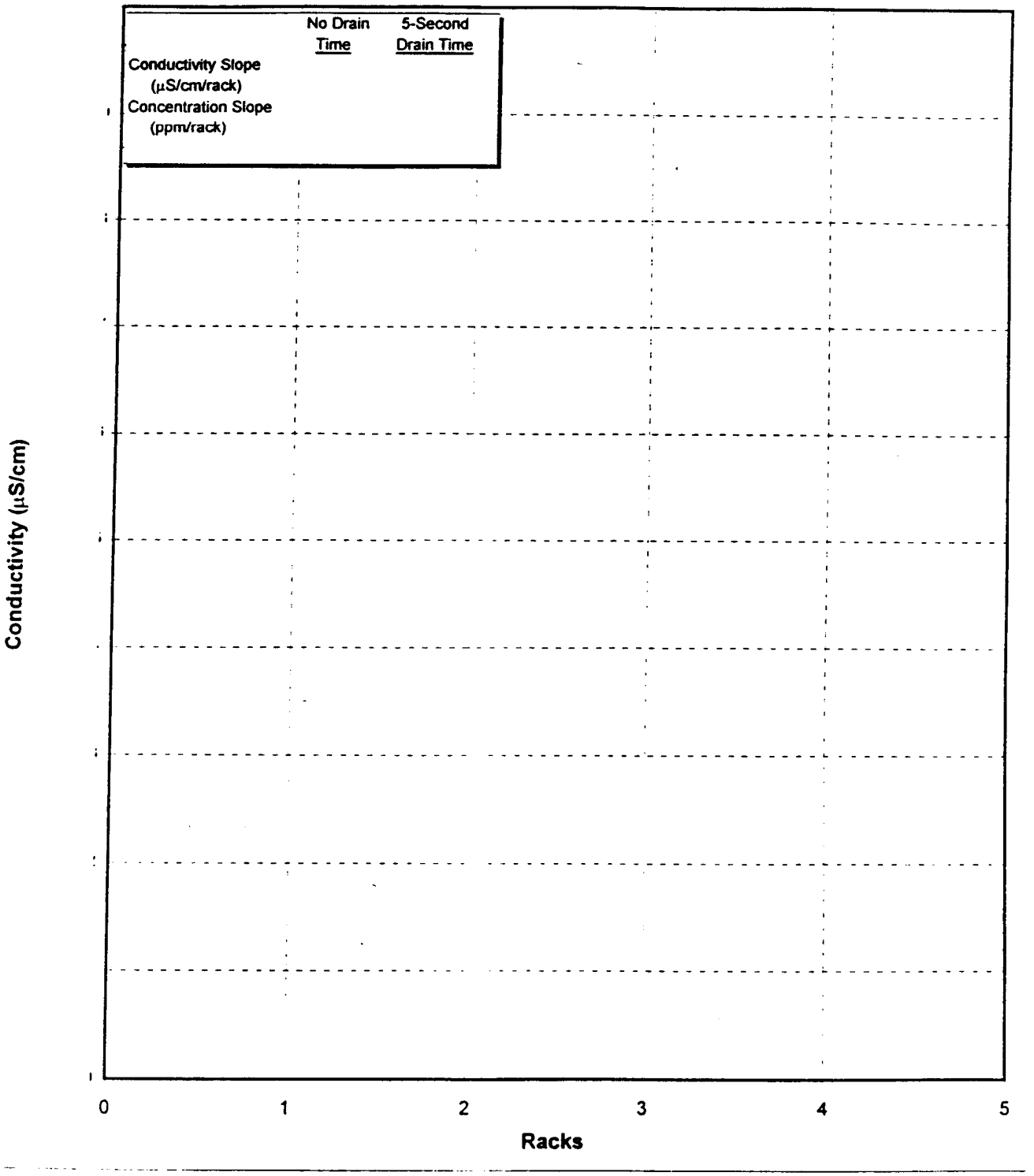
Drain Time

DRAIN TIME

Conductivity Measurements Log (µS/cm)

	No Drain Time		5-Second Drain Time	
	Measurement	**Increase from Start**	**Measurement**	**Increase from Start**
First Rinse Tank				
Start		-------		-------
Rack 1				
Rack 2				
Rack 3				
Rack 4				
Rack 5				
Second Rinse Tank				
Start		-------		-------
Finish				

DRAIN TIME


No Drain Time
5-Second Drain Time
Conductivity Slope (µS/cm/rack)
Concentration Slope (ppm/rack)
Conductivity (µS/cm)
0
1
2
3
4
5
Racks

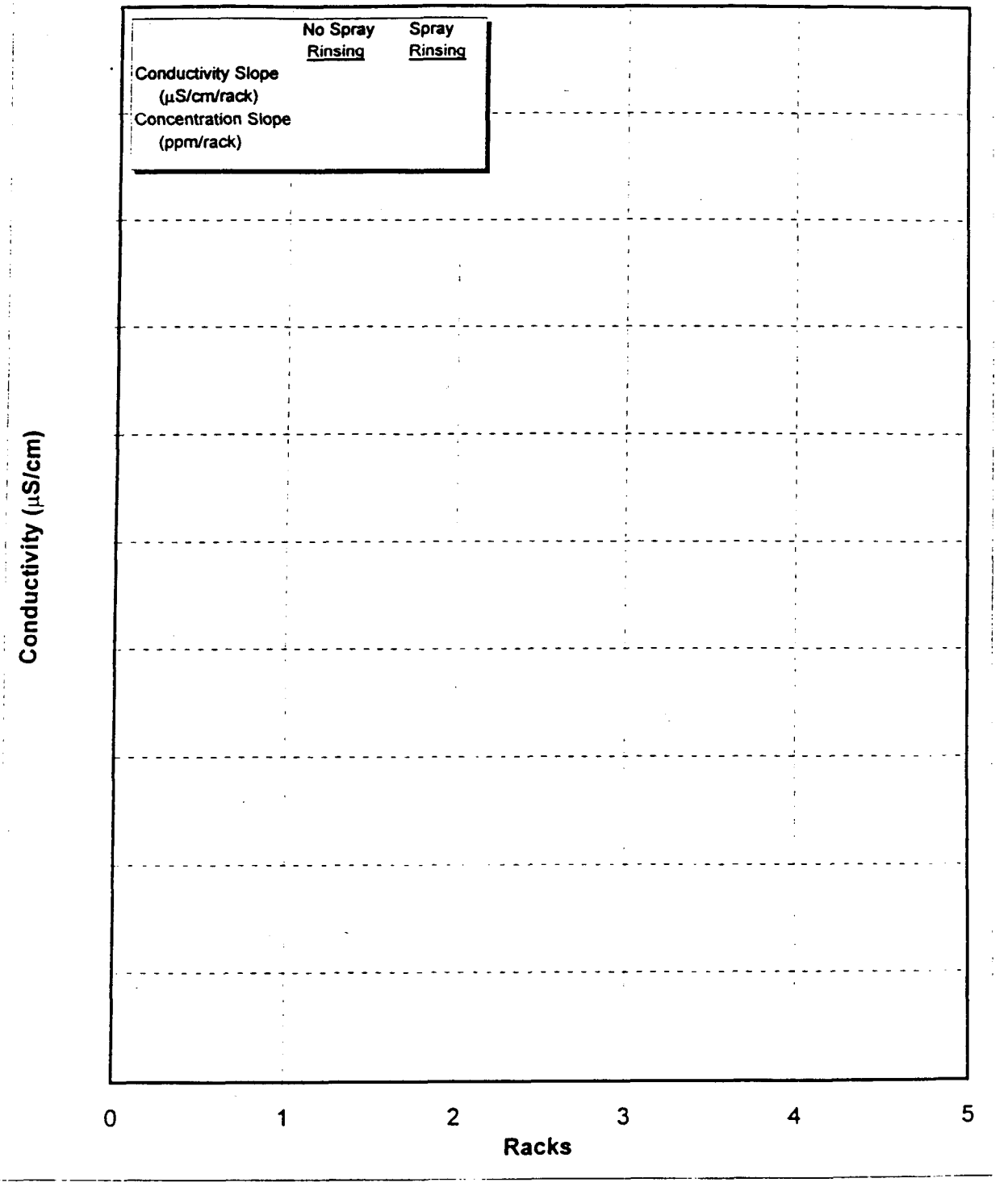
Exercise No. 3

Spray Rinsing

Spray Rinsing
Conductivity Measurements Log (µS/cm)

	No Spray Rinsing		Spray Rinsing	
	Measurement	**Increase from Start**	**Measurement**	**Increase from Start**
First Rinse Tank				
Start		-------		-------
Rack 1				
Rack 2				
Rack 3				
Rack 4				
Rack 5				
Second Rinse Tank				
Start		-------		-------
Finish				

SPRAY RINSING



Exercise No. 4

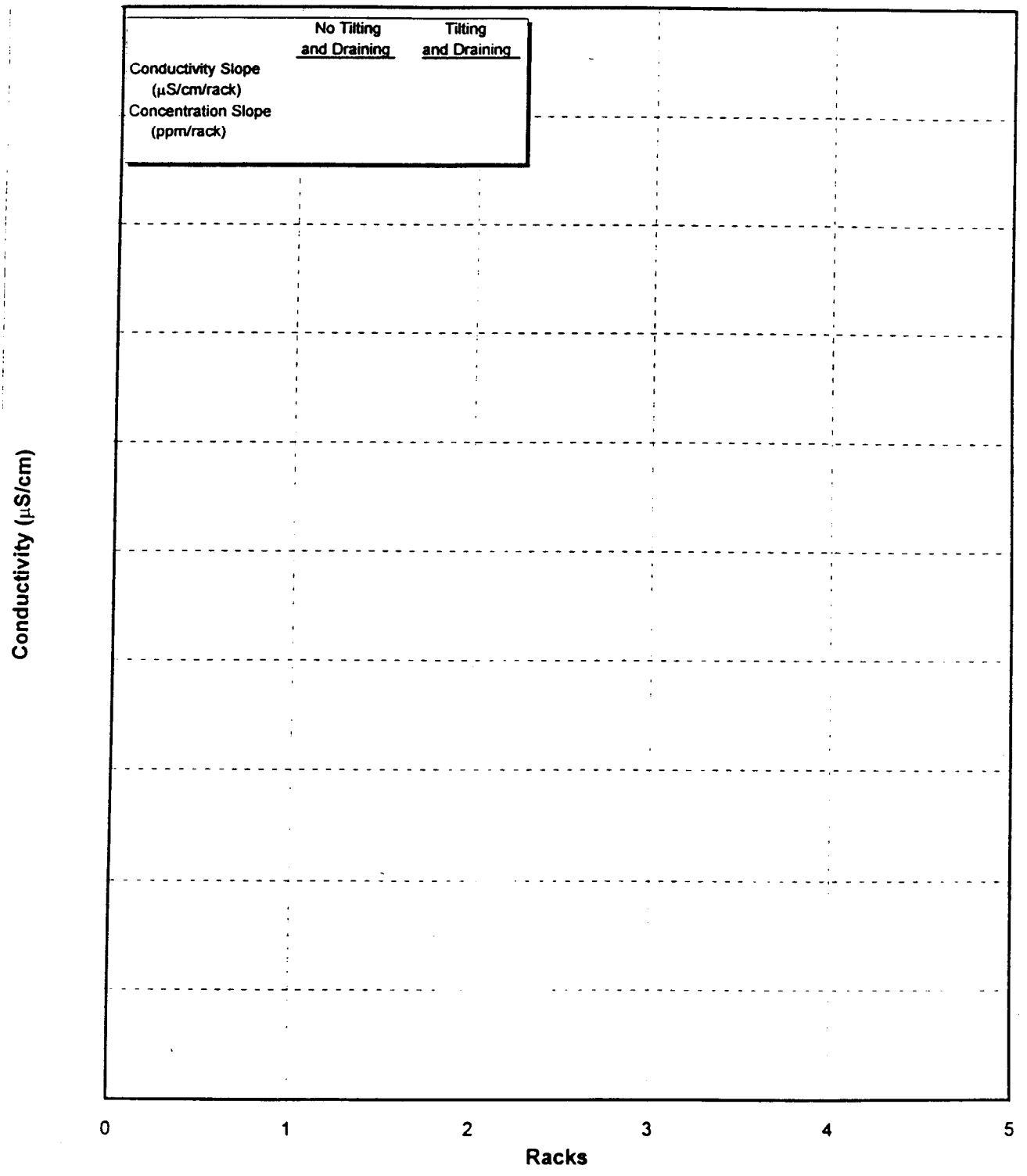
Tilting and Draining

TILTING AND DRAINING

Conductivity Measurements Log (µS/cm)

	No Tilting and Draining		Tilting and Draining	
	Measurement	**Increase from Start**	**Measurement**	**Increase from Start**
First Rinse Tank				
Start		-------		-------
Rack 1				
Rack 2				
Rack 3				
Rack 4				
Rack 5				
Second Rinse Tank				
Start		-------		-------
Finish				

TILTING AND DRAINING



Unit 5

Impacts of Various Handling Techniques

Impacts of Various Handling Techniques

+ Process chemical dragout
+ Rinse quality
+ Rinse water use
+ Wastewater generation
+ Wastewater treatment

WORKSHEET EQUATIONS AND ASSUMPTIONS

Dragout Equation: $\Delta V_d = (\Delta C)(V_r)/C_p$

ΔV_d = Dragout volume (L/rack)
ΔC = Increase in rinse water metal concentration (mg/L/rack)
V_r = Rinse tank water volume (L)
C_p = Concentration of metal in process tank (mg/L)

Facility Production Rate: 20 racks/hour
Facility Production Hours: 8 hours/day, 22 days/month

Rinse Water Use Reduction: Calculated based on dragout reduction percentage

Nickel Process Solution Unit Cost: $10/gal.

Water Purchase Unit Cost: $1.48/1,000 gal.
Sewer Fee Unit Cost: $0.97/1,000 gal.
Total Unit Cost of Water: $2.45/l,000 gal.

WWTS O&M Unit Cost: $12/1,000 gal.
(including labor and treatment chemicals)

WORKSHEET SUMMARY

1. PARTS RACKING

	Parts Racking Position		Difference
	Horizontal	Vertical	
Dragout Volume			
for 5 racks (gal/rack)			
per month (gal/month)			
Rinse Quality (mg/L)			
Rinse Water Use (gal/month)			
Chemical Costs ($/month)			
Water Costs ($/month)			
WWTS Costs ($/month)			
		Total Cost Savings =	

2. DRAINTIME

	Drain Time		Difference
	None	5-Second	
Dragout Volume			
for 5 racks (gal/rack)			
per month (gal/month)			
Rinse Quality (mg/L)			
Rinse Water Use (gal/month)			
Chemical Costs ($/month)			
Water Costs ($/month)			
WWTS Costs ($/month)			
		Total Cost Savings =	

WORKSHEET SUMMARY

3. SPRAY RINSING

	No Spray Rinsing	Spray Rinsing	Difference
Dragout Volume			
for 5 racks (gal/rack)			
per month (gal/month)			
Rinse Quality (mg/L)			
Rinse Water Use (gal/month)			
Chemical Costs ($/month)			
Water Costs ($/month)			
WWTS Costs ($/month)			
		Total Cost Savings =	

4. TILT AND DRAIN

	No Tilt and Drain	Tilt and Drain	Difference
Dragout Volume			
for 5 racks (gal/rack)			
per month (gal/month)			
Rinse Quality (mg/L)			
Rinse Water Use (gal/month)			
Chemical Costs ($/month)			
Water Costs ($/month)			
WWTS Costs ($/month)			
		Total Cost Savings =	

Unit 6

Workshop Wrap Up

Improving Process Efficiency

+ **Process Efficiency includes:**
  - *** Production rate**
  - ***Getting the most out of materials**
  - *** Controlling processes and minimizing rework/rejects**
  - ***Minimizing the waste generated**
  - ***Producing parts at the lowest cost**

Improvements Require Your Involvement!

+ **Operators control or impact process quality**
  * **Rejects/rework**
  * **Bath conditions**
  * **Rinse quality**
+ **Operators control or impact process efficiency**
  * **Dragout loss**
  * **Rinse water use**
  * **Wastewater generation**
  * **Treatment costs**
+ **Material reuse and recycling technologies successful when processes are in control**

Operator Challenge!

+ **Consider overall process impacts of your actions**
+ **Share your knowledge of process and areas for improvement with managers**
+ **Promote your role and importance to other operators and management**