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U.S. EPA Region 5 Waste Minimization/P2 Conference 1997

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Sponsored by

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 5

Valdas V. Adamkus, Regional Administrator
Norman R. Niedergang, Director, Waste, Pesticides and Toxics Division

Presenters Include:

3M Company	Enviro Filtration, Inc.	RUST Environmental & Infrastructure
A.T. Kearney, Inc.	Environmental Resources Management	Sinclair Mineral and Chemical - Better Engineering Manufacturing Rep.
Abbott Laboratories	Fluor Daniel Fernald	Tennessee Valley Authority
Amerdec, Inc.	General Electric	U.S. EPA Region 5
Amoco Corporation	General Services Administration	U.S. EPA Headquarters
Bowling Green State University	Harza Environmental Services, Inc.	U.S. EPA, Waste Minimization Branch
Cartwright Consulting Co.	Illinois EPA	University of Louisville
Chicago Mayor's Office	Industrial Towel and Uniform	University of Wisconsin
Chrysler Corporation	Iowa Waste Reduction Center, University of Northern Iowa	University of Wisconsin Extension School
City of Cincinnati Office of Environmental Management	Modern Technologies Corporation	Viatec Recovery Systems, Inc.
ComAd Management Group, Inc.	Motorola, Inc.	Waste Management and Research Center
Commonwealth Edison	PRC Environmental	Wisconsin Department of Natural Resources
Eastman Kodak Co.	PROCOR Technologies	WRATT Foundation

Exhibitors Include:

AlliedSignal Aerospace	Full Circle, Inc.	RUST Environment & Infrastructure
Better Engineering Mfg., Inc.	Graymills Corporation	U.S. EPA
Chemco Manufacturing Co., Inc.	Indiana Department of Environmental Management	Versar, Inc.
Chemical Management Services, LLC	Industrial Towel & Uniform, Inc	Viatec, Inc.
EnviroPure Solutions	Kinetico, Inc.	State of Wisconsin's Environmental Assistance Programs
EPI Electrochemical Products, Inc.	Modern Technologies Corporation	
ERM - North Central, Inc.	National Environmental Testing, Inc.	

Coordinated by:

Janet L. Haff, Waste Minimization Coordinator
of the
U.S. EPA Region 5, Waste Management Branch

U.S. EPA Region 5 Waste Minimization/P2 Conference
for
Hazardous Waste Generators

PROCEEDINGS MANUAL

February 25-27, 1997

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Section

Regretfully, this manual is not available on disk. Due to cost prohibitive production of such a manual and the difficulty in coordinating formatting issues with the volunteer speakers, we apologize that the manual can not be obtained electronically.

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
LIST OF SPEAKERS

Attn	FirstName	LastName	Title	Company	Phone	PaperTitle	Address
Mr.	Bill	Abolt		Chicago Mayor's Office	(312) 744-1614	Solid Waste Recycling in Chicago	City of Chicago Department of the Environment 30 N. LaSalle Street 25th Floor Chicago, IL 60602-2575
Mr.	Tom	Adkisson	Project Manager	PRC Environmental	(312) 856-8700 OR (415) 222-8320	Establishing Effective Pollution Prevention Programs for Industrial Manufacturing Operations	200 East Randolph Drive, Suite 4700 Chicago, IL 60601
Mr.	Thomas	Allegretti	Vice President	Amerdec, Inc.	(847) 537-3334	Pollution Prevention by the Amerdec System	65 E. Palatine Road, #209 Prospect Heights, IL 60070
Mr.	Phillip	Annis	Waste Reduction & Management Specialist	University of Wisconsin Extension School	(414) 227-3371	Practical Methods for Reducing Waste in Machine and Metal Fabrication Shops	161 West Wisconsin Avenue, Suite 6000 Milwaukee, WI 53203
Mr.	Todd	Balzer	Business Development Manager	Modern Technologies Corporation	(937) 252-9199	Utilizing Environmental Management Information Systems to Facilitate and Monitor Waste Minimization & Pollution Prevention	4032 Linden Avenue Dayton, OH 45432
Mr.	James	Brossman	Regulatory Services Coordinator for Solid Waste Management	Amoco Corporation	(312) 856-5111	Plenary Speaker	200 E. Randolph Floor P-0630H Chicago, IL 60601

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
LIST OF SPEAKERS

Attn	FirstName	LastName	Title	Company	Phone	PaperTitle	Address
Mr.	Peter	Cartwright	President	Cartwright Consulting Co.	(612) 854-4911	Membrane Separation Technologies for Environmental Compliance	8324 16th Avenue South Minneapolis, MN 55425
Ms.	Jennifer	Cawein	Environmental Engineer	Commonwealth Edison	(312) 394-3968	ComEd's Pollution Prevention Strategy: Life Cycle Management	10 S. Dearborn, 35FNW Chicago, IL 60603
Mr.	Charles	Czarnecki	President	PROCOR Technologies	(810) 816-1048	Successful Pollution Prevention Projects	2300 West Big Beaver Road Troy, MI 48084
Ms.	Phebe	Davol	Project Director	A.T. Kearney, Inc.	(817) 793-3419	Texas Clean Industries 2000 Program - 1996 Update	5675 West FM 487 Florence, TX 76527
Mr.	Marvin	Fleischman	Professor of Chemical Engineering	University of Louisville	(502) 852-6357	Pollution Prevention & Energy Assessments at a Smokeless Tobacco Products Manufacturer and an Industrial Laundry	Industrial Assessment Center Louisville, KY 40292
Mr.	Glenn	Gabriel	Corporate Pollution Prevention Coordinator	Abbott Laboratories	(847) 935-2845	Lessons Learned from Abbott's Pollution Prevention Program	200 Abbott Park Road (Dept. 539, AP52-S) Abbott Park, IL 60064-3537
Mr.	Dave	Heinlen	Safety & Health Coordinator	Bowling Green State University	(419) 372-2171 (419) 372-2194	Bowling Green State University's Chemical Recycling Program: A Community Effort	102 College Park Office Building Bowling Green, OH 43403-0381

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Attn	FirstName	LastName	Title	Company	Phone	PaperTitle	Address
Mr.	Stephen J.	Hillenbrand	Waste Reduction Engineer	Tennessee Valley Authority	(423) 632-8489 (423) 632-3616	Overview of fourteen Applied Technologies	400 West Summit Hill Drive, WT 11A Knoxville, TN 37902
Mr.	James B.	Hogenson	Environmental Services Manager	Eastman Kodak Co.	(630) 218-5988	Photo Industry Creates A Win/Win Proposition With A Code of Management Practice	1901 W. 22nd Street Oak Brook, IL 60521
Mr.	Evan	Jones	Technical Manager	Viatec Recovery Systems, Inc.	(509) 375-0370	Recovering Spent Acids Using the WADR™ Technology	3200 George Washington Way, Suite A-12 Richland, WA 99352
Mr.	James	Kiriazes	Industrial Program Manager	Commonwealth Edison	(630) 684-3711	Beyond Energy Conservation - ComEd's Efforts to Assist It's Customers with Waste Reduction and Pollution Prevention	1919 Swift Drive Oak Brook, IL 60521
Mr.	Peter	Ko	Environmental Engineer	PRC Environmental	(312) 946-6455	Using Innovative Conductivity Control Systems to Reduce Rinse Water Use in Metal Finishing Operations	200 East Randolph Drive, Suite 4700 Chicago, IL 60601
Mr.	George	Makrauer	President	ComAd Management Group, Inc.	(813) 363-7373 (813) 367-0222	Plastic Packaging and Pollution Prevention Working Together	119 - 108th Avenue Suite 185 Treasure Island, FL 33706
Mr.	Joe	Mattson	Product Manager	Industrial Towel and Uniform	(414) 729-6100 (414) 729-6707	Networking To Minimize Waste and Prevent Pollution	945 Apple Blossom Neenah, WI 54956

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
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Attn	FirstName	LastName	Title	Company	Phone	PaperTitle	Address
Mr.	Charles	McEntyre	Waste Reduction Engineer	Tennessee Valley Authority	(423) 751-7310 (423) 751-8404	Waste Reduction - Metal Fabrication Fluids and Wastewaters	1101 Market Street, WR 4P Chattanooga, TN 37402
Mr.	Doug	Meyers		WRATT Foundation	(205) 386-3633 (205) 386- 2674	Three Steps in Conducting a Waste Minimization/Pollution Prevention Audit	P.O. Box 1010 Muscle Shoals, AL 35662-1010
Mr.	William	Nelson	Alternative Process Chemist	Waste Management and Research Center	(217) 244-5521	Solvent Substitution Testing Program	One E. Hazelwood Drive Champaign, IL 61820
Dr.	Shawn	Niaki	Head of Hazardous/ Industrial Wastes	Harza Environmental Services, Inc.	(312) 831-3819	Waste Minimization/Pollution Prevention Audits for 10 Major Industries	233 S. Wacker Drive Chicago, IL 60606
Ms.	Donna	Perla		U.S. EPA Headquarters		Plenary Speaker	401 M Street SW (5302W) Washington, DC 20460
Ms.	Lynn	Persson	Waste Minimization Coordinator	Wisconsin Department of Natural Resources	(608) 267-3763 (608) 267-0496	Wisconsin's Great Printers and Consolidated Reporting Project	Bureau of Solid and Hazardous Waste Management 101 S. Webster Street Madison, WI 53707-7921
Mr.	Joseph	Phillips	Waste Reduction Engineer	Tennessee Valley Authority	(205) 386-3035 (205) 386-3108	Documented Results of 35 Waste Reduction Assessments in Alabama	P.O. Box 1010, SB 1E Muscle Shoals, AL 35662
Mr.	Robert	Potter	Environmental Coordinator	Chrysler Corporation	(419)661-3398	Waste Minimization at The Toledo Machining Plant	8000 Chrysler Drive Perrysburg, OH 43551

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Attn	FirstName	LastName	Title	Company	Phone	PaperTitle	Address
Mr.	Mark	Ralston	Analyst	U.S. EPA, Waste Minimization Branch	(703) 308-8595	Developing Measures of Progress for the Waste Minimization National Plan	401 M Street SW (5302W) Washington, DC 20460
Mr.	Peter A.	Reinhardt	Asst. Director Safety Dept.	University of Wisconsin	(608) 262-9735 (608) 262-6767	What Is Different About Pollution Prevention in Laboratories	30 N. Murray Street 2nd Floor Madison, WI 53715
Mr.	Dan	Reinke	Office Manager	Environmental Resources Management	(612) 225-4554	Effluent Compliance Through Pollution Prevention in Assembly/Testing Operations	289 East 5th Street, Suite 201 St. Paul, MN 55101
Ms.	Alisa	Rhodes	Environmental Waste Specialist	Fluor Daniel Fernald	(513) 648-4968	A Discussion of Fernald's Waste Minimization/Pollution Prevention Program Accomplishments	P.O. Box 538704 Cincinnati, OH 45253-8704
Ms.	Mary	Setnicar	Section Chief, P2 & Special Initiatives	U.S. EPA Region 5	(312) 886-0976	Government Voluntary Programs Section	77 W. Jackson Blvd. Chicago, IL 60604
Ms.	Patricia	Sheller	Environmental Engineer	3M Cordova Plant	(309) 654-2291 x1344	3M's Pollution Prevention Pays (3P): Plant applications	3M Cordova Plant Route 84N Cordova, IL 61242
Dr.	Mark	Singleton	Manager, Chemical Mgmt & Pollution Prevention	General Electric	(513) 672-3989	Case Studies in Hazardous Waste Reduction at GE	1 Neumann Way (T165) Cincinnati, OH 45215
Mr.	Kendal	Smith	Chief Engineer	Enviro Filtration, Inc.	(219) 884-7963	The 96,000 Mile Oil Change Innovation: The Enviro High Efficiency Secondary Oil Filter	4719 Roosevelt Street Gary, IN 46408

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
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Attn	FirstName	LastName	Title	Company	Phone	PaperTitle	Address
Mr.	John	Stanberry	Environmental Executive	General Services Administration	(202) 208-7929	The Environment - The Frame Around Your Picture	18th and F Streets, NW - Room 4338 Washington, DC 20405
Mr.	Jim	Stouch	Vice President	Malcolm Pirnie	(614) 888-4953	Integrating Pollution Prevention and Manufacturing Improvements: Illustrating Cost Savings Opportunities Through Two Case Studies	445 Hutchinson Avenue Columbus, OH 43235
Mr.	George	Strapko	Better Engineering Representative	Sinclair Mineral & Chemical	(847) 480-9290	Case Studies Of Solvent Replacement	3030 Commercial Avenue Northbrook, IL 60062
Mr.	J. Bruce	Suits	Pollution Prevention Program Manager	City of Cincinnati Office of Environmental Management	(513) 352-6270	Creating an Urban Area Pollution Prevention Strategy	Office of Environmental Management Two Centennial Plaza 805 Central Avenue Suite 610 Cincinnati, OH 45202-1947
Ms.	Collette	Sun	Director, Env. Affairs & Safety	Motorola, Inc.	(954) 723-5605 OR (954) 723-4306	Promoting a Pollution Preventive Culture	8000 W. Sunrise Blvd. Ft. Lauderdale, FL 33322
Mr.	Greg	Terdich	Manager	A.T. Kearney, Inc.	(312) 223-6233	Leveraging Life Cycle Management For Business Gains	222 W. Adams Street Chicago, IL 60606
Ms.	Suzanne T.	Thomas	Senior Program Manager	Rust Environmental & Infrastructure	(864)234-3016	Information Management: Key to a P2 Action Plan	15 Brendan Way Greenville, SC 29616

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Attn	FirstName	LastName	Title	Company	Phone	PaperTitle	Address
Mr.	Robert	Tolpa	Regional Team Manager, Common Sense Initiatives	U.S. EPA Region 5	(312)	Region 5's Common Sense Initiative	77 W. Jackson Blvd. Chicago, IL 60604
Mr.	David	Ullrich		U.S. EPA Region 5	(312)	Plenary Speaker	77 W. Jackson Blvd. Chicago, IL 60604
Mr.	Peter	Wise	Associate Director	Illinois EPA	(217) 785-8786	International Diffusion of Pollution Prevention Technologies Through Technology Outreach, Assessments, Demonstrations, and Evaluations for Metal Finishing, Petrochemical, and Pharmaceutical Industries in China	2200 Churchill Road Springfield, IL 62702
Mr.	David	Wolfe	Manager	Rust Environmental & Infrastructure	(717) 796-0336	Zero Discharge in the Lead Battery Industry	2 Market Plaza Way Mechanicsburg, PA 17055
Mr.	Patrick	Wooliever	Environmental Engineer	PRC Environmental Management	(312) 856-8700	Reducing Dragout From Electroplating Operations With Spray Rinse Systems	200 E. Randolph Drive, Suite 4700 Chicago, IL 60601
Ms.	Catherine	Zeman	Program Manager	Iowa Waste Reduction Center, University of Northern Iowa	(319) 273-2079	Low VOC / Alternative Soy Ink Solvents	75 Biology Research Complex University of Northern Iowa Cedar Falls, IA 50614-0185

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LIST OF EXHIBITORS

Company	Address	Phone	Product/Services	Booth
AlliedSignal Aerospace	P.O. Box 419159 Kansas City, MO 64141-6159	816/997-2711	AlliedSignal has managed and operated the Department of Energy's Kansas City Plant, a three million square foot manufacturing facility, for over forty years. During that time we have incorporated GREEN manufacturing in our operation by using environmentally safe materials and manufacturing processes, minimizing waste generated during manufacturing, and conserving rew materials, natural resources and energy. In the course of converting our own manufacturing operations to environmentally conscious manufacturing, we continue to develop technologies and knowledge that is available to private industry.	15
Better Engineering Mfg., Inc.	8361 Town Center Court Baltimore, MD 21236	410/931-0000	Aqueous Parts Washers	1
Chemco Manufacturing Co., Inc.	3175 MacArthur Blvd. Northbrook, IL 60062	847/480-7700	Maintenance products for liquid and powder paint spray booths, including: filters for liquid paint overspray collection and powder cartridge.	4
Chemical Management Services, LLC	P.O. Box 884 Fox River Grove, IL 60021	847/382-7651	On-site membrane filtration service for treatment and regeneration of aqueous cleaners used in metal parts washing, floor washing and other plant & machinery cleaning operations	2
EnviroPure Solutions	The DuPage Technology Center 100 Bridge Street Wheaton, IL 60187	630/871-1001 x1119 Fax: 0303	The Dupage Technology Center is home for EnviroPure Solutions, Seprotech Systems Inc., Milieu-Nomics Inc. and Arctyme Inc. Together, the team supplies custom designed fluid treatment systems. We specialize in and build systems for waste water recycling, chemical production, influent water purification, and a variety of novel applications. We are extremely knowledgeable in metal recovery and recycle applications, BOD reduction and removal, and environmental discharge requirements. We are "Problem Solving Specialists" for industrial fluid treatment using ion exchange systems and regeneration services, RO, NF, UF an d MF membrane separation, dissolved air flotation, solvent recovery systems, and a variety of other pre-treatment and post-treatment technologies. We also represent ECO-TEC Inc. in the Midwest.	12

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Company	**Address**	**Phone**	**Product/Services**	**Booth**
EPI Electrochemical Products, Inc.	17000 W. Lincoln Ave. New Berlin, WI 53151	414/786-9330	E-Brite 30/30 Non-cyanide alkaline copper plating process	5
ERM - North Central, Inc.	540 Lake Cook Road, Suite 300 Deerfield, IL	847/940-7200	ERM is a global consulting firm with over 2,500 professional staff in 100 offices. Pollution Prevention services include opportunity assesments, planning, employee training, corporate program development, process engineering and implementation support. We service all industrial sectors and in the past year have worked with 80 of the Fortune 100 companies.	6
Full Circle, Inc.	509 Manida Street Bronx, NY 10474	718/328-4667	Nationwide recycling and disposal services for PCTS and Non-PCTS ballasts...	13
Graymills Corporation	3705 N. Lincoln Avenue Chicago, IL 60613-3594	773/ 477-4100	PH522 - Aqueous Free standing, soak & recirculating parts cleaner TL2 - Aqueous jet spray, top loading parts cleaner	10
Indiana Department of Environmental Management	100 N. Senate Avenue Indianapolis, IN 46202	317/233-5189	State of Indiana waste minimization and pollution prevention assistance	18
Industrial Towel & Uniform, Inc.	2700 S. 160th Street New Berlin, WI 53151	414/729-6100	Launderable/reusable oil absorbants Eliminate wastes through use of launderable/reusable textile products	11
Kinetico, Inc.	Engineered Systems Division 10845 Kinsman Road Newbury, OH 44065	216/564-5397	Manufactures deionization, ion exchange, electrowinning, and membrane systems for process and wastewater treatment.	7

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Company	Address	Phone	Product/Services	Booth
Modern Technologies Corporation	4032 Linden Avenue Dayton, OH 45432	937/252-9199 x134	Modern Technologies Corporation (MTC/s) Environmental Technologies Division is a leader in Environmental Health & Safety software and related services. Our Enviro-Office™ suite of software products is designed to allow each customer to choose the particular software that is best suited to their individual environments. MTC is also a proven leader in MSDS management, hazardous materials/waste management, ISO 14000 consulting, and chemical management outsourcing..	16
National Environmental Testing, Inc.	850 W. Bartlett Road Bartlett, IL 60103	630/289-3100	Laboratory testing for environmental compliance; Analytical services	14
RUST Environment & Infrastructure	3121 Butterfield Road Oak Brook, IL 60521	630/574-2384	Waste Min. Audkõs, Program Planning, Redesign...	8
U.S. EPA	Waste Minimization National Plan 401 M Street SW MC5302W Washington, DC 20460	703/308-8489	Branch of Federal Government providing technical assistance and other literature to promote the reduction of the most persistent bioaccumulative and toxic chemicals in the nation's hazardous waste	17
Versar, Inc.	200 W. 22nd Street, Suite 250 Lombard, IL 60148	630/268-8555	Environmental Consultants & Engineers	3
VIATEC, Inc.	202 S. Broadway Hastings, MI 49058	616/948-3860	VIATEC Recovery System: Waste Acid Detoxification & Reclamation (WADR™)	9
State of Wisconsin's Environmental Assistance Programs	Box 7921 (CO/8) Madison, WI 53707	608/267-3763	Three different agencies work cooperatively in Wisconsin to provide waste reduction and compliance assistance information and technical assistance to businesses and local government.	20

Phillip Annis

University of Wisconsin Extension School

USING THE CENTER'S SERVICES

To use SHWEC's services, contact your county extension office. The Community Resource Development (CRD) agent will identify what services the program will provide. The agent will also act as the long-term liaison for your waste reduction needs.

You may also contact SHWEC directly:

Madison
UW-Extension
610 Langdon Street, Rm 529
Madison, WI 53703
Phone 608/262-0385 --- Fax 608/262-6250

Milwaukee
University Center for Continuing Education
161 W. Wisconsin Avenue, Suite 6000
Milwaukee, WI 53203-2602
Phone 414/227-3175 --- Fax 414/227-3165

Stevens Point
College of Natural Resources
University of Wisconsin-Stevens Point
Stevens Point, WI 54481
Phone 715/346-2793 --- Fax 715/346-3624

Green Bay
University of Wisconsin-Green Bay
2420 Nicolet Drive, ES 317
Green Bay, WI 54311
Phone 414/465-2327 --- Fax 414/465-2143

E-Mail
shwec@epd.engr.wisc.edu

Solid and Hazardous Waste Education Center
610 Langdon Street, Room 529
Madison, WI 53703-1195

SHWEC

Waste Reduction Solutions

from the

Solid and Hazardous Waste Education Center

UNIVERSITY OF WISCONSIN-EXTENSION

❑ WHAT IS SHWEC?

[T]he UW-Extension Solid and Hazardous Waste [E]ducation Center (SHWEC) was created to [p]rovide waste reduction services to waste [g]enerators in Wisconsin. SHWEC specialists [w]ork in collaboration with county extension [a]gents to:

- Improve compliance with environmental regulations.
- Promote the benefits of source reduction, recycling and pollution prevention strategies.
- Encourage municipal integrated solid waste management and household hazardous waste planning and implementation.
- Support utilization of recycled materials and compost.
- Provide solid & hazardous waste educational support to state agencies, local governments, and other organizations.

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❑ WHO CAN BENEFIT?

[S]HWEC's services benefit the following groups [th]at generate solid and hazardous wastes, have [t]oxic wastewater or air emissions, or use [h]azardous or toxic materials:

- Industries and Businesses
- Institutions
- Governmental Units

❑ SERVICES

SHWEC is a reliable, non-regulatory technical provider of:

➤ On-site Assessments
➤ Training
➤ Assistance by Phone
➤ Publications

• • • • •

For **businesses and industries,** controlling production costs is vital in today's market. SHWEC technical assistance in ***pollution prevention*** and ***by-product utilization*** can eliminate or reduce:

➤ costs for lost raw material, waste disposal, and permit fees.
➤ the risk of long-term liability.
➤ regulatory burden.
➤ safety and health issues.

• • • • •

For **local governments**, controlling waste management costs is increasingly important to efficiently and effectively manage tax-payer dollars and resources. SHWEC technical assistance in ***source reduction, recycling, composting, and integrated waste management*** can help achieve:

➤ reduced costs for waste disposal.
➤ compliance with the recycling law.
➤ effective, sustainable waste management programs.

SHWEC Assistance To Wisconsin Businesses and Local Government

➤ **Reduces Costs**
➤ **Improves Efficiency**
➤ **Boosts Competitiveness**
➤ **Reduces Liability**

Solid and Hazardous Waste Education Center
Waste Education Series
Cooperative Extension • University of Wisconsin—Extension

Pollution Prevention Case Study

Modine Manufacturing Company
Racine, Wisconsin

Zero Discharge Aqueous Cleaning Line

Industry; SIC Code	Manufacturer of Heat Transfer Products for Vehicles, Heavy Equipment Commercial Heating and Ventilating Products for Buildings; SIC 3714, 3583, 3442
Process	Cleaning or degreasing of metal parts prior to assembly or painting.
Type of Waste	Hazardous wastes and emissions from 1,1,1 Trichloroethane(TCA).
Strategies	Eliminate the use of TCA through implementation of an aqueous cleaning system. The original strategy considered a conventional alkaline cleaning system with a 11 gallon per minute(GPM) flow to wastewater treatment. However after careful study it was determined that a zero discharge cleaning system was feasible.
Background	The Modine facility in Racine Wisconsin is the corporate headquarters and manufacturing research and development center for the corporation. Extensive prototype work and testing is accomplished at the plant. These processes require cleaning of sub-components before they are assembled and or in some instances prior to painting. The Modine Company used TCA as the cleaning agent to remove grease and oils from parts in an open top vapor degreaser.
Motivation	The Modine Company has a strong corporate commitment to reduce waste and emissions wherever possible. In recognition of the costs and issues associated with TCA it was decided to eliminate the chemical by implementing an aqueous cleaning process.
Changes Implemented	The attached schematic demonstrates the general layout of the cleaning system designed and built by company process chemists and engineers. Evaporation is incorporated as part of the cleaning system and operates on demand versus continuous operation. Incoming water is also on a demand basis which is driven by the total amount of water consumed during operation. Permeate from the filtration system is returned to the cleaning tank. There is zero discharge from this cleaning system.

Problems Encountered

Selecting the best filtration media for the process and the actual engineering and design of the filtration system was the most challenging task. Other consideration were selection of the cleaning chemical and achieving the supply/consumption balance for water needed to operate the system.

Material/Energy Balance

Original Approach		*Considered Approach*		*Zero Discharge System*	
Feedstocks		*Feedstocks*		*Feedstocks*	
9,800 lbs/yr TCA		*275 gal/yr Alkaline Cleaner*		*55 gal/yr Alkaline Cleaner*	
Cooling Water		*Process water*		*Process Water*	
Wastes/Disposal		*Wastes/Disposal*		*Wastes/Disposal*	
TCA 9,800 lb/yr Emissions		*990 gal/yr Cleaner/Water*		*0 gal/yr Cleaner/Water*	
Hazardous waste 55 gal/yr		*15,840 gal/day Wastewater Treatment*		*0 gal/yr Wastewater Treatment*	
Cooling Water Discharge		*Sludge Unknown lb/yr*		*0 lb/yr Sludge*	
Economics					
Operating Costs		*Operating Costs*		*Operating Costs*	
TCA	*$8,900*	*Alkaline Cleaner*	*$ 750*	*Alkaline Cleaner*	*$ 150*
Cooling Water	*$2,200*	*Process Water/Disposal*	*$8,700*	*Process Water/Disposal*	*$ 115*
Chemical Disposal	*$ 550*	*Chemical Disposal*	*$5,400*	*Chemical Consumption*	*>$150*
Totals	*$11,560*		*$14,850*		*$ 415*
Capital Investment					
	$ -0-		*$18,510*		*$59,950***

*** Microfiltration System Cost: $15,000*

Energy Costs, in BTU/Hour					
	Unknown		*577,980*		*110,480*

Approximate Payback

Based upon a minimum annual savings of $14,435 experienced in operating costs only, the payback period on $59,950 capital investment is 4 years. However this payback period does not include cost savings for labor, avoided costs for handling wastes, reduced time for reporting emissions and hazardous waste and the liability that was eliminated because there is no accountable waste from the zero discharge system.

Other Minimization Activities Modine Manufacturing has had an aggressive and very effective waste reduction program for several years. The *"Shrinking Drum"* is awarded to each facility that achieves the waste reduction goals which are established by that facility. The Corporate Headquarters in Racine leads this program by testing new pollution prevention/waste reduction measures such as the zero discharge system, before they are implemented in the field.

Company Address

Modine Manufacturing Company
1500 Dekoven Avenue
Racine, Wisconsin 53403

Contact Person

Mr David Peterson, Process Chemist, 414-636-1253
Mr Edward Besaw Environmental Engineer, 414-636-1396

FAX 414-636-1424

Additional Publications Available

SHWEC Publications
Pollution Prevention: A Guide to Program Implementation.
Industrial Cleaning Source Book.
Waste Reduction Assessment for the Fabricated Metal Prod. Ind.
Closed Loop Metal Finishing, factsheet.

Department of Natural Resources Publications

Contact the Wisconsin Department of Natural Resources, Pollution Prevention Clearinghouse, P.O. Box 7921, SW/3, Madison WI 53707, for a Publications Order Form, # PUBL-SW-199, or call 608/267-9700.
Suggested publications include:
Aqueous Industrial Cleaning Chemicals, # PUBL-SW-147.
Aqueous Parts Washing Equipment, # PUBL-SW-148.
Guides to Pollution Prevention, The Metal Finishing Industry, EPA/625/R-92/011
Guides to Pollution Prevention, The Fabricated Metal Products Industry, EPA/625/7-90/006.
Facility Pollution Prevention Guide, EPA/600/R-92/088.

Other Pollution Prevention Resources Available

Free, Nonregulatory, On-site Technical Assistance
University of Wisconsin-Extension
Solid and Hazardous Waste Education Center
Pollution Prevention Specialists
Area Code 414 call the Milwaukee Office at 414/475-3371
Area Code 608 call the Madison Office at 608/262-0385
Area Code 715 call either Madison or Milwaukee for assistance.
To learn more about on-site assistance programs call SHWEC at either office listed above and ask for "*Understanding Pollution Prevention Assessments*", a factsheet which explains SHWEC on-site assessments.

For More Information, Contact Your County Extension Agent

Call the University of Wisconsin-Cooperative Extension Office in your County. Ask for the Community Natural Resource and Development (CNRED) Agent. The CNRED agent can provide information concerning local community resources as well as information available from SHWEC pertaining to recycling, solid waste management, yard waste, composting, household hazardous waste and industrial pollution prevention.

Other SHWEC Offices

UW-Green Bay
University of Wisconsin
Environmental Science 317
2420 Nicolet Drive
Green Bay, WI 54311
414/465-2707, FAX 414/465-2143

UW-Stevens Point
College of Natural Resources
University of Wisconsin
Stevens Point, Wisconsin 54481
715/346-2793, FAX 715/346-3624

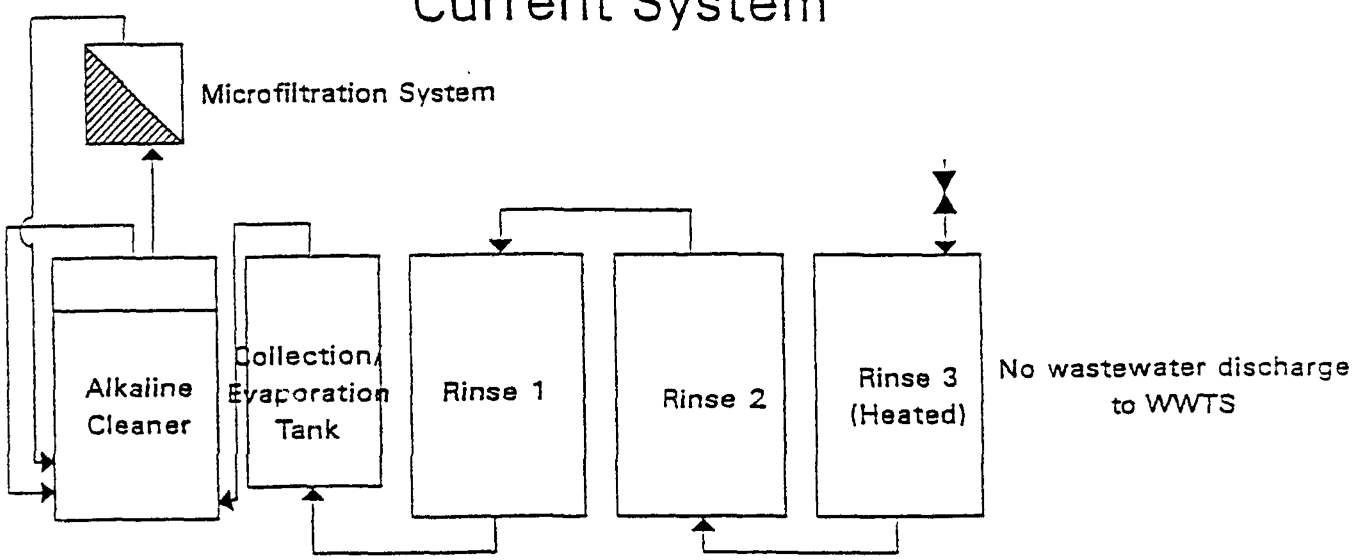
Zero Discharge Cleaning System

Modine Manufacturing Company

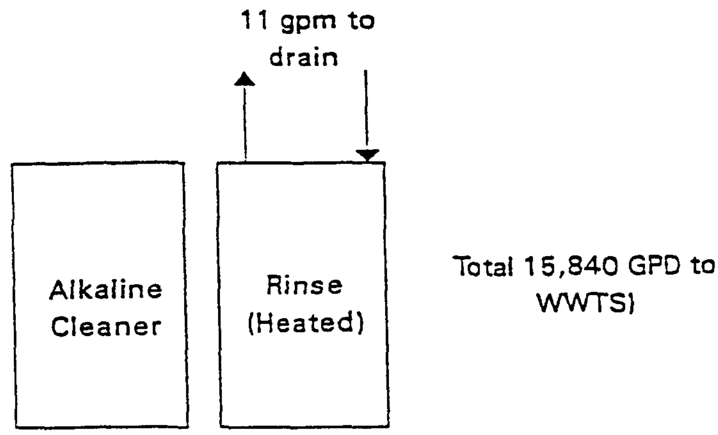
Provided by

David S. Peterson
and
Edward L. Besaw

Current System



Minimum System Required



Pollution Prevention

Case Study

APV Crepaco

Machining Fluid Waste Reduction Program

Industry/SIC Code

Equipment for food processing, pharmaceutical, cosmetics and chemical Industries/3556

Company Background

APV CREPACO is a 650-employee company manufacturing equipment for the food processing, pharmaceutical, cosmetics and chemical industries. It operates a large metal fabrication shop in Lake Mills employing 300 machinists using over 130 machine tools to fabricate equipment from ferrous and nonferrous stock.

Original Process

APV CREPACO uses metal working fluids as coolants and lubricants for machining ferrous and non-ferrous metals. In 1993 the company began experiencing serious problems with its machining fluid management system. Although the existing method of fluid management was well within regulatory guidelines, the system was generating problems with product quality due to excessive fluid usage and disposal. There were also employee health problems resulting from contact dermatitis caused by spoiled fluids.

Pollution Prevention Process

During 1993 APV CREPACO employees founded the "Missing Link" machining fluid management team and began an organized effort to develop a machining fluid management program to reduce waste and eliminate health problems. The team was made up of seven members representing the employee groups that used or managed the fluids (i.e., machinists and maintenance personnel). The team began by defining the nature of the machining fluid problem, first as a small group, and then by applying statistical analysis of the input of other employees in the facility. The team then identified the following problems related to the machining fluid system: the use of obsolete fluid formulations; poor mixing water quality; lack of quality control over fluid concentrations; cross contamination between fluid types; bacterial and fungal contamination of fluids; and machining fluid recycling equipment that was inoperative.

The team members then made use of a number of educational opportunities, including vendor videos and UW-Extension teleconferences, to learn more about coolant management and waste reduction. They put together a list of possible solutions to the machining fluid problems and surveyed other employees for both additional suggestions and to encourage project ownership by non-team members. Based on their research and findings, the team implemented a number of waste reduction options and used outside vendors and the UW-Extension Solid and Hazardous Waste Education Center to review progress and make additional recommendations. These options include:

- Using best available fluid formulations to extend fluid life
- Reducing the numbers of fluid types to two, simplifying recycling
- Improving mixing water quality to avoid fluid degradation
- Adding external sumps and reservoirs with skimmers to maintain fluid quality
- The creation of machine clean-out and a fluid recycling schedule to eliminate equipment contamination and unnecessary fluid disposal
- Improvement of ease of fluid level monitoring to simplify fluid maintenance and minimize unnecessary fluid change-out
- Training machinists to measure fluid quality to insure ongoing fluid quality
- Tracking of fluid waste generation to identify problems
- Labeling materials to avoid cross contamination
- Brought the fluid recycling equipment up to operating specifications
- Development of standard operating procedures for fluid use, recycling, and disposal.

The team conducted employee training sessions to insure that the new fluid management program would be accepted by the machinists and be integrated into normal duties. The team insured the long term viability of the fluid management program by: calculating the financial gains and reduced waste resulting from their efforts; making a presentation to company employees and management to explain the program and underscore the importance of their accomplishments; and making recommendations for ongoing management and machinist support of the new fluid management program.

Material/Energy Balance

Original Process

Feedstock

Soluble oil type grinding and cutting fluids.

Waste

Spoiled coolant and waste machine cleaner. 50,000 gallons/year of machining fluid was being disposed of as waste.

Disposal

Hazardous waste was removed by a waste management company.

Pollution Prevention Process

Feedstock

Synthetic grinding and cutting fluids.

Waste

24,000 gals/year of used coolant. New fluid purchases have been reduced by 60%.

Disposal

Hazardous waste is removed by a waste management company. Waste machining fluid disposal has been reduced by 50%.

Economics

The company was originally spending over $75,000/year on new fluids and fluid disposal. Ongoing annual cost savings of $54,000 (a 70% reduction).

Benefits

As a result of the changes implemented, cases of dermatitis attributed to spoiled fluids have been eliminated. The improved fluid quality has also reduced tooling wear and has improved product quality.

Obstacles

Organization and education of machine operators.

Technology Transfer

The team has transferred the lessons learned from their experience to others by providing tours of their facility to other companies with similar problems and their experiences have served as a machining fluid management model for other metal fabricators in Wisconsin.

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APV CREPACO
100 South CP Avenue
Lake Mills, Wisconsin 53511

Company Contact
Kevin Q. Johnson
414/648-8311

Pollution Prevention Resources

Free, On-site Technical Assistance
University of Wisconsin Extension
Solid and Hazardous Waste Education Center
Milwaukee area: 414/475-2845
Remainder of state: 608/262-0385

Pollution Prevention Information Clearinghouse
Wisconsin Department of Natural Resources
Hazardous Waste Minimization Program
608/264-8981, 608/264-8852, 608/267-9523 or
608/267-3763

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Office of Technical Assistance
Executive Office of Environmental Affairs
Commonwealth of Massachusetts

Toxics Use Reduction Case Study

COOLANT MANAGEMENT AT BELOIT CORPORATION

SUMMARY

Beloit-Jones Fiber Finishing Systems Division of Beloit Corporation in Dalton, MA, replaced the water-based coolant used in its metalworking operation with a mineral oil-based coolant. This change has nearly eliminated the dumping of spent coolant due to rancidity caused by tramp oil accumulation. Beloit expects that the change will save it more than $88,000 in associated machine tooling costs. This amounts to cutting costs by 28% in the first year and 32% in succeeding years.

BACKGROUND

Beloit Corporation employs nearly 400 people at its Fiber Finishing Systems Division, which manufactures heavy machinery for paper mills, designs paper mills and factories, and rebuilds old machinery. In the manufacturing process, metal stock and large castings are placed in CNC machines, lathes and milling machines to be cut into the required shape. The cutting tools on the machines are flood-cooled to reduce heat and increase lubricity. Every two weeks the coolant becomes rancid due to bacteriological growth. Tramp oil floating on the top of the sump prevents aeration, resulting in the flourishing of anaerobic bacteria. This requires that the sump be emptied, the coolant filtered in a central area, and the sump recharged. Additionally, the machine operators experienced dermatitis due to contact with the coolant.

TUR PLANNING

The coolant at Beloit had many drawbacks: short life, high disposal costs, poor lubricity and skin irritation problems. Plant Engineering Manager Paul Norcross, together with the tool room and maintenance supervisors, began looking for alternatives which would remedy these problems.

The first step was to invite representatives from five coolant manufacturers to run tests on machines within the plant. Beloit chose three milling machines which are used to manufacture identical stainless steel parts. The substitute coolant used in the first machine produced immediate results. The operator's skin irritation ceased and the cutting tool ran two to three times longer between changes. After three weeks, the coolant remained unaffected by tramp oil. The other two machines were changed over to different coolants, but dermatitis and poor cutting tool life problems persisted.

By the 75th day of the trial, other operators were clamoring for the coolant used on the first machine and all other testing was terminated. The other 37 cutting machines were then systematically switched over to the new coolant with similar positive results. (It was found that the new coolant produced poor results in the grinding area.)

TUR MODIFICATIONS

The change required no operator retraining in order to implement. Maintenance operators are required to check coolant concentration and make-up levels. An oil skimmer for the tramp oil was added to the sump of each machine which did not already have such a skimmer, in order to achieve the maximum benefit from the coolant. The new coolant has eliminated dermatitis problems and increased tool life with no apparent need for disposal, thus reducing maintenance. Operators have been able to increase machine feed rates, yet even with the increased tool use, the savings potential in tool costs is around 24%, and finished surface quality has improved dramatically.

RESULTS

Reductions Achieved: Beloit no longer has to dispose of spent coolant, and this has reduced the amount of hazardous material which is disposed of off-site.

Economics: Equipment costs for the wheel skimmers, which were manufactured in-house, amounted to $9,000. The new coolant costs $11.34 per gallon, an increase of 47% over the old coolant. However, reduced disposal costs and make-up for spent coolant saves Beloit $18,000 annually. While difficult to quantify due to a wide variety of operations and materials, maintenance time and costs for the coolant has been reduced. Tool life has been extended by two to two-and-a-half times that achieved with the old coolant. Machine feed rates have increased at a similar rate (from 7 in./min. to 18 in./min.), more than doubling productivity. These factors combine to yield a savings of $61,200 (24%) annually in cutting tool purchases. Overall, this project generated savings of more than $88,000 of 1991.

EPA/600/R-95/070
May 1995

POLLUTION PREVENTION POSSIBILITIES FOR SMALL AND MEDIUM-SIZED INDUSTRIES

Results of the WRITE Projects

by

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NEW JERSEY

Seven technologies were evaluated under the New Jersey contingent of the WRITE program. The projects were performed with the help of the New Jersey Department of Environmental Protection and Energy (NJDEPE, Project Officer, Norine Binder) and the New Jersey Institute of Technology (NJIT, Project Officer, Daniel Watts). The EPA Project Officer was Johnny Springer Jr.

#23 MOBILE ONSITE RECYCLING OF METALWORKING FLUIDS

Participants

The hosts for the evaluation were three, small-to-medium sized machine shops in the Philadelphia, PA, area (known to EPA only as E1, E2, and S1). The Safety-kleen Corporation of Elgin, Illinois was the vendor, providing the metalworking fluids and operating the mobile, on-site recycling units. Battelle, Columbus Laboratories helped design the test program, supplied test personnel and equipment, and wrote the draft report.

Technology/Testing

Safety-Kleen provides metalworking fluid recovery services to a variety of businesses, primarily those that generate relatively small quantities of fluid waste. The mobile service performs the recycling on the generator's property, thus eliminating the need to transport potentially hazardous waste. Each mobile truck-mounted unit, operating on its own power, is capable of processing fluid at a maximum rate of 300 gal/hr.

The recycling process (Figure 1) consists of filtering, pasteurizing, and centrifuging the spent fluid. The fluid is first sent through a 100-þ filter to remove any large particulates. It is then pumped through a preheater and then a heat exchanger to kill bacteria and fungi, as well as to reduce fluid viscosity. Centrifuging to separate tramp oil and other debris from the usable fluid, is next. Additives are then incorporated into the fluid to restore performance. In the final step, the fluid flows through a 1-þ filter to remove any remaining particulates.

The technology was evaluated at three small-to-medium sized machine shops (sites) in the Philadelphia, PA, vicinity. The three sites were chosen from among Safety-Kleen's customer base. Two of the sites (called E1 and E2) used emulsion-type metalworking fluids. The third site (called S1) used a synthetic fluid.

At each site, one sample each of the spent, recycled, and virgin fluids (at their normal use concentrations) was collected and subjected to a series of tests. The comparison were then made between the virgin, spent and recycled fluids.

The accumulation of very small particulates over time and use could limit the number of times a given batch of fluid could be recycled. Conductivity of the samples was measured as an indicator of the dissolved solids levels in the fluids.

Users of metalworking fluid often monitor the pH as an easily measured indicator of fluid quality. A change in pH may indicate chemical degradation or degradation due to microbial growth. The recycling process seeks to restore pH to a range of 8.5 to 9.5. This alkaline pH improves emulsion stability and corrosion resistance characteristics of the fluid.

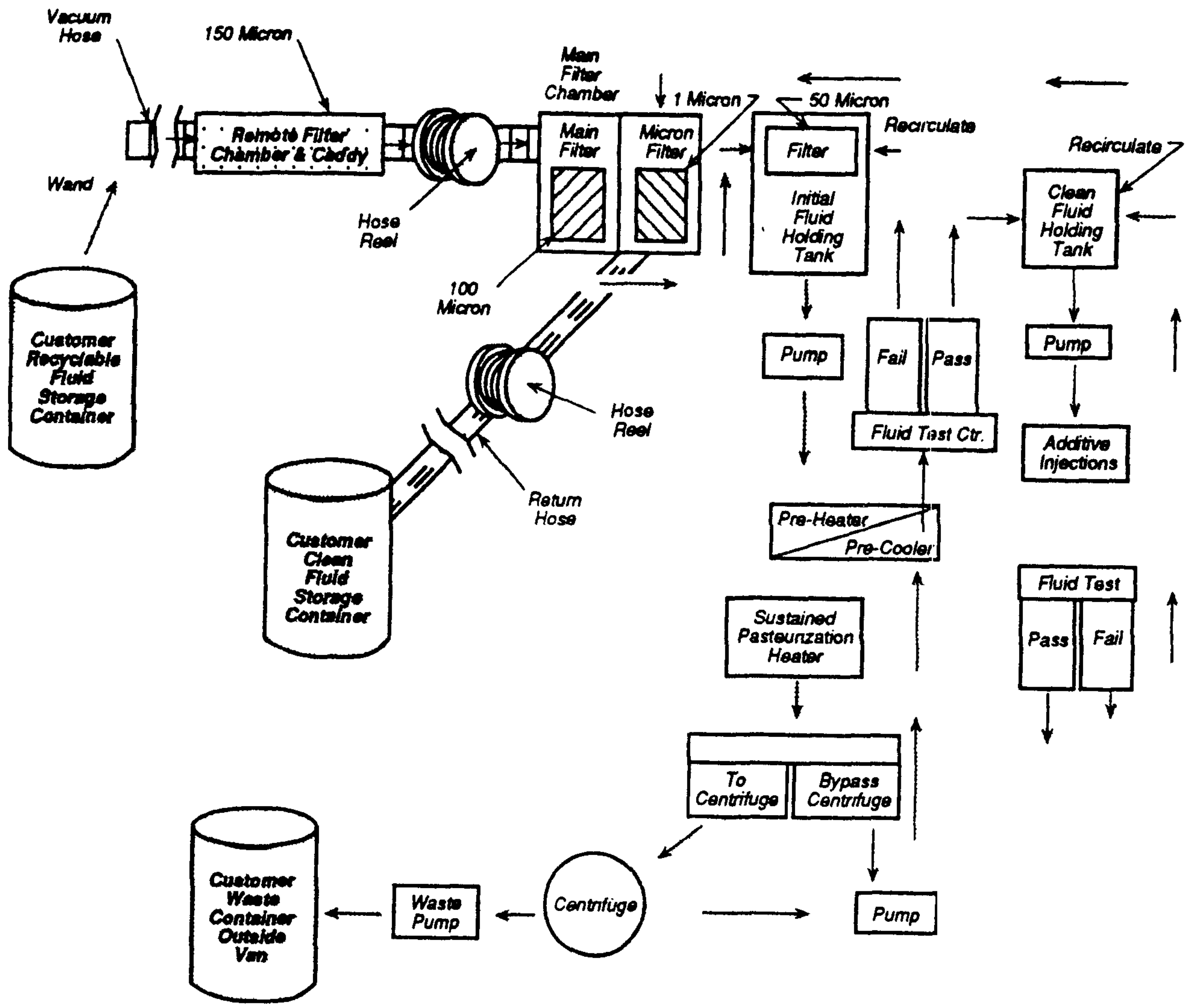


Figure 1. Metalworking fluids recycling system flowchart

The main purpose of metalworking fluids in machining operations is to provide lubricity and cooling without causing corrosion or other problems.

Results:

Degree of removal of non-dissolved and dissolved particulates during recycling is shown in Table 1. High concentrations of these particulates affect tool life, surface finish, and chemical breakdown. Particulates also provide substrates for microbial growth. At all three sites, the results showed considerably lower concentrations of nondissolved particulates in the recycled fluids (E1-R, E2-R, and S1-R) as compared with concentrations in the spent fluids (E1-S, E2-S, S1-S0).

Dissolved solids levels remained approximately the same after recycling, which indicated the effect of contaminant precipitation and fresh additive introduction. At the three sites tested, the pH of the recycled fluids was returned to a range between 8.5 and 9.5.

Corrosion characteristics are important parameters for water-based metalworking fluids because of their effect on workpiece quality and tool life. The results of the iron chip corrosion test (ASTM D4627) on the virgin samples (E1-V, E2-V, and S1-V) showed that E1-V and S1-V generated no rust at the use concentration (approximately 5% solution of the concentrate in tap water).

Tramp oil is the nonemulsified floating oil that builds up in metalworking fluid sumps from sources such as leaking equipment seals (hydraulic oils, gear oils) or from the workpiece itself. No phase separation was noticed in any of the recycled samples, indicating the tramp oil had been removed.

TABLE 1. ANALYSIS OF NON-DISSOLVED SOLIDS

Sample No.	Non-Dissolved Solids Concentration (mg/100 mL)[a] Total	Inorganic	Dissolved Solids (Conductivity) μmhos/cm²
E1-S[b]	79.10	27.25	2,400
E1-R	22.55	1.45	1,810
E1-V	3.55	2.50	700
E2-S[b]	12.55	0.50[c]	1,820
E2-R	5.60	3.00	1,750
S1-S	33.80	14.50	1,450
S1-R	17.00	1.95	1,460
S1-V	5.18	0.78	1,930

[a] By ASTM D 2276. Particulates smaller than 8 microns
[b] Analyzed skimming off and discarding the floating tramp oil E1-S=spent emulsion, site 1, E1-R=recycled emulsion, site 1; E1-V=virgin emulsion, site 1; etc
[c] Possible inhomogeneity giving a low value.

The results of emulsion stability testing at elevated temperature showed small amounts of phase separation in spent samples E1-S and E2-S. The recycled samples remained as a single phase even after 96 hrs, indicating that emulsion stability had been restored during recycling.

Foaming can reduce effective film strength, reduce heat transfer, and interfere with the settling of metal fines. Tendency of the fluids to foam was tested by ASTM D 892-89. Foam volume in the recycled samples (E1-R, E2-R, and S1-R) was significantly higher than that in the spent or virgin samples. This can be attributed to introducing fresh emulsifier (surfactant) during recycling. A correction can be made for this effect by adding an antifoam agent during reycling. Safety-Kleen, however, does not add an antifoam agent unless the user specifically reports a foaming problem.

At all three sites, the recycled and virgin fluid viscosities were very close. This indicated that the recycling process had restored this parameter. The viscosity measurements also indicated that the recycling process succeeded in returning the fluids to the required use concentration (oil/water ratio).

Lubricity and wear preventive characteristics of a metalworking fluid affect workpiece quality and tool life. Lubricity and wear characteristic were measured by the standard "four-ball test" (ASTM D 445). For Site E1, the recycled sample caused a much lower average scar diameter than did the spent sample, but not as low as the virgin sample. This indicated that the recycled and virgin samples performed about the same. The presence of some emulsified tramp oil could have improved the lubricity results of the spent sample E2-S.

A major factor in metalworking fluid spoilage (rancidity) is microbial growth. In the recycling process, existing microbes are killed during the pasteurization step, the dead biomass is removed during the centrifugation step, and a measured quality of biocide is added to control future microbial growth. ASTM E 686-85 evaluates the effectiveness of biocides at use concentrations. No microbial growth was observed in the samples up to 6 weeks after recycling.

Currently, there are no published standards for recycled fluids. Each user establishes requirements based on the same factors used in selecting a virgin fluid. At the three test sites evaluated in this study, recycled fluids appeared to satisfy the functional requirements of the users.

On an average, Safety-Kleen visits each user once every 10 weeks and recycles 250 gallons of spent fluid per visit, thereby yielding a potential annual reduction of 1250 gallons for a typical small user. Approximately 4 gallons of tramp oil per visit are generated during recycling. The tramp oil is hauled away at a competitive fee by Safety-Kleen for use as supplemental fuel. Residue generated on the filters (mostly metal chips) is transferred to the user's waste metal bin and later reclaimed for its metal value.

According to a 1991 study by the Independent Lubricant Manufacturer's Association, the volume of metalworking fluids (concentrate) manufactured in the United States, has increased from 67 million gallons in 1985 to 92 million gallons in 1990. By extending the life of metalworking fluids through onsite recovery, considerable amounts of fluid can be prevented from going to waste. The total volume of fluids going to waste, may be significantly higher than the manufacturer volumes (as much as 20 times higher,in some cases) since many types of fluids are diluted into 3% to 5% solutions with water.

The economic evaluation compared costs for recycling versus costs for disposal. Recycling costs included the onsite service charge for the customer and tramp oil disposal cost. Disposal costs included spent fluid disposal cost and hazard analysis costs. The annual savings for a typical small user, who recycles 1,250 gallons/yr of metalworking fluid was approximately $1,600 if the spent fluid was nonhazardous, and $7,800, if the spent fluid was hazardous (by the Toxicity Characteristic Leaching Procedure).

This evaluation found that recycling of metalworking fluids is a good option for small-to medium-sized plants with machining operations. In the absence of published standards for recycled fluids quality and performance, the user has to evaluate the recycled product by the same criteria used to select a virgin brand. Direct, extended time testing of tool life and work piece quality vs. recycled fluid characteristics may be desirable to establish recycled fluid standards.

<u>Report</u>

The full report, titled "Mobile Onsite Recycling of Metal Working Fluids" by Arun Gavaskar, et al., is available as report no. EPA/600/SR-93/114.

#24 A FLUID SORBENT RECYCLING DEVICE FOR INDUSTRIAL FLUID USERS

Participants

The host for the evaluation was Cook's Industrial Lubricants Incorporated of Linden, NJ who is a custom blender of industrial lubricants. Battelle, Columbus, Laboratories supplied test personnel and equipment, and wrote the draft report.

Technology/Testing

In the process of mixing, handling, and packaging of fluids, spills occasionally occur. At the end-users's sites, the fluids may be spilled or cutting oils splattered during their use in the machining process. Currently, the spilled or splattered fluid is removed by hand with sorbent pads made of melt-blown polypropylene. Workers simply lay the pads over the spilled fluid and mop the spilled areas. Once the pads are saturated with fluid, they are drummed for disposal.

During the evaluation the Extractor™, manufactured by Environmental Management Products, was used to recover the spilled fluid from the saturated sorbent pads. The Extractor™, recovers the fluid by compressing the pads between two gear-driven counter-rotating rollers. The desaturated sorbent pads are then reused several times until the quality of the pads degrades.

The two types of waste considered in this study were the spent sorbent pads themselves and the waste fluid adsorbed. The current practice of once through use was compared to desorption and recycling. The roller compression method extracts the sorbed fluid and permits reuse of the pads. Although the extracted fluid is contaminated with the dirt and debris picked up during the spill, it may be processed for reuse. Therefore, this technology reduces the number of sorbent pads used and the volume of sorbent pads and fluids sent to disposal. Additionally, there is potential for reprocessing and recycling the desorbed fluid.

The extraction efficiency test (ASTM Standard Method F726-81) was used to determine the number of extraction cycles a sorbent pad could endure before becoming unusable due to tearing, deforming, and other general deterioration. The test was also used to examine the rate of decrease in the pads' sorbing capacity (or adsorbency ratio) and the percentage of fluid to be removed by roller compression. Because fluid removal is dependent on the fluid viscosity, tests were conducted with three different fluids covering a range of viscosities.

The correlation of performance of the sorbent pads vs. the number of cycles through the extraction process was investigated. To determine product performance, both quantitative and qualitative aspects of pad degradation were examined. Pad degradation was quantified using the rate-of-release test (ASTM Standard Method F716-82).

The Maximum Practical Pickup (MPP) and Maximum Effective Pickup (MEP) of new pads were compared with those of pads that had passed through the Extractor™ four and eight times, respectively. If the used pads had a different rate of release, the test indicated degraded pad performance.

The ability of sorbent pads to leave a clean floor after use was measured by the fluid pickup test. The percentage of pickup by a new pad was compared with that of recycled pads.

Results

The average adsorbency ratio and extraction efficiency for low viscosity fluids is plotted against the number of extraction cycles in Figures 1 and 2. The average adsorbency ratio 13.99 g to to 14.79 g of fluid per g of dry weight of pad.

The results of the rate-of-release tests are given in Table 1. The MPP and MEP of the fresh pads for the low-viscosity fluid were 6.19 and 5.21 g/g, respectively. The decrease in MPP was 23.6% and 28.9% for pads reused for four and eight times, respectively, and the decrease in MEP was 24.8% and 31.1%, respectively.

Although the pad performance was degraded by approximately 25% after four uses, the degradtion in performance was relatively insignificant for 4 additional uses. For the medium and high-viscosity fluids, the MPP and MEP were measured only for the fresh sorbent pads.

The results of the fluid pickup tests are presented in Table 2. Regardless of fluid types, the sorbent pads effectively removed fluids from the floor. Only 2.4% to 5.2% of the spilled fluids were left on the floor. Moreover, the sorbent pads effectively removed low and medium-viscosity fluids even after they were reused four or eight times.

The objective of comparing costs of pad disposal versus reuse was met by using fluid capacities and process time measured during the study and supplemented by literature and company hitorical data. Fow low-viscosity fluid, substantial savings occurred as a result of pad recycling. Savings of up to 51.4% and 75.3% were possible with as few as two and as many as eight reuse cycles, respectively. Additional savings were also possible, but much less significant, as reuse cycles increased to more than eight times. Similarly, the cost per use was greatly reduced, from $4.80 for single use to $1.19 for eight uses (see Figure 3). For medium viscosity fluid, the annual pad recycling savings were 50.5% and the per use cost was $2.38 for two uses. Additional uses and savings are very unlikely because the sorbent pads became severely separated and deformed as a result of the extraction process.

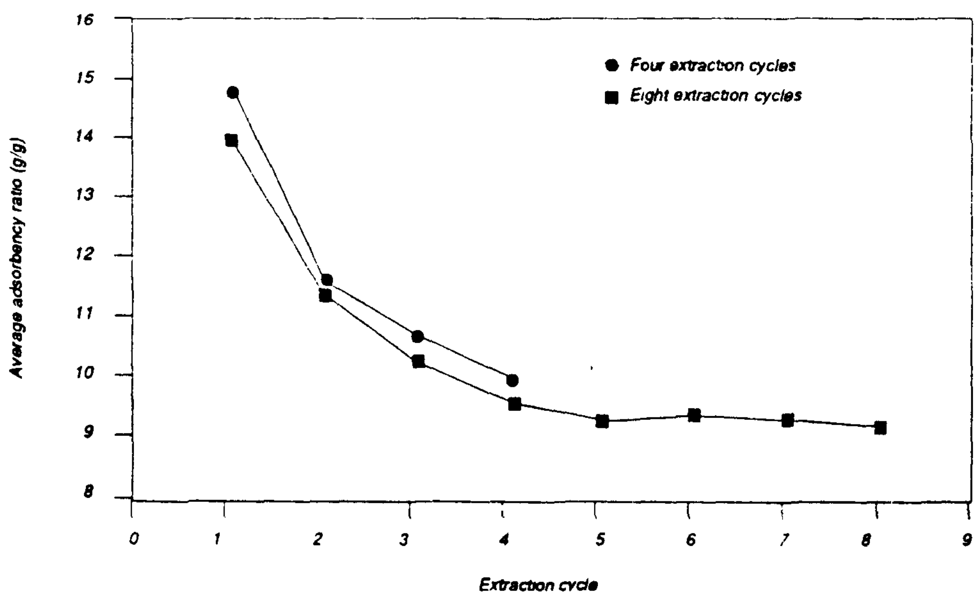


Figure 1. Absorbency ratio for low-viscosity fluid

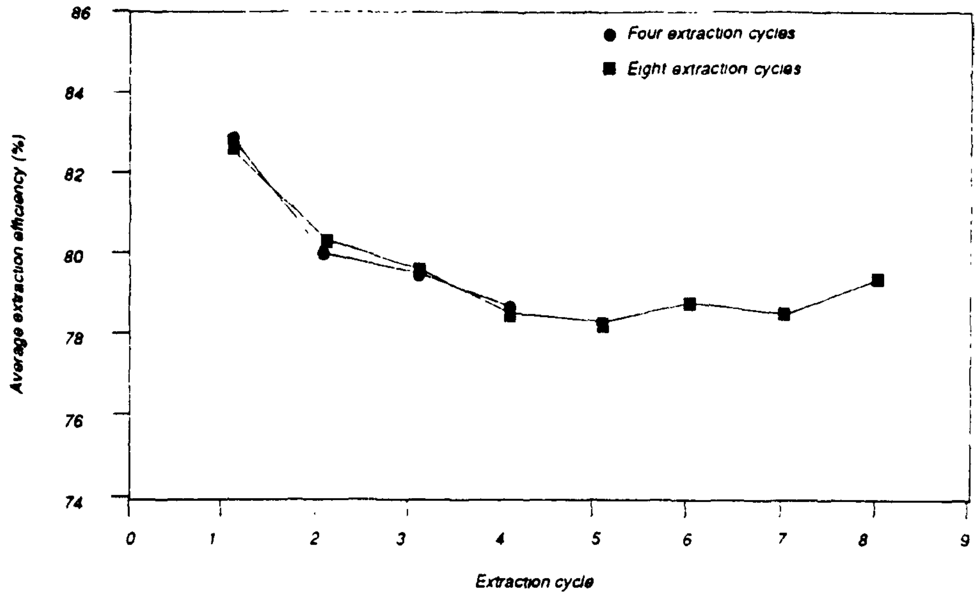


Figure 2. Extraction efficiency for low-viscosity fluid

TABLE 1. MAXIMUM PRACTICAL PICKUP AND MAXIMUM EFFECTIVE PICKUP

Pad condition	Fluid viscosity	Pad texture	Pad no.	Fluid sorbed at saturation (g)	Time to "stop" dripping[a] (min)	Maximum effective pickup (g/)[b]	Time to "stop" dripping[a] with fan on (min)	Maximum effective pickup[c] (g/g)
Fresh	Low	Unpleated	1	346.54	120	5.55	61.0	4.69
			2	360.28	120	6.57	61.5	5.57
			3	350.83	120	6.45	62.0	5.37
			Average	325.55	120	6.19	61.5	5.21
Extracted four times	Low	Unpleated	4	255.95	120	4.51	60.0	3.90
			5	203.96	120	4.62	60.0	3.75
			6	195.71	120	5.07	60.0	4.13
			Average	218.54	120	4.73	60.0	3.92
Extracted eight times	Low	Unpleated	7	194.06	>120	4.42	60.0	3.58
			8	195.57	>120	4.34	60.0	3.47
			9	197.65	>120	4.45	60.0	3.58
			Average	195.76	>120	4.40	60.0	3.54
Fresh	Medium	Unpleated	10	445.65	>120	11.82	60.0	9.19
			11	447.36	>120	11.18	60.0	8.58
			12	452.59	>120	11.75	60.0	9.36
			Average	448.53	>120	11.58	60.0	9.04
Fresh	Medium	Pleated	10B	306.25	>120	7.78	60.0	6.86
			11B	292.09	>120	7.80	60.0	6.96
			12B	303.41	>120	7.81	60.0	6.95
			Average	300.58	>120	7.80	60.0	6.92
Fresh	High	Unpleated	19	444.54	120	13.67	60.9	12.14
			20	417.91	120	13.54	60.9	12.19
			21	392.16	120	13.68	60.9	12.38
			Average	418.20	120	13.63	60.9	12.24

[a] At the end of the time recorded, dripping continued at a rate of more than 5 to 15 drops/min.
[b] Maximum Practical Pickup = Fluid sorbed at the end of 2 hr/sorbent pad dry weight.
[c] Maximum Effective Pickup = Fluid sorbed at the end of 1 hr with fan on/sorbent pad dry weight.

TABLE 2. FLUID PICKUP BY SORBENT PADS

Fluid viscosity	Pad Condition	Fluid pickup (%)			
		Replicate No. /pad No.			
		1/28	2/29	3/30	Average
Low	Fresh	96.4	98.2	98.2	97.6
	4X[a]	93.2	97.2	96.2	95.5
	8X[b]	94.2	95.8	95.8	95.3
		1/31	3/32	3/33	
Medium[c]	Fresh	97.1	96.2	97.5	96.9
	4X	97.5	94.1	94.2	95.3
	8X	95.8	93.8	99.5	94.8[d]
		1/34	2/35	3/36	
High	Fresh	100	94.2	100	98.1
	4X	N/A	N/A	N/A	N/A
	8X	N/A	N/A	N/A	N/A

a Pad extracted four times.
b Pad extracted eight times.
c For all medium-viscosity fluid tests, pads were soaked at 50% pad sorbing capacity before extractions.
d Based on the performance of Pads No. 31 and 32 only.
N/A = Data not available because pad could not pass through Extractor$_{TM}$

Because the capital cost for the Extractor™ was relatively insignificant ($699) and the annual savings would be substantial, the payback period of the investment would be only 2.8 to 5 weeks.

The sorbent pad recycling evaluation demonstrated that roller compression technology can be effectively used to extract low and medium-visocsity fluids from meltblown polypropylene sorbet pads. The Extractor™ is particularly useful for low-viscosity fluid applications; the sorbent pads can be reused at least eight times. For medium-viscosity fluids, no more than two to three reuse cycles are possible. The potential to reduce waste by recycling sorbent pads can be substantial. For example, for a 1,858-m^2 (20,000-ft^2) plant, annual sorbent pad consumption can be reduced from 3,600 pads to 1,800 or 450 if the pads can be reused for two or eight times, respectively. Correspondingly, the number of drums for disposal of pads would be reduced from 24 drums (assuming 150 oil-saturated pads per drum) to 6.5 or 1.6 drums (assuming 275 desaturated pads per drum). The 14 to 16 drums of waste fluids extracted from the sorbent pads would be processed for reuse or hauled away for disposal at a waste-to-energy facility.

The economic benefits of the roller compression technology were substantial. The use of the Extractor™ by shops and plants that handle and/or use various oils and fluids would result in annual savings of 51% to 75%. The savings come primarily from the lower disposal costs for spent pads. Further savings may be possible if exracted fluids can be recycled. The per use cost of sorbent pads can be significantly reduced from $4.80 for a single use to $1.19 or less for eight or more reuse cycles.

Report

The full report, titled "A Fluid Sorbent RecyclingDevice for Industrial Fluid Users" by Abraham S.C. Chen, et al., is available as EPA/600/SR-93/154.

Todd Balzer
Jack Smith

Modern Technologies Corporation

BIOGRAPHIES

Todd Balzer

Todd is Business Development Manager for the Environmental Technologies Division of Modern Technologies Corporation in Dayton, Ohio. Todd is responsible for sales and marketing activities of MTC's software and consulting services. Todd holds a Bachelor of Science degree in Industrial Management from University of Cincinnati and is a Certified Hazardous Materials Manager. He has been in the environmental services industry for nearly ten years and has worked for Rust Remedial Services, Chemical Waste Management, Maecorp, and CECOS International.

Jack Smith

Jack is a Lead Environmental Analyst with Modern Technologies Corporation in Dayton, Ohio where he is involved with EH&S software implementations and consulting to industry and government. Jack received a Bachelor of Science in Hazardous Materials Management from the University of Findlay and is currently working toward a Master of Science in Environmental Management also from Findlay.

EPA REGION V Waste Minimization/Pollution Prevention Conference

Utilizing Environmental Management Information Systems to Facilitate and Monitor Waste Minimization and Pollution Prevention Efforts

Thursday February 27, 1997 Chicago, IL

TODD BALZER, JACK SMITH *Modern Technologies Corporation*

Agenda

Todd Balzer -

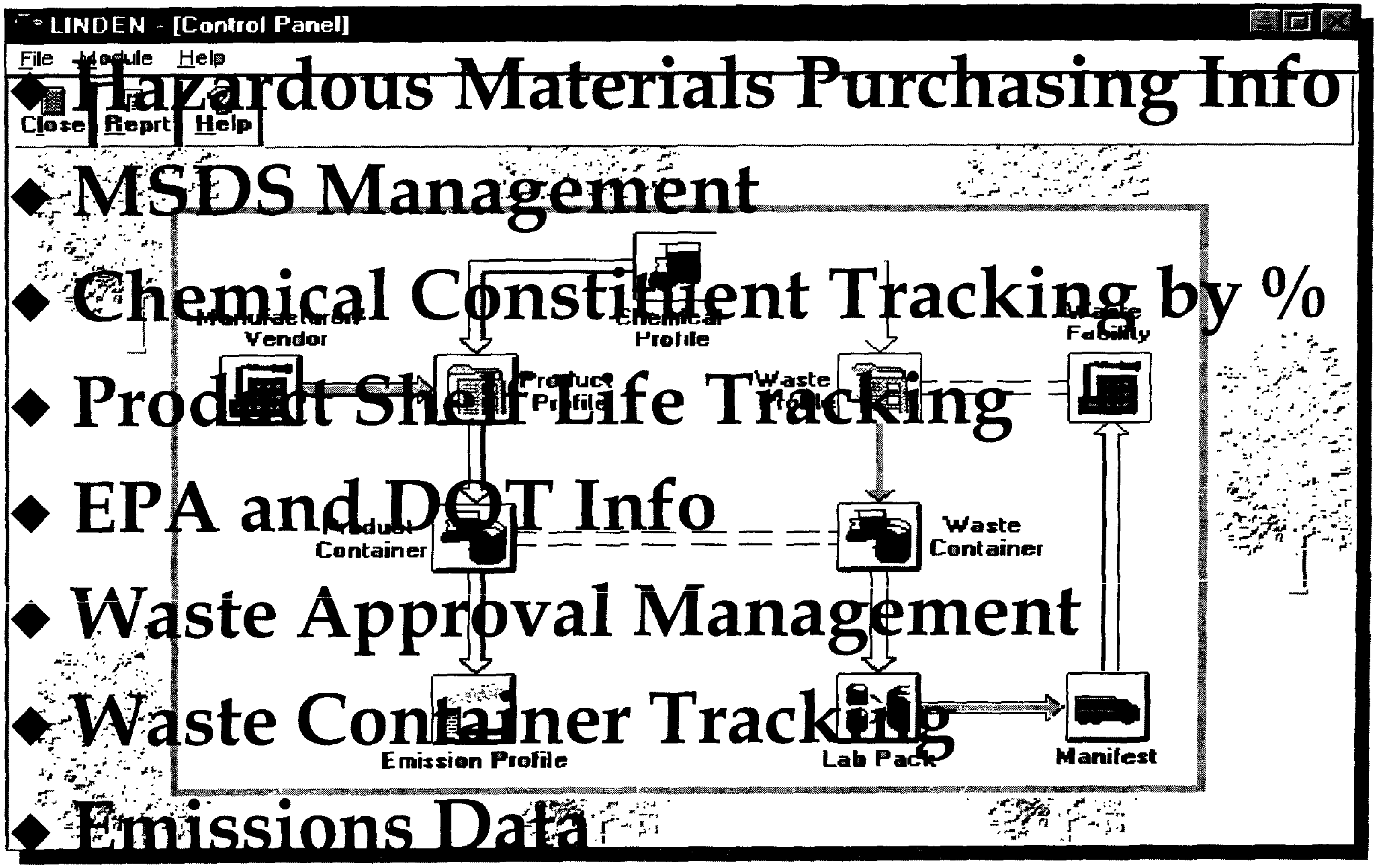
EMIS/P2 Relationship

Jack Smith -

Case Study

What is an EMIS?

Elements of an Effective EMIS



- Hazardous Materials Purchasing Info
- MSDS Management
- Chemical Constituent Tracking by %
- Product Shelf Life Tracking
- EPA and DOT Info
- Waste Approval Management
- Waste Container Tracking
- Emissions Data

What is Pollution Prevention?

- The use of Materials, Processes, or Practices that Reduce or Eliminate the Creation of Pollutants or Wastes at the Source.

OR

- The Maximum Feasible Reduction of All Wastes Generated at Production Sites.

What is Waste Minimization?

- The Means of Reduction, to the extent Feasible, of Hazardous Waste that is Generated Prior to Treatment, Storage, or Disposal.
- Any Source Reduction or or Recycling Activity that results in:
  - Reduction of Total Volume of waste,
  - Reduction of the Toxicity of the Waste, or
  - Both.

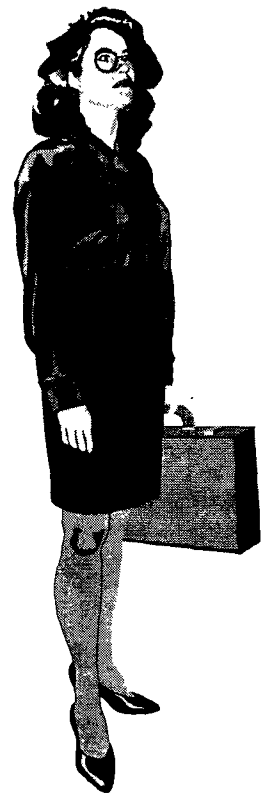
How can an EMIS Help Me with P2/ Waste Min?

- List All Hazardous Constituents
- Identify High-Use Items
- Ensure Environmental & Safety Compliance
- Track Containers by Process, Department, Individuals and Location (Allowing Charge-Backs)
- Compares Actual vs. Expected Use

P2 /Waste Min Actions

- Eliminate Virgin Materials with Non-Desirable Ingredients
- Reduce Hazardous Materials Inventory Levels
- Encourage Chemical Sharing
- Ensure Usage of Chemicals Before Expiration Date
- Provide a Chemical Approval Process (Restrict Chemicals)

How can an EMIS Help Me with P2/ Waste Min?



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P2 /Waste Min Actions

- Eliminate Virgin Materials with Non-Desirable Ingredients
- Reduce Hazardous Materials Inventory Levels
- Encourage Chemical Sharing
- Ensure Usage of Chemicals Before Expiration Date
- Provide a Chemical Approval Process (Restrict Chemicals)

Benefits

- Increased Worker Safety
  - Greater Awareness/Information Access
  - Less Individual Chemical Stockpiling
- Increased Environmental Protection
- Reduced Inventory Costs
- Reduced Disposal Costs
- Reduced Re-order Costs for Expired Chemicals

Peter S. Cartwright

Cartwright Consulting Co.

BIOGRAPHICAL INFORMATION FOR PETER CARTWRIGHT

- Born December 2, 1937
- Education: University of Minnesota, Minneapolis, MN
  B.S. Chemical Engineering - 1961
- Registered Professional Engineer in: Minnesota, Pennsylvania, Vermont
- Entered the water/wastewater treatment industry in 1974
- Self-employed consulting engineer since 1980

Peter Cartwright specializes in technical consulting for environmentally conscious manufacturing processes for water purification, wastewater treatment and food/chemical processing applications. His expertise includes such high technology separation processes as reverse osmosis, ultrafiltration, microfiltration, electrodialysis, deionization , carbon adsorption and ozonation & other disinfection processes.

Peter provides complete training and education programs in all areas of his expertise.

He has authored more than 100 papers, written several book chapters and presented many lectures in conferences around the world.

He is also active in most of the societies and professional organizations associated with the water and wastewater treatment industry.

Consulting Engineering
Water Purification
Waste Treatment
Food and Chemical Processing

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MEMBRANE SEPARATION TECHNOLOGIES FOR ENVIROMENTAL COMPLIANCE

By: Peter S. Cartwright, P.E.

INTRODUCTION

What's in a name? The mindset which has infiltrated America's industry with regard to environmental stewardship has been called "pollution prevention", "effluent treatment", "reuse", "resource recovery", etc. The paridigm shift behind this plethora of names signals a perceptible movement from a regulatory driven to an economy driven industrial climate.

This attitudinal change can only become a reality if there are treatment processes to support and facilitate it. Membrane separation technologies do just that. The characteristics which contribute to their usefulness in pollution environmental compliance include:

- Continuous process, resulting in automatic and uninterrupted operation
- Low energy utilization involving neither phase nor temperature changes
- Modular design - no significant size limitations
- Minimum of moving parts with low maintenance requirements
- No effect on form or chemistry of the contaminant
- Discrete membrane barrier to ensure physical separation of contaminants
- No chemical addition requirements

There are many examples of membrane separation technologies applied to water purification, ranging from seawater desalination to the production of ultrapure water for semiconductor device rinsing or pharmaceutical production. The same engineers who readily accept these technologies to purify water for an industrial application cringe in fear when approached with the idea of using them to dewater a waste stream or recover a valuable component from a process effluent.

If asked to explain their fear, they likely try to disguise their ignorance by citing one or more of the following reasons:

- Waste streams are too concentrated.

In reality, there are few waste streams with a higher concentration of ionic contaminants than sea water.

- The quality of the waste stream varies over time.

While to an extent this is true, many water purification feed streams come from multiple sources.

The quantity from each source can vary from time to time, thereby significantly altering the feed water analysis. In addition, if the wastewater source is a manufacturing operation, its rigid quality control requirements guarantee an extremely consistant wastewater stream analysis, certainly more uniform than many raw water feed streams.

- Waste stream chemicals will harm the membrane.

Although there are certainly chemistries and extreme concentrations that will degrade many membranes, the newer polymers are much more stable than the earlier materials. Chemistries which still cause problems with polymeric membranes (particularly RO) include pH extremes (below 1 and above 13), high concentrations of very strong oxidizing agents and certain oils, greases and surfactants. The point is that the vast majority of waste stream chemistries can be readily accommodated by most of the currently available membranes.

- The waste stream is likely to foul the membrane.

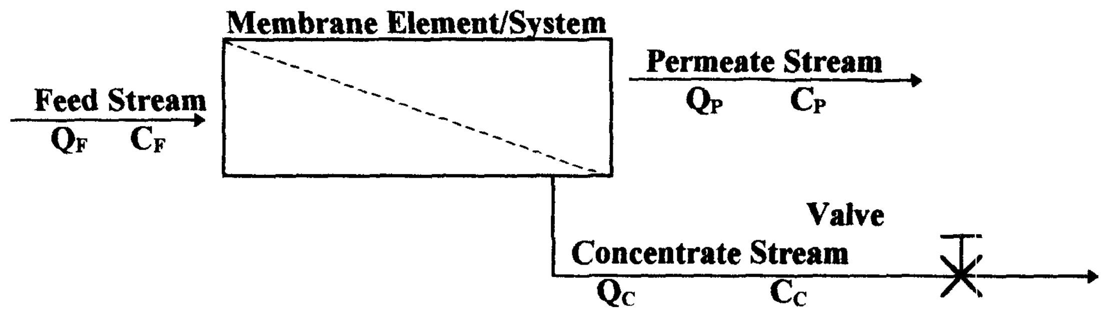
Because waste streams are usually the result of carefully controlled processes, their compositions are well known and usually quite consistent. Since testing is absolutely mandatory in all waste treatment applications, a well designed testing program will evaluate the effect of increasing concentrations of the waste stream on the fouling propensity of a given membrane or element configuration. This will allow the total system design to minimize fouling. In water purification applications, colloidal materials and slightly soluble ionic species such as iron, barium, calcium, silica, etc. create their own fouling problems in membrane applications.

-The life of a membrane element is much shorter in a waste application.

The primary cause of membrane failure is fouling. If a system is designed with proper pretreatment and sufficient turbulent flows within the membrane element, the membrane life should not be dependent upon the source of the feed stream.

TECHNICAL

Having said all of this, it is important to point out that there is one significant difference between the average water purification application and a waste treatment application. But first, some definitions are in order. Figure 1 illustrates a typical reverse osmosis system (or single membrane element). Note that the stream that passes through the membrane and is purified is called the "permeate" stream, while that stream which exits the system containing the rejected contaminants is known as the "concentrate" stream.



Recovery $= \dfrac{Q_P}{Q_F}$

(Expressed as Percent)

Q_F - Feed Flow Rate
C_F - Solute Concentration in Feed
Q_P - Permeate Flow Rate
C_P - Solute Concentration in Permeate
Q_C - Concentrate Flow Rate
C_C - Solute Concentration in Concentrate

FIGURE 1, Membrane System Schematic

Recovery is defined as the permeate flow rate divided by the feed flow rate; in other words, that percentage of the feed flow which is pumped through the membrane. Typically, for wastewater treatment applications, recovery is at least 90%, whereas for water purification applications, it rarely exceeds 80%. As recovery is increased (to decrease the concentrate volume), the concentration of solute and suspended solids in the concentrate stream increases rapidly.

In an ideal system, all of the contaminants to be removed are separated by the membrane and exit in the concentrate stream. As recovery is increased, the concentration of contaminants in the concentrate stream increases dramatically. Table 1 summarizes this increasing concentration factor as a function of system recovery, and Figure 2 illustrates this graphically.

TABLE 1, Effect of Recovery on Solute Concentration

$$C_C \approx \frac{C_F}{1 - \text{Recovery}} = XC_F$$

X = Concentration Factor

Recovery	X
33%	1.5
50%	2
67%	3
75%	4
80%	5
90%	10
95%	20
$97\frac{1}{2}$%	40
98%	50
99%	100

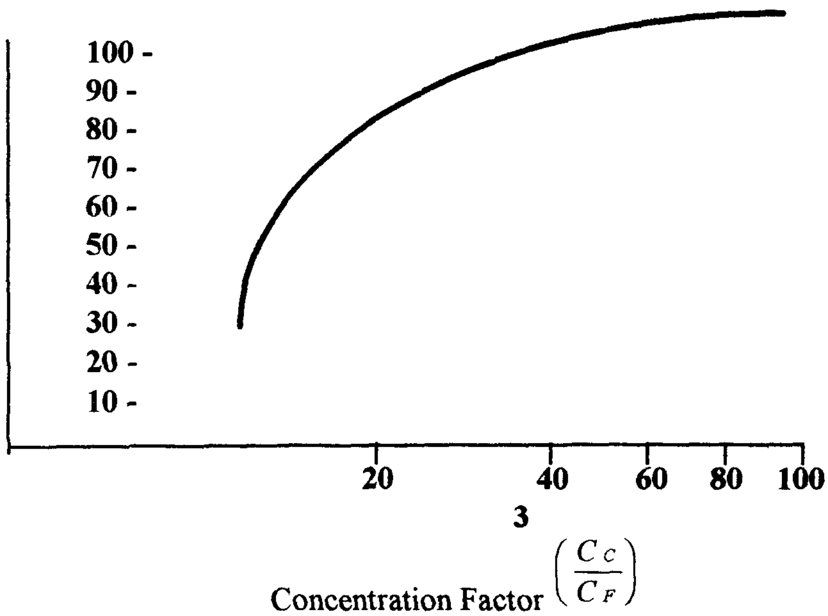


FIGURE 2, Concentration Effects of Increasing Recovery

For the processes of nanofiltration and reverse osmosis (and to a lesser extent, ultrafiltration) which deal with dissolved materials, a property of the solution known as "osmotic pressure" usually becomes the limiting factor. Osmotic pressure is a characteristic of all solutions, and is loosely defined as the resistance of the solvent portion of the solution to passage through the membrane. Osmotic pressure is a function of both the particular solute as well as its concentration. A specific test is almost always required to determine osmotic pressure.

As recovery is increased (typically through the use of a flow restrictor or concentrate valve), with the resulting decrease in concentrate flow, the concentration of solute in the concentrate stream increases resulting in increased osmotic pressure.

No membrane is perfect in that it rejects 100% of the solute on the feed side; this solute leakage is known as "passage". Expressed as "percent passage", the actual quantity of solute which passes through the membrane is a function of the concentration of solute on the feed side. Under high recovery conditions, the concentration of solute on the feed side is increased, and, therefore, the actual quantity of solute passing through the membrane also increases. Because most effluent applications demand that, in addition to a minimum concentrate volume, the permeate quality be high enough to allow reuse or to meet discharge regulations. The "catch-22" predicament of permeate quality decreasing as recovery is increased can impose design limitations. Additionally, the increased osmotic pressure resulting as recovery is increased also imposes a design limit. Generally, pumping pressures in excess of 68 bar (1000 psi) are impractical for most applications.

Membrane polymers must be packaged into practical "device" or "element" configurations which allow the most efficient use of the polymer. The typical element configurations available today include tubular, capillary fiber, hollow fine fiber, plate and frame and spiral-wound.

Packing density is an indication of the membrane area contained within a given volume of an element. In general, as packing density increases, element cost decreases, but, as a result of the closer spacing and restricted flow patterns, the propensity for fouling increases.

Typical membrane element configurations are illustrated in figure 3.

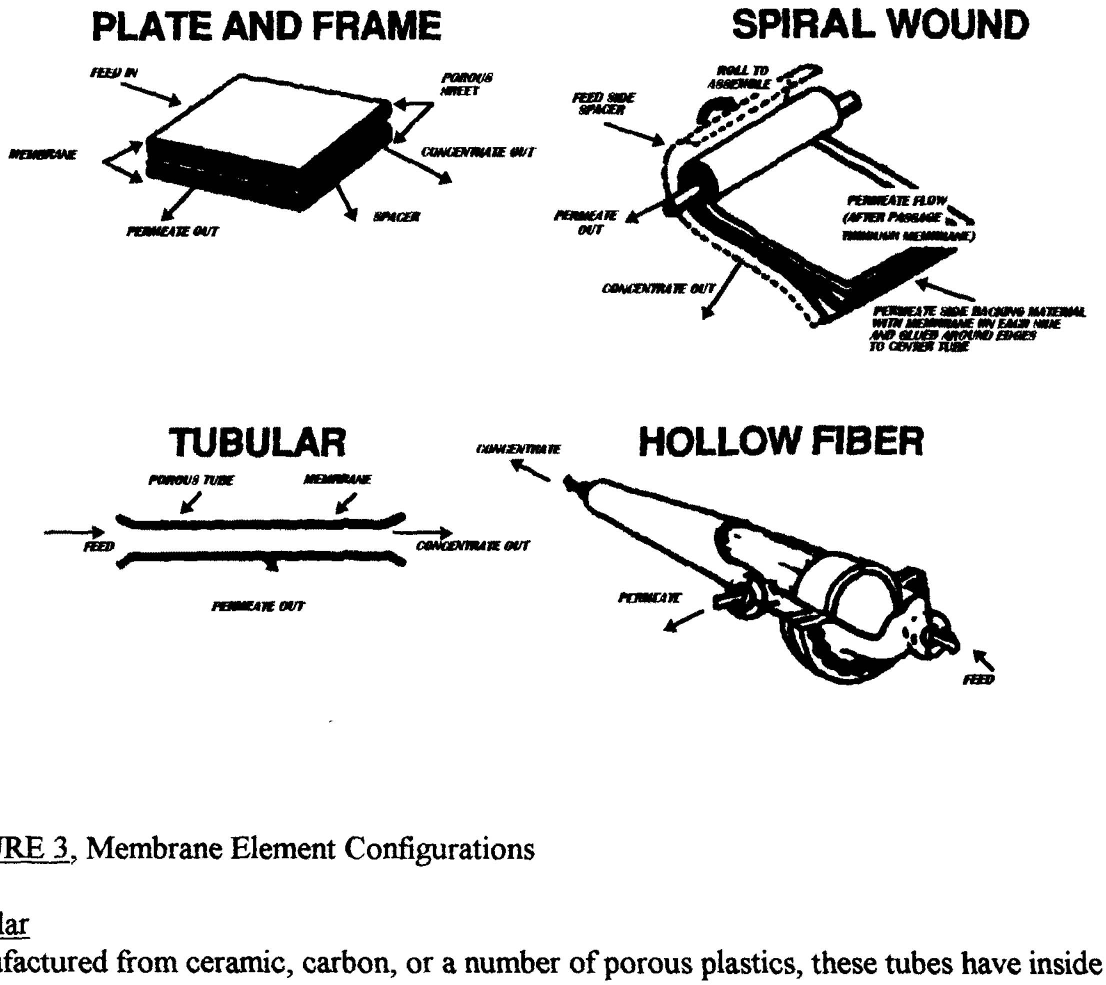


FIGURE 3, Membrane Element Configurations

Tubular

Manufactured from ceramic, carbon, or a number of porous plastics, these tubes have inside diameters ranging from about 3/8 inch up to approximately one inch (9 to 25 mm). The membrane is typically coated on the inside of the tube and the feed solution flows through the interior from one end to the other, with the permeate passing through the wall to be collected on the outside of the tube. Packing density is low, but resistance to fouling is very high.

Capillary Fiber
These elements are similar to the tubular element in design, but smaller in diameter and usually require rigid support such as is obtained from the "potting" of a fiber bundle inside a cylinder. Feed f low is either down the interior of the fiber or around the outside of fiber. Packing density is medium and fouling resistance is high.

Hollow Fine Fiber
Also similar to the tubular element in design, the hollow fine fibers are very much smaller in diameter (about the diameter of a human hair). Feed flow is from outside to inside. Packing density is very high, but fouling resistance is very low. As a result, this configuration is generally not applicable to pollution control applications.

Plate and Frame
This device, similar to a plate and frame filter press, incorporates sheet membrane stretched over a frame to separate the layers and facilitate collection of the permeate. Packing density is low and resistance to fouling quite high.

Spiral-Wound
This device is constructed from an envelope of sheet membrane wound around a permeate tube that is perforated to allow collection of the permeate. Packing density is medium and resistance to fouling is moderate.

Following is a list of important physical characteristics of the various membrane element configurations available today:

Element Configuration	Packing Density *	Fouling Resistance**
Tubular	low	high
Capillary Fiber	medium	high
Hollow Fine Fiber	high	very low
Spiral-Wound	medium-low	moderate
Plate and Frame	low	high

* Membrane area per unit volume of space required.
** Tolerance to suspended solids

As stated earlier, the primary difference between a water purification application and a wastewater treatment application is the much higher recoveries utilized in the latter to make the concentration stream as small as possible. As indicated, these high recoveries exact a price in that the increased osmotic pressures require higher pressure pumps; the higher concentrate concentrations can result in precipitation of slightly soluble materials; and with reverse osmosis and nanofiltration technologies, the lower permeate quality.

TESTING

So how does one determine the efficacy of membrane technology in a wastewater application? The answers are: testing, testing and more testing.

In general, every stream must be tested to determine the following design factors:

- Optimum membrane element design
- Total membrane area
- Specific membrane polymer
- Applied pressure
- Maximum system recovery
- Flow conditions
- Membrane element array
- Pretreatment requirements

Specific properties of streams which influence the design factors include:

- Stream chemistry
  - Total solids content
    - Suspended (TSS)
    - Dissolved organic (TOC, MBAS, COD, BOD)
    - Dissolved inorganic (TDS)
  - Specific chemical constituents
    - Oxidizing chemicals
    - Organic solvents
    - Saturated solutes
  - pH
  - Operating temperature
- Osmotic pressure as a function of recovery
- Variation in chemistry as a function of time

One or more of the following test procedures should be utilized when evaluating membrane technology with a particular effluent stream.

Cell Test

Utilizes small (approximately 40 sq. cm.) cut pieces of sheet membrane mounted in a "cell" that exposes the membrane to the test solution using the crossflow mechanism. This test is effective for quick evaluation of a number of different membrane polymers to determine degree of separation. The cell test device is illustrated in Figure 4.

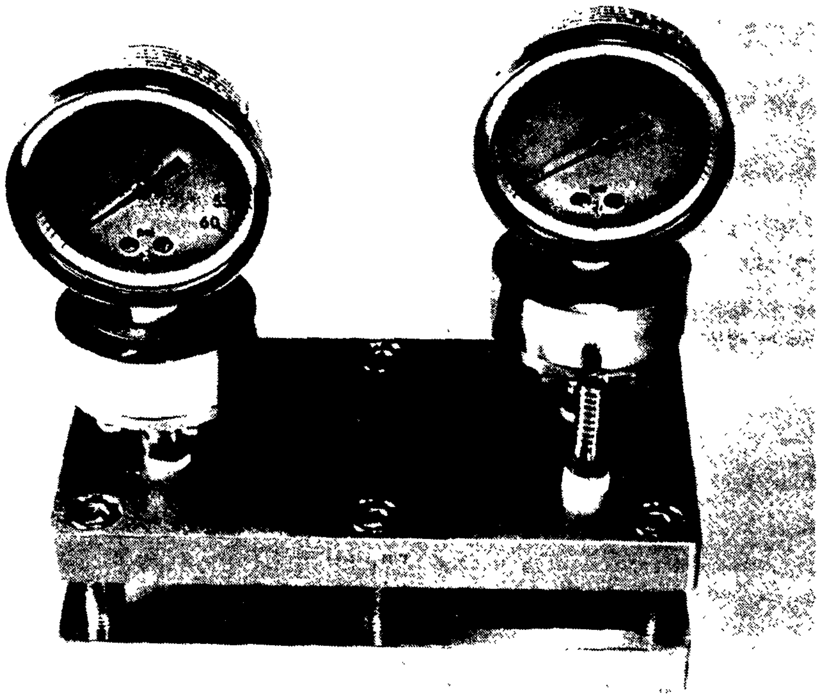


FIGURE 4, Cell Test Apparatus

Advantages:	Fast Inexpensive equipment involved Only small quantities of test solution required
Disadvantages:	Cannot indicate long-term effects of solution on polymer Does not provide engineering scale-up data Gives no indication of optimum membrane element configuration Does not provide data on fouling effects of test solution

Applications Test

This typically involves the evaluation of a 100-200 liter sample of solution with a production-sized membrane element. The element is mounted in a test machine with the engineering features of production systems. For a given element, the test can be completed within 1-2 hours. Figure 5 illustrates the applications test system design.

Advantages:	Fast Provides scale-up data (flow, element efficiency, osmotic pressure as a function of recovery, pressure requirements, etc.) Can provide an indication of membrane stability
Disadvantages:	Does not indicate long-term chemical effects Does not provide data on fouling effects of the test solution

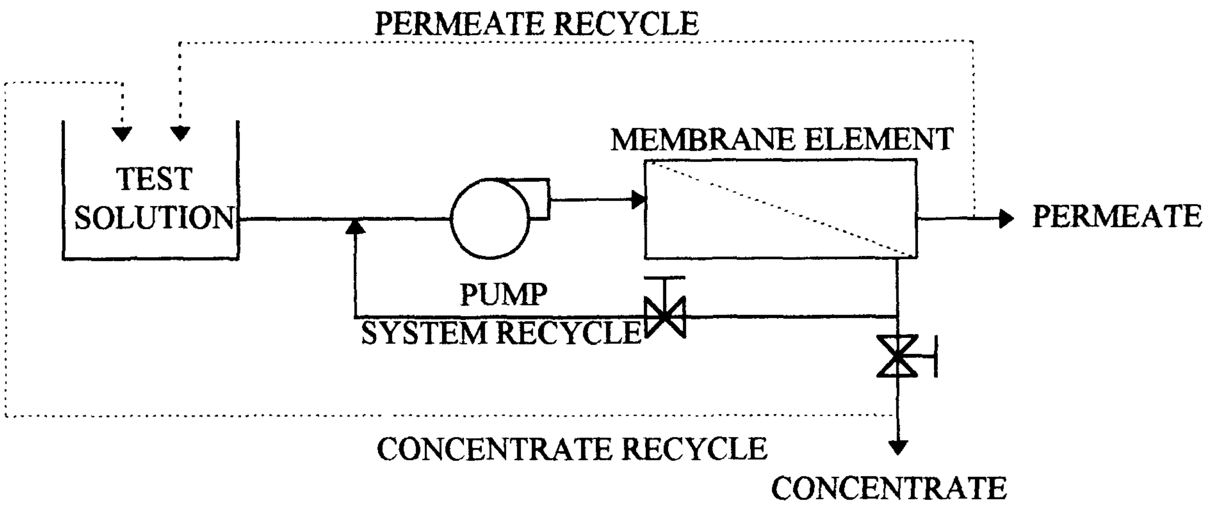


FIGURE 5, Applications Testing Schematic

Pilot Test

Usually this involves placing a test machine (such as that used for the applications test) in the process, operating on a "side-stream" for a minimum of 30 days.

Advantages: Accomplishes all of the functions of the applications test plus provides long-term membrane fouling and stability data

Disadvantages: Expensive in terms of monitoring and time requirements

SPECIFIC APPLICATIONS

Although there are many applications of membrane technologies applied to wastewater streams, the actual number is tiny when considering the total market potential.

Existing applications include reverse osmosis used to recover and recycle electroplating salts in rinse water baths. Chemistries include nickel, copper and zinc, among others.

Ultrafiltration and some microfiltration membranes have proved very effective at separating emulsified oils from machine coolants and aqueous cleaning baths. In some cases, valuable surfactants and emulsifiers pass through the membrane into the permeate stream and can be reused. There are even some cases where the concentrated oily waste can be used as fuel.

Ultrafiltration membranes have been used for years to dewater electrodepostion paint baths. The latex based emulsions are returned to the bath, and the permeate is recycled to the rinse stream; a true "zero discharge" application.

There are a number of "once-off" applictions, primarily concentrating waste components for further processing or transportation to landfills. One such application follows.

CASE HISTORY

A large transportation maintenance facility generates a concentrated wastewater stream from their metal cleaning operation.

Cadmium, a regulated heavy metal, has been found in this stream in concentrations as high as 3 ppm. The wastewater analysis, although highly variable, is represented as follows:

Parameter	Maximum Concentration, ppm
TDS	6000
TSS	1000
TOC	4500
Oil & grease	100

Cartwright Consulting Co. was retained to evaluate membrane technologies to be used to preconcentrate the contaminants prior to studge generation to facilitate removal to a hazardous waste disposal operation. The water obtained during this ""dewatering" activity had to be suitable for discharge to the local POTW or reused within the facility.

An applications test was performed to identify the best membrane candidates, followed by a four month pilot test on a side stream to identify the optimum pretreatment technologies and accumulate long term operating data. The pilot testing revealed that this particular wastewater stream contains "film formers" which tend to coat the surface of normal depth cartridge filters and render them largely ineffective for pretreatment.

The optimum pretreatment, in this application, was determined to be crossflow microfiltration, which effectively reduced the potential foulants (suspended solids, oil & grease) ahead of the spiral wound membranes.

In one location, the permeate is to be discharged to surface water. This requires an extremely low concentration of cadmium. Testing with a reverse osmosis membrane consistently produced permeate streams with cadmium concentration below the analytical detection level of 0.02 mg/L.

The other location uses a municipal wastewater treatment plant to accept the permeate. This POTW discharge limit for cadmium is 0.26 mg/L. A nanofilter membrane produce a permeate stream which consistently met this requirement.

The outcome of this program was the design of one 10,000 gpd reverse osmosis system and 2 - 20,000 gpd (each) nanofiltration systems for the one client. 2 of the 3 systems have been constructed and are satisfactorily treating the effluent from the 2 locations.

CONCLUSIONS

The time is right for the serious integration of membrane technologies into wastewater treatment and processing applications. The potential user needs to understand and appreciate the flexibility and diversity of currently available membrane polymers and element configurations.

As the user recognizes the attributes of membrane technology and the provider displays proficiency in process evaluation, waste stream testing and system design, membrane technologies will become standard unit operations in the lexicon of waste treatment.

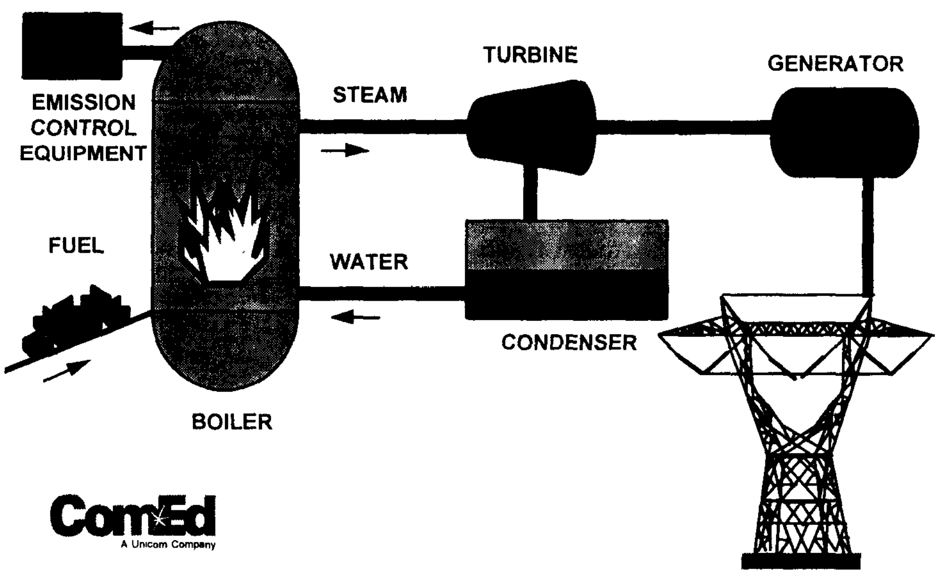
Jennifer Cawein

Commonwealth Edison

ComEd's Pollution Prevention Strategy:

Life Cycle Management

PRODUCTION OF ELECTRICITY



ComEd
A Unicom Company

Life Cycle Management Definition

Life Cycle Managment is the process of strategic asset management. It is the systematic consideration of the total life cycle of an asset, from effective design and aquisition to prudent consumption and disposition.

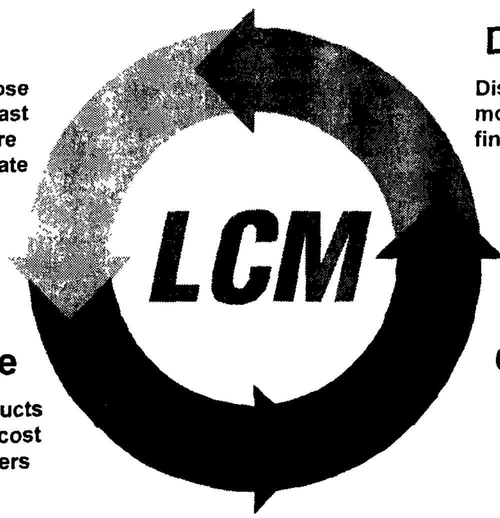
Life Cycle Management

Design

Design or choose products that last longer, are more efficient or create less waste.

Dispose

Dispose of what's left more economically or find other uses for it.



Acquire

Acquire products that actually cost less than others over time.

Consume

Consume products more efficiently.

LCM Guiding Principles

- Reduce life cycle costs
- Extract the greatest value from each asset
- Share responsibility through teamwork
- Promote environmental stewardship

ComEd's Strategy for Implementing Rapid Pollution Prevention Improvements

- Create LCM staff separate (but closely aligned with) environmental group
- Explore grassroot employee ideas
- Encourage the team concept
- Incorporate environmental concerns into business decisions

ComEd LCM Projects

- Chemical Commodity Replacement Program
- Waukegan Retired Equipment Removal
- Dehumidification - Biofouling Control without Biocides
- Wood Pole Re-Use Project
- Expansion of Coal Ash Reclamation Program

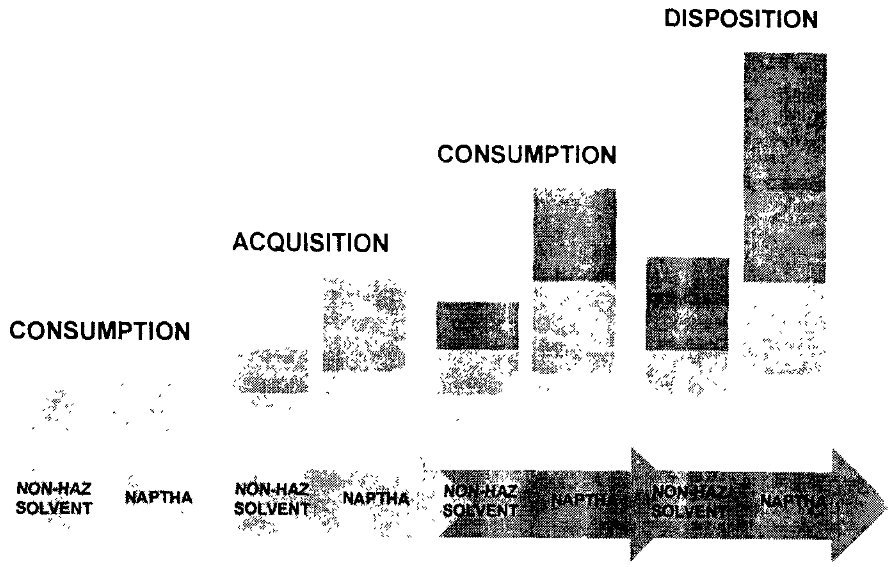
Chemical Commodity Replacement Program

- Accounting
- Cross-functional team
- Goal: Reduce inventory, create safe working environment, minimize waste, lower costs

Result: Replacement of over 100 different solvent commodities with non-hazardous alternatives AND annual cost savings of $61,000.

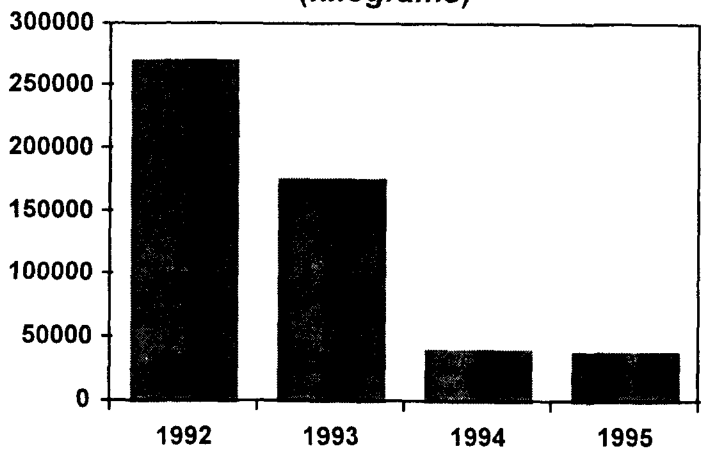
Applying Life Cycle Management

Solvents



Chemical Commodity Replacement Program

Hazardous Solvent Minimization (kilograms)



Waukegan Retired Equipment Removal

- Vendor & supplier partnerships
- Innovative contracts

Result: Every scrap of recoverable material is recovered and not discarded.

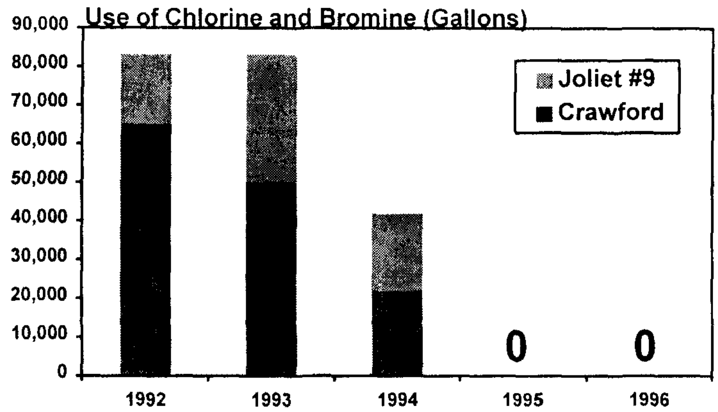
Biocide Use Reduction

Thermal Controls & Dehumidification

- Cross-functional team
- Innovative technologies

Result: Elimination of chemical biocides (bromine and chlorine) AND estimated capital cost savings of $700,000 and annual operational cost savings of $67,000.

Condenser Tube Biofouling - Biocide Reduction



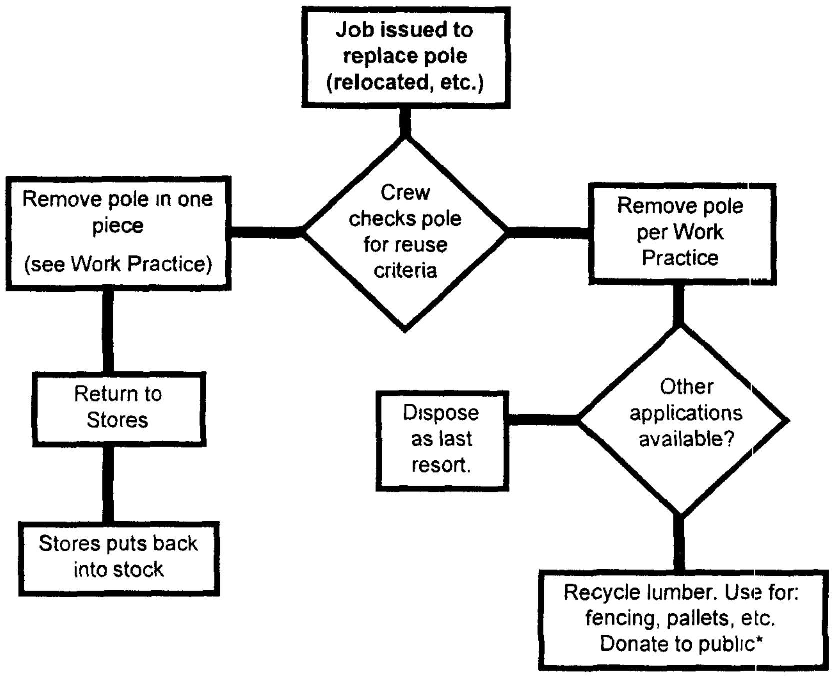
Data from two ComEd generating stations, able to fully utilize dehumidification to control condenser tube biofouling, show how they have eliminated the use of chemical biocides.

Wood Pole Re-Use Program

- **Search for Opportunity (SFO)**
- **Cross-functional team**
- **Goal: Investigate cost-effective, environmentally responsible opportunities in the management of used poles**

Result: **Save trees, avoid landfilling, with anticipated cost savings of $100,000 per year.**

Wood Pole Re-Use Program

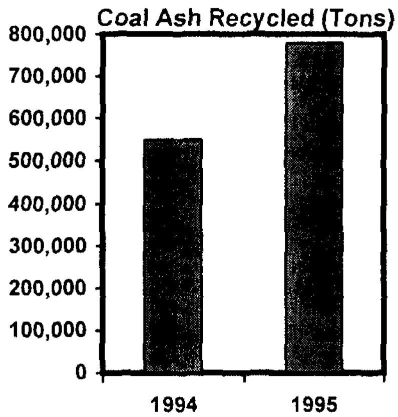


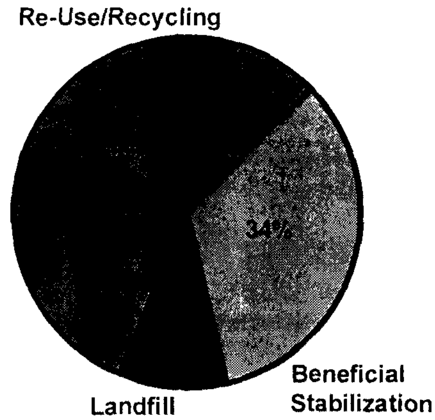
Coal Ash Reclamation

- Vendor partnership
- Innovative technologies

Result: **Nearly 90% of ComEd's coal ash was kept from commercial landfills through recycling and beneficial stabilization.**

Expansion of Coal Ash Reclamation Program





LCM Key to Our Effective Strategy

- Organized approach
- Dedicated LCM staff (drawn from business)
- Grassroot employee ideas
- Cross-functional teams
- Partnering with vendors & suppliers

Phebe Davol

A.T. Kearney, Inc.

<u>**PHEBE DAVOL**</u>
A.T. Kearney

Ms. Phebe Davol is a Project Director and certified professional soil scientist with A.T. Kearney, Inc. She has over 15 years of experience in various projects involving investigations/remediation projects, environmental regulations and engineering processes for management and treatment of hazardous wastes. She as a B.S. and M.S. from Texas A&M University.

Recent projects include assisting EPA and states in working with the regulated facilities to develop strategies for investigating and remediating sources of contamination under the RCRA Corrective Action Program. She is also currently involved in developing training courses for EPA and state regulators as well as the regulated community. The courses encompass many areas of the RCRA program including Corrective Action, Sampling Procedures, the conduct of inspections for storage treatment and disposal facilities, as well as compliance with groundwater monitoring requirements. Her interest in the Texas Clean Industries 2000 program began in 1995 when she returned to her home state of Texas and began working with the Texas Natural Resource Conservation Commission (TNRCC) on various projects in several programs.

TEXAS CLEAN INDUSTRIES 2000 PROGRAM-1996 UPDATE

Phebe Davol
A. T. Kearney, Inc.
Dallas, Texas

and

Robert Borowski
Texas Natural Resource Conservation Commission
Austin, Texas

Texas generated approximately one-third of the nation's hazardous waste total in 1991 and is ranked fifth in the nation in the number of large quantity hazardous waste generators. Beginning in 1991 with the passage of the Waste Reduction Policy Act and the Omnibus Recycling Act, the Texas Legislature directed the Texas Natural Resource and Conservation Commission (TNRCC) to create programs that would help facilitate voluntary pollution reductions, including technical assistance programs, pollution reduction incentives and a statewide public education and awareness campaign. To manage these initiatives, the Legislature required TNRCC to establish an office of recycling and waste minimization and an office of pollution prevention and conservation. In response to these mandates, the TNRCC created CLEAN TEXAS 2000 to bring these mandated programs under one unifying theme.

Clean Industries 2000, a program developed from the Clean Texas 2000 initiative, is a national model for government/industry/public cooperation in the environmental arena. It is currently the nation's largest statewide environmental public-private partnership to address industrial pollution. Texas' Clean Industries 2000, asks industrial facilities to achieve a 50 percent reduction in volumes of hazardous waste generated and/or releases of pollutants and contaminants into the environment by the year 2000 from 1987 baseline levels. Membership in this program is based on four commitments by industry. These are a commitment to reduce hazardous waste, toxic release inventory (TRI) releases, or both; a commitment to develop an internal environmental management program; a commitment to implement a citizen's communication program; and a commitment to perform a community outreach project.

Since it's advent, Clean Industries 2000 members have pledged to reduce hazardous waste generation by 68 percent and toxic chemical releases by 62 percent. Since 1992, actual reductions of hazardous waste have been 15.3 million tons. In the past three years, the program has grown to 147 Clean Industries 2000 member facilities. In 1994, Clean Industries 2000 members continued to make progress by reducing their hazardous waste generation by 5.9 million tons, a 6.6 percent reduction in one year. Clean Industries 2000 members now participate in or sponsor 515 community environmental projects across Texas, including 154 educational programs, 66 cleanups, 57 recycling programs, 47 household hazardous waste collection programs, 42 scholarships, and 32 nature preserve and habitat restoration programs. In addition, the facilities have established or participate in 152 citizen communication programs which provide regular forums for the discussion of environmental issues between facility managers and members of the community. Programs include 90 citizens advisory panels, 30 facility open houses and 32 environmental ombudsmen.

Advantages to participating in the program include improving public relations and outreachability. As an added benefit, the participant receives pollution prevention technical resource and service assistance from the TNRCC. Companies who join Clean Industries 2000 receive public recognition for their commitments to pollution prevention. Members are recognized with a letter from the Governor of Texas and local press releases. Members are highlighted in the CLEAN TEXAS 2000 newsletter and are able to use the CLEAN INDUSTRIES 2000 logo. Each year the annual Governor's Awards Banquet for Environmental Excellence is held to recognize CLEAN TEXAS 2000 participants with outstanding environmental projects and accomplishments. Finally, all CLEAN INDUSTRIES 2000 members are special honorees each year for their commitment to pollution prevention and receive special recognition from the governor.

This paper conveys the program's goals, discusses mechanisms to achieve the program's four commitments, and provides an overview of the program's success. The presentation consists of a 15 minute video highlighting case studies from actual Clean Industries 2000 facilities.

Texas' Clean Industries 2000 Program Goals

Clean Industries 2000 participation is offered on a facility basis. Participants must meet four criteria:

1. Commit to carry out a pollution prevention plan that will reduce TRI chemical releases and/or reduction of hazardous waste that is disposed of or released to the environment, fifty percent or more from 1987 levels by the year 2000.

2. Implement an internal environmental management program to assure high levels of environmental compliance with state and federal standards.

3. Participate in a citizen communication program.

4. Participate in one or more community environmental projects each year.

Mechanisms for Achieving Goals

The TNRCC's Permanent Pollution Prevention Program (P4), an eight step workshop prepared by the TNRCC, is one mechanism used to assist Clean Industries 2000 members in achieving the four criteria. The following eight steps apply total quality management (TQM) principles to develop a program to implement pollution prevention ideas. The goals of a permanent pollution prevention program are to eliminate end of pipe thinking, establish permanent pollution prevention programs at facilities, have facilities form partnerships, reduce environmental impacts and maintain economic competitiveness. The video highlights each of the steps.

1. Management Proclaims Support

Management support may involve an evaluation of the total costs of a waste stream, a determination of the true savings of a pollution prevention project, and assessment of the benefits of achieving "beyond compliance". In order to formally initiate the program, a new mission statement and company policy should be developed or renewed. Management should involve the whole team in the final version of the mission statement and policy. The policy should reflect teamwork and a sense of ownership.

2. Select Pollution Prevention Team

Employees are the first to recognize the problems because they are on the firing line therefore are the most appropriate team members. The team may be developed from existing teams such as those from the Safety or Quality Assurance/Quality Control. The team should consist of a mix of management and line workers. The team should have representatives from each department. Representatives serve as volunteers and alternates. Benefits of the team approach include workers who are more receptive to change, managements confidence is increased and there are fewer departmental "turf battles".

3. Select Team Leader

The Team Leader should be selected from and by the team. The leader does not necessarily need to be the environmental manager but should exhibit enthusiasm for the program and be respected by both management and workers. Team leader skills include strong communication and organization capabilities, effectiveness as a project manager, possess team-building skills and have the ability to handle multiple tasks. Examples of the team leader's duties will be to chair meetings and publish the agenda, list and track task assignments, link to outside organizations and keep upper management informed.

4. Educate the Organization

Educating the organization requires three phases. The phases are to educate the team, educate management and then educate line employees. Team education consists of reviewing the facility and waste streams, determining any environmental impact off-site, determining the economic costs and reviewing environmental health and safety issues.

As the first phase, the team tours the facility in order to understand the process and to look for good pollution prevention examples. The team is further educated by reviewing the results of the reviews and tour. Through the findings, the team identifies main waste issues, outlines action items, and formulates program goals. These are presented to upper management. Through management's guidance the team develops a presentation which concentrates on important issues, and proposes goals, through the inclusion of success stories. The goal of the management presentation is that it educates on the costs and liabilities, and shows that pollution prevention can save money. At this point the mission statement can be formalized/presented and obtaining support for the program goals can be achieved.

Finally, in order to educate line employees the team takes the information back to the respective department. The team representative reviews the mission statement and goals with the employees, uses photographs/slides to illustrate points, and describes the environmental and economic costs. Emphasis on the importance of their ideas are essential.

Once employees understand the economic and environmental impact of their actions they will want to do their part in reducing waste. It is management's responsibility to provide the supporting structure to help employees implement a permanent pollution prevention program.

5. Brainstorm Ideas

The best place to look for ideas is your employee resource. The employees are the most knowledgeable about where to reduce and prevent waste. Brainstorming meetings facilitate the generation of ideas. During the meetings, write down all presented ideas and let everyone have a say and withhold judgement. Alternative means to gather ideas are through circulation memos and suggestion boxes. Where there is a financial incentive to respond are the most successful.

6. Evaluate Ideas

In order to evaluate ideas, selection and screening criteria should be developed. Considerations include the amount of effort and time required, health and safety as well as regulatory compliance, the cost of the project/availability of funding, impact on personnel/training, high visibility for promotional efforts and impact on the community. The team should develop a proposal for management. This proposal will determine a baseline of costs/wastes, project benefits to the company, show buy in by workers and address uncertainties.

7. Implement Ideas

In a study conducted of 350 executives in 1994, management identified barriers for change were due primarily to a lack of organizational buy in. Other barriers include no senior management champion, lack of skills or experience, turf battles, and lack of appropriate rewards.

In order to implement ideas, the most obvious is to address the "low hanging fruit" first. This will build program momentum, win support for complex projects and builds confidence in the program. As part of the implementation, barriers and uncertainties should be addressed. Quantification of the results should be made and then be remeasured. Examples of quantification would be to take before and after photographs/slides and documenting all savings.

8. Continue the Process

In order to continue the process, upper management support is imperative. Pollution prevention should also be on the agenda and added to merit reviews. Good ideas should be rewarded and there should be support for promotional activities. Promotional activities keep the program going. These promotions can be announced, placed in newsletters or on bulletin boards, or publicized through awards.

Successes should be documented through the local press, having open houses for the community, ideas should be transferred throughout the corporation. Communication of the success to the regulatory agency will enable information sharing with other industries. By forming partnerships with suppliers, customers, contractors, local companies, governmental agencies, and community groups, the process will continue.

Overview of Program's Success

Texas leads the major industrial states in reducing the amount of pollution produced by industrial facilities in 1993, according to a report released in March 1995 by EPA. Data compiled for the national TRI show Texas, with 60 percent of the nation's petrochemical production capabilities and 25 percent of its oil refining capacity, in the forefront of industrial reduction efforts.

Members involved in the Clean Industries 2000 are achieving substantial results in reducing the amount of toxic emissions or hazardous waste generated. The following examples are all based on normalized data. From 1992 to 1993, for example, Phillips Petroleum's Sweeny Complex reduced toxic releases by 488,000 pounds by enclosing a wastewater treatment system and recovering vapors, recycling catalysts, and establishing more reliable operations to prevent upsets. During the same period, DuPont's Victoria facility reduced toxic releases by 734,000 pounds by recycling nitric acid and installing a thermal incinerator to reduce emissions.

Other Texas industrial facilities are implementing similar measures. Mobil Oil Corporation's Beaumont Refinery reduced TRI on-site releases by over 500,000 pounds from 1992 to 1993, even with an increase in production. The facility implemented a fugitive leaks program that reduced methyl ethyl ketone and toluene emissions, installed carbon canisters on tanks to reduce hydrocarbon emissions, changed cooling tower technology to eliminate chromium and zinc compounds from release, and installed a scrubber to reduce hydrogen chloride and chlorine emissions. Amoco Chemical, located in Alvin, reduced hazardous waste generation by 99 percent, almost two million tons - by installing a system to recover hydrocarbons now used in the production process.

ARCO Chemical's Bayport production facility reduced on-site releases of TRI chemicals by 22 percent from 1992 to 1993, largely from improvements in chemical processing that prevent chemical losses into the plant wastewater collection system. These improvements reduced on-site releases by 560,000 pounds and off-site transfers for treatment by 1.6 million pounds. Shell Oil Company's petrochemical facility and refinery in Deer Park reduced the amount of hazardous wastewater generated by 9.4 million tons each year. Plant operators reuse benzene and keep it out of the waste stream.

The Phillips 66 Borger Complex, a petroleum refinery, is one of the first participants in TNRCC's new flexible Permit Program. The flexible permit is a joint effort between Phillips 66 and the TNRCC to reduce air emissions by replacing multiple permits with a single permit which sets maximum allowable emissions but allows facility managers to decide how to meet the requirements. Under the terms of the permit, emissions are decreased during the next 10 years. By the final year of the permit, in 2005, total emissions will be reduced by 13,000 tons per year, a 40 percent reduction.

The Huntsman Corporation Organic Chemical Research and Development Center in Austin installed the first commercial-scale Supercritical Water Oxidation Unit developed jointly by Eco Waste Technologies and the University of Texas at Austin. By using this unit, Huntsman will be able to reduce its releases and transfers of waste methanol reported under the Toxic Release Inventory (TRI) program by 93 percent.

The Amoco Chemical Company in Texas City involves 560 employees in an ongoing Responsible Care Program that has encouraged source reduction and waste minimization projects since 1991. Several projects have cut Toxic Chemical Inventory emissions by 65 percent from 1988 levels and hazardous waste generation by 99.9 percent from 1983 levels. Successful projects include elimination of 500,000 pounds of hazardous waste and reductions in the use of chlorinated solvents. Amoco also has established a comprehensive community outreach program that includes other Amoco sites, fellow industries, schools, civic groups and environmental organizations.

Future plans for the Clean Industries 2000 staff and Team members includes working to develop the next phase (Clean Industries Plus) beyond compliance, which is a voluntary program to further encourage pollution prevention and community programs. The Clean Industries members currently are working with representatives of the Clean Cities 2000 program to provide mentorship in pollution prevention projects and leverage resources.

In conclusion, the Clean Industries 2000 program has created productive and viable partnerships between government, environmental groups and industry. Specific questions regarding the program may be directed to Mr. Borowski at 512-239-3187.

Resources utilized to prepare this paper include the following documents.

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POLLUTION PREVENTION AND ENERGY ASSESSMENTS AT A SMOKELESS TOBACCO PRODUCTS MANUFACTURER & AN INDUSTRIAL LAUNDRY

by

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Industrial Assessment Center

Introduction

Using engineering-student faculty teams, the U.S. Department of Energy sponsored Industrial Assessment Center at the University of Louisville does free pollution prevention, energy, and productivity assessments at small to medium size plants in Kentucky and Indiana (Fleischman, 1996). Assessments at an industrial laundry and a manufacturer of smokeless tobacco products are briefly described, with an emphasis on waste minimization/pollution prevention.

Smokeless Tobacco Products

The plant produces loose leaf, plug, moist snuff (a fermented product), and smoking (pipe) tobacco. They also do silk-screen printing on and packaging of about 75 million butane lighters per year. There are about 350 employees, and annual sales of the 30 million pounds of tobacco products (at 21% moisture) are between $80 million to about $100 million, including the lighter operation. The entire facility is housed in one building of about 10 acres (400,000 ft^2).

Leaf yields vary with type of leaf, for example cigar (large leaf) and sumatra (small leaf). Production efficiency is generally about 75-80% leaf yield and as low as 50% on some grades. 80% yield means that 20% of the incoming tobacco leaf (including stems) is not converted into product , i.e., about 7.5 million lb./yr. is wasted, most of it being landfilled or composted. **Figure 1** is a process flow diagram for the loose leaf process line. There are three other similar manufacturing lines at the facility which are similar to the loose leaf line. **Table 1** summarizes waste generation and disposal costs for the entire plant.

Process Description:

Receiving

Cured tobacco received in bales, burlap bags, or boxes, is unloaded by hand onto a conveyor, from where it is unloaded by hand onto racks. Considerable tobacco is lost during unloading because it is dry and brittle, and falls apart and shrinks. There is no guard on the conveyor to prevent falloff. Any tobacco that hits the floor is swept up, along with string, paper, etc. and placed in a general trash dumpster. Mechanical methods of unloading have been tried to reduce this waste, but the leaf got cut up and damaged. Another major limitation to automated unloading is the variety of sizes and shapes in which the tobacco is delivered.

Any product returned from retailers e.g., expired, is shredded (both foil and product) because of scavengers who may have taken expired product from landfills or dumpsters. An excise tax (Bureau of Alcohol, Tobacco, and Firearms) refund is given for the destroyed product, with destruction being required by law. If this product were resold, this tax would have to be paid again.

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Leaf Processing

Stems and wigglers (byproducts) are separated from the leaf in the **stemmary.** Leaf bundles are broken up in the **delaminator**, and tobacco is segregated into different sizes and weights in a **thresher** with **air separators**, ideally removing stems and wigglers from the leaf. Stems are wetted in an **ordering cylinder**, flattened in the **stem mill**, and sent to **bulkers** for blending with the leaf from which they were removed. A **vibrating screen** passes the very fine leaf pieces into an open box. It was observed that the box was not centered, creating the potential of tobacco missing the box or the box overflowing onto the floor. These fines go into the manufacture of pipe tobacco elsewhere in the plant. The leaves then pass through **velcro rollers** and a **magnetic sensor** to remove hair, string, feathers, metal shavings, etc., which are commonplace in the barns where tobacco ages. Metal detectors for pins, baling wire, ferrous & non-ferrous machine pieces are found in several places in most if not all of the product lines. Following metal removal, the tobacco goes to **bulking.**

Dust from the stemmery is captured in the **dust room** in bag collectors through an airlock screw conveyor, and the collected dust is composted. The dust cannot be reused in the tobacco products because of sand, dirt, and wheat seed. If the machines in the stemmary are set wrong, leaves will carry over into the dust collectors. A great deal of dust was observed on the walls and floor. **On average, 75%-80% of the incoming tobacco makes it through the stemmary. Some yields are as low as 50%, and others are as high as 80-85%. It appears that the largest generation of waste tobacco occurs in the stemmary, including the byproduct stems and wigglers.**

The tobacco is layered in **bulkers** (long horizontal silos) and then run through spiral **doffers** (mixers) that turn and shear the different layers to blend them into a uniform product. Mixed tobacco is conveyed to **casing and drying** where weighed and dried tobacco is mixed in wringers with flavoring (liquid casing) such as molasses or dark syrup metered in from the kitchen. Excess liquid is caught in the tub and reused. The plant tries to use the exact amount of materials needed for a batch, but the 15 gal. residual in the 40 gal. reservoir is required to keep the tobacco submerged in the wringer. When the flavoring formulation is to be changed for the next day, the residual flavoring is drained from the reservoir. **There was some confusion as to whether this liquid went to the sewer or was saved for the next run of that formulation. If it goes to the sewer, the residual would probably be the largest or one of the largest BOD contributors.**

The tub and wringer are then sprayed down with hot water from hose, causing splattering and dripping of casings and solids onto the floor. This is the only equipment cleaned at this point because of the stickiness of the flavoring. Without almost immediate cleaning, the flavoring would "glue-up" and intense cleaning would then be required. All of the wash water runs through a dike (which restricts the water to a limited area) and subsequently to a floor drain with a wire mesh basket. The floor is washed at the end of the day by a contractor. **Solids are not removed from the casing equipment by dry (mechanical) cleaning prior to wet cleaning.** Solids from the floor sweeping and the mesh basket go to the dumpster.

In the **kitchen**, water, liquid ingredients from dedicated tank farm pipelines, and powdered flavorings for the casing, are added to steam jacketed kettles for cooking. Glycerin and glycol are used for parts lubrication and to keep product from sticking, as many of the parts come into direct contact with the product. Currently all powdered materials are added from paper bags to the kettles by hand. Empty bags are landfilled, and the company is considering pneumatic loading. To minimize washing frequency, the exact amount of flavoring needed for a batch is used. Thus most kettles are usually empty by the end of the shift and are rinsed daily. Some kettles however, are only emptied and cleaned as necessary, e.g., these will be used again shortly for the same formulation. Lines are rinsed and flushed three times weekly and at the onset of a brand switch. Between brand changes, the flavoring in the line is recaptured, i.e., the initial plug pushed out by the rinse water is stored until the next run of that formulation.

After casing and drying, the tobacco is again fed to a large **bulker** where the flavor sets into the leaf during several hours storage. Then the leaf is conveyed through a wall of **doffers** to thoroughly mix the layers, followed by **drying**. Due to the large amount of flavoring now in the leaf, mostly molasses or dark syrup, **a significant amount of casing (high BOD) drains from the bulker to the floor**. This liquid is washed through the floor drains to the POTW at the end of each shift. The tobacco is again run through a large **bulker** for final mixing prior to **packaging**.

After a series of inspections, 85 grams of tobacco are added to a foil pouch, which is then sealed, boxed, and cased for shipping. Waste foil results from loading new rolls onto the feeder spools, i.e., start up waste, and foil comprises about 90% of the 2 yd^3 dumpster in this area. **Waste pouches containing tobacco are generated in automated packaging due to under/over-filling, improper pouch sealing, empty pouches, torn pouches, etc.** These pouches are blown from the conveyor into adjacent plastic trash bins. It is not clear whether all incorrectly filled pouches are reworked. The assessment team was told that overfilled pouches are emptied back into the front end of the line and the pouch is trashed, and underfilled pouches are trashed with the tobacco.

Waste Generation and Management

Table 1 summarizes waste generation. The company is a limited-quantity hazardous waste generator, and is concerned with possible generator status change to a higher level. Hazardous waste includes solvent and paint wastes from painting (maintenance) cleanup, and spent silk-screen printing cleaner. These are disposed in a fuels program or incinerated. Solvents from the quality control lab to extract nicotine are also hazardous and are burned in an incinerator. Naptha from a leased parts washer service and non-hazardous waste oils, including water based machining coolants, are reclaimed off-site.

The company landfills about 22 million pounds of waste per year at a cost of about $40,000. Landfilled waste includes tobacco, burlap bags, paper bags, aerosol cans, aluminum foil, and incoming lighter trays from butane lighter screen printing About 3.5 million pounds of waste (nearly 100% tobacco) is composted yearly, at a cost of about $28,000. An average of about 40,000,000 gallons of water costing about $56,000 are consumed annually in tobacco processing, and approximately 60% is discharged to the POTW (Publicly Owned Treatment Works) without any pretreatment. Annual sewer bills average about $57,000/yr., plus quality surcharges of about $36,000 per year for biochemical oxygen demand (BOD_5) and total suspended solids (TSS) above 400 ppm, respectively

The assessment team's observations include:

- Tobacco falling to the floor from equipment such as conveyor belts and during unloading in receiving
- Tobacco leakage through or from equipment, e.g., dust collectors, between the head roller and a cutting knife on one unit, and under a drier

- Tobacco clingage to equipment, e.g., sides of conveyor belts, because it is wet and sticky, requiring equipment washdown

Equipment washdowns carry tobacco solids and associated sorbed flavorings onto the floor and into the sewer. Also, some of the tobacco solids that hit the floor (from conveyors, etc.) enters the sewer when the floors are washed down.

Conveyors are not covered (to accommodate periodic visual tobacco inspection and sampling) leading to product falloff to the floor and dusting, particularly when transporting dry leaf. Airborne particles collect on equipment, walls, and floor. In addition, most conveyor systems are not optimally placed at points where tobacco transfers between 2 belts. Thus, at direction changes, i.e., turns or drop-offs, tobacco sticks to the conveyor's metal sides and/or spills to the floor. **Throughout the plant, any tobacco that hits the floor is landfilled.**

Waste tobacco, which ends up in the landfill, compost, or wastewater effluent, is generated in almost every operation observed during the plant tour. An estimated 1.7 million lb/yr. of waste thus results in large solid waste hauling and disposal fees, POTW quality surcharges, and labor for on-site waste handling. In addition, the lost product value and associated production costs to the point of waste generation is estimated at $6.9 million/yr.

Assessment Recommendations (ARs)

Energy

Recommendations for energy conservation are summarized in **Table 2**. Additional energy conservation measures considered but not costed, out include:

. Light timing systems in areas occupied only during certain periods
. Set back thermostats in temperature controlled areas such as offices
. Preheating inlet boiler air using the exiting stack gas

Waste

Potential pollution prevention/waste minimization recommendations are summarized in **Table 3**. Estimated waste reduction from implementing the suggested ARs could be as high as 6.1 million pounds of solid waste. In addition, the current amount of hazardous waste generated could be reduced by as much as 790 pounds per year. Implementing the hazardous waste reduction suggestions could avoid the possibility of a higher waste generator status. The total potential net annual savings that could be realized by implementation of all 3 ARs is estimated at about $32,000/yr. Other potential pollution prevention/waste minimization opportunities that were identified but not costed, out include:

. Standardization of paints to reduce the number of different types of paints used in plant maintenance
. Reuse plastic trays from incoming lighter shipments
. Put empty canvas bags from tobacco delivery on a waste exchange
. Extend machine shop coolant life by: using deionized water, adding biocides, aerating sumps, recirculating coolant during down time, and keeping trash out of the sump.
. Get powdered kitchen ingredients in bulk containers rather than paper bags
. Recycle steel banding from incoming materials shipments as scrap metal
. In Packaging, place the weight sensors before the pouch sealer to avoid over or underfilling, and otherwise make reject pouches with tobacco available for rework.

. Use catch pans in the Cutting and Bulking area to prevent excess flavoring from draining to the floor and reuse the captured material

Several additional potentially important waste reduction ideas listed below, could not be addressed adequately. These areas should be explored as the potential for savings and waste reduction is significantly greater than for the above mentioned ARs:

1) Reducing the amount of water used in processing and therefore wastewater volume
2) Reducing the surcharges levied by the POTW
3) Preventing tobacco wasting (or recovery of waste tobacco) for greater finished product yield.

Each pound of finished tobacco requires about 1.3 gallons of water. This ratio could be reduced by dry-cleaning or mechanical methods prior to water washing of equipment. Also, more use of high pressure water spraying would reduce water consumption. Mechanical (dry) cleaning of equipment prior to aqueous washdown would also accomplish:

- Recovery of tobacco for possible reuse or alternative uses
- Keeping solids from the floor and drain during washdown, thereby reducing labor for sweeping, and cleaning drains, which in turn would decrease POTW quality surcharges.

Removal of solids prior to washdown can also reduce soluble BOD by eliminating solubilization of flavorants sorbed on the tobacco solids. Potential dry cleaning methods include:

- Continuous or periodic compressed air blowing
- Sweeping or scraping residual tobacco from equipment

A preliminary economic analysis indicated that even a 3 year payback would be difficult to meet for treating the final effluent for TSS and BOD surcharge removal. Depending upon the number and nature of individual wastewater sources, it might be more feasible to treat strong waste streams at their source. For example, belt casing wash water showed TSS as much as 300 times that of total effluent and total and soluble COD up to 5 times greater. Total effluent flow rate is almost 5 times as great. Thus smaller units, lower space requirements, and more flexibility in treatment methods are possible. Because of the much higher wastewater COD (and by inference, high BOD), a relatively high percent BOD reduction should be achievable at the source by ozone or hydrogen peroxide oxidation.

Available data indicate that the smaller sized particles contribute more significantly to the COD. This suggests that microfiltration could be effective in removing TSS and associated BOD surcharges. However, because of the stickiness of the tobacco, filtration could be difficult, and flocculation/coagulation (or electrocoagulation) followed by settling might be more appropriate. Since most of the solids readily settled in beaker and centrifuge tests, a hydroclone might also be effective.

Additional benefits from reducing tobacco wastage are further illustrated by using night cleaning (major source of waste tobacco to composting and effluent to the POTW) as an example. If all the solids could be recovered and used in processing, the savings could be as high as $6,800,000/yr. Conservatively estimating that only 10% of the lost value can be recovered, a one year payback would require an investment of no more than $680,000, not accounting for reduced POTW surcharges and cleaning labor. It would seem that a lot of tobacco could be recovered by an investment of this magnitude, and some potential measures described below should involve little or no operating costs.

- **Cover conveyors in receiving and throughout the processing lines.** Hinged clear plastic covers would allow tobacco removal at selected points for unloading, sampling, and visual inspection. Perhaps only the sections where falloff or dusting is greatest would have to be covered.
- **Strategically placed containers** to catch and prevent tobacco from hitting the floor and becoming "worthless", e.g., catch pans below conveyors. For example, a vibrating screen is used to collect the very fine leaf pieces into an open box. Centering the box would reduce the potential of tobacco missing the box or overflowing.
- **Reduce product losses from transfer between belts** with strategically placed sterile catch pans or boxes below the intersections. Covers at these points would deflect falling tobacco onto the lower belt. Another approach is to **redesign** the conveyor systems to avoid or minimize changes in direction, i.e., drop-offs, turns
- Switch to **enclosed air blowing** (conveying systems). This would require a partial or complete redesign and new equipment. Compressed air costs would be a primary consideration, and additional air compressors might be necessary
- Reduce dust room leakage by tightening up the system and initiating a preventative maintenance program
- Increase or extend height of conveyor side walls
- Wider conveyors
- Belts with **better release characteristics** to reduce tobacco sticking, e.g., nylon surfaces rather than metal at conveyor turns, coating or spraying belts with non-stick material, e.g., Silicone, Teflon. This can this lead to product recovery and reduce the amount of solids washed off of equipment, some of which gets into floor drains and the sewer..

Of the above measures, replacing current conveyors with a closed air blowing system should be the most effective, but could also be the most expensive. **Priority could be given to covering conveyors and reducing product losses at transfer points between conveyor belts.**

Industrial Laundry

The facility rents and launders uniforms, shop towels, shop aprons, coveralls, and other items for a variety of manufacturers. There are about 120 employees, and annual sales are about $8,000,000. Washing is done in seven washers, and subsequent drying in 5 gas fired dryers. Approximately 7,000,000 lbs. of laundry is processed annually. **Figure 2** is a process flow diagram and **Figure 3** shows the water flow. **Table 4** summarizes the waste generation.

An estimated 13 millon gallons of process water are consumed annually. Sewer bills are based on the amount of water purchased rather than what is actually discharged to the POTW. Lint, dirt, sand, and metals pieces (nuts, bolts, etc.) are removed from the washer discharge (waste)water by a series of stationary screens and one vibrating screen. POTW surcharges are incurred for BOD above 250 mg/l. and for TSS above 275 mg/l. Heat from the wastewater is reclaimed in a shell and tube heat exchanger to preheat incoming city water. Modification of the pretreatment system is a priority, since the facility was in significant non-compliance for oil and grease, with a potential penalty of $10,000/day. The facility does not have a preventive maintenance program, but one is being developed.

The plant is not a hazardous waste generator nor a SARA 313 TRI reporter. Air permits are not required for the dryers which have baghouses to remove particulates. A wastewater discharge permit is required by the POTW. A small amount of waste hydraulic oil generated from washer, dryer, and compressor changeouts is reclaimed off-site. Pit sludge (containing dirt, oil, grease, and other solids) are landfilled as special waste. All other wastewater solids are landfilled as general trash.

Assessment Recommendations

Table 5 summarizes energy conservation recommendations Additional energy suggestions not costed out include:

- Light timing devices
- Set back thermostat
- Boiler air preheat
- Switch to lower Industrial Power rate from General Service rate
- Insulate dock doors
- Reduce leaks in compressed air lines

Table 6 summarizes potential waste minimization recommendations. Reuse of the relatively clean rinse waters in the early stages of subsequent wash cycles would save water and associated sewer charges. Additional piping and trenching and washer reprogramming would be necessary. A skimmer in the settling basin might consistently reduce oil and grease below regulatory levels, thereby avoiding potential fines and reducing BOD surcharges. However, because free and emulsified oil are present, testing would be required. If O&G removal were insufficient, more expensive removal methods would be required, e.g., coalescers, dissolved air flotation, or membrane separators. In this case it may be sufficient to process only the washwaters from the most oily loads.

Additional waste minimization possibilities not costed out include:

- Segregation of high oil content wastewater
- Redesign pretreatment system following equalization, to provide solids removal prior to heat recovery. This should reduce heat exchanger fouling and float more of the oil for greater removal by skimming
- Additional pretreatment for reduction of TSS and BOD and water reuse
- Optimize and revise chemical usage program
- Re-evaluate criteria for accepting customer items, e.g., require customers to remove excess oil and nuts and bolts
- Increase mixing in solids pit to minimize solids settling and subsequent required pit cleanouts
- Use a shaker or magnetic device to remove metal pieces from laundry prior to washing
- Install a sewer meter and pay sewer volume charges on actual discharge

References

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Table 1 - Tobacco

Waste Generation					
Waste	Operation	Annual Quantity	Quantity per 10^3 lb. of tobacco	Management Method	Annual Disposal Cost †
Effluent to POTW	Process/ Nightly Washing	23,400,000 gal	780 gal	POTW - average TSS: 1081 ppm,	$57,000 ††
Surcharges (BOD,TSS)				BOD: 2853 ppm, and COD: 8323 ppm	$36,000 ††
Dust in dust box	Processing	1,400,000 lb.	47 lb.	Composted	$10,300
Machining Coolants	Process/ Maintenance	40 gal		disposed with waste oil (off-site recovery)	
Paint Booth Filters	Maintenance	15 lb.		stored	
‡ Parts Washer Spent Solvent	"	375 lb.		recovered off-site	$860
‡ Paint Solvents	"	50 lb.		incinerated	
Unmarked Light Ballasts	"	120 lb.		stored for recycle	
Washroom Sludge	"	60 lb.		still in pit	
White Rags & gloves with O&G	"	1920 lb.		previously landfilled, now being stored	
Oil Filters	"	10 lb.		containerized for recycling	
Absorbents (corn cob)	"	408 lb.		stored/ landfilled	
Steel	"			recycled off-site	
Fluorescent Tubes	"	650 lb.		stored for recycle	
‡ Methylene Chloride/ Methanol	R & D / QC	372 lb.		Incinerated	$1,000 total
‡ MTBE / NaOH	"	264 lb.		Incinerated	for all three
‡ Acetonitrile/ Acetic Acid/ Sulfuric Acid/ Methanol	"	852 lb.		replaced with aqueous extractor	waste streams
Ink	Lighter Printing	180 lb.	2.4 lb. *	dried on cardboard and stored	
Used Screens	"	24 lb.	0.3 lb. *	stored	
‡ Solvents (Easi Sol 120)	(screen cleaning)	390 lb.	5.2 lb. *	Incinerated	$1,000
Fiber Drums	Kitchen			dechimed & recycled/ corrugated & steel	
Rags & Gloves	General	480 lb.		laundered	
Corrugated	"			recycled	
Damaged Pallets	"	430,000 lb.	14 lb.	chipped for mulch	$5,600
Tobacco, dirt, etc.	Nightly Cleanup	1,700,000 lb.	57 lb.	composted	$12,000 **
General Trash, includes:		22,000,000 lb.	733 lb.	Landfilled	$40,000
- Tobacco Waste	Processing				
- Burlap Bags	Receiving	1,000 lb. ***	0.03 lb.		
- Aerosol Cans	Maintenance	600 lb.			
- Foil	Packaging	1,800 yd^3 ****	0.05 yd^3		
- Lighter Trays	Lighter Printing	5,000 lb. *****	67 lb. *		
	Total Waste to Compost:	3,500,000 lb/yr			
	Total Compost Cost:	$28,000/yr			

† - Includes 6% tax
†† - Includes 9% tax

‡ Hazardous Waste
* Per million lighters processed
** Does not include hauling cost which is included in cleaning fee.
*** Estimated (14 bags/day @ 0.3 lb.)
**** Based on 90% of 4 2 yd^3 dumpsters per day
***** Estimated (500 per day @ 18g)

Figure 1

Loose Leaf Process Flow

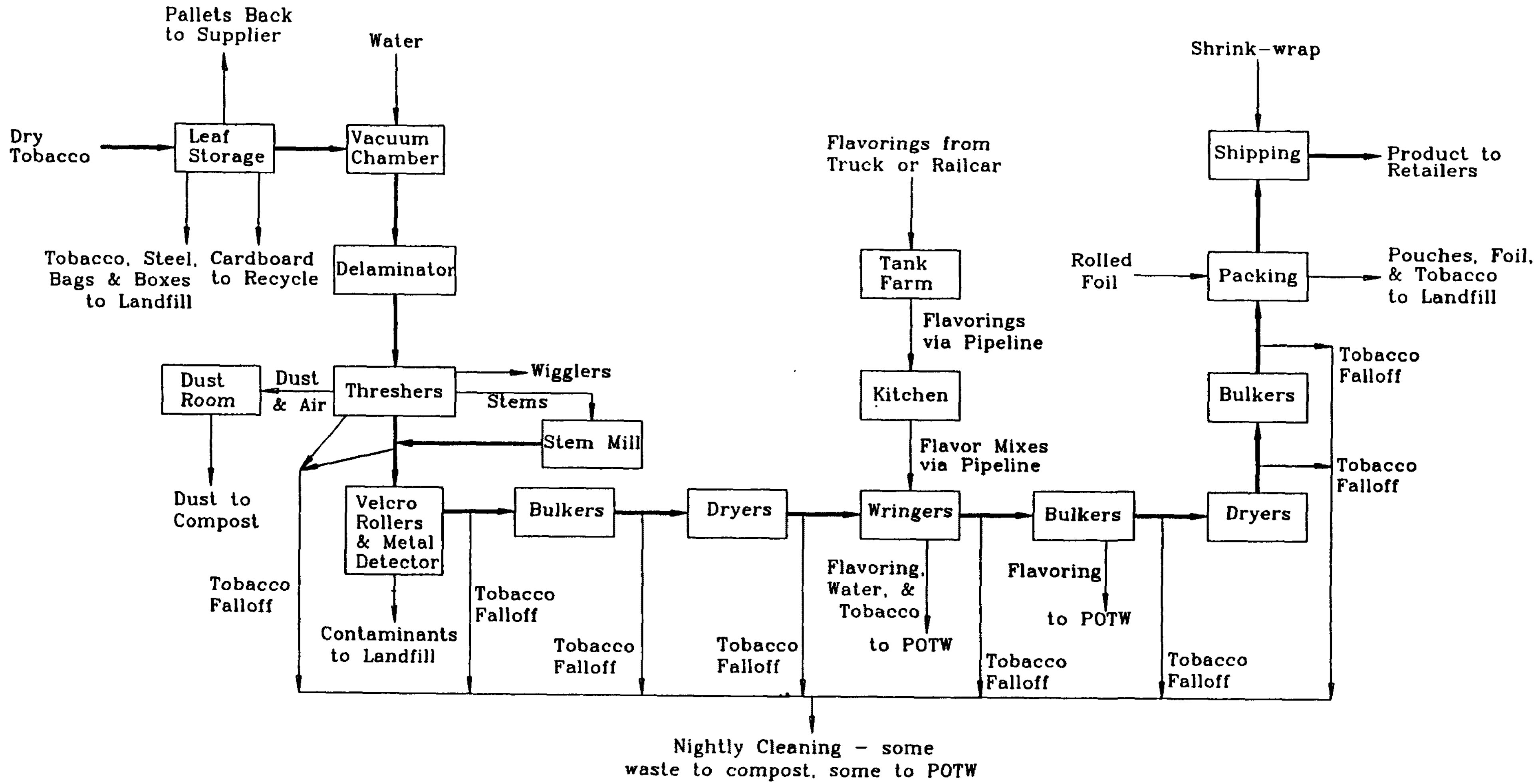

Table 2 - Energy Recommendations (Tobacco) Summary of Savings and Costs

AR No.	Description	Potential Conservation (MMBtu/yr)	Potential Savings ($/yr)	Resource Conserved	Impl. Cost ($)	Payback Time
1	Reduce Compressor Operating Pressure	78	$880	Electricity	$100	1 month
2	Install High Efficiency Motors	462	$4,620	Electricity	$12,140	31.5 months (2.6 years)
3	Adjust Boiler Air-Fuel Ratio	6,331	$16,145	Natural Gas	$2000	2 months
	Total Savings	6,871	$21,645		$14,240	≈ 8 months

Table 3 - Tobacco

Summary of Waste Assessment Recommendations

Current Practice	Proposed Action	Estimated Net Annual Savings
Waste tobacco is either landfilled or composted	Give the waste to potential users through a waste exchange or go through a broker	**Waste Reduction:** 4.2 million lb. **Investment:** Minimal **Savings:** $24,250/yr. **Simple Payback Time:** Immediate
The company is concerned about their hazardous waste generator status increasing from limited to small quantity generator	Reduce hazardous waste generation by using an aqueous-based parts washer and substitute the silk screen cleaner	**Waste Reduction:** 790 lb./yr. hazardous waste reduction **Investment:**[1] $572 **Savings:**[2] $4,677/yr. **Simple Payback Time:** 5.3 months[1] 1.5 months[3]
Waste foil (and some tobacco) generated in the packaging area is landfilled or composted	Give the foil to an Indiana manufacturer for use as a raw material	**Waste Reduction:** 1.9 million lb. **Investment:** Minimal **Savings:** $3,500/yr. **Simple Payback Time:** Immediate

[1] For the substitute parts washer only

[2] Includes administrative & analytical savings

[3] Based on total savings and parts washer investment

Figure 2

PROCESS FLOW DIAGRAM

(Industrial Laundry)

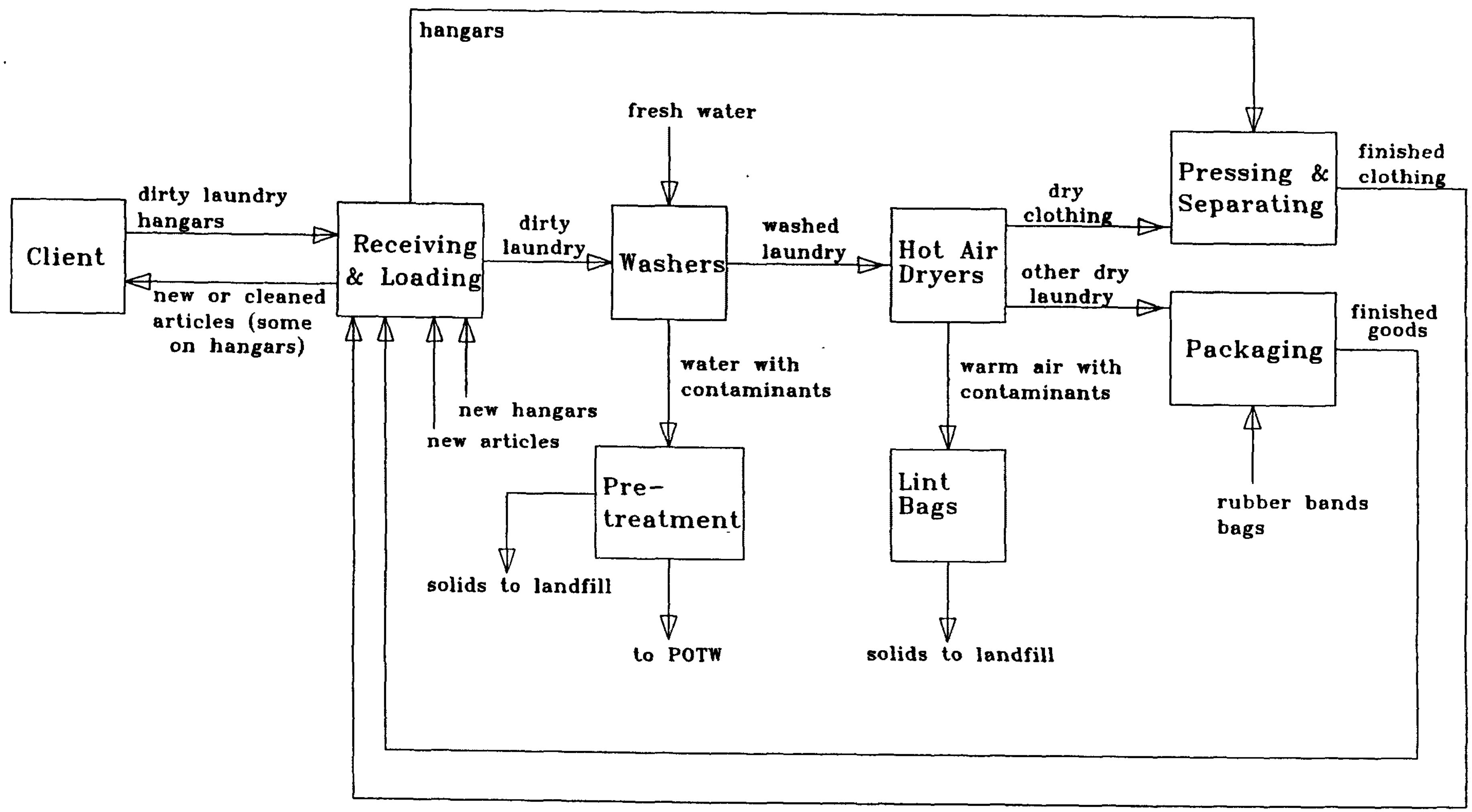

Figure 3

WATER FLOW DIAGRAM

(Industrial Laundry)

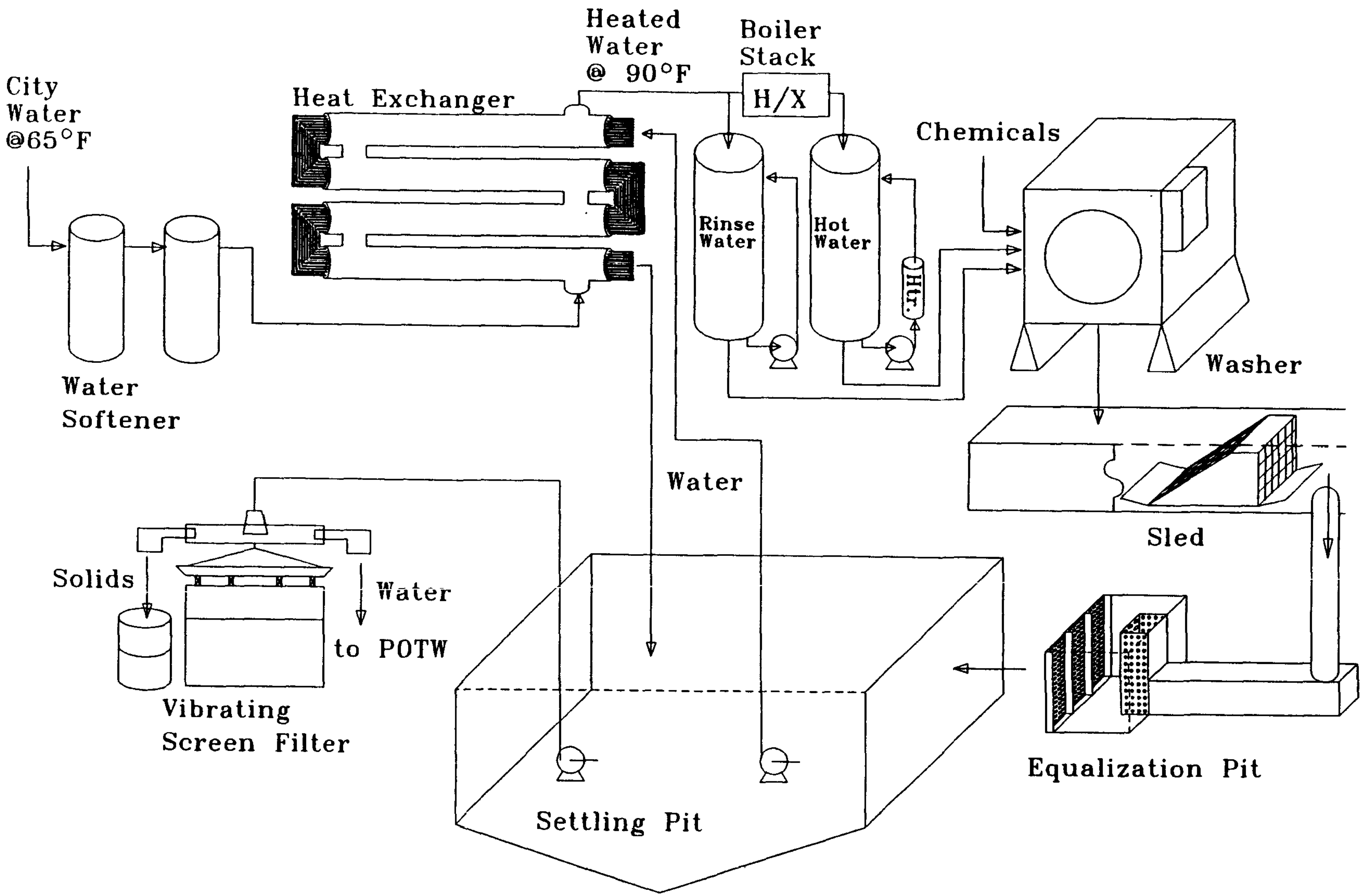

Table 4
(Industrial Laundry)

Waste Generation				
Waste	**Operation**	**Annual Quantity**	**Management Method**	**Annual Disposal Cost †**
Effluent to POTW Surcharges (BOD, TSS)	Washing	13,000,000* gal	POTW	\$29,000 \$10,000
Solids from trench, from sleds, from equalization/screens, from vibrating screen, from dryer exhaust bags. Total	Water Treatment " " " Drying	1 yd³ 6 yd³ 2 yd³ 7 yd³ 100 yd³ 116 yd³	Landfilled " " " "	 \$360
Oils from machines	Maintenance	250 gal	Off-site Reclamation	\$200
Pit sludge	Pit Cleanouts	4 yd³	Landfilled (?)	N/A
Cardboard Boxes	Receiving	150 yd³	Recycled	\$600
General Trash, includes: White Paper Fluorescent Bulbs Pallets (damaged) Drums (some)	Overall	520 yd³	Landfilled " " (Reused, Reconditioned or Trashed) (Returned, Reused, or Trashed)	\$1,440
Total Waste to Landfill:		**640 yd³/yr**		
Total Landfill Cost:		**\$1,800/yr**		

† - Includes 6% tax

* estimated - see Appendix I

N/A = not available

Table 5
Energy Recommendations
(Industrial Laundry)

AR No.	Description	Potential Conservation (MMBtu/yr)	Potential Savings (\$/yr)	Resource Conserved	Impl. Cost (\$)	Payback Time
1	Adjust Boiler Air-Fuel Ratio	725	2783	natural gas	2000	9 months
2	Reduce Compressor Operating Pressure	11	219	electricity	20	1 month
3	Install High Efficiency Motors	109	2143	electricity	2720	13 month
4	Install High Efficiency Lighting	78	1537	electricity	2468	19 months
	Total Savings	923	6682		7208	11 months

Table 6
(Industrial Laundry)

Summary of Proposed Waste Assessment Recommendations

Current Practice	Proposed Action	Potential Estimated Annual Benefits	
No water is recycled; all water used for all stages is fresh city water	Reuse the last few rinse stages of each wash cycle in subsequent washes	Waste Reduction: Investment: Savings: Simple Payback Time:	4,800,000 gal $10,500 $14,800 37 weeks
No system is in place to remove oil and grease from the wastewater effluent	Purchase and install an oil skimmer to facilitate oil and grease removal	Waste Reduction: Investment: Savings: * Simple Payback Time:	3100 lb. $8,000 $60,500 7 weeks
Removal of solids using a series of fixed screens and a vibrating screen	Install a hydrocyclone in series with the screens to increase solids removal	Waste Reduction: Investment: Savings: Simple Payback Time:	54,000 lb $5,400 $4,000 1.4 years

* Savings include avoided potential fines for non-compliance with oil and grease in discharge to POTW.

Glenn Gabriel

Abbott Laboratories

Glenn Gabriel, P.E.
Abbott Laboratories
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(847) 935-2845

Glenn Gabriel joined Abbott in 1995 as its corporate pollution prevention programs coordinator. Glenn's prior experience includes environmental management and manufacturing support posiitons with G.D. Searle, Baxter, and AT&T. Glenn has a B.S. degree in Chemistry from the University of Illinois at Chicago and an M.S. in Chemical Engineering from the Illinois Institute of Technology. Glenn is also a registered professional engineer in Illinois.

November 26, 1996

Title: Lessons Learned from Abbott's Pollution Prevention Program

Abstract:

My presentation will include a discussion of several recent pollution prevention successes as reported by various Abbott manufacturing, research and development facilities located in Northern Illinois (Lake County). These case studies will focus on the lessons learned from each scenario and will present a "how to" picture from which the audience can learn.

These cases will be organized by the familiar P2 hierarchy: source reduction, recycle, reuse, etc. Furthermore, cases will be discussed from various stages of the production life cycle, i.e., design, production, use, and ultimate product disposal. There will be a general discussion of the various categories of P2 cases with a more detailed treatment of three of four of them.

Abbott Laboratories is a global, diversified company dedicated to the discovery, development, manufacture, and marketing of health care products and services. Abbott has several diverse operating divisions with facilities in Lake County, Illinois. Each division is a unique entity unto itself with pollution prevention cases which reflect this diversity. Therefore, the cases presented will be relevant to people employed outside the health care products industry.

Dave Heinlen

Bowling Green State University

BIOGRAPHICAL INFORMATION FOR DAVE HEINLEN

- Safety and Health Coordinator for the Department of Environmental Health and Safety - Bowling Green State University since 1984
- Bachelor of Science degree in Zoology - Ohio State University
- Masters of Science and Education in Public Health degree - University of Toledo
- Worked for the City of Bucyrus and City of Galion, Ohio health departments prior to joining BGSU
- Registered Sanitarian
- Affiliate faculty with BGSU's College of Health and Human Services

Orphan Chemical Recycling Program Recognitions

- Award of Distinction for Innovative Programming from the National Safety Council/Campus Safety Association
- Governor's Award for Outstanding Achievement in Pollution Prevention

BGSU'S ORPHAN CHEMICAL RECYCLING PROGRAM: A COMMUNITY EFFORT

Introduction

In most academic laboratory settings, it is common for chemicals that are still useful to remain on shelves, under hoods, and in other areas of storage, unwanted or unneeded by those who maintain them. Eventually, a majority of these "orphans" make their way into a particular waste stream, necessitating some form of appropriate management. In addition to staff time and disposal costs associated with this management, environmental and liability issues attend the handling and disposal of chemical waste. While these chemical "orphans" remain in storage, departments within the University may be purchasing virgin chemicals identical to the orphans in other University locations.

Because of these circumstances, the Department of Environmental Health and Safety at Bowling Green State University (BGSU) began an in-house orphan chemical recycling program in the fall of 1991. This project was implemented primarily to identify and transfer unwanted chemicals between University departments as a means of minimizing hazardous waste generation. Even though this initial project was not extensively promoted, it is estimated that 700 pounds of solid materials and 50 gallons of liquids were transferred between University departments.

In the fall of 1992, BGSU began to develop a plan that would expand the existing orphan chemical program to include nonUniversity academic institutions. Reasoning for the participation of nonUniversity institutions centered on several factors. First of all, involvement of nonUniversity institutions would increase the potential for the distribution of the University's orphans. It was felt that similar departments (chemistry, biology, art, etc.) from different institutions would have the same types of chemicals available, thus providing a better opportunity for distribution. Secondly, the program would provide a financial incentive to these institutions as well as BGSU because of the added potential for orphan distribution. A dual cost-savings to the participating institutions and the University could be realized by keeping usable materials out of wastes streams as well as eliminating the need to purchase new materials. The expanded recycling program would have an additional benefit of enhancing the cooperative relationships between the University and nonUniversity institutions by making assistance with other hazardous materials/waste management issues available if requested. Institutions viewed as potential participants were high schools, Jr. high schools, technical colleges, and similar facilities, primarily within Wood County, Ohio. Since the program was designed to be of service to the participating institutions, a decision was made that no fee would be charged for taking part in the program. Also, an institution would not have to submit an orphan chemical inventory (explained later) to participate.

To assure that the program would not conflict with current regulations, a draft of the program proposal was developed and submitted to the Ohio EPA and the Public Utilities Commission of Ohio for review. Representatives from both agencies accepted the concept and the procedures outlined in the proposal. Department of Transportation officials were also informed of our intentions to confirm that our planned method of chemical transfer was consistent with their requirements. Once the regulatory concerns had been addressed, the plan was presented to the University administration where it was again favorably received. Final acceptance of the program came following discussions with representatives of the Wood County Board of Education. After gaining the support of the proposal from these necessary constituency groups, a description of program parameters and recommended handling procedures for the orphans was sent to the institutions desiring to participate in the program.

Thirteen nonUniversity academic institutions (eight high schools, two Jr. high schools, a medical college, a technical college, and a joint vocational school) were initially considered formal participants in the recycling program. In 1994, a local hazardous waste management company (RES) began participating in the program. Due to the involvement of RES, other academic and nonacademic facilities in Ohio and Michigan (forty-two to this point) have been a part of the program on either a one-time or an occasional basis.

Methods

Under the provisions of the program, each participating institution/facility selects an individual to serve as the contact for the facility. Generally, this person functions within the institution's department of chemistry, facilities research and development division, or similar science-related area. BGSU departments are represented by individuals who are the primary departmental contacts within the University's hazardous waste management program.

Institution and facility representatives subsequently conduct an inventory of their chemical stocks, listing the available orphans on a standardized orphan inventory form. The program's hazardous waste management company is able to identify potential orphans from the materials inventoried during routine disposal activities for their clients. Requested information on the inventory include, for each chemical, the number of containers, the total quantity of the material, the manufacturer and chemical grade (if known), and whether the chemical containers are unopened or the chemical has been repacked.

As indicated earlier, the quality of the chemical is a major factor during the selection of orphans. It is the responsibility of the facility contact to assure the usability of the chemical. The quality of the orphan should not have diminished to the point where it can no longer be used. If requested, the University or hazardous waste management company may be able to assist the institution or facility in determining the chemical quality of the orphan(s).

Institutional and management company representatives submit lists of their available orphans to BGSU's Hazardous Waste Coordinator as frequently as the orphans are identified. The Hazardous Waste Coordinator then compiles the chemical data onto an alphabetized master list using spreadsheet computer software.

Hard copies of the master list are then sent to each facility representative who oversees its distribution within the institution, department, or facility. Updates to the list are normally sent on a quarterly basis. Hard-copy updates may be sent more frequently if a significant number of "new" orphans have been identified or numerous chemical transactions have taken place.

The orphan list is also a component of BGSU's GOPHER CWIS (Campus-Wide Information Server). This computer resource is available to any institution/facility having access to the INTERNET system. The listings can be viewed and/or printed from this source but cannot be modified. The listings on the server are updated regularly and are therefore more current than the quarterly hard copy listings. The listings can be accessed using the URL identification as follows:

gopher://gopher.bgsu.edu/1/Departments/ehs

Those alreadt into the GOPHER system can access the listings under the BGSU (Ohio) Gopher Server → Departments → Environmental Health and Safety.

All orphan chemicals remain at the originating institution/facility until they are claimed or otherwise managed. This limits problems in multiple material handling and prevents questions of responsibility for disposal should the orphan(s) continue to be unclaimed. An exception to this policy involves potential orphans identified by RES during normal waste management activities. Since these wastes/orphans generally necessitate expeditious movement off site, there would be insufficient time to disseminate information on orphan availability prior to their removal. To address this potential loss of orphans, utilization of the University's hazardous waste facility for the temporary storage of "high visibility" orphans is being planned. Use of the facility would allow the time necessary to properly advertise orphan availability while providing a safe storage site. A formal agreement would be used to affirm RES's responsibility for the final disposition of any unclaimed orphans.

An institution/facility desiring to obtain an orphan (or orphans) is responsible for initiating the transfer. To facilitate the movement of orphans from one location to another, the facility representative contacts the University's Hazardous Waste Coordinator or RES representative. Specific arrangements for orphan transfer are then made through their combined efforts. This procedure permits the most feasible control of orphan transport while assuring that all transfers are properly documented.

Handling procedures during the transfer of BGSU orphans primarily follow DOT shipping requirements. Containers of orphans covered by DOT regulations are packaged individually (or "labpacked" if compatible) in DOT acceptable boxes and labeled according to DOT specifications. For orphans not covered under DOT shipping requirements, no formal packaging is performed other than securing the containers during shipment. Orphans transported by the University are moved using a capped University pickup truck. The containers of orphans are placed in a 3' X 5' wooden box located in the rear of the vehicle. The shipping box has a bottom layer of absorbent material and is equipped with removable partitions for separating containers of various sizes and compatibilities. A spill kit and shipping paper are also taken during BGSU's movement of regulated orphans.

In conjunction with each shipment, a Material Safety Data Sheet (MSDS) for each orphan is offered to the institution/facility receiving the orphan(s). A formal document on MSDS distribution has recently been developed. This form will be used to indicate whether the orphan recipient needs particular data sheets or currently has them available. The form will accompany all orphan transfers and will be signed by the recipient of the orphans.

Once a transaction has taken place, the Hazardous Waste Coordinator removes the chemical(s), in whole or in part, from the master list. Changes in the orphan inventory are reflected on the hard copies of the updated master list resubmitted quarterly to those institutions/facilities not using the Gopher CWIS system. Changes on the CWIS are made following each transaction.

Conclusion

Since April of 1993, the orphan chemical recycling program has transferred approximately 3,000 pounds of solids and 900 gallons of liquids to "needy" institutions and facilities. The dual cost savings associated with these transfers (for purchase and disposal) have been approximated at between $265,000 and $350,000.

In addition to the chemicals being transferred, there are also "nonchemical" items that are given away or reused as a part of the orphan chemical program. Empty five-gallon containers that have been cleaned and sealed are taken from one University department and delivered to others to use for storage. DOT shipping boxes used in the transportation of chemicals to the University are kept for transporting regulated orphans. Bags of vermiculite are saved for packing orphans or given to the hazardous waste management company. Cleaned 55-gallon drums can be reused as refuse containers or kept for the storage of other liquid wastes Cost savings for these storage/packaging materials are not included in the overall savings of the program.

In addressing the issue of potential liability for the distribution of these chemicals, the University, together with RES, has developed an indemnification document. The document is an attempt to protect the University and the waste management company from liability for the misuse of the orphan chemicals following their transfer. The document is to be signed by a formally designated representative of the institution/facility (principal, superintendent, facility manager, etc.).

Yet to be determined is the length of time that an orphan spends on the list before implementing some other form of management. Realized and planned expansions of the program have warranted that those on the list remain, at least until newly added participants have an opportunity to obtain them. Once program participant levels have stabilized, a specific time frame for orphan availability will be set. The University and RES will subsequently assist participants with disposal/management options for unclaimed orphans.

The cooperative efforts between the University and the local hazardous waste management company have added a new dimension to the recycling program. As stated earlier, RES is able to identify potential orphans during routine waste management activities at both academic and nonacademic facilities. Working in conjunction with facility representatives, the company's identification of orphans not only increases the quantities of available materials within the program, but it also demonstrates appropriate waste management techniques to these facilities while reducing their waste disposal costs.

Through this established relationship with RES, a further expansion of the program is currently being implemented. The expansion is directed mainly toward academic institutions within the seven counties surrounding Wood County. An explanation of the program has been sent to representatives of these institutions, requesting their consideration of participating in the recycling effort. Contact with potential participants will proceed on a regular basis to include as many institutions/facilities as possible within the program. Nonacademic facilities will be encouraged to participate either as a one-time effort or on a continual basis, depending upon their particular orphan inventories.

In conjunction with this expansion, periodic discussions with the contacts of participating institution and other facility representatives are ongoing. These informal meetings assist in resolving any misunderstandings encountered in program implementation and serve to further strengthen cooperative relationships. Also, through formal presentations to environmental colleagues and discussions with other interested parties, information about the program will be disseminated whenever possible to encourage the development of similar programs.

It is hoped that through the success of this program, more facilities will become participants, additional monies will be saved, cooperative relationships between the University and other nonUniversity institutions/facilities will be strengthened, and further protection of the environment will be achieved. It is also hoped that other institutions and waste management companies will investigate the possibilities of implementing these or similar chemical recycling efforts. Others may then experience success in minimizing waste and preserving the environment while demonstrating financial responsibility by providing cost savings to both the "giver" and the "receiver."

ORPHAN CHEMICAL RECYCLING PROGRAM FOR NONUNIVERSITY INSTITUTIONS AND FACILITIES (A PROPOSAL)

The Department of Environmental Health and Safety (EH&S) of Bowling Green State University in conjunction with Rader Environmental Services of Findlay, Ohio, are proposing an expansion of an existing chemical recycling program for academic and nonacademic institutions primarily within an eight county region centering on Wood County.

The recycling program involves the identification of **useable** chemicals that are unwanted (orphans) and makes them available for other institutions/facilities to obtain and use.

Purpose

The purpose of the orphan chemical recycling program is:

1) to reduce the amount of hazardous wastes being generated by participating institutions and the University thereby decreasing the costs of proper hazardous waste management,

2) to reduce the costs to these institutions in purchasing new chemicals,

3) to reduce the inventories of unwanted chemicals, and

4) to strengthen the cooperative relationships between the University and area academic/nonacademic institutions by providing a means to minimize hazardous wastes and, if requested, to assist these institutions with other waste management issues.

Procedures

The information included with this proposal provides an overview of the recycling program and the procedures implemented by BGSU and other current program participants. A brief explanation of the basic program parameters is given below.

1. Identification of Participants

Institutions/facilities interested in participating need to contact Dave Heinlen at (419) 372-2173 or Joe Rader or Bruce Deppen of Rader Environmental Services at 1-800-858-7374. Each participating institution will be asked to select a representative who will serve as the contact for their facility. Participants will be placed on a roster which will serve as the primary "transfer network."

2. Submission of Orphan Chemical Information

Using the enclosed form, the contact for each participating institution submits an inventory of any orphan chemicals available for transfer. Only useable materials are considered acceptable. An institution is not required to submit an inventory in order to participate in the recycling program. Inventories should be sent to the following address:

HAZARDOUS WASTE/ORPHAN CHEMICAL INVENTORY FORM/SHIPPING PAPER

Bowling Green State University

Date of Shipment ______________

Department/Institution ______________________________

Department/Institution Contact ______________________________

CHEMTREC Emergency Number: 1-800-424-9300

Hazardous Waste/Orphan Chemical Information					Orphan Inventory Information Only			EHS Shipping Information	
STATUS	CHEMICAL/PRODUCT NAME	NO. OF CONT.	TOTAL QUANTITY	HAZ. CLASS	UNOPENED/ REPACKED	MANUFACTURER	GRADE	DOT ID# (IF APPLICABLE)	DOT ERG #

STATUS
W - Waste   O - Orphan

HAZ. CLASS
C - Corrosive   I - Ignitable   T - Toxic   R - Reactive

GRADE
C - Certified   P - Practical   T - Technical   R - Reagent   Other (Write In)

FREE
CHEMICALS

Courtesy of :

Bowling Green State University's Orphan Chemical Recycling Program

January 1997

Chemical Name	No. of Cont.	Total Quantity	Unopen./ Repacked.	Chemical Manufacturer	Original Grade	Location Code
Fuchsin Carbol	1	5 g		Allied Chem.		BU(W)
Fuchsin-Carbol (Kinyorin modified stain)	1	16 oz.				BU(W)
Gabroth Hajna	1	1 lb.				BU(W)
Hexadecanol	1	1 kg				BH(W)
Histidine Assay Medium	1	100 g	Unopened	Difco		BU(W)
Hydroquinone	1	400 g				BH(W)
Hydroxy-L-Proline	1	1 g	Unopened	Sigma		BU(W)
Indole	1	1 oz.		Fisher	Certified	BU(W)
Inositol Assay Medium	1	100 g	Unopened	Difco		BU(W)
Iodine Germicide	1	150 ml		Lilly		BU(W)
Iodine Solution (for Amoeba differentiation)	1	300 ml		Harlco		BU(W)
Iron Sulfide	1	2200 g				E(W)
Isoelectric Casein	1	60 g		Difco		BU(W)
Jenner's Stain	1	25 g		Matheson	Certified	BU(W)
Koser Citrate Medium	1	1 lb.	Unopened	Difco		BU(W)
L(+) Arabinose	1	4 g	Unopened	Sigma		BU(W)
L-Citrulline	1	100 g				MC(L)
L-Glutamine	1	25 g				MC(L)
Lead Carbonate (basic)	1	200 g				E(W)
Lead Chromate	1	250 g				E(W)
Lead Nitrate	1	100 g				MC(L)
Lead Nitrate	1	4 oz.		Fisher	Reagent	BU(W)
Lead Oxide (Litharge)	8	40 lbs.	Repacked	Coleman	Technical	BU(W)
Lead Peroxide	1	60 g				E(W)
Lipid Crimson Stain	1	10 g		ESBE Lab.		BU(W)
Lysine Assay Medium	1	100 g	Unopened	Difco		BU(W)
Magnesium Chloride	1	98 lbs.		Malin	Technical	BU(W)
Magnesium Hydrogen Orthophosphate	1	375 g		Difco		BU(W)
Maleic Acid Hydrazide	1	100 g		Eastman O.	Practical	BU(W)
Malt Extract	2	2 lbs.	Unopened	Difco		BU(W)
May Greenwald Stain	1	25 g		Harleco		BU(W)
Mercuric Chloride	1	100 g				MC(L)
Mercuric Iodide	1	200 g				BH(W)
Methonine Assay Medium	1	100 g	Unopened	Difco		BU(W)
Methyl Red (granular)	1	9 g		Difco		BU(W)
Methyl Salicylate	1	1 lb.		Central		BU(W)
Methyl Sulfoxide	20	500 ml				MC(L)
Methylene Blue Thiocyanate	1	100 tablets	Unopened	Pharmaceutical	Certified	BU(W)
Molybdic Acid	23	23 lbs.	Repacked	Fisher,Baker	Reagent	BU(W)
Molybdic Acid (85%)	1	400 g				E(W)
Monochlorobenzene	1	1 pt.		Fisher	Certified	BU(W)
Monothioglycerol	1	25 g		Sigma	Grade II	BU(W)
Mycobiological Broth	1	1 lb.	Unopened	Difco		BU(W)
Mycobiotic Agar	1	1/4 lb.				BU(W)
N-Ethyl Maleimide	1	5 g				MC(L)
Naphthalene Acetic Acid	2	2 g	Unopened	Gen. Biol.		BU(W)
Naphthalene Monobromide	1	100 g		Fisher		BU(W)
Neutral Red (granular)	1	10 g		Baker	Reagent	BU(W)
Niacin	1	100 g				MC(L)
Niacinamide	1	100 g	Unopened	Sigma		BU(W)
Nickel Ammonium Sulfate	2	100 g				E(W)
Nitrobenzene	1	470 ml				E(W)
O-Dianisidine DiHCl	1	1 g				MC(L)
Octadecanol	1	1 kg				BH(W)
Octyl phenoxy polyethyoxyethanol	1	100 ml				BH(W)
Oil Red O	1	25 g		Matheson		BU(W)
Orange G	1	10 g		Pharmaceutical		BU(W)
Oxythiamine HCL	1	0.1 g	Unopened	Nutritional Bio.		BU(W)
Papain, NFVII	1	100 g				BU(W)

ORPHAN CHEMICAL SHIPPING FORM
Bowling Green State University

Receiving Department/Institution ______________________________ Date of Shipment ________

Receiving Department/Institution Contact ______________________________

CHEMICAL/PRODUCT NAME	NO. OF CONT.	TOTAL QUANTITY	HAZ. CLASS	DOT ID# (IF APPLICABLE)	DOT ERG #

HAZ. CLASS
I - Ignitable C - Corrosive T - Toxic R - Reactive

CHEMTREC Emergency Number: 1-800-424-9300

BOWLING GREEN STATE UNIVERSITY'S
ORPHAN CHEMICAL RECYCLING PROGRAM

MATERIAL SAFETY DATA SHEET DISTRIBUTION

Please check one of the following:

_____ I have current Material Safety Data Sheets for the chemicals obtained as part of BGSU's Orphan Chemical Recycling Program.

_____ I wish to obtain Material Safety Data Sheets for the chemical(s) identified below:

Chemical Name

____
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____
(Name/Title - Printed)

____
(Signature)

____
(Institution/Facility)

____
(Date of Transfer)

Draft

BOWLING GREEN STATE UNIVERSITY'S ORPHAN CHEMICAL RECYCLING PROGRAM

Dear Program Participant:

Since April of 1993, BGSU's Orphan Chemical Recycling Program has transferred free chemicals between academic institutions and other facilities. These transactions have resulted in a dual cost savings for disposal as well as purchase. It is the desire of Bowling Green State University and Rader Environmental Services, Inc. to continue this program as long as possible.

Even though this program is a service to participating institutions and facilities, BGSU and Rader Environmental Services, Inc. do not wish to incur liability for the mishandling of these chemicals once they are received by the program participants. In addressing this issue, we have developed the agreement below. We ask that it be signed by the authorized representative of the institution/facility receiving the materials. Thank you for you understanding and for your participation in this most valuable program.

Sincerely,

Dave Heinlen
BGSU

Joe Rader
Rader Environmental Services, Inc.

LIABILITY RELEASE, WAIVER, DISCHARGE AND COVENANT NOT TO SUE

____________________________________, ("Participant") in consideration for participation in the Orphan Chemical Recycling Program sponsored by Bowling Green State University ("BGSU") and Rader Environmental Services, Inc. ("Rader"), agrees to release and hold harmless BGSU, RADER, their officers, employees, agents, and students, from any and all liability, claims, demands, and actions or causes of action, whether caused by negligence of BGSU or RADER or otherwise arising out of its participation in this program. In no event shall BGSU or RADER be liable for attorneys fees, punitive damages, damages for pain and suffering, loss of companionship, consortium, and the like.

Participant recognizes that this release means it is giving up, among other things, rights to sue BGSU and RADER, their officers, employees, agents, and students for injuries, damages, or losses that Participant and its representatives, employees, and agents may incur. Participant also understands that this Release binds its heirs, executors, administrators, and assigns.

Participant has read this entire Release, and fully understands it and agrees to be legally bound by it.

THIS IS A RELEASE OF YOUR RIGHTS. PLEASE READ CAFEFULLY BEFORE SIGNING

____________________________________ ____________________

(Authorized Agent for Participant) (Date)

Stephen J. Hillenbrand

Tennessee Valley Authority

Overview of Fourteen Applied Technologies

Stephen J. Hillenbrand, PE
Industrial Waste Reduction Engineer
Tennessee Valley Authority
Knoxville, Tennessee

Presented at the
U.S. EPA Region 5 Waste Minimization/Pollution Prevention Conference
February 25 - 27, 1997
Chicago, Illinois

Waste Reduction Through Applied Technologies (AT)

The following overview briefly describes fourteen technologies that have traditionally not been considered for their Waste Reduction benefits, but primarily as process technologies for enhanced product quality or for their economic benefits. These ATs also do have potential Waste Reduction capabilities.

These technologies are not "one size fits all." They are practical only under certain conditions, but they can greatly reduce waste and save money where they can be used. However, these technologies do lend themselves to innovative applications and should be considered as an option even outside their traditional industrial sectors.

This overview will familiarize you with the basic information about ATs. If a potential application is suspected, contact an equipment vendor or an engineering consultant that specializes in the technology. This should be the first step in determining whether the potential use is practical. Your electric utility or the Electric Power Research Institute (800-432-0267) are also valuable resources.

Waste Reduction through *Applied Technologies*

TECHNOLOGY	Saves $$$	Increases Quality	Reduces Air Emissions	Reduces Hazardous Waste	Reduces Solid Waste	Reduces Waste Water	Reduces Energy Use
Direct Resistance	X	X	X	X	X	X	X
EDM Electrical Discharge Machining	X	X	X		X		X
Heat Pump	X	X	X		X		X
Indirect Resistance	X	X	X		X		X
Infrared	X	X	X	X			X
Induction	X	X	X	X	X	X	X
Laser	X	X	X		X	X	X
Membrane	X	X	X	X	X	X	
Microwave	X	X	X				X
Plasma Arc	X	X	X		X	X	
Plasma Nitriding	X	X	X	X			X
RF Radio Frequency	X	X	X				X
UV Ultraviolet	X	X	X	X	X	X	X
Waterjet	X	X	X		X		

Waste Reduction through *Applied Technologies*

Process / Technology	Direct Resistance	EDM	Heat Pump	Indirect Resistance	Infrared	Induction	Laser	Membrane	Microwave	Plasma Arc	Plasma Nitriding	RF	UV	Waterjet
Heating - metals	X			X	X	X	X			X				
Heating - nonmetals	X low T°			X	X				X	X		X		
Heating - in vacuum				X	X	X			X			X		
Heating - brazing & welding				X		X	X			X				
Heating (pre) - metals	X			X	X	X								
Heating (pre) - plastics				X	X				X			X		
Heating (post) - non-metals				X	X				X			X		
Heat treating	X			X	X low T°	X	X			X	X	X low T°		
Heating - space			X	X	X									
Cooling - space			X											
Kiln Drying - Lumber			X	X					X			X		
Drying, evap., distill. Concentration			X	X	X	X		X	X			X		

Waste Reduction through *Applied Technologies*

Process / Technology	Direct Resistance	EDM	Heat Pump	Indirect Resistance	Infrared	Induction	Laser	Membrane	Microwave	Plasma Arc	Plasma Nitriding	RF	UV	Waterjet
Drying - foundry sand core				X	X				X			X		
Bonding - metal to plastic				X		X	X					X		
Curing - thermoset adhesive				X	X	X	X		X			X	X	
Curing or drying- textiles			X	X	X	X			X			X	X	
Curing - coatings and inks				X	X	X			X			X	X	
Stripping - coatings				X		X	X					X		X
Machining - tools, dies, molds		X					X							
Fluid recovery or separation								X						
Cutting							X			X				X
Reuse - process fluid			X	X				X					X	
Food processing	X		X	X	X			X	X			X		X
Papermaking			X	X	X		X	X				X	X	X
Petrochemical			X	X		X		X	X					
Electronics									X				X	

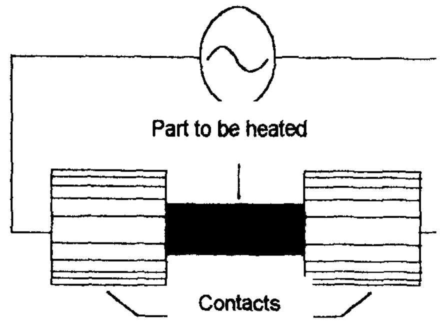
Applied Technology
Potential in Manufacturing

Industry SIC / Applied Tech	Food 20	Tobac 21	Textile 22	Apparel 23	Lumber 24	Furn 25	Paper 26	Printing 27	Chem 28	Petrol 29
Direct Resistance	MED	LOW	LOW	LOW	LOW	MED	LOW	LOW	LOW	LOW
EDM	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Heat Pump	**HI**	LOW	MED	LOW	**HI**	LOW	MED	LOW	MED	MED
Indirect Resistance	**HI**	MED	MED	MED	MED	MED	MED	MED	MED	MED
Infrared	MED	MED	**HI**	MED	MED	MED	**HI**	**HI**	MED	MED
Induction	LOW	LOW	MED	LOW	LOW	MED	LOW	LOW	MED	LOW
Laser	LOW	LOW	LOW	LOW	LOW	MED	MED	LOW	LOW	LOW
Membrane	**HI**	MED	**HI**	LOW	LOW	MED	**HI**	MED	**HI**	MED
Microwave	**HI**	MED	LOW	LOW	LOW	LOW	LOW	LOW	MED	LOW
Plasma Arc	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Plasma Nitriding	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
RF	MED	MED	**HI**	LOW	MED	MED	MED	LOW	LOW	LOW
UV	LOW	LOW	MED	LOW	LOW	MED	MED	**HI**	LOW	LOW
Waterjet	MED	LOW	LOW	LOW	LOW	MED	MED	LOW	MED	MED

Applied Technology
Potential in Manufacturing

Industry SIC Applied Tech	Rubber 30	Leather 31	Stone 32	Pmetal 33	MetFab 34	Mach 35	Elect 36	Transp 37	Instr 38	Misc 39
Direct Resistance	LOW	LOW	MED	**HI**	**HI**	MED	MED	MED	MED	MED
EDM	LOW	LOW	LOW	LOW	MED	**HI**	**HI**	**HI**	MED	MED
Heat Pump	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Indirect Resistance	MED	MED	MED	MED	**HI**	MED	MED	MED	MED	MED
Infrared	**HI**	MED	**HI**	MED	**HI**	**HI**	**HI**	**HI**	**HI**	**HI**
Induction	MED	LOW	MED	**HI**	**HI**	**HI**	**HI**	**HI**	MED	MED
Laser	LOW	LOW	LOW	LOW	**HI**	**HI**	**HI**	**HI**	**HI**	MED
Membrane	LOW	MED	LOW	MED	MED	MED	MED	MED	MED	MED
Microwave	MED	LOW	MED	MED	LOW	LOW	**HI**	LOW	LOW	LOW
Plasma Arc	LOW	LOW	MED	**HI**	**HI**	**HI**	**HI**	**HI**	LOW	MED
Plasma Nitriding	LOW	LOW	LOW	LOW	MED	**HI**	**HI**	**HI**	MED	MED
RF	**HI**	LOW	LOW	LOW	LOW	LOW	**HI**	LOW	LOW	LOW
UV	MED	LOW	LOW	LOW	**HI**	**HI**	**HI**	**HI**	**HI**	MED
Waterjet	MED	MED	MED	LOW	**HI**	**HI**	**HI**	**HI**	MED	MED

Applied Technology: Direct Resistance



Source: EPRI TechCommentary V2, N8, 19

Concept

Direct Resistance heating involves passing an alternating current directly through the workpiece to be heated. Since the part must be electrically conductive, it is often also referred to as conduction heating. With this type of heating, clamp or roll types of electrodes must be used to physically make contact with the workpiece. For food products, the sauce or gravy is the workpiece. The resistance (R) of the workpiece to the current (I) passing through generates the I^2R heating. Low frequency current (60 Hz) heats the part throughout. High frequency current (400 kHz) tends to heat only the surface of the part.

Applications

- **Hot Metal Working; forging, stamping, extrusion, rolling, and upsetting**
- **Heat Treating**
- **Metal Joining; spot, seam, and flash welding**
- **Preheated Glass and Semiconductor**
- **Food Sterilization (Ohmic Heating)**

Technologies Replaced

- **Salt/Lead Bath Heat Treating**
- **Fossil/Electric (indirect resistance) Furnace**
- **Retort Canning of Food**
- **Flame Hardening**
- **Torch Welding**

Wastes Reduced

- **Combustion Pollutants; ROG, SO_X, NO_X, CO_X, Particulate**
- **Material Oxidation; slag, scale**
- **Salt/Lead Bath; hazardous salts/metals**
- **Process and Waste Water (Ohmic Heating)**

Potential in Manufacturing

Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot
Food	20	MED	Lumber	24	LOW	Chem	28	LOW	Stone	32	MED	Elect	36	MED
Tobac	21	LOW	Furn	25	MED	Petrol	29	LOW	Pmetal	33	HI	Transp	37	MED
Textile	22	LOW	Paper	26	LOW	Rubber	30	LOW	MetFab	34	HI	Instr	38	MED
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	MED	Misc	39	MED

Credits: George Bobart, Bobart Associates; Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Direct Resistance *continued*

Technology Advantages

- **Fast Heating**
- **Selective and Uniform Heating**
- **Small Space Requirements**
- **Moderate Cost**
- **High Efficiency**

Technology Disadvantages

- **Heating; uniform part cross-section required**
- **Heating; part must be long and slender**
- **Heating; low to moderate production rates**
- **Welding; part configuration must provide high resistance to flow of current**
- **Contact Surfaces; must be clean for good electrical connection**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
moderate: $25k - $100K	**low maintenance, costs highly dependent on electric rates**	**1 - 2 years**

Installations

Case A **- An open flame oxy-fuel type of heat treat equipment was originally utilized by a midwestern machine tool manufacturer to selectively harden the teeth on a long gear rack. Using the flame process, there were basic problems with part distortion and uniformity of the hardening pattern. Due to the extremely low heating efficiency, the flame process also had high energy costs and air pollutants (combustion by-products). All of the process problems were corrected by installing a direct resistance heating system with direct contacts on each end of the hardened area. This greatly improved the quality of the part, reduced the energy cost by 70%, and eliminated all of the air pollutants.**

Case B **- Most of the tube and pipe around the world was produced by a process that utilized a fossil furnace to heat flat strip, form it into pipe and weld it along the length with an oxy-fuel torch. A newer type of high frequency direct resistance heating only heats a narrow area of the edge of the pipe that is to be welded. It therefore significantly reduces the energy required and the air pollutants associated with the older fossil fuel based welding processes. It is also much faster than certain conventional rotating electrode or the arc welding technologies, such as TIG or MIG processes. In addition, it provides far greater control of the seam temperature for the welding process, thus reducing product scrap due to rejects. While induction heating is often used for small diameter pipe and tube, direct resistance RF contact welding is extremely cost effective on larger diameter pipe, and generally provides a payback of less than 1 year.**

Major Vendors

Direct Resistance

APV Crepaco*
395 Fillmore Avenue
Tonawanda, NY 14150
(716) 744-2336

*** For Ohmic Heating (Food)**

IHS-Inductoheat
5009 Rondo Drive
Fort Worth, TX 76106
(800) 486-5577

Newcor Bay
1846 Trumbell Drive
Bay City, MI 48707
(517) 893-9509

Seco/Warwick
180 Mercer St
Meadville, PA 16335
(814) 724-1400

Taylor-Winfield
P.O. Box 500
Brookfield, OH 44403-0500
(216) 448-4464

Thermatool
31 Commerce St
East Haven, CT 06512
(203) 468-4100

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Direct Resistance Heating

***Direct & Encased Resistance Heating*, EPRI CMF TechCommentary, Vol 3, No 8, 1986**

***Direct Resistance Heating Blanks For Forging*, EPRI CMF TechApplication, Vol 1, No 19, 1987**

***High-Frequency Resistance Welding of Tube*, EPRI CMF TechApplication, Vol 1, No 15, 1987**

***Electric Arc Furnace Steelmaking ... The Energy Efficient Way to Melt Steel*, EPRI CMF TechCommentary, Vol 1, No 3, 1985**

***Understanding Electric Arc Furnace Operations for Steel Production*, EPRI CMP TechCommentary, Vol 3, No 2, 1987**

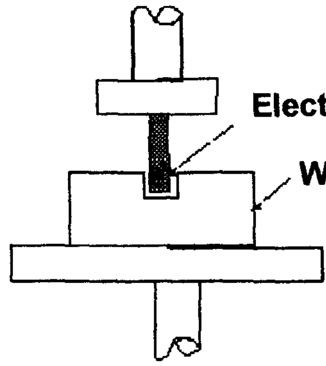
***Direct Current Electric Arc Furnaces*, EPRI CMP TechCommentary, CMP-063, 1991**

***Static Var Control for Electric Arc Furnaces*, EPRI CMP TechApplication, CMP-100, 1995**

Special Publications

Parrott, Dr. David L.; *Use of Ohmic Heating for Aseptic Processing of Food Particulates*; Food Technology, December 1992, pp 68-72

Applied Technology:
Electrical Discharge Machining (EDM)



Concept

Electrical Discharge Machining (EDM) is a technique used to cut complex shapes, particularly in very hard materials such as tool steels. Conventional EDM immerses the workpiece in a dielectric fluid, such as oil, and brings it close to a specially shaped tool. The tool is connected to DC, high voltage/frequency power. Millions of tiny electric arcs erode away microscopic bits of the workpiece, producing a hole which exactly matches the shape of the tool.

Wire EDM passes a very fine wire through a starter hole in the workpiece and cuts complex shapes as the workpiece is moved. The wire is continuously spooled, much like a bandsaw blade, to prevent it from breaking.

Applications

- **Cutting; dies, punches and molds**
- **Drilling; small micro-holes**

Technologies Replaced

- **Mechanical Milling, Cutting, and Drilling**
- **Laser Cutting and Drilling**
- **Broken Cutting and Drilling Tools**

Wastes Reduced

- **Scrap, Filings, and Swarf**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	LOW	Lumber	24	LOW	Chem	28	LOW	Stone	32	LOW	Elect	36	HI
Tobac	21	LOW	Furn	25	LOW	Petrol	29	LOW	Pmetal	33	LOW	Transp	37	HI
Textile	22	LOW	Paper	26	LOW	Rubber	30	LOW	MetFab	34	MED	Instr	38	MED
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	HI	Misc	39	MED

Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow;
Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Electrical Discharge Machining (EDM) *continued*

Technology Advantages

- **Non-Contact; handles delicate tasks**
- **Cuts or Drills Very Hard Material**
- **Highly Accurate; very small kerf (wire EDM)**
- **Produces Complex, Deep, or 3-D Shapes**
- **No Burrs**

Technology Disadvantages

- **Slow Cutting Rate**
- **Electrode Wear**
- **Thin Brittle Heat-Affected Zone**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
\$100k - \$200k depends on size, cutting rate, and controls	**Low energy costs; maintenance are application and automation dependent**	**< 1 year or more**

Installations

Case A **- The auto industry used conventional drills for precise holes in fuel injector nozzles. Tolerance and accuracy were a problem. Annual replacement costs for drills was \$180,000.**

A switch was made to EDM. Typical drilling time is now 3 - 15 seconds per hole, and tolerances of better than 0.0025 mm (0.0001 ") are maintained on a hole diameter of 0.175 mm (0.0069 "). In addition to the high degree of repeatability, annual tool replacement costs were reduced to \$2,000.

Case B **- An aerospace fastener firm replaced their conventional manual process for producing special dies for custom orders with a wire EDM machine driven by CNC software. Time required to produce dies for prototype fasteners reduced from 40 hours to 4. Production die sets are now produced in 125 hours compared with 300 - 400 hours previously. This substantially reduces inventory requirements for special die sets.**

Die quality and durability also improved since EDM parts are of more consistent dimensional tolerances and a harder steel can be used than was feasible with conventional production techniques.

Scrap rates reduced from 10 - 20% to less than 1%.

The company estimates its Payback period on the EDM system to be about 6 months.

Major Vendors

Electrical Discharge Machining (EDM)

Agie and Elox Corporation
565 Griffith Street
Davidson, NC 28036
(800) 438-5021

Easco-Sparcatron
10799 Plaza Drive
Whitmore Lake, MI 48189-9737
(800) 523-4443

Hansvedt Industries Inc.
803 Kettering Park
Urbana, IL 61801
(217) 384-5900

MC Machinery Systems, Inc.
Mitsubishi EDM Division
1500 Micheal Drive
Wood Dale, IL 60191
(708) 860-4210

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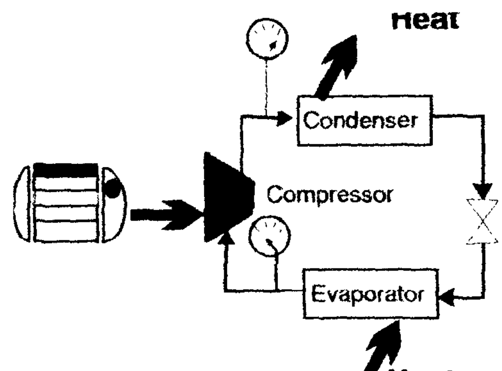
Electrical Discharge Machining (EDM)

***Electrical Discharge Machining*, EPRI CMF TechCommentary, Vol 3, No 1, 1986**

***Electrical Discharge Machining*, EPRI CMF TechApplication, Vol 1, No 9, 1987**

Applied Technology: Industrial Heat Pump



Concept

Credit: U S DOE

Industrial heat pumps are used to recover waste heat from one part of a process and boost its temperature so that it can be used in another part. The basic means to achieve this is mechanical compression. In a *closed cycle* heat pump, the working fluid circulates through heat exchangers, picks up waste heat in a low temperature evaporator, is compressed and elevated to a higher temperature in a mechanical compressor, and discharges heat to the process through a higher temperature condenser before being returned to the evaporator. In an *open cycle* heat pump , also called a *Mechanical Vapor Recompression (MVR)* heat pump, the process stream itself (e.g., low pressure discharge steam) is compressed to provide a higher temperature heat source to the process, eliminating the need for one or both heat exchangers.

Applications

- **Heat recovery from wastewater, process, or refrigeration streams**
- **Facility heating, cooling, and dehumidification**
- **Multistage evaporation systems**
- **Distillation separation systems**
- **Lumber kiln drying**

Technologies Replaced

- **Direct fuel fired lumber kilns**
- **Steam heated evaporators**
- **Fossil fuel heating**
- **Steam heated reboilers for distillation**
- **Chemical dehumidification**

Wastes Reduced

- **Combustion products: COx, SOx,**
- **Hot wastewater stream thermal pollution**

Industrial Heat Pump *continued*

Technology Advantages

- **Reduces overall energy consumption**
- **Reduces distillation system pressures giving higher efficiency**
- **Faster, more uniform lumber drying**
- **Reduces combustion related emissions**
- **Boilers may be shut down for lower maintenance costs**

Technology Disadvantages

- **More sophisticated controls and technical support required**
- **High capital costs**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
$20k - $50k/MBTU depending on size and application	Energy cost reductions of 60-90% are not unusual	**1 - 3 years depending on application**

Installations

Case A - **A conventional distillation column for separation of propane and propylene in a petrochemical plant was retrofitted with an MVR heat pump to recover the latent heat of the overhead vapor and recycle it into the reboiler. The heat pump ΔT or lift in this case was about 11 C°. The suction side of the 1,300 kW compressor reduced the pressure in the column, enabling distillation at low temperature. Once started, only the electrical energy of compression was required to operate the system, completely eliminating steam heating. Operating costs were reduced by over 70%, yielding a return on investment of 39% or payback less than 3 years for the installation.**

Case B - **Closed cycle dehumidification heat pumps are used in about 20% of existing lumber plants (approximately 1,000 units in place). These units are typically rated at 1-2 MBTU/hr of output and costs are $100k - $300k. Energy savings compared with conventional direct gas-fired kilns are on the order of 90%, yielding simple paybacks of 3-5 years on energy savings alone. Because the closed-cycle kilns operate at lower temperature and more uniform humidity conditions, product quality is higher and losses lower than in conventional kilns. It is claimed that many firms now prefer to buy lumber that has been dehumidification-kiln dried.**

Major Vendors

Industrial Heat Pump

APV Crepaco ***(heat exchangers)***
395 Fillmore Ave.
P.O. Box 366
Tonawanda, NY 14150
(716) 692-3000

Atlas Copco Comptec
(compressors)
Applications Department
46 School Road
Voorheesville, New York 12186
(518) **765-3344**

Brown Fintube
(heat exchangers)
12602 FM 529
Houston, TX 77041
(713) 466-3535

Crispaire Corporation
(industrial water heaters)
E-Tech Division
3285 Saturn Court NW
Norcross, GA 30092
(770) 734-9696

E Back Systems, Inc
(dehumidiers)
106 John Jefferson Road, Suite 102
Williamsburg, VA 23185
(800) 454-6012

Hitachi Zosen USA, Ltd.
150 East 52nd Street, 20th Floor
New York, NY 10022
(212) **355-5650**

McQuay, Inc. ***(HVAC)***
P.O.Box 1551
Minneapolis, MN 55440
(612) **553-5330**

Nyle Corporation
(wood drying)
P.O. Box 1107
Bangor, ME 04402
(800) 777-6953

Tecogen ***(chillers)***
P.O.Box 9046
Waltham, MA 02254
(617) 622-1400

---Note---
Most process heat pump applications are custom engineered. Check with a process engineering consultant for your application.

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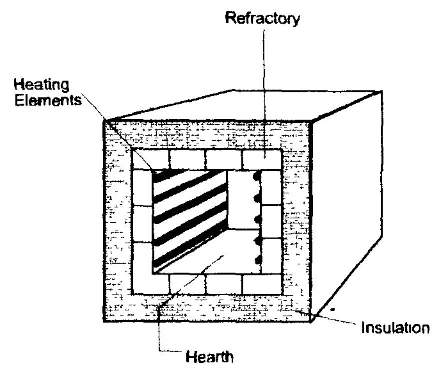
Industrial Heat Pump

Applied Technology: Indirect Resistance



Source: EPRI TechCommentary V3, N7R, 1994

Concept

Indirect resistance heating involves passing line frequency current through high resistance heating elements. The resistance to the current flow generates heat. The heat is transferred to the workpiece via conduction, convection, and/or radiation. The workpiece temperatures can range from ambient to 1700 C° (3100 F°) or more (with an inert atmosphere), depending on the application and type of heating elements. This type of heating is typically performed in a well insulated enclosure, like an electric oven. This minimizes thermal losses and provides a high heating efficiency, typically in the 80% range.

Applications

- **Heat Treating**
- **Forming**
- **Melting**
- **Drying**
- **Cooking**
- **Joining**
- **Curing**
- **Sintering**

Technologies Replaced

- **Fuel-Fired Furnace or Flame Hardening**
- **Salt/Lead Bath Heat Treating**

Wastes Reduced

- **Combustion Pollutants; ROG, SO_X, NO_X, CO_X, Particulate**
- **Salt/Lead Bath; hazardous salts/metals**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	HI	Lumber	24	MED	Chem	28	MED	Stone	32	MED	Elect	36	MED
Tobac	21	MED	Furn	25	MED	Petrol	29	MED	Pmetal	33	MED	Transp	37	MED
Textile	22	MED	Paper	26	MED	Rubber	30	MED	MetFab	34	HI	Instr	38	MED
Apparel	23	MED	Printing	27	MED	Leather	31	MED	Mach	35	MED	Misc	39	MED

Credits: George Bobart, Bobart Associates; Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Indirect Resistance *continued*

Technology Advantages

- **Application Flexibility**
- **Precise Temperature Control**
- **Melting; can decrease dross or material loss**
- **Accommodates Special Atmosphere or Vacuum**

Technology Disadvantages

- **Operating Cost may be high (depends on cost of electricity)**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
depends on size and type; usually about same as comparable fossil: $10k - $200k and more	**low maintenance; costs highly dependent on electric rates**	**about 2 years**

Installations

Case A **- Foundry operations have generally used gas fired pot furnaces to melt aluminum for permanent mold and die casting processes. However, the aluminum reacts with the moisture created by combustion, causing up to 12% dross or metal loss. Gas fired furnaces have very low heating efficiency of 15% - 20% (Indirect Resistance is typically 70%) and melt quality is difficult to control.**

Permanent Casting in Hot Springs, Arkansas replaced five of their gas fired melting furnaces with electric indirect resistance melting units. This conversion provided a 28% savings in both energy and maintenance cost, 10% productivity improvement, and reduced metal losses to nearly 0%.

Case B **- Kopp Glass of Pittsburgh, Pennsylvania is a jobshop producer of glassware for aircraft, medical, and theatrical applications. Their gas fired oven used for annealing the finished glass was causing problems with startup time, energy cost, temperature control, and downtime for maintenance. Replacing their old unit with a conveyorized indirect resistance electric oven resulted in instant startup/shutdown time and a significant improvement in process control. It also reduced overall energy and maintenance costs.**

Major Vendors

Indirect Resistance

Abar-Ipsen Industries
3260 Tillman Drive
Bensalem, PA 19020
(215) 244-4900 (in PA)
(800) 374-7736 (outside PA)

Barnstead/Thermolyne Corp.
2555 Kerper Boulevard
Dubuque, IA 52001
(800) 553-0039

C. I. Hayes, Inc.
800 Wellington Ave
Cranston, RI 02910
(401) 467-5200

Cooperheat, Inc.
1021 Centennial Avenue
Piscataway, NJ 08854
(800) 526-4233

Despatch Industries, Inc.
P.O. Box 1320
Minneapolis, MN 55440-1320
(612) 469-5424

Dynarad Corp.
575 Whitney St.
San Leandro, CA 94577
(510) 638-2000

The Grieve Corporation
500 Hart Road
Round Lake, IL 60073-9989
(708) 546-8225

Industrial Heating and Finishing Co., Inc.
P.O. Box 129
Pelham Industrial Park
Pelham, AL 35124
(205) 663-9595

Lindberg
304 Hart St
Watertown, WI 53094
(414) 261-7000

Seco/Warwick
180 Mercer St
Meadville, PA 16335
(814) 724-1400

Rapid Engineering, Inc.
P.O. Box 700
Comstock Park, MI 49321-0700
(616) 784-0435

Surface Combustion, Inc.
1700 Indian Wood Circle
Maumee, OH 43537
(800) 537-8980

Thermotron
291 Kollen Park Drive
Holland, MI 49423
(616) 393-4580

Thermtronix Corp.
17129 Muskrat Ave.
Adelanto, CA 92301
(619) 246-4500

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Indirect Resistance Heating, **EPRI CMF TechCommentary, Vol 3, No 7R, 1994**

Electric Resistance Melting, **EPRI CMP TechCommentary, CMP-1188-036, 1988**

Resistance Melting for Low Capital Investment, **EPRI CMP TechApplication, CMP-045, 1989**

Electric Ladle Preheaters, **EPRI CMP TechCommentary, CMP-0589-024, 1988**

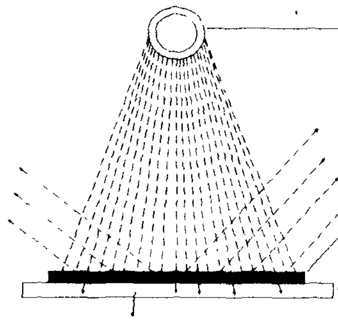
All-Electric Annealing Furnace, **EPRI CMP TechApplication, CMP-075, 1991**

Electric Resistance Ladle Preheating Improves Foundry Operations, **EPRI CMP TechApplication, CMP-079, 1992**

Resistance Melting - A Bellringer at Temple Aluminum, **EPRI CMP TechApplication,**
CMP-086, 1993

Electric Resistance, Indirect Radiant-Heated Sand Reclaimer Economic Answer to Sand Reclamation, **EPRI CMP TechApplication, CMP-087, 1993**

Applied Technology: Infrared



Source: EPRI TechCommentary V3, N6R, 1994

Concept

Infrared heating is produced by electromagnetic radiation generated from a heat source that typically operates in the range of 425 C° (800 F°) to 2200 C° (4000 F°). It is similar to the heat on an object directly exposed to the sun. Infrared is actually an extension of electric resistance heating since the electric IR emitters are heated by passing a current through a heating element. The elements may be in glass bulbs, quartz or metallic tubes, or in ceramic panels. IR is classified by its wavelength:

Type	Emitter Temperature C° (F°)	Wavelength range, microns
long wave	450 - 750 (800 - 1400)	10 - 4
medium wave	750 - 1100 (1400 - 2000)	4 - 2
short wave	1100 - 2200 (2000 - 4000)	< 2

Applications

- **Surface Heating**
- **Preheating**
- **Space Heating**
- **Curing**
- **Foundry Sand Reclamation**
- **Food Cooking and Browning**
- **Drying and Evaporation**
- **Heat Treating**

Technologies Replaced

- **Convection Ovens**
- **Air Drying**
- **Salt/Lead Bath Heat Treating**
- **Gas IR**
- **Steam Drying**

Wastes Reduced

- **Combustion Pollutants; ROG, SO_x, NO_x, CO_x, Particulate**
- **Salt/Lead Bath; hazardous salts/metals**
- **VOC's from solvents (with powder coatings)**

Potential in Manufacturing

Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot
Food	**20**	**MED**	**Lumber**	**24**	**MED**	**Chem**	**28**	**MED**	Stone	32	HI	Elect	36	HI
Tobac	**21**	**MED**	**Furn**	**25**	**MED**	**Petrol**	**29**	**MED**	**Pmetal**	**33**	**MED**	Transp	37	HI
Textile	22	HI	Paper	26	HI	Rubber	30	HI	MetFab	34	HI	Instr	38	HI
Apparel	**23**	**MED**	Printing	27	HI	**Leather**	**31**	**MED**	Mach	35	HI	Misc	39	HI

Credits: George Bobart, Bobart Associates; Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Infrared *continued*

Technology Advantages

- Fast
- Rapid Startup
- Precise Temperature Control
- Enclosure not Required
- **Easily Automated**
- **High Efficiency**
- **Low Floor Space Required**
- **Low Capital and Operating Costs**

Technology Disadvantages

- **Requires Line of Sight**
- **Reflective Coatings are Difficult**
- **Maintenance of IR Emitters Higher in a Dirty Environment**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
low to moderate: $10k - $500K depending on application and size	**low maintenance primarily emitter cleaning and replacement, operating costs low due to high efficiency**	**1 - 2 years**

Installations

Case A **- A company cured the coating on an architectural column with a gas fired oven in 1.5 hours using 8,000 ft^2 of floor space. They also experience environmental compliance problems with their emissions. The gas fired oven solvent based coating process was replaced with a short wave powder coating process. The new process only required 210 ft^2, cured in 34 seconds, increased production capability from 300 to 10,000 parts/shift, and met full environmental compliance.**

Case B **- A steel building components manufacturer bought strip precoated with a plastic protective finish. The strips were formed into specific panel sizes at their facility. They experienced high levels of inventory, scrap, and could not meet many of the color requirements of their customers. The installation of a 32 foot medium wavelength IR unit and powder coat system reduced their inventory and labor requirements by 50%, reduced their scrap generation from 30% to less than 10%, increased available product colors for their customers from 12 to 300, and kept them in full environmental compliance.**

Major Vendors

Infrared

BGK Finishing Systems
4131 Pheasant Ridge Drive North
Blaine, MN 55449-7102
(612) 784-0466

Casso-Solar Corp
230 US Route 202
Pomona, NY 01970
(914) 354-2500

Fostoria Industries Inc
Process Heat Division
P.O. Box E
Fostoria, OH 44830
(419) 435-9201

Industrial Heating and
Finishing Co., Inc.
P.O. Box 129
Pelham Industrial Park
Pelham, AL 35124
(205) 663-9595

Lindberg
304 Hart Street
Watertown, WI 53094
(414) 261-7000

Rapid Engineering, Inc.
P.O. Box 700
Comstock Park, MI 49321-0700
(616) 784-0435

Research, Inc.
P.O. Box 24064
Minneapolis, MN 55424
(612) 941-3300

Thermal Designs & Mfg. Inc.
16043 23 Mile
Macomb TWP, MI 48045
(810) 786-0164

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Infrared Drying in Papermaking, EPRI PIO TechCommentary, Vol 2, No 1, 1989

Medium & Short Wave Infrared Curing, EPRI CMF TechApplication, Vol 1, No 3, 1987

Short Wave Infrared Curing, EPRI CMF TechApplication, Vol 1, No 1, 1991

Infrared Drying of Paint, EPRI CMF TechApplication, Vol 3, No 1, 1991

Infrared Drying of Anodized Aluminum , EPRI CMF TechApplication, Vol 7, No 4, 1994

Infrared Curing for Spot Repair of Auto Paint Surfaces, EPRI CMF TechApplication, Vol 8, No 3, 1994

Infrared Heating, Drying, and Curing, EPRI CMF TechCommentary, Vol 8, No 1, 1992

Infrared Curing of Powdered Coatings, EPRI CMF TechApplication, Vol 4, No 1, 1990

Infrared Drying of Inks, EPRI CMF TechApplication, Vol 6, No 3, 1992

Infrared Curing of Silk Screen Apparel, EPRI CMF TechApplication, Vol 7, No 3, 1993

Using Electric IR to Finish Oil Filters, EPRI CMF TechApplication, Vol 7, No 2, 1987

Infrared Drying of Automotive Seat Risers, EPRI CMF TechApplication, Vol 8, No 1, 1994

Powder Coated Castings Achieve Cure With Electric IR, EPRI CMF TechApplication, Vol 8, No 4, 1994

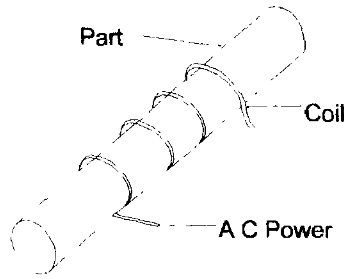
Infrared-Assisted Drying of Foundry Mold Wash Coatings, EPRI CMP TechApplication,
CMP-091, 1994

IR Moisture Profiling of Linerboard, EPRI PIO TechApplication, Vol 4, No 7, 1992

Electric Infrared Boarding of Hosiery, EPRI PIO TechApplication, Vol 5, No 1, 1993

Electric IR Curing of Textile Resin Finishes, EPRI PIO TechApplication, Vol 6, No 3, 1994

Applied Technology: Induction



Source: Bobart Associates

Concept

Induction heating uses an electromagnetic field that is generated via an inductor coil. The magnetic field is produced by applying an AC current with a frequency of 60 Hz to 800 kHz into the inductor coil. The magnetic field intersects the workpiece generating a circulating current. The resistance of the workpiece to this current generates heat. Shallow heating for surface applications such as case hardening can be obtained with medium to high frequencies. Deeper or through heating applications such as hot metal working is achieved at lower frequencies. Various types of inductor coils can be designed to heat any conductive material placed within, outside, or along side the inductor coil.

Applications

- **Melting**
- **Heating**
- **Heat Treating**
- **Welding, Brazing, Soldering, and Bonding**
- **Curing of coatings**
- **Conductive Susceptor or Metal Interface: heat non-conductive materials**
- **Electromagnetic Stirring and Casting**
- **Levitation Melting**

Technologies Replaced

- **Fossil/Electric Furnace Heating**
- **Salt/Lead Bath Heat Treating**
- **Flame Heat Treating**

Wastes Reduced

- **Combustion Pollutants; ROG, SO_X, NO_X, CO_X, Particulate**
- **VOCs (in curing powder coating)**
- **Material Oxidation; slag, scale**
- **Salt/Lead Bath; hazardous salts/metals**

Potential in Manufacturing

Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot
Food	20	LOW	Lumber	24	LOW	Chem	28	MED	Stone	32	MED	Elect	36	HI
Tobac	21	LOW	Furn	25	MED	Petrol	29	LOW	Pmetal	33	HI	Transp	37	HI
Textile	22	MED	Paper	26	LOW	Rubber	30	MED	MetFab	34	HI	Instr	38	MED
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	HI	Misc	39	MED

Credits: George Bobart, Bobart Associates; Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Induction *continued*

Technology Advantages

- **Fast, efficient, highly controllable heating**
- **High level of productivity**
- **High quality**
- **Reduced wastes**
- **Overall reduced operating costs**

Technology Disadvantages

- **High capital cost for low volume applications**
- **Part must be conductive**
- **Inflexible for production of wide range of sizes and shapes**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
$25,000 - $1,000,000 depending on size and application	**low maintenance, costs usually lower than alternative fuels due to greater efficiency**	**about a year**

Installations

Case A **- A major hand tool manufacturer in the Midwest installed an induction heating system to replace a process that hardened hammers in a salt bath then tempered them in a gas fired furnace. The induction system used a rotary table to automatically harden and temper both the head and claw areas of the hammer. This system provided a 50% reduction in energy costs and a 40% increase in productivity. It also reduced rejects by 20%, improved safety, and eliminated all of the hazardous wastes.**

Case B **- An aftermarket automotive supplier was hardening valves with an aluminizing process. But higher compression engines required improved hardening properties and environmental regulations were increasing the cost of properly handling the aluminum waste stream. The company replaced the aluminizing process with an in-line induction hardening system. The induction system met all process performance requirements for use in high compression engines, eliminated the aluminum sludge waste stream, reduced energy costs by 20%, and improved productivity by 25%.**

Major Vendors

Induction

Abar-Ipsen Industries
3260 Tillman Drive
Bensalem, PA 19020
(215) 244-4900 (in PA)
(800) 374-7736 (outside PA)

ABB Metallurgy, Inc.
Induction Furnace Division
North Brunswick, NJ 08902
(908) 932-6134

Ajax Magnethermic Corp.
1745 Overland Ave
Warren, OH 44482
(216) 372-8511

American Induction Heating Corporation
33842 James J. Pompo Drive
Fraser, MI 48026
(810) 294-1700

Cooperheat, Inc.
1021 Centennial Avenue
Piscataway, NJ 08854
(800) 526-4233

IHS-Inductoheat
5009 Rondo Drive
Fort Worth, TX 76106
(800) 486-5577

Inductoheat
32251 N. Avis Dr
Madison Heights, MI 48071
(810) 585-9393

Inductotherm Corporation
10 Indel Avenue
Rancocas, NJ 08073
(800) 257-9527

Pillar Industries
N92 W 15800 Megal Dr
Menomonee Falls, WI 53501
(800) 558-7733

Taylor-Winfield
P.O. Box 500
Brookfield, OH 44403-0500
(216) 448-4464

Thermatool Corporation
31 Commerce Street
East Haven, CT 06512
(203) 468-4100

TOCCO, Inc.
30100 Stephenson Highway
Madison Heights, MI 48071
(810) 399-8601

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Induction Melting for a Competitive Advantage, **EPRI CMP TechApplication, CMP-048, 1990**

Induction Melting for Pollution Elimination, **EPRI CMP TechApplication, CMP-1289-010, 1989**

Induction Melting for Profit-Improving, **EPRI CMP TechApplication, CMP-0689-016, 1989**

Induction Melting for Business Building, **EPRI CMP TechApplication, CMP-1289-020, 1989**

Induction Melting for Operating **Flexibility, EPRI CMP TechApplication, CMP-1289-021, 1989**

Induction Heating Billets for Forging, **EPRI CMF TechApplication, Vol 1, No 20, 1987**

Induction Through Heating for Forging, **EPRI CMF TechApplication, Vol 1, No 7, 1991**

Vacuum Induction Melting Technology, **EPRI CMP TechCommentary, Vol 3, No 3, 1987**

Induction Heating, **EPRI CMP TechApplication, CMP-0689-015, 1988**

Induction Melting for Higher Productivity, **EPRI CMP TechApplication, CMP-1188-018, 1988**

Electromagnetic Stirring for Aluminum Melting, **EPRI CMP TechApplication, CMP-101, 1995**

Transverse Flux Induction Heating of Continuous Caster Belts for Producing Aluminum Strip, **EPRI CMP TechApplication, CMP-102, 1995**

Induction Heating for Textile Printing and Embossing, **EPRI Textile Office TechApplication, No 1, 1995**

Induction Heat Treatment

***Induction Heat Treatment*, EPRI CMF TechCommentary, Vol 2, No 2, 1990**

***Induction Hardening with a Flux Field Concentrator*, EPRI CMF TechApplication, Vol 1, No 11, 1991**

***Post-Grinding Induction Hardening*, EPRI CMF TechApplication, Vol 1, No 2, 1987**

***Induction Heating Technology*, EPRI CMF TechCommentary, Vol 2, No 1R, 1993**

***Selective Induction Heat Treatment*, EPRI CMF TechCommentary, Vol 2, No 3, 1991**

***Induction Tempering*, EPRI CMF TechCommentary, Vol 2, No 4, 1991**

***Induction Hardening for Durable Camshafts*, EPRI CMF TechApplication, Vol 8, No 2, 1994**

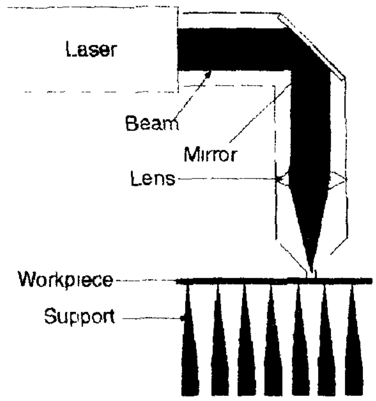
***Induction Susceptor Furnaces*, EPRI CMF TechApplication, Vol 2, No 2, 1988**

Induction Bonding

***Induction Bonding Metal to Plastic*, EPRI CMF TechApplication, Vol 2, No 3, 1988**

***Induction Heating of Thermoset Adhesives*, EPRI CMF TechApplication, Vol 1, No 12, 1987**

Applied Technology: Laser



Credit: EPRI CMP V3,N9, 1986

Concept

Lasers are beams of monochromatic (all one wavelength) light focused precisely to produce a very intense energy beam. The power density in the beam can be high enough to vaporize, melt, or red-heat virtually any material. Lasers commonly cut, weld, and heat treat materials ranging from wood and plastics to the most heat resistant metals and ceramics. Because laser light beams have no inertia, they can be easily and rapidly controlled in intensity and direction with computer control systems. Thus, laser material processing systems lend themselves especially well to modern digital automation and flexible manufacturing operations.

Applications

- **Cutting and Drilling**
- **Welding**
- **Heat Treating**
- **Engraving**
- **Biomedical**
- **Sealing (packaging)**

Technologies Replaced

- **Mechanical Metal Removal**
- **Arc and Gas Welding**
- **Induction, Flame, and Plasma Hardening**

Wastes Reduced

- **Metal Cutting Fluids and Wastewater (machining)**
- **Scale and Slag (welding)**
- **Wastewater and Emissions (heat treating)**
- **Material Removal**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	LOW	Lumber	24	LOW	Chem	28	LOW	Stone	32	LOW	Elect	36	HI
Tobac	21	LOW	Furn	25	MED	Petrol	29	LOW	Pmetal	33	LOW	Transp	37	HI
Textile	22	LOW	Paper	26	MED	Rubber	30	LOW	MetFab	34	HI	Instr	38	HI
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	HI	Misc	39	MED

**Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow;
Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute**

Laser *continued*

Technology Advantages

- **Fast Cutting and Welding**
- **High Surface Quality**
- **Ability to Machine Difficult Materials (e.g. superalloys, ceramics)**
- **Reduced Material Loss**
- **Flexibility and Controllability**
- **Repeatability (non-contact processing)**
- **Minimal or No Thermal Effects**

Technology Disadvantages

- **High Capital Cost**
- **Line-of-Sight Limitation**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
high. 10 times some other cutting and welding systems; 5 times induction heat treatment units. These costs due in part to extensive digital control equipment needed	**application dependent. slightly higher energy for cutting and drilling; 15-30% lower for welding and heat treating. Labor cost usually lower. Maintenance cost comparable**	**very application dependent. Generally good for high product lots, high-valued products (requiring high quality), or for operations requiring high flexibility and quick changeover**

Installations

Case A **- Carbon dioxide laser systems are used by a large auto manufacturer for heat treating the inside of malleable cast iron housings for power steering gears. Because the laser beam can be accurately controlled and directed, only specific areas of the housing wall that are contacted by metal components (so-called "wear tracks") need be heat treated. The process saves over 10% of the energy associated with induction heat treating on the entire housing inner wall and eliminates the spray quenching required with induction hardening. More importantly, it is faster and requires less labor. Estimated savings of about $0.11 per part are realized.**

Case B **- Laser welding systems are used by an appliance manufacturer to weld the corners of hot-rolled steel refrigerator doors. The laser system requires about 16% less electricity than the competing arc welding process, and requires less setup time. Net savings of $150,000 have been reported on production of 970,000 doors per year.**

Major Vendors

Laser

Amada
2025 Firestone Blvd
Buena Park, CA 90621
(714) 739-2111

Cincinnati, Inc.
Box 11111
Cincinnati, OH 45211
(513) 367-7100

Coherent, Inc.
5100 Patrick Henry Drive
Santa Clara, CA 95054
(800) 227-1955

Coherent General, Inc.
1 Picker Road
Sturbridge, Massachussetts 01566
(508) 347-2681

Convergent Energy, Inc
1 Picker Road
Sturbridge, MA 01566
(508) 347-2681

Excel\Control Laser, Inc.
7503 Chancellor Drive
Orlando, FL 32809
(407) 438-2500

Hobart Laser Products
238 Executive Drive
Detroit, MI 48083
(810) 588-8812

Laser Applications, Inc.
6371 North Orange Blossom Trail
Orlando, FL 32810
(407) 290-0336

Lumonics Corporation
6690 Shady Oak Road
Eden Prairie, MN 55344
(612) 941-9530

MC Machinery Systems, Inc.
Laser Division
1500 Michael Drive
Wood Dale, IL 60191
(708) 860-2572

Mazak Nissho-Iwai
140 E. State Parkway
Schaumburg, IL 60173
(708) 882-8777

U.S. Laser Corporation
825 Windham Court North
Wyckoff, NJ 07481
(201) 848-9200

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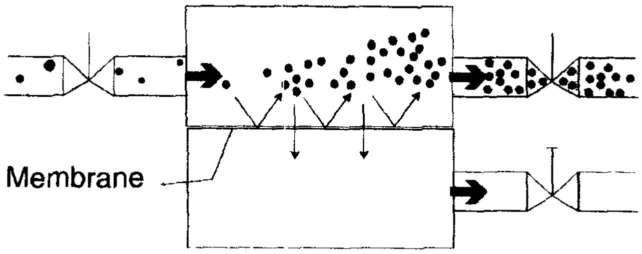
Laser Cutting, **EPRI CMF TechCommentary, Vol 3, No 9, 1986**

Laser Cutting of Metal, **EPRI CMF TechApplication, Vol 1, No 6, 1987**

Laser Cutting & Scribing of Ceramics, **EPRI CMF TechApplication, Vol 1, No 5, 1987**

Applied Technology: Membrane



Credit: Ontario Hydro Research Division

Concept

Membranes selectively filter gases or liquids in solutions or mixtures into their different components. Membranes generally use thin plastic tubes or sheets, bundled into a metal vessel similar to a heat exchanger. Other membrane types, including porous metals and ceramics, are also being developed. The membrane micropores are sized to allow some molecules and particles through while blocking others. Thus membranes are very application-specific, with their molecular structure tailored to the particular species to be separated. The "pressure" used to drive the selected species through the membrane can be mechanical (reverse osmosis, ultrafiltration, microfiltration, and gas permeation) for molecules or electrical (electrodialysis) for ions.

Applications

- **Wastewater purification for reuse**
- **Concentration of food liquids and proteins**
- **Desalting and deacidification of food**
- **Separation of organic chemicals, gas molecules (O_2, N_2), Cl_2 and caustic (chlor-alkali)**
- **Recovery of sizing, dye, and others in textile/leather and electrophoretic paint in metal fab**
- **Removal of trace gases in oil refinery, bacteria/viruses from biofluids, and alcohol from beer**

Technologies Replaced

- **Fuel fired distilling and evaporating**
- **Chemical wastewater treatment**
- **Chemical separation**

Wastes Reduced

- **Combustion products: COx, SOx, ROG, particulates**
- **Wastewater pollutants and treatment chemicals**
- **Hazardous Air Pollutants (HAPs) from thermal treatment of process emissions**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	HI	Lumber	24	LOW	Chem	28	HI	Stone	32	LOW	Elect	36	MED
Tobac	21	MED	Furn	25	MED	Petrol	29	MED	Pmetal	33	MED	Transp	37	MED
Textile	22	HI	Paper	26	HI	Rubber	30	LOW	MetFab	34	MED	Instr	38	MED
Apparel	23	LOW	Printing	27	MED	Leather	31	MED	Mach	35	MED	Misc	39	MED

Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow;
Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Membrane *continued*

Technology Advantages

- **Provides major reduction in overall energy use and associated emissions**
- **Suitable for temperature sensitive products**
- **High separation % (product purity)**
- **No boiling/freezing point limitations**
- **Mechanically simple, reliable, and easy to maintain.**
- **Compact size**
- **Low capital cost for low capacities**

Technology Disadvantages

- **Suitable membranes hard to find for some applications**
- **Some stream contaminants may damage membrane**
- **May not be suitable for pressure sensitive products**
- **Little economy of scale; may be uneconomic for large flows**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
Very application, size, and flow dependent. Typical Ultrafiltration costs: $600-$1200/m2 or $1-$3/liter flow.	**Energy savings typically >90% over evaporative systems. Membrane replacement 1-6 years depending on type, application, and operating conditions.**	**1 - 3 years depending on application.**

Installations

Case A **- Conventional chemical treatment of oily wastewaters in a metal fab plant produces an oily sludge. The sludge must be stabilized before disposal and the water effluent must treated before discharge. Ultrafiltration systems directly produce water pure enough to be discharged with no post-treatment. The oil is concentrated (3-5% of the original stream volume) and can either be incinerated or reprocessed. Installed capital cost for a 40,000 liter/day system is around $100,000. Total operating cost is about $2.50/liter or a penny a gallon. And this assumes no credit for oil reuse or combustion as fuel. Energy requirements are about 400-600 kwh/day or 10-15 kwh per cubic meter flow, and operating labor requires about 7-10 hrs/week.**

Case B **- Reverse osmosis systems are now commonly used to reprocess rinse waters from metal galvanizing plants. The purification is effective enough to permit reuse in the process, eliminating treatment and disposal costs. More importantly, nickel and other valuable metals can be recovered, turning a liability (disposal of heavy-metal-contaminated wastewater) into an asset. Membranes typically last over 2 years. Paybacks of 2 months to 2 years have been reported based on the value of recovered metals alone.**

Major Vendors

Membrane

A/G Technology Corp.
(Ultra and microfiltration)
101 Hampton Avenue
Needham, MA 02194
(800) 248-2535

Aqualytics
(electrodialysis)
7 Powder Horn Drive
Warren, NJ 07059
(908) **563-2800**

Dedert Corporation
20000 Governors Dr.
Olympia Fields, IL 60461
(708) 747-7000

Graver Separations, Inc
(Micro, ultra, and nanofiltration)
200 Lake Drive
Glasgow, DE 19702
(302) 731-1700

Ionics, Inc.
5455 Garden Grove Blvd.
Westminster, CA 92683
(714) 893-1545

Koch Membrane Systems, Inc.
850 Main St
Wilmington, MA 01887
(800) 343-0499

Niro Hudson, Inc
1600 O'Keefe
Hudson, WI 54016
(715) 386-9371

Osmonics, Inc.
5951 Clearwater Dr.
Minnetonka, MN 55343
(612) 933-2277

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Membrane

Special Publications

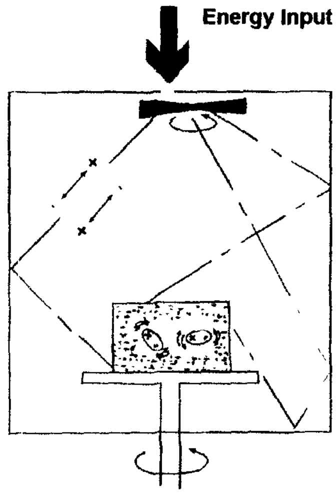
Osmonics Relative Membrane and Filtrate Size Chart

EPRI Publications

***Membrane Separation in Food Processing*, EPRI PIO TechApplication, Vol 3, No 1, 1991**

***Ultrafiltration in Food Processing*, EPRI PIO TechApplication, Vol 4, No 6, 1992**

Applied Technology: Microwave



Concept

Microwaves are electromagnetic waves in the frequency range of 300 to 3,000 megahertz (MHz, million cycles per second) generated by a magnetron-type vacuum tube. Electromagnetic energy at 915 and 2,450 MHz can be absorbed by materials containing water or other "lossy" substances, such as carbon and some organics, and converted to heat. Because the waves can penetrate to the interior of the material, heating is volumetric ("from the inside out"). The degree of penetration and rate of heat generation depend on the selected frequency and the dielectric characteristics of the material, as well as the power rating of the generator. Microwaves can heat certain products selectively. In drying, more uniform moisture profiling in the product is possible.

Applications

- **Drying, Tempering, Proofing, Precooking, Pasteurization of foods**
- **Preheating and curing of rubber**
- **Recycling spent asphalt paving**
- **Drying of foundry molds**
- **Drying and sintering ceramics**
- **Plasma etching semiconductors**

Technologies Replaced

- **Gas fired drying and curing ovens**
- **Salt-bath curing of rubber**
- **Wet-chemical etching semiconductors**
- **Cool room tempering frozen foods**
- **Disposing (landfill) waste asphalt paving**

Wastes Reduced

- **Combustion Pollutants; ROG, SOx, NOx, COx, Particulate**
- **Equipment corrosion from salt vapors**
- **Startup product quality losses**
- **Wastewater in food processing**
- **Wet-chemical etch haz chemicals**
- **Used asphalt and virgin asphalt emissions**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	HI	Lumber	24	LOW	Chem	28	MED	Stone	32	MED	Elect	36	HI
Tobac	21	MED	Furn	25	LOW	Petrol	29	LOW	Pmetal	33	MED	Transp	37	LOW
Textile	22	LOW	Paper	26	LOW	Rubber	30	MED	MetFab	34	LOW	Instr	38	LOW
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	LOW	Misc	39	LOW

Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow;
Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Microwave *continued*

Technology Advantages

- **Fast heating, startup and shutdown**
- **Can dry to consistent levels**
- **High energy efficiency**
- **High quality and controllability**
- **Compact, easy to clean equipment**
- **Low emissions**
- **Can heat in vacuum or low temperature**

Technology Disadvantages

- **Product can overheat**
- **Not as tolerant of product variability or geometry as convection**
- **Will not work on all products**
- **Higher capital cost**
- **Requires specialized technical support**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
High: $2k - $4k per kW	**low to moderate operating, high maintenance**	**1 - 2 years**

Installations

Case A **- A number of U.S. pasta producers have installed microwave-enhanced drying ovens for drying of short-goods products. The microwave ovens require less than one-fifth the floor area of conventional drying ovens for the same throughput and have often been selected to expand production capacity within a constrained space environment. The microwave process decreases both fuel and electricity requirements and their associated emissions; overall fuel costs are reduced by about 30%. Because of their ability to come on-line and off-line in a matter of minutes, the microwave units provide an increase in output of about 6% in a typical 2-shift production day, compared with conventional gas-fired dryers which take longer to heat up and cool down.**

Case B **- A new process has been developed using microwaves to reclaim asphalt pavement that has been stripped from the surface of roadways. The asphalt in paving mix is virtually transparent to microwaves, while the crushed stone aggregate, which constitutes 95% of the mix, is readily heated. A plant which has been running for several years in Los Angeles, processing 1000 tons/day of reclaimed paving mix, has produced recycled asphalt at $15/ton, compared with $22-28/ton for virgin mix. Recycling the paving mix eliminates the land-fill costs associated with disposal of spent paving and the plant operates with none of the liquid and gaseous effluents associated with conventional asphalt production plants.**

Major Vendors

Microwave

AGL, Inc.
(semiconductor plasma processing)
1132 Doker Drive
Modesto, CA 95351
(209) **521-6549**

Amana Refrigeration, Inc
Industrial Microwave Division
2800 220th Trail
Amana, IA 52204
(319) 622-5850

Berstorff Corporation
8200 Arrowridge Blvd.
Charlotte, NC 28273
(704) 523-2614

Cober Electronics, Inc
102 Hamilton Avenue
Stamford. CT 06902
(203) 327-0003

Microdry
7450 Highway 329
Crestwood, KY 40014
(502) 241-8933

Nemeth Engineering Associates
5901 W. Highway 22
Crestwood, KY 40014
(502) 241-1502

Sanitec ***(medical waste)***
26 Fairfield Place
West Caldwell, NJ 07006
(800) 551-9897

Thermex-Thermetron, Inc.
60 Spence Street
Bayshore, NY 11706
(516) **231-7800**

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Microwave

Dielectric Heating: RF and Microwave, **EPRI CMF TechCommentary, Vol 4, No 1, 1990**

Industrial Microwave Heating Applications, **EPRI CMF TechCommentary, Vol 4, No 3R, 1993**

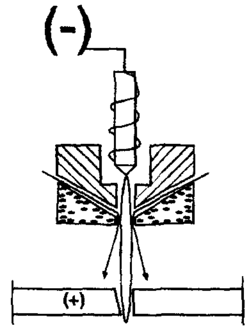
Microwave Curing of Rubber, **EPRI CMF TechApplication, Vol 2, No 1, 1988**

Microwave Process for Asphalt Pavement Recycling, **EPRI CEC TechApplication, No 2, 1992**

Food Processing Using Microwaves, **EPRI PIO TechApplication, Vol 2, No 1, 1990**

Microwave Curing of Lumber Adhesives, **EPRI PIO TechApplication, Vol 6, No 1, 1994**

Applied Technology: Plasma Arc



Credit. Philip Schmidt, University of Texas, Austin

Concept

A plasma is an ionized gas which has become an electrical conductor. Gas is passed through an electric arc, thus reaching approximately 5500 °C. This is known as a "thermal" or "hot" plasma. *See "Plasma (Ion) Nitriding" for "cold plasma" applications such as semiconductor etching.* Containing tremendous energy, thermal plasmas produce very fast and precise melting and cutting of metals.

Applications

- **Melting; metals, ceramics, and glasses**
- **Reduction; ores**
- **Ladle Refining; steel**
- **Surface Treating; wear and corrosion resistance**
- **Welding; metals**
- **Cutting; metals**

Technologies Replaced

- **Cutting Metals by Mechanical or Laser**
- **Welding by Conventional Arc, Laser, or Gas**
- **Melting Metals, Ceramics, and Glasses by Conventional Arc or Fossil Fuels**
- **Heat Treating Metal Surfaces**

Wastes Reduced

- **Metal Cutting Fluids and Wastewater (machining)**
- **Scale and Slag (welding)**
- **Wastewater and Emissions (heat treating)**
- **Material Removal**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	LOW	Lumber	24	LOW	Chem	28	LOW	Stone	32	MED	Elect	36	HI
Tobac	21	LOW	Furn	25	LOW	Petrol	29	LOW	Pmetal	33	HI	Transp	37	HI
Textile	22	LOW	Paper	26	LOW	Rubber	30	LOW	MetFab	34	HI	Instr	38	LOW
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	HI	Misc	39	MED

Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow;
Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Plasma Arc *continued*

Technology Advantages

- **High Productivity; due to high speed of energy deposition**
- **Small Equipment Size**
- **Enhanced Flexibility; automation**
- **Cuts and Melts Difficult Materials**
- **Eliminates or Reduces Oxidation (due to controlled atmosphere)**
- **Process Control Simplification**

Technology Disadvantages

- **High energy-Density Processes; leave small margin of error, require careful control**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
$1k - $50k for cutting and spray; similar to conventional arc and oxyfuel-based systems; about 1/10 cost of laser **>$1 million; for large melting systems**	**application dependent; typical operating cost, including power, labor, and inert gases of plasma cutting for 6 mm (¼") steel plate is about $0.23/m ($0.07/ft); electrode replacement every 2-8 hours ($15-$40/set) takes only a few minutes**	**< 1 year; small plasma cutting systems require little capital investment** **< 1 year - 2 years or more; large melting systems are very capital intensive**

Installations

Case A **- Four shop workers using a mechanical cutting system in a plant producing custom fabricated AC ductwork supplied 30 field installers. The plant needed higher productivity and the metal cutting operation was the bottle neck. Laser cutting was investigated but the capital cost was too high and the laser precision was not necessary.**

A plasma cutting system was installed. Now 2 shop workers supply 50 field installers. The installed capital cost was $130,000 and payback was about 1 year.

Case B **- Plasma heaters are now used in over a dozen steel mills around the world for maintaining precise control of steel temperature as it passes down a tundish to a continuous caster. These units range in power rating from 350 kW to about 2.5 MW. Steel temperature entering the caster is controlled to a precision of 1 °C. The systems produce higher yields, better refractory life, and improved steel quality.**

Major Vendors

Plasma Arc

Century Manufacturing Company
(cutting, welding equipment)
9231 Penn Avenue
Bloomington, MN 55431
(800) 328-2921

Hard Face Alloy
(spray coating equipment)
8351 Securia Way
Santa Fe Springs, CA 90670
(310) 945-5477

Hypertherm Inc.
P.O. Box 5010
Hanover, NH 03755
(800) 643-0030

Thermal Dynamics
Industrial Park #2
West Lebanon, NH 03784
(603) 298-5711

Weldcraft Products, Inc.
119 E. Graham Plaza
Burbank, CA 91502
(818) 846-8181

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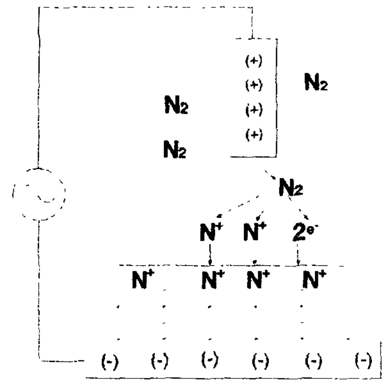
Plasma Arc

Plasma Arc Cutting, **EPRI CMF TechCommentary, Vol 4, No 5, 1987**

Plasma Cutting, **EPRI CMF TechApplication, Vol 1, No 14, 1991**

Plasma Arc Technology, **EPRI CMP TechCommentary, No 76, 1992**

Applied Technology: Plasma (Ion) Nitriding



Concept

Plasma (sometimes called ion) Nitriding is a process for surface treatment of metal parts to make them resistant to wear and fatigue. Parts to be treated are placed in a vacuum chamber and a high DC voltage (typically around 100 volts) is established between the parts and the chamber wall. As nitrogen gas is introduced into the chamber, a glow discharge plasma (ionized gas) builds up around the parts. This plasma is highly energetic. The reactive nitrogen atoms thus bombard the surface, forming a thin layer of hard metal nitrides.

Applications

- **Surface Hardening; dies, cutting tools, parts, and molds**

Technologies Replaced

- **Salt Bath Nitriding (reactive ammonia and cyanide)**
- **Thermal Heat Treatment and Carburizing**

Wastes Reduced

- **Explosive Gases and Toxic Salts**
- **Chromium Plating wastes (from hard chrome resurfacing)**
- **Combustion Pollutants: ROG, COx, SOx, NOx, and Particulate**

Potential in Manufacturing

Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot
Food	20	LOW	Lumber	24	LOW	Chem	28	LOW	Stone	32	LOW	Elect	36	HI
Tobac	21	LOW	Furn	25	LOW	Petrol	29	LOW	Pmetal	33	LOW	Transp	37	HI
Textile	22	LOW	Paper	26	LOW	Rubber	30	LOW	MetFab	34	MED	Instr	38	MED
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	HI	Misc	39	MED

Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow; Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Plasma (Ion) Nitriding *continued*

Technology Advantages

- **Better Product Quality**
- **Faster Cycle Time**
- **No or Little Thermal Effects**
- **Simpler Automation and Control**
- **Easy to Mask Unnitrided Areas**
- **Less Floor Space (1/2 other technologies)**

Technology Disadvantages

- **Parts Must Be Separated**

Typical Costs (compared to other technologies)

Capital Costs	O & M Costs	Potential Payback
higher baseline; but does not require dissociaters and cooling pits	**energy costs: 1/3** **labor: < other nitriding** **overall: ½ (salt bath) to 1 (ammonia)**	**< 1 year or more; very application dependent**

Installations

Case A **- A company producing large injection molded fiberglass components, such as outboard motors, basketball backboards, and automotive body components, replaced its chromium-plated molds with ion nitrided molds. The new molds last 5 times as many molding cycles as the chromium-plated molds before they have to be refinished. This has reduced the number of spare molds required (at $200k - $300k each) and reduced the number of mold-refinishing operations (at $25k - $40k each) by 80%. The surface quality of the molded parts is improved substantially, reducing part finishing costs.**

Major Vendors

Plasma (Ion) Nitriding

Abar-Ipsen Industries
905 Pennsylvania Blvd
Feasterville, PA 19047
(215) 355-4900

Seco/Warwick Corp.
180 Mercer Street
Meadville, PA 16335
(814) 724-1400

Surface Combustion, Inc.
1700 Indian Wood Circle
Maumee, OH 43537
(419) 891-7150

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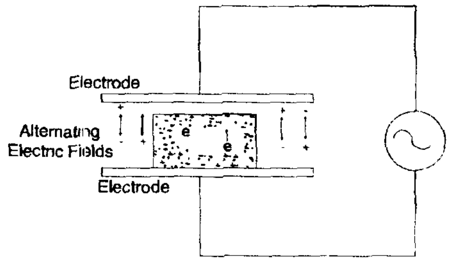
Plasma (Ion) Nitriding

***Ion Nitriding*, EPRI CMF TechCommentary, Vol 2, No 5R, 1994**

***Ion Nitriding Injection Molds*, EPRI CMF TechApplication, Vol 1, No 13, 1987**

Applied Technology: Radio Frequency (RF)



Concept

Radio frequency (RF) electromagnetic waves cover the frequency spectrum from 30 to 300 MHz and, like microwaves, can be absorbed and converted to heat in nonmetallic materials known as "lossy dielectrics". For this reason, both RF and microwave heating are known as "dielectric heating". The two technologies can affect materials differently and require different equipment. RF energy mainly acts through the electrical conductivity of the material, so the presence of ionic species (e.g., dissolved salts) tends to make materials good heating candidates. RF generally heats more uniformly than microwave. RF energy is less expensive per kilowatt than microwaves; RF generator capacities range from a kilowatt to hundreds of kilowatts. RF heating has been used for commercial applications since World War II.

Applications

- **Curing wood adhesives and glass fiber coatings**
- **Drying wood, textiles and paper adhesives**
- **Moisture leveling**
- **Welding plastics**
- **Preheating plastics**
- **Post-baking food**
- **Plasma etching and vapor deposition for semiconductors**

Technologies Replaced

- **Gas fired drying, curing, and preheating ovens**
- **Wet-chemical etching**
- **Use of organic solvent-based adhesives**

Wastes Reduced

- **Combustion Products: COx, SOx, NOx, ROG, and particulates**
- **Off-spec moisture profile product waste**
- **Wet-chemical etch hazardous chemicals**
- **Solvent-based adhesive VOCs**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	MED	Lumber	24	MED	Chem	28	LOW	Stone	32	LOW	Elect	36	HI
Tobac	21	MED	Furn	25	MED	Petrol	29	LOW	Pmetal	33	LOW	Transp	37	LOW
Textile	22	HI	Paper	26	MED	Rubber	30	HI	MetFab	34	LOW	Instr	38	LOW
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	LOW	Misc	39	LOW

**Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow;
Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute**

Radio Frequency (RF) *continued*

Technology Advantages

- **Fast uniform heating**
- **Some tolerance of complex shapes**
- **Levels moisture while drying**
- **Enhances use of water based coatings and adhesives**
- **Fast startup/shutdown**
- **Precise control (can be computerized)**
- **Compact equipment**
- **High throughput rate**
- **Low emissions**
- **High energy efficiency**

Technology Disadvantages

- **Not inherently self-regulating; product can overheat**
- **Can arc in high humidity or low pressure**
- **Convection systems more tolerant of complex shapes**
- **Effectiveness dependent on product dielectric characteristics**
- **High capital cost**
- **Requires specialized technical support**
- **Must be shielded (FCC regs)**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
$1.5k - $3k/kw depending on size and application	**Energy costs low due to high efficiency and elimination of large fan loads associated with combustion-fired ovens. Higher maintenance cost for specialized technical support.**	**About 1 year or more depending on application**

Installations

Case A **- Over 300 RF textile yarn drying units have been installed in plants in Europe, Taiwan and the U.S. Typical reduction in energy consumption per unit of product is 50-65%. Since this is all electric energy, on-site combustion emissions are eliminated. Because of the high efficiency of RF-based drying, net emissions, including the powerplant, are actually lower than those associated with conventional drying. The RF units achieve 70-120% increase in product throughput in the same space, and require about half the operating labor of conventional dryers..**

Case B **- A major wood products corporation installed a 300 kW RF redryer in one of its plywood plants for production of softwood veneer. Due to wide variations in the moisture content of wood, about 15% of the veneer exiting from the main steam-heated dryer is typically above the target moisture level and has to be redried. Conventional redrying, by recycling the veneer through the main dryer, results in scrap losses of 10 to 25% (1.5-5% of total production) due to uneven moisture profiling, with associated splitting, warping and cracking. With the RF redryer, scrap losses have been substantially reduced and productivity of the primary dryer has been increased by 15-20%. Payback period on the RF installation was estimated at 1.5 years.**

Major Vendors

Radio Frequency (RF)

Microdry
7450 Highway 329
Crestwood, KY 40014
(502) 241-8933

Nemeth Engineering Associates
5901 W. Highway 22
Crestwood, KY 40014
(502) 241-1502

Strayfield
Green Hills Corporate Center
2675 Morgantown Road, Suite 1405
Reading, PA 19607
(610) 856-5760

PSC, Inc.
21761 Tungsten Road
Cleveland, OH 44117
(216) 531-3375

Radio Frequency Company
150 Dover Road
Millis, MA 02054
(617) 762-4900

Thermex/Thermatron, Inc
60 Spence Street
Bayshore, NY 11706
(516) 231-7800

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Radio Frequency (RF)

***Electroforming*, EPRI CMF TechCommentary, Vol 3, No 5, 1986**

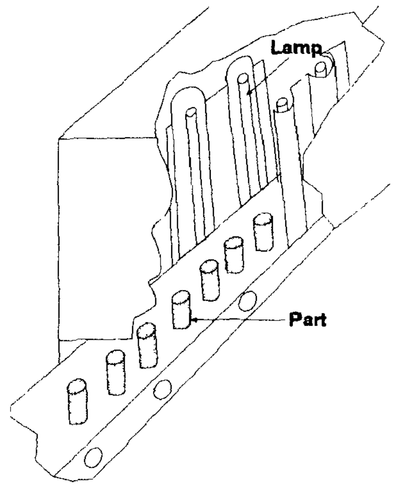
***Radio Frequency Heating of Plastics*, EPRI CMF TechCommentary, Vol 4, No 2, 1987**

***RF Curing of Furniture Adhesives*, EPRI CMF TechApplication, Vol 5, No 1, 1991**

***RF Drying of Textiles*, EPRI PIO TechApplication, Vol 2, No 2, 1990**

[SEE ALSO MICROWAVE]

Applied Technology: Ultraviolet (UV)



Concept

Ultraviolet radiant curing is an alternative to conventional thermal curing of coatings, inks, and adhesives. Conventional solvent or water based formulations must be first dried (to evaporate the solvent or water), then cured with heat or long exposure to air to convert the soft organic base to a tough polymer. UV-curable formulations contain little or no solvent. The organic base contains a photo-sensitive component ("photoinitiator") that triggers a nearly instantaneous curing reaction upon exposure to ultraviolet light. Thus UV curing produces a completely dry and finished surface in a second or two, compared with minutes or hours for conventional curing. This yields coatings and inks of the highest quality with very high production rates in minimal equipment space.

UV can also disinfect clear or translucent fluids (water, air, etc.) for reuse or recycle.

Applications

- **Curing Coatings, Inks, and Adhesives; metal, wood, plastic, fabrics, mag tape, electronics**
- **Curing Textile Fiber Sizing**
- **Compact Disc Production**
- **Disinfection of Water, Wastewater, Air, and Other Fluids**

Technologies Replaced

- **Conventional Thermal Curing; solvent based**
- **Chemical or Heat Disinfection of Some Fluids**

Wastes Reduced

- **Combustion Pollutants: ROG, COx, SOx, NOx, Particulate**
- **VOC Emissions; from solvents**
- **Coating Overspray (can be recycled)**
- **Waste Heat (curing ovens)**
- **Sludge, Chemicals, and Emissions from Chemically Treated Waters and Wastewaters**

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	**20**	LOW	**Lumber**	**24**	MED	**Chem**	**28**	LOW	**Stone**	**32**	MED	Elect	36	HI
Tobac	**21**	LOW	Furn	25	HI	**Petrol**	**29**	LOW	**Pmetal**	**33**	LOW	Transp	37	HI
Textile	**22**	MED	**Paper**	**26**	MED	**Rubber**	**30**	MED	MetFab	34	HI	Instr	38	HI
Apparel	**23**	LOW	Printing	27	HI	**Leather**	**31**	LOW	Mach	35	HI	**Misc**	**39**	**MED**

Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow; Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Ultraviolet (UV) *continued*

Technology Advantages

- **Cures Fast**
- **Reduces or Eliminates Solvents**
- **No Curing Ovens**
- **Can Coat Heat Sensitive Substrates (plastic and wood)**
- **Less Coating Materials Required**
- **Small Equipment and Staging Area Required**
- **Improves Coating Quality**
- **Aids VOC Regulatory Compliance**

Technology Disadvantages

- **Higher Cost of UV Materials**
- **Some UV Materials Require Special Care (toxic)**
- **More Worker Protection Required (high energy UV)**
- **Line of Sight Limitation**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
low; curing units < ½ thermal curing ovens; control required little or no emission control required	**energy cost: 1/3 - ½ of thermal oven** **labor cost: 1/3** **floor space: 1/10** **material: same cost/unit area covered**	**< 1 year or more; application dependent**

Installations

Case A **- A major brewing company implemented a UV curing process for coating 15 million cans per day. Wet UV curable inks are applied to the cans followed by a clear overvarnish to give the can a high gloss and abrasion-resistant surface. The entire ink/overcoat system is cured in about ½ second. The system uses less than 10% of the energy required by a conventional thermal curing oven (not even counting emission controls not needed) and occupies 1/5 of the space. Further energy, space and cost savings accrue from increased production rates and elimination of the solvent vapor incinerator required to meet tough new emission standards.**

Case B **- A printing company is using UV curing on a print line to produce labels, coupons, and tags. UV-curable inks and overprint varnish maintain high quality and consistency in the colors and give the product an attractive and durable finish. Print quality variations due to evaporation of solvent in ink trays have been eliminated. Line speed is about 67% higher for the UV-cured lines. Startup and shutdown/cleanup times have been reduced dramatically with the UV inks. Rejects and product loss at startup have also been sharply reduced.**

Major Vendors

UV

Crown Metro
(coatings)
P.O. Box 5857
Greenville, SC 29606
(803) 299-1331

Eye Ultraviolet
(equipment)
42 Industrial Way
Wilmington, MA 01887
(508) 694-9060

Fusion UV Systems
7600 Standish Pl
Rockville, MD 28055
(301) 251-0300

Industrial Heating and Finishing Co., Inc.
(equipment)
P.O. Box 129
Pelham Industrial Park
Pelham, AL 35142
(205) 663-9595

Hanovia, Inc.
(equipment)
100 Chestnut Street
Newark, NJ 07105
(800) 229-3666

RPC Industries
(electron beam equipment)
21325 Cabot Blvd.
Hayward, CA 94545
(510) 785-8040

Specialty Coating Systems
5707 West Minnesota Street
Indianapolis, IN 46241
(800) 356-8260

Sun Chemicals
(coatings, inks)
135 West Lake Street
Northlake, IL 60164
(800) 933-7863

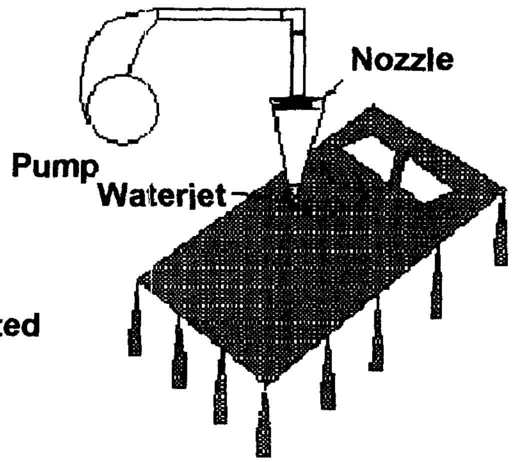
UCB Chemical Corporation
(coatings)
Radcure Business Unit
2000 Lake Park Drive
Smyrna, GA 30080
(770) 434-6188

This list of vendors of the indicated technology is not meant to be a complete or comprehensive listing. Mention of any product, process, service, or vendor in this publication is solely for educational purposes and should not be regarded as an endorsement by the authors or publishers.

Index to EPRI DOCUMENTS

Ultraviolet Curing

Applied Technology: Waterjet



Concept

Waterjet cutting applies the force of a very concentrated high velocity stream of water to cut through materials ranging from the hardest metals to food products. Special pumps and pressure intensifiers boost the water to pressures in excess of 3400 atmospheres. The water is then concentrated through a metal or sapphire nozzle to a stream diameter of a few micrometers, reaching velocities several times the speed of sound. For cleaning, lower pressures (1/2 - 700 atmospheres) and larger nozzles are used. For very hard materials, abrasives may be added to the water to enhance cutting action.

Applications

- **Cutting; plastic, fiberglass, glass, metal, leather, food, composites, paper, cardboard, rock, concrete**
- **Cleaning; scale, deposits, coatings, contaminated layers of concrete**

Technologies Replaced

- **Cutting; by mechanical saw, laser, plasma, or oxyfuel**
- **Cleaning; by solvents, chemicals, or abrasives**

Wastes Reduced

- **Metal Cutting Fluids and Contaminated Wastewater**
- **Slag and Scale; from oxyfuel**
- **Dissolved Scale, Abrasives, and Solvents; from cleaning**
- **Material Removal**

Potential in Manufacturing

Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot	Indust	SIC	Pot
Food	20	MED	Lumber	24	LOW	Chem	28	MED	Stone	32	MED	Elect	36	HI
Tobac	21	LOW	Furn	25	MED	Petrol	29	MED	Pmetal	33	LOW	Transp	37	HI
Textile	22	LOW	Paper	26	MED	Rubber	30	MED	MetFab	34	HI	Instr	38	MED
Apparel	23	LOW	Printing	27	LOW	Leather	31	MED	Mach	35	HI	Misc	39	MED

AT14

Credits: Dr. Philip Schmidt and Dr. F.T. Sparrow;
Unimar Group, Ltd; The Electrification Council; Electric Power Research Institute

Waterjet *continued*

Technology Advantages

- **Fast Cutting**
- **Clean Cutting**
- **Cuts Difficult Materials**
- **Better Tolerances (than mechanical or torch cutting)**
- **No Thermal Effects**
- **Flexible and Controllable**
- **Reduces Material Loss**
- **Fast Cleaning of Difficult Scale; without solvents or abrasives**

Technology Disadvantages

- **Higher Capital Cost**
- **Larger Tolerances than Laser**

Typical Costs

Capital Costs	O & M Costs	Potential Payback
$165k - $600k; baseline: $65k - $100k controls: $100k - $500k abrasive: $10k	**overall operating nonabrasive: $3/hour abrasive: $11/hr labor: often lower than alternatives**	**< 1 year or more; very application dependent**

Installations

Case A **- An automaker installed six waterjet cutting systems on a conveyor line to cut asbestos brakelining strips. Waterjet was chosen because it produces a minimum kerf, < ¼ mm (<0.01 "), eliminates airborne asbestos dust, and is simple to automate for safety and production control. Cutting efficiency increased an estimated 30 - 50% with an annual savings of about $25k.**

Case B **- An Aerospace firm purchased a waterjet cutting system equipped with hydroabrasive nozzles to cut titanium and other hard materials for aircraft components. The system feeds two cutting stations, one manual for complex contoured components, and the other a CNC X-Y positioning table for sheet metal. The system cuts 1.5 mm (1/16") titanium plate at a rate of 5 mm/second (1 foot/minute). The company estimates overall production cost savings is 50%.**

Major Vendors

Waterjet

Aqua-Dyne Inc
3620 W. 11th Street
Houston, TX 77008-6004
(800) 324-5151

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Ingersoll-Rand
Waterjet Cutting Systems
634 West 12th Street
Baxter Springs, KS 66713
(316) 856-2151

Jet Edge
825 Rhode Island Ave, South
Minneapolis, MN 55426
(800) 538-3343

Pratt & Whitney Waterjet Systems
(cleaning and stripping)
P.O. Box 070019
Huntsville, AL 35807
(800) 239-2773

Robotics Inc.
2421 Route 9
Ballston Spa, NY 12020
(518) 899-4211

Trumpf, Inc.
Large Machinery Sales
Farmington Industrial Park
Farmington, CT 06032
(860) 677-9741

Index to EPRI DOCUMENTS

Waterjet

***Waterjet Cutting*, EPRI CMF TechCommentary, Vol 5, No 1, 1988**

James B. Hogenson

Eastman Kodak Co.

EXECUTIVE SUMMARY

The Silver Coalition and the Association of Metropolitan Sewerage Agencies (AMSA) have prepared and issued recommendations on technology, equipment and management practices for controlling silver discharges from facilities that process photographic materials. These recommendations are known as the Code of Management Practice (CMP), and will be used to develop a consensus among the regulated and regulatory communities for controlling silver discharges in a cost-effective and environmentally sound manner. Implementation of the CMP recommendations will result in many benefits, including improved selection, operation, maintenance and monitoring of silver recovery and management systems among all types and sizes of photographic processing facilities; an increase in the amount of silver recycled and reused; and a reduction in the amount of silver discharged to sewage treatment plants and the environment.

The large numbers of facilities that process small volumes of photographic products in most communities make the control of their discharges to sewage treatment plants through typical pretreatment programs difficult, costly and resource intensive. However, there is a strong desire from both the regulated and the regulatory communities to reduce the amount of silver discharged to POTWs, to achieve more silver recovery and recycling, and to encourage water conservation, particularly from these numerous small volume facilities. Consequently, resources from the Silver Coalition and AMSA developed the CMP.

The CMP describes the technologies and capabilities of the different types of silver recovery and management systems and equipment. The CMP recommends specific silver recovery and management systems and equipment, along with management practices that will ensure optimum recovery in a cost-effective manner for all sizes and types of facilities that process photographic materials. Recommendations are provided for both on-site and off-site silver recovery and management. Implementation of the CMP recommendations will result in reduced silver loading to POTWs, reduced regulatory burdens and costs for municipalities, health care facilities, and small businesses, and increased amounts of silver recycled and reused. These benefits have been demonstrated in three municipalities that have already implemented the recommendations of the CMP -- Hampton Roads, VA, Albuquerque, NM and Colorado Springs, CO. Other municipalities which plan to implement the recommendations of the CMP in 1995 include New York City, NY, Atlanta, GA, Salisbury, MD, and Tacoma, WA.

Other groups which have expressed support for the CMP process include the Environmental Protection Agency, the Water Environment Federation, and the Ontario Ministry of Environment in Canada. For more information on the CMP, please contact Tom Dufficy at the National Association of Photographic Manufacturers (NAPM) at (914) 698-7603 or Sam Hadeed at AMSA at (202) 833-2672.

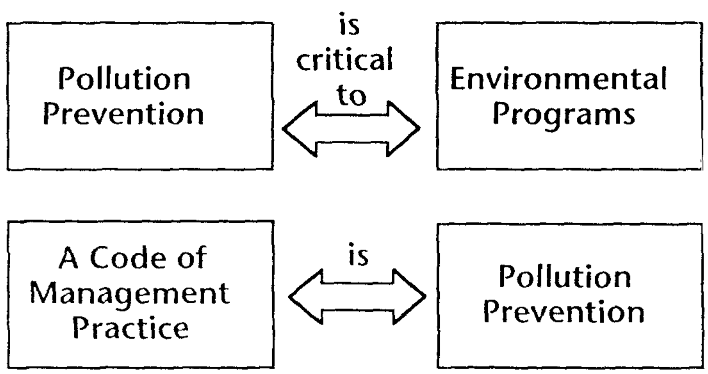
Code of Management Practices

Introducing a...

Code of Management Practice

for
Controlling Silver Discharges
from
Facilities Processing Photographic Materials

1



A Win-Win for Everyone!

2

The Code of Management Practice Is Supported by:

- Silver Coalition
- Association of Metropolitan Sewerage Agencies (AMSA)

3

Code of Management Practices

The Code of Management Practice for Silver

- Conserves a natural resource

4

The Code of Management Practice for Silver

- Conserves a natural resource
- Provides for the recovery and management of silver at the source

5

The Code of Management Practice for Silver

- Conserves a natural resource
- Provides for the recovery and management of silver at the source
- Reduces silver loading to POTWs

6

Code of Management Practices

Facilities That Process Photographic Material:

- Banks
- Chiropractors
- Dentists
- Government Agencies
- Hospitals
- Industrial X-ray Labs
- Medical Clinics
- Minilabs
- Microfilm Labs
- Motion Picture Labs
- Printers
- Photofinishers
- Professional Studios
- Schools
- Universities
- Veterinarians

7

The Code of Management Practice Provides...

1. Understanding of silver recovery and management technologies

8

The Code of Management Practice Provides...

1. Understanding of silver recovery and management technologies
2. Equipment recommendations

9

Code of Management Practices

The Code of Management Practice Provides...

1. Understanding of silver recovery and management technologies
2. Equipment recommendations
3. Standards for operation and maintenance

10

The Code of Management Practice Provides...

1. Understanding of silver recovery and management technologies
2. Equipment recommendations
3. Standards for operation and maintenance

4. Analytical recommendations

11

The Code of Management Practice Provides...

1. Understanding of silver recovery and management technologies
2. Equipment recommendations
3. Standards for operation and maintenance
4. Analytical recommendations

5. Training information

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Code of Management Practices

The Code of Management Practice Provides...

1. Understanding of silver recovery and management technologies
2. Equipment recommendations
3. Standards for operation and maintenance
4. Analytical recommendations
5. Training information
6. Improved record keeping

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The Code of Management Practice Provides...

1. Understanding of silver recovery and management technologies
2. Equipment recommendations
3. Standards for operation and maintenance
4. Analytical recommendations
5. Training information
6. Improved record keeping

7. Spill control plans

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The Code of Management Practice Also Provides...

- A process of silver management attractive to POTWs

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Code of Management Practices

There are more than 360,000 facilities in the United States that process photographic materials such as films and prints.

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Over 99% of those 360,000 facilities discharge to POTWs. However, many POTWs do not have the resources to regulate and monitor large numbers of small generators.

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Management and recovery by the generator should be encouraged by both POTWs and the photographic Industry

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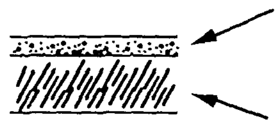
Code of Management Practices

Sources of Silver

Silver-based Photographic Materials Have a Light-sensitive Emulsion Coated on a Support



Emulsion:

Crystals of silver halides in gelatin

Support:

Plastic film or paper

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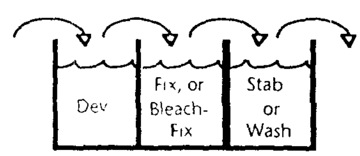
Sources of Silver

Processing of Photographic Materials Consists of Three Steps:



- ❖ Development
- ❖ Removal of some or all the silver (fix, bleach-fix)
- ❖ Stabilization of the image via rinsing (stabilizers, washes)

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Sources of Silver

Types of Photographic Materials:

- ❖ Black-and-White (X-rays, graphic arts films & papers, microfilms, motion picture films, professional films, & papers)

- ❖ Color (amateur and professional films & papers, motion picture films)

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Code of Management Practices

Sources of Silver

After Processing

- Black & white films and papers contain an image of metallic silver
- Color films and papers contain an image formed by dyes (no silver remains)

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Sources of Silver

During Processing,
Two Types of Solutions are Generated:

- Silver-Rich
- Low-Silver

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Sources of Silver

Silver-Rich Solutions:
(a solution with enough silver to justify recovery)

- Fix, bleach-fix
- Low-flow washes
- Stabilizers from washless minilabs

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Code of Management Practices

Sources of Silver

Low-Silver Solutions:

- Developers
- Bleaches
- Stop baths
- Pre-bleaches
- Stabilizers following washes
- Wash waters

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Technologies for Silver Recovery and Management

Recovery Technologies	Cost effective silver recovery
Management Technologies	Volume reduction for off-site recovery
	Primary focus on discharge requirements
	Costs are a secondary concern

26

Technologies for Silver Recovery

1. Electrolysis
2. Metallic Replacement
3. Precipitation

27

Code of Management Practices

Technologies for Silver Management

1. Evaporation — Distillation
2. Ion Exchange
3. Reverse Osmosis

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Metal Finishing

- Technologies such as electrowinning cannot be used to treat photographic processing solutions
- Intense heat produces noxious odors and hazardous gases (due to presence of sulfur, ammonia)

29

Metal Finishing vs. Photographic Processing

Never appropriate to apply Best Available Technology limits (0.24 / 0.43 ppm silver) used for metal finishers to photographic processors

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Code of Management Practices

Discharger	*Wash Water Usage (GPD)*	*Silver-Rich Solution Generated (GPD)*
Small	<1,000	<2
Medium	<10,000	<20
Large	>10,000	>20
Significant Industrial User	>25,000	(Process Waste Water)

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The Code of Management Practice Recommends

Small Facilities...>90% removal

Medium Facilities...>95% removal

Large Facilities and SIUs...>99% removal

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The Code of Management Practice Recommends

- Equipment specifications
- Operating procedures

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Code of Management Practices

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The Code of Management Practice Recommends for *Small* Facilities

At Least (or >) 90% Removal of Silver Using:

A) 1 or 2 metallic replacement cartridges with flow control
or B) 1 electrolytic unit
or C) 1 precipitation unit
or D) 1 evaporative or distillation unit

(plus standard operating procedures and verification)

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Operating Procedures — *Small* Facilities

- Spill prevention systems
- Spill plan
- Analytical / record-keeping requirements*
  - Weekly, if continuous
  - By batch, if batch processing
  - Information recorded in silver recovery log

Verification

Semiannual analytical test to verify 90% recovery

*with test papers, analytical test kit or lab analysis

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The Code of Management Practice Recommends for *Medium* Facilities

At Least (or >) 95% Removal of Silver Using:

A) 2 or more metallic replacement cartridges with flow control
or B) 1 electrolytic unit & 1 metallic replacement unit and flow control
or C) 1 precipitation unit
or D) 1 evaporative or distillation unit

(plus standard operating procedures and verification)

Code of Management Practices

Operating Procedures — *Medium* Facilities

- Spill prevention systems
- Spill plan
- Analytical / record-keeping requirements*
  - For batch operations:
    - Primary unit checked before & after each batch
    - Effluent checked after secondary unit

*with test papers, analytical test kit or lab analysis

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Operating Procedures — *Medium* Facilities

- Analytical / record-keeping requirements*
  - For Continuous Operations:
    - Weekly testing of primary unit
    - Weekly testing of effluent from the secondary unit
  - Information recorded in silver recovery log

Verification

Quarterly analytical test to verify 95% recovery

*with test papers, analytical test kit or lab analysis

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The Code of Management Practice Recommends for *Large* Facilities

At Least (or >) 99% Removal of Silver Using:

A) 1 electrolytic unit and 2 metallic replacement units with flow control

or B) 1 electrolytic unit and 1 precipitation unit

or C) 1 evaporative or distillation unit

(plus standard operating procedures and verification)

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Code of Management Practices

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Operating Procedures — Large Facilities

- Same procedures as medium facilities
- In-line electrolytic units in use
- Squeegees, air knives and low-flow washes used
- Wash water conservation program
- Analytical / record-keeping requirements*
  - Access to analytical testing capability for rapid process control evaluations
  - Silver recovery system tested at least weekly
  - Record information in silver recovery log

Verification

Quarterly analytical test to verify 99% removal

*with test papers, analytical test kit or lab analysis

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The Code of Management Practice Recommends for Significant Industrial User

- All of the large facility requirements as a minimum
- POTWs could consider mass-based loading to encourage water conservation

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The Code of Management Practice Recommends the Following for *Off-Site* Silver Recovery

A) Notification to the POTW of the off-site services used

B) Storage of silver-rich liquids in DOT approved containers

C) Compliance with all hazardous waste and transportation regulations

D) Maintenance of records for three years

Code of Management Practices

Additional Recommendations of the Code of Management Practice:

A) A silver-rich solution inventory

B) Floor plan for spill containment

C) Response plan for spill handling and proper disposal

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Considerations for Compliance with Silver Pretreatment Limits

Provide...

- Compliance sampling location
- Silver concentrations before recovery
- Silver concentrations after recovery

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Silver Concentrations *BEFORE* Recovery

Combined silver-rich solutions will range between 2,000 and 8,000 mg/l or ppm, BEFORE treatment or recovery.

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Code of Management Practices

Silver Concentrations *AFTER* Recovery

% Recovery	*Silver in Silver Rich Solutions After Recovery* (mg/L)	*When Combined with Low Silver Solutions* (mg/L)	*When Combined with Wash Waters* (mg/L)
90	200-800	100-400	10-40
95	100-400	50-200	5-20
99	20-80	10-40	1-4
99.9	2-8	1-4	0.1-4

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Compliance Sampling Location

- End of process
  - No categorical requirements
- End of pipe — facility outfall
  - Correct for uniform concentration limits

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Silver Pretreatment Limits

Range	*Technology Required*
2.5-5.0 mg/L	99% removal Efficiency from recovery systems
1.0-2.5 mg/L	99% removal efficiency; Wash water control / treatment

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Code of Management Practices

Silver Pretreatment Limits

Range	*Technology Required*
0.1-1.0 mg/L	❖ On site silver recovery • 99% removal efficiency • Wash water control / treatment • Extensive equipment modifcations ($$) ❖ Haul away required for many facilities ($$$)
Less than 0.1 mg/L	❖ Haul away ($$$)

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Silver Pretreatment Limits

Range	*Cost of Compliance*	*Equipment Requirement*
2.5-5.0 mg/L	$200-8,000	<5GPD: MRC's >5GPD: Electrolytic & MRC's
1.0-2.5 mg/L	$400-16,000	Electrolytic and MRC's Processor Modifications
0.1-1.0 mg/L	$600-29,000	Electrolytic and MRC's Processor Modifications Wash water treatment
Less than 0.1mg/L	$1,100-105,000	Hauling

*Operating cost and capital equipment costs amortized over 5 years

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Pollution Prevention

A Soon to Be
Released Addition
to the Code of
Management Practice

Pollution Prevention

Shifts the Focus from End-of-Pipe to Front of Process

- ❖ Source Reduction
- ❖ Process Control
- ❖ Cost Control

P^2 and the Photographic Industry

An Ongoing Activity

- Less Silver in Films and Papers
- Reformulated Chemicals (up to 80% less)
- Washless Process
- Some Chemicals Are Easier to Regenerate
- Equipment Designed to Reduce Waste

EPA's Guidance Manual for Developing Best Management Practices

Good Housekeeping

- Preventative Maintenance
- Employee Training
- Inspections
- Security
- Recordkeeping and Reporting

Involving Employees

- Commitment from Management
- P^2 Team
- Training

Managing Chemicals

- Process Control
- Good Housekeeping
- Chemical Inventory
- Chemical Storage and Containment
- Spill Response Plan
- Chemical Usage Monitoring
- Safety and Security

Modifications to Equipment

- Squeegees
- Closed-Loop Silver Recovery
- Counter-Current Wash Tanks
- Low-Flow Wash

Modifications to Processes

- Low Replenishment Rate Chemicals
- Regeneration and Reuse of Chemicals
- Dry Chemicals and Auto Mixing
- Water Reuse and Recycling
- Washless Process

Tracking Results

- Maintain Quality
- Reduce Pollution
- Reduce Cost
- Compare New Technologies

Evan Jones

Viatec Recovery Systems, Inc.

RECOVERING SPENT ACIDS USING THE WADR™ TECHNOLOGY

Evan Jones
Viatec Recovery Systems, Inc.
3200 George Washington Way
Richland, WA 99352
Ph: (509) 375-0370 Fax: (509) 375-3017

Introduction

More than 15,000 companies, large and small, generate nearly 1 billion pounds per year of spent acids and are affected by the problem of disposing of this waste. Typical industrial activities that generate these spent acids include: electroplating and surface finishing operations in electronics, aerospace, automotive, metal working, steel, and defense industries.

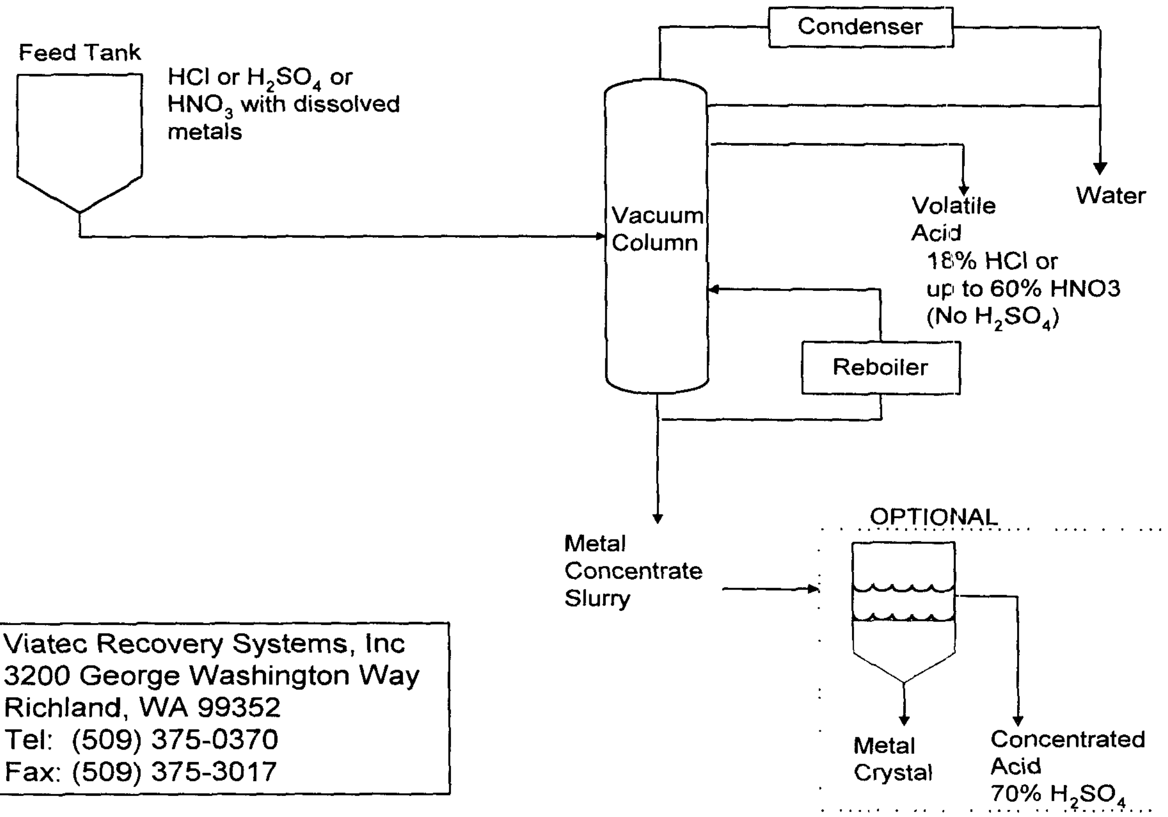
The Waste Acid Detoxification and Reclamation (WADR) system was designed to help companies meet regulatory restrictions and public demand for pollution prevention by transforming the waste into a reusable acid and reclaimable metal byproduct. Through a combination of simple and proven distillation technology together with advanced corrosion-resistant materials and specialty manufacturing, the WADR process concurrently concentrates the metals and recovers clean acid. Over 90% of the spent acid can be recovered as a reusable product, and the volume of waste to be disposed of is minimized or possibly eliminated. The concentrated metal byproduct is frequently suitable for recovery by metal reclamation companies. Acid recoveries and waste reductions will vary with the spent acid compositions and client requirements. Using the WADR™ system will reduce raw material and waste disposal costs while improving process quality through cleaner process acids. Typical simple payback periods range from 12 to 24 months in many cases, making WADR™ systems both economic and environmental friendly.

Viatec Recovery Systems and the Viatec group provide custom turnkey acid recovery systems, and can conduct sampling, analysis, and testing through process design and manufacturing to delivery, start-up, and technical service.

Description of the Technology

The WADR™ design can be tailored to accommodate a wide variety of potential users, types of wastes, and financial resources. The WADR™ system uses vacuum distillation and crystallization technology to produce clean reusable water and concentrated acids and a potentially reclaimable metal by-product. The process produces concentrated acid (up to 18% HCl or 75% H_2SO_4) with ppm levels of metals and clean water with <200 ppm Cl^- or SO_4^{-2}. The diagram below describes the WADR™ process. Operation of the WADR™ system varies, depending on the composition of the spent acid. The spent acid is heated and partially vaporized under vacuum in the reboiler. The acid and water vapors are then separated and condensed. The metals are concentrated in the reboiler tank and may crystallize as metal salts (e.g., iron chloride or copper sulfate).

WADR™ Process Flow Schematic



Viatec Recovery Systems, Inc
3200 George Washington Way
Richland, WA 99352
Tel: (509) 375-0370
Fax: (509) 375-3017

The key equipment in the system is constructed of advanced laminated materials using corrosion resistant liners (e.g., polyvinyldiene fluoride (PVDF) fluoropolymer, chlorinated polyvinyl chloride (CPVC), etc.) laminated with Fiberglass Reinforced Plastics (FRP). These laminates combine the corrosion resistance of fluoropolymers or other thermoplastics with the strength and economy of FRP. This combination provides corrosion-resistant, lightweight equipment capable of processing nearly any type of mineral acid. Due to the fluoropolymer and other thermoplastic materials of construction, WADR™ acid recovery systems can process nearly any type of concentrated mineral acid such as hydrochloric, nitric, hydrofluoric, and sulfuric acids contaminated with metals such as iron, zinc, nickel, chrome, copper and others.

The key attributes of the system are highlighted below:

- Vacuum Operation - Operating under a vacuum lowers fluid temperatures and reduces side-reactions, lengthens the life of the equipment, reduces equipment costs, and allows the use of lower-temperature heat transfer media (e.g., low-temperature steam). In addition, vacuum operation is an inherently safe operation with respect to personnel exposure and environmental releases.
- Advanced Materials of Construction - Dual-laminate equipment combining fluoropolymer liners with reinforced thermosetting plastic (RTP) is lightweight, corrosion resistant, and custom configured.

- No dilution - The WADR process does not use chemicals or water to perform the separation. The entire volume of spent acid is converted to a reusable acid and potentially reclaimable metal byproduct; there is no net increase in the volume of chemicals used or discharged.
- Variety of Acids Rejuvenated - The WADR system is capable of processing a variety of spent acids using the same system.
- Uses Waste Energy for Waste Recovery - The WADR process can use low-temperature waste energy such as low-pressure steam to recover spent acids.
- Flexible and simple operation - The WADR process can be designed to operate as batch, semi-batch, or continuous operation for multiple or single acid streams, and it can be built as a mobile or fixed system. It can be constructed as a large continuous system for aerospace and steel manufacturers generating thousands of gallons of spent acids every week. It also can be constructed as a portable batch system for small plating shops generating only hundreds of gallons of spent acids per month. Distillation is a proven technology that is easily and safely operated and maintained with little impact from misoperation or variation in feed compositions.

Industrial applications of the WADR™ technology

1/ U.S. Air Force/Oklahoma City Air Logistic Center (OC-ALC) application

The electroplating shop at the U.S. Air Force/Oklahoma City Air Logistics Center (OC-ALC) has several acid baths that were dumped after metal contaminant concentrations interfere with the bath efficiency. A 200-gallon batch WADR™ system was installed to process HCl, HNO_3 and H_2SO_4 baths contaminated with Fe, and Ni at OC-ALC's electroplating shop in late 1994. The OC-ALC acid baths that were treated with the WADR process include 14% HCl, 10% HNO_3, 12% H_2SO_4, and 40% H_2SO_4/1% HF. A significant volume reduction of waste (~80% to 90%) is achieved as the acid is recovered. For HCl and HNO_3, the overhead distillate product is clean and reusable representing 80% to 85% of the initial batch volume. The still bottoms with concentrated metal contaminants are cooled and disposed of as waste. The H_2SO_4 acid is concentrated to 70 wt% while water evaporates and gets condensed as a relatively clean stream containing < 50 ppm SO_4^- to be used as process makeup water or discharged. Crystallized metal salts are separated from the concentrated bottoms after cooling and filtration.

2/ U.S. Filter application

A 250 gallons/hr WADR™ system was installed at US Filter waste treatment facility in Minneapolis to process spent hydrochloric acids generated from the galvanizing industry. Spent acids concentrations range from 5% to 15% HCl while metal concentrations vary from 5g/L to 50 g/L of Fe, Cu, Ni. This is a large, continuous operation using fractional distillation to provide a sharper separation and produce clean, reusable or disposable process water with < 200 ppm Cl^- and concentrated acid at 18 wt% HCl to be reused in the process. The recovered acid contains less than 1 ppm total metals and has a high purity. The concentrated metal byproducts are disposed accordingly. The WADR process achieves an 80% acid recovery and therefore substantially reduces the amount of waste to be disposed.

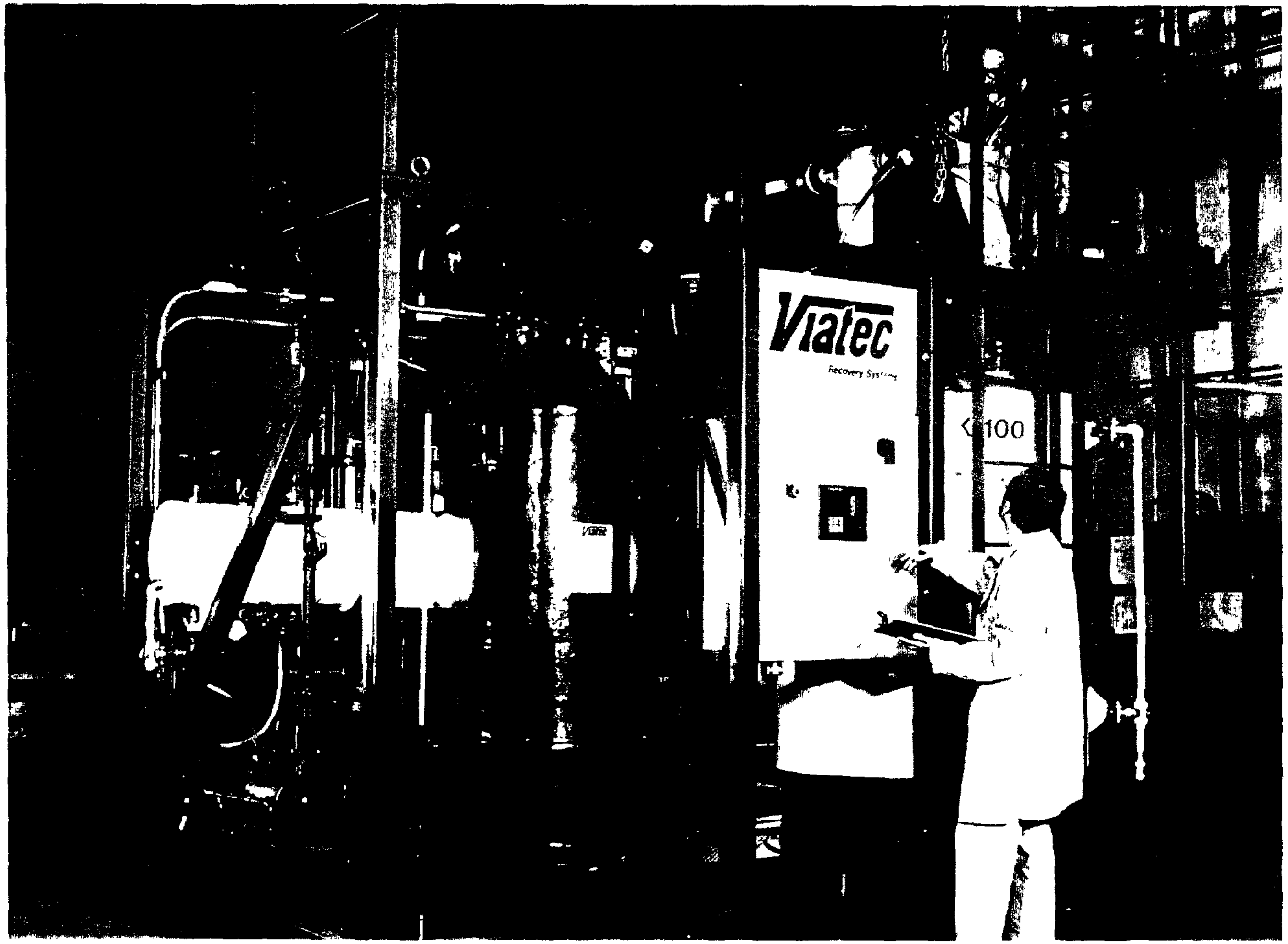
3/ Watervliet Arsenal application

A 300 gallons batch WADR™ system was designed to regenerate sulfuric and phosphoric acids for reuse in the electropolishing baths at Watervliet Arsenal. The spent electropolishing baths were rejected when the sulfuric and phosphoric acids get diluted in the process or when the iron concentration exceeds the specified tolerance level. The WADR ™ process successfully maintains the acid mixture at desirable concentration by vaporizing water off the solution. Clean water is then condensed and collected for reuse or discharge.

A demonstration unit is currently under construction and will be available for companies interested in on-site testing with their spent acid solutions. The demo unit will enhance the acceptance of the WADR™ process in the related industry in the US and worldwide.

Summary

The WADR™ process reduces disposal costs, produces cleaner process chemicals, and could eliminate the liability from the disposal of hazardous wastes - all this while using a "waste" energy source such as low-pressure steam. Several commercial applications have demonstrated that the volume of spent acid can be reduced up to 90%. The WADR™ system frequently has payback periods of 12 to 24 months, proving the economics and effectiveness of the WADR™ technology in recovering spent acids.



WADR SYSTEM AT WATERVLIET ARSENAL

James Kiriazes

Commonwealth Edison

BIOGRAPHICAL INFORMATION FOR JAMES KIRIAZES

James Kiriazes is the Industrial Programs Manager for the Marketing Technical Services Department at ComEd. James has been with ComEd for the past five years where he has held positions as an Energy Engineer, Modification Design Engineer and Technical Staff Engineer at the Zion Nuclear Generating Station. He has a strong background in manufacturing which includes engineering positions in such companies as Miller Fluid Power and Camcar Division of Textron. James holds a BSME from Illinois Institute of Technology, an MBA with a career organization in leadership and organizational development from DePaul University and is currently a registered EIT in the State of Illinois.

Peter Ko

PRC Environmental

Using Innovative Conductivity Control Systems to Reduce Rinse Water Use in Metal Finishing Operations

Overview

- Industry overview
- Conductivity basics
- System components
- System installation
- System operation and maintenance
- Case study

PRC

Metal Finishing in the U.S.

- In 1993, 98% of facilities had end-of-pipe wastewater treatment systems
- Average discharge is about 35,000 gpd and average F006 sludge generation is about 80 tons per year
- The estimated number of industrial facilities that use metal finishing processes range between 20,000 to 80,000 (OTA 1993)

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Conductivity Control Systems

- Basic concept: Add water to rinse tanks only when necessary instead of continuous addition at a constant rate
- How? Use rinse water conductivity to determine when clean water should be added to rinse tanks

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Conductivity Control Systems

- Perception: Conductivity control systems are difficult to maintain and do not significantly impact water use
- Reality: With a small amount of regular maintenance, conductivity control systems can work effectively to control rinse water flow

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Conductivity Basics

- Conductivity = a material's ability to conduct electrical current
- All aqueous solutions conduct electrical current
- Conductivity is an indicator of total ion concentration in a solution
- Increase ions = increase conductivity
- Measuring conductivity
  - Conventional sensor
  - Electrodeless sensor

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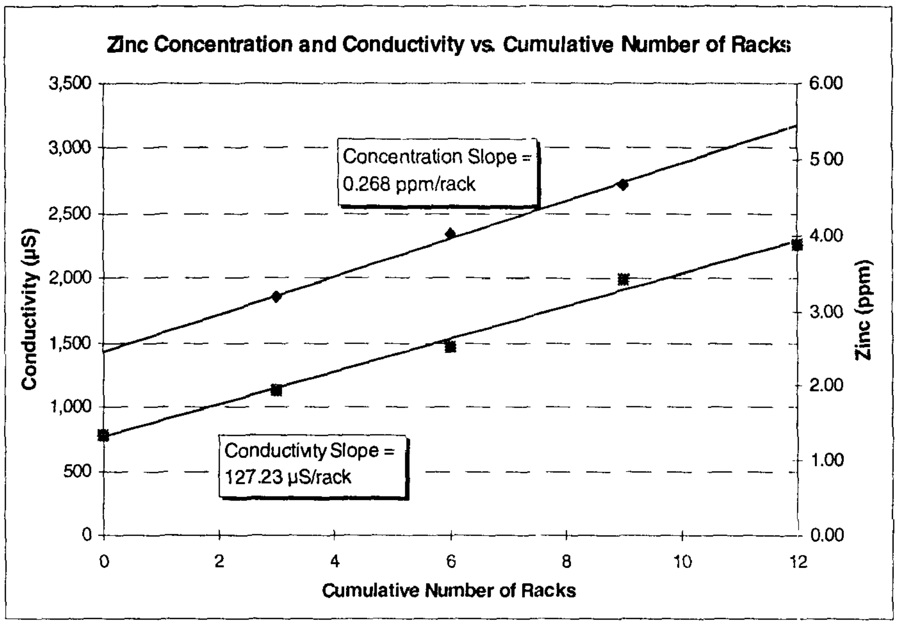
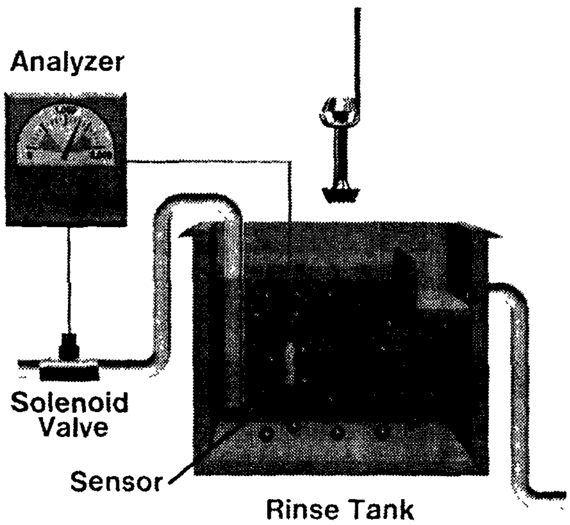
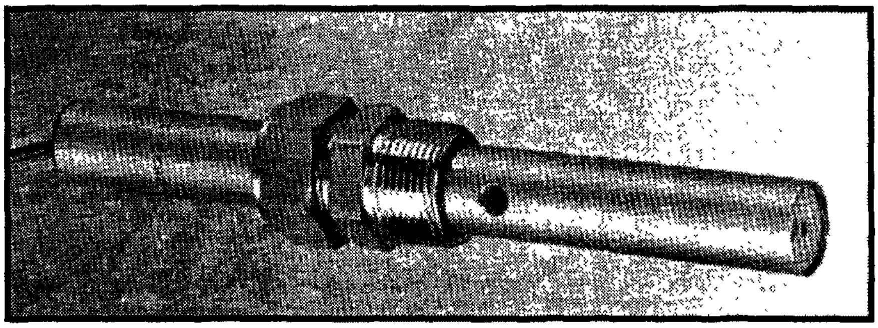
Conductivity Basics



Conductivity Control System Components



Conventional Sensor



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Conventional Sensor

- Two electrodes are placed in solution
- Electrical potential applied between electrodes
- Current and voltage values measured
- Size and spacing of electrodes determines cell constant
- Cell constant values: 0.05, 0.5, or 10.0
- Prone to fouling

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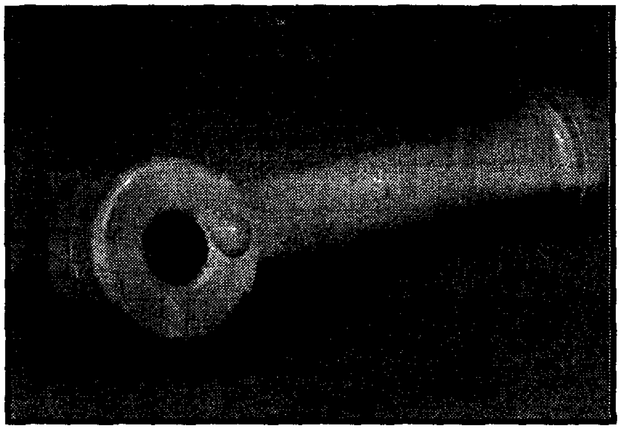
Electrodeless Sensor



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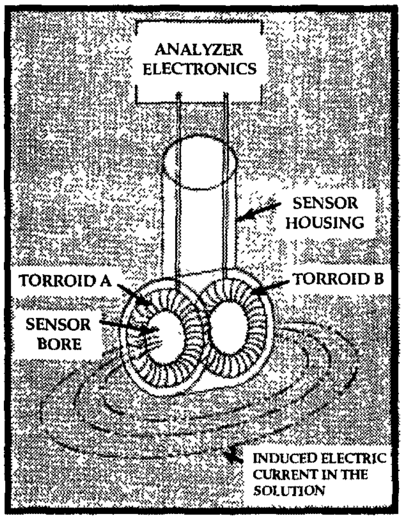
Electrodeless Sensor

- Uses two parallel torroids
- First torroid induces alternating current in water passing through torroid
- Second torroid senses the magnitude of the induced current
- Non-conductive casing (polypropylene or PVDF)
- No electrodes; no fouling
- Can measure full range of conductivity

Electrodeless Sensor



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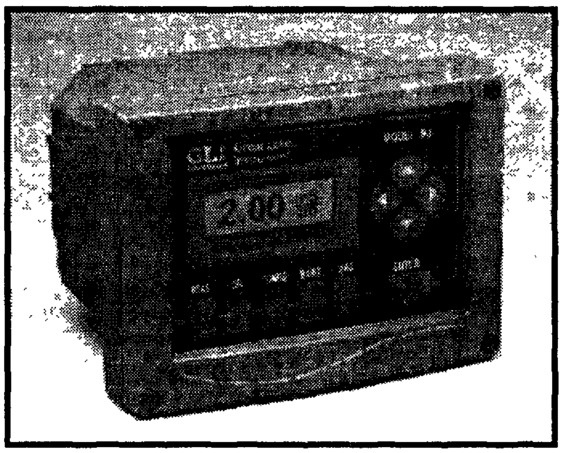
Analyzer



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Analyzer

- The system "brain"
- Receives input from sensor
- Displays conductivity reading
  - Digital, analog, or none
- Sends output signal to solenoid valve
- Key features:
  - Programmable set point
  - Programmable deadband
- Enclosure: NEMA 4X or regular
- Number of channels: singe or dual

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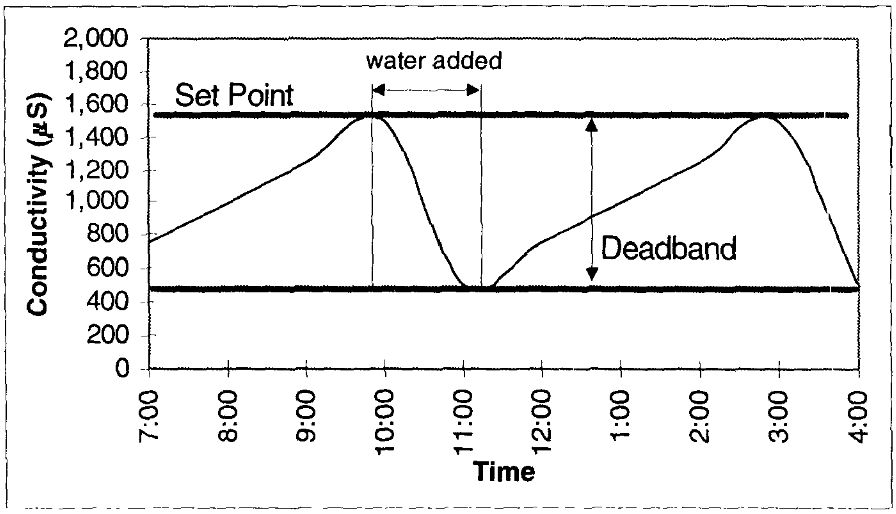
Conductivity Measurements in Rinse Tank



Component Purchase Considerations

- Conductivity range of rinse water
- Mounting of analyzer and sensor
  - Analyzer: panel, surface, or pipe mount
  - Sensor: submersion or union mount
- Environment where components will be located
- Distance from sensor to analyzer
- Number of channels on analyzer

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Sensor Installation

- Sensor placement
  - Halfway down from top of water level
  - Away from stagnant areas
  - Away from clean water inlet
  - In final stage of multistage counterflow rinse
- Good circulation of rinse water
  - Mechanical mixing
  - Double dipping parts

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Determining the Initial Set Point

- Set point is the upper limit of acceptable metal concentration for quality rinsing
- Determines amount of water used
- Before installation, monitor conductivity in rinse tank to determine conductivity range
- Program set point initially at high end of the rinse water conductivity range
- Deadband determines cycle frequency

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NAMF Survey Says . . .

". . . choosing the range [of conductivity] is the hardest part of the design . . . this problem is mainly caused by lack of information and data available."

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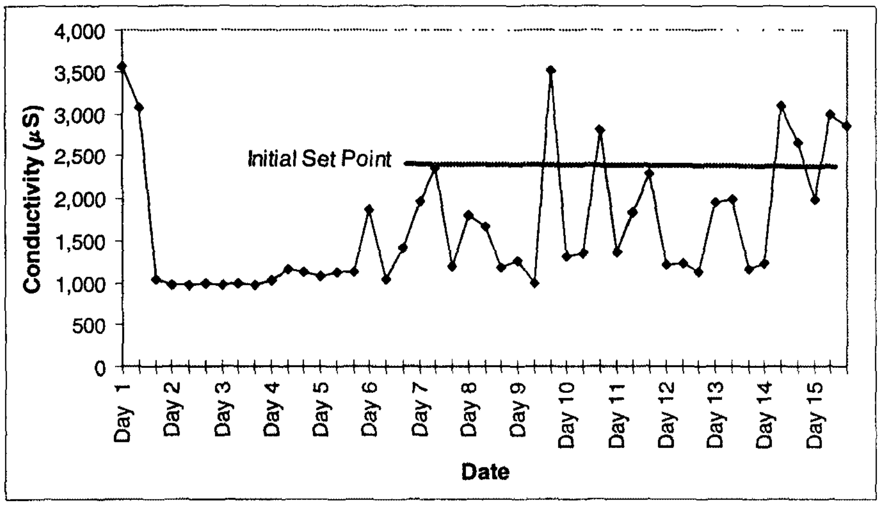
Determining the Initial Set Point



Fine Tuning the Set Point

- Maintain log of set points and reject parts related to rinse quality
- Increase set point until quality is "threatened"
- Reduce set point if parts are not rinsing adequately

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Sensor Maintenance

- Conventional
  - Regular cleaning required
  - Cleaning schedule varies according to process solution type and concentration in rinse water
  - Monthly calibration checks recommended
- Electrodeless
  - No fouling
  - Monthly calibration checks recommended

Conductivity Control System Case Study

Facility Description

- Sports, plumbing, automotive hardware
- Specializes in electroplating zinc die-cast parts
  - Also electroplates steel and brass parts
- Hand Operated Rack Line
  - Brass, copper, nickel, chrome
- Manually-Operated Barrel Hoist Line
  - Copper
- 60 employees

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Facility Operating Costs

	Monthly Rate	Monthly Cost
Rinse Water Use	520,000 gal	$640
Wastewater Discharge	520,000 gal	$260
WWTS Operation	520,000 gal	$5,800
Sludge Generation	2.6 tons	$1,400
Total =		**$8,100**

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Conductivity Control Systems Implementation

- Nine conductivity control systems
- Three systems from three different manufacturers
  - Cole-Parmer (conventional system)
  - Foxboro (electrodeless system)
  - Great Lakes Instruments (electrodeless system)
- Two on barrel line, seven on rack line

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Conventional Conductivity Control Systems

- Analyzer
  - No conductivity display
  - Single channel
  - Regular enclosure
- Sensor
  - Conventional

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Electrodeless Conductivity Control Systems

- Analyzer
  - NEMA 4X enclosure
  - Digital display
  - Single channel
- Sensor
  - Electrodeless
  - Small bore

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Rinse Tank Types with Conductivity Control Systems

- Acid activation (new parts)
- Acid activation (nickel-plated)
- Acid activation (barrel line)
- Chrome
- Copper cyanide and brass
- Copper (barrel line)
- Nickel (satin)
- Nickel (die-cast)
- Nickel (steel)

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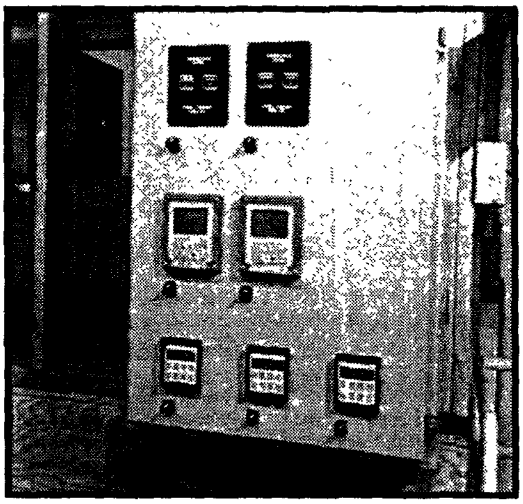
Conductivity Analyzers



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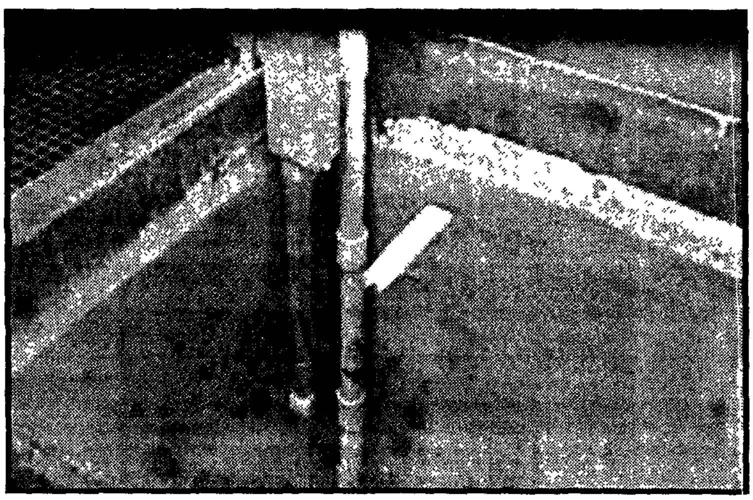
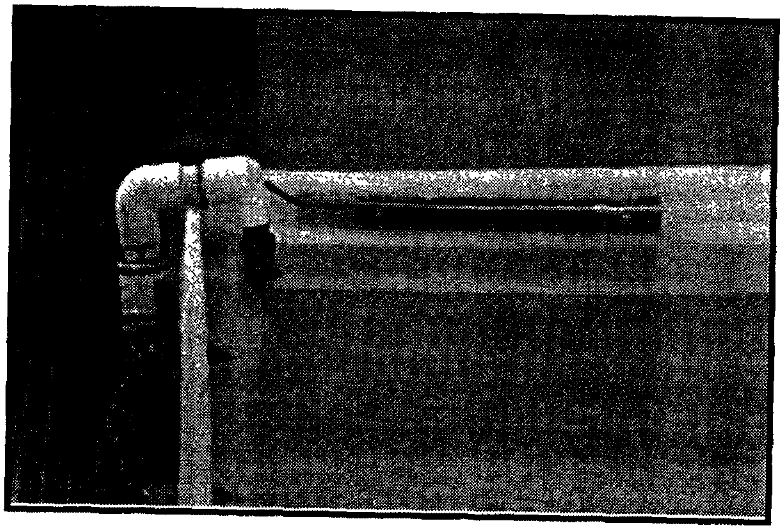
Electrodeless Sensor



Conventional Sensor



Installation and Operation Issues

- Contractor bids
- Installation location of sensors
- Final rinse of a 2-stage counterflow
- Malfunctioning systems
- Workers bypassing solenoid valves
- Parts plating quality
- Adjusting set points and deadbands

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Conductivity Control System Costs

	Conventional[a]	Electrodeless[b]
Capital	$290	$1,140
Additional Hardware	$100	$250
Installation	$400	$600
Total **(per system)**	$790	$1,990

[a] Conventional sensor, analyzer with no display, and analog set point and deadband
[b] Electrodeless sensor, analyzer with digital display, and programmable set point and deadband

Impact of Conductivity Control Systems

- Rinse water use
- Wastewater discharge
- Sludge generation
- Wastewater treatment system operation

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Conductivity Control System Results

	Per Month Before	Per Month After	Monthly Savings
Rinse Water Use	516,000 gal	296,000 gal	$280
Wastewater Discharge	516,000 gal	296,000 gal	$110
WWTS Chemical Use	$4,000	$3,200	$800
WWTS Sludge		Not Quantified	

Total Cost for Nine Systems = $14,500
Total Cost Savings = $14,300/yr
Payback Period = 1.0 year

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Conclusion

- Electrodeless sensors eliminate fouling problems associated with conventional sensors
- Analyzers with digital displays are more user friendly and accurate
- Conductivity control systems can reduce rinse water use without sacrificing rinse quality
- Conductivity control systems can reduce the following operating costs
  - Water use
  - Wastewater surcharges
  - Treatment chemicals
  - Sludge disposal

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Engagements:
Certified Professional Consultant to Management and invited speaker on management, communications, environmental affairs, new technologies and government relations in manufacturing and service industries. Spokesman before the U.S. Senate Committee on governmental Affairs Hearing on Degradable Plastics (Washington, DC, September 1988); before a Joint Congressional Sub-Committee Hearing on Foreign Imports (Washington, DC, October 1980); and before the Ohio Senate Finance Committee (Columbus, Ohio, May 1995). Invited lecturer, panelist and program moderator for universities and organizations throughout the U.S. and in Canada, Japan, Sweden, Finland and The Netherlands. In addition to corporate clients, has consulted for the PRISMA Project (NOTA and Erasmus University, The Netherlands) and the TEM Organization (University of Lund, Sweden). Personal recipient of a 1994 Ohio Governor's Award for Outstanding Achievement in Pollution Prevention, a U.S. Department of Commerce NOAA Public Service Award and other recognitions. Professional memberships include the Air and Waste Management Association, American Society for Testing and Materials (ASTM), Society of Plastics Engineers (Senior Member), the Flexographic Technical Association, and is credited with an active role in founding the American Plastics Council. Holds patents in package design and trade secrecy agreements on manufacturing processes. Board and leadership positions have included many industry associations, private companies and civic groups.

Professional Service:
- The Society of the Plastics Industry (SPI), Board of Directors, Exec. Cmte, 1994-1995
- American Plastics Council (APC), Advertising Committee 1995-present
- Plastic Bag Association, President 1989-1992; Board and Exec. Cmte 1989-1996
- Degradable Plastics Council, Special Purpose Group of SPI, Chairman 1989-1993
- Ohio Technology Network (OTNET) Ohio Department of Development, Board of Directors 1994-1995
- Flexographic Technical Association, Board of Trustees 1985-1986

Plastic Packaging and Pollution Prevention Working Together

A Case Study in Successful
Product and Process Design for the Environment.

Presented at

U.S. EPA Region V
Waste Minimization/Pollution Prevention Conference

February 25 - 27, 1997
Chicago, Illinois

by

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Abstract

Plastic Packaging and Pollution Prevention Working Together: A Case Study in Successful Product and Process Design for the Environment; George A. Makrauer, CPCM, President; ComAd Management Group, Inc.; 119 - 108th Avenue, Suite 185; Treasure Island, Florida 33706; Phone 813.363.7373; Fax 813.367.0222; Email <georgem@comad.com>; Web <http://www.comad.com>. "Plastics" and "packaging" have been popular targets for individuals and groups concerned about environmental degradation and the impact of pollution. Amko Plastics Inc. of Cincinnati, Ohio is an example of successful product and process design for the environment while at the same time satisfying customers and business objectives. By involving its employees, suppliers and customers in the process, Amko has shown that a plastic packaging manufacturer can contribute positively to an enhanced environment - both inside and outside its facility - in the manufacture, use, reuse, recycling and disposal of its products.

Fear and profit are the two strongest motivators of business behavior, not necessarily in that order. How motivated might a manager be after receiving the following communiqué?

Dear (company):

I represent Atlantic States Legal Foundation, Inc. ("ASLF"), 658 West Onondaga Street, Syracuse, New York 13204, telephone (315) 475-1170.

NOTICE IS GIVEN by ASLF, pursuant to section 326 (d) of the Emergency Planning and Community Right to Know Act ("EPCRA"), 42U.S.C. 11001, et seq., and its regulations, of ASLF's intent to file suit against (your company) for violations of EPCRA. ASLF, a not-for-profit environmental organization with members residing in your state and throughout the United States, is informed and believes that (you) , as the owner or operator of the manufacturing facility located at (address), has failed to comply with the reporting obligations imposed by section 313 of EPCRA, 42 U.S.C. section 11023.

ASLF is informed and believes that the (street address) plant of (your company) has manufactured, processed, or used toxic chemicals, including, but not limited to, various liquids in excess of statutory thresholds and subject to the reporting requirements of section 313 EPCRA.

As the owner or operator of the (street address) plant, (your company) is responsible, with respect to such toxic chemicals, for the failure to accurately complete and submit toxic chemical release forms (EPA Form Rs) as required by section 313 (a) of EPCRA:

(1) by July 1, 1988, for releases during the calendar year 1987;
(2) by July 1, 1989, for releases during the calendar year 1988;
(3) by July 1, 1990, for releases during the calendar year 1989; and
(4) by July 1, 1991, for releases during the calendar year 1990.

(Your company) may also be responsible for violations not yet known to ASLF of other EPCRA reporting requirements.

YOU ARE FURTHER NOTIFIED that, after the expiration of sixty (60) days from the date of this NOTICE OF INTENT TO SUE, ASLF intends, on behalf of itself and its members, to file suit against (your company) in the appropriate federal district court pursuant to section 326 (a) of EPCRA. ASLF will request that the court enforce the requirements of section 313 of EPCRA, impose civil penalties of $25,000 per day of violation from the required dates of submittal, and award costs of litigation (including reasonable attorney and expert witness fees) to ASLF.

During the sixty (60) day notice period, we will be available to discuss resolution of this matter. If you wish to avail yourself of this opportunity, please contact me.

Respectfully,

Counsel for Notifier

cc: Hon. William K. Reilly, Administrator; U.S. EPA
Valdas V. Adamkus, Regional Administrator; U.S. EPA, Region V
xxxxxxxxxxxxxxxxx, Director; (State) EPA

Welcome to the calm, peaceful world of environmental bounty hunting.

Consider this. For several years, a midwestern metropolitan sewer district office failed to adequately bring about improvements in the quality of industrial water discharges into its municipal water sewer system. The district was chastised and fined by its state EPA. After several years of renewed effort, a district representative speaking at a Waste Prevention Conference geared to educating business managers about pollution prevention proudly offered the following as evidence of the district office's achievements in improving the quality of discharges: "In 1989 we issued 25 citations with fines for violations; in 1990 we issued 72."

In 1987, I spoke at a state regional air pollution control association conference about my work with a client in converting from alcohol based liquids to water-based liquids. In the question/answer session, an attendee told me she had heard that three companies with similar operations had "come into compliance" in the Tampa, Florida area. Thinking I'd learn something about new P3[1] technologies, techniques or materials, I called the Air Quality Enforcement official for Hillsborough Count and repeated the comment, "I understand three companies have come into compliance with the emissions regs. Is that true?" "Yes," he said, with enough satisfaction in his tone to suggest it was an exciting accomplishment. Thinking I was getting closer to some enlightening new body of knowledge, I asked, "Great. How'd they do it?" "Easy," he replied, "two of them shut down, and one of them moved out of the county."

All the above stories are true; the names have been changed to protect the innocent - and the guilty.

Second to fear, the incentive to increase profits has become the popular method of P2 pollution prevention. When customers demand "cleaner" products and the processes that manufacture them, and when implementing waste prevention includes source reduction and sound-science/sound-economics recycling (along with other methods of integrated waste management), then business people are even happier to practice P3 - Pollution Prevention Pays.

Amko Plastics Inc. of Cincinnati, Ohio was founded in 1966 as a "converter" of plastic films into plain and printed Low Density Polyethylene bags for food and industrial packaging. As its markets changed through the 1970s and early 1980s, its product and technology innovations allowed it to expand into the manufacture of specialty plastic bags for non-food retail store carry-out. Products included drawstring, rigid handle, die-cut, garment and other bags for up-scale retailers of clothing, accessories, jewelry, shoes and similar consumer products.

By the mid-1970s, Amko's major manufacturing processes included:

1. Blown film extrusion - a process of heating and melting polyethylene plastic pellets into a highly viscous liquid and "blowing" a vertically moving, never-ending continuous tube of plastic film which is cooled into a stable shape and wound into rolls of sheeting material for subsequent processing.
2. Injection molding - a process of heating and melting High Density Polyethylene pellets and injecting the molten material into a mold with cavities of rigid

[1] P3 = "Pollution Prevention Pays"

handles to be affixed in a subsequent manufacturing step onto the top opening of bags.

3. Flexographic printing - a method of rotary letterpress printing using flexible rubber or photopolymer plates and liquid inks which are air dried after deposition on a substrate using an inking system of either four rollers or a doctor blade assembly and three rollers.
4. Machine fabrication and repair - a machine shop with turning, cutting, grinding, drilling, welding and other metal fabrication techniques.

All of these processes were originally designed around the use of hazardous materials, high energy consumption and inefficient materials usage. These materials and practices were the "industry standard" of the time. One particular element of plastic film processing, however, was inherently beneficial - plastic industry technology was continuously driving to develop stronger resins with better, stronger physical properties in the finished film structure. As stronger resins were introduced, industry practice became a cutback of film thickness in the finished product. This "source reduction" was cost and profit motivated. Not only would thinner plastic bags cost less than and replace thicker plastic bags made of older type resins, but, more importantly, the new, thinner, lower cost plastic bags would also replace the traditional paper bags that had always previously been less expensive than plastic. As the packaging materials war heated up at the check-out counter, a planned war based on fear and paranoia was implemented using conspiracy, obfuscation and a bit of fraud here and there. But, that's another story for another time.

Through it all, Amko Plastics evaluated its position and made its decisions based on a simple premise - it was going to obey the law; it was going to use available technologies that seemed affordable; it would develop new techniques and introduce new materials to meet and then beat the regulations. That was not the philosophical environment Amko competed in. It's three major competitors did the following.

1. A midwestern producer was its town's major employer. That company's general manager proudly boasted that its local EPA was afraid to impose regulations that might result in lay-offs. It continued to run 6-color presses unregulated and uncontrolled with alcohol emissions directly vented to the atmosphere.
2. A Long Island competitor continued to run alcohol presses unregulated and uncontrolled, venting directly outside in violation of the local regulations. It's

approach was to willingly run in violation and pay EPA fines, which amounted to $13,000 per quarter, $52,000 per year. It viewed penalties for violation as nothing more than an indirect permit cost.

3. Another Long Island competitor continued to run alcohol presses unregulated and uncontrolled, venting directly outside in violation of the local regulations. It chose to do so, because the Suffolk County air quality inspector at the time believed that "if an emitter of alcohol fumes from printing does not directly vent its emissions outside its plant, it does not require a permit to install or to operate." So, it continued to vent its printing presses inside its building. The concept of "fugitive emissions" was a mystery to the regulator...until she was smartened up. (True story.) The company had to make a choice. It didn't want to invest in incinerators; it didn't want to spend money on modifications for water-based inks. It did the next best thing - converted to an ink system that poured through an EPA loophole, one based on the use of 1,1,1-trichloroethane as the solvent. After many years of use, this company became Suffolk County's second largest polluter. After EPA finally banned methyl chloroform's use, the company installed alcohol incinerators and converted back to alcohol-based inks.

All three of those competitors enjoyed significant economic cost benefit over Amko for many years of competitive activity.

Nonetheless, following its commitments, Amko innovated processes and products which not only improved the performance and value of its products for its customers, but also reduced the environmental impact of its manufacturing activities and its products. Here is a list of Amko's more significant work in these areas.

1. Solid Waste Reduction - In 1979, Amko Plastics was the first U.S. film and bag producer to introduce new thin gauge low density polyethylene materials (Linear Low Density Polyethylene, LLDPE; Unipol technology from Union Carbide Corporation) which made the first substantive source reduction benefit in shrinking solid waste generated by the plastic bag industry. Because of their superior strength and performance, these films allowed for a 25% to 40% reduction of raw materials - in both manufacturing and later waste disposal - because of dramatically improved resin technology. The replacement of conventional thick plastic film and thicker paper materials by these thin plastics resulted in benefits for customers, consumers,

and the environment. Amko continues to work with its resin suppliers in commercializing new high strength materials which offer similar benefits in both monolayer films, 3-layer films, 7-layer films and more using coextrusion and solventless laminating technology.

2. Air Pollution Reduction - In 1984, Amko became the first plastic film printer to commit to and implement a company-wide elimination of alcohol based inks to reduce air pollutants in the printing process. Over the next three and a half years (through September 1987) Amko, in conjunction with its key suppliers, developed the systems, materials and process to convert entirely to water based inks for printing plastic film. As a result, Amko was able to make more than an 85% reduction in the emission rate of alcohol to the atmosphere in its printing operations. In addition, the health benefit to employees who no longer worked in an alcohol air plant environment was an added benefit.

3. Heavy Metal Reduction and Elimination - In 1987, Amko commenced the replacement of ink pigments based on potentially toxic heavy metal bases and replaced them with non-heavy metal counterparts that comply with regulations of the Council of Northeastern Governors (CONEG).

4. Plastic Pellet Litter Elimination - In 1987, Amko introduced a railroad siding vacuum maintenance program to capture polyethylene resin pellets which were lost during the railroad hopper car unloading process. This keeps plastic pellets from contaminating the immediate vicinity and from potential contamination of waterways if flushed into sewer systems. It was not until 1992 that USEPA issued new stormwater permit requirements that this practice was required of plastics processors. Amko commenced this practice early because it was the right thing to do, not because it was required.

5. Plastics Recycling - Beginning in mid-1989, Amko has been incorporating post-industrial and post-consumer recycled plastic materials in select products of its own or its customers' choosing. In April, 1991, Amko began operation of a plastic waste recycling and repelletizing system for recycling both its own industrial waste, purchased post-industrial waste, and some processable post-consumer plastic bags returned via special customer programs.

6. Heat/Energy Conservation and Recapture - In 1985, 1987 and 1990, Amko installed heat recapture systems in air compressor, printing press, and film extrusion operations to reduce energy consumption in the operation of its equipment and processing of its materials.

7. Recycled Newspapers - On an experimental basis, Amko used corrugated cartons which incorporated a liner board manufactured from 25% recycled newspapers. If that had become successful throughout its operations, based on average corrugated usage, the facility would have consumed approximately 8,000 lbs. of old newsprint per month. To date, however, the cartons have not performed satisfactorily and their cost has been prohibitive. The company hopes that improvements by its suppliers will allow Amko to re-evaluate that opportunity at some time in the future.

8. Hazardous Waste Water Treatment and Elimination - In 1990, Amko installed a waste water treatment system to eliminate hazardous waste elimination and recycle printing system water. The system allows for disposal of remnant solids as non-hazardous waste in a sanitary landfill and provides recycling of the reclaimed water which was previously a part of our water based inks. When overflow conditions are met, the water is clean enough to meet standards for disposal into the sanitary sewer. This system has eliminated the generation of waste water from Amko's manufacturing and cleaning processes.

9. Toxic wastes have been eliminated throughout all of Amko's operations to the point where Amko is classified in the lowest category of hazardous waste generation as a Conditionally Exempt Small Quantity Generator. To qualify for this designation, a facility must generate less than 220 pounds (100 Kg) of hazardous waste per month. Amko's operations comprise a 7-day per week, 24-hour per day production schedule, 365 days a year in a 224,000 sq ft (20,810 square meters) facility.

10. Elimination of Perchloroethylene Use - In 1992, Amko eliminated the use of perchloroethylene as a solvent in the production of its photopolymer printing plates and replaced it with a petroleum blend as a solvent. This material completely eliminated the health issues uniquely related to perchloroethylene. The new material is also recycled in-house by Amko for use in future batch processing.

11. Office and Plant Paper Collection and Recycling - Office paper waste (fax, copier, letters and others) and factory corrugated containers are collected for recycling.

12. Shared Information - Since 1985, Amko has willingly shared its successes in environmental technological development with other organizations both in the U.S. and internationally. A list of selected papers and speaking engagements on those issues can be provided on request. In addition, private sector and public sector organizations from around the US and from other countries visit Amko to learn about Amko's efforts, successes and challenges in developing sustainable manufacturing practices ("clean production" practices in Europe.)

13. Solventless Lamination - In 1996, Amko installed a solventless laminator which bonds two different web materials together using a 2-part chemically curing adhesive. This technology is relatively new in the U.S., where the traditional and majority of equipment uses either solvent-based or water-based adhesives.

Amko's work covers a wide range of efforts in product and process design for the environment. In recognition of its work and successes, the Greater Cincinnati Chamber of Commerce presented the company its 1994 Corporate Environmental Achievement Award. In addition, Ohio Governor Voinovich presented Amko Plastics as a company and its president individually with 1994 Governor's Awards for Outstanding Achievement in Pollution Prevention.

Joe Mattson

Industrial Towel and Uniform

NETWORKING TO MINIMIZE WASTE AND PREVENT POLLUTION

A presentation outline by Joe Mattson, SorbIts® Product Manager, Industrial Towel and Uniform, Inc.

I. Biographical Information

A. Who is Joe Mattson?
B. Why would Joe Mattson have information valuable to me?

II. Reduce - Suggestions for methods of reducing the volume of waste you generate.

A. Bulk Containers vs Convenience Packaging
Examples: chemicals, soap ...
B. Suppliers Involvement
reusable containers & packaging, process changes, line employee involvement
C. Dumpster Diving

III. Reuse - Evaluate waste streams for alternatives to disposable products.

A. SorbIts - launderable & reusable oil absorbents.
B. Wipers
C. Filters, gloves, leathers

IV. Recycle

A. Solvents, Cutting and Cooling fluids, foundry sand ...
B. Examples: hangers, uniforms, roll towels ...

V. Resources - Where to look for assistance.

A. US EPA - Wastewi$e and Assessment Programs
B. State Regulatory Agency
C. Trade Associations

Charles L. McEntyre

Tennessee Valley Authority

Waste Reduction - Metal Fabrication Fluids and Wastewaters

U.S. EPA Region 5 Waste Minimization/Pollution Prevention Conference for Hazardous Waste Generators February 25-27, 1997, Chicago, Illinois

by
Charles L. McEntyre, P.E., CHMM

INTRODUCTION

Waste reduction is the most efficient and cost effective way to solve the environmental problems of industry. There are many reasons to do waste reduction. The best is it saves money! Waste reduction is not usually high-tech or real complicated. The best waste reduction program is a team effort with all employees doing their part. It can be adapted to your company's needs and culture. There are many resources available to help you get started and succeed.

The metal fabrication industry needs technical assistance in this area. EPA CERI in Cincinnati, Ohio, awarded an Interagency Agreement to TVA to develop training manuals and workshops to help this industry apply current waste reduction techniques.

TVA is partnering with the Waste Reduction And Technology Transfer Foundation (WRATT) and the Institute of Advanced Manufacturing Sciences (IAMS) to deliver this training. IAMS wrote the manuals with input from many companies and other organizations. WRATT is coordinating scheduling and delivery of the workshops. Partners and cosponsors for workshops are being used to ensure industries are reached. Five workshops were completed in 1996 in locations ranging from Miami, Florida, to Detroit, Michigan, and the remainder are being scheduled for 1997.

The training focuses on effective application of proven waste reduction processes for metal fabrication companies. The two waste types are metal fabrication fluids (coolants and lubricants) and wastewaters. Plating and coating wastes have been well covered elsewhere and coverage will be limited, possibly tables listing options and references. The primary audience selected are small to medium-sized companies with less than 200 employees. The metal fabrication processes covered include: broaching, turning, milling, threading, and tapping.

WASTEWATER AND WASTE REDUCTION

Wastewater P2 can be very cost-effective. Based on 15 cases studied in California, which covered several industries (electronics manufacturing, metal finishing, paper reprocessing, and food processing), the water savings were 20 to 40 percent (2 to 470 million gallons per year). The average cost savings were $150,000 per year with capital pay-back periods ranging from 2 months to 3 years with most less than 1 year.

Common sources of wastewater include the following:
- Aqueous cleaning of parts or equipment
- Water-based coolants
- Cooling water
- De-burring and mass finishing
- Boiler blow-down
- Wastewater from cutting and blasting
- Wastewater from air pollution control such as scrubbers

As with all waste reduction you must be open to new ideas and evaluate various options. There are no "magic bullets" which will solve every situation cost-effectively. The first step is to determine which processes are generating wastewater and the quantity and quality of each stream. You can not evaluate options if you do not know what you are generating. Track water use and wastewater generation over time, including nights and weekends and outage periods. PROPER SAMPLING & ANALYSIS ARE ESSENTIAL. Most people don't understand importance and difficulty of representative sampling. Bad data about wastewater streams results in bad P2 decisions.

Waste segregation is very important for pollution prevention. It is more difficult to find beneficial uses for mixtures. Also, small concentrated streams are easier to manage than large dilute streams and streams with few contaminants are easier to treat than complex mixtures.

There are several basic P2 measures for wastewater which do not involve any significant equipment or process redesign. First ask if you can eliminate the process (do the parts really need cleaned?). Then ask if you can eliminate the use of water in the process. Can you reduce the use of water in the process? Finally can you reuse the water in another process, with or without treatment? Examples include:
- Turn valves down or off (automatic controllers instead of manual)
- Preventative maintenance, i.e. stop leaks (pumps, seals, piping)
- Change to dry clean up methods (use a broom not a hose)
- Reuse water as is without treatment for a less stringent process
- Ensure proper mixing of chemicals

The next level is to evaluate P2 measures that are more complex. Examples are: substitution of less toxic raw materials, training operators to ensure proper and consistent methods are used; optimizing your processes; installing closed-loop systems; treating a wastewater to allow reuse; and exchanging wastes with other industries.

Other P2 measures which are usually cost-effective include:
- using de-mineralized water for makeup for: metal working fluids, plating baths & rinses, or parts
- using cleaning rinses

- reuse of cooling tower blowdown
- recovery of metals from plating baths & rinses
- reducing oily waste from aqueous cleaners

Cleaning

Cleaning is a process which often generates wastewater in the metal fabrication industries. Selection of the best cleaning process addresses the surface being cleaned, the soil to be removed from the surface, and the required level of cleanliness. The amounts of wastewater generated may be minimized by: (1) avoiding the need for cleaning, (2) maximizing the efficiency of the existing cleaning systems, and (3) using the least hazardous media. Some alternatives which will avoid or reduce the need for cleaning include: indoor storage, just-in-time delivery, using shrink wrap to protect parts, and improving coating efficiency. The latter will reduce rejects and the related need to strip and clean parts.

Some source reduction options for cleaning wastewater include:

- changing to non-detergent cleaning solutions, i.e. using hot water and/or high pressure,
- extending solution life by on-line filtration or other means,
- minimizing losses,
- reducing drag-out or carryover from one process tank to the next,
- making pre-cleaning inspections so you don't clean unnecessarily,
- proper makeup and mixing to ensure proper concentrations, and
- periodically monitor concentrations and bring them back to recommended levels.

Drag-out or carryover can be reduced by many methods which keep more of each solution in its respective tank or container. Some options include the following:

- using less concentrated solutions which reduces the contaminant load in each drop and may also reduce viscosity,
- increasing drip times over the originating tank (a total of 10 to 30 seconds is usually adequate),
- using drip boards to direct drainage back into the originating tank,
- positioning the work-piece on rack to maximize drainage and minimize the volume of solution cupped within the piece,
- increasing solution temperatures or adding wetting agents to reduce viscosity and speed drainage,
- using air knives to blow drainage back into the originating tank, or
- using drag-out tanks (dead or static rinse tanks).

Proper work-piece positioning depends on the shape of the part and the rack or conveying mechanism. The best position will: tilt each piece so drainage is consolidated; avoid, if possible, positioning parts directly over one another; tip parts to avoid large flat surfaces or pockets; and position parts so only a small surface area comes in contact with the solution surface as it is removed from the solution.

Common pollution prevention measures for rinse-waters often involve relatively minor piping or equipment changes. Examples are: counter-flow rinsing, still rinses, flow and/or conductivity controls, spray or fog rinses, and agitating rinses to improve cleaning.

<u>Wastewater Treatment</u>
Treatment should be evaluated if the wastewater can not be eliminated at the source. Treatment processes should be optimized to ensure the most cost-effective treatment of any remaining wastewater. Concentrated brines or sludges should be evaluated to determine if their metal content can be recovered cost-effectively. The water content of all sludge should be reduced to the maximum extent practicable using filter presses or dryers. This will reduce paying for shipping and disposal of water.

METALWORKING FLUIDS
Metalworking fluids are used to facilitate the cutting operation by one or more of the following: lubrication, cooling, cleaning out chips, and inhibiting corrosion. The common waste fluids and lubricants in the metal fabrication industry include:

- Non-dilutable straight oils
- Water soluble oils
- Semi-synthetic fluids
- Synthetic Fluids

These range from 100 percent petroleum oil in the concentrate to zero.

Fluid management can have tremendous impact on metalworking costs and productivity. The primary aim should be to extend the useful life of fluids through source reduction, reuse, and recycling. This will improve product quality, reduce purchases of new fluids, decrease disposal of spent fluids, reduce downtime for machine clean-outs, and improve working conditions for the operator.

Price should **never** be the primary criteria for choosing metalworking fluids. Many other factors such as: part & machine requirements, fluid life, treatability, disposal costs, microbial resistance, and corrosion protection. If possible standardize on as few fluids as practicable based on the issues above. This will simplify operations, minimize contamination, enhance recycling, and allow volume price reductions.

<u>Waste Reduction for Metalworking Fluids</u>
The fluids must be routinely checked for such things as: water level, tramp oil, fluid concentration, biological growth, dirt, rust, foam, filterability, and surface tension. Where practical checks should be made with a test method not some type of operator observation so the results will be more consistent and reproducible from operator to operator.

Control concentrations for optimum performance and life. Many people seem to assume that a more concentrated solution delivers better performance, but in fact, performance often decreases.

The most common cause of fluid degradation is bacterial contamination. It is essential that sumps and machines be cleaned according to manufacturers recommendations on a regular basis. If practical, the sumps should be disinfected.

Use demineralized water to blend synthetic coolants and lubricants. High mineral content often causes stability problems with soluble oils and semi-synthetic fluids. These minerals will also build up over time and result in changes in fluid alkalinity. Therefore, demineralized water will increase performance and extend fluid life. Maintain gaskets, wipers, and seals. These are essential in keeping contaminants, such as tramp oil, out of the metalworking fluid.

Standardize fluids to enhance treatment and reuse options. This will usually also allow for some economy of scale in purchasing new fluids. Keep metalworking fluids clean! Install screens or covers to keep trash out of the fluid in the sump. Also evaluate use of ultrafiltration or skimming equipment to remove contaminants before they can further degrade the metalworking fluid.

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Abstract:

Solvent Substitution Testing Program

Objectives of the Alternative Cleaning Technology Laboratory:

-Assist industries with cleaning technologies appropriate to current environmental regulations
-Provide an unbiased evaluation of cleaning technologies alternatives -explore new options in areas of alternative cleaning

The increasing amount of regulations regarding the waste effluents from manufacturing facilities has likewise increased the need for a systematic approach for industries to meet this challenge. The industries in USEPA Region 5 facing decisions regarding switching cleaning technologies lack the information and/or resources to accomplish this task. The alternative cleaning technology laboratory (ACTL) at WMRC is attempting to do this, providing direct means of expressing practical pollution prevention. The approach of WMRCs ACTL is both systematic and scientifically rigorous. The center, through funding by the USEPA, other agencies, and industry investigates techniques and technologies designed to reduce or eliminate the use of organic solvents.

a. WMRC-Industry Dialog: Through channels ranging from public presentations to phone inquiries to references from the state/federal regulatory agencies, potential clients learn of WMRC's expertise in this area. The discussions initially focus on the nature of the problem, then gradually move to attempting to define a systematic plan, which will result in potential financial savings, improved positive public image, safer and healthier workplace, and continued industrial improvement. The subsequent work may range from a simple solvent substitution to reevaluation of a cleaning operation. WMRC is equipped to do bench-scale testing of potential cleaners and pilot-scale tests, as the work progresses. It is at this point that we can assist industries in directly implementing the new technologies.

b. Commercially available Alternative Cleaners: The work involves a direct and scientific search for a technology solution. Possible solutions to any industrial problem are dictated by the currently available resources, and this is a primary consideration. Ongoing work at WMRC involves the evaluation of potential cleaners, regarding their effectiveness under numerous possible conditions. The results are being systematically documented. Further, the cleaners are being classified according to their physical properties, health and safety hazards, the surfaces on which they work, and their chemical activity. The latter work does involve both analysis of the available literature and doing actual laboratory experiments. From this work, potential replacements for the existing cleaning methods of the client are identified. As the work progresses, the experience will simultaneously expand WMRCs repertoire of cleaning alternatives and will improve prediction of cleaning technology replacements.

c. Alternative Cleaners Wastestream: The replacement of an undesirable cleaning technology with a more desirable one is valuable, but it is only a partial solution. An important component of the service which WMRC will supply to its clients will be the detailed understanding of the resultant waste stream produced by the new cleaning technology. WMRC also retains expertise in close-looping cleaning systems and in prolonging the lifetime of cleaning systems.

d. Database Development: The amount of data generated from this laboratory will be organized in a readily accessible form. As part of this effort, a database is being constructed which will systematize the detailed results of the ACTL work done at WMRC, incorporating both the experimental results and existent literature and references to regulatory requirements.

Shawn R. Niaki

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WASTE MINIMIZATION/POLLUTION PREVENTION AUDITS FOR 10 MAJOR INDUSTRIES

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1.0 INTRODUCTION

This paper presents detailed activities for the Pollution Prevention and Waste Minimization (PP/WM) Program which were performed during a two-year period in one of the middle eastern countries. During this period, comprehensive PP/WM feasibility studies were performed at ten major industries. These industries included refinery, thermal power plant, steel, potash manufacturing, phosphate manufacturing, brewery, sulfur-chemicals, vegetable oil, yeast, and slaughterhouse.

2.0 OBJECTIVES

Objectives of the Program are as follows:

- To assist the water-using and waste-discharging manufacturing industry to adopt and practice PP/WM; and
- To develop, stimulate, and strengthen the private sector environmental services and equipment supply sectors.

3.0 APPROACH

The entire tasks for the PP/WM Program during the 4-year life of the project are as follows:

- Task 1- Prepare Work Plan and Establish Pollution Prevention Office
- Task 2- Conduct Audit, Feasibility Studies, Demonstrations, and Training
- Task 3 - Design and Assist in the Implementation of Financial Mechanisms
- Task 4- Short-Term Training

This paper covers Tasks 1 and 2 of the project.

3.1 Prepare Work Plan and Establish Pollution Prevention Office

This task consists of the following steps:

- Establish PP Office;
- Establish PP/WM Committee;
- Prepare Work Plan for the Life of the Project; and
- Prepare Annual Work Plan.

3.1.1 Establish PP Office

In February 1994, with assistance of the Chamber of Industry (Chamber), a PP Office was established. With assistance from the Chamber, the industries are encouraged to conserve and monitor water use and to use PP/WM as part of the every day operational practice.

The PP Office operates as the PP Section under the Chamber's Environmental Department. During the first two years of the Program. The PP Office was directed by a Program Director, a pollution prevention specialists from Harza Engineering Company in Chicago, Illinois.

3.1.2 Establish PP/WM Committee

With assistance of the Chamber and the government a PP/WM Committee was organized. For this purpose, members from the following organizations were identified:

- Chamber of Industry (Chamber);
- Ministry of Water;
- Ministry of Planning (MOP);
- Private Scientific Society;
- Ministry of Industry and Trade (MIT);
- Central Bank;
- Two (2) Major Industries; and
- Ministry of Municipal and Rural Affairs/Department of the Environment.

The committee was the driving force to provide guidance, advice, and suggestion on priorities for preparation of work plans for development of the PP/WM Program appropriate for majority of existing and new industries.

3.1.3 Prepare Work Plan for the Life of the Project

This step consists of preparation of a WP for the 4-year life of the project.. This WP provided the background information and a summary of the tasks to accomplish the PP/WM objectives during the life of the project. In design of each task, existing data from other PP/WM projects were considered.

3.1.4 Prepare Annual Work Plan

An Annual WP were prepared for each year of the project.

3.2 Conduct Audit, Feasibility Studies, Demonstrations, and Training

This task consists of the following steps:

- Conduct Audits;
- Perform Feasibility Studies;
- Perform Demonstrations; and
- Provide Training.

This report covers the first two items. Training task was completed by Harza in the first two years of the project. Currently, Harza is involved in implementation of demonstration task at a refinery plant and a yeast manufacturing facility.

3.2.1 Conduct Audits

This step consists of the following activities:

- Collect and Summarize Data;
- Rank Polluting Industrial Facilities;
- Select facilities for Auditing;
- Select Audit Teams;
- Define Scope of Work for Each Audit;
- Hire Local Consultants;
- Inform Short-Term and Local Consultants;
- Conduct Audit;
- Perform Reconnaissance Facility Visits;
- Prepare Draft Audit Evaluation Report;
- Prepare Pre-Final Audit Evaluation Report; and
- Prepare Final Audit Evaluation Report;

3.2.1.1 - Collect and Summarize Data In this step, the following information for both connected (discharging to the sewer system) and non-connected (discharging to a river or land) industrial facilities (facilities) were collected:

- Name;
- Type (i.e., facilities with similar processes);
- Effluent discharge characteristics (average, maximum, and standard

deviation); and
- Flow rates.

The above information were obtained from the MW's Industrial Department, and the Chamber. The information was summarized in tabulated forms for subsequent ranking in Section 3.2.1.2.

3.2.1.2 - Rank Polluting Facilities Data collected were used to estimate the average total daily loading (TDL) of pollutants for each facility. Based on the average TDLs, facilities were ranked for auditing purposes.

3.2.1.3 - Select Facilities for Auditing For each industrial type, at least one facility with highest average TDL and/or hazardous nature effluent was selected, as the candidate for the PP/MW auditing. Exceptions to this criterion were made if the future planning identified any other industrial types or facilities for selection and auditing purposes.

A list of the candidate facilities, including 10 with highest potential, was submitted to the PP/WM Committee for review, comments, and approval. Total of 10 facilities were selected for the PP/MW auditing.

3.2.1.4 - Select Audit Teams In this activity, qualifications of all short-term and local Non-Government Organization (NGO) consultants proposed for PP component were collected and reviewed. For each industrial type selected for auditing, based on the qualifications of these consultants, an Audit Team was selected. Each team consisted of a combination of the following members:

- PP Program Director;
- The Chamber's Environmental Director;
- MW Counterpart;
- A Short-Term Consultant; and/or
- A Local NGO Consultant, if required;
- A Facility Manager; and
- A Production line Employee.

3.2.1.5 - Define Scope of Work for Audit For each audit, a Scope of Work (SOP) was prepared for distribution to the members of the Audit Team. This SOP provided procedures, responsibilities of each member, and schedule for activities for each audit.

3.2.1.6 - Hire Local NGO Consultants Following the completion of activities described in Sections 3.2.1.4 and 3.2.1.5, the local NGOs selected for auditing were hired. The contract for each NGO included SOP, responsibilities, deliverables, budget, schedule, and the required level of effort.

3.2.1.7 - Inform Short-Term Consultants The SOPs described in Section 2.2.5 were sent to the short-term consultants selected for auditing. Each consultants were informed about his responsibilities, deliverables, schedules, budget, and the required level of effort.

3.2.1.8 - Conduct Audit The goal of the audit was to evaluate and identify the possible PP/MW and water conservation techniques which were appropriate.

This activity consisted of the following activities:

a. Audit Coordination;
b. PP/WM Background Materials Preparation;
c. Pre-Investigation Meeting;
d. Audit;
e. Post-Inspection Meeting; and
f. Audit Evaluation Report.

a. Audit Coordination

At least four weeks prior to an audit at each facility, the Chamber sent a letter to the management of the facility for scheduling a date for the audit. This letter also included the types of information needed to be provided by the facility during the audit. This information included process flow sheets, mass balance, material inventory, costs, etc.

Additionally, with assistance of the Chamber, two weeks prior to the auditing date at each facility, the date for the audit was confirmed with the facility managements by telephone.

Furthermore, upon confirming the audit date, all Audit Team were informed to attend for auditing on this date. Also, as part of the coordination, arrangement for transportation of the Audit Team to and from the facility were made, as appropriate.

b. PP/WM Background Materials Preparation

For each audit, a comprehensive literature review was performed to identify the most effective techniques and clean technologies being practiced for PP/MW for the related industrial type. The literature review included, but not be limited to, the following sources: published literature, vendors, and the United States (U.S.) Environmental Protection Agency (EPA) personnel contact, and U.S.EPA's Pollution Prevention and SITE Programs.

The literature consisted of PP/WM related articles, journals, proceedings, U.S.EPA documents/communication, vendor communication and publications, and books on pollution and controls.

Based on the literature review, the PP/WM background materials were prepared for each industrial type selected for audit.

This information was very useful for the facility, and as a consulting aid and/or background information for the Chamber, MW, or other interested governmental organizations and NGOs.

c. Pre-Investigation Meeting

Prior to an inspection for each audit, a pre-investigation meeting was held at the facility. All members of the Audit Team attended at this meeting. The intent of this meeting was to inform the team and the facility managements about the conduct and goals of the audit. This meeting provided the Audit Team with specific background information about the facility to be audited.

d. Audit

A PP audit was performed at each selected facility. The PP audit was based on a comprehensive inspection of the facility, characterization of waste generated, compliance with waste discharge limitations, reviewing the facility's compliance history, and identifying issues involving potential non-compliance.

The intent of each audit was to collect the following information for each facility for PP/MW evaluation purposes:

- Input materials summary (components, annual consumption rates, cost, etc.);
- Type of products;
- Facility/Equipment age;
- Production processes;
- Material balance;
- Manufacturing areas;
- Chemical storage and handling areas;
- Individual wastewater streams' quantities and qualities for each process;
- Description of generation of each wastewater streams;
- Management method practiced for each wastewater stream;
- Wastewater treatment facilities;
- Waste management practice;
- Ancillary facilities;
- Annual cost for management of the wastewater discharge;
- Data on water and energy use; and
- Photographic records.

The above information was used to familiarize the Audit Team with the industrial production processes, particularly those unique to each industry, and water use and conservation techniques.

The Audit Team visually examined the facility for waste and wastewater issues. The objective was to examine the current conditions of the facility, obtain first hand information regarding the size and layout of the facility, and characterize the waste discharge characteristics and compliance status.

As part of the site inspection, the Audit Team reviewed the available records related to the facility. The purpose was to compile available data regarding waste and wastewater discharge characteristics, and other pertinent data sufficient for determining the status of regulatory compliance. Other available records, such as flow sheets, plans, operating procedures, spill reports, spill prevention and control plans, releases and fires, and other data were obtained and reviewed.

Facility personnel familiar with and responsible for the facility were interviewed to compile information on the history, operation and current status of the facility. Facility personnel were interviewed during the course of either the visual inspections or the records review. Follow-up interviews, if necessary, were conducted by telephone.

e. Post-Inspection Meeting

After each audit, a post-inspection meeting was held, prior to the leaving the facility. Appropriate facility's management staff and members of the Audit Team attended at this meeting. The goals of this meeting were as follows:

- To discuss preliminary findings with the facility's management staff;
- To provide technical training to all involved parties; and
- To encourage industry action and participation in PP/WM practices.

The Audit Team discussed findings and presented background information materials which was prepared for worldwide existing techniques for PP/MW being used by the related industrial type facilities.

f. Audit Evaluation Report

An Audit Evaluation Report was prepared for each audited facility. Data compiled during the facility audit, observations made during the reconnaissance site visit (s) at similar industrial type facilities (Section 3.2.1.9) and during the visual inspection, and results of personnel interviews were organized and evaluated to identify significant waste and wastewater discharge of concerns and to identify potential existing PP/WM and water and energy conservation techniques. These alternatives included instruments such as remote sensors for early monitoring of pollutants before discharge to the sewage system. In conjunction with the data evaluation, applicable standards and regulations that could impact facility's waste and wastewater discharges or future operation of the facility were reviewed and summarized. This included assessment of pending legislation related to the site activities.

The report provided a summary descriptions of significant concerns. In essence, the available information was used to determine the "what, how much, how, why, when, and where" of potential waste and wastewater discharges, issues necessary to identify and describe significant potential constraints. It also helped to identify data gaps and determine the needs for further work to fill such gaps.

3.2.1.9 Perform Reconnaissance Facility Visits Several other facilities were visited by PP/WM Program Director and members of the PP/MW Committee. Attempts were made to visit one or two facilities, other than the facility selected for an audit, among each industrial type selected for audit. This visit was just for reconnaissance purposes. The PP/MW practices in these facilities were considered as some of the feasible alternatives for related industrial types.

3.2.2 Perform Feasibility Studies

The goal of the Feasibility Studies (FS) was to evaluate the technical, financial, and logistical feasibility of the water conservation and PP/MW techniques provided in the Audit Evaluation Reports for each facility.

The FS consisted of the following steps:

- Select FS Team;
- Meeting for Initial Screening of Alternatives;
- Screening of Alternatives;
- Detailed Analysis and Selection of Alternatives; and
- FS Report.

3.2.2.1 Select FS Team Based on the background and experience of the short-term or NGO consultants, for each FS, a FS Team was selected. The members of the FS Team were as follows:

- PP Program Director;
- Members of PP/WM Committee;
- Management staff from the selected facility; and
- Production staff from the selected facility.

The FS Teams evaluated the potential water conservation and PP techniques and energy reduction ideas identified in the audit reports, and develop FS Reports. The team coordinated with representatives from the Chamber, and Non-Governmental Organization (NGO).

3.2.2.2 Meeting for Initial Screening of Alternatives The FS Team for each FS met with related facility representatives and local NGO environmental contractor to review and discuss the alternatives presented in the Audit Evaluation Report for the facility. During this meeting, facility officials and local NGOs were encouraged to discuss the alternatives with respect to operation of the facility, and availability of the resources to implement the possible alternatives. Those techniques determined to be technically infeasible were deleted for further considerations.

3.2.2.3 Screening of Alternatives The screening of alternatives consisted of the identification of a reduced list of alternatives for PP/WM which were analyzed in detail. Alternative screening aided in streamlining the FS process while ensuring that the most promising alternatives were being considered for detail analysis. The screening of alternatives was accomplished by the completion of the following activities:

- Refinement of alternative definition;
- Preliminary evaluation of alternatives based on:
    - Effectiveness
    - Implementability
    - Cost

The cost evaluation involved the development of capital and operating cost estimates based on preliminary process design, using facility-specific parameters such as:

- Wastewater characteristics;
- Quantities;
- Discharge criteria;
- Availability and cost for utilities;
- Assumed value for key design parameters; and
- Fate of by-products.

A treatment cost was assembled from:

- Operating cost;
- Labor;
- Capital cost; and
- Cleanup time.

The completion of this initial task established the framework for completing the FS.

3.2.2.4 Detailed Analysis and Selection of Alternatives Specific detailed evaluations of the remaining alternatives from Section 3.2.2.3 were performed. This included the detailed analysis of alternatives to be accomplished by refinement of alternatives definition. Information included the following:

- Preliminary design calculations;
- Process flow diagrams;
- Sizing of the key process components;
- Preliminary site layouts;
- All assumptions; and
- Limitations and uncertainties.

Specific detailed evaluations of each of the remaining alternatives was performed. The alternatives were evaluated based on the following criteria:

- Short-term effectiveness and performance;
- Long-term effectiveness and performance;
- Reduction of toxicity/mobility/volume;
- Implementability;
- Protection of human health and the environment;
- Compliance with regulations;
- Community acceptance; and
- Cost.

As part of this step, comparative analysis of alternatives was provided and preferred alternatives were highlighted.

3.2.2.5 FS Report For each FS, a FS Report was prepared. This report included results of Sections 3.2.2.1 through 3.2.2.4. Each report consisted of descriptions of technologies/processes and alternatives and preliminary cost estimates for the most feasible alternatives identified in the Audit Evaluation Report for the related facility. .

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Documented Results of 35 Waste Reduction Assessments in Alabama

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for the
U.S. EPA Region 5
Waste Minimization/Pollution Prevention Conference
February 25-27, 1997
Chicago, Illinois

Introduction:

With the passage of the Pollution Prevention Act of 1990, congress established a national policy that pollution should be prevented or reduced at the source whenever feasible. Responsibility for implementing this policy fell primarily to state and federal environmental regulatory agencies.

These agencies recognize that many business lack sufficient technical resources for the in-house identification of waste reduction opportunities. While many of these agencies are willing to allocate resources to waste reduction technical assistance, business have demonstrated a reluctance to requires such assistance from regulators. This reluctance has created a gap between the agencies who have the mandate and resources to provide the technical assistance and the companies who most need the help.

An Alabama Waste Reduction and Technology Transfer Program (WRATT) was begun in 1990 as a Tennessee Valley Authority concept, assisted by the Alabama Department of Environmental Management to fill that gap by offering technical assistance in a non-threatening way to Alabama businesses. This program was so successful, that it was incorporated in 1993 as the WRATT Foundation a non-profit 501[c][3] Alabama corporation to enhance economic development and the quality of life in Alabama by providing resources to help business and industry reduce costs and waste through technical assistance, education, and research. Services provided by the Foundation are available to both the public and private sector. All technical assistance activities offered by the Foundation are conducted by teams of retired engineers and scientists.

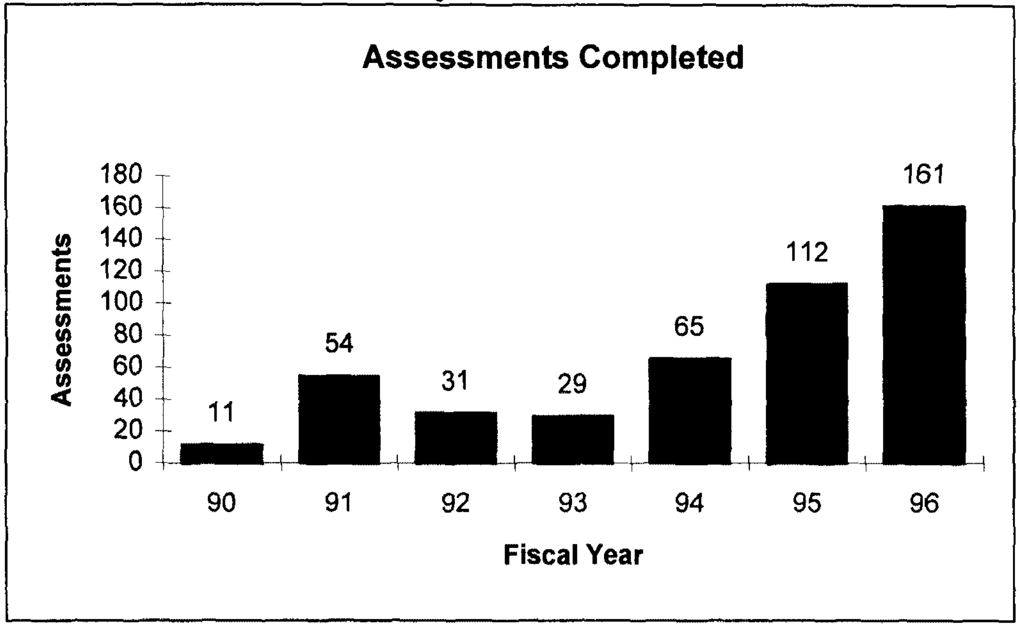
The public/private nature of WRATT's support has been a model of cooperation and efficiency in this era of reinventing government. From 1990 through 1994, $695,794 was spent on this project. Of this only $100,000 was provided by TVA. The balance was provided by private companies, other foundations, and EPA. The TVA support for this project was leveraged nearly 7 times.

In 1995, the Foundation began asking past clients to report on cost-effectiveness of implementing recommendations of the WRATT assessment teams. Of the first set of 50 companies, responses were received from 35. For a variety or reasons including lack of capital, and simple inertia, not all of the recommendations were implemented, but the total savings reported by these companies was still almost 3.5 million dollars per year. In addition, the companies that did report acknowledged that other savings have been realized but cannot be quantified at this time.

Summary

The success of the program is measured by the number of companies requesting the service, but more importantly by the actual number of assessments conducted. Since its inception in 1990, the number of assessments per year has increased dramatically through 1996. This annual increase is shown in Figure 1.

Figure 1: WRATT Assessments by Fiscal Year



Another measure of the effectiveness of the WRATT Foundation program is the dollar amount of savings achieved by the reporting companies as the result of implementing WRATT suggestions. The data presented in Table 1 represents total amounts of dollars saved and waste quantities eliminated from only 35 reporting companies not all of which reported savings and quantities. Most of these data represent annually recurring savings or reductions.

Table 1: Summary of Savings and Reductions

	Savings	Reductions
Solid Waste	$2,648,432	36,419.90 tons/yr
Hazardous Waste	$174,260	78.90 tons/yr
Utility Savings	$444,400	
Water Usage	$186,201	103,400 gallons/day
Volatile Organic Compounds	$27,000	11.00 tons/yr
TOTAL	**3,480,293**	

Still another fact to be considered is the ratio of company dollar savings to dollars spent by WRATT on the assessments. This is covered in detail in sections "Study Results" and "Benefits to Cost Ratios" of this report. However, to summarize, saving the companies $3.48 million with an expenditure of $126,884 yields a benefit to cost ratio of about 27 to 1. That is, the program saves the companies about $27 for every dollar WRATT spends in providing this service.

Study Results:

The data received from 35 responding companies referred to in the introduction are discussed in detail in the following Tables 2-6 in this section and Table 7 in the section "Benefits to Cost Ratios" for WRATT assessments. Because of the diverse nature of companies and the individual nature of the information that was documented the data are not comparable in all cases. However, the overwhelmingly positive results from WRATT waste reduction opportunity assessments is clear.

Tables 2 through 6 document annual savings and waste reductions by the individual companies as supplied by the companies themselves. Because of the nature of the data, the amounts may not be related. Companies not included in these tables reported that WRATT suggestions have saved them money and reduced waste, but the dollar amounts and tonnage have not been quantified.

Table 2: Reported Reductions in Solid Waste

WRATT #	Savings	Reduction	Units
8/103	$510,500	850.0	tons/yr scrap iron
12	$49,500	5.5	tons @ 30 lb/drum (368 Scrap drums)
30	$300		Reduced solid waste
45-51	NA	28,000.0	tons/yr Solid waste
67-68, #1	$29,820	7.2	tons/yr solid waste
#2	$28,000		Reduced raw material (solid waste)
69	$28,500		Reduced solid waste
70	$1,540,000	5,200.0	tons/yr solid waste
75	$40,000	75.0	tons/yr solid waste
76	$68,000	79.0	tons @ 7 lb/gal (22,500 gal/yr waste oil)
79-86	$9,000		Reduced Solid Waste
88	$8,100	108.0	tons/yr solid waste
91	$16,525		Reduced solid waste
100	$4,500	4.2	tons/yr solid waste
105	$25,070	846.0	tons @ 25 lb/ft^3 (2507 yd3/yr solid waste)
106	$42,000	1,200.0	tons/yr solid waste
107	$2,000	25.0	tons/yr scrap iron
108	$6,289		Reduced solid waste
109	$9,020	20.0	tons/yr solid waste
112	$250,000		Reduced solid waste
121	$10,000		Reduced solid waste
143	$5,508		Reduced solid waste
Total	$2,648,432	36,419.9	

Table 3: Reported Reductions in Hazardous Waste

WRATT #	Savings	Reductions	Units
20	$93,400	12.00	tons/yr hazardous waste
41-42	$420.00	2.40	tons/yr hazardous waste
45-51		18.70	tons/yr hazardous waste
67	$1,200	1.20	tons/yr hazardous waste
69	$1,190		reduced hazardous waste
75	$50,000	37.50	tons/yr hazardous waste
91	$4,050		reduced hazardous waste
121	$24,000	7.10	tons/yr hazardous waste
Total	$174,260	78.90	

Table 2: Reported Utility Savings

WRATT #	Savings	Reductions	Units
8/103	$40,000		Electrical usage
32	$80,000	4,602.00	MCF Natural Gas & Utility
67	$6,000		Utility cost
79-86	$134,400		Reduced utility cost
110	$84,000		Electrical usage
133	$100,000		Electrical usage
Total	$444,400		

Table 5: Reported Reductions in Water Useage

WRATT #	Savings	Reductions	Units
41-42	$43,250	86,400.00	gallons/day water
69	$4,042		reduced water consumption
79-86	$63,400		reduced water consumption
108	$50,789	17,000.00	gallons/day waste water
	$16,320		reduced water useage
143	$8,400		reduced waste water
Total	$186,201		

Table 6: Reported Reductions in Volatile Organic Emissions

WRATT #	Savings	Reductions	Units
67	$15,000	6.00	tons/yr
68	$12,000	5.00	tons/yr
Total	$27,000	11.00	tons/yr

Benefit to Cost Ratios

The benefits of waste reduction opportunity assessments go far beyond savings. In fact, the purpose of the WRATT program is to help companies to see waste as a business competitiveness issue as well as an environmental issue. Data indicate that in many industry segments, the total cost of waste is more than the cost of labor; in some cases the differential is great. Helping companies to recognize this important fact and learn to identify and eliminate waste at every opportunity is an important economic factor in strengthening the competitiveness of our existing Alabama industries.

Also, an important evaluation tool is the ratio of company savings to the cost of assessments; i.e. the benefit to cost ratio. To evaluate the savings demonstrated by this study, it is necessary to determine the total and average costs of assessments during the time they were conducted. During 1990 through 1994, the WRATT Foundation spent $695,794 to conduct 195 waste reduction opportunity assessments for an average of $3,570 for each assessment. The actual cost of each individual assessment varied based on the size and complexity of the company. The Tennessee Valley Authority provided $100,000 of the $695,794 to support these assessments, which represents a leveraging rate of almost 7 to 1.

Therefore, the 50 assessments conducted at 35 (5 companies that could not quantify costs were excluded) companies cost WRATT a total of **$126,844** and resulted in reported savings at assessed industries of **$3,480,293**. The overall benefit to cost ratio for this work was **27** and the average savings per company assessed was about **$102,000**. This is an amazing rate of return to have been based on so few of the total number of assessments that have been conducted.

This evaluation has been so successful that the Foundation has undertaken a full study of all companies receiving assistance to determine results. This study is being supported by the Alabama Department of Environmental Management.

Table 7: Benefit to Cost ratios for WRATT Assessments

WRATT No.	Assessment Cost	Reported Savings	Benefit/Cost Ratios
8/103	$8,079	$550,500	68
12	$4,194	$49,500	12
20	$2,347	$93,400	40
26	$1,508	$0	0
30	$1,769	$300	0
32	$1,754	$80,000	46
41-42	$3,889	$43,670	11
67-68	$1,009	$57,820	57
69	$3,557	$33,732	9
70	$7,721	$1,540,000	199
75	$10,761	$90,000	8
76	$2,518	$68,000	27
79-86	$7,151	$206,800	29
88	$7,606	$8,100	1
89	$7,785	$0	0
91	$2,615	$20,575	8
95	$3,062	$0	0
100	$2,481	$4,500	2
105	$11,938	$25,070	2
106	$4,008	$42,000	10
107	$6,894	$2,000	0
108	$2,604	$73,398	28
109	$1,181	$9,020	8
110	$1,955	$84,000	43
112	$7,449	$250,000	34
121	$3,062	$34,000	11
133	$5,103	$100,000	20
143	$2,846	$13,908	5
Total	$126,844	$3,480,293	27

Mark Ralston

U.S. EPA, Waste Minimization Branch

MARK RALSTON

Mark Ralston is a senior analyst in the Waste Minimization Branch at the U.S. EPA in Washington, DC. Most recently, he has supported the development and implementation of the Waste Minimization National Plan. His work has focused on identification of risk-based priorities for source reduction and recycling of hazardous wastes. He recently lead an EPA/state team that recommended a cross-program cooperative effort to modify an existing EPA risk screening tool for the purpose of identifying national priorities under the Waste Minimization National Plan. He is also involved in EPA's work to develop measurement methodologies to track national progress under the Plan.

Prior to his work in waste minimization, Mr. Ralston analyzed the costs and benefits of hazardous waste regulations at EPA. He has a bachelors degree in biology from the State University of New York at Albany and a masters degree in natural resource economics from the University of Washington in Seattle.

Developing Measures of Progress for the *Waste Minimization National Plan*

The *Waste Minimization National Plan* established a goal to reduce the most persistent, bioaccumulative, and toxic (PBT) chemicals in the nation's hazardous wastes by 50 percent by the year 2005. This goal has also been integrated in the Agency's *Goals 2000* report, and reductions in PBT chemicals will therefore serve as an important indicator of environmental progress under the Government Performance and Results Act (GPRA).

EPA is now working to develop methods to track progress toward this goal. As part of this effort, EPA is working to develop appropriate measures to be tracked, which will include the quantities of PBT chemicals themselves as well as the quantities of wastestreams that may contain these chemicals. A measure based on the quantities of PBT chemicals is the preferred way to assess progress, but implementation of this measure currently presents some challenges due to the limitations in available reporting mechanisms (such as the Biennial Reporting System (BRS) and Toxics Release Inventory (TRI)) for this purpose. A measure of progress based on quantities of wastestreams containing PBT chemicals may be advantageous for tracking highly-PBT chemicals that are generated in small quantities (and are therefore not reported in the TRI or other sources) or as an interim measure en-route to tracking the PBT chemicals themselves. However, this measure also presents implementation challenges related to identifying the wastestreams and tracking them across reporting periods.

For a measure of progress based on either PBT chemical quantities or wastestream quantities, the starting point is a relative ranking of chemicals based on the PBT criteria. EPA has developed a risk screening tool to provide this relative ranking for hundreds of chemicals that are regulated under RCRA and other statutes. This long list of chemicals ranked based on the PBT criteria can be narrowed down and focused in a number of ways. One way is to "weight" the PBT scores by national estimates of the quantities of the chemicals in hazardous wastes, where these estimates are available from the TRI or the National Hazardous Waste Constituent Survey. Another way is to focus on chemicals that are regulated not only under RCRA, but under other media statutes, since there will be obvious cross-media concerns regarding these chemicals. A third approach is to focus on chemicals for which there are good analytical methods. The end result of this process is a measure of progress based on PBT chemical quantities.

Once an appropriate subset of PBT chemicals is identified for measurement, the measure of progress based on wastestream quantities can be developed by cross walking the PBT chemicals first with RCRA waste codes and then with RCRA wastestreams reported in the BRS. Alternatively, it may be possible to make a direct linkage between some chemicals and the hazardous wastestreams containing them using the National Hazardous Waste Constituent Survey.

Peter A. Reinhardt and
K. Leigh Leonard

University of Wisconsin

Peter A. Reinhardt is the Assistant Director for Chemical & Environmental Safety at the University of Wisconsin-Madison's Safety Department. Since 1979 he has held positions in radiation safety and as the Hazardous Waste Officer and the Chemical Safety Supervisor there. He directs a staff of ten who perform hazardous waste management, industrial hygiene, environmental engineering, chemical analysis, site remediation, and environmental audits to manage the University's chemical and environmental risks. His program oversees the University's compliance with environmental and safety laws pertaining to hazardous waste, Superfund, chemical emergency planning and response, toxic substances, water, air and other chemical uses. He inspired and edited the University's *Chemical Safety and Disposal Guide* (1984, 1994) and assists other Wisconsin state agencies as a member of the Environmental Management Committee.

He is an active member of the American Chemical Society and its division of Chemical Heath and Safety. He was appointed to the ACS's task force on Laboratory Waste Management in 1989 and was selected as Chair in 1994.

Since 1992 he has been elected to Chair the Dane County Local Emergency Planning Committee. He had been elected Vice Chair since the Committee's inception in 1987.

He is an appointed member of the National Committee on Clinical Laboratory Standard's subcommittee on waste management that prepared the 1993 NCCLS guideline on Clinical Laboratory Waste Management.

He coauthored *Hazardous Waste Management at Educational Institutions* (1987), *Infectious and Medical Waste Management* (1991) and *Laboratory Waste Management* (1994), coedited *Pollution Prevention and Waste Minimization in Laboratories* (1996) and has written several other technical publications, contributed chapters and articles. He is also a frequent speaker, instructor and presenter on the topics of hazardous waste and chemical safety.

In 1993 he was appointed by the National Research Council to subcommittees on *Mixed Waste* and *Pollution Prevention* to help draft parts of *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (1995).*

Mr. Reinhardt has a B.S. in Biochemistry (with a concentration in toxicology) from the University of Wisconsin-Madison, and an M.A. in Public Policy and Administration (Environmental Risk Policy focus) from the UW-Madison's Robert M. La Follette Institute of Public Affairs.

K. Leigh Leonard, CHMM
University of Wisconsin System Administration

Ms. Leonard is the Associate Environmental/ Occupational Health and Safety Manager for the University of Wisconsin System, which includes twenty-six campuses. She provides policy development and technical oversight for the UW's hazardous waste management program. She works with a multi-agency committee to administer the State of Wisconsin's mandatory hazardous waste services contract. In this capacity, she monitors the hazardous waste market, conducts hazardous waste facility inspections, and recently worked on a rebid of the contract that resulted in a 50 percent cost savings to the State. Ms. Leonard's role in the State's contract earned her a State of Wisconsin award for Excellence in Purchasing in 1995.

Other professional specialties include laboratory waste minimization, management of high hazard wastes, chemical safety, safety in the arts, and biosafety. Leigh has worked in environmental health & safety at the University for over eight years.

Professional Affiliations

- Certified Hazardous Material Manager (CHMM).

- Federation of Environmental Technologists (FET) a Wisconsin-based organization dedicated to the education of environmental compliance professionals (co-founder and past officer of Madison Chapter).

Publications

- Reinhardt, Leonard, and Ashbrook, ed. 1995. Pollution Prevention and Waste Minimization in Laboratories. Lewis Publishers. New York.

Education

- Master's degree from University of Wisconsin-Madison in Urban and Regional Planning with a concentration in environmental planning (1989); Bachelor's degree from Oberlin College in Biology (1982).

What Is Different About Pollution Prevention In Laboratories?

... and how to take advantage of the differences

by Peter A. Reinhardt[1] and K. Leigh Leonard[2]
University of Wisconsin

presented at
U.S. EPA Region 5 Waste Minimization and Pollution Prevention Conference
Chicago, February 26, 1997

Pollution prevention presents unique challenges for laboratories. We've noted in our book that, "Laboratory operations are notoriously difficult to prescribe waste minimization solutions for. Their waste types are numerous, and usually small in volume... These challenges are further compounded in pure research labs where there is a high frequency of change in experimental procedures and reagents used. Just when you have found a way to minimize a wastestream from a particular protocol, the study or project comes to an end."[3]

The way people work in laboratories tends to be different than in manufacturing. Scientists and researchers rely on widely established, published protocol, which may have been developed without regard to environmental impact. People who work in labs tend to have considerable discretion with regard to their laboratory operations. Due to the nature of laboratory operations, researchers can change their procedures quickly and drastically as their results open new paths of investigation. Factors that motivate and inhibit pollution prevention activities are different in the laboratory environment, especially in academia. Scientists making decisions at the laboratory benchtop are more insulated from understanding the environmental impacts and costs of their operations. This is because waste disposal expenses, compliance responsibilities, and sometimes product costs

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[3] *Pollution Prevention and Waste Minimization in Laboratories,* Reinhardt, P. A., Leonard, K. L., Ashbrook, P. A., eds., CRC Press/Lewis Publishers (1996), p. 4.

are managed centrally at many institutions, and not allocated back to the laboratory unit.

As a result, the systematic pollution prevention framework developed for industrial processes does not work well when planning and implementing pollution prevention in laboratories. The comprehensive planning approach does not lend itself to the laboratory setting where major process changes occur overnight. In particular, systems analyses and production or activity indices are difficult to apply due to number and variability of processes. Unit cost allocations are generally not meaningful to the people who work in labs and make choices about laboratory operations and chemicals used.

National Survey of Laboratory Chemical Waste Minimization

The findings of our National Survey of Laboratory Chemical Waste Minimization practices underscore the points made above. [4] The survey gathered waste minimization data from Howard Hughes Medical Institute member institutions (mostly academic labs) and firms with members of the American Chemical Society's Division of Chemical Health and Safety (private labs). 120 total respondents provided information on their laboratory waste management activities in 1993.

The survey found over 90% of the labs engaged in waste minimization activities. However, many of these labs do not have a plan, and few labs have stated goals for waste minimization. Very few laboratories have accounted for the money they saved from waste minimization activities.

The popularity of laboratory waste minimization methods was also surveyed; substitution with a with less hazardous material was listed most often. Reducing scale (e.g., microscale) manage inventory management were given by respondents as their most beneficial waste minimization methods. Chemical inventory management included procedures to purchase smaller quantities and control purchases, and redistribution of surplus laboratory chemicals.

As shown in our survey, laboratories have found that certain pollution prevention activities are more likely to succeed than others. When considered together, these activities can be used as a "toolbox" by laboratory managers and staff to apply as appropriate in their changing laboratory environment and unique culture.

[4] Chapter 2 of our book provides detailed results of our survey.

Laboratory Pollution Prevention "Toolbox"

- Substitute with Less Hazardous Product
- Reduce Scale
- Chemical Inventory Management
    - ➢ purchase less
    - ➢ control/ monitor purchases
    - ➢ redistribute excess product

A Strategy for Lab Pollution Prevention Strategy

Considering the limitations of the traditional pollution prevention approach and the survey results described above, a reasonable strategy for pollution prevention in laboratories would include:

- Replicate the success of proven methods (i.e., the "Lab Pollution Prevention Toolbox");
- Take advantage of the inherent discretion and empowerment of people who work in labs;
- Take advantage of the flexibility of lab processes;
- Take advantage of trends that facilitate Pollution prevention;
- Evaluate and consider emerging and new lab processes.

What You Can Do to Facilitate Laboratory Pollution Prevention

There are several things institutions and firms can do to facilitate laboratory pollution prevention. Environmental Health & Safety and other support staff facilitate pollution prevention by providing resources to initiate change (e.g., loaning or funding equipment such as a solvent still or a non-mercury thermometer). They can also make available timely consulting services for specific decisions. Because processes need to be evaluated quickly in the laboratory, a "back-of-the-envelope" cost-benefit analysis will usually suffice for evaluating opportunities. To abbreviate the analysis, focus on high risk or volume wastes, occupational safety concerns, the cost and difficulty of waste disposal, or the ease of implementing a proposed solution.

A pollution prevention facilitator will benefit by becoming familiar with laboratory processes. In doing so, they will gain the confidence of people who work in laboratories. This positions the facilitator to provide timely and concise assistance and is in keeping with the "customer service" and Continuous Quality Improvement impulse of many organizations today.

Scientists are often willing to understand the environmental impacts and costs of their activities, and the benefits of pollution prevention, but do not want to invest time in assembling the appropriate data. Interest in pollution prevention and proven methods will grow when successes are rewarded and publicized. When convinced, laboratory staff and researchers often have the requisite tools and expertise to quickly adopt new procedures that prevent pollution.

Some unrelated trends in laboratory operations have pollution prevention as a byproduct. Institutions and firms that assist these trends will facilitate pollution prevention. The ability to detect and study chemicals in increasingly small quantities has enabled the miniaturization of laboratory experiments. Reduced scale has the added advantages of reducing the cost of sampling, the use of valuable product, and personnel exposures. Undergraduate chemistry laboratories have embraced those microscale experiments that are safer, faster and less costly.

There is a heightened awareness and concern of the occupational risks of laboratory chemicals. When less toxic chemicals are substituted, they usually create less toxic waste and emissions.

Affordable database applications and bar coding make it easier to manage the inventory of many chemicals. The incentive for doing so includes reducing chemical purchasing costs as well as reducing disposal costs. Because of these new capabilities, purchase controls have expanded, as have redistribution programs for surplus chemicals.

Performance Indicators for Lab Pollution Prevention

It is important to measure progress in any pollution prevention program. Documentation will help other laboratories prioritize their efforts and help convince administrators that waste minimization is worthwhile. Laboratories again present a special challenge. Indicators that can work include waste stream goals specific to a stable process, and measures of publicity, training and consultation. An indicator pollution prevention acceptance would be particularly important for researchers who have great discretion in the products, techniques and procedures they choose.

Pollution Prevention in Laboratories

Examples of Performance Indicators and Metrics

"What gets measured gets done."

Performance Indicator: A quantifiable attribute of an enterprise's activities that characterizes the potential implications of these activities with respect to the environment (EPRI definition).

Metric: A chosen method for quantifying a specific Environmental Performance Indicator (EPRI definition).

Performance Indicator	Sample Metrics
Waste Stream Goals Specific to Stable Process Example: reduction in hazardous solvents wastes in histology procedure due to substitution with non-hazardous substitute.	gallons per year OR pounds per month
Training and Information Exchange (Example: seminars, informational fact sheets.)	# of P2 seminars per semester # of attendees per session # of labs per semester receiving fact sheet
P2 Consultation Effort (Examples: phone or in-lab consultation and degree of follow-through.)	# lab staff assisted per year # of lab procedures modified

Help for Laboratory Pollution Prevention

Laboratories would benefit from a more active exchange of information on methods and substitutes that prevent pollution. Our book acts as an information clearinghouse for one point in time, but ongoing data collection and dissemination would be of great benefit.

EPA's Green Chemistry Challenge was successful in promoting pollution prevention techniques for chemical manufacturing. A Green Chemistry Challenge for laboratories might produce similar gains.

1 What Is Different About Pollution Prevention In Laboratories?

... and how to take advantage of the differences

2 How Labs Differ From Industry

- Great number of chemicals used result in...
  - numerous waste types
  - small in volume
- Many processes that change often and radically...
  - lead to variable waste streams

3 People who work in labs...

- Tend to rely on widely established, published protocol...
- ...but do have discretion/empowerment for benchtop decisionmaking
- Tend to be insulated from environmental impacts and costs

4 Limitations of Traditional P2 Approaches in Laboratories

- Systematic planning is too time consuming
- Process analysis takes too long for processes that change often
- Production/activity indices are difficult to apply due to number and variability of processes
- Unit cost allocation not meaningful to people who work in labs

5 National Survey of Laboratory Waste Minimization

Profile of Respondents

- Howard Hughes Medical Institute member institutions (mostly academic labs)
- Firms with ACS DivCHAS members (private labs)
- 120 total respondents

6 National Waste Minimization Survey

Summary of Findings

The Good News:

- Over 90 % of labs are engaging in waste minimization activities!

7 National Survey Results

The "Lab P2 Toolbox"

Most popular:

- Substitute with less hazardous material

8 ❑P2 Strategies for Laboratories

- Replicate the success of proven methods (The "Lab P2 Toolbox")
- Take advantage of the inherent discretion and empowerment of people who work in labs
- Take advantage of the flexibility of lab processes
- Take advantage of trends that facilitate P2
- Evaluate and consider emerging and new lab processes (check your radar screen)

9 ❑Facilitating Implementation of Lab P2

- Get close to the "customer" to:
  - understand lab processes
  - gain the confidence of people who work in labs
  - ...to thereby P2 empower them

10 ❑Facilitating Implementation of Lab P2, cont.

- Back-of-the-Envelope C-B Analysis
  - high risk or volume
  - occupational safety
  - cost and difficulty of waste disposal
  - ease of implementation (are the tools and expertise already there?)
- Publicize and reward successes

11 ❑P2 Empower People Who Work in Labs

- Explain the environmental impacts and costs
- Explain the benefits of P2
- Provide P2 Information and Toolbox
- Consult for specific decisions
- Provide resources to overcome inertia

12 ❑Trends Are Already In Place *that facilitate P2*

- Miniaturization
  - Reducing scale
  - Microscale chemistry
- Safer substitutes tend to be greener
- Inventory Management
  - *Less is better*
  - Purchase controls

- Redistribution of surplus chemicals

13 ❑ Performance Indicators for Lab P2

Goal-setting and Measuring Progress

- Waste stream goals specific to a stable process
- Publicity and training effort
- P2 consultation effort
- P2 acceptance

Documentation will help other labs prioritize their efforts and help convince administrators that waste minimization is worthwhile

14 ❑ Help for Laboratory P2

- Information clearinghouse for greener methods and substitutes
  - *Pollution Prevention and Waste Minimization in Laboratories*, Reinhardt, Leonard and Ashbrook, eds., CRC/Lewis, 1996
- Green Chemistry Challenge for research and analysis laboratories

Daniel P. Reinke

Environmental Resources Management

EFFLUENT COMPLIANCE THROUGH POLLUTION PREVENTION IN ASSEMBLY/TESTING OPERATIONS

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INTRODUCTION

This case study presents the results of work at a machinery manufacturer to reduce the amount of zinc in wastewater from assembly and testing operations. Facility operations include assembly, welding, product testing and packaging. The facility also houses repair operations for products sent in by customers. These repair and rebuild operations include aqueous cleaning, simple machining and painting.

In the 1980s, wastewater was generated from a number of operations at the site. At that time, products were assembled, tested, cleaned using a manual pressure washer, and painted using a solvent-based paint in a water wall paint booth. During the products testing process, there would be occasional leaks of the machine lubricant/coolant. This lubricant would drain into trenches which were connected to an oil/water separator. The test cells would be regularly cleaned with water which also drained through the trenches. The trenches were covered with galvanized metal screen material to catch dropped bolts and other small parts. Cleaning in the rebuild area was accomplished using petroleum distillate soak cleaners in which parts often had to sit overnight to loosen stubborn carbon deposits, oils and greases. Process wastewater was generated from the product testing area, discharge of water from the wet paint booths and general floor cleaning. Site wastewater discharges averaged 11,000 gallons per day of a mixed process and sanitary flow.

In the midst of a major redesign of the products and manufacturing process, the plant was notified by the local control authority and the zinc discharge limits in the discharge permit were to be significantly reduced from 0.42 milligrams per liter (mg/l) to 0.05 mg/l to accommodate a lack of zinc loading capacity at the publicly owned treatment works (POTW). The company worked with their environmental consultant to assist in identifying zinc sources within the facility and to jointly develop a plan to attain compliance through pollution prevention rather than expensive end-of-pipe treatment.

METHODOLOGY

The strategy for effluent compliance through pollution prevention included the following steps:

- Source sampling and analysis
- Data evaluation
- Strategy development
- Pilot testing
- Final design
- Implementation and training
- Continuous improvement

The activities taken under each step are described below.

Source Sampling and Analysis

This initial task included evaluating all wastewater sources to determine the contribution of each process to the overall facility wastewater loading. To get an accurate evaluation of the sources, multiple samples were collected and analyzed for zinc and chemical oxygen demand (COD) from the following areas:

- Incoming water at several locations
- Trench water
- Oil/water separator effluent
- Floor cleaning water
- Compressor lubricants

Sample analysis was completed using colormetric test kits to allow for immediate test results. Select samples were also sent off site for laboratory analysis.

Data Evaluation

The data collected was evaluated to determine the relative significance of the various wastewater sources. There were several interesting findings.

The first finding was that the product lubricants contained significant levels of zinc and that when the lubricants were mixed with water, the water would pick up zinc at levels above the discharge limits.

A second finding was that a new, more biodegradable lubricant that was being used had a specific gravity of 0.99, which was too high to allow effective removal through an oil/water separator. Fluid suppliers were contacted and it was found that low levels of zinc were added to the materials to increase lubricity. While reformulation may have been possible to eliminate this source of zinc, the more logical approach was to eliminate the discharge of any lubricants to the wastewater. This strategy was consistent with the product and process redesign activities which were aimed to eliminate all machine leaks and rework processes.

A third finding was that while incoming zinc levels were significant, 0.03 to 0.06 mg/l, in one area of the building where there had been extensive remodeling, the incoming water was found to contain 0.56 mg/l of zinc. We suspected that galvanic action was causing erosion of new galvanized water supply piping where it was connected with older copper lines. This piping was immediately replaced with copper piping.

A fourth finding was that the water from the trenches and the oil/water separator contained especially high levels of zinc at the beginning of the day. What we determined was that dropped galvanized fasteners were dissolving in the trenches, releasing zinc into the wastewater. We also found that there was a buildup of sludge in the oil/water separator which also contained high levels of zinc and released this material into the wastewater. Levels were highest in the morning at startup and decreased through the day. The trenches and the oil/water separator were cleaned out, lowering zinc levels in the discharge. Regular cleaning of the trenches and the oil/water separator was added to the facility preventative maintenance program to prevent further buildup.

Strategy Development

Based on this evaluation, which included calculations of total mass loading of contaminants from industrial processes, a strategy was developed to meet POTW loading requirements. This strategy was developed in conjunction with the local control authority which was very supportive of the plant's desire to address the issue through pollution prevention rather than extensive end-of-pipe metals removal equipment. The strategy was as follows:

1. Segregate industrial flows from sanitary flows and reduce the permit flow limit from 14,000 gpd to 5,000 gpd.

2. Increase zinc limits on a concentration basis to reflect the lower permit flow rate.

3. Eliminate lubricant leaks and discharges wherever possible through improved product and process design and increased employee awareness.

4. Perform regular cleaning of trenches and the oil/water separator to reduce sludge buildup.

5. Purchase a non-chelated cleaner for use in floor cleaning.

6. Investigate the use of plastic screens over the trenches to eliminate the galvanized material. The trenches were later eliminated in the redesign of the product test area.

7. Investigate the use of an ultrafiltration system to remove any oil and high COD contaminants that would come from the product test area, floor cleaning and new aqueous cleaning systems.

As part of an overall objective to reduce the environmental impact of the manufacturing operations, the facility tested and purchased several high pressure cabinet washers for use in rebuild and manufacturing operations. These washers significantly reduced the amount of time and labor required in these operations, reduced the generation of hazardous waste from the facility and reduced employee exposure to hazardous chemicals.

Another significant change was the elimination of painting operations through the use of prepainted parts. The use of prepainted sheet stock gives a better product appearance and also allows these sheets to be coated more efficiently, reducing manufacturing costs. The elimination of all production painting at the facility also reduces the impact of air permitting requirements, reduces the generation of hazardous waste and reduces employee exposure to chemical solvents. All of these items reduce the cost of manufacturing at the facility.

Pilot Testing

Testing the impact of the procedural changes was completed by thoroughly cleaning out the trenches and oil/water separator, and repeating the source sampling and analysis. Operators were trained to prevent the discharge of product lubricants to the drains. These changes were found to effectively eliminate zinc contributions from the test area operations.

While the procedural changes alone may have been able to maintain regular compliance, facility management personnel were concerned that there was no effective system to remove lubricants from the wastewater. Since the new, more biodegradable fluid had a specific gravity close to water, the oil/water separator was not able to reduce the oil and grease and COD loadings that would result from a machine leak in the test areas. Membrane technologies were tested, first on a bench scale and later with a pilot scale system, to determine the potential of this method to reduce these loadings.

The bench and pilot testing showed that ultrafiltration was effective in reducing COD loadings of wastewater containing lubricant by approximately 80 percent. Since these fluids also contain low levels of zinc, it was expected that this technology could reduce zinc loadings from any fluid leaks. Pilot equipment performed well, and facility personnel were able to easily maintain the system with minimal labor requirements.

Final Design

Based on the results of the pilot testing, a final design for installing an ultrafiltration system was submitted to, and approved by, the local control authority. Due to a lack of adequate space in the existing oil/water separator area, a new building was designed to house storage tanks and the ultrafiltration system. This new building included secondary contaminant for spill protection and a sprinkler system.

Implementation and Training

The product and process redesign involved a total revision of the manufacturing facility layout. Quality teams assisted in improving the designs to simplify the manufacturing process. New test areas were built and the old trench system was eliminated.

The ultrafiltration system was installed in 1992 and has allowed the facility to remain in compliance with the new discharge standards. One process modification was made to bubble air through the wastewater holding tank to prevent the buildup of anaerobic bacteria. Prior to this modification, the smell from the stagnant water would build up, especially over weekend shutdown periods.

Continuous Improvement

The facility is dedicated to a total quality management program that stresses continuous improvement in all of the operations. This program has had a measurable impact on product quality and manufactured cost.

RESULTS

Since implementation of the process changes, the facility has been in full compliance with effluent discharge limits, including the zinc discharge limits. Average process wastewater flows are 2,000 gallons per day. The most recent effluent analysis gave the following results:

BOD	83 mg/l
TSS	8 mg/l
Zinc	0.01 mg/l

CONCLUSION

Pollution prevention techniques were successful at this facility in addressing stringent zinc discharge limitations proposed by the local control authority. While some treatment was necessary to assure COD loadings would be within standards, the product and process modifications that were completed successfully kept zinc out of the wastewater. These modifications, which were initially developed to reduce manufacturing costs and improve product quality, had the following environmental impacts:

- Significantly reduced generation of hazardous waste, to below small quantity generator limits.
- Effectively eliminated the volatile organic compound (VOC) emissions from the facility, reducing air permitting requirements.
- Effectively eliminated employee exposure to solvents.
- Allowed compliance with stringent zinc discharge limits without the investment in a major end-of-pipe treatment system.

Patricia Sheller

3M Company

Presenter: Patricia Sheller, 3M Cordova Plant

Title of talk: 3M's Pollution Prevention Pays (3P): Plant applications

Quick background on the corporate 3P award system.

Brief description of 3M Cordova plant: two divisions, one with one major product line, one with hundreds of products, both supplying mostly other 3M plants.

Top-down interest in pollution prevention: From CEO on down, our management is very interested in seeing the plant continue to get large numbers of 3P awards.

Bottom-up interest in pollution prevention: Plant engineers and operators have become vividly aware that waste disposal is the single most controllable part of their product costs.

Waste disposal costs are directed back to the products generating wastes. In addition, we track quarterly what all our wastes are - outside disposal, wastewater, air emissions, etc. This is also a tool for addressing major changes at the plant - how will they affect this balance? Monthly reports go to our operating units telling them which products are generating the most waste.

Many of our past successes have come from actions the plant could take on its own using this information. Most of the easy stuff has already been done. The biggest future opportunities are in developing new or replacement products that are inherently less wasteful. The Governor's Award the plant got was an example of this approach.

Kendal R. Smith

Enviro Filtration, Inc.

BIOGRAPHICAL INFORMATION FOR KENDAL SMITH

Kendal Smith is the chief engineer for Enviro Filtration (1-800-368-4763). He has a BS in chemical engineering from Rose-Hulman Institute of Technology and a MBA from the University of Michigan. He is a member of the American Filtration and Separations Society, the Society of Automotive Engineers, and The Maintenance Council of the American Truck Association. His work experience includes product management with Cummins Engine Company and research and production engineering with Amoco Oil Company. The author has presented papers on various technologies for pollution prevention at EPA Waste Minimization conferences, the National Pollution Prevention Roundtable, and the Joint Service Pollution Prevention Conference.

The 96,000 Mile Oil Change Innovation:
The Enviro High Efficiency Secondary Oil Filter

Kendal R. Smith, Chief Engineer
Enviro Filtration
4719 Roosevelt St.
Gary, IN 46307
800-368-4763

Executive Summary

Cost pressures, government regulations, and environmental responsibility continue to drive American industry toward waste stream reduction and financial efficiency. Yet these concerns cannot impede mission performance. For fleet maintenance managers this means reducing waste oil generation, cutting costs, and enhancing vehicle reliability. A solution to this challenge is an extended oil drain program. New oil formulations and advances in filtration technology are creating opportunities to extend significantly and safely oil drain intervals, resulting in less waste generation, lower costs, and increased engine protection. One such technology offering high returns is the Enviro high efficiency secondary(HES) oil filter. The Enviro HES oil filter removes the most damaging contaminants in the oil and maintains the oil's additive package enhancing oil life and performance. This technology has demonstrated in military and commercial field evaluations the ability to increase drain intervals 400% to 800%, decrease waste oil generation 70-80%, and reduce operating costs 40-50%. There is no magic here. The effectiveness of the HES oil filter results from understanding the effects of engine operation on oil quality and applying purification technology to minimize the adverse effects. The technical basis for the effectiveness of HES oil filtration, results of commercial and military field evaluations, and suggestions for achieving extended oil drains follow.

The Challenge - The Opportunity

According to the RCRA Hotline of the EPA over 1,000,000,000 gallons of used oil were generated in 1991. The cost to industry and consumers to replace this oil is estimated to be $640 million annually. This does not include disposal, clean-up, or liability costs. In addition, American industry continues to cut costs and strive for efficiency. Environmental projects must be cost effective. Finally, costs and environmental concerns need to be balanced against mission performance. How does a maintenance or environmental manager reduce waste stream significantly and costs without jeopardizing mission performance? The answer is high efficiency secondary (HES) oil filtration for internal combustion engines. The Enviro HES oil filter enables engine oil drain intervals to be extended substantially without compromising engine protection.

Why Change the Oil - Additive Depletion and Contamination

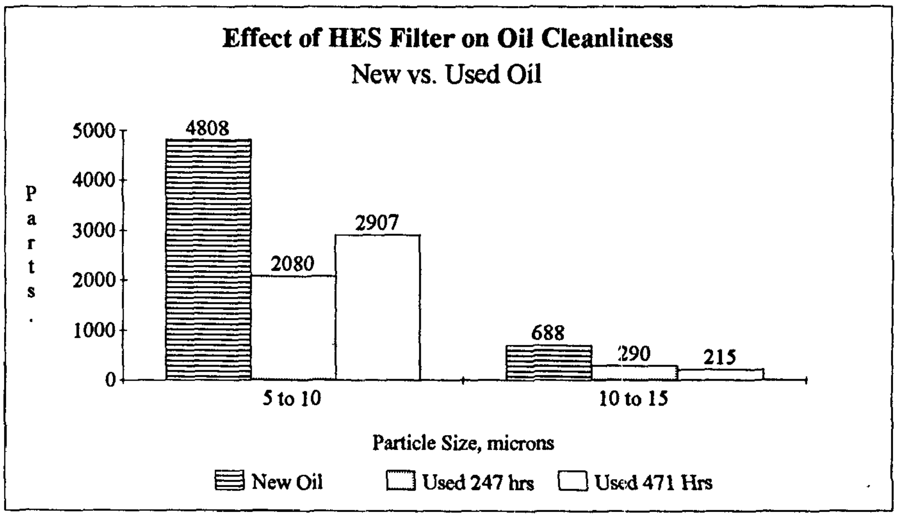
"Additive depletion and contamination are really the only two reasons that oil needs to be changed." That's what Don Johnson, Vice President of Product Engineering for Pennzoil Products Co., wrote in the September 1995 issue of the National Oil and Lube News. Dirt, metal particles, and combustion by-products accumulate in the oil and wear engine parts. For diesel engines, particles in the range of 0-10 microns cause the most wear. According to a Cummins Engine Company study, particles between 0-5 microns and 5-10 microns exhibit wear rates 3.4 times and 3.6 times higher than the wear rates of 10-20 micron size particles. To protect the engine properly these particles must be removed.

Oil also needs to be changed when oil quality suffers from additive depletion. Elements of the oil's additive package such as acid neutralizers, anti-oxidants, detergents, and dispersants are consumed protecting the engine and oil. When the additives are depleted, the oil is no longer able to protect the engine properly.

Because of these reasons, oil was changed routinely. The existing technology did not adequately address these problems. For example, OEM primary, or full flow, filters remove effectively only the 20-40 micron size particles, leaving the most damaging particles in the oil. In addition, they fail to maintain or replenish the additive package.

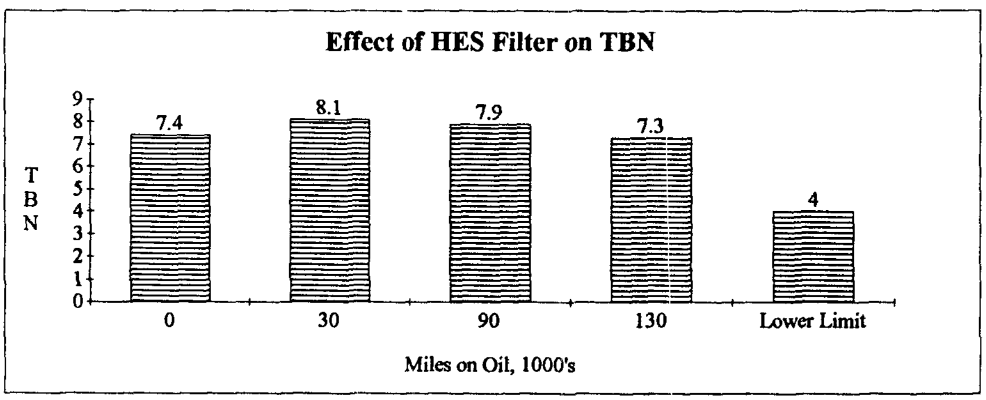
HES Oil Filters - The Enabling Technology

The Enviro HES oil filter affects both the accumulation of damaging particles and the depletion of the oil's additive package enabling oil drains to be extended significantly while increasing engine protection. As the name implies, the HES oil filter is a high efficiency filter. That means it removes a significant amount of the 0-10 micron particles, over 99% in a single pass. The effect of the Enviro HES oil filter on oil cleanliness is presented in the figure to the right. Particle counts for new oil are compared with those of oil used in vehicles equipped with the HES oil filter. As illustrated, the used oil after 247 hours and 471 hours had fewer particles than the new oil out of the drum. In the critical zone of 5-10 microns, the oil used 247 hours and 471 hours contained 57% and 40% fewer particles ,respectively, than the new oil. Fewer particles mean less wear and better engine protection.



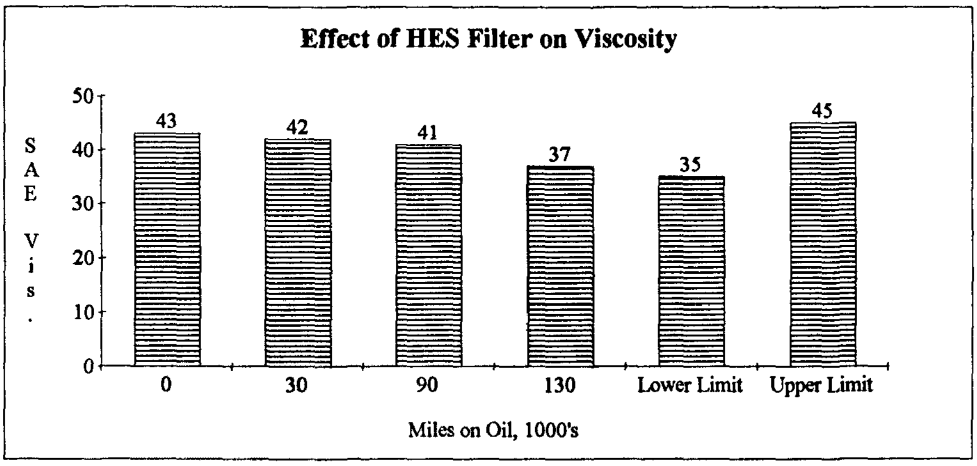
The HES oil filter also maintains and replenishes the oil's additive package. Since most of the particulate contamination is captured in the filter, the demand on detergents and dispersants is lower. Neutralizers are preserved because the HES oil filter removes moisture from the oil preventing the formation of sulfuric and nitric acid. Finally, the additive package is replenished when make-up oil is added at the time of the HES filter change.

Examples of the impact of the filter on oil quality are demonstrated by its effect on total base number(TBN) and viscosity. The effect on TBN is presented in the figure to the right. TBN is a measure of the oil's acid neutralizing capability. The figure shows TBN as a function of miles on oil. The TBN of the new oil was 7.4. After 130,000 miles



on oil the TBN was 7.3, well above the suggested minimum of 4.0. As a basis for comparison, the typical oil change interval for this type of application is 16,000 miles.

The effect of the HES filter on viscosity is presented in the figure to the right. The SAE viscosity of the new oil was 43. After 130,000 miles the SAE viscosity had dropped only to 37, still within the recommended range of 35 to 45.



Field Results - The 96,000 Mile Oil Change Interval

A field test was begun in 1991 with a major on-highway, heavy-duty truck fleet. After accumulating approximately 2.5 million miles on test, the oil change intervals are averaging 95,000 miles. Vehicles not equipped with an HES oil filter average 16,000 miles. Oil analysis is used to monitor oil quality. The average waste reduction is 79%. If the technology were applied to the entire fleet, 40 million quarts of oil would be saved every year! The estimated payback is 1 year. For the remainder of the evaluation, the fleet has established a PM at 96,000 miles for an oil change. HES cartridges are changed every 16,000 miles, and the primary filter is changed every 48,000 miles.

An evaluation of HES oil filters was also conducted by the Air Force's Material and Equipment Evaluation Project. An Enviro HES oil filter was installed in June of 1992 on an aircraft refueling vehicle. The test was terminated in June of 1994. The oil remained in excellent condition throughout the test period. The maximum oil drain interval possible with the HES oil filter was not determined, since the test was terminated before the oil needed to be changed. The standard oil change interval for aircraft refueling vehicles is 6 months. Among the conclusions drawn by MEEP from the testing are:

> "All preliminary results indicate these filters perform exactly as advertised & could revolutionize the automotive repair industry if properly used."
>
> - MEEP Management Office
> Project Update, 2/95

> "Based on what we have seen over the past two years, we are strongly recommending that these filters be considered for use on Air Force vehicles as a method of reducing engine wear, oil depletion trends, and used oil disposal difficulties."
>
> - Jake Detweiler, MEEP Chief
> Minutes from 9 May 95
> meeting with WR-ALC/LV

As a result of this and other USAF testing, HES oil filters have been authorized for use on PACAF vehicles. An evaluation to assess the impact of the Enviro HES oil filter on tactical vehicles is being conducted by the USMC.

Reducing the Risk - Suggestions for Implementing Extended Oil Drains

We have learned many things through our experience with extended oil drains and HES filtration. Below are seven tips which will aid you in safely and sensibly implementing an extended oil drain program.

1. Use an HES oil filter capable of removing 5-10 micron particles efficiently (>99%).
2. Monitor oil quality using oil analysis conducted by a reputable lab.
3. Increase drain intervals gradually.
4. Use an oil formulated for longer drain intervals.
5. Start with vehicles offering the highest potential savings.
6. Seek help from a consultant specializing in extended oil drain to establish your program.
7. Refer to the TMC's RP 318 Used Oil Analysis and RP 1403 Determining Engine Oil Change Intervals for Light- and Medium Duty Vehicles.

Conclusion

The extension of oil drain intervals holds enormous environmental and financial potential. The key to realizing this potential is HES oil filtration. The enviro HES oil filter removes the most damaging particles in the oil and maintains the additive package ensuring high oil quality and enabling oil drain extension. Through the use of HES filters, oil drain intervals increase 400 to 800%, waste oil generation decreases 70 to 80%, and operating costs decrease 30 to 40%. As a win-win financially and environmentally, HES oil filtration is an ideal pollution prevention tool.

About the Author: *Kendal Smith is the chief engineer for Enviro Filtration(1-800-368-4763). He has a BS in chemical engineering from Rose-Hulman Institute of Technology and a MBA from the University of Michigan. He is a member of the American Filtration and Separations Society, the Society of Automotive Engineers, and The Maintenance Council of the American Truck Association. His work experience includes product management with Cummins Engine Company and research and production engineering with Amoco Oil Company. The author has presented papers on various technologies for pollution prevention at EPA Waste Minimization conferences, the National Pollution Prevention Roundtable, and the Joint Service Pollution Prevention Conference.*

John L. Stanberry

General Services Administration

BIOGRAPHICAL INFORMATION FOR JOHN L. STANBERRY

Dr. John L. Stanberry is the General Services Administration's (GSA) Environmental Executive. He is responsible for coordinating all GSA environmental programs in the areas of procurement and acquisition, standards and specification review, facilities management, waste prevention and recycling, and logistics. He previously was responsible for the design and implementation of GSA's nationwide recycling program.

Dr. Stanberry has spent most of his Government career with GSA, holding such positions as Deputy Associate Administrator for Operations, Assistant Commissioner for Public Utilities, and Deputy Assistant Commissioner for Procurement. Prior to working for GSA, he held responsible positions with NASA and the Air Force. John is a member of the Federal Government's Senior Executive Service.

He is a registered professional engineer, holding BS and MS degrees in Industrial Engineering and Management and a Ph.D. in Business Administration.

George Strapko

Sinclair Mineral & Chemical

BIOGRAPHICAL INFORMATION FOR GEORGE STRAPKO

Mr. Strapko is a Career Marketing Professional serving the Industrial Sector developing new products/processes for the Surface Finishing and Parts Cleaning markets. Primary areas of focus have been on emerging technology which is Environmentally conscious and effective. He currently represents the premier manufacturers of Industrial Finishing & Cleaning Equipment and related supplies.

CASE STUDIES OF SUCCESSFUL SOLVENT REPLACEMENT IN INDUSTRIAL CLEANING APPLICATIONS

I. BRIEF OVERVIEW OF AQUEOUS CLEANING PROCESS

II. CASE HISTORIES

1. A. Screw machine parts
   1/2"OD x 4"OAL x (3" deep blind hole 1/4" NPT)

   B. Old process (agitated dunk tank with solvent)

   C. New cleaning process (Cyclojet 1)

   D. Benefits: chip removal, oil seperation, increased production, environmental safety

2. X-Ray equipment overhaul

   A. Meehanite castings, various shapes, sizes

   B. Old Process (Solvent Sinks)

   C. New Process (Jet Washing)

   D. Benefits: labor savings, degree of cleanliness, thru-put environmental safety

3. Precision Valve Assemblies

   A. Stainless stems, carbide seats

   B. Old Process (Solvent Sinks)

   C. New Process (Jet Washing)

   D. Benefits: labor savings, thru-put, environmental safety

III. Question & Answer

Better Engineering Mfg., Inc. supplies a line of aqueous degreasing equipment designed to replace solvents in most cleaning applications. These machines have been widely accepted as an alternative to solvents at hundreds of U. S. Military Bases across the country and on foreign soil.

Better Engineering's "Jet Washers" use a heated, recirculated detergent and water solution instead of solvents. This solution is constantly filtered, skimmed of oil, and used again and again. Parts are placed on a rotating turntable and as the turntable rotates within the sealed cabinet, the parts are blasted from all sides with the 180° F detergent and water solution.

Machines are available in a full range of sizes. Our smallest unit, the "Impulse" is designed as a unit-by-unit replacement for the typical solvent sink. Larger equipment is available to accommodate motor vehicle engines and transmissions, weapon systems, aircraft wheels, etc., up to entire jet engine assemblies. All units clean automatically, reducing parts washing labor to simply loading and unloading parts.

Better Engineering's Jet Washers are available with wash, rinse, and dry cycles, as well as a full complement of options, including automatic level controls, additional filtration, auto-steam exhaust, and small parts baskets.

Better Engineering also supplies a full line of detergent products.

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Better Engineering also supplies a full line of detergent products that is on the QPL for Mil-Spec No. MIL-C-29602 (cleaning aircraft components).

Better Engineering machines and detergents are available on GSA Contract #GS07F-5778A.

Collette Sun

Motorola, Inc.

Promoting A Pollution Preventive Culture

Colette Sun, Mary Beth Northrup
Motorola, Plantation, FL

To be presented at the EPA Region 5 Waste Minimization/Pollution Prevention Conference, Chicago, Ill., Feb. 25-27, 1997

Introduction

Over the last two decades, corporate environmental programs have undergone a steady evolutionary process. There were few environmental regulations in the 1970's, and public awareness and corporate environmental programs were limited in scope. Exponentially-increasing environmental regulations, as well as rapidly escalating public concern during the 1980's, spurred the development of compliance-based corporate environmental programs.

As we approach the next century, companies are awakening to the fact that good environmental practices are consistent with the goals of good management. The concept of "total quality management" is embraced and integrated into business operations. Likewise, environmental management systems, with emphasis upon environmental proactivity and pollution prevention, are being developed which look beyond compliance and into protecting the resources of future generations.

As environmental professionals, we undertand the benefits of preventing pollution: decreased negative environmental impact, reduced cost, improved public image, and so on. Most of the information published explains the technical approaches to preventing pollution in "how to" guides for specific processes. But seldom does the literature address how to move the responsibility for pollution prevention from the Environmental Department to the process areas; how to promote a corporation culture that embraces and supports the concept of preventing pollution in all aspects of the business.

Establishing A Proactive Culture - Commitment from the Top

Motorola is one of the world's leading providers of wireless communications, semiconductors, and advanced electronic systems and services for worldwide markets. Our major equipment businesses include two-way radio, cellular telephones, paging and data communication, personal communications, automotive, defense and space electronics, and computers. Motorola is comprised of a number of individual business groups and sectors with manufacturing facilities throughout the Americas, Europe and the Asia-Pacific Region.

Our Corporate Environmental Health & Safety (EHS) vision is "to be a recognized global corporate leader for progressive and best-in-class EHS practices." Support from all levels of management is the key to any EHS program's success. Motorola's commitment to quality, continuous improvement and global leadership in developing electronics products also extends to protecting and promoting environmental, health and safety values. Motorola's EHS policy is "to conduct all operations in a responsible manner, free from recognized hazards; to respect the environment, health and safety of our employees, customers, suppliers, and community neighbors; and to comply with all applicable environmental, safety, and industrial hygiene laws and regulations of countries where we conduct operations." Site or Business Group General Managers are held accountable for ensuring that this policy is followed.

From Pollution Abatement to Pollution Prevention
In the 70's, the pollution prevention focus was at the "end of the pipe," controlling or abating emissions from waste streams generated by industrial processes. Growing public awareness of the impact of pollution to air and water supplies drove regulators to pass laws requiring industry to throttle back emissions. This was accomplished by installing a wide range of pollution abatement devices (air scrubbers, waste water treatment plants, and the like) to meet regulatory emission limits. This all was viewed strictly as a cost drain by industry, a necessary expense, a cost of doing business.

By the 1980's, industry began to recognize that rapidly growing waste disposal costs (with its associated long term liability) was increasingly impacting profitability. It was in the best interest of business, from a cost standpoint, to reduce the quantity of waste generated. Thus, a new concept was introduced -- waste minimization. Here the goal was not just to treat what spit out of the pipe, but to try to reduce the quantity and toxicity of waste being generated. Often this could be achieved by relatively simple means such as proper waste segregation, improved housekeeping and better process control. Still, the focus was primarily en-of-pipe rather than upstream in the process itself.

In the last few years, the concept of "minimizing waste" has evolved into the concept of "preventing pollution." Rather than just trying to reduce the volume of waste generated, pollution prevention seeks to avoid the creation of pollutants or waste altogether. This may necessitate fundamental process changes requiring the invention or implementation of new technologies.

From a philosophical viewpoint, we are transitioning from outside the process, further upstream into the production process itself.

Management Approaches To Pollution Prevention
The following case studies illustrate an evolution in management style and approach to pollution prevention projects at the Motorola Plantation, Florida facility.

<u>Case #1: Management mandate - Freon elimination</u>
In the late 1980's, it became increasingly clear that the use of ozone depleting substances was compromising the Earth's ozone layer protection, and that aggressive action was needed to stop continued destruction. In 1988, The Chief Executive Office passed a mandate that all Motorola operations, world wide, would eliminate the use of Freon 113 in manufacturing operations by the end of 1992.

At the time, Freon 113 (trade name Freon TF) was as widely used in the electronics manufacturing business as water. When originally introduced, Freon TF appeared to be the ideal solution for many applications; a highly effective, nonflammable, relatively nontoxic agent. However, scientific evidence mounted indicating that the use of Freon had potentially devastating, but previously unrecognized, global impact. Motorola leadership acted proactively to issue a mandate, and a substitute would have to be found.

The best research engineers in Motorola were tasked with developing process alternatives to eliminate the use of Freon. Depending upon the particular process involved, a variety of different solutions were implemented. Most sites transitioned to alternative aqueous or semi-aqueous degreasing agents to meet the 1992 deadline. And we did meet the deadline. Here in the Plantation facility, we implemented a cleaning process using a naturally-occurring citrus-based product as an alternative to Freon. Ultimately, as a result of continued research efforts, the cleaning process step has been completely eliminated. The resulting manufacturing process is cleaner, faster, and better.

There is no doubt that a mandate from the top is one effective method for accomplishing a pollution prevention goal.

<u>Case 2: Linking Process with Environment - Phosphoric acid cleaner reduction</u>
A few years ago, plating area production volumes were increasing and the discharge rate of a particular cleaning bath - one that was phosphoric acid based - had increased substantially. Once spent, this bath required treatment to meet effluent discharge standards and this treatment process generated a substantial quantity of waste water treatment sludge. As a result a significantly higher quantity of hazardous waste sludge was being generated, driving up disposal costs.

Process engineers were aware only of the relatively minimal cost to purchase and use this cleaning bath. As manufacturing volumes increased, chemical usage had simply been increased proportionally. What the process engineers didn't see was the cost impact of waste chemical treatment and disposal. After both pieces were connected, it became apparent that the total cost of use was much higher than previously realized. When the process engineers rigorously characterized the process, they discovered that the chemical use rate could be decreased to one-fourth the previous rate without impacting product quality. The end result was cost savings at every step: decreased virgin material use, less time spent handling and treating the chemical, and a reduction in the quantity of hazardous waste generated.

In this case, simply looking at the bigger picture and bringing it to the attention of those in control of the process, was enough to prompt investigation which resulted in change.

<u>Case 3: Working together as a team - Environmental Awareness Team</u>
Increasing plating production volumes also required increased usage of photoresist developers and strippers which contained glycol ether and monoethanolamine. These organic compounds contributed to our waste water discharge levels for Biological Oxygen Demand (BOD) and Total Kjeldahl Nitrogen (TKN). Our onsite waste water pretreatment system is designed to treat for metals (primarily copper and nickel), not organics. Therefore, any organics introduced into the system simply pass through. At the projected rate of

production use, we saw that we would exceed our local waste water discharge permit limits for those two parameters if nothing was changed.

We formed a cross-functional team to work on the problem, with members from the environmental group, process engineering and production. Together, we developed a short term strategy (reduction in chemical use) and a long term strategy (glycol ether elimination). The end result was implementation of a new chemistry that totally eliminated the use of glycol ether and greatly reduced the use of monoethanolamine. The chemistry was actually less expensive to use and was easier to control, which improved the overall process.

An environmental requirement provided the catalyst for change, but the change resulted in a better process, saved money, AND ensured compliance.

We used the Motorola TCS (Total Customer Satisfaction) team program as a forum to internally publicize our positive results. The TCS program is a quality teaming program in which teams form to work on projects using a defined problem-solving process. When results have been achieved, teams have the opportunity to present their projects in "showcases." High scoring teams are selected to advance to successively higher level showcases (site, group, Sector) all the way up to the Corporate Showcase - the highest level of recognition. Rewards ranging from T-shirts, to dinners, to trips to exotic locales (in this case, Hawaii) are built into the system as incentives.

The Environmental Awareness Team advanced through all levels to the Corporate TCS Showcase in Chicago in January 1995. The team won a gold medal (the highest award given) AND a special merit award for "Outstanding Process Creativity." This was especially significant in that this was the first gold medal ever awarded to a team whose project had an environmental focus - let alone for pollution prevention. This sent a message to the entire corporation that environmental issues - and pollution prevention - were recognized as being an important means of achieving Motorola's key initiatives.

In this case study, the key was working together as a team to view all sides of the issue and come up with the best solution, and that the solution made good business sense, as well.

Case 4: Grass roots effort - water use reduction

With the success of the Environmental Awareness Team, interest was high in launching other environmentally-oriented projects. Several members of the plating area advanced the idea of a water conservation team and asked the environmental group to mentor the team. Upon closer examination, it was surprising to learn that water was the second highest material cost, second only to the plating substrate itself. This was due to the cost of first purchasing city water, then processing it to meet production specifications, treating the resulting waste water and disposing of both treated water and hazardous waste sludge. Substantial cost savings could be realized by reducing water consumption.

After studying the rinsing process and rates of water consumption, one of the team members came up with a concept for an on-demand rinsing module to replace free-flowing cascade rinses. We built and piloted a model, and ultimately replaced all of the cascade rinses with these modules. As a result, overall water use decreased by about 50%, saving over 6 million gallons of water per year.

Surprisingly, another benefit of standardizing the rinsing process was enhanced product yield. The new module actually produced a better rinse with less water, reducing blistering defects and thus reducing process scrap. We realized more cost savings from reduced scrap than reducing water consumption!

Again, teamwork was the key to finding the solution - and the best ideas came from the owners of the process. The result was cost savings, process improvement, AND resource conservation.

Fitting Pollution Prevention Into Environmental Management Systems

The four case studies illustrate an evolution in not only "how" projects were managed to develop innovative solutions but also "why" and "how" they were selected. Although the solutions found were proactive, the project selection in the first three examples was driven by "reactive" concerns. A problem existed that had to be addressed. Certainly, involving all parties was effective in finding the solution, but disconnects still existed in the process which sometimes contributed to creating the problems in the first place. In the final case study, we have an example of true proactivity. No "problem" existed, simply an opportunity for improvement.

The evolution of pollution prevention mirrors the evolution of the environmental management system as a whole. It can also be compared to the quality movement -- originally measured at the finished product by "quality inspectors," it became clear that quality could only be achieved when built into the entire process and by everyone involved.

So, too, with pollution prevention. Environmental Management started as reactive, "end of pipe", driven by regulatory edicts. Pollution prevention, and environmental management systems as a whole, function best when integrated into the overall business management systems and involve everyone at all levels. As it becomes part of the culture, pollution prevention simply becomes another tool to use in achieving the fundamental business objectives of quality, cost, cycle time, and customer satisfaction.

How To Drive The Culture?

Changing the pollution prevention culture is no different than changing any culture. It requires a change in how people think and act in their job.

Attitude roadblocks are often encountered -

Fear :

> "I don't really understand how the process works, but it is working so DON'T MESS WITH IT!"
> "It will negatively impact (pick one) cycle time, cost, quality, production, my job."
> "I will have to change."

Lack of resources:

"We have insufficient money, expertise, equipment, time to implement."

Short Term Thinking:

"I gotta get production out the door right now; I'll take care of tomorrow, later."

So, how to overcome the barriers?

Fight fear with facts. Spread the message that preventing pollution is not just a "feel good" program for bunny huggers, it just makes good business sense. Select projects that will yield true business improvements and publicize the results.

Use the same problem solving tools as you use for quality issues. Go after the big cost items, get the most bang for your effort. But look at TOTAL cost -- short-term and long-term. Only do it if it makes sense.

Use all available resources: vendors, trade associations, consulting services, and the internet. Don't reinvent the wheel, benchmark what others have done. You may well find a drop in replacement has been rolled out just last month to accomplish exactly what you need.

Don't dismiss the simple things. Sometimes a fresh perspective can reveal something so obvious it was overlooked. Pollution prevention doesn't have to be a doctoral thesis project. Get only as detailed as makes sense to evaluate alternatives, identify opportunities, and implement process enhancements.

Make it a team effort. Several minds are (usually) better than one.

Use reward and recognition systems that exist in your firm to promote environmental and pollution prevention successes. Put pollution prevention on the map, remind, encourage others to look for opportunities. Success builds upon success.

Environmental Evolution Continues

As in all aspects of business, the evolutionary process continues. We have already moved from "end of pipe" up the pipeline into the process and are poised to embrace the total life cycle of our products. We soon may have "cradle to grave" responsibility for our products as well as our processes and wastes. Customers in Europe are already beginning to require less-toxic products and product end-of-life take back programs. Total product stewardship and designing for the total product life cycle is the next frontier in our quest for better, cheaper, faster, and more environmentally-friendly.

As environmental systems management evolves toward integration into all aspects of the operation, the environmental professional has more opportunity than ever to provide value to the business by lending our special expertise to all phases of the product life cycle.

Greg Terdich

A.T. Kearney, Inc.

U.S. EPA Region 5

Waste minimization/pollution prevention conference

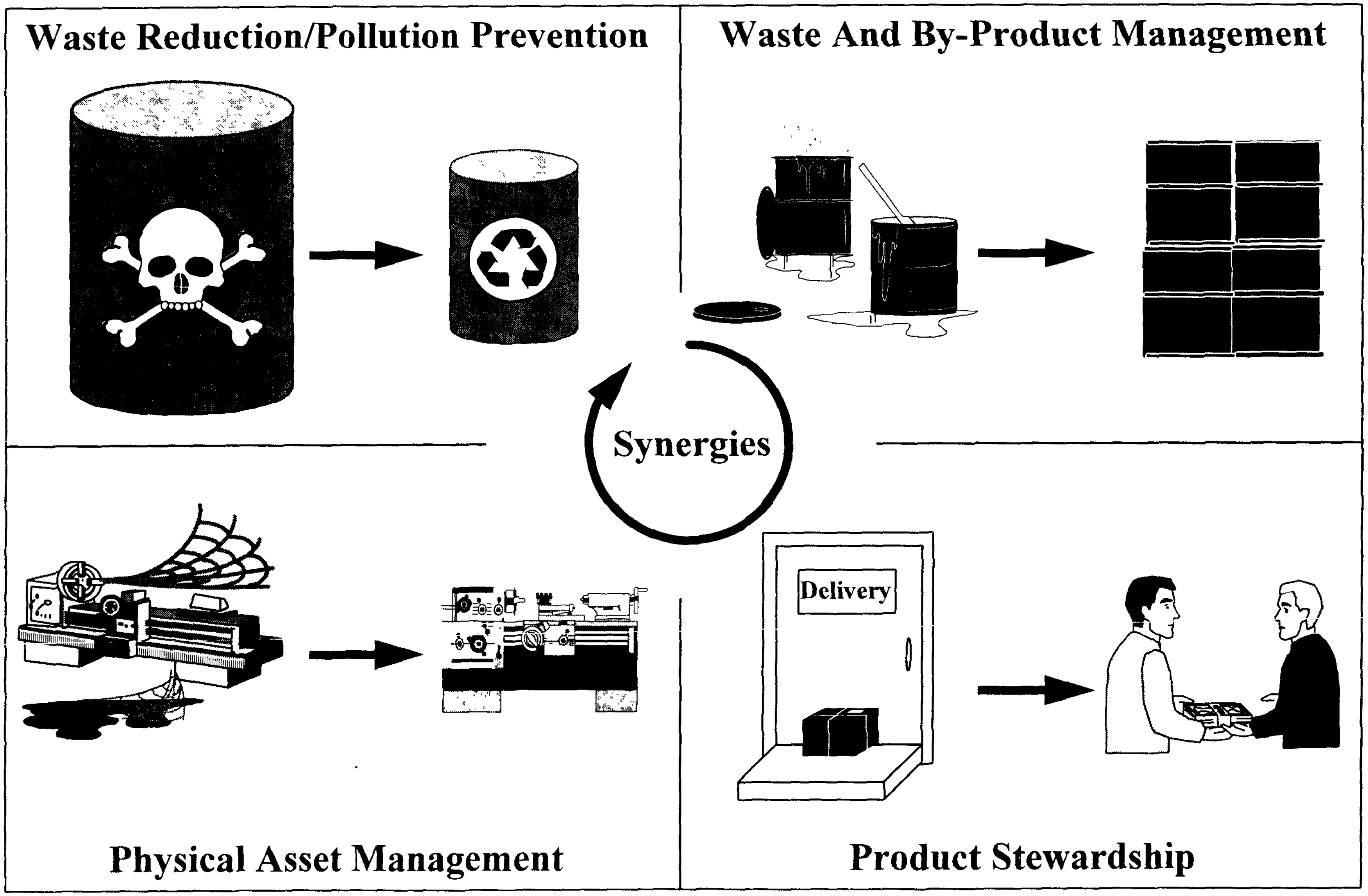
Leveraging life cycle management for business gains

February 25, 1997

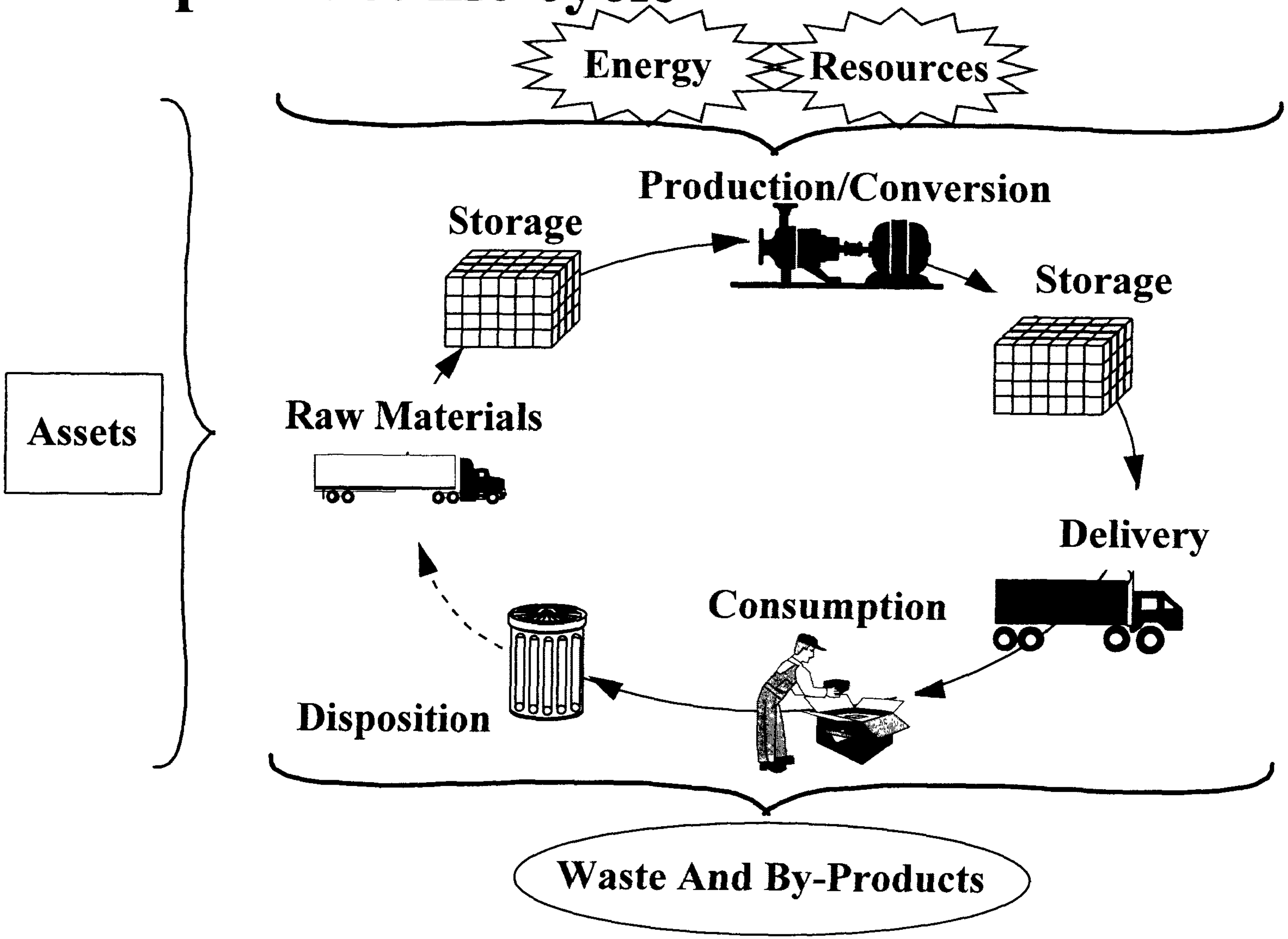
Agenda

- Understand the audience
- The life cycle management (LCM) concept
- LCM drivers
- Keys to success
- Applying LCM principles
- Case study
- Integrating LCM into the business

Life cycle management components



The product life cycle



Management systems must capture the LCM opportunities

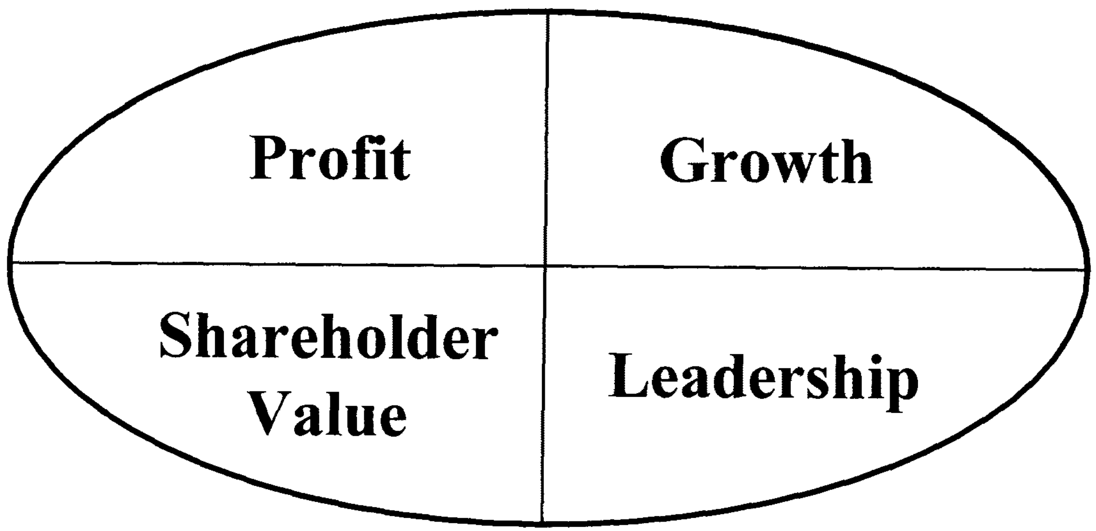
LCM drivers are changing

Traditional	Emerging
• RCRA — Burdensome • CERCLA — Frightening • CAAA — Confounding • CWA — Tightening	• Global competition — Cost pressures • International standards — Price of admission • New products and services — Early mover benefits • Sustainable development — Market leaders

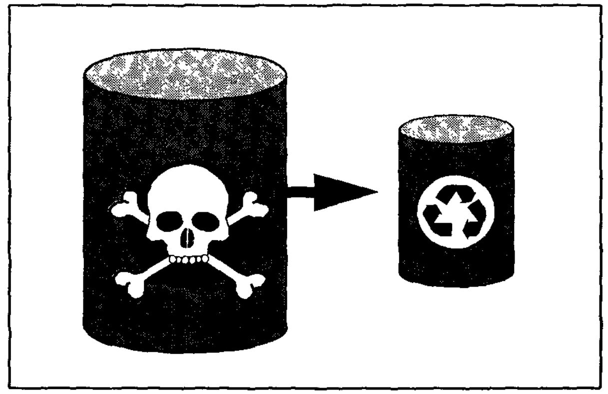
Top management's expectations have shifted from problem avoidance to competitive advantage

The keys to success

- Seek breakthrough improvements
- Be creative — think “outside the box”
- Design LCM initiatives to achieve principal business objectives

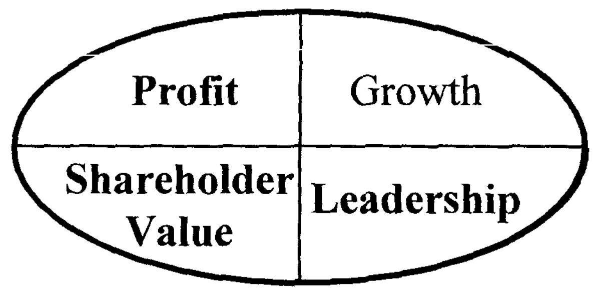


Waste reduction/pollution prevention

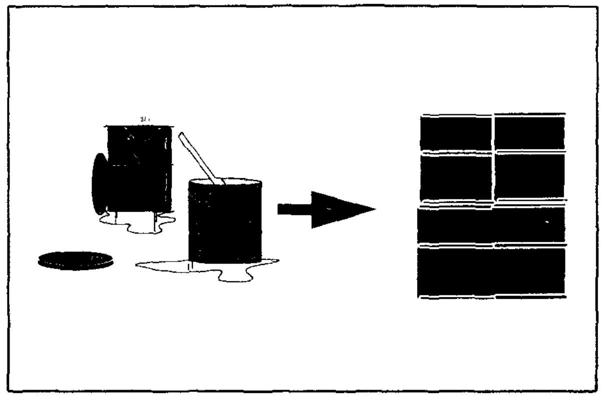


- Goals and benefits
  - Reduce or eliminate quantity and toxicity of wastes
  - Reduce energy consumption
  - New product or service offerings

- Methods
  - Upstream process changes
    - —Material substitution
    - —Closed loop recovery
  - End of pipe treatment
  - New beneficial uses

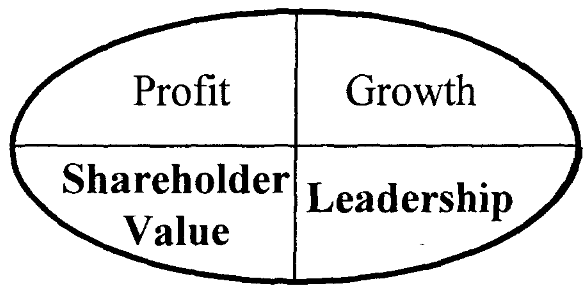


Waste and by-product management

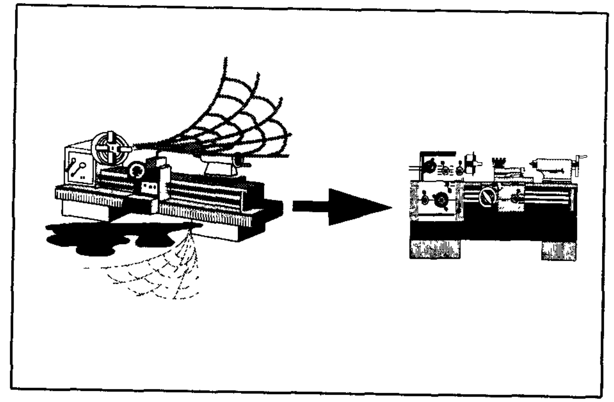


- Goals and benefits
  - Effective, efficient compliance
  - Zero spills/leaks
  - Eliminate third-party risks
  - Good actor status

- Methods
  - Strong programs and training
  - QA/QC, internal audits
  - Waste vendor audits
  - Regulatory relations

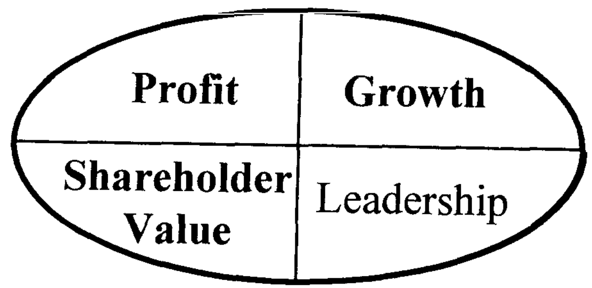


Physical asset management

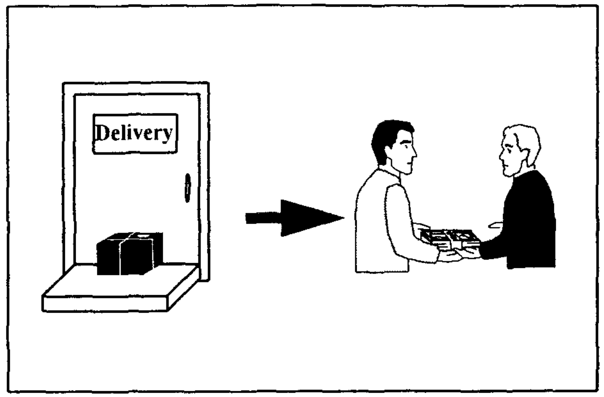


- Goals and benefits
  - Long-term benefits with short-term return on investment
  - Extended service life
  - Energy and production efficiencies
  - Salvage value

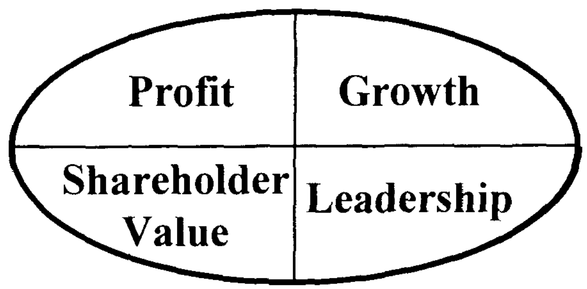
- Methods
  - True cost and production metrics
  - Solid cost/benefit analyses
  - Design for environment



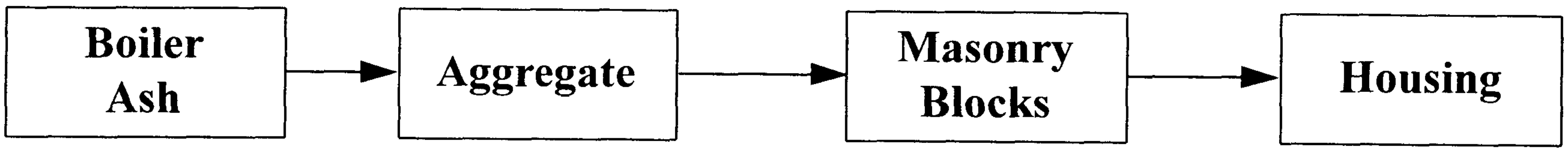
Product stewardship



- Goals and benefits
  - Minimize environmental impacts of goods and services produced
  - Assist customers with cradle to grave management
- Methods
  - External application of previous three elements
  - Product takebacks
  - Strong communications, assistance, training



A synergistic example



Component	From	To
Waste Reduction/ P2	Waste Cost	Product **Profit**
Waste And By-Product Management	Liability Regulated	**Value** Resource
Physical Asset Management	Landfill Abandonment	Production Facility **Growth**
Product Stewardship	Underprivileged Monopoly	Customer **Leader**

Ensuring continuous improvement

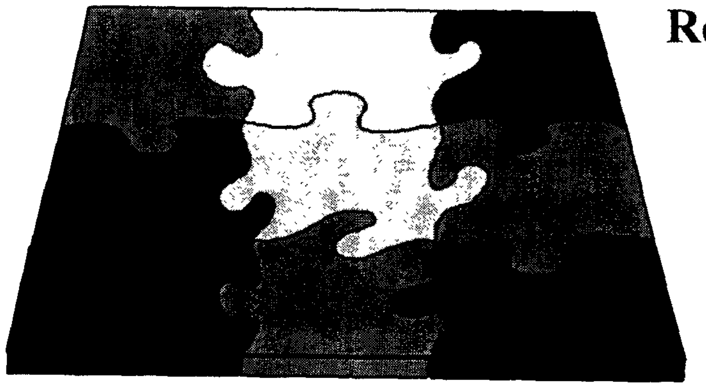
- Establish LCM as part of an integrated environmental management system

Corporate Commitment

Integrated Planning

Organization And Human Resources

Operating Systems



Communication

Information Management

Cost And Financial Management

Risk Management — LCM —

Auditing/Quality Assurance

Suzanne T. Thomas

Rust Environmental & Infrastructure

Information Management: Key to a P^2 Action Plan

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Introduction

Pollution Prevention (P^2) plans have had a change in status over the last several years. P^2 at one time meant mandatory hazardous waste minimization plans and/or optional EPCRA one-liners for TRI chemicals but, now, P^2 is the core of existing and future environmental regulatory compliance programs within the commercial/industrial and federal sector. The main reason for this shift was in response to the spiraling costs of waste disposal, additional regulations requiring a P^2 focus, and executive orders demanding P^2 programs - and a realization that fundamental changes in how compliance issues are handled was necessary for true cost-effective compliance. The P^2 plans are now plans for action - action at both the management level and at the shop level.

This sounds great in theory - but when we sit down to write our P^2 plans, we face a plethora of data and information that has been collected over the years at great expense. Data which relates to our end-of-the-pipe mentality but which, although necessary, does not really fit well into our P^2 culture. How do we manage all of the old data and information - and what new data and information should we be collecting - simply and inexpensively - and how should it become the basis for responsible action?

The construction of a P^2 plan is an exercise in information and data management. If you have the correct data and can manage it easily, you can have effective action plans to prevent waste and to ensure compliance.

Data/ Information Relationships

Every facility - whether industrial/commercial or federal - has invested significant resources into acquiring data to address wastewater issues, air emissions, hazardous waste, TRI chemicals, ODS usage and substitutes, and EPA-17 materials. In addition, many other types of environmental data must be collected and managed; data, such as, groundwater and soil characteristics for remediation activities, wastewater quality data, and solid waste characterization data. Then, as we look outside the environmental arena, most facilities track their raw material purchases and their product shipments. Many of these tracking systems are geared towards the procurement issues and accounting practices. This data can be useful to P^2 actions - but it often doesn't go far enough to be useful. For example, many accounting systems may track the total purchase of solvent ABC but they often do not track who the actual users of the solvent are or, even more specifically, where the solvent is being used in the process.

What are the common denominators? Environmental data is usually media-specific, i.e., soil, groundwater, wastewater, or air; and it is usually location-specific, i.e., end-of-the-pipe, wastewater sump, stack sampling port, or fence line. Environmental data is specific to a target compound or material or characteristic which is responsible for the undesirable environmental impact. Purchasing information is component-specific - meaning it usually identifies the compounds or materials which can eventually be directly or indirectly associated with the undesirable impact. In addition, purchasing information may identify the users of the materials and, in some rare instances, the uses may also be identified. All of this information is related and can be connected. The one component that is missing in these relationships described is in identifying the generating source. If the components in purchased materials can be tracked to their end-user and the environmental data can also be linked with the generator across all media (air, water and land) - then closure can be ensured based on a mass balance at the source. With the introduction of mapping and location coordinates, data also begins to provide an added dimension.

Management of Information

Connections and relationships between data can be used to create roadmaps - roadmaps for action. Several examples of data collections and connections versus information roadmaps are described below for various industries. These collectively illustrate how the management of information is crucial to effective action. By managing data and information and their relationships, we can effectively develop solutions for many of our environmental problems. Understanding the relationships, we can also predict the impact of future activities. This is the fundamental principle of P^2.

Case Studies

It should be noted that all of the examples to follow assume that pollution prevention is the objective of the study rather than strict compliance with end-of-the-pipe standards. The presentation portion of this paper will include graphics which further illustrate these examples.

1. Water Use/Wastewater

The first example is a food/beverage facility with discharges to a POTW. The cost to discharge has become outrageously expensive because of surcharges for BOD and flow. There are no hazardous or toxic components in the wastewater discharges therefore no significant risk to the community is involved. Table 1 shows the data collected when a traditional approach is used versus the desirable data for the information roadmap. The traditional data is end-of-the-pipe data on the parameters against which compliance will be judged. But the more valuable information is obtained when a water balance is developed with process-specific water usage and wastewater generation data. With the water balance as a basis, effective water use reduction can be the first priority followed by reuse and recycle solutions. Ultimately, this approach will reduce wastewater discharges which in turn will reduce the need to collect end-of-pipe data to track compliance - a win-win situation with resulting cost reductions in materials management and energy usage.

2. Ventilation/air toxics

The second example is a battery manufacturing facility which has high air toxic levels at the property boundary. Again, in Table 1, we see the traditional approach would be to perform stack sampling to collect data being emitted from the building. This data can then be used as input to air dispersion modeling. What-if analysis can then lead to the specification of air pollution control efficiencies necessary to comply with standards at the property line. The alternate approach involves obtaining a deeper understanding of the process areas and their chemistry, the construction of mass balances to differentiate point sources from fugitive releases, and an accurate set of production procedures which identify the "how" and "why" for the releases. Analysis of this information leads to identification of waste reducing measures within the plant rather than end-of-pipe control equipment. Cost savings result from an integration of information which can segregate streams and treat the air toxic components at the point of generation where the volumes which must be treated are much smaller and more manageable.

3. Ventilation/visible emissions

The third example involves a textile operation with visible oil emissions being produced at the calendar hoods. Stack sampling carried out in the past produced extremely variable results; the use of these results as a design basis for add-on control equipment would result in over-design and additional cost since each line would require control. An alternate approach involves examining the calender operation and the individual raw material/product scenarios. In this case, this examination revealed a relationship between the quantity of oily emissions being generated and the different types of products being run. The end-result was the development of an emission rate equation which calculated emission rate as a function of product type and machine data. Subsequently, segregation of product lines was implemented such that product lines with problematic emission levels were assigned to machines with newly-designed air pollution control equipment. Savings in capital and operating cost were realized by installing control only on those lines running the problematic emission-generating products.

4. Multi-media compliance/pollution prevention

The fourth example involves a federal DOD base with a high level of industrial activity. The single-media compliance focus had resulted in many separately-funded projects awarded to different contractors with considerable overlap in data collection and data organizational activities. In addition, P^2 projects and compliance projects were separately funded when they, in fact, had identical objectives and focus. For example, hazardous waste reduction projects aimed at reducing the use of chlorinated solvents in cleaning operations were funded separately from NESHAPs compliance projects which were intent on reducing the toxic air emissions from the use of chlorinated solvents in the same cleaning operations. Although compliance projects have additional elements which needed to be addressed, such as record keeping and monitoring, the best outcome from these projects should meet all requirements. A cost effective approach involves a multi-media data collection activity by process or by shop - with all raw material and production data collected alongside waste disposal data to all media (air, water and land). The organization of data into a mass balance becomes the information roadmap around each logical process unit which will allow assessment of all potential options for reduction or elimination of materials and for all compliance issues. This not only saves time and money in data collection but also ensures that all media and all compliance issues are addressed. If the data is further organized into database format by location, it can be accessed for multiple uses.

Conclusions

In past years, more available data meant better information to address environmental problems. Today, 'more data' is not necessarily 'better information'; solving environmental problems requires the correct mix of data to create an information 'roadmap'. These types of roadmaps are action-oriented and lead to quicker and cheaper environmental compliance and reduced environmental impacts on production costs.

Table 1: Data/Information Relationships

EXAMPLE	DATA COLLECTED	INFORMATION/DATA COLLECTED
Beverage/Food	Wastewater: BOD, COD, Flow, TSS, TDS	Water balance process; process specific BOD, TSS/TDS and flow loadings
Battery Manufacturer	Stack emissions	Production logs, procedures, fugitive activities, chemical usage and reaction kinetics, mass balances on key pollutants.
Textile Operation	Stack emissions	Production schedules and procedures, usage of processing materials and components.
Federal Facility	Single media data: wastewater discharge data for flow, BOD/COD, TSS; stack emissions data; hazardous waste shipment logs.	Process-specific generation rates for all media; process-specific production and throughput information; costs for tracking compliance on each media.

Peter Wise

Illinois EPA

IEPA China
Pollution Prevention Project

"International Diffusion of Pollution Prevention Technologies Through Technology Outreach, Assessments, Demonstrations, and Evaluations for Metal Finishing, Petrochemical, and Pharmaceutical Industries in China"

U.S. TIES

U.S. Technology for International Environmental Solutions

U.S. ETI

U.S. Environmental Technology Initiative

- Promote Cleaner Production/Pollution Prevention
- Facilitate Technology Transfer
- Build Chinese/U.S. Relationships

CHINA PROJECT
IEPA - The Lead Agency in Partnerships

- China's National Environmental Protection Agency (NEPA)
- U.S. EPA
- World Bank
- United Nations Environmental Programme
- Chemical Industry Council of Illinois

Three Targeted Industrial Sectors

- Metal Finishing
- Petrochemical
- Pharmaceutical

China Project Time Line

SEPTEMBER 1995

- IEPA delegation to China for project scoping
- Identified critical government and industry representatives
- Toured Chinese industrial facilities

China Project Time Line

DECEMBER 1995

- IEPA hosted Chinese delegation for project planning and to finalize the project work plan and January Cleaner Production Workshop Agenda
- Chinese delegation toured Illinois industries

China Project Time Line

DECEMBER 1995 *(continued)*

- Chinese delegation met with petrochemical, metal finishing, and pharmaceutical industry representatives
- Chinese delegation visited U.S. Environmental Protection Agency Office of Pollution Prevention in Washington, D.C.

China Project Time Line

JANUARY 1996

- IEPA and NEPA presented four-day Cleaner Production Workshop in Beijing
- Pollution Prevention experts from U.S. toured six Chinese facilities

China Project Time Line
MARCH 1996

- Six facilities performed extensive pollution prevention audits
- All facilities produced excellent thorough audit reports
- Project team identified opportunities for Cleaner Production options and technology demonstrations

China Project Time Line

MARCH TO OCTOBER 1996

- NEPA conducted Market Analysis of three targeted industrial sectors
- Presented results in insightful reports
- Reports identified significant opportunities for the transfer of environmental technologies

Market Analysis Results
PETROCHEMICAL INDUSTRY

- Sulfur recovery system
- Continuously catalytic reconstruction system
- H2S/SO2 ratio on-line analyzer
- System to strip and recycle sulfur contaminated wastewater

Market Analysis Results

METAL FINISHING INDUSTRY

- Automatic bath analysis and chemical addition
- Continuous filter pumps and air agitation systems
- Counter-flow rinsing systems
- Constant electric current density controls
- Thermal spraying technologies
- Dacrotized coating and carbon black
- Zinc alloy substitutes
- Wastewater metal recovery systems

Market Analysis Results

PHARMACEUTICAL INDUSTRY

- Closed-loop centrifuge/drying systems
- Membrane recovery technologies
- Solvent extraction systems

China Project Time Line
APRIL TO JUNE 1996

- NEPA and IEPA identified one facility from each sector to participate in demonstration phase of project
    - Taiji Computer Company
    - Shandong Xinhua Pharmaceutical Corporation
    - Tianjin Petrochemical Refinery
- Based on audit results, NEPA and IEPA identified possible technologies
- IEPA initiated vendor identification

China Project Time Line

JULY 1996

- IEPA delegation toured three selected demonstration sites in China
- IEPA delegation met with NEPA and CNCPC to identify potential problems with installation and operation of demonstration technologies
- Two Chinese delegations toured U.S. facilities and met with U.S. vendors of environmental technologies

China Project Time Line
SEPTEMBER TO DECEMBER 1996

- Technology demonstrations at three Chinese facilities
    - Electrowinning technology for copper recovery at Taiji Computer Company
    - Centrifuge/Dryer closed loop technology at Xinhua Pharmaceutical Corporation
    - Wastewater analysis at Tianjin Petrochemical Refinery

China Project

METAL FINISHING DEMONSTRATION

- Electrowinning copper recovery system to reclaim spent copper from waste streams
- U.S. vendor is Memtek, a Division of Wheelabrator Water Technologies, Inc. of Naperville, Illinois
- First demonstration at Taiji Computer Corporation
- Subsequent demonstrations at other metal finishing shops coordinated by CRAES
- Installation and data collection in December 1996

China Project
PHARMACEUTICAL DEMONSTRATION

- Centrifuge/dryer technology for a liquid to solid batch process
- Scoping trip occurred in October 1996
- Demonstration at Shandong Xinhua Pharmaceutical Group Corporation

China Project
PETROCHEMICAL DEMONSTRATION

- Problem is unidentified waste water contamination at Tianjin Petrochemical Refinery
- Tianjin collected wastewater samples and shipped samples to IEPA laboratories for thorough analysis
- Analytical results currently being evaluated for possible technology recommendation

China Project Time Line

OCTOBER 1996

- Final Project Workshop was held in Beijing
- Presented current and anticipated results of demonstrations
- Discussed overall success of project and lessons learned

China Project Future Plans

- Continued Monitoring and Reporting
- Fact Sheets and Mailing
- Technology Matching Initiative

What Does This Mean to U.S. Environmental Technology Vendors?

- Interest in China is growing
- Variety of needs
- Project has opened doors and built relationships

David W. Wolfe

Rust Environmental & Infrastructure

BIOGRAPHICAL INFORMATION FOR DAVID W. WOLFE

Mr. Wolfe is a Senior Project Engineer and Manager of Engineering and Industrial Services for the Harrisburg, Pennsylvania office of RUST Environment and Infrastructure, Inc. He has over 20 years of environmental engineering and environmental management experience. Prior to his current consulting position, he managed a corporate environmental compliance program for 13 plants involved in the organic and inorganic chemical, nonferrous metals, and energy industries.

Mr. Wolfe is responsible for projects related to water, wastewater, and hazardous waste management engineering design. He has managed projects involving RCRA corrective action, waste minimization audits, engineering feasibility studies, environmental permitting, and conceptual, preliminary, and detailed engineering designs. His experience includes most recently, manager for the design and construction of a $15,000,000 industrial wastewater recovery project.

Zero Discharge in the Lead Battery Industry

Presented for
EPA Region 5 Waste Minimization/Pollution Prevention Conference

February 1997

David W. Wolfe, P.E.
Rust Environment & Infrastructure

RUST

Company Profile

- Large Lead Acid Battery Manufacturing Complex
- 225 Acre Site - Over 3,000 Employees
- Facilities Include:
  - Industrial Battery Plant
  - Three Automotive Battery Plants
  - Specialty Battery Plant
  - EPA Permitted Secondary Lead Smelter and Refinery
  - New Industrial Wastewater Reclamation Plant

8

The Problem

- Wastewater Treatment Capacity
- Dissolved Solids Removal
- Process Water Quality
- Site Water Supply
- Solids Disposal

RUST

The Solution

- Closed - Loop Process Wastewater Treatment
- Dissolved Solids Removal and Recovery
- High Quality Distillate and RO Water Make-up
- 50 to 70 Percent Reduction in Make-up Water
- 100 Percent Reduction in Sludge Disposal

Process Wastewater Treatment and Water Reclamation

- Complete Facilities Integration
- Segregated Wastewater Conveyance
- Process Water Supply and Distribution

Pretreatment Processes

- Screening
- Oil and Sediment Removal
- Equalization
- Neutralization
- Clarification and Sand Filtration
- Ultraviolet Disinfection
- Carbon Adsorption
- Sludge Dewatering

Pretreatment System Performance

	Feed	***Effluent***
Antimony (Sb)	0.1 ppm	0.002 ppm
Arsenic (As)	0.2 ppm	<0.06 ppm
Cadmium (Cd)	0.1 ppm	0.003 ppm
Copper (Cu)	2.62 ppm	<0.03 ppm
Iron (Fe)	>200 ppm	0.05 ppm
Lead (Pb)	185 ppm	<0.03 ppm
Nickel (Ni)	0.94 ppm	<0.20 ppm
Zinc (Zn)	2.32 ppm	<0.03 ppm

Dissolved Solids Removal

- Large Feed/Storage Capacity
- Evaporation
- Crystallization
- Pressure Filtration
- Salt Drying
- Salt Storage
- Truck Loading

Dissolved Solids Removal System Performance

- 25,000 ppm Total Dissolved Solids in Feed
- <10 ppm Total Dissolved Solids in Distillate
- 15 Tons/Day Sodium Sulfate Production
- Zero Discharge

Process Water Reclamation

- High Quality Distillate
- Reverse Osmosis
- UV Disinfection
- Large Storage Capacity
- Process Water Distribution

Sodium Sulphate Salt Product

- 99.7 Percent Sodium Sulfate
- Meets Food Codex
- Anhydrous (< 0.02 Percent Moisture)
- Revenue $

Patrick Wooliever

PRC Environmental Management

Reducing Dragout from Electroplating Operations with Spray Rinse Systems

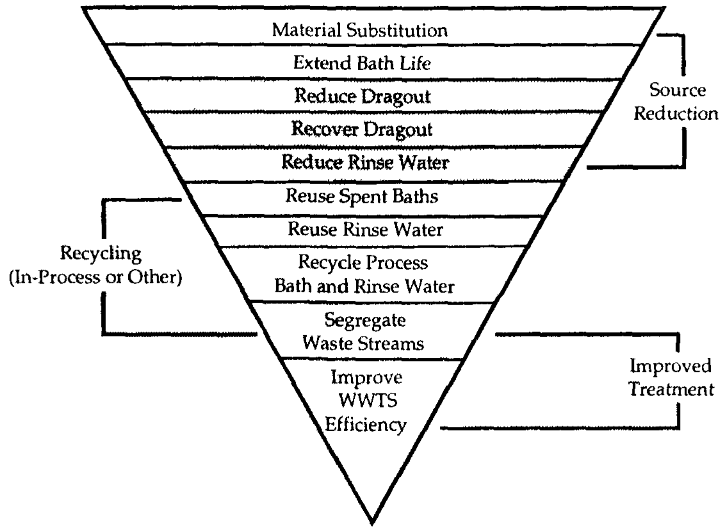
Patrick Wooliever
PRC Environmental

Overview

- Applications
- Types of spray nozzles
- Design considerations
- Maintenance
- Case study: All American Manufacturing Company

PRC

Hierarchy of P2 and Waste Management Strategies for Metal Finishing



Frequency of Spray Rinses

NAMF National Survey on Pollution Prevention

Only 39% of respondents that pursued rinse water reduction used spray rinses

PRC

Why Consider Spray Rinses

- Reduce and recover dragout
  - Over plating tank
  - Over stagnant tank
  - Hand held
- Improve rinsing quality
  - Improve finish quality
  - Reduce drag in between processes
- Reduce water use

PRC

Design Considerations

- Operating conditions:
  - Type
  - Pressure
  - Spray pattern and angle
  - Flow rate
- Evaporation rate
- Timing and actuation
- Material and compatibility
- Placement

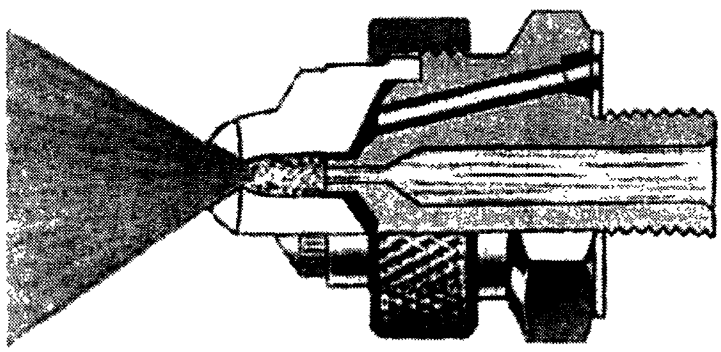
PRC

Spray Nozzles

- Hydraulic: Water only
- Air Atomizing: Water with compressed air; air increases impact and affects droplet size

PRC

Air Atomizing Spray Nozzle



Spray Patterns

- Hollow cone
- Full cone
- Flat spray
- Fine spray

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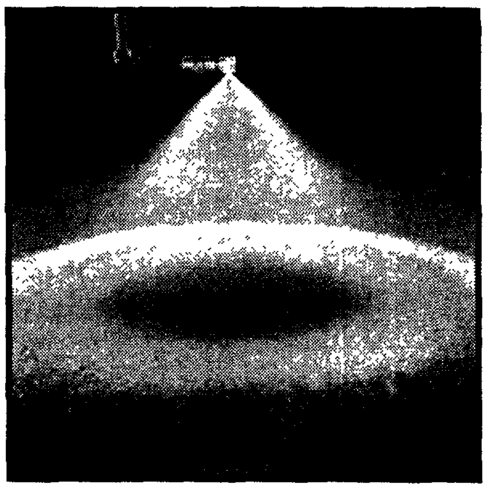
Hollow Cone



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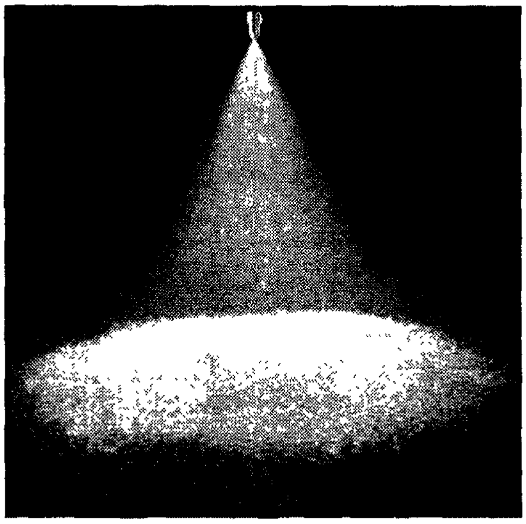
Full Cone



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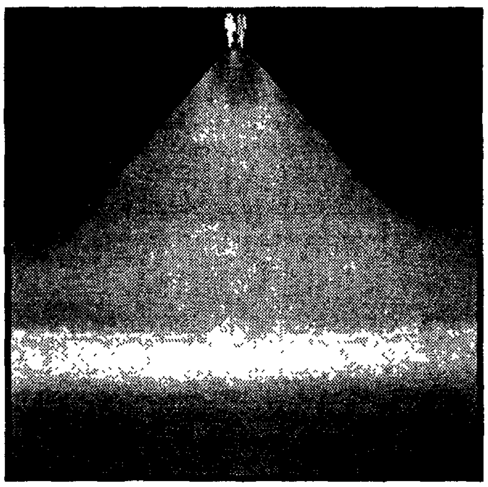
Flat Spray



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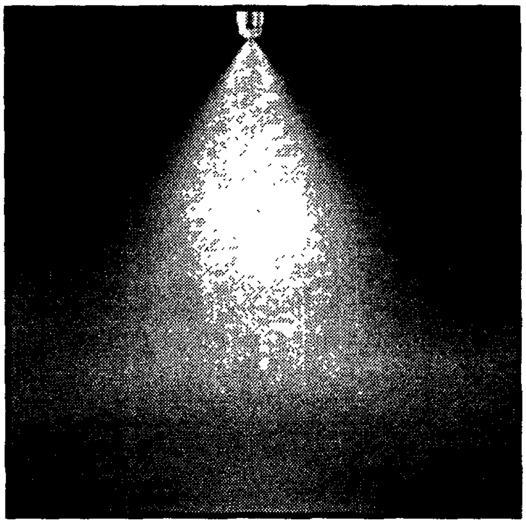
Fine Spray



Spray Rinse Flow Rate

- Flow rate = evaporation rate
- Estimating evaporation rate - chart
  - Temperature of solution
  - Surface area
- Flow at virtually any rate (0.01 to 142 gpm)
- Flow rate determined by nozzle design and water pressure
- Droplet size and impact determined by nozzle design, air pressure, and water pressure

Spray Pattern and Angle

- Maximize coverage
- Spray with downward angle to knock dragout off parts
- Use spray pattern to target certain areas
- Use offset spray position to spray interior surfaces of parts
- Overlap patterns to concentrate spray in areas of high dragout
  - Rough surfaces
  - Areas with "pockets"

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Evaporation Rate

- For dragout recovery, spray rinse flow rate should equal plating bath evaporation rate (to avoid need for an evaporator)
- Still tank evaporation rate (gal/hr/ft^2) = $e^{(0.03236T - 7.2)}$
- Agitated tank evaporation rate (gal/hr/ft^2) = $e^{(0.02655T - 5.95)}$

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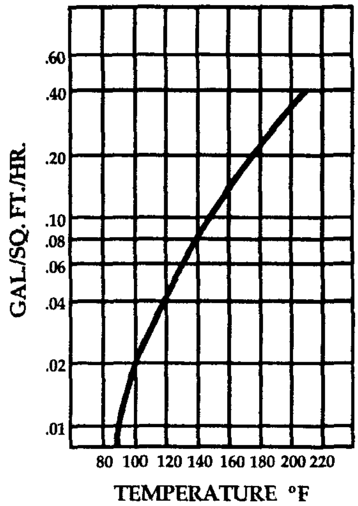
Evaporation Rate



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Timing and Actuation

- Manual operation
  - Hand-operated
  - Foot pedal-operated
- Conveyor actuated solenoids/timers
- Common problems with timing and actuation
  - Response time
  - Line drainage

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Check Valves

- Specifications
  - Crack pressure
  - Shutting pressure
- Adjustable
  - Change springs
  - Rotate screw

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Durability of Nozzles

- Durability
  - Corrosion resistance
  - Heat resistance
  - Strength
- Materials
  - PVC
  - PVDF thermoplastic
  - Polypropylene
  - Stainless Steel
  - Brass

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Placement Issues

- Corrosion
- Caking
- Exposure to damage by operator or hoist
- Accessibility for service

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Maintenance

- Nozzle wear characterized by:
  - Decrease in system operating pressure
  - Deterioration in spray pattern
- Regular inspection
  - Spray pressure
  - Spray pattern
  - Flow rate
  - Nozzle alignment
  - Product quality
- Remove nozzle and check for deposits
- Clean with compressed air or water

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Common Causes of Spray Nozzle Problems

- Erosion and wear
- Corrosion
- Clogging
- Caking
- Temperature damage
- Improper reassembly
- Accidental damage
- Improper worker training

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All American Manufacturing Company Los Angeles, CA

John Norton
President

All American

- Metal stamping of plumbing parts
- Decorative chrome and nickel plating

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Motivation for Pursuing P2

- Competitive market: high volume, low profit margin
- Process control and efficiency
- Cost of raw materials and waste
- Compliance with wastewater limits
- Company TQM program
- Good environmental citizen

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Two-Phase Approach

- Phase I: Reduce dragout; need to reduce loading first to stay under the POTW discharge limits
- Phase II: Once loading has been reduced, water use can be reduced on running rinses

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Phase I

- Reduce dragout volume through spray rinses
  - Over plating tanks (nickel and chrome)
  - In dragout tanks (nickel)
  - Over rinse tanks (chrome)
- Measure dragout reduction due to spray systems

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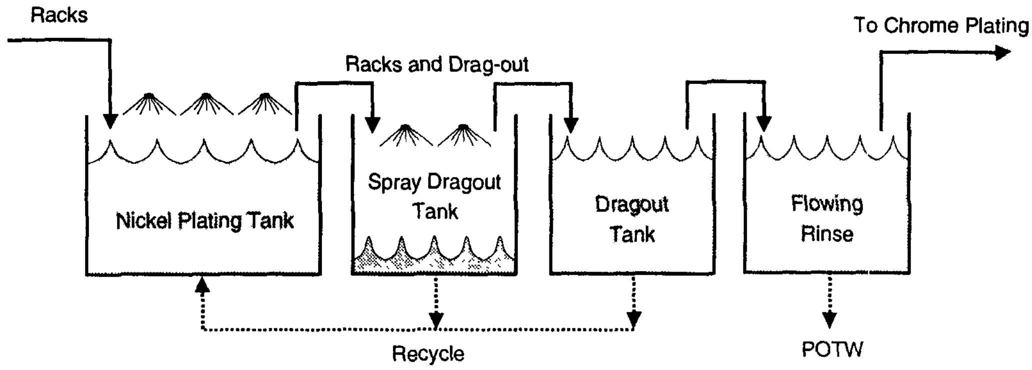
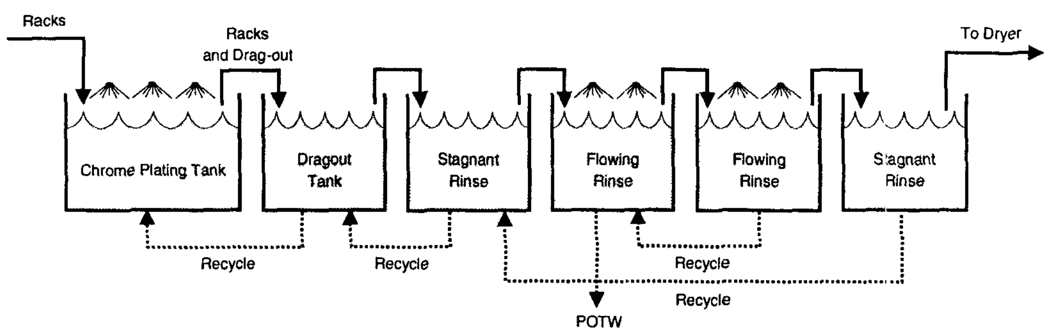
Nickel Plating Tank Layout



Chrome Plating Tank Layout



Spray Rinses Over Nickel Plating Tanks

- Nozzles
  - Hydraulic
  - Flat pattern
  - 84° angle
  - 0.5 gpm/nozzle at 40 psi
- Configuration
  - 6 nozzles per tank
  - Configured in two rectangles, 3 nozzles per long side
  - Installed 2 inches above process solution

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Spray Rinses Over Nickel Plating Tanks

- Sprays parts from four sides to form plane of rinsing through which parts pass
- Total spray flow = 4.0 gpm for 3 seconds; activated with timer
- Spray directed into the tank to minimize overspray and maximize dragout recovery
- Pressure relief valves and shutoff rate

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Spray Rinses In Dragout Tanks

- Two nickel dragout tanks
- Nozzles
  - Air atomizing
  - Flat pattern
  - 84^{o} angle
  - 0.29 gpm/nozzle at 40 psi

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Spray Rinses In Dragout Tanks

- Configuration
  - Eight nozzles in each tank
  - 3 nozzles per long side, one nozzle per short side
  - Nozzles installed below tank lip level
  - Back-side nozzles several inches higher to spray at more of a downward angle
- Total spray flow = 2.3 gpm for 5 seconds
- Hang time of up to 1 minute
- All rinse water returned to process tank

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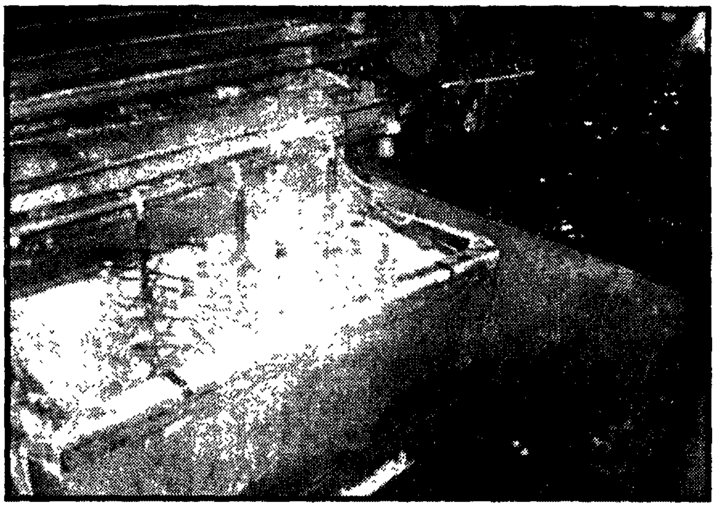
Spray Rinse In Dragout Tanks



Spray Rinses Over Chrome Plating Tank

- Mist spray rinse - 0.04 gpm/nozzle
- Configuration
  - Six nozzles evenly spaced along length of tank
  - One nozzle for each rack
- Location
  - Above chrome plating tank
  - In front of and slightly below vibrating hang bar
- Timer activated by placing rack on vibrating hang bar
- Stratification in plating tank
- Work environment improvement

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Spray Rinses Over Chrome Plating Tank

Spray Rinses Over Flowing Rinse Tanks

- Two chrome rinse tanks
  - Dragout reduced through vibrator and impact
- Purpose
  - Conserve water
  - Improve rinsing effectiveness
- Nozzles
  - Hydraulic
  - Full cone pattern
  - Two over each tank
- Quick-connect exchangeable nozzles
  - 3.5 to 8.5 gpm

Spray Rinses Over Flowing Rinse Tanks

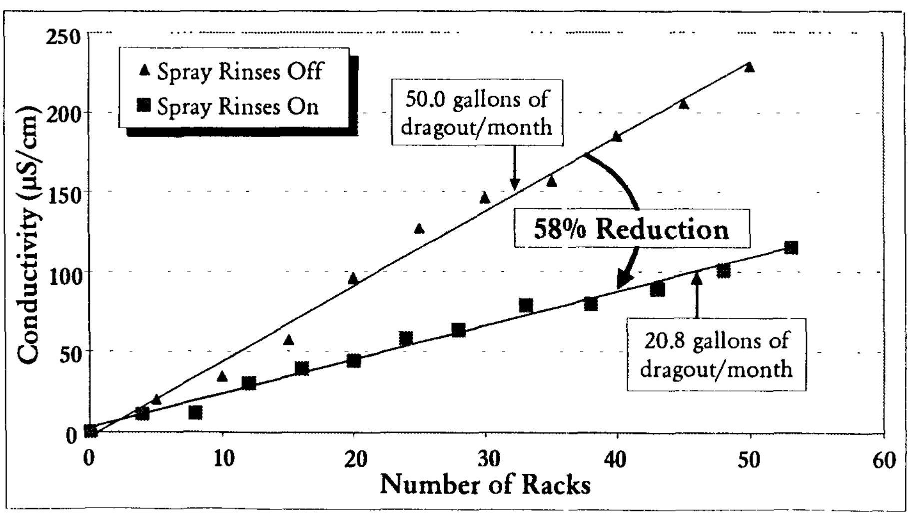
Spray Rinse Results

- Spray system performance was determined by measuring the decrease in dragout due to the spray systems
- Approach:
  - Under identical conditions (same part number and same worker), operate plating line with spray rinses on and off
  - Measure the conductivity increase in a stagnant rinse tank following the spray rinses (µS/rack)
  - Relate conductivity increase to volume of dragout over time (gallons of dragout/month)

Nickel Spray Rinse Results

- **Process order:**
  1) Nickel plating with spray rinse
  2) Spray rinse dragout tank
  3) Stagnant rinse with conductivity meter
- **Conductivity increase with both spray rinses off = 5.50 µS/rack**
- **Conductivity increase with both spray rinses on = 2.35 µS/rack**
- **Dragout reduction = 58%**

Spray Reduce Nickel Dragout by 58%



Chrome Spray Rinse Results

- Process order:
  1) Chrome plating with mist spray over hang bar
  2) Stagnant rinse with conductivity meter
- Dragout volume
  - With sprays off = 63.1 gallons/month
  - With spray on = 23.0 gallons/month
- Dragout reduction = 63%

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Other Positive Impacts

- Positive feedback from platers about air quality
- Reduced evaporator use

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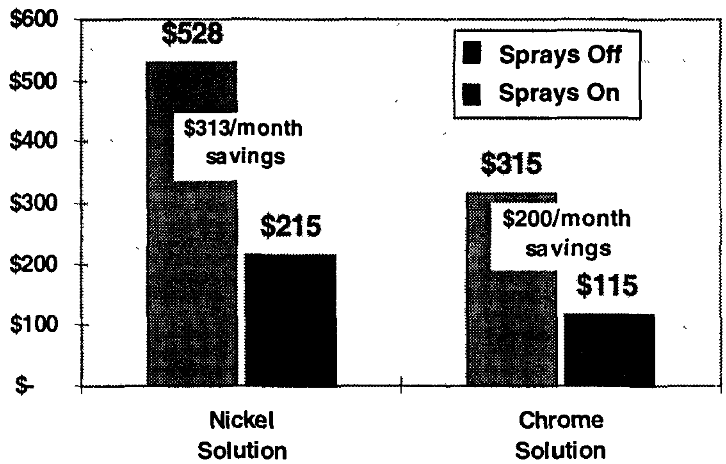
Monthly Savings from Dragout Reduction



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Spray Rinse Results

	Without Sprays	With Sprays	Monthly Savings
Nickel Solution Dragout	50.0 gal/mo	20.8 gal/mo	$313
Chrome Solution Dragout	63.1 gal/mo	23.0 gal/mo	$200
Rinse Water*	380,000 gal/mo	152,600 gal/mo	$185

Total Cost Savings = $8,376/year

Total Cost = $4,890

Payback Period = 0.6 year

*Estimated based on dragout reduction

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The Next Step: Phase II

- Generate calibration curves for nickel and chrome
- Calculate the actual decrease in dragout volume associated with the conductivity measurements
- Reduce rinse water use on flowing rinses while maintaining nickel and chrome discharge levels below POTW limits
- Train workers and continuously monitor dragout as part of company TQM program

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Catherine Zeman

Iowa Waste Reduction Center, University of Northern Iowa

Low VOC/Alternative Soy Ink Solvents

Lisa Hurban and Catherine Zeman
Iowa Waste Reduction Center
University of Northern Iowa
Cedar Falls, Iowa

Presentation Abstract

Soy inks and low VOC solvents provide well known air emissions reduction benefits to lithographic printers. For printers in areas where non-attainment for ozone emissions is a concern, the use of soy inks along with low VOC solvents can be an essential component to pollution prevention programs that aid in meeting regulatory requirements. However, a comprehensive analysis of the best low VOC solvents for use with soy based inks is not readily available.

This presentation addresses the design of a low VOC solvent and soy ink compatibility study. Presenters will discuss the various aspects of study design such as choice of printed material, controlling for ink density on the blanket, desensitizing the transfer blanket between test runs, the choice of performance criteria, and the choice of cleaning methodologies. A method for tabulating and analyzing test data will also be described. Audience discussion and participation concerning study design will be encouraged. The performance of test solvents to date will be summarized.

Project Description and Need

- *Overall project design*
  - *Previous work*
    - *DfE*
    - *Other*
  - *Distinctions from previous work*
    - *Project design*
    - *Cleaning methodology*

Project Partners

- *Educational Partners*
- *Industry Partners*
- *Finding Contacts*
- *Liability and Commitment Issues*

Data Collection Design

- *What Data to Collect*
- *Why This Data?*
- *Standardization Measures*

Data Collection Analysis

- *Real World Statistical Analysis*
- *Statistics of Value*
- *Data Presentation for Clientele*

Findings To Date

- *Number of Sites Scheduled/Completed*
- *Issues of Interest*
- *Findings to Date/Generalizations*

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